



# महाराष्ट्र शासन राजपत्र

## असाधारण भाग चार-अ

वर्ष ५, अंक १६(२)]

गुरुवार, ऑगस्ट २२, २०१९/श्रावण ३१, १९४१

[पृष्ठे ५०९, किंमत : रुपये १५.००]

असाधारण क्रमांक २१३

### प्राधिकृत प्रकाशन

महाराष्ट्र शासनाने केंद्रीय अधिनियमान्वये तयार केलेले  
(भाग एक, एक-अ आणि एक-ल यांमध्ये प्रसिद्ध केलेले नियम व आदेश यांव्यतिरिक्त) नियम व आदेश.

उद्योग, ऊर्जा व कामगार विभाग

मादाम कामा मार्ग, हुतात्मा राजगुरु चौक,

मंत्रालय, मुंबई ४०० ०३२, दिनांक २२ ऑगस्ट २०१९

### अधिसूचना

ऊर्जा संवर्धन अधिनियम, २००१.

क्रमांक अपाऊ- २०१८/प्र.क्र.८७/ऊर्जा-७(भाग-१). — ऊर्जा संवर्धन अधिनियम, २००१ (२००१ चा ५२) याच्या कलम ५७ च्या पोट-कलम (२) चा खंड (क), तसेच, कलम १५ चा खंड (क) याद्वारे प्रदान करण्यात आलेल्या, अधिकारांचा आणि त्याबाबतीत त्यास समर्थ करणाऱ्या इतर सर्व अधिकारांचा वापर करून, महाराष्ट्र राज्यातील, वाणिज्यिक इमारतींमध्ये ऊर्जा वापराच्या बाबतीत, ऊर्जा दक्षता विभाग (बी.इ.इ.) यांच्याशी सल्लामसलत करून, ऊर्जा संवर्धन इमारत संहिता विनिर्दिष्ट व अधिसूचित करण्यासाठी, महाराष्ट्र शासनाने करण्याचे योजिलेल्या नियमांचा पुढील मसुदा हा, त्यामुळे बाधा पोचण्याची शक्यता असलेल्या सर्व व्यक्तींच्या माहितीकरिता, याद्वारे प्रसिद्ध करण्यात येत आहे आणि याद्वारे अशी नोटीस देण्यात येत आहे की, महाराष्ट्र शासन, ही अधिसूचना **राजपत्रात** प्रसिद्ध झाल्याच्या दिनांकापासून ३० दिवसांचा कालावधी संपल्यानंतर, उक्त नियमांचा मसुदा विचारात घेईल.

२. उक्त मसुद्याच्या संबंधात उपरोक्त कालावधीत ज्या कोणत्याही व्यक्तीकडून ज्या कोणालाही हरकती किंवा सूचना महाव्यवस्थापक (ऊर्जा संवर्धन), महाराष्ट्र ऊर्जा विकास अभिकरण, स. नं. १९१, फेज — १, म्हाडा वाणिज्य संकूल, दुसरा मजला, त्रिदल नगर समोर, येरवडा, पुणे ४०० ००६ यांच्याकडे किंवा [ecbc@mahaurja.com](mailto:ecbc@mahaurja.com) या ईमेलवर प्राप्त होतील, शासन त्या विचारात घेईल.

### प्रारूप नियम

१. **संक्षिप्त नाव.** — या नियमांना, महाराष्ट्र ऊर्जा संवर्धन इमारत नियम, २०१९, असे म्हणावे.

२. **व्याख्या.** — (१) या नियमांद्वारे, संदर्भानुसार दुसरा अर्थ अपेक्षित नसेल तर, —

(क) "अधिनियम" याचा अर्थ, ऊर्जा संवर्धन अधिनियम, २००१ (२००१ चा ५२) असा आहे;

(ख) "वास्तव ऊर्जा कार्यमान निर्देशांक" याचा अर्थ, इमारतीच्या वास्तविक ऊर्जा वापरानुसार गणना केलेला, ऊर्जा कार्यमान निर्देशांक, असा आहे;

(ग) "जोडपत्र" याचा अर्थ, या नियमांसोबत जोडलेले जोडपत्र, असा आहे;

(घ) "अधिकारिता असलेले प्राधिकरण (ए एच जे)" याचा अर्थ, जे समुचित शासन आपल्या अधिकारितेखालील जमिनीसंबंधीच्या प्राधिकारांचा वापर करते आणि ज्याला अशा स्थावर मालमत्तेच्या विकासाकरिता परवानगी देण्याचे अधिकार आहेत अशा समुचित शासनाने त्या त्या वेळी अंमलात असलेल्या कोणत्याही कायद्यान्वये निर्माण केलेले किंवा स्थापन केलेले स्थानिक प्राधिकरण किंवा कोणतेही प्राधिकरण, असा आहे;

(ङ) "उत्कृष्ट उपयोजन" याचा अर्थ, केंद्राच्या किंवा राज्याच्या कायद्यातील इमारत संरचनेची सुरक्षा, स्थैर्य, आरोग्य व पर्यावरण विषयक तरतुदी विचारात घेता, ज्यायोगे एकात्मिक संकल्पन (दृष्टीकोन आधारित) एकरूप घटकांचा व सुविधांचा कार्यक्षमपणे वापर होऊन, इमारतीचे कार्यमान वाढते किंवा बांधकामाचा खर्च कमी होतो, अशी उपाययोजना, असा आहे, आणि त्यामध्ये पदनिर्देशित अभिकरणाने किंवा राष्ट्रीय ऊर्जा संवर्धन इमारत संहिता अंमलबजावणी समितीने मान्यता दिलेल्या उर्जा संवर्धनविषयक उपायोजनांचा समावेश होतो;

(च) "मंडळ" याचा अर्थ, या नियमांच्या नियम ७ च्या उप नियम १ अन्वये स्थापन केलेले ऊर्जा संवर्धन इमारत संहिता मंडळ, असा आहे;

(छ) "बांधीव क्षेत्रफळ" याचा अर्थ, एखाद्या इमारतीने सर्व मजल्यांवर तसेच, प्रवाहू भाग, पोटमाळे, कोणतेही असल्यास, यांवर व्यापलेले एकूण क्षेत्रफळ, असा आहे, परंतु, त्यामध्ये अधिकारिता असलेल्या प्राधिकरणाच्या विनियमां अन्वये चटईक्षेत्र निर्देशांकामधून विनिर्देशपूर्वक वगळलेल्या क्षेत्राचा समावेश होणार नाही;

(ज) "विभाग" याचा अर्थ, भारताचा ऊर्जा दक्षता विभाग, असा आहे;

(झ) "उप विधी" याचा अर्थ, अधिकारिता असलेल्या प्राधिकरणाने अधिसूचित केलेले उप विधि, असा आहे;

(ञ) "केंद्र सरकार" याचा अर्थ, भारत सरकार, असा आहे;

(ट) "संलग्न भार" याचा अर्थ, ऊर्जा संवर्धन इमारत संहितेच्या प्रकरण ८ च्या उप-परिच्छेद (२) मध्ये व्याख्या केल्याप्रमाणे इमारत संकुलाचा मंजूर भार, असा आहे;

(ठ) "बांधकामाचे दस्तऐवज" याचा अर्थ, ऊर्जा संवर्धन इमारत संहितेच्या प्रकरण ८ च्या उप-परिच्छेद (२) मध्ये व्याख्या केल्याप्रमाणे दस्तऐवजांचा संच, असा आहे;

(ड) "संविदा मागणी" याचा अर्थ, ऊर्जा संवर्धन इमारत संहितेच्या प्रकरण ८ च्या उप-परिच्छेद (२) मध्ये व्याख्या केल्याप्रमाणे संविदा मागणी, असा आहे;

(ढ) "पदनिर्देशित अभिकरण" याचा अर्थ, अधिनियमाच्या कलम १५ च्या खंड (घ) अन्वये राज्य शासनाने पदनिर्देशित केलेले, महाराष्ट्र ऊर्जा विकास अभिकरण, असा आहे;

(ण) "वितरण लायसनधारक" याचा अर्थ, वीज अधिनियम, २००३ (२००३ चा अधिनियम ३६) याच्या कलम २ च्या खंड (१७) नुसार महाराष्ट्र वीज नियामक आयोगाने प्राधिकृत केलेला विद्युत वितरण लायसनधारक, असा आहे;

(त) "ऊर्जा संवर्धन इमारत संहिता (इसीबीसी)" याचा अर्थ, अधिनियमाच्या कलम १४ च्या खंड (प) अनुसार ऊर्जा दक्षता विभागाने प्रसिद्ध केलेली "महाराष्ट्र ऊर्जा संवर्धन इमारत संहिता", असा आहे, आणि त्यामध्ये याबाबतीत वेळोवेळी केलेल्या महाराष्ट्र सुधारणेचा समावेश होतो;

(थ) "ऊर्जा संवर्धन इमारत संहिता निरीक्षण अधिकारी" याचा अर्थ, अधिनियमाच्या कलम १७ च्या पोट-कलम (१) अन्वये राज्य पदनिर्देशित अभिकरणाने नियुक्त केलेला निरीक्षण अधिकारी, असा आहे;

(द) "नामिकाप्रविष्ट महा-ऊर्जा संवर्धन इमारत संहिता लेखापरीक्षा अभिकरण" याचा अर्थ, ऊर्जा दक्षता विभाग (ऊर्जा लेखापरीक्षक व ऊर्जा व्यवस्थापक यांच्याकरिता प्रमाणन पद्धती) विनियम, २०१० अन्वये प्रमाणित केलेल्या ऊर्जा लेखापरीक्षक आणि ऊर्जा लेखापरीक्षक (इमारत) यांचा समावेश असलेली आणि पदनिर्देशित अभिकरणाकडे नामिकाप्रविष्ट असतील अशी भागीदारी अभिकरणे, असा आहे;

(ध) "ऊर्जा लेखापरीक्षक (इमारत)" याचा अर्थ, ऊर्जा संवर्धन (ऊर्जा लेखापरीक्षक आणि ऊर्जा व्यवस्थापक यांची किमान अर्हता) नियम, २००६ यामध्ये विनिर्दिष्ट केलेले पात्रता निकष, ज्या व्यक्तीने पूर्ण केलेले असतील आणि जी विभागाकडून घेण्यात येणाऱ्या, ऊर्जा संवर्धन इमारत संहिता अनुपालनांसाठीच्या राष्ट्रीय परीक्षेत अर्ह ठरली असेल, अशी व्यक्ती, असा आहे;

(न) "ऊर्जा संवर्धन उपाय योजना" याचा अर्थ, या नियमांच्या नियम ५ मध्ये विनिर्दिष्ट केलेल्या ऊर्जा संवर्धन इमारत संहितेच्या अनुपालन कार्यतंत्राच्या अपेक्षित पातळीपर्यंत ऊर्जेची कमाल गरज भागविण्यासाठी इमारतीच्या संकल्पनामध्ये अंतर्भूत केलेले ऊर्जा बचतीचे उपाय, असा आहे;

(प) "ऊर्जा कार्यमान निर्देशांक" किंवा "इपीआय" याचा अर्थ, ऊर्जा संवर्धन इमारत संहितेच्या प्रकरण ३ च्या उप-परिच्छेद (१.१) मध्ये निर्दिष्ट केल्याप्रमाणे ऊर्जा कार्यमान निर्देशांक, असा आहे;

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| ऊर्जा कार्यमान निर्देशांक = | <div>वार्षिक ऊर्जा वापर (kwh मध्ये)</div> <hr/> <div>एकूण बांधीव क्षेत्रफळ (बिगर-वातानुकुलीत तळघर सोडून) (चौ.मी. मध्ये)</div> |
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(फ) "ऊर्जा कार्यमान निर्देशांक गुणोत्तर" याचा अर्थ, ऊर्जा संवर्धन इमारत संहितेच्या प्रकरण ३ च्या उप-परिच्छेद १.२ मध्ये नमूद केलेल्या सुत्रानुसार निर्धारित केलेले ऊर्जा कार्यमान निर्देशांक गुणोत्तर, असा आहे;

(ब) "नमुना" याचा अर्थ, या नियमांसोबत जोडलेले नमुने, असा आहे;

(भ) "निधी" याचा अर्थ, अधिनियमाच्या कलम १६ च्या पोट-कलम (१) अन्वये राज्य शासनाने घटित केलेला ऊर्जा संवर्धन निधी, असा आहे;

(म) "जवळजवळ शून्य - ऊर्जा इमारत" याचा अर्थ, ज्या इमारतीचा ऊर्जा कार्यमान निर्देशांक, दरवर्षी प्रती चौरस मीटर १० किलोवॉट-तास (केडब्ल्यूएच) पेक्षा कमी आहे, आणि जेथे एकूण ऊर्जेची गरज ही नवीकरणीय ऊर्जा स्रोतांद्वारे भागविली जाते, अशी निम्न ऊर्जा कार्यमान निर्देशांक गुणोत्तर असलेली, ऊर्जा कार्यक्षम इमारत, असा आहे, अशा इमारती त्यांच्या स्थळी दरवर्षी जेवढ्या प्रमाणात ऊर्जेचा वापर होतो तेवढ्याच प्रमाणात अपारंपरिक ऊर्जा निर्माण करतात.

(य) "मालक" याचा अर्थ, - ज्यांच्या नावाने महसुली अभिलेख्यांमध्ये स्थावर मालमत्तेची नोंदणी केली आहे अशी व्यक्ती,

व्यक्तीचा गट, कंपनी, विश्वस्त मंडळ संस्था, नोंदणीकृत निकाय, राज्य शासनाचे किंवा केंद्र सरकारचे विभाग, उपक्रम व अभिकरणे किंवा अशी संघटना, असा आहे; किंवा पुढील संदर्भात .—

(एक) जी वाणिज्यिक इमारतीचे बांधकाम करते किंवा बांधकाम करून घेते अथवा विद्यमान इमारतीचे किंवा तिच्या भागाचे वाणिज्यिक इमारतीत परिवर्तन करते अशी व्यक्ती, असा आहे;

(दोन) जी स्वतः बांधकाम व्यावसायिक, वसाहतकार, कंत्राटदार, विकासक, वसाहत विकासक किंवा इतर कोणत्याही नावाने ज्या जागेवर इमारत बांधण्यात आली असेल त्या जागेच्या मालकाच्या वतीने मुख्यतः पत्रधारक म्हणून काम करीत आहे किंवा काम करीत असल्याचा दावा करीत आहे, अशी कोणतीही अन्य व्यक्ती, असा आहे;

(कक) "प्रस्तावित संकल्पचित्र" याचा अर्थ, ऊर्जा संवर्धन इमारत संहितेच्या प्रकरण ८ च्या उप-परिच्छेद (२) मध्ये व्याख्या केलेले प्रस्तावित संकल्पचित्र, असा आहे;

(खख) "मानक संकल्पचित्र" याचा अर्थ, ऊर्जा संवर्धन इमारत संहितेच्या प्रकरण ८ च्या उप-परिच्छेद (२) मध्ये व्याख्या केलेले मानक संकल्पचित्र, असा आहे;

(गग) "राज्य आयोग" किंवा "महाराष्ट्र वीज नियामक आयोग" याचा अर्थ, वीज अधिनियम, २००३ याच्या कलम ८२ च्या पोट-कलम (१) अन्वये घटित केलेला महाराष्ट्र विद्युत नियामक आयोग, असा आहे आणि त्यामध्ये त्या अधिनियमाच्या कलम ८३ च्या पोट-कलम (१) नुसार घटित केलेल्या संयुक्त आयोगाचा समावेश होतो;

(घघ) "राज्य शासन" याचा अर्थ, महाराष्ट्र शासन, असा आहे;

(ङङ) "तांत्रिक तक्रार समिती" किंवा "समिती" याचा अर्थ, या नियमांच्या नियम ८ च्या उप नियम (२) अन्वये स्थापन केलेली, महाराष्ट्र ऊर्जा संवर्धन इमारत संहिता तांत्रिक तक्रार समिती, असा आहे;

(२) या नियमांमध्ये वापरलेले, परंतु व्याख्या न केलेले आणि त्या त्या वेळी अंमलात असलेल्या इतर कोणत्याही कायद्यात, अथवा शासनाच्या इतर संबंधित कायद्यांमध्ये व्याख्या केलेले शब्द व शब्दप्रयोग यांना त्या कायद्यात अनुक्रमे जे अर्थ नेमून दिलेले असतील, तेच अर्थ असतील.

**३. प्रयोज्यता .—** (१) हे नियम, १०० किलोवॉट किंवा त्यापेक्षा अधिक किलोवॉट इतका संलग्न भार असलेल्या, किंवा १२० किलो व्होल्ट ॲम्पिअर (केव्हीए) किंवा त्यापेक्षा अधिक किलो व्होल्ट ॲम्पिअर इतकी संविदा मागणी असलेल्या, किंवा १००० चौरस मीटर इतके बांधीव क्षेत्रफळ असलेल्या, ज्या इमारतीचा वाणिज्यिक प्रयोजनांसाठी वापर केला जातो किंवा ज्यांचा वापर करण्याचे उद्देशित केले आहे, अशा प्रत्येक वाणिज्यिक इमारतीस किंवा इमारत संकुलास किंवा इमारतीच्या भागास, लागू होतील आणि त्यामध्ये, पुढील इमारत घटक भागांचा समावेश असेल, —

(क) इमारतीचे आवरण ;

(ख) सुख-सुविधा आणि नियंत्रण व्यवस्था (उष्मन, वायुवीजन व वातानुकूलन, गरम पाण्याची सेवा सुविधा);

(ग) दिवाबत्ती व्यवस्था आणि नियंत्रण व्यवस्था;

(घ) विद्युत आणि नवीकरणीय ऊर्जा प्रणाली; आणि

(ङ) विभागाकडून वेळोवेळी विनिर्दिष्ट करण्यात येईल अशी, इतर कोणतीही यंत्रणा.



(२) जेथे विद्यमान इमारतींमध्ये वाढीव बांधकाम किंवा फेरबदल केल्याच्या परिणामी, १०० किलोवॉट किंवा त्यापेक्षा अधिक किलोवॉट इतका एकूण संलग्न भार किंवा १२० किलो व्होल्ट ॲम्पिअर (केव्हीए) किंवा त्यापेक्षा अधिक किलो व्होल्ट ॲम्पिअर इतकी संविदा मागणी किंवा १००० चौरस मीटर इतके बांधीव क्षेत्रफळ निर्माण झाले असेल तेथे, अशा वाढीव किंवा फेरबदल केलेल्या भागाच्या बाबतीत, उप कलम (१) च्या खंड (क) ते (ड) मध्ये निर्दिष्ट केलेल्या घटकांचे पालन करण्यात येईल.

**४. अप्रयोज्यता.** — हे नियम पुढील बाबतीत लागू होणार नाहीत, —

- (१) ज्यामध्ये विद्युत ऊर्जेचा किंवा जीवाश्म इंधनाचा वापर होत नाही अशा इमारती;
- (२) जेथे ऊर्जा वापर मुख्यत्वेकरून उत्पादन प्रक्रियेसाठी केला जातो अशी उपकरणे आणि इमारतीचा भाग;
- (३) जेथे केंद्राच्या किंवा राज्याच्या कायद्यातील सुरक्षा, आरोग्य किंवा पर्यावरणविषयक तरतुदी किंवा इमारत उप विधी किंवा इमारत विनियम यांच्याशी या नियमांचा विधिसंघर्ष निर्माण होईल तेथे अशा इमारती किंवा इमारतीचे घटकभाग यांच्याबाबतीत, हे नियम अधिभावी होतील.

**५. अनुपालन कार्यतंत्र.** — (१) अनुपालनाच्या पद्धती : —

(क) मालक, ऊर्जा संवर्धन इमारत संहितेच्या प्रकरण २ च्या उप परिच्छेद (५) मध्ये विनिर्दिष्ट केलेल्या इमारत वर्गीकरणानुसार, प्रस्तावित वाणिज्यिक इमारतीचे, तिच्या संरचनेच्या कार्यात्मक आवश्यकतेप्रमाणे वर्गीकरण करील.

(ख) इमारत अथवा इमारतीच्या संकुलामध्ये ऊर्जा संवर्धन इमारत संहितेच्या प्रकरण ३ मध्ये विनिर्दिष्ट केलेल्या अनुपालन व अनुपालनाच्या पद्धतीशी संबंधित आवश्यकतांचे पालन करण्यात येईल आणि ऊर्जा संवर्धन इमारत संहितेच्या परिशिष्ट बी-१ मध्ये विनिर्दिष्ट केलेल्या हवामान आधारित वर्गीकरणाप्रमाणे इमारतीच्या अनुपालनाचे वर्गीकरण केले असल्याबाबतची सुनिश्चिती करण्यात येईल.

(२) ऊर्जा कार्यमान अनुपालनाचा स्तर: पदनिर्देशित अभिकरण, अनुपालनासाठी पुढील तक्ता क्र. १ मध्ये नमूद केल्याप्रमाणे तारांकित मापन प्रणाली विनिश्चित करील : —

**तक्ता १— ऊर्जा कार्यमान अनुपालनाचा स्तर**

| अनुपालनाचा स्तर    | निकष  |
|--------------------|---|
| १ महाऊर्जा २ स्टार | ऊर्जा संवर्धन इमारत संहितेप्रमाणे इसीबीसी अनुपालनार्थी इमारत,   |
| २ महाऊर्जा ३ स्टार | ऊर्जा संवर्धन इमारत संहितेप्रमाणे इसीबीसी + अनुपालनार्थी इमारत,   |
| ३ महाऊर्जा ४ स्टार | ऊर्जा संवर्धन इमारत संहितेप्रमाणे उत्कृष्ट इसीबीसी इमारत,   |
| ४ महाऊर्जा ५ स्टार | ऊर्जा संवर्धन इमारत संहितेमध्ये नमूद केलेल्या इमारतीतील समान प्रकारनिष्ठ वर्गीकरणाचे उत्कृष्ट कार्यमान निर्देशांक गुणोत्तरापेक्षा ऊर्जा कार्यमान निर्देशांक गुणोत्तर प्रमाणामध्ये १०% ते २०% इतकी घट        |
| ५ महाऊर्जा ६ स्टार | ऊर्जा संवर्धन इमारत संहितेमध्ये नमूद केलेल्या इमारतीतील समान प्रकारनिष्ठ वर्गीकरणाचे उत्कृष्ट इसीबीसी ऊर्जा कार्यमान निर्देशांक गुणोत्तरापेक्षा निर्देशांक गुणोत्तर प्रमाणामध्ये २० टक्के पेक्षा अधिकची घट. |

६. इमारतीचे बांधकाम किंवा पुनर्बांधकाम किंवा फेरबदल याबाबतचा अनुपालन अहवाल प्राप्त करण्याची कार्यपद्धती - इमारतीचे बांधकाम, पुनर्बांधकाम किंवा फेरबदल अथवा वाढ करण्याचा हेतू असणारा प्रत्येक मालक, या नियमात नमूद केल्याप्रमाणे पुढील टप्प्यांचे पालन करील :-

(१) इमारत संरचनेचा टप्पा -

(क) मालक -

(एक) ऊर्जा संवर्धन इमारत संहितेमध्ये विनिर्दिष्ट केल्याप्रमाणे ऊर्जा लेखा परीक्षक (इमारत) व तांत्रिक तज्ज्ञ यांचा समावेश असलेल्या इमारत संकल्पन गटाची नेमणूक करील.

(दोन) पदनिर्देशित अभिकरणाकडे इमारत संकल्पचित्राच्या मान्यतेसाठी नमुना - एक, दोन व तीन मध्ये अर्ज करील.

(ख) पदनिर्देशित अभिकरण -

(एक) ऊर्जा संवर्धन इमारत संहितेप्रमाणे इमारत संकल्पचित्राची छाननी व पडताळणी करील.

(दोन) पदनिर्देशित अभिकरण पुढील बाबींची पडताळणी करील, त्या बाबी म्हणजे -

(क) प्रस्तावित संकल्पचित्रामध्ये ऊर्जा संवर्धनाच्या विशेष उपाययोजना लागू करण्यात आल्या आहेत;

(ख) प्रस्तावित इमारतीचे अनुपालन व बांधकामाशी संबंधित दस्तऐवज यांबाबतचे निष्कर्ष हे, आदेशानुरूप किंवा पूर्णतः इमारत कार्यमान पद्धतीनुरूप आहेत;

(ग) प्रस्तावित संकल्पचित्रात योजलेले ऊर्जा कार्यमान निर्देशांक गुणोत्तर हे, ऊर्जा संवर्धन इमारत संहितेनुसार आहे.

(तीन) जर संकल्पचित्राच्या आवश्यकतांच्या बाबतीत कोणत्याही विसंगती असल्यास, पदनिर्देशित अभिकरण त्या विसंगतीबाबतचा अहवाल नमुना - चार मध्ये मालकाला अनुपालनार्थ कळवील.

(चार) पदनिर्देशित अभिकरण नमुना-५ मध्ये विशेष इमारत ओळख क्रमांक (युबीआयडी) निर्देशित करणारा अनुपालन अहवाल अधिकारिता असलेल्या प्राधिकरणाला कळवील आणि त्याची प्रत मालकाला व संबंधित वितरण लायसन धारकाला अग्रेषित करील.

(ग) अधिकारिता असलेले प्राधिकरण इमारत बांधकामाच्या संकल्पचित्रास अंतिम मंजूरी देण्यापूर्वी, ज्या संकल्पचित्रास अधिकारिता असलेल्या प्राधिकरणाकडून मंजूरी दिली आहे ते मंजूर संकल्पचित्र हे ज्याच्या बाबतीत पदनिर्देशित अभिकरणाने इसीबीसी अनुपालन प्रमाणपत्र दिलेले आहे, तेच असल्याबद्दलची खातरजमा करील.

(२) बांधकामाचा टप्पा -

(क) अधिकारिता असलेल्या अभिकरणाकडून इमारत बांधकामासाठी आवश्यक ती परवानगी मिळाल्यानंतर मालक -

(एक) बांधकाम कार्य सुरु करण्यापूर्वी नमुना ६ मध्ये पदनिर्देशित अभिकरणाला सूचना देईल;

(दोन) अधिकारिता असलेल्या प्राधिकरणाकडे भोगवटा प्रमाणपत्रासाठी अर्ज करण्यापूर्वी, ऊर्जा लेखापरीक्षक (इमारत), आवश्यक असलेले अनुपालन दस्तऐवज, तपासणी सूची व स्थळ पाहणी अहवाल यांची पडताळणी करील आणि पदनिर्देशित अभिकरणाला नमुना-आठ मधील बांधकाम कार्याच्या सूचनेसह नमुना-सात मधील अनुपालन अहवालाशी सदर बाबी सुसंगत असल्याचे प्रमाणित करील.

(तीन) जर बांधकाम कार्य हे अनुपालन अहवालाशी सुसंगत नसेल तर, मालक, या नियमाच्या उप नियम (१) प्रमाणे पदनिर्देशित अभिकरणाकडून नवीन अनुपालन अहवाल प्राप्त करील.

(ख) पदनिर्देशित अभिकरण —

(एक) नमुना - सात व नमुना- आठ मध्ये मालकाकडून प्राप्त झालेल्या माहितीची छाननी करील आणि इमारत बांधकामाच्या प्रस्तावित ऊर्जा कार्यमान निर्देशांक गुणोत्तराची पडताळणी करील;

(दोन) नमुना - नऊ मध्ये जर कोणतीही विसंगती आढळून आली असेल तर, छाननी करून अनुपालन न केल्याची कारणे नमूद असलेला अहवाल मालकाला देईल;

(तीन) नमुना दहा व अकरा मधील इसीबीसी अनुपालन प्रमाणपत्र देईल.

(३) इमारत परिचालनाचा टप्पा —

(क) मालकाने भोगवटा प्रमाणपत्र निर्गमित केल्यापासून किंवा इमारतीचा पूर्ण ताबा घेतल्याच्या दिनांकापासून यांपैकी जे आधी घडेल तेव्हापासून १८ महिन्यांच्या आत ऊर्जा संवर्धन इमारत संहितेच्या प्रकरण ३ मध्ये व्याख्या केलेल्या अनुपालनाच्या पद्धतीनुसार ऊर्जा कार्यमान निर्देशांक गुणोत्तर साध्य करील.

(ख) वितरण लायसनधारकाने भोगवटा प्रमाणपत्र निर्गमित केल्यापासून किंवा इमारतीचा पूर्ण ताबा घेतल्याच्या दिनांकापासून, यांपैकी जे आधी घडेल तेव्हापासून १८ महिन्यांनंतर इमारतीच्या ऊर्जा वापराबाबतची तपासणी करील आणि पदनिर्देशित अभिकरणाला दरमहा तसे कळवील;

(ग) पदनिर्देशित अभिकरण —

(एक) इमारतीच्या कार्यपालनाच्या टप्प्यादरम्यान, इमारतीच्या ऊर्जा कार्यमानाबाबतच्या सनियंत्रणाद्वारे परिपूर्ण तपासणी करून आणि ऊर्जा कार्यमान निर्देशांक गुणोत्तराची तुलना करून त्या इमारतीचे इसीबीसी अनुपालन विधिग्राह्य करील आणि मालकाला त्याबाबतची माहिती देईल;

(दोन) प्रत्येक वर्षी, ऊर्जा कार्यमान निर्देशांकावरून इमारतीच्या ऊर्जा कार्यमानाचे सनियंत्रण करील आणि प्रस्तावित ऊर्जा कार्यमान निर्देशांकाशी त्याची तुलना करील आणि मालकाला त्याबाबतची माहिती देईल;

(तीन) सर्व इसीबीसी अनुपालनार्थी इमारतींमधील ऊर्जा वापराबाबतची आकडेवारी प्राप्त करील आणि तिचा अभिलेख ठेवील;

(चार) एखादा मालक, या नियमांखालील कोणत्याही निर्णयामुळे व्यथित झाल्यास, त्यास, ३० दिवसांच्या कालावधीच्या आत तांत्रिक तक्रार समितीकडे आपली तक्रार दाखल करता येईल;

७. मंडळाचे अधिकार, कार्य व कर्तव्ये —

(१) महा-इसीबीसी मंडळ घटित करणे —

(क) राज्य शासनाकडून नामनिर्देशित करावयाच्या सदस्यांसह, प्रभारी मंत्री, नवीन व नवीकरणीय ऊर्जा, महाराष्ट्र शासन याच्या अध्यक्षतेखाली मंडळाची स्थापना करण्यात येईल आणि त्यामध्ये पुढील संबंधित प्रशासकीय विभागातील इतर पाच नामनिर्देशित व्यक्तींचा समावेश असेल—

(एक) ऊर्जा विभागाचा एक प्रतिनिधी;

- (दोन) नगर विकास विभागाचा एक प्रतिनिधी;
- (तीन) मुख्य नगर रचनाकार किंवा नगर रचना संचालनालयाची नामनिर्देशित व्यक्ती;
- (चार) राज्य शासनाच्या विद्युत वितरण लायसन्धारकांचा एक प्रतिनिधी;
- (पाच) पदनिर्देशित अभिकरणाचा प्रमुख हा या मंडळाचा सदस्य सचिव असेल;
- (ख) मंडळामध्ये विभागाच्या प्रतिनिधींचा समावेश असेल;
- (ग) मंडळाला, आवश्यक वाटल्यास, तज्ज्ञ व्यक्तींच्या सेवा घेण्याची मुभा असेल.

(२) मंडळ -

- (क) इमारतीचे कार्यमान वाढवण्यासाठी इमारतीच्या विविध घटकांमध्ये आणि सुविधांमध्ये ऊर्जा कार्यक्षम वापर अंतर्भूत असलेल्या इमारतीच्या ऊर्जा-कार्यक्षम संकल्पचित्रास चालना देईल आणि त्यास इमारतीच्या ऊर्जा वापराची मानके विकसित करण्यासाठी किंवा त्यात सुधारणा करण्यासाठी राष्ट्रीय ऊर्जा संवर्धन इमारत संहिता अंमलबजावणी समितीला सहाय्य करता येईल;
- (ख) एखाद्या ठिकाणचे हवामान आणि तेथील प्रकल्पांच्या गरजा विचारात घेता, त्यातील इमारतीच्या बांधकामाचा दर्जा आणि सातत्य सुनिश्चित करण्याच्या ऊर्जा कार्यक्षम इमारतीच्या बांधकामाला चालना देईल;
- (ग) सर्व नामिकाप्रविष्ट महा-लेखा परीक्षण अभिकरणांच्या अधिकारपत्रांची तपासणी करण्यासाठी त्यांच्या वार्षिक कार्याचे, कार्यपरीक्षण हाती घेईल.

८. तांत्रिक तक्रार समितीचे अधिकार, कार्ये व कर्तव्ये -

(१) तांत्रिक तक्रार समिती घटित करणे: -

- (क) नगर विकास विभागाने नामनिर्देशित केलेल्या, परंतु उप-संचालक नगर रचना संचालनालय याच्या दर्जापेक्षा कमी दर्जा नसलेल्या एका प्रतिनिधी/प्रमुखाच्या अध्यक्षतेखाली तांत्रिक तक्रार समितीची स्थापना करण्यात येईल.
- (ख) तांत्रिक तक्रार समिती, इमारतीच्या बांधकामाशी संबंधित बाबींवर न्यायनिर्णय करण्याचा अनुभव व प्रशिक्षण यांद्वारे अर्हताप्राप्त असतील अशा, राज्याच्या प्रशासकीय विभागांतील इतर चार पुढील नामनिर्देशित व्यक्तींनी मिळून घटित केलेली असेल, म्हणजे -
  - (एक) पदनिर्देशित अभिकरणाने नामनिर्देशित केलेला एक इसीबीसी तांत्रिक तज्ज्ञ;
  - (दोन) वास्तुशास्त्र परिषदेचा एक प्रतिनिधी;
  - (तीन) पदनिर्देशित अभिकरणाकडून नामनिर्देशित करण्यात येईल असा विधि अधिकारी;

(२) समिती -

- (क) पक्षकारांना आपले म्हणणे मांडण्याची संधी दिल्यानंतर, मालकाच्या तक्रारीवर सुनावणी करील आणि त्यावर वाजवी वेळेत आदेश देईल.
- (ख) जर समितीच्या आदेशाने एखादा पक्षकार व्यथित झाला असेल तर, त्यास, आदेश प्राप्त झाल्याच्या दिनांकापासून ३० दिवसांच्या आत, राज्य विद्युत नियामक आयोगाकडे अपील दाखल करता येईल.

**९. ऊर्जा लेखा परीक्षक (इमारत) यांची कर्तव्ये - ऊर्जा लेखा परीक्षक (इमारत), -**

(क) पुढील बाबींची पडताळणी करून त्या प्रमाणित करील, —

(एक) प्रकल्पाच्या संकल्पचित्राचे निकष, ऊर्जा विषयक उद्दिष्टे, एकात्मिक ऊर्जा स्थापित संकल्पन दृष्टीकोन, ऊर्जा सुविधा कार्यमान प्रणालीच्या संपादनूक पडताळणी आराखडा, आणि संरचना दृष्टिकोन लक्षात घेऊन, इमारतीचे संकल्पचित्र तयार करणे.

(दोन) विचाराधीन प्रकल्पाच्या संकल्पचित्र विषयक दृष्टिकोन आधारित ऊर्जा संवर्धनाच्या उपाययोजना;

(तीन) इमारत या नियमांचे अनुपालन करते, याची सुनिश्चिती करण्यासाठी पदनिर्देशित अभिकरणाला अपेक्षित असलेले बांधकामविषयक दस्तऐवज, अनुपालन दस्तऐवज आणि विनिर्दिष्ट केलेली तपासणी सूची व इतर कोणतेही दस्तऐवज;

(ख) ऊर्जा संवर्धन इमारत संहितेची अंमलबजावणी सुकर करण्यासाठी आणि देशाच्या विविध हवामान विभागाच्या विविध प्रवर्गातील इमारतीच्या निकषांना आणि मानकांना चालना देण्यासाठी पदनिर्देशित अभिकरणाला आणि राष्ट्रीय ऊर्जा संवर्धन इमारत संहिता समितीला आवश्यक ती तांत्रिक माहिती पुरवील;

(ग) पदनिर्देशित अभिकरणाला सादर करण्यासाठी इसीबीसी संबंधित सिद्ध दस्तऐवज अंतर्भूत असणारे, सिद्ध आरेखने, विनिर्देश, बांधकामविषयक दस्तऐवज, अनुपालन दस्तऐवज हे प्रमाणित करून त्याची मोहोर व स्वाक्षरीनिशी प्रमाणपत्र सादर करील.

(घ) या नियमान्वये प्रदान केलेल्या अधिकारांचा वापर करून, इमारतीच्या संकल्पचित्रापासून ते इमारतीच्या वापरासह, त्या इमारती कार्याद्विष्ट घेण्याच्या टप्प्यापर्यंतच्या, इमारत कार्याची तपासणी करील.

(ड) नामिकाप्रविष्ट महा - ऊर्जा संवर्धन इमारत संहिता परीक्षण अभिकरण, त्याच्या अखत्यारीत कार्यरत असलेला कोणताही व्यावसायिक किंवा कर्मचारी त्याच्या/तिच्या पदीय कर्तव्यांचा हितसंबंध, अधिकारिता असणाऱ्या प्राधिकरणाच्या हिताविरोधी नाही याची सुनिश्चिती करण्याच्या उद्देशाने, या नियमांतर्गत येणाऱ्या संबंधित इमारतीच्या बांधकामाशी व फेरबदलाशी संबंधित कोणत्याही कामामध्ये सहभागी नाही याची खात्री करील.

**१०. मालकाची कर्तव्ये - उक्त इमारतीचे बांधकाम या नियमांप्रमाणेच करण्याचे संपूर्ण आबंधन व जबाबदारी ही, मालकाची असेल. प्रत्येक मालक —**

(क) ऊर्जा संवर्धन इमारत संहितेच्या आणि नियमांच्या आवश्यकतांची पूर्तता करण्यासाठी ऊर्जा संवर्धन उपाय अंतर्भूत करण्याच्या कामी ऊर्जा लेखा परीक्षक (इमारत) याची नेमणूक करील आणि पुढील बाबींची खात्री करील : —

(एक) ऊर्जा लेखा परीक्षक (इमारत) याच्या सहाय्याने, प्रस्तावित इमारतीच्या संकल्पनात विद्युतभाराचा सविस्तर लेखा तयार करील आणि इमारतीच्या संकल्पचित्राच्या मंजूरीबाबतचा अर्ज सादर करतेवेळी तो, घोषणापत्रासह सादर करील.

(दोन) इमारतीच्या बांधकामाची जटिलता, खर्चाचे अंदाजपत्रक तसेच प्रकल्पाच्या मुदतीमध्ये येणाऱ्या अडचणी लक्षात घेऊन, त्याच्या इमारत प्रकल्पाकरिता आवश्यक अशा अनुपालन कार्यपद्धतीला अंतिम रूप देईल;

(तीन) प्रस्तावित इमारतीचे ठिकाण लक्षात घेऊन, ऊर्जा संवर्धन इमारत संहितेनुसार ऊर्जा संवर्धन उपायांना अंतिम रूप देईल;

(चार) या नियमांतील तरतुदीनुसार इष्टतम ऊर्जा कार्यक्षमता साध्य करण्याच्या उद्देशाने इमारतीच्या व सुविधेच्या संकल्पनामध्ये ऊर्जा संवर्धन उपाययोजना अंतर्भूत करील;

(पाच) इमारत विषयक कागदपत्रांमध्ये, आरेखने, विनिर्देश व अनुपालन नमुने तयार केले आहेत आणि इमारत संकल्पन दस्तऐवजांमध्ये ऊर्जा संवर्धन उपाय योजलेले आहेत, याची खात्री करील.

(ख) इमारतीचे जागेवर बांधकाम सुरु करण्यापूर्वी, पदनिर्देशित अभिकरणाला त्याबाबत सूचित करील;

(ग) इमारतीच्या बांधकामामध्ये तसेच तिच्या सुविधांच्या मांडणीमध्ये ऊर्जा संवर्धन उपाय योजलेले आहेत, याची सुनिश्चिती करील;

(घ) या नियमांच्या अनुपालनाची सुनिश्चिती करण्याकरिता पदनिर्देशित अभिकरणाने वेळोवेळी मागितलेली माहिती, बांधकामात सुचविलेल्या सुधारणा आणि यांसारख्या इतर सूचनांना प्रतिसाद देईल;

(ङ) ऊर्जा संवर्धन इमारत संहितेनुसार बांधकाम केले असल्याची सुनिश्चिती करण्यासाठी पदनिर्देशित अभिकरणाला आवश्यकता भासल्यास, कोणत्याही वेळी इमारतीमध्ये अथवा इमारत परिसरात पडताळणीच्या प्रयोजनार्थ, प्रवेश करण्याची परवानगी देईल;

(च) पदनिर्देशित अभिकरणाला बांधकाम पूर्ण झाल्याची सूचना लेखी स्वरूपात कळवील;

(छ) मालकाने ऊर्जा लेखा परीक्षक (इमारत) याची सेवा समाप्त केल्यास आणि त्याच्या जागी दुसऱ्या व्यावसायिकाची नियुक्ती केल्यास, त्याबाबत पदनिर्देशित अभिकरणाला लेखी स्वरूपात कळवील;

(ज) इमारतीचे बांधकाम पूर्ण झाल्यावर, त्यास पूर्ण इमारतीसाठी अथवा त्या इमारतीच्या काही भागासाठी पदनिर्देशित अभिकरणाकडून भोगवटा प्रमाणपत्र मिळवील;

(झ) अधिकारिता असलेल्या प्राधिकाऱ्याकडून कोणतीही नोटीस प्राप्त झाल्यावर, अशा नोटीशीत विनिर्दिष्ट केलेल्या योग्य कालावधीच्या आत, असा वापर करण्याचे थांबवील आणि तो कोणत्याही परिस्थितीत या नियमाच्या तरतुदींचा अनादर करणार नाही;

(त्र) मंजूर संकल्पचित्र आराखड्यात दर्शविलेल्या सुविधा, साहित्य किंवा साधने यांच्या तुलनेत, मालक इमारतीच्या ऊर्जा कार्यक्षमतेला बाधा करणारी, सुविधा, साहित्य किंवा साधने बसवण्यामधील बदल सूचित असेल तर, इमारत पूर्ण होण्याआधी, पदनिर्देशित अभिकरणाची आवश्यक ती मंजूरी प्राप्त केल्यानंतर, अशी सुविधा, साहित्य, किंवा साधने याचा वापर करील किंवा मांडणी करील.

**११. पदनिर्देशित अभिकरणाची कर्तव्ये आणि कार्ये** - पदनिर्देशित अभिकरण राज्यात या नियमांचे विनियमन, आणि त्यांच्या तरतुदींची अंमलबजावणी करण्याच्या बाबतीत, विविध हितसंबंधित घटकाशी समन्वय साधील. पदनिर्देशित अभिकरण,—

(क) इसीबीसी अनुपालनार्थी इमारतींविषयी तसेच अशा इमारती उभारण्याच्या कार्यपद्धती विषयी जनजागृती करील.

(ख) राज्यात इमारतींच्या ऊर्जा कार्यक्षम संकल्पचित्राला चालना देण्यासाठी, नागरी व ग्रामीण स्थानिक संस्थांच्या निकट समन्वयाने इमारत बांधकाम व्यावसायिक, विकासक व कंत्राटदार यांच्या क्षमता उभारणीला प्रोत्साहन देईल;

(ग) मालकाकडून प्राप्त झालेला अर्ज, नियम ३ च्या प्रयोज्यतेच्या कक्षेत येत असल्याची निश्चिती करील;

(घ) या नियमांच्या व्याप्तीत येणाऱ्या इमारतींमधील अनुपालनाच्या प्रमाणाचे मोजमाप करण्यासाठी एक आधारसामग्री निर्माण करील आणि ती संग्रहीत करून ठेवील, आणि इसीबीसी अनुपालन प्रमाणपत्र देण्याच्या वेळी, या नियमांच्या अनुपालनाच्या परिणामी, झालेल्या ऊर्जा बचतीचा अचूक लेखा ठेवील.

- (ड) विविध प्रवर्गातील इमारतींमध्ये या नियमांचे अनुपालन करण्याबाबतचा एक उपाय म्हणून ऊर्जा कार्यमान निर्देशांक गुणोत्तर काढण्यासाठी आवश्यक ते उपाय योजील, आणि भौगोलिक प्रदेशांनुसार बांधण्यात येणाऱ्या विविध प्रवर्गातील इमारतीबाबत ऊर्जा वापराचे निकष आणि मानके तयार करण्यासाठी विभागाकडे आपल्या शिफारशी पाठवील;
- (च) नामिका प्रविष्ट महा—इसीबीसी लेखापरीक्षण अभिकरणाचा समायोजित आढावा घेईल;
- (छ) उल्लंघनांचा एक सारांश तयार करील, आणि त्यांच्या व्यावसायिक कौशल्यांचे मूल्यमापन करण्याच्या प्रयोजनासाठी, त्या उल्लंघनाचा आढावा घेण्याकरिता, पदनिर्देशित अभिकरणाकडून तो सारांश विभागाला पुरविण्यात येईल;
- (ज) या नियमांच्या व्याप्तीत येणाऱ्या विभिन्न भौगोलिक प्रदेशात बांधल्या जाणाऱ्या विविध प्रवर्गातील इमारतींच्या उपयोगिता वर्गीकरणानुसार आणि इमारतींच्या सांख्यिकीय आकडेवारीवर आधारित विविध स्वरूपानुसार, अशा इमारतींच्या संबंधात ऊर्जा कार्यमान निर्देशांकाप्रमाणे ऊर्जावापर मानके विकसित करण्यात विभागाला सहाय्य करील.
- (झ) इमारत क्षेत्रात ऊर्जा कार्यक्षमतेस चालना देण्यासाठीचे एक प्रभावी साधन म्हणून, नामिकाप्रविष्ट ऊर्जा लेखापरीक्षक (इमारत) यांचा संवर्ग तयार करण्यासाठी राज्यातील ऊर्जा लेखापरीक्षक (इमारत) यांच्या कामगिरीवर देखरेख ठेवील;
- (त्र) ऊर्जा लेखापरीक्षक (इमारत) यांच्या अहवालाची अचूकता पडताळून पाहण्यासाठी, आवश्यकता भासल्यास इमारतीचे प्रत्यक्ष भेट देऊन निरीक्षण करील;
- (ट) सदर नियमांचे अनुपालन करून इमारतींचे बांधकाम करण्याच्या प्रयोजनार्थ इमारत उप विधींमध्ये या नियमांच्या तरतुदींचा समावेश करून त्यांमध्ये सुधारणा करण्यासाठी अधिकारिता असलेल्या प्राधिकरणाशी समन्वय साधील.
- (ठ) इमारत उप विधींमध्ये तरतुदींचा समावेश करण्यासाठी राज्य शासनाला शिफारस करील;
- (ड) समितीने दिलेल्या आदेशाच्या बाबतीत बांधकामाच्या कोणत्याही टप्प्यात ऊर्जा संवर्धन इमारत संहितेचे पालन झाले नसल्याचे आढळून आल्यास, दंडात्मक कार्यवाहीसाठी राज्य विद्युत नियामक आयोगाकडे याचिका दाखल करील;
- (ढ) ऊर्जा संवर्धन इमारत संहितेच्या अनुपालनासाठी इष्टतम ऊर्जा कार्यमान निर्देशांक गुणोत्तर अनुकूल करताना मालकाने ऊर्जा संवर्धनाचे उपाय, उत्तम उपयोजन किंवा कार्यपद्धती किंवा संकल्पचित्र किंवा बांधकाम यांचा वापर करील.
- (ण) पदनिर्देशित अभिकरण प्रोत्साहन आणि दंड यांसाठी कृति आराखडा प्रस्तावित करील;

**१२. वितरण लायसनधाराची कर्तव्ये.**— ऊर्जा संवर्धन इमारत संहिता लागू होणाऱ्या इमारतींमध्ये नवीन विद्युत जोडणी देताना, विद्युत वितरण लायसनधारक, पुढील बाबींची खात्री करून घेईल

(क) वितरण लायसनधारकाला प्राप्त झालेला अनुपालन अहवाल हा, ज्या इमारतीला विद्युत जोडणीची परवानगी दिलेली आहे, त्याच इमारतीचा आहे.

(ख) इमारतीमधील विद्युत ग्राहकांच्या ऊर्जा वापरासंबंधीची माहिती, नियमितपणे पदनिर्देशित अभिकरणाकडे पाठविलेली आहे.

**१३. संकीर्ण.**— ऊर्जा संवर्धन इमारत संहितेचा, विभागाशी विचारविनिमय करून या नियमांमध्ये विनिर्दिष्ट केल्याप्रमाणे, ५ वर्षांतून किमान एकदा अथवा ऊर्जा संवर्धन इमारत संहितेमध्ये सुधारणा करण्यासाठी आवश्यक असेल. त्या त्या वेळी नियमितपणे आढावा घेण्यात येईल.

## नमुना एक ते अकरा



**संकल्पचित्राचा टप्पा**

**नमुना एक**  
[ नियम ६ (१) (क) (दोन) पहा ]

**इमारतीचे बांधकाम/पुनर्बांधकाम/विद्यमान इमारतीमध्ये वाढीव बांधकाम किंवा फेरफार करण्याकरिता इसीबीसी अनुपालनार्थी इमारतीच्या बांधकाम परवान्याकरिता अर्ज.**

प्रति,

(पदनिर्देशित अभिकरणाचे नाव)

पदनिर्देशित अभिकरणाचा पत्ता : .....

दिनांक : / / .

**विषय** .—इसीबीसी अनुपालनार्थी इमारतीचे बांधकाम/पुनर्बांधकाम/ वाढीव बांधकाम किंवा बांधकामात फेरफार करण्यासाठी अर्ज.

महोदय,

मी/आम्ही खाली स्वाक्षरी करणार, याद्वारे, महाराष्ट्र ऊर्जा संवर्धन इमारत नियम, २०१९ अन्वये ऊर्जा संवर्धन बांधकाम संहितेचे अनुपालन करणाऱ्या पात्र इमारतीचे बांधकाम करण्याचा/पुनर्बांधकामात फेरफार करण्याचा प्रस्ताव सादर करीत आहे/आहोत.

**मालकाचा/अर्जदाराचा आणि प्रकल्पाचा तपशील**

| एक | मालक/मालकाचा नामनिर्देशिती यांचा तपशील |  |
|----|--|--|
|    | नाव                                    |  |
|    | कायमचा पत्ता                           |  |
|    |  |  |
|    |  |  |
|    | दूरध्वनी क्रमांक                       |  |
|    | भ्रमणध्वनी क्रमांक                     |  |

| दोन | नियुक्त केलेला ऊर्जा लेखापरीक्षक (इमारत) याचा तपशील |  |
|-----|---|--|
|     | नियुक्त ऊर्जा लेखापरीक्षक (इमारत)                   |  |
|     | नोंदणी क्रमांक                                      |  |
|     | संपर्कासाठीचा पत्ता                                 |  |
|     | दूरध्वनी क्रमांक                                    |  |

| तीन | इसीबीसी अनुपालनार्थी इमारतीच्या परिवास्तूचा तपशील |  |
|-----|---|--|
|     | प्रकल्पाचे नाव                                    |  |
|     | प्रकल्पाचा तपशील                                  | नवी/जुनी/विस्तारित/फेरफार/वापर बदल                                   |
|     | प्रकल्पाचा पत्ता                                  |  |
|     | इमारतीच्या उपयोगितेचे वर्गीकरण                    | (ऊर्जा संवर्धन इमारत संहितेच्या प्रकरण २ मधील उप परिच्छेद ५ प्रमाणे) |
|     | ऊर्जा संवर्धन इमारत संहितेच्या अनुपालनाची पद्धत   | आदेशानुरूप / संपूर्ण इमारत कार्यमान/ बांधकाम लवचिकता पद्धतीनुरूप/    |
|     | प्रकल्पाचा हवामान विभाग                           |  |

| चार | नमुना १ सोबत जोडलेले दस्तऐवज     |  | (✓/×) |
|-----|----------------------------------|--|-------|
|     | बांधकाम दस्तऐवज                  | महाराष्ट्र शासनाने अधिसूचित केलेल्या, ऊर्जा संवर्धन इमारत संहितेच्या प्रकरण ८ मधील उप-परिच्छेद २ मध्ये व्याख्या केल्याप्रमाणे.   |       |
|     | अनुपालन दस्तऐवज                  | पुढील मध्यमातून ऊर्जा संवर्धन इमारत संहितेचे अनुपालन दर्शविले आहे —<br>१. ऊर्जा कार्यमान निर्देशांक गुणोत्तराचा अहवाल<br>२. अनुपालनाची पद्धत<br>३. अनुपालन दर्शविणारा ऊर्जा संवर्धन इमारत संहिता अनुपालन अहवाल-उष्मन, वायूवीजन आणि वातानुकूलन जलतापन सेवा व पंप आणि दिवाबत्ती, विद्युत उर्जा यांसह इमारत कवच, यांत्रिक सुविधा व साधनसामग्री.<br>४. महाराष्ट्र शासनाने अधिसूचित केलेल्या ऊर्जा संवर्धन इमारत संहितेमधील तपासणी सूचीमध्ये विनिर्दिष्ट केल्याप्रमाणे. |       |
|     | ऊर्जा संवर्धन उपायांबाबतचा अहवाल | इमारत बांधकामच्या/ विस्ताराच्या सर्व टप्प्यांमध्ये योजलेले उर्जा संवर्धन उपाय विनिर्दिष्ट करतो.  |       |
|     | अनुपालनाचे प्रमाणपत्र            | प्रमाणित ऊर्जा लेखापरीक्षक (इमारत) यांचेकडून मंजूर आणि स्वाक्षरी केलेले.   |       |

**मालकाकडून उद्घोषणा :**

(एक) मी/आम्ही अशी हमी देतो की, यासोबत जोडलेल्या अनुपालनाच्या दस्तऐवजांमध्ये तसेच नमुन्यांमध्ये दिलेली सर्व माहिती माझ्या/आमच्या माहितीप्रमाणे खरी आहे, आणि ती कोणतीही माहिती खोटी निघाल्यास, अशी माहिती दिल्याच्या परिणामी, केंद्र अथवा राज्य शासनाची अथवा त्याच्या अखत्यारितील इतर कोणत्याही प्राधिकरणाची हानी झाल्यास त्याबद्दलची नुकसानभरपाई करण्याची मी/आम्ही हमी देतो.

(दोन) मी/आम्ही अशी हमी देतो की, सदर इमारतीचे बांधकाम हे, नगरपालिका प्राधिकरणाच्या उप विधिनुसार आणि महाराष्ट्र ऊर्जा संवर्धन इमारत नियम, २०१९ याच्या तरतुदीनुसार बांधण्यात येईल. मी/आम्ही अशी हमी देतो की, सदर इमारतीचे बांधकाम हे, ऊर्जा संवर्धन इमारत संहितेनुसार झाले आहे. इमारतीच्या बांधकामादरम्यान कोणतेही विचलन झाल्याचे निदर्शनास आल्यास, मी/आम्ही अधिकारिता असणाऱ्या संबंधित प्राधिकरणास होणाऱ्या हानीची नुकसानभरपाई देण्याची हमी देतो.

(तीन) मी/आम्ही वरील तपशीलात कोणताही बदल केल्यास, त्याबद्दल अधिकारिता असलेले संबंधित प्राधिकरण, पदनिर्देशित अभिकरण आणि समिती यांना सूचित करण्याची हमी देतो.

(चार) मी/आम्ही, पदनिर्देशित अभिकरणाकडून अनुपालन प्रमाणपत्र मिळाल्यानंतर, संकल्पचित्रामध्ये नंतर कोणताही बदल झाल्यास त्याबद्दल सूचित करण्याची व त्याबाबत ठाम राहण्याची लेखी हमी देतो. बांधकामास प्रारंभ करण्यापूर्वी, पदनिर्देशित अभिकरणाकडून सुधारीत अनुपालन प्रमाणपत्र अवश्य मिळविले.

(पाच) मी/आम्ही, पदनिर्देशित अभिकरणास पूर्वसूचित करून, कमाल ऊर्जा कार्यक्षमता सुनिश्चित करण्यासाठी आणि ऊर्जा कार्यमान निर्देशांक गुणोत्तर इष्टतम करण्यासाठी इमारत घटकांची संरचनेत आणि बांधकाम दस्तऐवजात समाविष्ट करण्यात आलेल्या यंत्रणेची बांधणी करण्यामध्ये लवचिकता असेल असे सूचित करतो.

(सहा) मी/आम्ही, अशी हमी देतो की, इमारतीचे बांधकाम हे, पदनिर्देशित अभिकरणाने मंजूर केलेल्या संकल्पचित्रानुसार केले जाईल.

आपला विश्वासू,

(मालकाचे नाव)

सही

दिनांक .....

## संकल्पचित्राचा टप्पा

## नमुना-दोन

[ नियम ६ (१) (क) (दोन) पहा ]

**इमारतीकरिता ऊर्जा संवर्धन इमारत संहितेचे अनुपालन करण्यासाठी तांत्रिक सहाय्य पुरविण्याबाबत नियुक्त केलेल्या ऊर्जा लेखा परीक्षक (इमारत) यांचेकडून दिलेली सूचना व हमीपत्र**

प्रति,

(पदनिर्देशित अभिकरणाचे नाव)

पदनिर्देशित अभिकरणाचा पत्ता : .....

.....

दिनांक : / /

विषय. — खाली नमूद केलेल्या इमारती बाबत .....

ऊर्जा लेखा परीक्षक (इमारत) — नोंदणी क्रमांक .....

यांच्या तांत्रिक सहाय्याने ऊर्जा संवर्धन इमारत संहितेचे अनुपालन करण्यात येईल हे, सूचित करण्याबाबत.

महोदय,

मी/आम्ही खाली स्वाक्षरी करणार, इमारतीबाबत ऊर्जा संवर्धन इमारत संहितेच्या अनुपालनासाठी तांत्रिक सहाय्य पुरविण्यास याद्वारे संमती देत आहे/आहोत.

**ऊर्जा लेखा परीक्षक (इमारत) आणि प्रकल्प यांचा तपशील**

| एक | नियुक्त ऊर्जा लेखा परीक्षक (इमारत) यांचा तपशील |  |
|----|--|--|
|    | नियुक्त केलेला ऊर्जा लेखा परीक्षक (इमारत)      |  |
|    | नोंदणी क्रमांक                                 |  |
|    | सहाय्य पुरविले आहे                             | इमारत संकल्पचित्र आणि बांधकामाचा टप्पा |
|    | संपर्कासाठीचा पत्ता                            |  |
|    | दूरध्वनी क्रमांक                               |  |

| दोन | इसीबीसी अनुपालनार्थी इमारतीच्या परिवास्तूचा तपशील |   |
|-----|---|---|
|     | प्रकल्पाचे नाव                                    |   |
|     | प्रकल्प मालकाचे नाव                               |   |
|     | प्रकल्पाचा तपशील                                  | नवी/जुना/विस्तार/फेरबदल/वापरात बदल  |
|     | प्रकल्पाचा पत्ता                                  |   |
|     | एकूण बांधीव क्षेत्रफळ                             |   |
|     | इमारतीच्या वापराचे वर्गीकरण                       | (महाराष्ट्र शासनाने अधिसूचित केलेल्या ऊर्जा संवर्धन इमारत संहितेच्या प्रकरण २ मधील उप परिच्छेद ५ प्रमाणे) |
|     | ऊर्जा संवर्धन इमारत संहितेच्या अनुपालनाची पद्धत   | निर्धारित/संपूर्ण इमारत कार्यमान/<br>बांधकाम लवचिकता पद्धती   |
|     | प्रकल्पाचा हवामान विभाग                           |   |

**नियुक्त केलेला ऊर्जा लेखा परीक्षक (इमारत) याचे प्रतिज्ञापन**

(एक) मी याद्वारे अशी हमी देतो की, नमुना एक आणि दोन तसेच इतर कागदपत्रांमध्ये सादर केलेली सर्व माहिती माझ्या माहितीप्रमाणे खरी असून इमारतीबाबत ऊर्जा संवर्धन इमारत संहितेच्या अनुपालनाची सुनिश्चिती करण्यासाठी मी योग्य ती जबाबदारी घेईन.

(दोन) माझ्या या प्रकल्पाच्या काळात मी ऊर्जा संवर्धन इमारत संहितेच्या सर्व नियमांचे पालन करीन. तसेच सर्वोत्तम व्यावसायिक नितिमूल्ये व वर्तणूक यांची खात्री देतो.

(तीन) या नियमांमध्ये नमूद केलेल्या माझ्या जबाबदारींची मला पूर्ण जाणीव असून गुणवत्तापूर्ण चांगले काम करण्याची मी हमी देतो आणि ऊर्जेच्या इष्टतम वापराची आणि इमारतीच्या ऊर्जा बचतीत वाढ करण्याची खात्री देतो.

(चार) कोणत्याही टप्प्यावर, जर मी ऊर्जा संवर्धन इमारत संहितेनुसार इमारतीच्या अनुपालनाच्या सर्व टप्प्यांमध्ये सहाय्य देण्यात कसूर करील तर, मी संबंधित पदनिर्देशित अभिकरण आणि अधिकारिता असणारे प्राधिकरण आणि ऊर्जा संवर्धन इमारत संहिता अंमलबजावणी समिती यांना त्याबाबत कळविण्याची जबाबदारी माझी असेल.

आपला विश्वासू

[ऊर्जा लेखा परीक्षक (इमारत) यांचे नाव ]

(सही)

दिनांक \_\_\_\_\_

## संकल्पचित्राचा टप्पा

## नमुना तीन

[ नियम ६ (१) (क) (दोन) पहा ]

**ऊर्जा संवर्धन इमारत संहितेच्या अनुपालनाकरिता ऊर्जा लेखा परीक्षक (इमारत) याने करावयाचे इमारतीच्या संकल्पचित्राच्या टप्प्यावरील अनुपालन आणि त्याचे हमीपत्र**

## संकल्पचित्राचे अनुपालन/अनुपालनाचे हमीपत्र

मी, उर्जा कार्यक्षमता विभागाद्वारे प्रमाणित ऊर्जा लेखा परीक्षक (इमारत) नोंदणी क्रमांक \_\_\_\_\_ धारक असून मला/आम्हाला प्रकल्पाच्या मालकाकडून ऊर्जा संवर्धन इमारत संहिता पात्र इमारतीच्या संकल्पचित्रामध्ये सहाय्य, प्रयोगनिर्देशन व पडताळणी करण्यासाठी प्राधिकृत करण्यात आले आहे आणि मी असे प्रमाणित करतो की,—

- (क) मी, ज्यामध्ये इमारतीची सुसंगत माहिती व वैशिष्ट्ये, साधनसामग्री व यंत्रणा यांचा पर्याप्त तपशील, उष्मन, वायुवीजन, वातानुकूलन, जलतापन सेवा व दिवाबत्ती व्यवस्था आणि विद्युत व्यवस्था इ. घटक दर्शविणारा पुढील तपशील समाविष्ट आहे, अशा ऊर्जा संवर्धन इमारत संहितेनुसार असलेल्या, बांधकामाविषयक दस्तऐवजांबाबत सहाय्य केले आहे आणि त्याचे प्रयोगनिर्देशन व पडताळणी केली आहे.

मालकाचे नाव

पत्ता

प्रकल्प स्थळाचा पत्ता

- (ख) मी अनुपालनाचे नमुने, ऊर्जा संवर्धन उपयांचा अहवाल आणि अनुपालनाबाबतची कागदपत्रे त्याचबरोबर तपासणी सूची यांचे ऊर्जा संवर्धन इमारत संहितेच्या अनुपालनाची खात्री करण्याच्या दृष्टीने प्रयोगनिर्देशन केले आहे व ते या नमुन्यासोबत जोडले आहेत.
- (ग) मी बांधकामाच्या दस्तऐवजांची योग्य प्रकारे पडताळणी केली आहे.
- (घ) बांधकामाच्या दस्तऐवजांनुसार संकल्पचित्राच्या टप्प्यावरील, इमारतीच्या संकल्पचित्राचे ऊर्जा कार्यमान निर्देशांक गुणोत्तर हे, ऊर्जा संवर्धन संहितेशी सुसंगत आहे.
- (ङ) मी आणखी असे ही प्रमाणित करतो की, ऊर्जा संवर्धन इमारत संहितेच्या कक्षेत येणाऱ्या घटकांच्या विविध मूलतत्वांच्यादृष्टीने, बांधकामविषयक दस्तऐवज आणि अनुपालन नमुने यांची पडताळणी करण्याबाबत योग्य ती वाजवी व्यावसायिक कौशल्ये वापरण्यात आणि दक्षता व मेहनत घेण्यात आली आहे.

| अ. क्र. | इमारतीबाबत ऊर्जा संवर्धन इमारत संहितेचे अनुपालन |  |
|---------|---|--|
| १       | प्रकल्पाचे नोंदणीकृत नाव                        |  |
| २       | अनुपालनाची पद्धत                                |  |
| ३       | इमारतीचे वापरानुसार वर्गीकरण                    |  |
| ४       | इमारतीचे कार्यचालनाचे तास                       |  |

|    |   |  |
|----|---|--|
| ५  | एकूण बांधीव क्षेत्रफळ (तळघर वगळता)  |  |
| ६  | वातानुकूलित क्षेत्रफळ   |  |
| ७  | बिगर — वातानुकूलित क्षेत्रफळ  |  |
| ८  | ऊर्जा संवर्धन इमारत संहितेच्या अनुपालनामार्फत प्रस्तावित ऊर्जा कार्यमान निर्देशांक  |  |
|    | (एक) इमारतीचा आधारभूत ऊर्जा कार्यमान निर्देशांक<br>(दोन) इमारतीचा प्रस्तावित ऊर्जा कार्यमान निर्देशांक<br>(तीन) इमारतीचे राखावयाचे ऊर्जा कार्यमान निर्देशांक गुणोत्तर |  |
| ९  | एकूण ऊर्जा बचत टक्केवारीमध्ये   |  |
| १० | ऊर्जा संवर्धन इमारत संहितेच्या अनुपालनाचा स्तर  |  |

**संपूर्ण इमारतीच्या कार्यमानाच्या बाबतीत :**

इमारतीमध्ये ऊर्जा संवर्धन इमारत संहितेच्या संपूर्ण इमारत कामगिरी पद्धतीमध्ये विनिर्दिष्ट केलेल्या सर्व अनिवार्य तरतुदी आणि आवश्यकता यांचे तसेच या पद्धतीअंतर्गत प्रस्तावित संकल्पचित्राच्या ऊर्जा कार्यमान निर्देशांकाचे पालन करण्यात येईल.

|                                     |             |            |        |
|-------------------------------------|-------------|------------|--------|
| ऊर्जा लेखा परीक्षक (इमारत)<br>नाव : | नोंदणी क्र. | सही/शिक्का | दिनांक |
| मालक :<br>नाव :                     |             | सही        | दिनांक |

\* \* \* खाली सही करणाऱ्याची सही व शिक्का असलेली पूर्ण तपासणी सूची सोबत जोडलेली आहे.

प्रति,  
पदनिर्देशित अभिकरण

**नमुना चार****[पहा नियम ६ (१) (ख) (तीन) ]****अपालनाचा अहवाल**

प्रति,

(मालकाचे नाव)

पत्ता .....

.....

**विषय .—** इमारतीच्या संरचनेच्या टप्प्यात ऊर्जा संवर्धन इमारत संहिता अपालनाचा अहवाल.

संदर्भ .— १. आपला अर्ज क्र. .... दिनांक .....

**इमारतीच्या संरचनेच्या टप्प्यात ऊर्जा संवर्धन इमारत नियम पडताळणीतील अपालन**

महोदय,

इमारतीच्या संरचनेच्या टप्प्यावर ऊर्जा संवर्धन इमारत संहिता अनुपालनासाठी पदनिर्देशित अभिकरणाकडे सादर केलेल्या अनुपालनाच्या कागदपत्रांची सखोल पडताळणी केल्यानंतर असे निदर्शनास आले आहे की, सदर कागदपत्रांमध्ये नमूद माहिती अपूर्ण आहे / चुकीची आहे. त्यामुळे ऊर्जा संवर्धन इमारत संहिता अनुपालनाच्या मंजूरीसाठी सदर कागदपत्रांमध्ये सुधारणा आवश्यक आहे.

**ज्या कागदपत्रांमध्ये सुधारणा आवश्यक आहे अशा कागदपत्रांचा संक्षिप्त सारांश पुढीलप्रमाणे : —**

(एक) इमारत ऊर्जा संवर्धन इमारत संहितेशी अनुपालित होत नसल्याने सदर इमारतीच्या बांधकाम कार्यारंभास पदनिर्देशित अभिकरणाची मान्यता देता येत नाही.

(दोन) संकल्पचित्राचे दस्तऐवजामधील अनुपालनच्या त्रुटी सुधारून ऊर्जा संवर्धन इमारत संहिता अनुपालन मान्यतेसाठी पदनिर्देशित अभिकरणाकडे पुनःश्च सादर करावे.

| अ. क्र. | कागदपत्राचे नाव | इसीबीसी उल्लंघनाचा विषय | शेरा |
|---------|-----------------|-------------------------|------|
|         |                 |                         |      |
|         |                 |                         |      |
|         |                 |                         |      |



(तीन) मालकाने वरील सुचनांप्रमाणे संबंधित कागदपत्रांमध्ये आवश्यक त्या सुधारणा केल्यानंतर ऊर्जा संवर्धन इमारत संहिता अनुपालनाची निश्चिती करून सदर कागदपत्रे पुन्हा पदनिर्देशित अभिकरणाकडे मंजूरीसाठी सादर करावीत.

| पदनिर्देशित अभिकरण | शिक्का                       |
|--------------------|------------------------------|
| नाव:               | पदनिर्देशित अभिकरणाचा शिक्का |
| सही:               |                              |
| दिनांक:            |                              |

प्रत — अग्रेषित

अधिकारीता असलेले प्राधिकरण

**नमुना पाच**

[ पहा नियम ६ (१) (ख) (चार) ]

**ऊर्जा संवर्धन इमारत संहिता अनुपालित इमारत संरचनेच्या  
मंजूरीसाठीच्या अर्जासोबत जोडलेले पदनिर्देशित अभिकरणाचे अनुपालन प्रमाणपत्र****प्रमाणपत्र**

नोंदणीकृत महा - ऊर्जा संवर्धन इमारत संहिता लेखा परीक्षक अभिकरणाने पदनिर्देशित अभिकरणाचे प्राधिकृत प्रतिनिधी म्हणून सदर ऊर्जा संवर्धन इमारत संहितेप्रमाणे अनुपालित इमारतीच्या संरचनेची छाननी व पडताळणी केली आहे.

मी/आम्ही असे प्रमाणित करतो की -

(क) मी/आम्ही ..... राज्यातील..... शहरातील..... या योजनेअंतर्गत भूखंड क्र..... गट क्र..... येथे बांधण्यात येणाऱ्या इमारतीची अनुपालनाचे दस्तऐवज, ऊर्जा लेखा परीक्षक (इमारत) यांचे मालकाकडून पृष्ठांकित हमीपत्र ज्यामध्ये सर्व सुसंगत माहिती आणि इमारतीची वैशिष्ट्ये, उपकरणे आणि प्रणाली त्याचबरोबर इमारतीचे आवरण, उष्मन, वायुवीजन, वातानुकूलन, जलतापन सेवा व दिवाबत्ती व्यवस्था आणि विद्युत व्यवस्था इ. घटकांचा तपशील इ. नमूद आहे. अशा कागदपत्रांची बांधकाम उपविधी तसेच ऊर्जा संवर्धन इमारत संहितेनुसार पडताळणी केली आहे.

(ख) मी/आम्ही तपासणी सूचीप्रमाणे अनुपालन अर्जाची छाननी केली असून बांधकाम उपविधी व ऊर्जा संवर्धन इमारत संहितेनुसार अनुपालन असल्याची खातरजमा केली आहे.

(ग) निम्नस्वाक्षरीकृत यांनी अनुपालन दस्तऐवजाची तपासणी केली आहे.

(घ) असे प्रमाणित करण्यात येते की, सादर केलेल्या सर्व दस्तऐवजाची जसे, इमारतीचे आराखडे, अनुपालनाचे नमुने, इमारतीच्या सर्व घटकांचा समावेश असलेली तपासणी सूची, इ. ची पडताळणी आणि तपासणी पूर्ण क्षमतेने आणि सर्व आवश्यक व्यावसायिक नितीमुल्यांसह आवश्यक ती खबरदारी घेऊन केली आहे.

(ड) सदर अनुपालनाचे प्रमाणपत्र हे आजमितीस सादर केलेल्या इमारतीच्या संरचनेसाठी असून जर यानंतर यात काही बदल झाल्यास पदनिर्देशित अभिकरणाकडून सुधारित मंजूरी घेणे आवश्यक राहील.

(च) सदर मंजूरी प्रमाणपत्र हे महाराष्ट्र ऊर्जा संवर्धन इमारत संहितेच्या परिशिष्ट बी-१ मध्ये नमूद महाराष्ट्र राज्यातील जिल्हा निहाय हवामानाच्या वर्गीकरणानुसार दिले असून त्यात बदल झाल्यास बांधकाम सुरु करण्यापूर्वी पुन्हा सुधारित प्रमाणपत्र प्राप्त करून घेणे मालकास बंधनकारक राहील.

|      |   |  |
|------|---|--|
| (एक) | ईसीबीसी अनुपालित इमारत परिवास्तूचा तपशील (पदनिर्देशित अभिकरणाच्या वापराकरिता) |  |
|      | प्रकल्पाचे नाव  |  |
|      | प्रकल्प मालकाचे नाव   |  |
|      | नियुक्त ऊर्जा लेखा परीक्षक (इमारत) नाव आणि नोंदणी क्रमांक                     |  |
|      | प्रकल्पाचा तपशील  | नवी/जुना/विस्तार/फेरबदल/वापरात बदल                                   |
|      | प्रकल्पाचा पत्ता  |  |
|      | एकूण बांधीव क्षेत्रफळ (तळघर सोडून)  |  |
|      | इमारतीच्या वापराप्रमाणे वर्गीकरण  | (ऊर्जा संवर्धन इमारत संहितेच्या प्रकरण २ मधील उप-परिच्छेद ५ प्रमाणे) |
|      | प्रस्तावित ऊर्जा कार्यमान निर्देशांक गुणोत्तर                                 |  |
|      | ईसीबीसी अनुपालनाचा स्तर   |  |

|       |                       |   |
|-------|-----------------------|---|
| (दोन) | अनुपालनाची पडताळणी    | (✓/X)   |
|       | बांधकामाचे दस्तावेज   | स्थानिक बांधकाम नियमावलीचे अनुपालन  |
|       | अनुपालनाची कागदपत्रे  | ईसीबीसी चे अनुपालन (ऊर्जा कार्यमान निर्देशांक गुणोत्तर $\leq 1$ )                       |
|       | अनुपालनाचे प्रमाणपत्र | ऊर्जा लेखा परीक्षक (इमारत) यांचेकडून मंजूर व स्वाक्षरीकृत                               |
|       | अनुपालनाचे प्रमाणपत्र | नोंदणीकृत महा- ऊर्जा संवर्धन इमारत संहिता लेखा परीक्षक अभिकरणाकडून मंजूर व स्वाक्षरीकृत |

(तीन) मी/ आम्ही अनुपालनाची दस्तऐवज, मालकाचे तसेच ऊर्जा लेखा परीक्षक (इमारत) यांचे हमीपत्र इ. दस्तऐवजांची पडताळणी केली आहे.

(चार) मी/आम्ही इमारतीचे बांधकाम विषयक आराखडे आणि दस्तऐवज यांची छाननी व पडताळणी करून इमारत ईसीबीसी अनुपालित असल्याचे मंजूर करतो.

(पाच) मी याद्वारे इमारतीसाठी विशेष इमारत ओळख (युबीआयडी) क्रमांक नेमून देत आहे. जो इमारती विषयक सर्व दस्तऐवजांमध्ये नमूद केला जाईल.

(सहा) इमारतीच्या बांधकामाच्या व प्रत्यक्ष वापराच्या टप्प्यात प्रतिबद्ध केलेले ईसीबीसी अनुपालनाचे उपाय लागू होत आहेत याची मालकाने खातरजमा करावी. जर बांधकामाच्या व प्रत्यक्ष वापराच्या टप्प्यात इमारतीमध्ये अनुपालनात त्रुटी असल्याचे निर्दर्शनास आल्यास अधिकारिता असलेले प्राधिकरण बांधकामविषयक सर्व परवानग्या रद्द करील.

| विशेष इमारत ओळख क्रमांकाची नेमणूक |                                    |
|-----------------------------------|------------------------------------|
| इमारतीचे नाव                      | युबीआयडी क्रमांक<br>(XXXX/XX/ECBC) |

सदर प्रस्तावित इमारतीच्या संरचनेला ऊर्जा संवर्धन इमारत संहितानुसार परवानगी देण्यास काही हरकत नाही.

| पदनिर्देशित संस्था | शिक्का                      |
|--------------------|-----------------------------|
| नाव:               | पदनिर्देशित संस्थेचा शिक्का |
| सही:               |                             |
| दिनांक:            |                             |

प्रति,

अधिकारिता असलेले प्राधिकरण

प्रत — अग्रेषित

१. मालक

२. वितरण लायसनधारक

यूबीआयडी क्र. ....

**नमुना सहा**

[ नियम ६(२)(क)(एक) पहा ]

**ऊर्जा संवर्धन इमारत संहिता अनुपालित इमारतीच्या बांधकामाच्या कामाची सुरवात करण्याविषयीची सूचना**

दि.....

प्रति,

(पदनिर्देशित अभिकरणाचे नाव)

पदनिर्देशित अभिकरणाचा पत्ता -----

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**विषय - पदनिर्देशित अभिकरणाकडून आणि अधिकारिता असलेले प्राधिकरणाच्या संरचना अनुपालनाच्या मंजूरीनुसार बांधकाम सुरु करणेसंबंधी सूचना**

महोदय,

मी/आम्ही याद्वारे, पुढे नमूद तपशिलाप्रमाणे ऊर्जा संवर्धन उपायांचा वापर करून ऊर्जा संवर्धन इमारत संहिता अनुपालित इमारतीचे बांधकाम सुरु करण्याविषयी सूचित करित आहोत.

|      |   |  |
|------|---|--|
| (एक) | बांधकाम करण्यात येणाऱ्या ऊर्जा संवर्धन इमारत संहिता अनुपालित इमारतीचा तपशील |  |
| १    | यूबीआयडी क्र.   |  |
|      | प्रकल्पाचे नोंदणीकृत नाव  |  |
| २    | इमारतीचे वर्गीकरण   |  |
| ३    | इमारतीच्या वापराचे दैनिक तास  |  |
| ४    | एकूण बांधीव क्षेत्रफळ (तळघर वगळता)  |  |
| ५    | बांधकामाचा अंदाजित कालावधी  |  |
| ६    | ऊर्जा संवर्धन इमारत संहिता अनुपालनाचा स्तर                                  |  |
| ७    | प्रस्तावित इमारतीचे ऊर्जा कार्यमान निर्देशांक गुणोत्तर                      |  |
| ८    | अंदाजित सलग्न भार आणि संविदा मागणी  |  |

(एक) मी/आम्ही पदनिर्देशित अभिकरणाला असे सूचित करू इच्छितो की, पदनिर्देशित अभिकरणाच्या अनुपालनाचा अहवाल /फाईल क्र. /पत्र क्र..... आणि नमुना पाच नुसार इमारतीचे बांधकाम सुरु करत आहोत.

(दोन) मी/आम्ही अशी हमी देतो की, सदर इमारतीचे बांधकाम हे ऊर्जा संवर्धन इमारत संहिताच्या तरतुदीनुसारच केले जाईल. जर इमारत बांधकामादरम्यान कोणतेही विचलन आढळल्यास त्यामुळे होणाऱ्या हानीची भरपाई पदनिर्देशित अभिकरणास देण्याची सर्व जबाबदारी माझी/आमची राहील. मी /आम्ही अशी हमी देतो की, मंजूर संरचनेच्या अनुपालन दस्तऐवजांमध्ये नमूद ऊर्जा संवर्धन उपायांची अंमलबजावणी केली जाईल.

(तीन) इमारत बांधकामामध्ये अपरिहार्य बदल ऊर्जा संवर्धन इमारत संहिताच्या अनुपालनावर कोणताही परिणाम न होता करावे लागल्यास, मी/आम्ही त्याची माहिती पदनिर्देशित अभिकरण व अधिकारिता असलेल्या प्राधिकरणाला देऊन नवीन अनुपालनाचा अहवाल प्राप्त करून घेऊ.

(चार) मी/आम्ही अशीही हमी देतो की, सोबत जोडलेल्या आराखडे व अर्जामधील सर्व माहिती ही खरी आहे. जर कोणतीही माहिती चुकीची आढळल्यास त्यासाठी मी/आम्ही कायदेशीर कारवाईस पात्र असू.

आपला विश्वासू,

मालकाचे नाव व सही.

प्रत—अग्रेषित

अधिकारिता असलेले प्राधिकरण.

**बांधकामाचा टप्पा**

यूबीआयडी क्र. ....

**नमुना सात**

[ नियम ६ (२) (क) (दोन) पहा ]

**ऊर्जा लेखा परीक्षक (इमारत) यांचा बांधकामाच्या टप्प्यातील इमारत बांधकाम कार्याचा आढावा अहवाल**

दिनांक : .....

प्रति,

(पदनिर्देशित अभिकरणाचे नाव) ,

पत्ता : .....

.....

- एक. मी ..... (नाव), नियुक्त ऊर्जा लेखा परीक्षक (इमारत) नोंदणी क्र. .... असे नमूद करतो की, पदनिर्देशित अभिकरणाने यूबीआयडी क्र. ....अन्वये अनुपालन अहवाल दिला आहे आणि मालकाने दि.....रोजीच्या उद्घोषणेनुसार इमारतीचे बांधकाम करण्याचे आश्वासन दिले आहे. या नियमांमध्ये नमूद विविध इमारत घटकांच्या बांधकामादरम्यान/ मांडणीदरम्यान मी/आम्ही मालकाचे हमी पत्र, बांधकामादरम्यान योजलेले ऊर्जा संवर्धनाचे उपाय तसेच बांधकामाचे दस्तऐवज, अनुपालनाचे नमुने, तपासणी सूची इ. ची पडताळणी केली आहे. मी या इमारत बांधकामाची तपासणी केली असून सदर इमारतीचे बांधकाम हे पदनिर्देशित अभिकरणाच्या अनुपालन अहवालानुसार झाले आहे, अशी ग्वाही देतो.
- दोन. संरचना टप्प्यात मान्य केल्याप्रमाणे सर्व ऊर्जा संवर्धन उपाय बांधकाम करताना अंतर्भूत केला आहे. सदर इमारतीच्या बांधकामामध्ये योजलेल्या सर्व ऊर्जा संवर्धन उपायांची यादी सोबत जोडली आहे.
- तीन. मी याद्वारे असे प्रमाणित करतो की, इमारतीचे बांधकाम कार्याची ऊर्जा संवर्धन इमारत संहिता व पदनिर्देशित अभिकरणाच्या अनुपालन अहवालाप्रमाणे पडताळणी केली आहे.

|                                      |             |            |        |
|--------------------------------------|-------------|------------|--------|
| ऊर्जा लेखा परीक्षक (इमारत)<br>नांव : | नोंदणी क्र. | सही/शिक्का | दिनांक |
| मालक :<br><br>नाव :                  |             | सही        | दिनांक |

बांधकामाचा टप्पा

यूबीआयडी क्र. ....

नमुना आठ

[ नियम ६ (२) (क) (दोन) पहा ]

**बांधकाम टप्प्याच्या पूर्णत्वाची सूचना  
आणि इसीबीसी पूर्णत्व प्रमाणपत्रासाठी अर्ज**

दिनांक : .....

प्रति,

पदनिर्देशित अभिकरण,

पत्ता : .....  
.....

**विषय :-** यूबीआयडी क्रमांक ..... या इमारतीचे इसीबीसी अनुपालनार्थी बांधकाम पूर्ण झाल्यासंबंधी सूचना.  
महोदय,

मी/आम्ही, याद्वारे, असे सूचित करतो की, यूबीआयडी क्रमांक ..... या इमारतीचे बांधकाम ऊर्जा संवर्धन उपाययोजनांचे कार्यान्वयन व अंमलबजावणीयांसह आपल्या कार्यालयाच्या पत्र क्रमांक ..... दिनांक ..... अन्वये मंजूर केलेल्या आराखड्यानुसार आणि इमारतीच्या संकल्पन व बांधकाम टप्प्यात सादर केलेल्या सर्व बांधकाम व अनुपालन दस्तऐवजानुसार पूर्ण करण्यात आले आहे.

- (एक) मी/आम्ही अशी हमी देतो की, सोबत जोडलेल्या अनुपालनाच्या कागदपत्रांमधील व नमुन्यामधील सर्व तपशील माझ्या माहितीप्रमाणे खरा असून त्यात दिलेली कोणतीही माहिती खोटी असल्याचे आढळून आल्यास अशी माहिती दिल्याच्या परिणामी, केंद्र किंवा राज्य शासनाची किंवा त्याच्या नियंत्रणाखालील इतर कोणत्याही प्राधिकरणाचे नुकसान झाल्यास, त्याबद्दलची भरपाई करण्याची मी/आम्ही हमी देतो.
- (दोन) मी/आम्ही अशी हमी देतो की, सदर इमारतीचे बांधकाम हे, ऊर्जा संवर्धन इमारत संहितेनुसार झाले आहे. बांधकामादरम्यान कोणतेही विचलन झाल्याचे निदर्शनास आल्यास, त्यामुळे झालेल्या हानीची भरपाई पदनिर्देशित अभिकरणाला देण्यास मी/आम्ही जबाबदार राहू.
- (तीन) मी/आम्ही अशी खात्री देतो की, सदर इमारत ही, तिच्या उद्देशित वापरासाठी सक्षम आहे.

ऊर्जा लेखा परीक्षक (इमारत),

सही

आपला विश्वासू,

मालकाचे नाव व सही.



**बांधकामाचा टप्पा**

**यूबीआयडी क्र. ....**

**नमुना नऊ**

**[ नियम ६ (२) (ख) (दोन) पहा ]**

**पदनिर्देशित अभिकरणाने बांधकाम पूर्ण होण्यापूर्वी  
अपालनाबाबतचा अहवाल देणे.**

प्रति,

(मालकाचे नाव)

पत्ता : .....  
.....

**विषय :-** अपालन प्रमाणपत्र देणे.

महोदय,

याद्वारे मालकाच्या असे निदर्शनास आणून देतो की, पदनिर्देशित अभिकरणाने कागदपत्रांची सखोल छानणी व पडताळणी केली असता, यूबीआयडी क्रमांक ..... या इमारतीच्या बाबतीत, ऊर्जा संवर्धन इमारत संहितेचे अनुपान झालेले नाही आणि म्हणून, यासोबत अपालन प्रमाणपत्र देत आहे.

खाली नमूद केलेल्या बाबतीत अनुपालन न केल्याने सदर इमारत भोगवटा करण्यासाठी पात्र नाही.

निरीक्षण केले असता, पुढील गोष्टींचे अनुपालन न केल्याचे दिसून आल्याने, हा नमुना मालकाच्या माहितीसाठी देण्यात

आला आहे.

(एक)

(दोन)

(तीन)

(चार)

(पाच)

\* \* अपालनासंबंधीच्या अहवालाचा तपशील अर्जासोबत जोडावा.

हे पत्र निर्गमित केल्याच्या दिनांकापासून पंचेचाळीस दिवसांच्या आत सुधारात्मक कार्यवाही करण्याबद्दल आपणास निर्देश देण्यात येत आहेत. वरील अपालनासंबंधी समाधानकारक अनुपालन झाल्याची खात्री झाल्यानंतरच पूर्णत्वाचे प्रमाणपत्र देणेबाबतचा आपल्या अर्जावर कार्यवाही केली जाईल.

| पदनिर्देशित अभिकरण       |
|--------------------------|
| नाव                      |
| सही                      |
| निर्गमित केल्याचा दिनांक |

प्रत — अग्रेषित

अधिकारिता असलेल्या प्राधिकरणाला प्रत अग्रेषित.

बांधकामाचा टप्पा

यूबीआयडी क्र. ....

नमुना दहा

[ नियम ६ (२) (ख) (तीन) पहा ]

## इसीबीसी पूर्णत्वाचे प्रमाणपत्र

प्रति,

(अधिकारिता असलेले प्राधिकरण)

पत्ता : .....  
.....

विषय :- इसीबीसी पूर्णत्व प्रमाणपत्र देणेबाबत.

महोदय,

आपल्या दिनांक ..... च्या, इमारत यूबीआयडी ..... च्या इमारतीचे बांधकाम पूर्णतेबाबतच्या आपल्या दिनांक ..... रोजीच्या नोटिशी संदर्भात:-

(एक) मी/आम्ही याद्वारे असे प्रमाणित करतो की, सदर इमारतीचा तपशील पुढीलप्रमाणे आहे :-

|    | इमारत बांधकामाचा तपशील                                 |  |
|----|--|--|
| १  | यूबीआयडी क्रमांक                                       |  |
| २  | मालकाचे नाव  |  |
| ३  | प्रकल्पाचे नोंदणीकृत नाव                               |  |
| ४  | प्रकल्पाचा पत्ता                                       |  |
| ५  | इमारतीचे वर्गीकरण                                      |  |
| ६  | इमारतीचे दैनिक वापराचे तास                             |  |
| ७  | हवामान विभाग   |  |
| ८  | एकूण बांधीव क्षेत्रफळ (तळघर वगळता)                     |  |
| ९  | इसीबीसी अनुपालनाचा स्तर                                |  |
| १० | प्रस्तावित इमारतीचे ऊर्जा कार्यमान निर्देशांक गुणोत्तर |  |
| ११ | संलग्न भार   |  |
| १२ | संविदा मागणी   |  |

याकरिता क्र. .... दिनांक ..... अन्वये मंजूर करण्यात आलेल्या आराखड्यांची ऊर्जा संवर्धन इमारत संहितेच्या आवश्यकतांबाबत तपासणी करण्यात आली आहे.

| पदनिर्देशित अभिकरण |                          |
|--------------------|--------------------------|
| नाव                | नोंदणी क्रमांक आणि मोहोर |
| सही                |                          |

प्रत-अग्रपिप्त




१) मालक

२) वितरण लायसनधारक-नवीन जोडणी देताना या इमारतीच्या संबंधात यूबीआयडी क्रमांक नेमून देणे.

**नमुना अकरा**

[नियम ६ (२) (ख) (तीन) पहा]

**इसीबीसी पूर्णत्वाचे प्रमाणपत्र**

|   |   |   |
|---|---|---|
|  <p>MEDA महाराष्ट्र</p>  | <p><b>महाराष्ट्र ऊर्जा संवर्धन इमारत संहिता</b><br/><b>पूर्णत्व प्रमाणपत्र</b></p>  |  <p>ऊर्जा जीवन हे, संरक्षण करे<br/>Energy is Life, Conserve it</p> |
| <p>निर्गम दिनांक: _____ यूबीआयडी क्र. _____</p>   |   |   |
| <p><b>इमारतीचे नोंदणीकृत नाव</b></p>  |   |   |
| <p>पत्ता _____ या इमारतीने पृथ्वीलप्रमाणे महाराष्ट्र शासनाने निर्धारित केलेला ऊर्जा संवर्धन इमारत संहितेच्या अनुपालनाचा स्तर साध्य केला आहे.</p>  |   |   |
|  <p><b>महाऊर्जा ३ स्टार</b><br/><b>उत्कृष्ट इसीबीसी अनुपालनासह</b></p>  |   |   |
| <p>इमारत उपयोगिता : _____ वैधता दिनांक: _____</p>   |   |   |
| <p><b>अनुपालनाच्या पद्धती</b></p>   |   |   |
| <p> <input type="radio"/> आदेशानुरूप                 <input checked="" type="radio"/> संपूर्ण इमारत कार्यमान                 <input type="radio"/> इमारत आवरण लवचिकता             </p>  |   |   |
| <p><b>प्रकल्पाची माहिती</b></p>   |   | <p><b>तांत्रिक माहिती</b></p>   |
| <p>अर्जदारचे नाव: XXXX</p> <p>पत्ता: XXXX</p> <p>प्रकल्पाचा तपशील: XXXX</p> <p>प्रकल्पाचे वर्गीकरण: XXXX</p> <p>भूखंडाचे क्षेत्रफळ: XXXX</p> <p>बांधीव क्षेत्रफळ: XXXX</p> <p>वातानुकूलित क्षेत्रफळ : XXXX</p> <p>विगर वातानुकूलित क्षेत्रफळ : XXXX</p> | <p>इमारतीचे ऊर्जा कार्यमान निर्देशांक गुणोत्तर=</p> <p>वार्षिक ऊर्जा बचत _____ %</p> <p>प्रकल्पाचा आधारभूत ऊर्जा कार्यमान निर्देशांक * : XX</p> <p>प्रकल्पाचा सध्याचा ऊर्जा कार्यमान निर्देशांक * : XX</p> <p>दिलेले तारांकित मानांकन : महाऊर्जा- XX स्टार</p> <p>(*ऊर्जा कार्यमान निर्देशांक वार्षिक युनिट/चौ.मि.)</p> |   |
| <p>सदर प्रमाणपत्र हे विश्लेषण, अनुपालन अहवाल आणि मालक श्री..... यांचे प्रतिज्ञापनानुसार दिले आहे.</p> <p>प्रमाणित ऊर्जा लेखा परीक्षक (इमारत)..... नोंदणी क्र.....</p>   |   |   |
| <p>लायसन धारकाचे नाव: ..... (पद)</p>  |   |   |
| <p>प्राधिकारी : पदनिर्देशित अधिकरण</p>  |   | <p>लायसनधारकाची सही व शिक्का:</p>   |

# ECBC

Energy  
Conservation  
Building  
Code 2017



GOVERNMENT OF INDIA  
MINISTRY OF POWER



Bureau of Energy Efficiency  
Ministry of Power, Government of India



ENERGY  
CONSERVATION  
BUILDING  
CODE  
2017

# Energy Conservation Building Code

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पीयूष गोयल  
PIYUSH GOYAL



विद्युत, कोयला, नवीन और नवीकरणीय ऊर्जा एवं खान  
राज्य मंत्री (स्वतंत्र प्रभार)  
भारत सरकार  
Minister of State (Independent Charge)  
for Power, Coal, New & Renewable Energy and Mines  
Government of India



#### Message

Indian economy has expanded aggressively in the last few decades and it is poised for greater growth in the future. However, our progress is accompanied with unique local and global challenges. Rapid economic growth, urbanization and expanding population have imposed a great strain on energy supply resources. Our economic development policies and international commitments to climate change mitigation are centred on the twin targets of spurring rapid market growth with minimal environmental impact.

India has committed to reduce emissions intensity of the national GDP by 33% to 35% by 2030 from 2005 level. Transformation of the building sector to the most advanced standards of building energy efficiency like near zero energy buildings is crucial for achieving these targets. Buildings consume about one third of the total annual electrical energy consumption in the country and are one of the largest contributors to GHG emissions. With nearly 70% of the buildings required in 2030 yet to be built, this sector will continue to impact any efforts to contain GHG emissions.

Energy Conservation Building Code (ECBC) 2017 is a powerful regulation to encourage the transition of buildings to efficient use of energy. It is one of the first building energy codes to set provisions for achieving energy neutrality in buildings.

ECBC can be leveraged with government initiatives to encourage environmental sustainability through energy efficiency and renewable energy in buildings. The Government of India's Smart Cities Mission is focused on sustainable urban infrastructure development. Energy efficient buildings is one of the metrics recommended for Smart Cities and ECBC will provide a regulatory framework for accomplishing building energy efficiency as a part of the Mission.

Regulations can only achieve so much; our response must be market based to be self-sustaining in the long term. Enforcement of ECBC can transform markets towards more efficient building materials and technologies by creating a demand for them. India is the founding member of the International Solar Alliance. Provision for renewable energy systems in buildings is one of the requirements of ECBC 2017. This offers a great opportunity to create a demand for solar energy technologies and support the objectives of the International Solar Alliance.

We have witnessed substantial progress in adoption of ECBC across all states since its launch. I congratulate the Bureau of Energy Efficiency (BEE) and state governments in the progress achieved so far. I now urge all states and BEE to continue their aggressive pursuit of energy efficiency in buildings through the code.

Piyush Goyal

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सचिव

भारत सरकार

P. K. PUJARI  
Secretary  
Government of India



सत्यमेव जयते

Ministry of Power  
Shram Shakti Bhawan  
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29 March, 2017



### Message

India's Nationally Determined Contributions commit to reducing emissions intensity of its GDP to 35% below 2005 levels by 2030. Any effort to achieve this target is contingent upon the increases in efficiency of energy use across all sectors, especially in the building sector.

The building sector in India consumes over 30% of the total electricity consumed in the country annually and is second only to the industrial sector as the largest emitter of greenhouse gases. Energy demand is expected to grow aggressively in the coming years with rising population and technology intensive lifestyles.

Building energy codes have been adopted as a regulatory measure for ushering energy efficiency in the building sector by many countries. In India, the Energy Conservation Act, 2001 provides the basic framework for regulating all initiatives relating to the efficient use of energy and this includes building energy codes.

India's Energy Conservation Building Code (ECBC) was first launched in 2007 as a voluntary code by the Bureau of Energy Efficiency to fulfil its mandate of effecting energy efficiency in buildings under the Energy Conservation Act of 2001.

Updating the ECBC was a priority of the government under the 12<sup>th</sup> five-year plan. The technical update of ECBC 2007 has been carried out to reflect advancements in energy efficient building technologies and building management practices as well as to streamline the compliance processes.

I am confident that the updated ECBC will establish new benchmarks for energy efficient buildings in the country. I urge all stakeholders in the building industry to support effective implementation of ECBC 2017.

  
( P. K. Pujari )





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30 March, 2017



Buildings Energy Codes stipulate the minimum energy performance levels for buildings. These codes are updated for enhancing minimum energy conservation standards and also to keep pace with the technological developments. India's Energy Conservation Building Code (ECBC) was originally launched in 2007. Subsequently, with the amendment in Energy Conservation Act, the threshold for applicability of ECBC in buildings has been brought down. Accordingly, ECBC has been updated to expand its scope, incorporate technological advancements and to respond to the changed market scenario.

This updation has been guided keeping in view the ease of implementation for enforcement officials and ease of understanding for building designers. ECBC 2017 is designed to leverage existing knowledge of building designers. Methods for demonstrating compliance with complex code requirements have been added to the code.

The Bureau of Energy Efficiency (BEE) mapped ECBC implementation systems across different states that have adopted the code. In most states, enforcement authorities for bye-law compliance are also responsible for code compliance. BEE has sought to enable greater understanding of the code and its requirements by enforcement officials by synchronizing the Code with model building bye-laws, National Building Code, and other relevant mandatory guidelines for buildings established by Government of India.

I hope that ECBC 2017 will be instrumental in swifter adoption of energy efficient practices in buildings in the country.

( B.P. Pandey )

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30<sup>th</sup> March, 2017



## MESSAGE

The Government of India announced the Energy Conservation Building Code (ECBC) for new commercial buildings in May 2007. ECBC sets minimum energy standards for new commercial buildings having a connected load of 100 kW or contract demand of 120 kVA and above. While the Central Government has powers under the Energy Conservation Act, 2001 to notify standards of energy consumption in commercial buildings, the state governments can amend the code to suit local or regional needs and notify the same. The major components of the building which are being addressed through the code are: envelope (walls, roofs, windows), lighting systems, HVAC systems, water heating, water pumping and electrical power system.

The enforcement of ECBC lies with the state governments and urban local bodies. A number of states have notified ECBC 2007 with amendments, and several others are in the process of amending the ECBC to suit their local requirements.

In order to facilitate implementation of ECBC, the Bureau of Energy Efficiency (BEE) carried out several enabling measures which, inter alia, included: empanelment of ECBC expert architects, development of technical reference material, development of conformance, compliance check tool, standard training modules, etc.

Keeping in view the advancements in energy efficient building technologies and building management practices and also to streamline the implementation and compliance processes, a need was felt to update the ECBC.

ECBC 2017 is now ready for adoption by the building industry. I hope that all new commercial buildings will not only be ECBC 2017 compliant, but also look to adopting the ECBC+ and Super ECBC standards specified in the new code.

( Raj Pal )





**BUREAU OF ENERGY EFFICIENCY**  
(Ministry of Power, Government of India)

Abhay Bakre

Director General, Bureau of Energy Efficiency



Bureau of Energy Efficiency had launched Energy Conservation Building Code (ECBC) 2007 to establish minimum energy performance standards for buildings in India. Buildings consume significant proportion of our energy resources and the ECBC is an essential regulatory tool to curb their energy footprint.

Building energy codes are updated regularly to catch up with the curve of technology maturation and to set higher benchmarks for building energy efficiency. In alignment with current market scenario and advanced technologies ECBC has been taken for update also. Energy efficient technologies and materials that were aspirational in the years preceding launch of ECBC are now commonly available in Indian markets. Accordingly, ECBC 2017 has been revised to incorporate advanced technologies.

Additional parameters included are related to renewable energy integration, ease of compliance, inclusion of passive building design strategies and, flexibility for the designers. One of the major updates to the code is inclusion of incremental, voluntary energy efficiency performance levels. ECBC 2017 is one of the first building energy codes to recognize beyond code performance. There are now three levels of energy performance standards in the code. In ascending order of efficiency, these are ECBC, ECBCPlus and SuperECBC. The adherence to the minimum requirements stipulated for ECBC level of efficiency would demonstrate compliance with the code. Other two efficiency levels are of voluntary nature. This feature was added to prepare the building industry for meeting energy efficiency standards in coming years and give sufficient time to the market to adapt.

ECBC 2017 is technology neutral. Energy efficiency requirements have been framed to provide architects and engineers artistic and technical freedom as long as minimum efficiency requirements are fulfilled.

Provisions for installation of renewable energy generation systems is mandatory in ECBC 2017. Buildings compliant with the updated code must be ready for installation of renewable energy systems. Proportion of total electricity demand to be met through renewable energy systems increases with the efficiency level the project aspires to.

Passive designs strategies like daylight and shading are mandatory in ECBC 2017. Objective for this change is to encourage design with passive strategies to be the norm for buildings in India. Building energy codes are hinged on climate responsive buildings that use local natural resources and climatic conditions to their advantage.

Passive design strategies are one of the most effective methods to ensure that building designs and technologies are sensitive to the surroundings.

ECBC update process was designed to be a participative exercise that responded to the concerns of the building sector stakeholders while maintaining the technical rigor that must accompany any enforceable building energy code. Numerous meetings and regional workshops were held to develop and review the recommendations. Tremendous participation was seen from practitioners, developers, policy makers and manufacturers during the review workshops conducted in different regions of the country.

On behalf of BEE team, I appreciate the invaluable contributions of the all working group members. Each of them is a luminary of their respective field and have numerous other crucial commitments. Yet for more than three years they worked diligently to ensure that the update process is technically rigorous and the resultant code technically consistent.

The code would not have been completed without the commitment of officials from BEE. Their efforts have ensured that the vision set for code update is embedded in ECBC 2017. I also wish to acknowledge USAID and the team from USAID's Partnership to Advance Clean Energy - Deployment (PACE-D) Technical Assistance program for assisting BEE in anchoring the code update process.

Shri Pradeep Kumar Pujari, Secretary, Ministry of Power; Shri. B P Pandey, Special Secretary, Ministry of Power and Shri Raj Pal, Economic Advisor, Ministry of Power have facilitated the update process and their guidance was instrumental in navigating inter departmental coordination between several Government agencies that oversee building regulations in the country.

I do hope that this endeavour which is evolved through collaborative efforts of many officials will be instrumental in encouraging efficiency in building sector of India. ECBC 2007 laid the foundation for energy efficient buildings in India. ECBC 2017 would aspire to strengthen it further.

**Abhay Bakre**  
Director General  
Bureau of Energy Efficiency



**BUREAU OF ENERGY EFFICIENCY**  
(Ministry of Power, Government of India)



Saurabh Diddi

Director, Bureau of Energy Efficiency

The Energy Conservation Building Code (ECBC) 2017 is now ready for launch. The technical update of the code was required to reflect technological developments that have happened over the intervening period. Also, building management systems have now enabled building energy consumption to be managed and link the same to a number of external and internal operating parameters.

Energy Conservation Building Code 2017 is the culmination of close coordination that started in 2012. This update has been made possible with the commitment and knowledge of Chairs and members of the Working Groups. Dr. N K Bansal, Late Mr. H S Mamak, Dr. R S Agarwal, Dr. Bhim Singh, and Mr. Gulshan Aghi have contributed immensely in developing a comprehensive code. They were joined in the working groups by leading sustainable building experts in India - Mr. G S Modgil, Mr. Sanjay Prakash, Mr. Anurag Bajpai, Dr. Archana Walia, Dr. Milind Rane, Mr. Rajan Rawal, Dr. Jyotirmay Mathur, and Ms. Mili Majumdar.

Energy efficiency measures in ECBC 2017 are informed by actual construction practices and existing level of energy efficiency trends in Indian construction sector. Special thanks are due to members of Refrigeration and Air-Conditioning Manufacturers Association of India, Indian Society of Heating, Refrigerating & Air-conditioning Engineers, Electric Lamp and Component Manufacturers Association of India, International Copper Promotion Council, Indian Electrical and Electronics Manufacturers Association, Central Building Research Institute Roorkee, and Indian Society of Lighting Engineers who shared data on current market trends. Experts from Central Public Works Department, Administrative Staff College of India, Ministry of New and Renewable Energy, Town & Country Planning Organization, Bureau of Indian Standards and other government agencies were instrumental in ensuring that the code is synchronized with other standards and legislation applicable to buildings.

ECBC 2017 also provides for a futuristic building performance standard which the building industry can work towards, irrespective of updates to ECBC. The updated code has defined three levels of energy performance standards. In ascending order of efficiency, these are ECBC compliant building, ECBC+ Building and Super ECBC Building. Fulfilling requirements stipulated for ECBC building level of efficiency is necessary for demonstrating compliance with the code. The other two levels are voluntary. Subsequent updates in ECBC will be focused on making ECBC+ Building and Super ECBC Building the baseline of energy efficient buildings in the country. This feature was added to give notice to the building industry of baseline building energy efficiency standards in coming years and give time to the market to adapt.

The update process was a comprehensive exercise which was able to retain its rigor and technical consistency due to efforts of Ms. Apurva Chaturvedi, Senior Clean Energy Specialist, USAID. Dr. Bhaskar Natarajan from PACE-D TA program provided constant support and guidance in management of the code development processes.

BEE acknowledges Mr. Tanmay Tathagat, Mr. Govinda Somani, Mr. Mayank Bhatnagar, Mr. Hisham Ahmad, Mr. Syed Nabeel Ahmad, Ms. Aarti Nain, Mr. Gurneet Singh, Ms. Anamika Prasad, and the team of architects, engineers and renewable energy experts from Environmental Design Solutions. The code requirements and stringency for ECBC 2017 were informed by their research and analytical studies.

ECBC 2017 would not have been possible without the commitment and support of officers from BEE beginning with the former Director General Dr. Ajay Mathur, former Energy Economist Mr. Sanjay Seth, former Assistant Energy Economist Mr. Girja Shankar, Assistant Energy Economist Mr. Arijit Sengupta and Project Engineers Ms. Anju Singh, Mr. Niraj Rajesh Modi, and Mr. Ishan Jain.

BEE also appreciates the stakeholders from the building industry in India who have provided constant feedback on improving ECBC. I do hope that an endeavour that involved collaborative efforts of so many will be instrumental in encouraging efficiency in buildings in India.

**Saurabh Diddi**

Director  
Bureau of Energy Efficiency



Mark A. White

Mission Director, USAID



Energy cooperation is a key element of the U.S.-India strategic partnership. The two countries have been working together to accelerate clean energy deployment and ensure energy security since the 1950s. The most recent partnership between the U.S. and India, the Partnership to Advance Clean Energy – Deployment (PACE-D), was initiated in 2009 to leverage skills and resources of agencies from both the U.S. and India for scaling up deployment of energy efficiency and renewable energy technologies in India.

The U.S. Agency for International Development (USAID) and the Bureau of Energy Efficiency, Ministry of Power has a long standing and fruitful partnership in enhancing energy efficiency of buildings in India. In 2007, USAID supported the development of the Energy Conservation Building Code (ECBC) in 2007 under the Energy Conservation and Commercialization (ECO) II bilateral program. With PACE-D, we have extended this partnership in a logical direction through technical assistance for update of the ECBC 2007 and its implementation in states.

ECBC 2017 supports many of the Government of India's objectives for achieving energy security, economic growth and environmental sustainability. As a primary policy driver for guiding building construction, it is a forward looking code and will push the building sector towards near zero energy targets. USAID is proud to be associated with the Bureau of Energy Efficiency and the Ministry of Power on such a progressive and innovative building energy code, ECBC 2017.

I congratulate the Bureau of Energy Efficiency and the Ministry of Power on the launch of ECBC 2017. India is in a massive construction phase and the code can be a transformative tool for integrating energy efficient design and technologies in all new commercial buildings.

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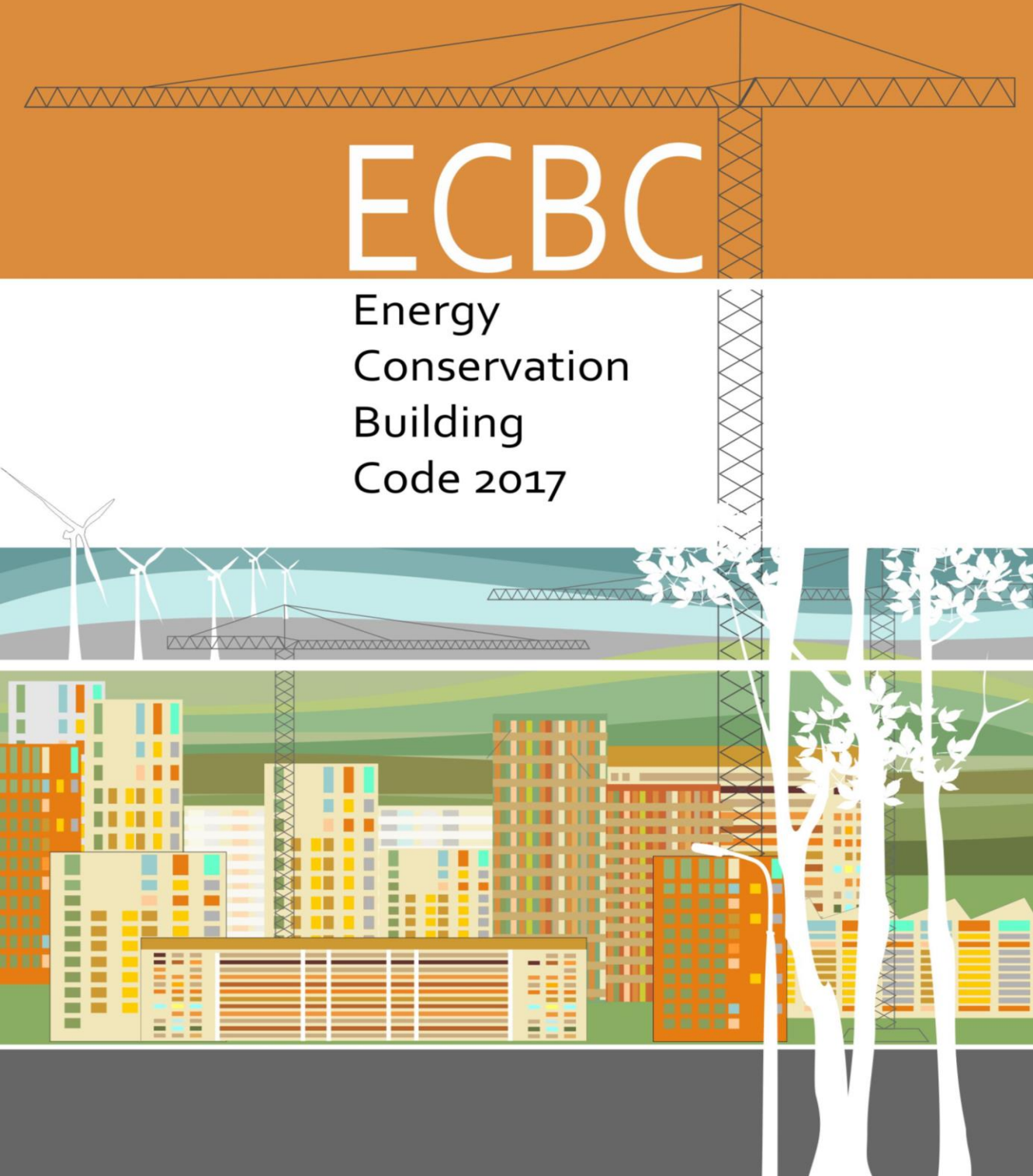
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Uttarakhand Renewable Energy Development Agency  
West Bengal Renewable Energy Development Agency

# ECBC

Energy  
Conservation  
Building  
Code 2017



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# 1 Purpose





# 1. Purpose

In accordance with section 14(p) of the Energy Conservation Act 2001 the purpose of the Energy Conservation Building Code (Code) is to provide minimum requirements for the energy-efficient design and construction of buildings. The Code also provides two additional sets of incremental requirements for buildings to achieve enhanced levels of energy efficiency that go beyond the minimum requirements.

## 2 Scope



## 2. Scope

The Code is applicable to buildings or building complexes that have a connected load of 100 kW or greater or a contract demand of 120 kVA or greater and are intended to be used for commercial purposes.

Buildings intended for private residential purposes only are not covered by the Code.

### 2.1 Energy Efficiency Performance Levels

The code prescribes the following three levels of energy efficiency:

(a) Energy Conservation Building Code Compliant Building (ECBC Building)

ECBC Buildings shall demonstrate compliance by adopting the mandatory and prescriptive requirements listed under ECBC Compliant Building requirements in §4 to §7, or by following the provisions of the Whole Building Performance (WBP) Method in §9.

(b) Energy Conservation Building Code Plus Building (ECBC+ Building)

ECBC+ Buildings shall demonstrate compliance by adopting the mandatory and prescriptive requirements listed under ECBC+ Compliant Building requirements in §4 to §7, or by following the provisions of the Whole Building Performance (WBP) Method in §9.

(c) Super Energy Conservation Building Code Building (SuperECBC Building)

SuperECBC Buildings shall demonstrate compliance by adopting the mandatory and prescriptive requirements listed under SuperECBC Compliant Building requirements in §4 to §7, or by following the provisions of the Whole Building Performance (WBP) Method in §9.

### 2.2 Building Systems

The provisions of this code apply to:

- (a) Building envelope,
- (b) Mechanical systems and equipment, including heating, ventilating, and air conditioning, service hot water heating,
- (c) Interior and exterior lighting, and
- (d) Electrical power and motors, and renewable energy systems.

The provisions of this code do not apply to plug loads, and equipment and parts of buildings that use energy for manufacturing processes, unless otherwise specified in the Code.

### 2.3 Precedence

The following codes, programs, and policies will take precedence over the Code in case of conflict:

- (a) Any policy notified as taking precedence over this Code, or any other rules on safety, security, health, or environment by Central, State, or Local Government.
- (b) Bureau of Energy Efficiency's Standards and Labelling for appliances and Star Rating Program for buildings, provided both or either are more stringent than the requirements of this Code.

## 2.4 Reference Standards

The National Building Code of India 2016 (NBC) is the reference standard for lighting levels, heating, ventilating, and air conditioning (HVAC), thermal comfort conditions, natural ventilation, and any other building materials and system design criteria addressed in this Code.

## 2.5 Building Classification

Any one or more building or part of a building with commercial use is classified as per the functional requirements of its design, construction, and use. The key classification is as below:

- (a) **Hospitality:** Any building in which sleeping accommodation is provided for commercial purposes, except any building classified under Health Care. Buildings and structures under Hospitality shall include the following:
  - i. No-star Hotels – like Lodging-houses, dormitories, no-star hotels/motels
  - ii. Resort
  - iii. Star Hotel
- (b) **Health Care:** Any building or part thereof, which is used for purposes such as medical or other treatment or care of persons suffering from physical or mental illness, disease, or infirmity; care of infants, convalescents, or aged persons, and for penal or correctional detention in which the liberty of the inmates is restricted. Health Care buildings ordinarily provide sleeping accommodation for the occupants. Buildings and structures like hospitals, sanatoria, out-patient healthcare, laboratories, research establishments, and test houses are included under this type.
- (c) **Assembly:** Any building or part of a building, where number of persons congregate or gather for amusement, recreation, social, religious, patriotic, civil, travel and similar purposes. Buildings like theatres or motion picture halls, gathering halls, and transport buildings like airports, railway stations, bus stations, and underground and elevated mass rapid transit system are included in this group.
- (d) **Business:** Any building or part thereof which is used for transaction of business, for keeping of accounts and records and similar purposes, professional establishments, and service facilities. There are two subcategories under Business – Daytime Business and 24-hour Business. Unless otherwise mentioned, Business buildings shall include both Daytime and 24-hour subcategories.
- (e) **Educational:** Any building used for schools, colleges, universities, and other training institutions for day-care purposes involving assembly for instruction, education, or

recreation for students. If residential accommodation is provided in the schools, colleges, or universities or coaching/ training institution, that portion of occupancy shall be classified as a No-star Hotel. Buildings and structures under Educational shall include following types-

- i. Schools
  - ii. All other types of institutes, e.g. college, university, training institutes etc.
- (f) **Shopping Complex:** Any building or part thereof, which is used as shops, stores, market, for display and sale of merchandise, either wholesale or retail. Buildings like shopping malls, stand-alone retails, open gallery malls, super markets, or hyper markets are included in this type.
- (g) **Mixed-use Building:** In a mixed-use building, each commercial part of a building must be classified separately, and –
- i. If a part of the mixed-use building has different classification and is less than 10% of the total above grade floor area, the mixed-use building shall show compliance based on the building sub-classification having higher percentage of above grade floor area.
  - ii. If a part of the mixed-use building has different classification and one or more sub-classification is more than 10% of the total above grade floor area, the compliance requirements for each sub-classification, having area more than 10% of above grade floor area of a mixed-use building shall be determined by the requirements for the respective building classification in §4 to §7.

Any building which does not fall under any of the categories defined above shall be classified in a category mentioned above that best describes the function of the building.

## Note 2-1 Building Typologies for ECBC 2017



Energy efficiency requirements for the Code were derived after analysing 16 different non-residential building typologies (shown below), that in turn are broadly based on building classification in the National Building Code of India. Spatial layouts, material specifications, façade characteristics, and occupancy patterns have an impact on energy efficiency of a building and differ for these typologies. Potential for reducing energy use with technology and materials thus varies from building type to type. By analysing this potential,

ECBC energy efficiency requirements are now sensitive to building typologies and, to the extent possible, only requirements that are feasible have been included.

**Hospitality**

1. Star Hotel
2. No Star Hotel
3. Resort

**Educational**

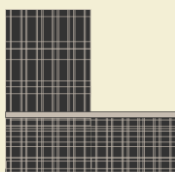
1. College
2. University
3. Institution
4. School

**Health Care**

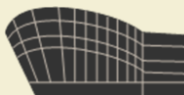
1. Hospital
2. Out-patient Healthcare

**Shopping Complex**

1. Shopping Mall
2. Stand-alone Retails
3. Open Gallery Malls
4. Super Markets

**Business**

1. Daytime use
2. 24-hours use

**Assembly**

1. Multiplex
2. Theatre
3. Building used for Transport Services



# 3 Compliance & Approach



## 3. Compliance and Approach

### 3.1 General

To comply with the Code, buildings shall

- (a) have an Energy Performance Index Ratio (EPI Ratio) as defined in §3.1.2 that is less than or equal to 1

and,

- (b) meet all mandatory requirements mentioned under §4.2, §5.2, §6.2, and §7.2.

#### 3.1.1 Energy Performance Index

The Energy Performance Index (EPI) of a building is its annual energy consumption in kilowatt-hours per square meter of the building. While calculating the EPI of a building, the area of unconditioned basements shall not be included. EPI can be determined by:

$$EPI = \frac{\text{annual energy consumption in kWh}}{\text{total builtup area (excluding unconditioned basements)}}$$

To comply with the Code, EPI value shall be rounded off to two decimal places in accordance with IS 2: 1960 'Rules for rounding off numerical values.

#### 3.1.2 Determining EPI Ratio

The EPI Ratio of a building is the ratio of the EPI of the Proposed Building to the EPI of the Standard Building:

$$EPI \text{ Ratio} = \frac{EPI \text{ of Proposed Building}}{EPI \text{ of Standard Building}}$$

where,

Proposed Building is consistent with the actual design of the building, and complies with all the mandatory requirements of ECBC.

Standard Building is a standardized building that has the same building floor area, gross wall area and gross roof area as the Proposed Building, complies with the mandatory requirements §4.2, §5.2, §6.2, and §7.2, and minimally complies with prescriptive requirements of §4.3, §5.3, and §6.3 for ECBC Buildings.



The EPI ratio of the Proposed Building shall be established through any one of the following two methods described in §3.2 –

- ( a) Prescriptive Method (see §3.2.2)
- ( b) Whole Building Performance Method (see §3.2.3)

### **3.1.3 EPI Ratio for Core and Shell Buildings**

EPI for core and shell buildings shall be calculated for the entire building based on the final design of the common areas and the relevant mandatory undertaking(s) in the tenant lease agreement for the leased areas, as per §3.2.2.1 or §3.2.3.1.

### **3.1.4 EPI Ratio for Mixed-use Development**

In a mixed-use building, each commercial part of a building must be classified separately, and EPI Ratio shall be calculated separately for each sub-classification, as per §3.2.2.1 or §3.2.3.1. The EPI Ratio of a mixed-use Proposed Building shall be calculated based on area-weighted average method. To calculate the reference maximum design EPI Ratio, listed in Table 9-5 through Table 9-9, applicable for the mixed-use building, each commercial part of mixed-use building shall be classified separately, and,

- (a) If a part of the mixed-use building has different classification and is less than 10% of the total above grade area (AGA), the EPI Ratio of the mixed-use Proposed Building shall be less than or equal to Maximum Allowed EPI ratio listed in Table 9-5 through Table 9-9 , for the building sub-classification having highest percentage of above grade floor area.
- (b) If a part of the mixed-use building has different classification and is more than 10% of the total above grade floor area, the EPI ratio of the mixed-use Proposed Building shall be less than or equal to Maximum Allowed EPI ratio for compliance calculated based on area weighted average method for all building sub-classifications listed in Table 9-5 through Table 9-9.

Exceptions to the above: Any portion of a mixed-use building classified in a category which does not fall under the scope of ECBC is exempted from demonstrating compliance.

## **3.2 Compliance Approaches**

Buildings that fall within the scope of the Code as mentioned in §2, shall comply with the Code by meeting all the mandatory requirements (see §3.2.1) and any of the compliance paths mentioned in §3.2.2, or §3.2.3.

### **3.2.1 Mandatory Requirements**

Buildings shall comply with all mandatory requirements mentioned under §4.2, §5.2 , §6.2, and §7.2, irrespective of the compliance path.

### 3.2.2 Prescriptive Method

A building complies with the Code using the Prescriptive Method if it meets the prescribed minimum (or maximum) values for envelope components (§4.3), comfort systems and controls (§5.3, §5.3.12, §5.3.13), and lighting and controls (§6.3), in addition to meeting all the mandatory requirements.

#### 3.2.2.1 EPI Ratio through Prescriptive Method

ECBC Buildings that demonstrate compliance through the Prescriptive Method (§3.2.2) shall be deemed to have an EPI equal to the Standard Building EPI, and therefore an EPI Ratio of 1. ECBC+ Buildings and SuperECBC Buildings that demonstrate compliance through the Prescriptive Method shall be deemed to have an EPI Ratio equal to the EPI Ratios listed in §9.5 under the applicable building type and climate zone.

#### 3.2.2.2 Building Envelope Trade-off Method

To comply with the Prescriptive Method of Section §4, the Building Envelope Trade-off Method may be used in place of the prescriptive criteria of §4.3.1, §4.3.2 and §4.3.3. A building complies with the Code using the Building Envelope Trade-off Method if the Envelope Performance Factor (EPF) of the Proposed Building is less than or equal to the EPF of the Standard Building, calculated as per §4.3.5.

#### 3.2.2.3 Total System Efficiency Method

For projects using central chilled water plants, the Total System Efficiency approach may be used to comply with the Prescriptive Method of §5. This approach may be used in place of the prescriptive criteria of chillers (§5.3.1 and §5.3.6), chilled water pumps (§5.3.2), condenser water pumps (§5.3.2), and cooling tower fan (§5.3.3). Per this approach, a building complies if the Total System Efficiency thresholds are met as per Table 5-23 Maximum System Efficiency Threshold for ECBC, ECBC+, and SuperECBC Buildings. Compliance with other prescriptive requirements (§5.3), as applicable, shall be met.

#### 3.2.2.4 Low Energy Comfort Systems

Low Energy Comfort Systems (§5.3.13) is a simplified approach that provides projects using Low Energy Comfort Systems an opportunity to achieve improved compliance levels of ECBC+ and SuperECBC. This approach is applicable to Prescriptive Method of Section §5. In addition to compliance with the applicable prescriptive requirements (§5.3), the projects must meet the sum of cooling and heating requirement using approved list of low energy systems as per requirements in §5.3.13.

### 3.2.3 Whole Building Performance Method

A building complies with the Code using the Whole Building Performance (WBP) Method when the estimated annual energy use of the Proposed Design is less than that of the Standard Design, even though it may not comply with the specific provisions of the prescriptive requirements in §4 through §7. The mandatory requirements of §4 through §7 (§4.2, §5.2, §6.2, and §7.2) shall be met when using the WBP Method.

### 3.2.3.1 EPI Ratio through Whole Building Performance Method

The EPI of buildings that demonstrate compliance through Whole Building Performance Method (§3.2.3) shall be calculated using the compliance path defined in §3.1.1 and detailed in §9. The EPI Ratio of a building that uses the Whole Building Performance Method to show compliance, should be less than or equal to the EPI Ratio listed in §9.5 for the applicable building type and climate zone.

## 3.3 Compliance Requirements

### 3.3.1 New Building Compliance

#### 3.3.1.1 Full building Compliance

New buildings with completed fit-outs shall comply with either the provisions of §3.2.1 and either the provision of §3.2.2 or §3.2.3.

#### 3.3.1.2 Core and Shell building Compliance

New core and shell building shall comply with the provisions of §3.2.1 and either the provision of §3.2.2 or §3.2.3 following base building systems in the common areas:

- (a) Building envelope
- (b) Thermal comfort systems and controls (only those installed by developer/ owner)
- (c) Lighting systems and controls (only those installed by developer/ owner)
- (d) Electrical systems (installed by developer/ owner)
- (e) Renewable energy systems

Additionally, the tenant lease agreement shall have a legal undertaking clause to ensure interior fit-outs made by tenant shall be Code compliant. The legal undertaking shall mandate the relevant energy efficiency compliance requirements in accordance with the provisions of §3.2.1 and §3.2.2 for all interior fit-outs within the tenant leased area.

### 3.3.2 Additions and Alterations to Existing Buildings

If any existing building after additions or alterations changes its connected load to 100 kilo-Watt (kW) or above or a contract demand of 120 kilo-Volt Ampere (kVA) or above shall comply with the provisions of §4 through §7. Compliance may be demonstrated in either of the following ways:

- (a) The addition shall comply with the applicable requirements, or
- (b) The addition, together with the entire existing building, shall comply with the requirements of this Code that shall apply to the entire building, as if it were a new building.

Exceptions to §3.3.2: When space conditioning is provided by existing systems and equipment, the existing systems and equipment need not comply with this code. However, any new equipment installed must comply with specific requirements applicable to that equipment.

### 3.4 Approved Compliance Tools

A building following the whole building performance method of §9 or Total System Efficiency – Alternate compliance approach of §5.3.12 shall show compliance through online BEP-EMIS or whole building energy simulation software endorsed by BEE.

Compliance to the daylight requirements of §4.2.3, if calculated through software tools, shall be shown through online BEP-EMIS or daylighting software approved by BEE.

### 3.5 Administrative Requirements

Administrative requirements, including but not limited to, permit requirements, enforcement, interpretations, claims of exemption, approved calculation methods, and rights of appeal are specified by the authority having jurisdiction.

### 3.6 Compliance Documents

#### 3.6.1 Compliance Documents

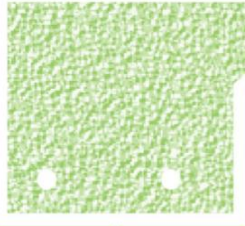
Construction drawings and specifications shall show all pertinent data and features of the building, equipment, and systems in sufficient detail to permit the authority having jurisdiction to verify that the building complies with the requirements of this code. Details shall include, but are not limited to:

- (a) Building Envelope: opaque construction materials and their thermal properties including thermal conductivity, specific heat, density along with thickness; fenestration U-factors, solar heat gain coefficients (SHGC), visible light transmittance (VLT) and building envelope sealing documentation; overhangs and side fins, building envelope sealing details;
- (b) Heating, Ventilation, and Air Conditioning: system and equipment types, sizes, efficiencies, and controls; economizers; variable speed drives; piping insulation; duct sealing, insulation and location; solar water heating system; requirement for balance report;
- (c) Lighting: lighting schedule showing type, number, and wattage of lamps and ballasts; automatic lighting shutoff, occupancy sensors, and other lighting controls; lamp efficacy for exterior lamps;
- (d) Electrical Power: electric schedule showing transformer losses, motor efficiencies, and power factor correction devices; electric check metering and monitoring system.
- (e) Renewable energy systems: system peak installed capacity, technical specifications, solar zone area

### **3.6.2 Supplemental Information**

The authority having jurisdiction may require supplemental information necessary to verify compliance with this code, such as calculations, worksheets, compliance forms, manufacturer's literature, or other data.

# 4 Building Envelope



## 4. Building Envelope

### 4.1 General

The building envelope shall comply with the mandatory provisions of §4.2, and the prescriptive criteria of §4.3. In case alternative compliance path of Building Envelope Trade-off Method is used for compliance, requirements of §4.3.5 and relevant criteria of §4.3 shall be met.

### 4.2 Mandatory Requirements

#### 4.2.1 Fenestration

##### 4.2.1.1 U-Factor

U-factors shall be determined for the overall fenestration product (including the sash and frame) in accordance with ISO-15099 by an accredited independent laboratory, and labeled or certified by the manufacturer. U-factors for sloped glazing and skylights shall be determined at a slope of 20 degrees above the horizontal. For unrated products, use the default table in Appendix A.

##### 4.2.1.2 Solar Heat Gain Coefficient

SHGC shall be determined for the overall single or multi glazed fenestration product (including the sash and frame) in accordance with ISO-15099 by an accredited independent laboratory, and labeled or certified by the manufacturer.

Exceptions to §4.2.1.2:

- (a) Shading coefficient (SC) of the center of glass alone multiplied by 0.86 is an acceptable alternate for compliance with the SHGC requirements for the overall fenestration area.
- (b) Solar heat gain coefficient (SHGC) of the glass alone is an acceptable alternate for compliance with the SHGC requirements for the overall fenestration product.

##### 4.2.1.3 Visible light transmittance

Visible light transmittance (VLT) shall be determined for the fenestration product in accordance with ISO-15099 by an accredited independent laboratory, and labeled or certified by the manufacturer. For unrated products, VLT of the glass alone shall be de-rate by 10% for demonstrating compliance with the VLT requirements for the overall fenestration product.

## 4.2.2 Opaque Construction

### 4.2.2.1 U-Factor

U-factors shall be calculated for the opaque construction in accordance with ISO-6946. Testing shall be done in accordance with approved ISO Standard for respective insulation type by an accredited independent laboratory, and labeled or certified by the manufacturer. For unrated products, use the default tables in Appendix A.

### 4.2.2.2 Solar Reflectance

Solar reflectance for the external opaque roof construction shall be determined in accordance with ASTM E903-96 by an accredited independent laboratory, and labeled or certified by the manufacturer.

### 4.2.2.3 Emittance

Emittance for the external opaque roof construction shall be determined in accordance with ASTM E408-71 (RA 1996) by an accredited independent laboratory, and labeled or certified by the manufacturer.

## 4.2.3 Daylighting

Above grade floor areas shall meet or exceed the useful daylight illuminance (UDI) area requirements listed in Table 4-1 for 90% of the potential daylit time in a year. For the purpose of daylighting compliance, the above grade floor area may exclude the wall thickness, columns, and, lift and building shafts. Mixed-use buildings shall show compliance as per the criteria prescribed in §2.5. Compliance shall be demonstrated either through daylighting simulation method in §4.2.3.1 or the manual method in §4.2.3.2. Assembly buildings and other buildings where daylighting will interfere with the functions or processes of 50% (or more) of the building floor area, are exempted from meeting the requirements listed in Table 4-1.

Exceptions to §4.2.3:

Assembly buildings and other buildings where daylighting will interfere with the functions or processes of 50% (or more) of the building floor area, are exempted from meeting the requirements listed in Table 4-1.



Table 4-1 Daylight Requirement

| Building Category     | Percentage of above grade floor area meeting the UDI requirement |       |           |
|-----------------------|--|-------|-----------|
|                       | ECBC   | ECBC+ | SuperECBC |
| Business, Educational | 40%  | 50%   | 60%       |
| No Star Hotel         | 30%  | 40%   | 50%       |
| Star Hotel            |  |       |           |
| Healthcare            |  |       |           |
| Resort                | 45%  | 55%   | 65%       |
| Shopping Complex      | 10%  | 15%   | 20%       |
| Assembly              | Exempted   |       |           |

#### 4.2.3.1 Daylighting Simulation Method

Only BEE approved software shall be used to demonstrate compliance through the daylighting simulation method. Buildings shall achieve illuminance level between 100 lux and 2,000 lux for the minimum percentage of floor area prescribed in Table 4-1 for at least 90% of the potential daylight time. Illuminance levels for all spaces enclosed by permanent internal partitions (opaque, translucent, or transparent) with height greater or equal to 2 m from the finished floor, shall be measured as follows:

- Measurements shall be taken at a work plane height of 0.8 m above the finished floor.
- The period of analysis shall be fixed for continuously 8 hours per day, anytime between 7:00 AM IST to 5:00 PM IST, resulting in 2,920 hours in total for all building types except for Schools. Schools shall be analyzed for continuously 7 hours per day, anytime between 7:00 AM IST to 3:00 PM IST.
- Available useful daylight across a space shall be measured based on point-by-point grid values. UDI shall be calculated for at least one point for each square meter of floor area.
- Fenestration shall be modeled with actual visible light transmission (VLT) as per the details provided in the material specification sheet.
- All surrounding natural or man-made daylight obstructions shall be modeled if the distance between the façade of the building (for which compliance is shown) and surrounding natural or man-made daylight obstructions is less than or equal to twice the height of the man-made or natural sunlight obstructions. If the reflectance of the surfaces is not known, default reflectance of 30% and 0% shall be used for all vertical surfaces of man-made and natural obstructions respectively.
- Interior surface reflectance shall be modeled based on the actual material specification. If material specification is not available, the default values in Table 4-2 shall be used:
- Documentation requirement to demonstrate compliance are:
  - Brief description of the project with location, number of stories, space types, hours of operation and and software used.
  - Summary describing the results of the analysis and output file from simulation tool outlining point wise compliance for the analysis grid and compliance in percentage.
  - Explanation of any significant modelling assumptions made.

- iv. Explanation of any error messages noted in the simulation program output.
- v. Building floor plans, building elevations & sections, and site plan with surrounding building details (if modeled).
- vi. Material reflectance, analysis grid size, total number of grid size/resolution, total number of grid points.

Table 4-2 Default Values for Surface Reflectance

| Surface Type                       | Reflectance |
|------------------------------------|-------------|
| Wall or Vertical Internal Surfaces | 50%         |
| Ceiling                            | 70%         |
| Floor                              | 20%         |
| Furniture (permanent)              | 50%         |

#### 4.2.3.2 Manual Daylighting Compliance Method

This method can be used for demonstrating compliance with daylighting requirements without simulation. Daylight extent factors (DEF) mentioned in Table 4-3 shall be used for manually calculating percentage of above grade floor area meeting the UDI requirement for 90% of the potential daylit time in a year.

Table 4-3 Daylight Extent Factors (DEF) for Manually Calculating Daylight Area

| Shading                | Latitude      | Window Type                           | VLT < 0.3 |       |      |      | VLT ≥ 0.3 |       |      |      |
|------------------------|---------------|---------------------------------------|-----------|-------|------|------|-----------|-------|------|------|
|                        |               |                                       | North     | South | East | West | North     | South | East | West |
| No shading or PF < 0.4 | ≥ 15°N        | All window types                      | 2.5       | 2.0   | 0.7  | 0.5  | 2.8       | 2.2   | 1.1  | 0.7  |
|                        | < 15°N        |                                       | 2.4       | 2.0   | 0.8  | 0.6  | 2.7       | 2.2   | 1.5  | 0.8  |
| Shading with PF ≥ 0.4  | All latitudes | All window types without light shelf* | 2.8       | 2.3   | 1.5  | 1.1  | 3.0       | 2.5   | 1.8  | 1.5  |
|                        |               | Window with light shelf*              | 3.0       | 2.5   | 1.8  | 1.6  | 3.5       | 3.0   | 2.1  | 1.8  |

\* To qualify as light shelf the internal projection shall meet the requirements specified under Exceptions to SHGC requirements in Table 4-10 and Table 4-11 (b)

(a) To calculate the daylit area:

- i. In a direction perpendicular to the fenestration, multiply daylight extent factor (DEF) by the head height of the fenestration or till an opaque partition higher than head height of the fenestration, whichever is less.

- ii. In the direction parallel to the fenestration, daylit area extends a horizontal dimension equal to the width of the fenestration plus either 1 meter on each side of the aperture, or the distance to an opaque partition of 2 m high, or one-half the distance to an adjacent fenestration, whichever is least.
- iii. For skylights, calculate the horizontal dimension in each direction equal to the top aperture dimension in that direction plus either the floor-to-ceiling height (H) for skylights, or 1.5 H for monitors, or H or 2H for the sawtooth configuration, or the distance to the nearest 1 meter or higher opaque partition, or one-half the distance to an adjacent skylight or vertical glazing, whichever is least.
- iv. Glazed façades, with non-cardinal orientation, shall be categorized under a particular cardinal direction if its orientation is within  $\pm 45$  degrees of that cardinal direction.
- v. Daylit area overlap: For overlapping daylit areas such as windows on different orientations or in case of skylights the overlapping daylit area shall be subtracted from the sum of daylit area.

(b) Documentation requirement:

- i. A separate architectural plan shall be prepared with all daylit areas marked on the floor plans.
- ii. A summary shall be provided showing compliance as per Table 4-1.

#### 4.2.4 Building Envelope Sealing

Following areas of the building envelope, of all except naturally ventilated buildings or spaces, shall be sealed, caulked, gasketed, or weather-stripped:

- (a) Joints around fenestration, skylights, and door frames
- (b) Openings between walls and foundations, and between walls and roof, and wall panels
- (c) Openings at penetrations of utility services through roofs, walls, and floors
- (d) Site-built fenestration and doors
- (e) Building assemblies used as ducts or plenums
- (f) All other openings in the building envelope
- (g) Exhaust fans shall be fitted with a sealing device such as a self-closing damper
- (h) Operable fenestration should be constructed to eliminate air leakages from fenestration frame and shutter frame

**Note 4.1 Daylight Extent Factor and Useful Daylight Illuminance**

Useful Daylight Illuminance (UDI) is defined as the annual occurrence of daylight between 100 lux to 2,000 lux on a work plane. This daylight is most useful to occupants, glare free and when available, eliminates the need for artificial lighting. Daylight extent factor provides a ratio of window sizes to floor area receiving UDI in accordance to window orientation.

**Calculating Useful Daylight Illuminance (UDI)**

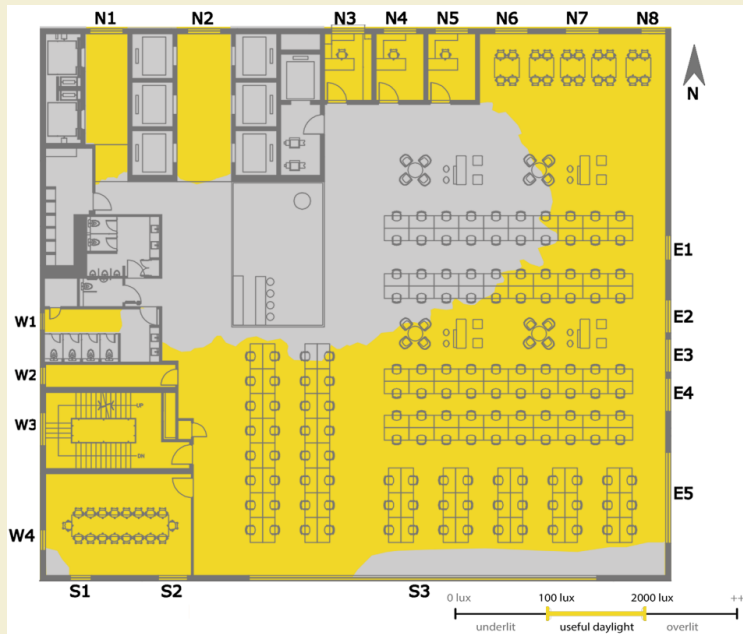
An office building located in New Delhi, India is pursuing ECBC compliance. Table 4-1 lists the minimum daylight area requirements for compliance. The table specifies that for office buildings, minimum 40% of its floor area shall receive daylight in range of 100 – 2,000 lux for at least 90% of the year.

This typical floor has a rectangular layout (33 m x 38 m) of 1,254 m<sup>2</sup>. Visible light transmission (VLT) of glazing in all orientations is 0.39. Windows have light shelves and external shading devices with Projection Factor (PF) ≥ 0.4. Head height of fenestrations is 3.0 m.

For compliance at least 502 m<sup>2</sup> (40% of 1,254 m<sup>2</sup>) of floor area shall fulfil the UDI requirements. Daylit area should be indicated in floor plans submitted to code enforcement authorities. Design guidelines on daylighting stated in NBC (Part 8: Building Services, Section 1: Lighting and Natural Ventilation, Subsection 4.2: Daylighting) should also be referred to achieve the ECBC, ECBC+, or Super ECBC requirement. Compliance with 4.2.3 Daylight Requirements can be checked for through two approaches.

**(a) Analysis through software**

If the whole building performance approach is used, compliance for daylighting requirements can be checked by analysing the façade and floor plate design in an analytical software approved by BEE (3.4). The image below, developed through an approved software, specifies the lux levels and time-period of a year during which lighting levels would be available. With this information, designers can check if the required minimum area as per 4.2.3 has the required daylight levels



*UDI Analysis with a Daylighting Analysis Software*

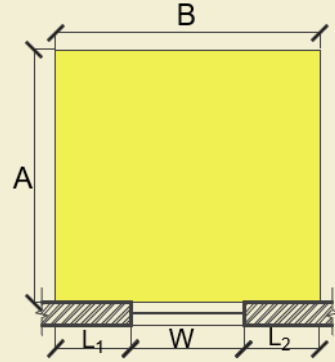
**(b) Manual calculation method**

For projects adopting the prescriptive compliance approach, manual calculation method can be used for UDI compliance.

1. From Table 4.3 determine the daylight extent factor (**DEF**) for each orientation. For a building located in Delhi (latitude > 15 degrees), with glazing of  $VLT \geq 0.39$ , shading  $PF \geq 0.4$  and light shelves in windows, DEFs for windows in North = 3.5, in South = 3.0, in East = 2.1, and in West = 1.8. Head height is 3.0 m.
2. For fenestration clear of any opaque obstructions calculate daylit floor area (**AxB**).

**A:**In the direction perpendicular to the fenestration, daylit area extends to head height of the fenestration multiplied by the daylight extent factor (DEF) or distance till an opaque partition higher than head height of the fenestration, whichever is less.

**B:**In the direction parallel to the fenestration daylit area extends a horizontal dimension equal to the width of the fenestration plus either one meter on each side of the aperture or the distance to an opaque partition, or one-half the distance to an adjacent fenestration, whichever is least.



3. For overlapping daylit areas such as corner windows. Subtract the overlapping daylit area from the sum of daylit area.



UDI Analysis with manual calculations

As per the calculations **616.5 m<sup>2</sup>** of floor area will meet the UDI requirements during 90% of the year. This is **49.2 %** of the total above grade floor area of 1,254 m<sup>2</sup>. Thus, the building floor will comply with UDI requirement. Following Tables shows calculated Daylight Area Meeting UDI Requirement.

Table 4-1-1 Manual calculation for Daylight Area Meeting UDI Requirement

| Orientation- <b>NORTH</b> , DEF- <b>3.5</b> , Fenestration Head Height H - <b>3m</b> |                          |   |   |   |
|--|--------------------------|---|---|---|
| Window without opaque obstructions   | Fenestration Width W (m) | A= H x DEF (m)                            | B= L <sub>1</sub> +W+ L <sub>2</sub> (m)<br>L <sub>1</sub> = L <sub>2</sub> =1m                                     | Area meeting the UDI requirements = AxB (m <sup>2</sup> ) |
| N7   | 2.0                      | 10.5                                      | 4.0   | 42.0  |
| N6   | 2.0                      | 10.5                                      | 4.0   | 42.0  |
| N2   | 2.0                      | 10.5                                      | 4.0   | 42.0  |
| Window with opaque obstructions  | Fenestration Width W (m) | A= Distance till parallel Obstruction (m) | B= L <sub>1</sub> +W+ L <sub>2</sub> (m)<br>L <sub>1</sub> = L <sub>2</sub> =Distance to perpendicular Obstructions | Area meeting the UDI requirements = AxB (m <sup>2</sup> ) |
| N1   | 2.0                      | 10.5                                      | 0.3+2+0.3=2.6   | 27.3  |
| N3   | 2.0                      | 4.0                                       | 0.4+2+0.4=2.8   | 11.2  |
| N4   | 2.0                      | 4.0                                       | 0.4+2+0.4=2.8   | 11.2  |
| N5   | 2.0                      | 4.0                                       | 0.4+2+0.4=2.8   | 11.2  |
| N8   | 1.5                      | 10.5                                      | 0+1.5+1.0=2.5   | 26.3  |
| Daylit area meeting UDI requirement  |                          |   |   | <b>213.2</b>  |
| Orientation- <b>SOUTH</b> , DEF- <b>3</b> , Fenestration Head Height H - <b>3m</b>   |                          |   |   |   |
| Window without opaque obstructions   | Fenestration Width W (m) | A= H x DEF (m)                            | B= L <sub>1</sub> +W+ L <sub>2</sub> (m)<br>L <sub>1</sub> = L <sub>2</sub> =1m                                     | Area meeting the UDI requirements = AxB (m <sup>2</sup> ) |
| S1   | 1.2                      | 6.2                                       | 1.0+1.2+1.0=3.3   | 20.1  |
| S2   | 1.7                      | 6.2                                       | 1.0+1.7+0.3=3.0   | 18.6  |
| S3   | 21.0                     | 9.0                                       | 1.0+21.0+1.0=24   | 216.0   |
| Daylit area meeting UDI requirement  |                          |   |   | <b>254.7</b>  |

| Orientation-EAST, DEF-2.1, Fenestration Head Height H - 3m |                          |                                |  |   |
|--|--------------------------|--------------------------------|--|---|
| Window without opaque obstructions                         | Fenestration Width W (m) | $A = H \times DEF \text{ (m)}$ | $B = L_1 + W + L_2 \text{ (m)}$<br>$L_1 = L_2 = 1m$  | Area meeting the UDI requirements = $A \times B \text{ (m}^2\text{)}$ |
| E1   | 1.5                      | 6.3                            | $1.0 + 1.5 + 1.0 = 3.5$  | 22.1  |
| E5   | 5.5                      | 6.3                            | $1.0 + 5.5 + 1.0 = 7.5$  | 47.3  |
| Adjacent fenestration less than two meter apart            | Fenestration Width W (m) | $A = H \times DEF \text{ (m)}$ | $B = L_1 + W + L_2 \text{ (m)}$<br>$L_1, L_2 = \text{one half of distance to adjacent fenestration}$ | Area meeting the UDI requirements = $A \times B \text{ (m}^2\text{)}$ |
| E2   | 2                        | 6.3                            | $1.0 + 2.0 + 0.2 = 3.2$  | 20.2  |
| E3   | 2                        | 6.3                            | $0.2 + 2 + 0.2 = 2.4$  | 15.1  |
| E4   | 2                        | 6.3                            | $0.2 + 2 + 1 = 3.2$  | 20.2  |
| Daylit area meeting UDI requirement                        |                          |                                |  | <b>124.9</b>  |
| Orientation-WEST, DEF-1.8, Fenestration Head Height H - 3m |                          |                                |  |   |
| Window without opaque obstructions                         | Fenestration Width W (m) | $A = H \times DEF \text{ (m)}$ | $B = L_1 + W + L_2 \text{ (m)}$<br>$L_1 = L_2 = 1m$  | Area meeting the UDI requirements = $A \times B \text{ (m}^2\text{)}$ |
| W3   | 2.0                      | 5.4                            | $1.0 + 2.0 + 1.0 = 4.0$  | 21.6  |
| W4   | 1.4                      | 5.4                            | $1.0 + 1.2 + 1.0 = 3.2$  | 17.3  |
| Window with opaque obstructions in daylit area             | Fenestration Width W (m) | $A = H \times DEF \text{ (m)}$ | $B = L_1 + W + L_2 \text{ (m)}$<br>$L_1 = L_2 = \text{Distance to perpendicular Obstructions}$       | Area meeting the UDI requirements = $A \times B \text{ (m}^2\text{)}$ |
| W1   | 1.0                      | 5.4                            | $0.3 + 1 + 0.3 = 1.6$  | 8.6   |
| W2   | 1.0                      | 5.4                            | $0.3 + 1 + 0.3 = 1.6$  | 8.6   |
| Daylit area meeting UDI requirement                        |                          |                                |  | <b>56.1</b>   |

|  |                  |           |           |
|--|------------------|-----------|-----------|
|  |                  |           |           |
| Overlapping area calculations  |                  |           |           |
| Window with overlap areas  | Width (m)        | Depth (m) | Area (m²) |
| N4 and S1  | 3.3              | 3.3       | 10.9      |
| S3 and E5  | 3.3              | 6.5       | 21.5      |
| Overlapping daylight area (b)  |                  |           | 32.4      |
|  |                  |           |           |
| Total Daylit area  |                  |           |           |
| ORIENTATION  | Daylit area (m²) |           |           |
| NORTH  | 213.2            |           |           |
| SOUTH  | 254.7            |           |           |
| EAST   | 124.9            |           |           |
| WEST   | 56.1             |           |           |
| Total daylight area (a)  | 648.9            |           |           |
| Total Overlapping daylit area (b)                                      | 32.4             |           |           |
| Total daylit area meeting UDI requirement during 90% of the year (a-b) | 616.5            |           |           |
|  |                  |           |           |



## 4.3 Prescriptive Requirements

### 4.3.1 Roof

Roofs shall comply with the maximum assembly U-factors in Table 4-4 through Table 4-6. The roof insulation shall be applied externally as part of the roof assembly and not as a part of false ceiling.

Table 4-4 Roof Assembly U-factor ( $W/m^2.K$ ) Requirements for ECBC Compliant Building

|   | Composite | Hot and dry | Warm and humid | Temperate | Cold |
|---|-----------|-------------|----------------|-----------|------|
| All building types, except below        | 0.33      | 0.33        | 0.33           | 0.33      | 0.28 |
| School <10,000 m <sup>2</sup> AGA       | 0.47      | 0.47        | 0.47           | 0.47      | 0.33 |
| Hospitality > 10,000 m <sup>2</sup> AGA | 0.20      | 0.20        | 0.20           | 0.20      | 0.20 |

Table 4-5 Roof Assembly U-factor ( $W/m^2.K$ ) Requirements for ECBC+ Compliant Building

|                                       | Composite | Hot and dry | Warm and humid | Temperate | Cold |
|---------------------------------------|-----------|-------------|----------------|-----------|------|
| Hospitality, Healthcare Assembly      | 0.20      | 0.20        | 0.20           | 0.20      | 0.20 |
| Business Educational Shopping Complex | 0.26      | 0.26        | 0.26           | 0.26      | 0.20 |

Table 4-6 Roof Assembly U-factor ( $W/m^2.K$ ) Requirements for SuperECBC Building

|                     | Composite | Hot and dry | Warm and humid | Temperate | Cold |
|---------------------|-----------|-------------|----------------|-----------|------|
| All buildings types | 0.20      | 0.20        | 0.20           | 0.20      | 0.20 |

#### 4.3.1.1 Vegetated and Cool Roof

All roofs that are not covered by solar photovoltaics, or solar hot water, or any other renewable energy system, or utilities and services that render it unsuitable for the purpose, shall be either cool roofs or vegetated roofs.

- For qualifying as a cool roof, roofs with slopes less than 20° shall have an initial solar reflectance of no less than 0.70 and an initial emittance no less than 0.75. Solar reflectance shall be determined in accordance with ASTM E903-96 and emittance shall be determined in accordance with ASTM E408-71 (RA 1996).
- For qualifying as a vegetated roof, roof areas shall be covered by living vegetation of >50 mm high.

### 4.3.2 Opaque External Wall

Opaque above grade external walls shall comply with the maximum assembly U-factors in Table 4-7 through Table 4-9.

Table 4-7 Opaque Assembly Maximum U-factor ( $W/m^2.K$ ) Requirements for a ECBC compliant Building

|   | Composite | Hot and dry | Warm and humid | Temperate | Cold |
|---|-----------|-------------|----------------|-----------|------|
| All building types, except below          | 0.40      | 0.40        | 0.40           | 0.55      | 0.34 |
| No Star Hotel < 10,000 m <sup>2</sup> AGA | 0.63      | 0.63        | 0.63           | 0.63      | 0.40 |
| Business < 10,000 m <sup>2</sup> AGA      | 0.63      | 0.63        | 0.63           | 0.63      | 0.40 |
| School <10,000 m <sup>2</sup> AGA         | 0.85      | 0.85        | 0.85           | 1.00      | 0.40 |

Table 4-8 Opaque Assembly Maximum U-factor ( $W/m^2.K$ ) Requirements for ECBC+ Compliant Building

|   | Composite | Hot and dry | Warm and humid | Temperate | Cold |
|---|-----------|-------------|----------------|-----------|------|
| All building types, except below          | 0.34      | 0.34        | 0.34           | 0.55      | 0.22 |
| No Star Hotel < 10,000 m <sup>2</sup> AGA | 0.44      | 0.44        | 0.44           | 0.44      | 0.34 |
| Business < 10,000 m <sup>2</sup> AGA      | 0.44      | 0.44        | 0.44           | 0.55      | 0.34 |
| School <10,000 m <sup>2</sup> AGA         | 0.63      | 0.63        | 0.63           | 0.75      | 0.44 |

Table 4-9 Opaque Assembly Maximum U-factor ( $W/m^2.K$ ) Requirements for SuperECBC Building

|                    | Composite | Hot and dry | Warm and humid | Temperate | Cold |
|--------------------|-----------|-------------|----------------|-----------|------|
| All building types | 0.22      | 0.22        | 0.22           | 0.22      | 0.22 |

Exceptions to §4.3.2: Opaque external walls of an unconditioned building of No Star Hotel, Healthcare, and School categories in all climatic zones, except for cold climatic zone, shall have a maximum assembly U-factor of 0.8  $W/m^2.K$ .

### 4.3.3 Vertical Fenestration

For all climatic zones, vertical fenestration compliance requirements for all three energy efficiency levels, i.e. ECBC, ECBC+, and SuperECBC, shall comply with the following:

- Maximum allowable Window Wall Ratio (WWR) is 40% (applicable to buildings showing compliance using the Prescriptive Method, including Building Envelope Trade-off Method)
- Minimum allowable Visible light transmittance (VLT) is 0.27

- (c) Assembly U-factor shall be determined for the overall fenestration product (including the sash and frame)

Vertical fenestration shall comply with the maximum Solar Heat Gain Coefficient (SHGC) and U-factor requirements of Table 4-10 for ECBC buildings and Table 4-11 for ECBC+ buildings and SuperECBC buildings. Vertical fenestration on non-cardinal direction, shall be categorized under a particular cardinal direction if its orientation is within  $\pm 45^\circ$  of that cardinal direction.

Table 4-10 Vertical Fenestration Assembly U-factor and SHGC Requirements for ECBC Buildings

|  | Composite | Hot and dry | Warm and humid | Temperate | Cold |
|--|-----------|-------------|----------------|-----------|------|
| Maximum U-factor (W/m <sup>2</sup> .K)                     | 3.00      | 3.00        | 3.00           | 3.00      | 3.00 |
| Maximum SHGC Non-North                                     | 0.27      | 0.27        | 0.27           | 0.27      | 0.62 |
| Maximum SHGC North for latitude $\geq 15^\circ\text{N}$    | 0.50      | 0.50        | 0.50           | 0.50      | 0.62 |
| Maximum SHGC North for latitude $< 15^\circ\text{N}$       | 0.27      | 0.27        | 0.27           | 0.27      | 0.62 |
| See Appendix A for default values of unrated fenestration. |           |             |                |           |      |

Table 4-11 Vertical Fenestration U-factor and SHGC Requirements for ECBC+ buildings and SuperECBC buildings

|   | Composite | Hot and dry | Warm and humid | Temperate | Cold |
|---|-----------|-------------|----------------|-----------|------|
| Maximum U-factor (W/m <sup>2</sup> .K)                  | 2.20      | 2.20        | 2.20           | 3.00      | 1.80 |
| Maximum SHGC Non-North                                  | 0.25      | 0.25        | 0.25           | 0.25      | 0.62 |
| Maximum SHGC North for latitude $\geq 15^\circ\text{N}$ | 0.50      | 0.50        | 0.50           | 0.50      | 0.62 |
| Maximum SHGC North for latitude $< 15^\circ\text{N}$    | 0.25      | 0.25        | 0.25           | 0.25      | 0.62 |

Exceptions to SHGC requirements in Table 4-10 and Table 4-11:

- (a) For fenestration with a permanent external projection, including but not limited to overhangs, side fins, box frame, verandah, balcony, and fixed canopies that provide permanent shading to the fenestration, the equivalent SHGC for the proposed shaded fenestration may be determined as less than or equal to the SHGC requirements of Table 4-10 and Table 4-11. Equivalent SHGC shall be calculated by following the steps listed below:
- i. Projection factor (PF) for the external permanent projection, shall be calculated as per the applicable shading type listed in §8.2. The projection factor for using the SEF is  $PF \geq 0.25$ . The SEF is applicable for both side fins shading only other than overhangs. The projection factor shall be calculated for both side fins and the lower projection factor of each fin shall be considered. Other shading devices shall be modeled through the Whole Building Performance Method in §9.
  - ii. A shaded vertical fenestration on a non-cardinal direction, shall be categorized either under a particular cardinal direction or a primary inter-cardinal direction if its orientation is within the range of  $\pm 22.5$  degrees of the cardinal or primary inter-cardinal direction.
  - iii. Any surrounding man-made or natural sunlight obstructions shall be considered as a permanent shading of PF equal to 0.4 if
    - a. the distance between the vertical fenestration of the building, for which compliance is shown, and surrounding man-made or natural sunlight obstructions is less than or equal to twice the height of the surrounding man-made or natural sunlight obstructions; and
    - b. the surrounding man-made or natural sunlight obstructions shade the façade for at least 80% of the total time that the façade is exposed to direct sun light on a summer solstice. Compliance shall be shown using a sun path analysis for summer solstice for the vertical fenestration.
  - iv. An equivalent SHGC is calculated by dividing the SHGC of the unshaded fenestration product with a Shading Equivalent Factor (SEF). SEF shall be determined for each orientation and shading device type from Table 4-10 and Table 4-11.
  - v. The maximum allowable SHGC is calculated by multiplying the prescriptive SHGC requirement for respective compliance level from Table 4-10 and Table 4-11 with the SEF.

Table 4-12 Shading Equivalent Factors for Latitudes greater than or equal to 15°N

| Shading Equivalent Factors (SEF) for latitudes greater than or equal to 15°N |      |       |      |       |      |            |            |            |            |
|--|------|-------|------|-------|------|------------|------------|------------|------------|
| SEF  | PF   | North | East | South | West | North-East | South-East | South-West | North-West |
| Overhang + Fins  | 0.25 | 1.25  | 1.37 | 1.58  | 1.36 | 1.47       | 1.47       | 1.42       | 1.53       |
|  | 0.3  | 1.29  | 1.48 | 1.72  | 1.43 | 1.54       | 1.65       | 1.57       | 1.58       |
|  | 0.35 | 1.34  | 1.58 | 1.88  | 1.51 | 1.62       | 1.81       | 1.73       | 1.65       |
|  | 0.4  | 1.39  | 1.67 | 2.06  | 1.61 | 1.70       | 1.97       | 1.89       | 1.75       |
|  | 0.45 | 1.43  | 1.76 | 2.26  | 1.71 | 1.78       | 2.11       | 2.06       | 1.87       |
|  | 0.5  | 1.47  | 1.85 | 2.47  | 1.83 | 1.86       | 2.25       | 2.23       | 2.00       |
|  | 0.55 | 1.51  | 1.94 | 2.69  | 1.96 | 1.94       | 2.38       | 2.40       | 2.13       |
|  | 0.6  | 1.55  | 2.03 | 2.92  | 2.09 | 2.02       | 2.51       | 2.58       | 2.27       |
|  | 0.65 | 1.59  | 2.13 | 3.15  | 2.24 | 2.10       | 2.64       | 2.76       | 2.40       |
|  | 0.7  | 1.63  | 2.24 | 3.18  | 2.39 | 2.18       | 2.77       | 2.94       | 2.53       |
|  | 0.75 | 1.66  | 2.37 | 3.19  | 2.56 | 2.25       | 2.90       | 3.12       | 2.64       |
|  | 0.8  | 1.70  | 2.52 | 3.20  | 2.72 | 2.33       | 3.04       | 3.18       | 2.73       |
|  | 0.85 | 1.73  | 2.69 | 3.21  | 2.90 | 2.40       | 3.11       | 3.23       | 2.80       |
|  | 0.9  | 1.76  | 2.89 | 3.24  | 3.07 | 2.46       | 3.15       | 3.25       | 2.84       |
|  | 0.95 | 1.79  | 3.11 | 3.28  | 3.25 | 2.52       | 3.17       | 3.27       | 2.85       |
|  | ≥1   | 1.80  | 3.30 | 3.33  | 3.33 | 2.57       | 3.23       | 3.30       | 2.82       |
| Overhang   | 0.25 | 1.09  | 1.21 | 1.28  | 1.20 | 1.17       | 1.26       | 1.23       | 1.20       |
|  | 0.3  | 1.11  | 1.26 | 1.34  | 1.27 | 1.22       | 1.32       | 1.27       | 1.24       |
|  | 0.35 | 1.13  | 1.30 | 1.39  | 1.33 | 1.26       | 1.39       | 1.32       | 1.28       |
|  | 0.4  | 1.15  | 1.35 | 1.46  | 1.38 | 1.30       | 1.46       | 1.38       | 1.32       |
|  | 0.45 | 1.16  | 1.40 | 1.52  | 1.43 | 1.33       | 1.53       | 1.46       | 1.36       |
|  | 0.5  | 1.18  | 1.45 | 1.59  | 1.48 | 1.35       | 1.60       | 1.54       | 1.40       |
|  | 0.55 | 1.20  | 1.51 | 1.66  | 1.52 | 1.38       | 1.67       | 1.62       | 1.44       |
|  | 0.6  | 1.21  | 1.56 | 1.73  | 1.57 | 1.40       | 1.74       | 1.70       | 1.47       |
|  | 0.65 | 1.22  | 1.62 | 1.81  | 1.61 | 1.42       | 1.81       | 1.79       | 1.51       |
|  | 0.7  | 1.24  | 1.68 | 1.88  | 1.66 | 1.45       | 1.88       | 1.87       | 1.55       |
|  | 0.75 | 1.25  | 1.74 | 1.95  | 1.72 | 1.48       | 1.94       | 1.94       | 1.58       |
|  | 0.8  | 1.26  | 1.80 | 2.02  | 1.77 | 1.51       | 2.00       | 2.01       | 1.61       |
|  | 0.85 | 1.27  | 1.86 | 2.09  | 1.84 | 1.56       | 2.06       | 2.06       | 1.64       |
|  | 0.9  | 1.28  | 1.92 | 2.15  | 1.91 | 1.61       | 2.11       | 2.10       | 1.67       |
|  | 0.95 | 1.29  | 1.99 | 2.21  | 1.98 | 1.67       | 2.15       | 2.13       | 1.70       |
|  | ≥1   | 1.30  | 2.06 | 2.26  | 2.07 | 1.75       | 2.19       | 2.14       | 1.72       |
| Side Fins  | 0.25 | 1.13  | 1.11 | 1.18  | 1.11 | 1.21       | 1.14       | 1.16       | 1.23       |
|  | 0.3  | 1.15  | 1.13 | 1.22  | 1.13 | 1.22       | 1.17       | 1.22       | 1.27       |
|  | 0.35 | 1.17  | 1.15 | 1.26  | 1.15 | 1.24       | 1.20       | 1.26       | 1.32       |
|  | 0.4  | 1.19  | 1.17 | 1.29  | 1.17 | 1.27       | 1.23       | 1.29       | 1.36       |
|  | 0.45 | 1.21  | 1.19 | 1.32  | 1.19 | 1.30       | 1.25       | 1.31       | 1.41       |
|  | 0.5  | 1.22  | 1.20 | 1.35  | 1.20 | 1.34       | 1.27       | 1.33       | 1.46       |
|  | 0.55 | 1.24  | 1.22 | 1.38  | 1.22 | 1.38       | 1.29       | 1.34       | 1.50       |
|  | 0.6  | 1.25  | 1.23 | 1.40  | 1.23 | 1.42       | 1.31       | 1.35       | 1.55       |

|  |      |      |      |      |      |      |      |      |      |
|--|------|------|------|------|------|------|------|------|------|
|  | 0.65 | 1.27 | 1.24 | 1.42 | 1.25 | 1.47 | 1.32 | 1.36 | 1.58 |
|  | 0.7  | 1.28 | 1.26 | 1.44 | 1.26 | 1.51 | 1.34 | 1.36 | 1.61 |
|  | 0.75 | 1.30 | 1.27 | 1.46 | 1.27 | 1.55 | 1.35 | 1.37 | 1.64 |
|  | 0.8  | 1.31 | 1.28 | 1.48 | 1.29 | 1.59 | 1.37 | 1.38 | 1.65 |
|  | 0.85 | 1.32 | 1.30 | 1.49 | 1.30 | 1.62 | 1.38 | 1.39 | 1.65 |
|  | 0.9  | 1.34 | 1.31 | 1.51 | 1.31 | 1.65 | 1.40 | 1.40 | 1.64 |
|  | 0.95 | 1.35 | 1.32 | 1.53 | 1.32 | 1.67 | 1.42 | 1.42 | 1.61 |
|  | ≥1   | 1.36 | 1.33 | 1.55 | 1.33 | 1.69 | 1.44 | 1.45 | 1.57 |

Table 4-13 Shading Equivalent Factors for Latitudes less than 15 °N

| Shading Equivalent Factors (SEF) for latitudes less than 15°N |      |       |      |       |      |            |            |            |            |
|---|------|-------|------|-------|------|------------|------------|------------|------------|
| SEF   | PF   | North | East | South | West | North-East | South-East | South-West | North-West |
| Overhang + Fins   | 0.25 | 1.38  | 1.33 | 1.30  | 1.34 | 1.42       | 1.41       | 1.37       | 1.42       |
|   | 0.3  | 1.44  | 1.42 | 1.35  | 1.42 | 1.49       | 1.46       | 1.41       | 1.52       |
|   | 0.35 | 1.50  | 1.50 | 1.42  | 1.50 | 1.57       | 1.52       | 1.47       | 1.63       |
|   | 0.4  | 1.56  | 1.59 | 1.50  | 1.59 | 1.66       | 1.59       | 1.54       | 1.73       |
|   | 0.45 | 1.61  | 1.67 | 1.59  | 1.69 | 1.76       | 1.67       | 1.61       | 1.84       |
|   | 0.5  | 1.67  | 1.76 | 1.68  | 1.80 | 1.87       | 1.75       | 1.70       | 1.94       |
|   | 0.55 | 1.72  | 1.85 | 1.79  | 1.90 | 1.98       | 1.85       | 1.80       | 2.05       |
|   | 0.6  | 1.77  | 1.94 | 1.89  | 2.02 | 2.09       | 1.94       | 1.89       | 2.15       |
|   | 0.65 | 1.82  | 2.02 | 1.99  | 2.13 | 2.20       | 2.04       | 2.00       | 2.25       |
|   | 0.7  | 1.86  | 2.11 | 2.08  | 2.24 | 2.31       | 2.15       | 2.10       | 2.36       |
|   | 0.75 | 1.90  | 2.19 | 2.17  | 2.35 | 2.42       | 2.25       | 2.21       | 2.46       |
|   | 0.8  | 1.94  | 2.28 | 2.25  | 2.46 | 2.53       | 2.35       | 2.31       | 2.55       |
|   | 0.85 | 1.98  | 2.36 | 2.31  | 2.56 | 2.64       | 2.45       | 2.42       | 2.65       |
|   | 0.9  | 2.02  | 2.44 | 2.35  | 2.66 | 2.74       | 2.54       | 2.52       | 2.74       |
|   | 0.95 | 2.05  | 2.51 | 2.38  | 2.75 | 2.84       | 2.63       | 2.61       | 2.83       |
|   | ≥1   | 2.08  | 2.58 | 2.38  | 2.83 | 2.93       | 2.71       | 2.70       | 2.91       |
| Overhang  | 0.25 | 1.15  | 1.19 | 1.09  | 1.20 | 1.17       | 1.08       | 1.04       | 1.18       |
|   | 0.3  | 1.17  | 1.23 | 1.07  | 1.24 | 1.22       | 1.12       | 1.08       | 1.21       |
|   | 0.35 | 1.20  | 1.28 | 1.07  | 1.29 | 1.26       | 1.16       | 1.12       | 1.25       |
|   | 0.4  | 1.22  | 1.32 | 1.07  | 1.33 | 1.30       | 1.19       | 1.17       | 1.29       |
|   | 0.45 | 1.24  | 1.37 | 1.09  | 1.38 | 1.33       | 1.23       | 1.21       | 1.32       |
|   | 0.5  | 1.26  | 1.42 | 1.12  | 1.42 | 1.37       | 1.28       | 1.25       | 1.35       |
|   | 0.55 | 1.28  | 1.46 | 1.15  | 1.46 | 1.40       | 1.32       | 1.29       | 1.39       |
|   | 0.6  | 1.30  | 1.51 | 1.18  | 1.50 | 1.43       | 1.36       | 1.33       | 1.42       |
|   | 0.65 | 1.32  | 1.55 | 1.22  | 1.55 | 1.46       | 1.40       | 1.37       | 1.45       |
|   | 0.7  | 1.33  | 1.60 | 1.26  | 1.59 | 1.48       | 1.43       | 1.40       | 1.48       |
|   | 0.75 | 1.35  | 1.64 | 1.29  | 1.62 | 1.51       | 1.47       | 1.44       | 1.50       |
|   | 0.8  | 1.37  | 1.67 | 1.32  | 1.66 | 1.53       | 1.51       | 1.47       | 1.53       |
|   | 0.85 | 1.38  | 1.71 | 1.35  | 1.70 | 1.55       | 1.54       | 1.51       | 1.56       |
|   | 0.9  | 1.39  | 1.74 | 1.37  | 1.73 | 1.57       | 1.56       | 1.54       | 1.58       |

|           |      |      |      |      |      |      |      |      |      |
|-----------|------|------|------|------|------|------|------|------|------|
|           | 0.95 | 1.40 | 1.77 | 1.38 | 1.77 | 1.59 | 1.59 | 1.56 | 1.61 |
|           | ≥1   | 1.41 | 1.79 | 1.38 | 1.80 | 1.61 | 1.61 | 1.59 | 1.63 |
| Side Fins | 0.25 | 1.17 | 1.10 | 1.06 | 1.10 | 1.15 | 1.14 | 1.16 | 1.16 |
|           | 0.3  | 1.20 | 1.12 | 1.11 | 1.12 | 1.18 | 1.18 | 1.21 | 1.19 |
|           | 0.35 | 1.23 | 1.13 | 1.16 | 1.14 | 1.21 | 1.20 | 1.25 | 1.22 |
|           | 0.4  | 1.26 | 1.15 | 1.20 | 1.15 | 1.24 | 1.23 | 1.29 | 1.25 |
|           | 0.45 | 1.28 | 1.16 | 1.23 | 1.17 | 1.27 | 1.25 | 1.31 | 1.28 |
|           | 0.5  | 1.30 | 1.18 | 1.25 | 1.19 | 1.30 | 1.27 | 1.34 | 1.30 |
|           | 0.55 | 1.32 | 1.19 | 1.27 | 1.20 | 1.33 | 1.29 | 1.36 | 1.33 |
|           | 0.6  | 1.34 | 1.20 | 1.29 | 1.22 | 1.36 | 1.31 | 1.37 | 1.35 |
|           | 0.65 | 1.36 | 1.21 | 1.30 | 1.23 | 1.38 | 1.34 | 1.38 | 1.38 |
|           | 0.7  | 1.38 | 1.22 | 1.31 | 1.24 | 1.41 | 1.36 | 1.40 | 1.40 |
|           | 0.75 | 1.40 | 1.23 | 1.33 | 1.26 | 1.43 | 1.38 | 1.41 | 1.42 |
|           | 0.8  | 1.42 | 1.24 | 1.34 | 1.27 | 1.46 | 1.41 | 1.43 | 1.44 |
|           | 0.85 | 1.43 | 1.25 | 1.35 | 1.28 | 1.48 | 1.44 | 1.45 | 1.47 |
|           | 0.9  | 1.45 | 1.26 | 1.37 | 1.29 | 1.50 | 1.47 | 1.47 | 1.49 |
|           | 0.95 | 1.46 | 1.27 | 1.39 | 1.31 | 1.52 | 1.50 | 1.50 | 1.51 |
|           | ≥1   | 1.47 | 1.28 | 1.42 | 1.32 | 1.53 | 1.54 | 1.53 | 1.53 |

(b) Vertical fenestration, located such that its bottom is more than 2.2 m above the level of the floor, is exempt from the SHGC requirements in Table 4-10 and Table 4-11, if the following conditions are complied with:

- i. The Total Effective Aperture (WWR X VLT) for the elevation is less than 0.25, including all fenestration areas more than 1.0 meter above the floor level; and,
- ii. An interior light shelf is provided at the bottom of this fenestration area, with a projection factor on interior side not less than:
  - a. 1.0 for E-W, SE, SW, NE, and NW orientations
  - b. 0.50 for S orientation, and
  - c. 0.35 for N orientation when latitude is less than 15°N.

*Note 4-1 Equivalent SHGC and Projection Factor*



A 5,400 m<sup>2</sup> two story office building in Delhi is trying to achieve ECBC level compliance. It has a rectangular layout (90 m x 30 m) with floor to floor height of 4.0 m and floor area is evenly distributed over the two floors. Windows are either east or west facing and equally distributed on the two floors. The windows are all 1.9m in length and 2.9m in height with an overhang of 0.9m, sill level is 0.9m above floor level. The overall glazing area is 374.7 m<sup>2</sup>. SHGC of the glazing in the East/West Fenestration is 0.3; area

weighted U-Factor is 3.0 W/m<sup>2</sup>.K. VLT of the glazing in all orientation is 0.5. Will the vertical fenestration comply with the ECBC through prescriptive approach?

**Solution:**

Table 4-10 and §4.3.3 lists the U-factor, SHGC and VLT requirements for vertical fenestration for ECBC compliant buildings. The building is located in Delhi (Latitude: 28°70' N, Longitude: 77°10' E), which falls under the composite climate, as per Appendix B, Table 12.1. To fulfil prescriptive requirements, Window to Wall ratio ≤ 40%, SHGC ≤ 0.27, U-factor ≤ 3.0 W/m<sup>2</sup>.K, and VLT ≥ 0.27.

Total Floor area = 5400 m<sup>2</sup>

Total wall area = 2 x (2x ((90m x 4m) + (30m x 4m))) = 1,920 m<sup>2</sup>

Total Fenestration area = 374.7 m<sup>2</sup>

Window to Wall Ratio (WWR) = 374.7/1,920 = 19.5%

As per the calculations, the building has a WWR of 19.5%, thus complying with the requirement for WWR. The U-factor is also equal to 3.0 W/m<sup>2</sup>.K. Similarly, the VLT is 0.5, which is greater than the minimum specified value of 0.27, thus complying with the U-factor and VLT requirement.

**Equivalent SHGC Calculation**

The window SHGC is 0.3 which is not meet the prescriptive requirement of Table 4-10. However, the windows have an overhang of 0.9m. As the windows have an overhang, this case will fall under the exception, and the *equivalent SHGC* value will be calculated by dividing fenestration SHGC by Shading Equivalent Factor (SEF).

*For projection factor (PF) 0.3, the SEF for east, and west are taken from*

Table 4-12, as the latitude is greater than 15°N.

SEF for east for PF = 0.3 = 1.26

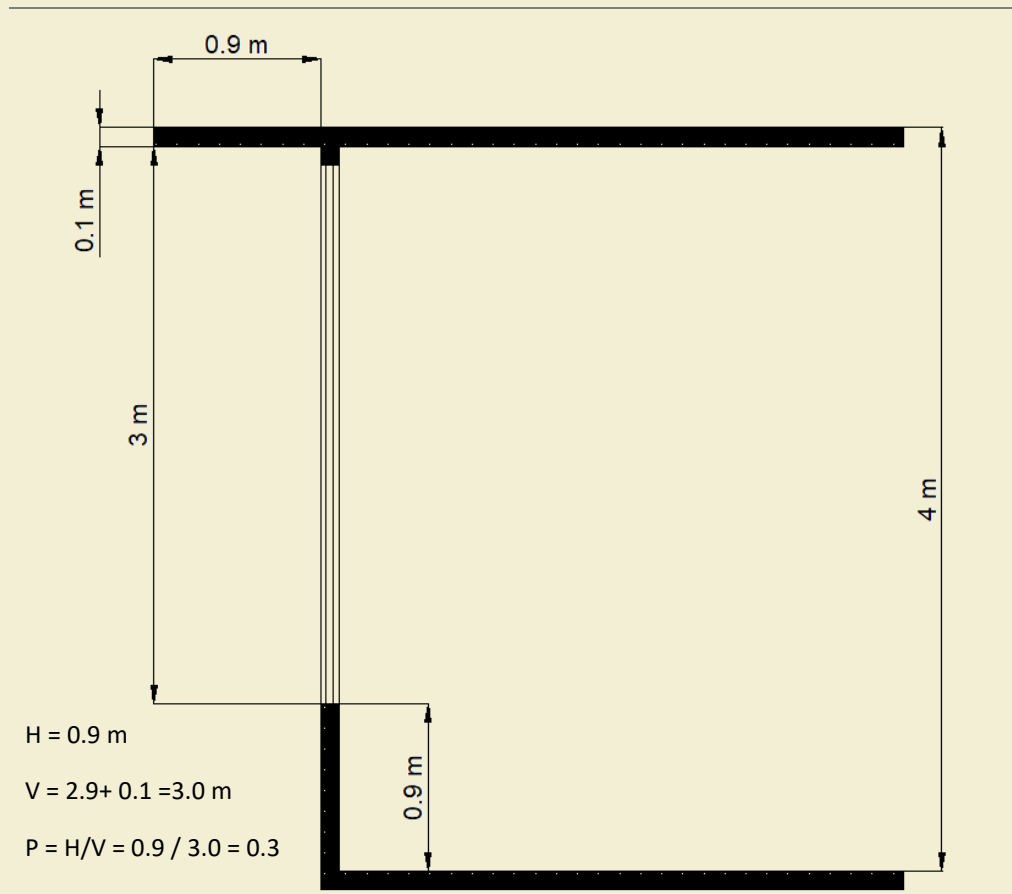
Therefore, equivalent SHGC<sub>East</sub> = 0.3 ÷ 1.26 = 0.24 Hence the vertical fenestration on the east façade will comply as per prescriptive approach, as the equivalent SHGC is less than maximum allowed.

Similarly, for the west façade:

SEF for west for PF = 0.3 = 1.27

Therefore, equivalent SHGC<sub>West</sub> = 0.3 ÷ 1.27 = 0.24, hence the vertical fenestration on the west façade will comply using the prescriptive approach, as the equivalent SHGC is less than maximum allowed.





Exceptions to U-factor requirements in Table 4-10 and Table 4-11:

Vertical fenestration on all unconditioned buildings or unconditioned spaces may have a maximum U-factor of 5 W/m<sup>2</sup>.K provided they comply with all conditions mentioned in Table 4-14.

Table 4-14 U-factor (W/m<sup>2</sup>.K) Exemption Requirements for Shaded Building

| Building Type                                   | Climate zone    | Orientation                     | Maximum Effective SHGC | Minimum VLT | PF    |
|---|-----------------|---------------------------------|------------------------|-------------|-------|
| Unconditioned buildings or unconditioned spaces | All except cold | Non-North for all latitudes and | 0.27                   | 0.27        | ≥0.40 |
|   |                 | North for latitude < 15°N       |                        |             |       |
|   |                 | North for latitude ≥ 15°N       | 0.27                   | 0.27        | ≥0.0  |

#### 4.3.4 Skylights

Skylights shall comply with the maximum U-factor and maximum SHGC requirements of Table 4-15. Skylight roof ratio (SRR), defined as the ratio of the total skylight area of the roof, measured to the outside of the frame, to the gross exterior roof area, is limited to a maximum of 5% for ECBC Building, ECBC+ Building, and SuperECBC Building, when using the Prescriptive Method for compliance.

Table 4-15 Skylight U-factor (W/m<sup>2</sup>.K) and SHGC Requirements

| Climate            | Maximum U-factor | Maximum SHGC |
|--------------------|------------------|--------------|
| All climatic zones | 4.25             | 0.35         |

Exception to §4.3.4 Skylights in temporary roof coverings or awnings over unconditioned spaces.

### 4.3.5 Building Envelope Trade-Off Method

The building envelope complies with the code if the Envelope Performance Factor (EPF) of the Proposed Building is less than the EPF of the Standard Building, where the Standard Building exactly complies with the prescriptive requirements of building envelope. This method shall not be used for buildings with WWR>40%. Trade-off is not permitted for skylights. Skylights shall meet requirements of 4.3.4. The envelope performance factor shall be calculated using the following equations.

Equation 4.1:  $EPF_{Total} = EPF_{Roof} + EPF_{Wall} + EPF_{Fenest}$

$$\begin{aligned}
 EPF_{Roof} &= c_{Roof} \sum_{s=1}^n U_s A_s \\
 EPF_{Wall} &= c_{Wall} \sum_{s=1}^n U_s A_s \\
 EPF_{Fenest} &= c_{1Fenest,North} \sum_{w=1}^n U_w A_w + c_{2Fenest,North} \sum_{w=1}^n \frac{SHGC_w}{SEF_w} A_w \\
 &+ c_{1Fenest,South} \sum_{w=1}^n U_w A_w + c_{2Fenest,South} \sum_{w=1}^n \frac{SHGC_w}{SEF_w} A_w \\
 &+ c_{1Fenest,East} \sum_{w=1}^n U_w A_w + c_{2Fenest,East} \sum_{w=1}^n \frac{SHGC_w}{SEF_w} A_w \\
 &+ c_{1Fenest,West} \sum_{w=1}^n U_w A_w + c_{2Fenest,West} \sum_{w=1}^n \frac{SHGC_w}{SEF_w} A_w
 \end{aligned}$$

|               |   |
|---------------|---|
| $EPF_{Roof}$  | Envelope performance factor for roofs. Other subscripts include walls and fenestration.                     |
| $A_s, A_w$    | The area of a specific envelope component referenced by the subscript "s" or for windows the subscript "w". |
| $SHGC_w$      | The solar heat gain coefficient for windows (w).  |
| $SEF_w$       | A multiplier for the window SHGC that depends on the projection factor of an overhang or side fin.          |
| $U_s$         | The U-factor for the envelope component referenced by the subscript "s".                                    |
| $c_{Roof}$    | A coefficient for the "Roof" class of construction.   |
| $c_{Wall}$    | A coefficient for the "Wall"  |
| $c_{1Fenest}$ | A coefficient for the "Fenestration U-factor"   |
| $c_{2Fenest}$ | A coefficient for the "Fenestration SHGC"   |

Values of "c" are taken from Table 4-16 through Table 4-20 for each class of construction.

Table 4-16 Envelope Performance Factor Coefficients – Composite Climate

|               | Daytime Business, Educational,<br>Shopping Complex |               | 24-hour Business, Hospitality, Health Care,<br>Assembly |               |
|---------------|--|---------------|---|---------------|
|               | C factor U-factor                                  | C factor SHGC | C factor U-factor                                       | C factor SHGC |
| Walls         | 24.3   | -             | 48.1  | -             |
| Roofs         | 40.9   | -             | 71.0  | -             |
| North Windows | 21.6   | 201.8         | 41.0  | 367.6         |
| South Windows | 19.1   | 342.5         | 41.0  | 546.3         |
| East Windows  | 18.8   | 295.6         | 38.4  | 492.2         |
| West Windows  | 19.2   | 295.4         | 38.3  | 486.1         |

Table 4-17 Envelope Performance Factor Coefficients – Hot and Dry Climate

|               | Daytime Business, Educational,<br>Shopping Complex |               | 24-hour Business, Hospitality,<br>Health Care, Assembly |               |
|---------------|--|---------------|---|---------------|
|               | C factor U-factor                                  | C factor SHGC | C factor U-factor                                       | C factor SHGC |
| Walls         | 27.3   | -             | 55.9  | -             |
| Roofs         | 43.9   | -             | 80.7  | -             |
| North Windows | 23.7   | 238.2         | 49.1  | 414.4         |
| South Windows | 22.8   | 389.7         | 49.2  | 607.4         |
| East Windows  | 21.6   | 347.4         | 46.2  | 556.2         |
| West Windows  | 21.7   | 354.1         | 46.0  | 560.8         |

Table 4-18 Envelope Performance Factor Coefficients – Warm and Humid Climate

|               | Daytime Business, Educational,<br>Shopping Complex |               | 24-hour Business, Hospitality, Health<br>Care, Assembly |               |
|---------------|--|---------------|---|---------------|
|               | C factor U-factor                                  | C factor SHGC | C factor U-factor                                       | C factor SHGC |
| Walls         | 24.5   | -             | 51.2  | -             |
| Roofs         | 40.1   | -             | 76.1  | -             |
| North Windows | 20.7   | 230.7         | 43.6  | 401.5         |
| South Windows | 20.1   | 347.1         | 43.9  | 546.4         |
| East Windows  | 19.0   | 301.8         | 41.1  | 490.6         |
| West Windows  | 18.7   | 303.1         | 40.5  | 483.5         |

Table 4-19 Envelope Performance Factor Coefficients – Temperate Climate

|               | Daytime Business, Educational,<br>Shopping Complex |               | 24-hour Business, Hospitality,<br>Health Care, Assembly |               |
|---------------|--|---------------|---|---------------|
|               | C factor U-factor                                  | C factor SHGC | C factor U-factor                                       | C factor SHGC |
| Walls         | 17.2   | -             | 39.1  | -             |
| Roofs         | 32.3   | -             | 76.1  | -             |
| North Windows | 12.6   | 201.4         | 32.3  | 338.41        |
| South Windows | 11.8   | 287.3         | 31.9  | 448.52        |
| East Windows  | 11.2   | 300.0         | 29.9  | 470.35        |
| West Windows  | 10.9   | 303.4         | 30.0  | 462.64        |

Table 4-20 Envelope Performance Factor Coefficients – Cold Climate

|               | Daytime Business, Educational,<br>Shopping Complex |               | 24-hour Business, Hospitality, Health<br>Care, Assembly |               |
|---------------|--|---------------|---|---------------|
|               | C factor U-factor                                  | C factor SHGC | C factor U-factor                                       | C factor SHGC |
| Walls         | 36.3   | -             | 30.7  | -             |
| Roofs         | 38.7   | -             | 46.0  | -             |
| North Windows | 21.8   | 137.6         | 28.3  | 163.86        |
| South Windows | 20.8   | 114.3         | 21.7  | 295.24        |
| East Windows  | 22.7   | 127.5         | 24.1  | 283.20        |
| West Windows  | 23.4   | 133.2         | 25.2  | 270.33        |

#### 4.3.5.1.1 Standard Building EPF Calculation

EPF of the Standard Building shall be calculated as follows:

- The Standard Building shall have the same building floor area, gross wall area and gross roof area as the Proposed Building. For mixed-use building the space distribution between different typologies shall be the same as the Proposed Design.
- The U-factor of each envelope component shall be equal to the criteria from §4 for each class of construction.
- The SHGC of each window shall be equal to the criteria from §4.3.3.
- Shading devices shall not be considered for calculating EPF for Standard Building (i.e. SEF=1).

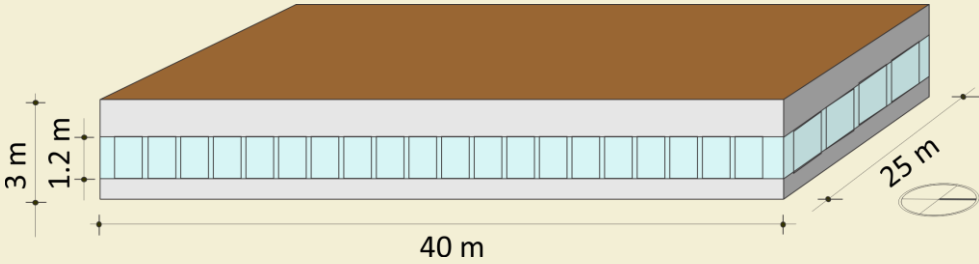
Note 4-2 Building Envelope Trade-off Method



Application of Building Envelope Trade-off method

A 1,000 m<sup>2</sup> single story daytime use office building in Ahmedabad is trying to achieve ECBC level compliance. Each side has a band of windows, without shading. The materials for the envelope have already been selected, prior to opting for ECBC compliance. Their thermal properties are: roof assembly U-value= .4 W/m<sup>2</sup>.K, external wall assembly U-value = .25 W/m<sup>2</sup>.K, glazing SHGC = .25, VLT = 0.27, area weighted U-value for glazing = 1.8 W/m<sup>2</sup>.K.

Dimensions of the building envelope are as follows:



According to Table 11-1, Appendix B, Ahmedabad falls under the hot and dry climate zone. To prove compliance through the prescriptive approach, U-factor, and SHGC must comply with requirements listed in Table 4-4, Table 4-7, Table 4-10 and VLT and window to wall ratio with requirements in § 4.3.3 for a daytime use building in the hot and dry climate zone. The table below lists thermal properties of the building envelope components and the corresponding prescriptive requirements for ECBC complaint buildings.

Table 4-3-1 Prescriptive Requirements and Proposed Thermal Properties

|                      | Prescriptive U-factor<br>(W/m <sup>2</sup> .K) |        |        | Proposed U-factor<br>(W/m <sup>2</sup> .K) |      |      | Area<br>(m <sup>2</sup> ) |
|----------------------|--|--------|--------|--|------|------|---------------------------|
| Wall 1– North, South | =<0.63   |        |        | 0.25                                       |      |      | 90                        |
| Wall 2– East, West   | =<0.63   |        |        | 0.25                                       |      |      | 144                       |
| Roof                 | =<0.33   |        |        | 0.4  |      |      | 1000                      |
|                      | U-factor                                       | SHGC   | VLT    | U-factor                                   | SHGC | VLT  |                           |
| Window – South       | =<3.0  | =<0.27 | =>0.27 | 1.8  | 0.25 | 0.27 | 30                        |
| Window – North       | =<3.0  | =<0.5  | =>0.27 | 1.8  | 0.25 | 0.27 | 30                        |
| Window-East          | =<3.0  | =<0.27 | =>0.27 | 1.8  | 0.25 | 0.27 | 48                        |
| Window-West          | =<3.0  | =<0.27 | =>0.27 | 1.8  | 0.25 | 0.27 | 48                        |

§4.3.3 requires the WWR to be less than 40%. This condition is fulfilled in the proposed buildings as can be seen in the calculations below.

$$\text{Total Fenestration Area}_{\text{North, South}} = 2 \times (25\text{m} \times 1.2\text{m}) = 60 \text{ m}^2$$

$$\text{Wall Area}_{\text{North, South}} = 2 \times (25\text{m} \times 3\text{m}) = 150 \text{ m}^2$$

$$\text{Total Fenestration Area}_{\text{East, West}} = 2 \times (40\text{m} \times 1.2\text{m}) = 96 \text{ m}^2$$

$$\text{Total Wall Area}_{\text{East, West}} = 2 \times (40\text{m} \times 3\text{m}) = 240 \text{ m}^2$$

$$\text{Total Fenestration Area} = 156 \text{ m}^2, \text{ Total Wall Area} = 390 \text{ m}^2$$

$$\text{WWR} = 156/390 = 0.4.$$

U-value of the roof of the proposed building, at 0.4 W/m<sup>2</sup>.K does not fulfil prescriptive requirements.

Hence, this building will not be compliant if the prescriptive approach is followed. The compliance in prescriptive approach can also be demonstrated through building envelope trade-off.

#### Compliance through Building Envelope Trade-off method

Envelope performance factor (EPF) for the Standard Building and Proposed Building must be compared. As per the Building Envelope Trade-off method, the envelope performance factor (EPF) shall be calculated using the following equations:

$$\text{Equation 11.1 } EPF_{\text{Total}} = EPF_{\text{Roof}} + EPF_{\text{Wall}} + EPF_{\text{Fenest}}$$

Where,

$$EPF_{\text{Roof}} = C_{\text{Roof}} \sum_{s=1}^n U_s A_s$$

$$EPF_{\text{Wall}} = C_{\text{Wall}} \sum_{s=1}^n U_s A_s$$

$$\begin{aligned} EPF_{\text{Fenest}} = & C_{1\text{Fenest,North}} \sum_{w=1}^n U_w A_w + C_{2\text{Fenest,North}} \sum_{w=1}^n \frac{SHGC_w}{SEF_w} A_w \\ & + C_{1\text{Fenest,South}} \sum_{w=1}^n U_w A_w + C_{2\text{Fenest,South}} \sum_{w=1}^n \frac{SHGC_w}{SEF_w} A_w \\ & + C_{1\text{Fenest,East}} \sum_{w=1}^n U_w A_w + C_{2\text{Fenest,East}} \sum_{w=1}^n \frac{SHGC_w}{SEF_w} A_w \\ & + C_{1\text{Fenest,West}} \sum_{w=1}^n U_w A_w + C_{2\text{Fenest,West}} \sum_{w=1}^n \frac{SHGC_w}{SEF_w} A_w \end{aligned}$$

Standard Building EPF will be derived from U-factors, SHGCs and VLTs of walls, roofs and fenestration from Table 4-4, Table 4-7, Table 4-10 and § 4.3.3 for a daytime use building in the hot and dry climate zone. Values of C are from daytime Office building in hot and dry climatic zone for each class of construction from Table 4-17. Since There is no shading for the windows, SEF<sub>w</sub> will not be considered.

**Step 1: Calculation of EPF *Proposed Building* from actual envelope properties**

$$EPF_{Roof,Actual} = C_{Roof} \sum_{s=1}^n U_s A_s$$

$$= 43.9 \times 0.40 \times 1,000 = 17,560$$

$$EPF_{Wall,Actual} = C_{Wall} \sum_{s=1}^n U_s A_s$$

$$= (27.3 \times 0.25 \times 90) + (27.3 \times 0.25 \times 144) = 1,597.05$$

$$EPF_{Fenest} = EPF_{Fenest,North} + EPF_{Fenest,South} + EPF_{Fenest,East} + EPF_{Fenest,West}$$

$$EPF_{Fenest} = C_{1Fenest} \sum_{w=1}^n U_w A_w + C_{2Fenest} \sum_{w=1}^n \frac{SHGC_w}{SEF_w} A_w$$

Hence,

$$EPF_{Fenest,North} = 23.7 \times 1.8 \times 30 + 238.2 \times 0.25 \times 30 = 1,279.8 + 1,786.5 = 3,066.3$$

$$EPF_{Fenest,South} = 22.8 \times 1.8 \times 30 + 389.7 \times 0.25 \times 30 = 1,231.2 + 2,922.75 = 4,153.95$$

$$EPF_{Fenest,East} = 21.6 \times 1.8 \times 48 + 347.4 \times 0.25 \times 48 = 1,866.24 + 4,168.8 = 6,035.04$$

$$EPF_{Fenest,West} = 21.7 \times 1.8 \times 48 + 354.1 \times 0.25 \times 48 = 1,874.88 + 4,249.2 = 6,124.08$$

Therefore,

$$EPF_{Fenest} = 19,379.37$$

$$EPF_{Proposed} = 17,560 + 1,597.05 + 19,379.37 = 38,536.42$$

**Step 2: Calculating EPF *Standard Building* from prescriptive envelope requirements**

$$EPF_{Roof,Actual} = C_{Roof} \sum_{s=1}^n U_s A_s$$

$$= 43.9 \times 0.33 \times 1000 = 14,487$$

$$EPF_{Wall,Actual} = C_{Wall} \sum_{s=1}^n U_s A_s$$

$$= (27.3 \times 0.63 \times 90) + (27.3 \times 0.63 \times 144) = 1,547.91 + 2,476.66 = 4,024.57$$

$$EPF_{Fenest} = EPF_{Fenest,North} + EPF_{Fenest,South} + EPF_{Fenest,East} + EPF_{Fenest,West}$$

Now,



$$EPF_{Fenest, North} = 23.7 \times 3.0 \times 30 + 238.2 \times 0.5 \times 30 = 2,133 + 3,573 = 5,706$$

$$EPF_{Fenest, South} = 22.8 \times 3.0 \times 30 + 389.7 \times 0.27 \times 30 = 2,052 + 3,156.57 = 5,208.57$$

$$EPF_{Fenest, East} = 21.6 \times 3.0 \times 48 + 347.4 \times 0.27 \times 48 = 3,110.4 + 4,502.3 = 7,612.7$$

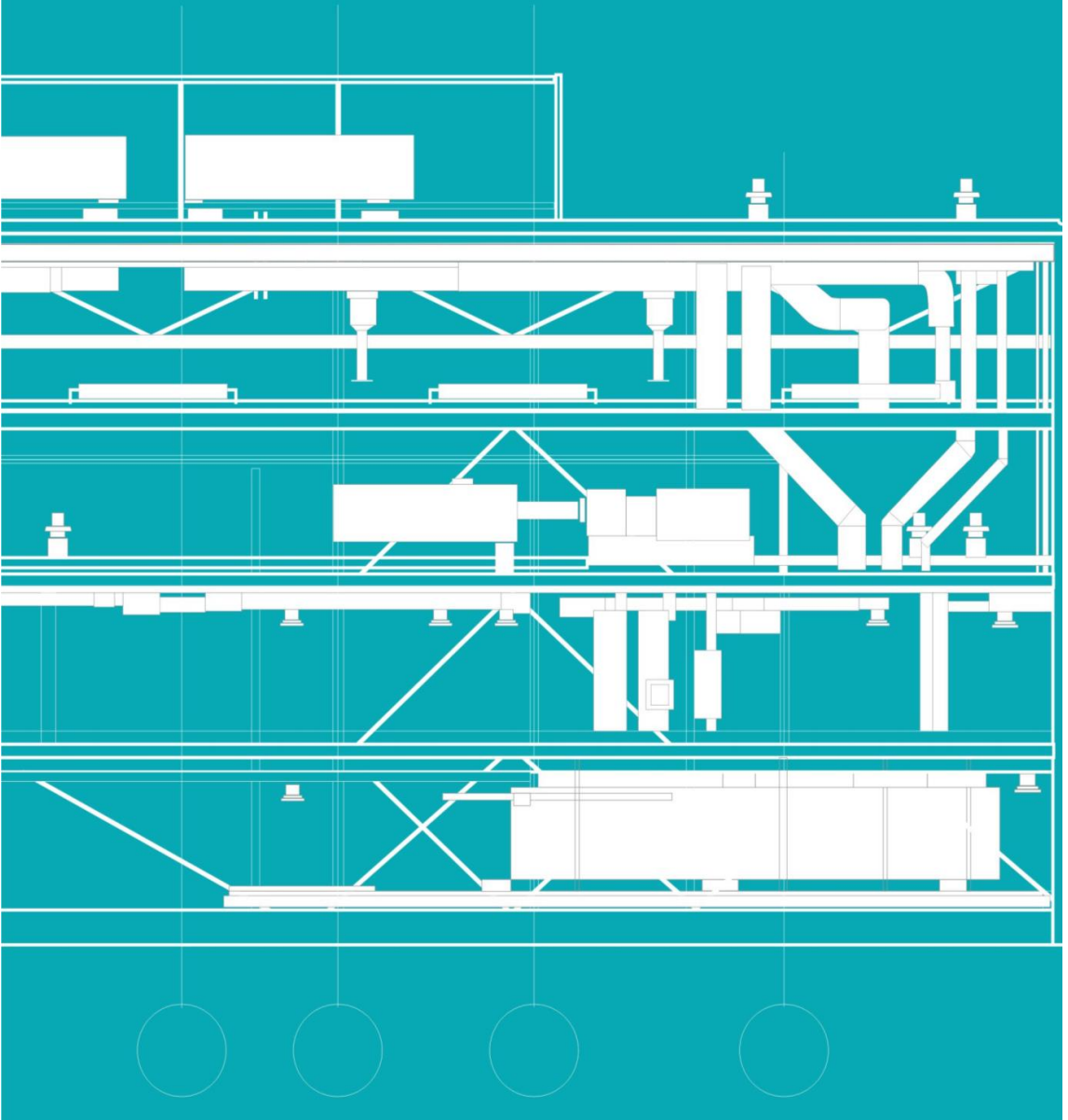
$$EPF_{Fenest, West} = 21.7 \times 3.0 \times 48 + 354.1 \times 0.27 \times 48 = 3,124.8 + 4,589.14 = 7,713.94$$

$$\text{Therefore, } EPF_{Fenest} = 26,241.21$$

$$EPF_{Baseline} = 14,487 + 4,024.57 + 26,241.21 = 44,752.78$$

Since  $EPF_{Baseline} > EPF_{Proposed}$ , therefore the building is compliant with ECBC building envelope requirements.

# 5 Comfort Systems & Controls



## 5. Comfort Systems and Controls

### 5.1 General

All heating, ventilation, air conditioning equipment and systems, and their controls shall comply with the mandatory provisions of §5.2 and the prescriptive criteria of §5.3 for the respective building energy efficiency level. In case alternative compliance path of Total System Efficiency or Low Energy Systems is used for compliance, respective requirements of §5.3.12 or §5.3.13 and relevant criteria of §5.3 shall be met.

### 5.2 Mandatory Requirements

#### 5.2.1 Ventilation

- (a) All habitable spaces shall be ventilated with outdoor air in accordance with the requirements of §5.2.1 and guidelines specified in the National Building Code 2016 (Part 8: Building Services, Section 1: Lighting and Natural Ventilation, Subsection 5: Ventilation).
- (b) Ventilated spaces shall be provided with outdoor air using one of the following:
  - i. Natural ventilation
  - ii. Mechanical ventilation

##### 5.2.1.1 Natural Ventilation Design Requirements

Naturally ventilated buildings shall:

- (a) Comply with guidelines provided for natural ventilation in NBC.
- (b) Have minimum BEE 3-star rated ceiling fans, if provided with ceiling fans.
- (c) Have exhaust fans complying with minimum efficiency requirements of fans in §5.3, if provided.

##### 5.2.1.2 Mechanical Ventilation Air Quantity Design Requirements

Buildings that are ventilated using a mechanical ventilation system that are ventilated with a mechanical system, either completely or in conjunction with natural ventilation systems, shall:

- (a) Install mechanical systems that provide outdoor air change rate as per NBC.
- (b) Have a ventilation system controlled by CO sensors for basement carpark spaces with total car park space greater than or equal to 600 m<sup>2</sup>.

### 5.2.1.3 Demand Control Ventilation

Mechanical ventilation systems shall have demand control ventilation if they provide outdoor air greater than 1,500 liters per second, to a space greater than 50 m<sup>2</sup>, with occupant density exceeding 40 people per 100 m<sup>2</sup> of the space, and are served by one or more of the following systems:

- (a) An air side economizer
- (b) Automatic outdoor modulating control of the outdoor air damper

Exceptions to § 5.2.1.3:

- (a) Classrooms in Schools, call centers category under Business
- (b) Spaces that have processes or operations that generate dust, fumes, mists, vapors, or gases and are provided with exhaust ventilation, such as indoor operation of internal combustion engines or areas designated for unvented food service preparation, or beauty salons
- (c) Systems with exhaust air energy recovering system

## 5.2.2 Minimum Space Conditioning Equipment Efficiencies

### 5.2.2.1 Chillers

- (a) Chillers shall meet or exceed the minimum efficiency requirements presented in Table 5-1 through Table 5-2 under ANSI/ AHRI 550/ 590 conditions.
- (b) The application of air-cooled chiller is allowed in all buildings with cooling load less than 530 kW. For buildings with cooling load equal to or greater than 530 kW, the capacity of air-cooled chiller shall be restricted to 33% of the total installed chilled water capacity unless the authority having jurisdiction mandates the application of air-cooled chillers.
- (c) Minimum efficiency requirements under BEE Standards and Labeling Program for chillers shall take precedence over the minimum requirements presented in Table 5-1 through Table 5-2.
- (d) To show compliance to ECBC, minimum requirement of both COP and IPLV requirement shall be met.

Table 5-1 Minimum Energy Efficiency Requirements for water cooled Chillers

| Chiller Capacity (kW <sub>r</sub> ) | COP | IPLV |
|-------------------------------------|-----|------|
| <260                                | 4.7 | 5.8  |
| ≥260 & <530                         | 4.9 | 5.9  |
| ≥530 & <1,050                       | 5.4 | 6.5  |
| ≥1,050 & <1,580                     | 5.8 | 6.8  |
| ≥1,580                              | 6.3 | 7.0  |

Table 5-2 Minimum Energy Efficiency Requirements for air cooled Chillers

| Chiller Capacity (kW <sub>r</sub> ) | COP | IPLV |
|-------------------------------------|-----|------|
| <260                                | 2.8 | 3.5  |
| ≥260                                | 3.0 | 3.7  |

### 5.2.2.2 Unitary, Split, Packaged Air-Conditioners

Unitary air-conditioners shall meet or exceed the efficiency requirements given in Table 5-3. Window and split air conditioners shall be certified under BEE's Star Labeling Program. EER shall be as per IS 8148 for all unitary, split, packaged air conditioners greater than 10 kW.

*Table 5-3 Minimum Requirements for Unitary, Split, Packaged Air Conditioners in ECBC Building*

| Cooling Capacity (kW) | Water Cooled | Air Cooled |
|-----------------------|--------------|------------|
| ≤ 10.5                | NA           | BEE 3 Star |
| > 10.5                | 3.3 EER      | 2.8 EER    |

### 5.2.2.3 Variable Refrigerant Flow

Variable Refrigerant Flow (VRF) systems shall meet or exceed the efficiency requirements specified in Table 5-4 as per the ANSI/AHRI Standard 1230 while the Indian Standard on VRF is being developed. BEE Standards and Labeling requirements for VRF shall take precedence over the current minimum requirement.

*Table 5-4 Minimum Efficiency Requirements for VRF Air conditioners for ECBC Building\**

| Type                             | Size category (kW) | For Heating or cooling or both |            |
|----------------------------------|--------------------|--------------------------------|------------|
|                                  |                    | EER (W/W)                      | IEER (W/W) |
| VRF Air Conditioners, Air cooled | < 40               | 3.28                           | 4.36       |
|                                  | ≥ 40 and < 70      | 3.26                           | 4.34       |
|                                  | ≥ 70               | 3.02                           | 4.07       |

\* The revised EER and IEER values as per Indian Standard for VRF corresponding to values in this table will supersede as and when the revised standards are published.

### 5.2.2.4 Air Conditioning and Condensing Units Serving Computer Rooms

Air conditioning and condensing units serving computer rooms shall meet or exceed the energy efficiency requirements listed in Table 5-5.

*Table 5-5 Minimum Efficiency Requirements for Computer Room Air Conditioners*

| Equipment type                                    | Net Sensible Cooling Capacity <sup>a</sup> | Minimum SCOP-127 <sup>b</sup> |        |
|---|--|-------------------------------|--------|
|   |  | Downflow                      | Upflow |
| All types of computer room ACs Air/ Water/ Glycol | All capacity                               | 2.5                           | 2.5    |

a. Net Sensible cooling capacity = Total gross cooling capacity - latent cooling capacity – Fan power

b. Sensible Coefficient of Performance (SCOP-127): A ratio calculated by dividing the net sensible cooling capacity in watts by the total power input in watts (excluding reheater and dehumidifier) at conditions defined in ASHRAE Standard 127-2012 Method of Testing for Rating Computer and Data Processing Room Unitary Air Conditioners)

### 5.2.2.5 Boilers

Gas and oil-fired boilers shall meet or exceed the minimum efficiency requirements specified in Table 5-6.

*Table 5-6 Minimum Efficiency Requirements for Oil and Gas Fired Boilers for ECBC building*

| <i>Equipment Type</i>             | <i>Sub Category</i> | <i>Size Category</i> | <i>Minimum FUE</i> |
|-----------------------------------|---------------------|----------------------|--------------------|
| Boilers, Hot Water                | Gas or oil fired    | All capacity         | 80%                |
| FUE - fuel utilization efficiency |                     |                      |                    |

## 5.2.3 Controls

To comply with the Code, buildings shall meet the requirements of §5.2.3.1 through §5.2.3.5.

### 5.2.3.1 Timeclock

Mechanical cooling and heating systems in Universities and Training Institutions of all sizes and all Shopping Complexes with built up area greater than 20,000 m<sup>2</sup> shall be controlled by timeclocks that:

- Can start and stop the system under different schedules for at least three different day-types per week,
- Are capable of retaining programming and time setting during loss of power for a period of at least 10 hours, and
- Include an accessible manual override that allows temporary operation of the system for up to 2 hours.

Exceptions to §5.2.3.1:

- Cooling systems less than 17.5 kW<sub>r</sub>
- Heating systems less than 5.0 kW<sub>r</sub>
- Unitary systems of all capacities

### 5.2.3.2 Temperature Controls

Mechanical cooling and heating equipment in all buildings shall be installed with controls to manage the temperature inside the conditioned zones. Each floor or a building block shall be installed with at least one control to manage the temperature. These controls should meet the following requirements:

- Where a unit provides both heating and cooling, controls shall be capable of providing a temperature dead band of 3.0°C within which the supply of heating and cooling energy to the zone is shut off or reduced to a minimum.

- (b) Where separate heating and cooling equipment serve the same temperature zone, temperature controls shall be interlocked to prevent simultaneous heating and cooling.
- (c) Separate thermostat control shall be installed in each
  - i. guest room of Resort and Star Hotel,
  - ii. room less than 30 m<sup>2</sup> in Business,
  - iii. air-conditioned class room, lecture room, and computer room of Educational,
  - iv. in-patient and out-patient room of Healthcare

### 5.2.3.3 Occupancy Controls

Occupancy controls shall be installed to de-energize or to throttle to minimum the ventilation and/or air conditioning systems when there are no occupants in:

- (a) Each guest room in a Resort and Star Hotel
- (b) Each public toilet in a Star Hotel or Business with built up area more than 20,000 m<sup>2</sup>
- (c) Each conference and meeting room in a Star Hotel or Business
- (d) Each room of size more than 30 m<sup>2</sup> in Educational buildings

### 5.2.3.4 Fan Controls

Cooling towers in buildings with built up area greater than 20,000 m<sup>2</sup>, shall have fan controls based on wet bulb logic, with either:

- (a) Two speed motors, pony motors, or variable speed drives controlling the fans, or
- (b) Controls capable of reducing the fan speed to at least two third of installed fan power

### 5.2.3.5 Dampers

All air supply and exhaust equipment, having a Variable Frequency Drive (VFD), shall have dampers that automatically close upon:

- (a) Fan shutdown, or,
- (b) When spaces served are not in use
- (c) Backdraft gravity damper is acceptable in the system with design outdoor air of the system is less than 150 liters per second in all climatic zones except cold climate, provided backdraft dampers for ventilation air intakes are protected from direct exposure to wind.
- (d) Dampers are not required in ventilation or exhaust systems serving naturally conditioned spaces.
- (e) Dampers are not required in exhaust systems serving kitchen exhaust hoods.

## 5.2.4 Piping and Ductwork

### 5.2.4.1 Piping Insulation

Piping for heating, space conditioning, and service hot water systems shall meet the insulation requirements listed in Table 5-7 through Table 5-9. Insulation exposed to weather

shall be protected by aluminum sheet metal, painted canvas, or plastic cover. Cellular foam insulation shall be protected as above, or be painted with water retardant paint.

Exceptions to § 5.2.4.1:

- (a) Reduction in insulation R value by 0.2 (compared to values in Table 5-7, Table 5-8 and Table 5-9) to a minimum insulation level of R-0.4 shall be permitted for any pipe located in partition within a conditioned space or buried.
- (b) Insulation R value shall be increased by 0.2 over and above the requirement stated in Table 5-7 through Table 5-9 for any pipe located in a partition outside a building with direct exposure to weather.

*Table 5-7 Insulation Requirements for Pipes in ECBC Building*

| Operating Temperature (°C)         | Pipe size (mm)              |      |
|------------------------------------|-----------------------------|------|
|                                    | <40                         | >=40 |
|                                    | Insulation R value (m².K/W) |      |
| Heating System                     |                             |      |
| >94°C and <=121°C                  | 0.9                         | 1.2  |
| >60°C and <=94°C                   | 0.7                         | 0.7  |
| >40°C and <=60°C                   | 0.4                         | 0.7  |
| Cooling System                     |                             |      |
| >4.5°C and <=15°C                  | 0.4                         | 0.7  |
| < 4.5°C                            | 0.9                         | 1.2  |
| Refrigerant Piping (Split systems) |                             |      |
| >4.5°C and <=15°C                  | 0.4                         | 0.7  |
| < 4.5°C                            | 0.9                         | 1.2  |

*Table 5-8 Insulation Requirements for Pipes in ECBC+ Building*

| Operating Temperature (°C)         | Pipe size (mm)              |      |
|------------------------------------|-----------------------------|------|
|                                    | < 40                        | >=40 |
|                                    | Insulation R value (m².K/W) |      |
| Heating System                     |                             |      |
| >94°C and <=121°C                  | 1.1                         | 1.3  |
| >60°C and <=94°C                   | 0.8                         | 0.8  |
| >40°C and <=60°C                   | 0.5                         | 0.9  |
| Cooling System                     |                             |      |
| >4.5°C and <=15°C                  | 0.5                         | 0.9  |
| < 4.5°C                            | 1.1                         | 1.3  |
| Refrigerant Piping (Split systems) |                             |      |
| >4.5°C and <=15°C                  | 0.5                         | 0.9  |
| < 4.5°C                            | 1.1                         | 1.3  |



Table 5-9 Insulation Requirements for Pipes in SuperECBC Buildings

| Operating Temperature (°C)         | Pipe size (mm)              |      |
|------------------------------------|-----------------------------|------|
|                                    | < 40                        | >=40 |
|                                    | Insulation R value (m².K/W) |      |
| Heating System                     |                             |      |
| >94°C and <=121°C                  | 1.5                         | 1.5  |
| >60°C and <=94°C                   | 1.0                         | 1.3  |
| >40°C and <=60°C                   | 0.7                         | 1.1  |
| Cooling System                     |                             |      |
| >4.5°C and <=15°C                  | 0.7                         | 1.2  |
| < 4.5°C                            | 1.5                         | 1.5  |
| Refrigerant Piping (Split systems) |                             |      |
| >4.5°C and <=15°C                  | 0.7                         | 1.1  |
| < 4.5°C                            | 1.5                         | 1.5  |

#### 5.2.4.2 Ductwork and Plenum Insulation

Ductwork and plenum shall be insulated in accordance with Table 5-10.

Table 5-10 Ductwork Insulation (R value in m<sup>2</sup>. K/W) Requirements

| Duct Location       | Supply ducts | Return ducts |
|---------------------|--------------|--------------|
| Exterior            | R -1.4       | R -0.6       |
| Unconditioned Space | R -0.6       | None         |
| Buried              | R -0.6       | None         |

## 5.2.5 System Balancing

### 5.2.5.1 General

System balancing shall be done for systems serving zones with a total conditioned area exceeding 500 m<sup>2</sup>.

### 5.2.5.2 Air System Balancing

Air systems shall be balanced in a manner to first minimize throttling losses; then, for fans with fan system power greater than 0.75 kW, fan speed shall be adjusted to meet design flow conditions.

### 5.2.5.3 Hydronic System Balancing

Hydronic systems shall be proportionately balanced in a manner to first minimize throttling losses; then the pump impeller shall be trimmed or pump speed shall be adjusted to meet design flow conditions.

## 5.2.6 Condensers

### 5.2.6.1 Condenser Locations

Condensers shall be located such that the heat sink is free of interference from heat discharge by devices located in adjoining spaces, and do not interfere with other such systems installed nearby.

## 5.2.7 Service Water Heating

### 5.2.7.1 Solar Water Heating

Hospitality and Healthcare in all climatic zones and all buildings in cold climate zone with a hot water system, shall have solar water heating equipment installed to provide for:

- (a) at least 20% of the total hot water design capacity if above grade floor area of the building is less than 20,000 m<sup>2</sup>
- (b) at least 40% of the total hot water design capacity if above grade floor area of the building is greater than or equal to 20,000 m<sup>2</sup>

Exception to § 5.2.7.1: Systems that use heat recovery to provide the hot water capacity required as per the building type and size.

### 5.2.7.2 Heating Equipment Efficiency

Service water heating equipment shall meet or exceed the performance and minimum efficiency requirements presented in available Indian Standards

- (a) Solar water heater shall meet the performance/ minimum efficiency level mentioned in IS 13129 Part (1&2).
- (b) Gas Instantaneous water heaters shall meet the performance/minimum efficiency level mentioned in IS 15558 with above 80% Fuel utilization efficiency.
- (c) Electric water heater shall meet the performance/ minimum efficiency level mentioned in IS 2082.
- (d) For evacuated tube collector the storage tanks shall meet the IS 16542:2016, tubes shall meet IS 16543:2016 and IS 16544:2016 for the complete system.

### 5.2.7.3 Other Water Heating System

Supplementary heating system shall be designed to maximize the energy efficiency of the system and shall incorporate the following design features in cascade:

- (a) Maximum heat recovery from hot discharge system like condensers of air conditioning units,
- (b) Use of gas fired heaters wherever gas is available, and
- (c) Electric heater as last resort.

#### 5.2.7.4 Piping Insulation

Piping insulation shall comply with § 5.2.4.1. The entire hot water system including the storage tanks, pipelines shall be insulated conforming to the relevant IS standards on materials and applications.

#### 5.2.7.5 Heat Traps

Vertical pipe risers serving storage water heaters and storage tanks not having integral heat traps and serving a non-recirculating system shall have heat traps on both the inlet and outlet piping.

#### 5.2.7.6 Swimming Pools

All heated pools shall be provided with a vapor retardant pool cover on or at the water surface. Pools heated to more than 32°C shall have a pool cover with a minimum insulation value of R-4.1.

### 5.3 Prescriptive Requirements

Compliance shall be demonstrated with the prescriptive requirements in this section.

Supply, exhaust, and return or relief fans with motor power exceeding 0.37 kW shall meet or exceed the minimum energy efficiency requirements specified in Table 5-11 through Table 5-13 except the following need not comply with the requirement

- (a) Fans in un-ducted air conditioning unit where fan efficiency has already been taken in account to calculate the efficiency standard of the comfort system.
- (b) Fans in Health Care buildings having HEPA filters.
- (c) Fans inbuilt in energy recovery systems that pre-conditions the outdoor air.

Table 5-11 Mechanical and Motor Efficiency Requirements for Fans in ECBC Buildings

| System type       | Fan Type                   | Mechanical Efficiency | Motor Efficiency<br>(As per IS 12615) |
|-------------------|----------------------------|-----------------------|---------------------------------------|
| Air-handling unit | Supply, return and exhaust | 60%                   | IE 2                                  |

Table 5-12 Mechanical and Motor Efficiency Requirements for Fans in ECBC+ Buildings

| System type       | Fan Type                   | Mechanical Efficiency | Motor Efficiency<br>(As per IS 12615) |
|-------------------|----------------------------|-----------------------|---------------------------------------|
| Air-handling unit | Supply, return and exhaust | 65%                   | IE 3                                  |

Table 5-13 Mechanical and Motor Efficiency Requirements for Fans in SuperECBC Buildings

| System Type       | Fan Type                   | Mechanical Efficiency | Motor Efficiency<br>(As per IS 12615) |
|-------------------|----------------------------|-----------------------|---------------------------------------|
| Air-handling unit | Supply, return and exhaust | 70%                   | IE 4                                  |

### 5.3.1 Chillers

Chillers shall meet or exceed the minimum efficiency requirements for ECBC+ and SuperECBC Buildings are presented in Table 5-14 and Table 5-15 under ANSI/ AHRI 550/ 590 conditions.

Table 5-14 Minimum Energy Efficiency Requirements for water cooled Chillers

| Chiller Capacity (kW <sub>r</sub> ) | ECBC+ Building |      | SuperECBC Building |      |
|-------------------------------------|----------------|------|--------------------|------|
|                                     | COP            | IPLV | COP                | IPLV |
| <260                                | 5.2            | 6.9  | 5.8                | 7.1  |
| ≥260 & <530                         | 5.8            | 7.1  | 6.0                | 7.9  |
| ≥530 & <1,050                       | 5.8            | 7.5  | 6.3                | 8.4  |
| ≥1,050 & <1,580                     | 6.2            | 8.1  | 6.5                | 8.8  |
| ≥1,580                              | 6.5            | 8.9  | 6.7                | 9.1  |

Table 5-15 Minimum Energy Efficiency Requirements for air cooled Chillers

| Chiller Capacity (kW <sub>r</sub> ) | ECBC+ Building |      | SuperECBC Building |
|-------------------------------------|----------------|------|--------------------|
|                                     | COP            | IPLV | COP/ IPLV          |
| <260                                | 3.0            | 4.0  | NA                 |
| ≥260                                | 3.2            | 5.0  | NA                 |

### 5.3.2 Pumps

Chilled and condenser water pumps shall meet or exceed the minimum energy efficiency requirements specified in

Table 5-16 through Table 5-18. Requirements for pumps in district chiller systems and hot water pumps for space heating are limited to the installed efficiency requirement of individual pump equipment only. To show compliance, calculate the total installed pump capacity in kilo watt and achieve the prescribed limits per kilo watt of refrigeration installed in the building.

Exceptions to §5.3.2: Pumps used in processes e.g. service hot water, chilled water used for refrigeration etc.

Table 5-16 Pump Efficiency Requirements for ECBC Building

| Equipment                                  | ECBC   |
|--|--|
| Chilled Water Pump (Primary and Secondary) | 18.2 W/ kW <sub>r</sub> with VFD on secondary pump |
| Condenser Water Pump                       | 17.7 W/ kW <sub>r</sub>                            |
| Pump Efficiency (minimum)                  | 70%  |

Table 5-17 Pump Efficiency Requirements for ECBC+ Building

| Equipment                                  | ECBC+ Building                                     |
|--|--|
| Chilled Water Pump (Primary and Secondary) | 16.9 W/ kW <sub>r</sub> with VFD on secondary pump |
| Condenser Water Pump                       | 16.5 W/ kW <sub>r</sub>                            |
| Pump Efficiency (minimum)                  | 75%  |

Table 5-18 Pump Efficiency Requirements for SuperECBC Building

| Equipment                                  | SuperECBC Building                                 |
|--|--|
| Chilled Water Pump (Primary and Secondary) | 14.9 W/ kW <sub>r</sub> with VFD on secondary pump |
| Condenser Water Pump                       | 14.6 W/ kW <sub>r</sub>                            |
| Pump Efficiency (minimum)                  | 85%  |

### 5.3.3 Cooling Towers

Cooling towers shall meet or exceed the minimum efficiency requirements specified in Table 5-19. ECBC+ and SuperECBC Buildings shall have additional VFD installed in the cooling towers.

Table 5-19 Cooling Tower Efficiency Requirements for ECBC, ECBC+, and SuperECBC Buildings

| Equipment type                  | Rating Condition    | Efficiency               |
|---------------------------------|---------------------|--------------------------|
| Open circuit cooling tower Fans | 35°C entering water | 0.017 kW/kW <sub>r</sub> |
|                                 | 29°C leaving water  | 0.31 kW/ L/s             |
|                                 | 24°C WB outdoor air |                          |

### 5.3.4 Boilers

Gas and oil-fired boilers shall meet or exceed the minimum efficiency requirements specified in Table 5-20.

Table 5-20 Minimum Efficiency Requirements for Oil and Gas Fired Boilers for ECBC+ and SuperECBC building

| Equipment Type                    | Sub Category     | Size Category | Minimum FUE |
|-----------------------------------|------------------|---------------|-------------|
| Boilers, Hot Water                | Gas or oil fired | All capacity  | 85%         |
| FUE - fuel utilization efficiency |                  |               |             |

### 5.3.5 Economizers

#### 5.3.5.1 Economizer for ECBC, ECBC+, and SuperECBC Building

Each cooling fan system in buildings with built up area greater than 20,000 m<sup>2</sup>, shall include at least one of the following:

- (a) An air economizer capable of modulating outside-air and return-air dampers to supply 50% of the design supply air quantity as outside-air.
- (b) A water economizer capable of providing 50% of the expected system cooling load at outside air temperatures of 10°C dry-bulb/7.2°C wet-bulb and below.

Exception to §5.3.5.1:

- (a) Projects in warm-humid climate zones.
- (b) Projects with only daytime occupancy in the hot-dry.
- (c) Individual cooling or heating fan systems less than 3,200 liters per second.

#### 5.3.5.2 Partial Cooling

Where required by §5.3.5.1 economizers shall be capable of providing partial cooling even when additional mechanical cooling is required to meet the cooling load.

#### 5.3.5.3 Economizer Controls

Air economizer shall be equipped with controls

- (a) That allow dampers to be sequenced with the mechanical cooling equipment and not be controlled by only mixed air temperature.
- (b) capable of automatically reducing outdoor air intake to the design minimum outdoor air quantity when outdoor air intake will no longer reduce cooling energy usage.
- (c) Capable of high-limit shutoff at 24 °C dry bulb temperature.

#### 5.3.5.4 Testing

Air-side economizers shall be tested in the field following the requirements in §12 Appendix C to ensure proper operation.

Exception to §5.3.5.4: Air economizers installed by the HVAC system equipment manufacturer and certified to the building department as being factory calibrated and tested per the procedures in §12.

## 5.3.6 Variable Flow Hydronic Systems

### 5.3.6.1 Variable Fluid Flow

HVAC pumping systems having a total pump system power exceeding 7.5 kW shall be designed for variable fluid flow and shall be capable of reducing pump flow rates to an extent which is lesser or equal to the limit, where the limit is set by the larger of:

- 50% of the design flow rate, or
- the minimum flow required by the equipment manufacturer for proper operation of the chillers or boilers.

### 5.3.6.2 Isolation Valves

Water cooled air-conditioning or heat pump units with a circulation pump motor greater than or equal to 3.7 kW shall have two-way automatic isolation valves on each water-cooled air-conditioning or heat pump unit that are interlocked with the compressor to shut off condenser water flow when the compressor is not operating.

### 5.3.6.3 Variable Speed Drives

Chilled water or condenser water systems that must comply with either §5.3.6.1 or §5.3.6.2 and that have pump motors greater than or equal to 3.7 kW shall be controlled by variable speed drives.

## 5.3.7 Unitary, Split, Packaged Air-Conditioners

Unitary air-conditioners shall meet or exceed the efficiency requirements given in Table 5-21 and Table 5-22. Window and split air conditioners shall be certified under BEE's Star Labeling Program. EER shall be as per IS 8148 for all unitary, split, packaged air conditioners greater than 10 kW.

*Table 5-21 Minimum Requirements for Unitary, Split, Packaged Air Conditioners in ECBC+ Building*

| Cooling Capacity (kW) | Water Cooled | Air Cooled |
|-----------------------|--------------|------------|
| ≤ 10.5                | NA           | BEE 4 Star |
| > 10.5                | 3.7 EER      | 3.2 EER    |

*Table 5-22 Minimum Requirements for Unitary, Split, Packaged Air Conditioners in SuperECBC Building*

| Cooling Capacity (kW) | Water Cooled | Air Cooled |
|-----------------------|--------------|------------|
| ≤ 10.5                | NA           | BEE 5 Star |
| >10.5                 | 3.9 EER      | 3.4 EER    |

## 5.3.8 Controls for ECBC+ and SuperECBC Buildings

ECBC+ building shall comply with requirements of § 5.3.8 in addition to complying with requirements of §5.2.3.

### 5.3.8.1 Centralized Demand Shed Controls

ECBC+ and SuperECBC Buildings with built up area greater than 20,000 m<sup>2</sup> shall have a building management system. All mechanical cooling and heating systems in ECBC+ and SuperECBC Buildings with any programmable logic controller (PLC) to the zone level shall have the following control capabilities to manage centralized demand shed in noncritical zones:

- (a) Automatic demand shed controls that can implement a centralized demand shed in non-critical zones during the demand response period on a demand response signal.
- (b) Controls that can remotely decrease or increase the operating temperature set points by four degrees or more in all noncritical zones on signal from a centralized control point
- (c) Controls that can provide an adjustable rate of change for the temperature setup and reset

The centralized demand shed controls shall have additional capabilities to

- (a) Be disabled by facility operators
- (b) Be manually controlled from a central point by facility operators to manage heating and cooling set points

### 5.3.8.2 Supply Air Temperature Reset

Multi zone mechanical cooling and heating systems in ECBC+ and SuperECBC Buildings shall have controls that automatically reset the supply-air temperature in response to building loads or to outdoor air temperature. Controls shall reset the supply air temperature to at least 25% of the difference between the design supply air temperature and the design room air temperature.

Exception to § 5.3.8.2 : ECBC+ and SuperECBC Buildings in warm humid climate zone.

### 5.3.8.3 Chilled Water Temperature Reset

Chilled water systems with a design capacity exceeding 350 kW<sub>r</sub> supplying chilled water to comfort conditioning systems in ECBC+ and SuperECBC Buildings shall have controls that automatically reset supply water temperatures by representative building loads (including return water temperature) or by outdoor air temperature.

Exceptions to §5.3.8.3: Controls to automatically reset chilled water temperature shall not be required where the supply temperature reset controls causes improper operation of equipment.

## 5.3.9 Controls for SuperECBC Buildings

SuperECBC Buildings shall comply with requirements of § 5.3.9 in addition to complying with requirements of § 5.2.3 and § 5.3.8.



### 5.3.9.1 Variable Air Volume Fan Control

Fans in Variable Air Volume (VAV) systems in SuperECBC Buildings shall have controls or devices that will result in fan motor demand of no more than 30% of their design wattage at 50% of design airflow based on manufacturer's certified fan data.

### 5.3.10 Energy Recovery

All Hospitality and Healthcare, with systems of capacity greater than 2,100 liters per second and minimum outdoor air supply of 70% shall have air-to-air heat recovery equipment with minimum 50% recovery effectiveness

At least 50% of heat shall be recovered from diesel and gas fired generator sets installed in Hospitality, Healthcare, and Business buildings with built up area greater than 20,000 m<sup>2</sup>.

### 5.3.11 Service Water Heating

For compliance with ECBC+ and SuperECBC,

- (a) Hospitality and Healthcare in all climatic zones shall have solar water heating equipment installed to provide at least 40% of the total hot water design capacity.
- (b) All buildings in cold climate zone with a hot water system, shall have solar water heating equipment installed to provide at least 60% of the total hot water design capacity.

Exception to §5.3.11: Systems that use heat recovery to provide the hot water capacity required as per the building type, size and efficiency level.

### 5.3.12 Total System Efficiency – Alternate Compliance Approach

Buildings may show compliance by optimizing the total system efficiency for the plant side comfort system instead of the individual equipment mentioned under the prescriptive requirement. This alternate compliance approach is applicable for central chilled water plant side system in all building types. The total installed capacity per kilo-watt refrigeration load shall be less than or equal to maximum threshold requirements as specified in Table 5-23. Equipment that can be included in central chilled water plant side system for this alternate approach are chillers, chilled water pumps, condenser water pumps, and cooling tower fan. Compliance check will be based on annual hourly simulation refer Table 9-1 for developing the proposed design.

Table 5-23 Maximum System Efficiency Threshold for ECBC, ECBC+, and SuperECBC Buildings

| <i>Water Cooled Chilled Water Plant</i> | <i>Maximum Threshold (kW/kWr)</i> |
|---|-----------------------------------|
| ECBC                                    | 0.26                              |
| ECBC+                                   | 0.23                              |
| SuperECBC                               | 0.20                              |

### 5.3.12.1 Documentation Requirement

Compliance shall be documented and compliance forms shall be submitted to the authority having jurisdiction. The information submitted shall include, at a minimum, the following:

- (a) Summary describing the results of the analysis, including the annual energy use (kWh) of chilled water plant (chillers, pumps and cooling tower) and annual chilled water use (kWh) for the Proposed Design, and software used.
- (b) Brief description of the project with location, number of stories, space types, conditioned and unconditioned areas, hours of operation.
- (c) List of the energy-related building features of the Proposed Design.
- (d) List showing compliance with the mandatory requirements of this code.
- (e) The input and output report(s) from the simulation program including an energy and chilled water usage components: space cooling and heat rejection equipment, and other HVAC equipment (such as pumps). The output reports shall also show the number of hours any loads are not met by the HVAC system the Proposed Design.
- (f) Explanation of any significant modelling assumptions made.
- (g) Explanation of any error messages noted in the simulation program output.

The total system efficiency shall be calculated as follows:

$$\text{Total System Efficiency} = \frac{\text{Chilled water plant use (kWh)}}{\text{Chilled water use (kWh)}}$$

### 5.3.13 Low-energy Comfort Systems

Alternative HVAC systems which have low energy use may be installed in place of (or in conjunction with) refrigerant-based cooling systems. Such systems shall be deemed to meet the minimum space conditioning equipment efficiency levels of §5.2.2, but shall comply with all other applicable mandatory provisions of §5.2 as applicable. Wherever applicable, requirements of §5.3 and §5.3.12 will be complied with. The approved list of low energy comfort systems<sup>1</sup> is given below:

- (a) Evaporative cooling
- (b) Desiccant cooling system
- (c) Solar air conditioning
- (d) Tri-generation (waste-to-heat)
- (e) Radiant cooling system
- (f) Ground source heat pump
- (g) Adiabatic cooling system

<sup>1</sup> This is not an all-inclusive list. The updated list of low energy comfort systems is available at BEE website (<https://www.beeindia.gov.in/>).

Buildings with an approved low-energy comfort system installed for more than 50% of the sum of cooling and heating capacity requirement of the building shall be deemed equivalent to the ECBC+ building standard prescribed in § 5.2.2.

Buildings having an approved low energy comfort system installed for more than 90% of the sum of cooling and heating capacity requirement of the building shall be deemed equivalent to the SuperECBC building standard prescribed in §5.2.2.

#### 5.3.13.1 Documentation Requirement

Compliance shall be documented and submitted to the authority having jurisdiction. The information submitted shall include, at a minimum, the following:

- (a) Summary describing the low-energy comfort system type, capacity, and efficiency.
- (b) List of showing compliance with the mandatory and prescriptive requirements other than exempted in §5.3.13.
- (c) Comparison of installed capacity of approved low-energy comfort system with other HVAC system to meet the comfort requirement of the building.

# 6 Lighting & Controls



## 6. Lighting and Controls

### 6.1 General

Lighting systems and equipment shall comply with the mandatory provisions of § 6.2 and the prescriptive criteria of § 6.3. The lighting requirements in this section shall apply to:

- (a) Interior spaces of buildings,
- (b) Exterior building features, including facades, illuminated roofs, architectural features, entrances, exits, loading docks, and illuminated canopies, and,
- (c) Exterior building grounds lighting that is provided through the building's electrical service.

Exceptions to §6.1: Emergency or security lighting that is automatically off during normal building operations.

### 6.2 Mandatory Requirements

#### 6.2.1 Lighting Control

##### 6.2.1.1 Automatic Lighting Shutoff

- (a) 90% of interior lighting fittings by wattage, in building or space of building larger than 300 m<sup>2</sup> shall be equipped with automatic control device.
- (b) Automatic control device shall function on either:
  - i. A scheduled basis at specific programmed times. An independent program schedule shall be provided for areas of no more than 2,500 m<sup>2</sup> and not more than one floor, or,
  - ii. Occupancy sensors that shall turn off the lighting fixtures within 15 minutes of an occupant leaving the space. Light fixtures controlled by occupancy sensors shall have a wall-mounted, manual switch capable of turning off lights when the space is occupied.
- (c) Additionally, occupancy sensors shall be provided in
  - i. All building types greater than 20,000 m<sup>2</sup> BUA, in
    - a. All habitable spaces less than 30 m<sup>2</sup>, enclosed by walls or ceiling height partitions.
    - b. All storage or utility spaces more than 15 m<sup>2</sup>.
    - c. Public toilets more than 25 m<sup>2</sup>, controlling at least 80 % of lighting by wattage, fitted in the toilet. The lighting fixtures, not

controlled by automatic lighting shutoff, shall be uniformly spread in the area.

- ii. Corridors of all Hospitality greater than 20,000 m<sup>2</sup> BUA, controlling minimum 70% and maximum 80% of lighting by wattage, fitted in the public corridor. The lighting fixtures, not controlled by automatic lighting shut off, shall be uniformly spread in the area.
- iii. All conference or meeting rooms.

Exception to § 6.2.1.1: Lighting systems designed for emergency and firefighting purposes.

#### 6.2.1.2 Space Control

Each space enclosed by ceiling-height partitions shall have at least one control device to independently control the general lighting within the space. Each control device shall be activated either manually by an occupant or automatically by sensing an occupant. Each control device shall

- (a) control a maximum of 250 m<sup>2</sup> for a space less than or equal to 1,000 m<sup>2</sup>, and a maximum of 1,000 m<sup>2</sup> for a space greater than 1,000 m<sup>2</sup>.
- (b) have the capability to override the shutoff control required in § 6.2.1.1 for no more than 2 hours, and
- (c) be readily accessible and located so the occupants can see the control.

Exception to § 6.2.1.2 (c): The required control device may be remotely installed if required for reasons of safety or security. A remotely located device shall have a pilot light indicator as part of or next to the control device and shall be clearly labeled to identify the controlled lighting.

#### 6.2.1.3 Control in Daylight Areas

- (a) Luminaires, installed within day lighting extent from the window as calculated in § 4.2.3, shall be equipped with either a manual control device to shut off luminaires, installed within day lit area, during potential daylit time of a day or automatic control device that:
  - i. Has a delay of minimum 5 minutes, and,
  - ii. Can dim or step down to 50% of total power.

- (b) Overrides to the daylight controls shall not be allowed.

#### 6.2.1.4 Exterior Lighting Control

- (a) Lighting for all exterior applications shall be controlled by a photo sensor or astronomical time switch that is capable of automatically turning off the exterior lighting when daylight is available or the lighting is not required.
- (b) Lighting for all exterior applications, shall have lamp efficacy not less than 80 lumens per watt for ECBC, unless the luminaire is controlled by a motion sensor or exempt under §6.1.

- (c) Façade lighting and façade non-emergency signage of Shopping Complexes shall have separate time switches.

Exemption to §6.2.1.4: Exterior Lighting systems designed for emergency and firefighting purposes.

#### 6.2.1.5 Additional Control

The following lighting applications shall be equipped with a control device to control such lighting independently of general lighting:

- (a) Display/ Accent Lighting. Display or accent lighting greater than 300 m<sup>2</sup> area shall have a separate control device.
- (b) Hotel Guest Room Lighting. Guest rooms and guest suites in a hotel shall have a master control device at the main room entry that controls all permanently installed luminaires and switched receptacles.
- (c) Task Lighting. Supplemental task lighting including permanently installed under shelf or under cabinet lighting shall have a control device integral to the luminaires or be controlled by a wall-mounted control device provided the control device complies with §6.2.1.2.
- (d) Nonvisual Lighting. Lighting for nonvisual applications, such as plant growth and food-warming, shall be equipped with a separate control device.
- (e) Demonstration Lighting. Lighting equipment that is for sale or for demonstrations in lighting education shall be equipped with a separate control device accessible only to authorized personnel.

### 6.2.2 Exit Signs

Internally-illuminated exit signs shall not exceed 5 Watts per face.

## 6.3 Prescriptive Requirements

### 6.3.1 Interior Lighting Power

The installed interior lighting power for a building or a separately metered or permitted portion of a building shall be calculated in accordance with §6.3.4 and shall not exceed the interior lighting power allowance determined in accordance with either §6.3.2 or §6.3.3.

Exception to §6.3: The following lighting equipment and applications shall not be considered when determining the interior lighting power allowance, nor shall the wattage for such lighting be included in the installed interior lighting power. However, any such lighting shall not be exempt unless it is an addition to general lighting and is controlled by an independent control device.

- (a) Display or accent lighting that is an essential element for the function performed in galleries, museums, and monuments,
- (b) Lighting that is integral to equipment or instrumentation and is installed by its manufacturer,

- (c) Lighting specifically designed for medical or dental procedures and lighting integral to medical equipment,
- (d) Lighting integral to food warming and food preparation equipment,
- (e) Lighting for plant growth or maintenance,
- (f) Lighting in spaces specifically designed for use by the visually impaired,
- (g) Lighting in retail display windows, provided the display area is enclosed by ceiling-height partitions,
- (h) Lighting in interior spaces that have been specifically designated as a registered interior historic landmark,
- (i) Lighting that is an integral part of advertising or directional signage,
- (j) Exit signs,
- (k) Lighting that is for sale or lighting educational demonstration systems,
- (l) Lighting for theatrical purposes, including performance, stage, and film or video production, and
- (m) Athletic playing areas with permanent facilities for television broadcasting.

### **6.3.2 Building Area Method**

Determination of interior lighting power allowance (watts) by the building area method shall be in accordance with the following:

- (a) Determine the allowed lighting power density for each appropriate building area type from Table 6-1 for ECBC Buildings, from Table 6-2 for ECBC+ Buildings and from Table 6-3 for SuperECBC Buildings.
- (b) Calculate the gross lighted area for each building area type.
- (c) The interior lighting power allowance is the sum of the products of the gross lighted floor area of each building area times the allowed lighting power density for that building area type.



Table 6-1 Interior Lighting Power for ECBC Buildings – Building Area Method

| Building Type   | LPD (W/m <sup>2</sup> ) | Building Area Type      | LPD (W/m <sup>2</sup> ) |
|---|-------------------------|-------------------------|-------------------------|
| Office Building   | 9.5                     | Motion picture theater  | 9.43                    |
| Hospitals   | 9.7                     | Museum                  | 10.2                    |
| Hotels  | 9.5                     | Post office             | 10.5                    |
| Shopping Mall   | 14.1                    | Religious building      | 12.0                    |
| University and Schools  | 11.2                    | Sports arena            | 9.7                     |
| Library   | 12.2                    | Transportation          | 9.2                     |
| Dining: bar lounge/leisure  | 12.2                    | Warehouse               | 7.08                    |
| Dining: cafeteria/fast food   | 11.5                    | Performing arts theater | 16.3                    |
| Dining: family  | 10.9                    | Police station          | 9.9                     |
| Dormitory   | 9.1                     | Workshop                | 14.1                    |
| Fire station  | 9.7                     | Automotive facility     | 9.0                     |
| Gymnasium   | 10.0                    | Convention center       | 12.5                    |
| Manufacturing facility  | 12.0                    | Parking garage          | 3.0                     |
| In cases where both a general building area type and a specific building area type are listed, the specific building area type shall apply. |                         |                         |                         |

Table 6-2 Interior Lighting Power for ECBC+ Buildings – Building Area Method

| Building Area Type  | LPD (W/m <sup>2</sup> ) | Building Area Type      | LPD (W/m <sup>2</sup> ) |
|---|-------------------------|-------------------------|-------------------------|
| Office Building   | 7.6                     | Motion picture theater  | 7.5                     |
| Hospitals   | 7.8                     | Museum                  | 8.2                     |
| Hotels  | 7.6                     | Post office             | 8.4                     |
| Shopping Mall   | 11.3                    | Religious building      | 9.6                     |
| University and Schools  | 9.0                     | Sports arena            | 7.8                     |
| Library   | 9.8                     | Transportation          | 7.4                     |
| Dining: bar lounge/leisure  | 9.8                     | Warehouse               | 5.7                     |
| Dining: cafeteria/fast food   | 9.2                     | Performing arts theater | 13.0                    |
| Dining: family  | 8.7                     | Police station          | 7.9                     |
| Dormitory   | 7.3                     | Workshop                | 11.3                    |
| Fire station  | 7.8                     | Automotive facility     | 7.2                     |
| Gymnasium   | 8.0                     | Convention center       | 10.0                    |
| Manufacturing facility  | 9.6                     | Parking garage          | 2.4                     |
| In cases where both a general building area type and a specific building area type are listed, the specific building area type shall apply. |                         |                         |                         |

Table 6-3 Interior Lighting Power for SuperECBC Buildings – Building Area Method

| <i>Building Area Type</i>   | <i>LPD (W/m<sup>2</sup>)</i> | <i>Building Area Type</i> | <i>LPD (W/m<sup>2</sup>)</i> |
|---|------------------------------|---------------------------|------------------------------|
| Office Building   | 5.0                          | Motion picture theater    | 4.7                          |
| Hospitals   | 4.9                          | Museum                    | 5.1                          |
| Hotels  | 4.8                          | Post office               | 5.3                          |
| Shopping Mall   | 7.0                          | Religious building        | 6.0                          |
| University and Schools  | 6.0                          | Sports arena              | 4.9                          |
| Library   | 6.1                          | Transportation            | 4.6                          |
| Dining: bar lounge/leisure  | 6.1                          | Warehouse                 | 3.5                          |
| Dining: cafeteria/fast food   | 5.8                          | Performing arts theater   | 8.2                          |
| Dining: family  | 5.5                          | Police station            | 5.0                          |
| Dormitory   | 4.6                          | Workshop                  | 7.1                          |
| Fire station  | 4.9                          | Automotive facility       | 4.5                          |
| Gymnasium   | 5.0                          | Convention center         | 6.3                          |
| Manufacturing facility  | 6.0                          | Parking garage            | 1.5                          |
| In cases where both a general building area type and a specific building area type are listed, the specific building area type shall apply. |                              |                           |                              |

### 6.3.3 Space Function Method

Determination of interior lighting power allowance (watts) by the space function method shall be in accordance with the following:

- Determine the appropriate building type and the allowed lighting power density from Table 6-4 for ECBC Buildings, Table 6-5 for ECBC+ Buildings and, Table 6-6 for SuperECBC Buildings. In cases where both a common space type and building specific space type are listed, building specific space type LPD shall apply.
- For each space, enclosed by partitions 80% or greater than ceiling height, determine the gross lighted floor area by measuring to the center of the partition wall. Include the area of balconies or other projections. Retail spaces do not have to comply with the 80% partition height requirements.
- The interior lighting power allowance is the sum of the lighting power allowances for all spaces. The lighting power allowance for a space is the product of the gross lighted floor area of the space times the allowed lighting power density for that space.

Table 6-4 Interior Lighting Power for ECBC Buildings – Space Function Method

| Category                            | LPD (W/m <sup>2</sup> ) | Lamp category                            | LPD (W/m <sup>2</sup> ) |
|-------------------------------------|-------------------------|--|-------------------------|
| Common Space Types                  |                         |  |                         |
| Restroom                            | 7.7                     | Stairway                                 | 5.5                     |
| Storage                             | 6.8                     | Corridor/Transition                      | 7.1                     |
| Conference/ Meeting                 | 11.5                    | Lobby                                    | 9.1                     |
| Parking Bays<br>(covered/ basement) | 2.2                     | Parking Driveways (covered/<br>basement) | 3.0                     |
| Electrical/Mechanical               | 7.1                     | Workshop                                 | 17.1                    |
| Business                            |                         |  |                         |
| Enclosed                            | 10.0                    | Open Plan                                | 10.0                    |
| Banking Activity Area               | 12.6                    | Service/Repair                           | 6.8                     |
| Healthcare                          |                         |  |                         |
| Emergency                           | 22.8                    | Recovery                                 | 8.6                     |
| Exam/Treatment                      | 13.7                    | Storage                                  | 5.5                     |
| Nurses' Station                     | 9.4                     | Laundry/Washing                          | 7.5                     |
| Operating Room                      | 21.8                    | Lounge/Recreation                        | 8.0                     |
| Patient Room                        | 7.7                     | Medical Supply                           | 13.7                    |
| Pharmacy                            | 10.7                    | Nursery                                  | 5.7                     |
| Physical Therapy                    | 9.7                     | Corridor/Transition                      | 9.1                     |
| Radiology/Imaging                   | 9.1                     |  |                         |
| Hospitality                         |                         |  |                         |
| Hotel Dining                        | 9.1                     | Hotel Lobby                              | 10.9                    |
| For Bar Lounge/<br>Dining           | 14.1                    | Motel Dining                             | 9.1                     |
| For food preparation                | 12.1                    | Motel Guest Rooms                        | 7.7                     |
| Hotel Guest Rooms                   | 9.1                     |  |                         |
| Shopping Complex                    |                         |  |                         |
| Mall Concourse                      | 12.8                    | For Family Dining                        | 10.9                    |
| Sales Area                          | 18.3                    | For food preparation                     | 12.1                    |
| Motion Picture<br>Theatre           | 9.6                     | Bar Lounge/ Dining                       | 14.1                    |
| Educational                         |                         |  |                         |
| Classroom/Lecture                   | 13.7                    | Card File and Cataloguing                | 9.1                     |
| For Classrooms                      | 13.8                    | Stacks (Lib)                             | 18.3                    |
| Laboratory                          | 15.1                    | Reading Area (Library)                   | 10.0                    |

| Category                          | LPD (W/m <sup>2</sup> ) | Lamp category                          | LPD (W/m <sup>2</sup> ) |
|-----------------------------------|-------------------------|--|-------------------------|
| <b>Assembly</b>                   |                         |  |                         |
| Dressing Room                     | 9.1                     | Seating Area - Performing Arts Theatre | 22.6                    |
| Exhibit Space - Convention Centre | 14.0                    | Lobby - Performing Arts Theatre        | 21.5                    |
| Seating Area - Gymnasium          | 4.6                     | Seating Area - Convention Centre       | 6.4                     |
| Fitness Area - Gymnasium          | 13.7                    | Seating Religious Building             | 16.4                    |
| Museum - General Exhibition       | 16.4                    | Playing Area - Gymnasium               | 18.8                    |
| Museum - Restoration              | 18.3                    |  |                         |

Table 6-5 Interior Lighting Power for ECBC+ Buildings – Space Function Method

| Category                        | LPD (W/m <sup>2</sup> ) | Lamp category                         | LPD (W/m <sup>2</sup> ) |
|---------------------------------|-------------------------|---------------------------------------|-------------------------|
| <b>Common Space Types</b>       |                         |                                       |                         |
| Restroom                        | 6.1                     | Stairway                              | 4.4                     |
| Storage                         | 5.4                     | Corridor/Transition                   | 3.6                     |
| Conference/ Meeting             | 9.2                     | Lobby                                 | 7.3                     |
| Parking Bay (covered/ basement) | 1.8                     | Parking Driveways (covered/ basement) | 2.5                     |
| Electrical/Mechanical           | 5.7                     | Workshop                              | 13.7                    |
| <b>Business</b>                 |                         |                                       |                         |
| Enclosed                        | 8.6                     | Open Plan                             | 8.6                     |
| Banking Activity Area           | 9.3                     | Service/Repair                        | 5.5                     |
| <b>Healthcare</b>               |                         |                                       |                         |
| Emergency                       | 18.2                    | Recovery                              | 7.0                     |
| Exam/Treatment                  | 10.9                    | Storage                               | 4.4                     |
| Nurses' Station                 | 7.5                     | Laundry/Washing                       | 6.0                     |
| Operating Room                  | 17.5                    | Lounge/Recreation                     | 6.4                     |
| Patient Room                    | 6.1                     | Medical Supply                        | 10.9                    |
| Pharmacy                        | 8.5                     | Nursery                               | 4.6                     |
| Physical Therapy                | 7.8                     | Corridor/Transition                   | 7.3                     |
| Radiology/Imaging               | 7.3                     |                                       |                         |
| <b>Hospitality</b>              |                         |                                       |                         |
| Hotel Dining                    | 7.3                     | Hotel Lobby                           | 8.8                     |
| For Bar Lounge/ Dining          | 11.3                    | Motel Dining                          | 7.3                     |

| Category                          | LPD (W/m <sup>2</sup> ) | Lamp category                          | LPD (W/m <sup>2</sup> ) |
|-----------------------------------|-------------------------|--|-------------------------|
| For food preparation              | 12.1                    | Motel Guest Rooms                      | 6.1                     |
| Hotel Guest Rooms                 | 7.3                     |  |                         |
| <b>Shopping Complex</b>           |                         |  |                         |
| Mall Concourse                    | 10.2                    | For Family Dining                      | 8.8                     |
| Sales Area                        | 14.6                    | For food preparation                   | 12.1                    |
| Motion Picture Theatre            | 10.3                    | Bar Lounge/ Dining                     | 11.3                    |
| <b>Educational</b>                |                         |  |                         |
| Classroom/Lecture                 | 10.9                    | Card File and Cataloguing              | 7.3                     |
| For Classrooms                    | 11.0                    | Stacks (Library)                       | 14.6                    |
| Laboratory                        | 12.1                    | Reading Area (Library)                 | 9.2                     |
| <b>Assembly</b>                   |                         |  |                         |
| Dressing Room                     | 7.3                     | Seating Area - Performing Arts Theatre | 18.1                    |
| Exhibit Space - Convention Centre | 11.2                    | Lobby - Performing Arts Theatre        | 17.2                    |
| Seating Area - Gymnasium          | 3.6                     | Seating Area – Convention Centre       | 5.1                     |
| Fitness Area - Gymnasium          | 7.9                     | Seating Religious Building             | 13.1                    |
| Museum - General Exhibition       | 11.3                    | Playing Area - Gymnasium               | 12.9                    |
| Museum - Restoration              | 11.0                    |  |                         |

Table 6-6 Interior Lighting Power for SuperECBC Buildings – Space Function Method

| Category                         | LPD (W/m <sup>2</sup> ) | Lamp category                 | LPD (W/m <sup>2</sup> ) |
|----------------------------------|-------------------------|-------------------------------|-------------------------|
| <b>Common Space Types</b>        |                         |                               |                         |
| Restrooms                        | 3.8                     | Stairway                      | 2.7                     |
| Storage                          | 3.4                     | Corridor/Transition           | 2.3                     |
| Conference/ Meeting              | 5.7                     | Lobby                         | 4.6                     |
| Parking Bays (covered/ basement) | 1.1                     | Driveways (covered/ basement) | 1.5                     |
| Electrical/Mechanical            | 3.5                     | Workshop                      | 8.6                     |
| <b>Business</b>                  |                         |                               |                         |
| Enclosed                         | 5.4                     | Open Plan                     | 5.4                     |
| Banking Activity Area            | 5.8                     | Service/Repair                | 3.4                     |
| <b>Healthcare</b>                |                         |                               |                         |
| Emergency                        | 11.4                    | Recovery                      | 4.4                     |
| Exam/Treatment                   | 6.8                     | Storage                       | 2.7                     |
| Nurses' Station                  | 5.0                     | Laundry/Washing               | 3.8                     |

| Category                          | LPD (W/m <sup>2</sup> ) | Lamp category                          | LPD (W/m <sup>2</sup> ) |
|-----------------------------------|-------------------------|--|-------------------------|
| Operating Room                    | 10.9                    | Lounge/Recreation                      | 4.6                     |
| Patient Room                      | 3.8                     | Medical Supply                         | 6.8                     |
| Pharmacy                          | 5.3                     | Nursery                                | 2.9                     |
| Physical Therapy                  | 4.9                     | Corridor/Transition                    | 4.6                     |
| Radiology/Imaging                 | 4.6                     |  |                         |
| <b>Hospitality</b>                |                         |  |                         |
| Hotel Dining                      | 4.6                     | Hotel Lobby                            | 5.5                     |
| For Bar Lounge/ Dining            | 7.0                     | Motel Dining                           | 4.6                     |
| For food preparation              | 7.5                     | Motel Guest Rooms                      | 3.8                     |
| Hotel Guest Rooms                 | 4.6                     |  |                         |
| <b>Shopping Complex</b>           |                         |  |                         |
| Mall Concourse                    | 6.4                     | For Family Dining                      | 5.5                     |
| Sales Area                        | 9.2                     | For food preparation                   | 7.5                     |
| Motion Picture Theatre            | 6.5                     | Bar Lounge/ Dining                     | 7.0                     |
| <b>Educational</b>                |                         |  |                         |
| Classroom/Lecture                 | 6.8                     | Card File and Cataloguing              | 4.6                     |
| For Classrooms                    | 6.9                     | Stacks (Library)                       | 9.2                     |
| Laboratory                        | 7.5                     | Reading Area (Library)                 | 5.7                     |
| <b>Assembly</b>                   |                         |  |                         |
| Dressing Room                     | 4.6                     | Seating Area - Performing Arts Theatre | 11.3                    |
| Exhibit Space – Convention Centre | 7.0                     | Lobby - Performing Arts Theatre        | 10.8                    |
| Seating Area - Gymnasium          | 3.4                     | Seating Area – Convention Centre       | 3.2                     |
| Fitness Area - Gymnasium          | 3.9                     | Seating Religious Building             | 8.2                     |
| Museum – General Exhibition       | 5.7                     | Playing Area - Gymnasium               | 6.5                     |
| Museum – Restoration              | 5.5                     |  |                         |

*Note 6-1 Calculating Interior Lighting Power – Space Function Method*



A four-story building has retail on the ground floor and offices on the top three floors. Area is 3,598 m<sup>2</sup>. Space types and their respective areas are mentioned below. Steps for calculating interior lighting power allowance using the space function method for a ECBC building is described below.

For each of the space type, corresponding Lighting Power Density (LPD) values for Business and Shopping complex building type from

Table 6-4 are used. Area is multiplied with the LPD values to estimate the lighting power allowance for the whole building. It is 40,242 W.

*Table 6-1-1 Space Types, Areas and Corresponding LPDs*

| Space Function         | LPD (W/ m <sup>2</sup> ) | Area (m <sup>2</sup> ) | Lighting Power Allowance (W) |
|------------------------|--------------------------|------------------------|------------------------------|
| <b>Office</b>          |                          |                        |                              |
| Office - enclosed      | 10.0                     | 720                    | 7,200                        |
| Office – open plan     | 10.0                     | 1,485                  | 14,850                       |
| Meeting Rooms          | 11.5                     | 120                    | 1,380                        |
| Lobbies                | 9.1                      | 93                     | 846                          |
| Restrooms              | 7.7                      | 51                     | 393                          |
| Corridors              | 7.1                      | 125                    | 888                          |
| Electrical/ Mechanical | 7.1                      | 14                     | 99                           |
| Staircase              | 5.5                      | 84                     | 462                          |
| Total                  |                          |                        | 26,118                       |
| <b>Retail</b>          |                          |                        |                              |
| General sales area     | 18.3                     | 669                    | 12,243                       |
| Offices - enclosed     | 10.0                     | 28                     | 280                          |
| Restrooms              | 7.7                      | 9                      | 69                           |
| Corridors              | 7.1                      | 79                     | 561                          |
| Storage                | 6.8                      | 93                     | 632                          |
| Food preparation       | 12.1                     | 28                     | 339                          |
| Total                  |                          |                        | 14,124                       |
| Building Total         |                          |                        | 40,242 W                     |

### 6.3.4 Installed Interior Lighting Power

The installed interior lighting power calculated for compliance with §6.3 shall include all power used by the luminaires, including lamps, ballasts, current regulators, and control devices except as specifically exempted in §6.1.

Exception to §6.3.4: If two or more independently operating lighting systems in a space are controlled to prevent simultaneous user operation, the installed interior lighting power shall be based solely on the lighting system with the highest power.

#### 6.3.4.1 Luminaire Wattage

Light output ratio shall be 0.7 or above. Luminaire wattage incorporated into the installed interior lighting power shall be determined in accordance with the following:

- (a) The wattage of incandescent luminaires with medium base sockets and not containing permanently installed ballasts shall be the maximum labeled wattage of the luminaires.
- (b) The wattage of luminaires containing permanently installed ballasts shall be the operating input wattage of the specified lamp/ballast combination. Operating input wattage can be either values from manufacturers' catalogs or values from independent testing laboratory reports.
- (c) The wattage of all other miscellaneous luminaire types not described in (a) or (b) shall be the specified wattage of the luminaires.
- (d) The wattage of lighting track, plug-in busway, and flexible-lighting systems that allow the addition and/ or relocation of luminaires without altering the wiring of the system shall be the larger of the specified wattage of the luminaires included in the system or 135 Watt per meter. Systems with integral overload protection, such as fuses or circuit breakers, shall be rated at 100% of the maximum rated load of the limiting device.

### 6.3.5 Exterior Lighting Power

Connected lighting power of exterior lighting applications shall not exceed the lighting power limits specified in Table 6-7 for ECBC Buildings, Table 6-8 for ECBC+ Buildings and Table 6-9 for SuperECBC Buildings. Trade-offs between applications are not permitted.



Table 6-7 Exterior Building Lighting Power for ECBC Buildings

| <i>Exterior lighting application</i>               | <i>Power limits</i>                          |
|--|--|
| Building entrance (with canopy)                    | 10 W/m <sup>2</sup> of canopied area         |
| Building entrance (w/o canopy)                     | 90 W/ linear m of door width                 |
| Building exit                                      | 60 W/lin m of door width                     |
| Building façade                                    | 5.0 W/m <sup>2</sup> of vertical façade area |
| Emergency signs, ATM kiosks, Security areas façade | 1.0 W/m <sup>2</sup>                         |
| Driveways and parking (open/ external)             | 1.6 W/m <sup>2</sup>                         |
| Pedestrian walkways                                | 2.0 W/m <sup>2</sup>                         |
| Stairways  | 10.0 W/m <sup>2</sup>                        |
| Landscaping  | 0.5 W/m <sup>2</sup>                         |
| Outdoor sales area                                 | 9.0 W/m <sup>2</sup>                         |

Table 6-8 Exterior Building Lighting Power for ECBC+ Buildings

| <i>Exterior lighting application</i>               | <i>Power limits</i>                          |
|--|--|
| Building entrance (with canopy)                    | 8.0 W/m <sup>2</sup> of canopied area        |
| Building entrance (w/o canopy)                     | 72 W/ linear m of door width                 |
| Building exit                                      | 48 W/lin m of door width                     |
| Building façade                                    | 4.0 W/m <sup>2</sup> of vertical façade area |
| Emergency signs, ATM kiosks, Security areas façade | 0.8 W/m <sup>2</sup>                         |
| Driveways and parking (open/ external)             | 1.3 W/m <sup>2</sup>                         |
| Pedestrian walkways                                | 1.6 W/m <sup>2</sup>                         |
| Stairways  | 8.0 W/m <sup>2</sup>                         |
| Landscaping  | 0.4 W/m <sup>2</sup>                         |
| Outdoor sales area                                 | 7.2 W/m <sup>2</sup>                         |

Table 6-9 Exterior Building Lighting Power for SuperECBC Buildings

| <i>Exterior lighting application</i>               | <i>Power limits</i>                          |
|--|--|
| Building entrance (with canopy)                    | 5.0 W/m <sup>2</sup> of canopied area        |
| Building entrance (w/o canopy)                     | 45 W/ linear m of door width                 |
| Building exit                                      | 30 W/lin m of door width                     |
| Building façade                                    | 2.5 W/m <sup>2</sup> of vertical façade area |
| Emergency signs, ATM kiosks, Security areas façade | 0.5 W/m <sup>2</sup>                         |
| Driveways and parking (open/ external)             | 0.8 W/m <sup>2</sup>                         |
| Pedestrian walkways                                | 1.0 W/m <sup>2</sup>                         |
| Stairways  | 5.0 W/m <sup>2</sup>                         |
| Landscaping  | 0.25 W/m <sup>2</sup>                        |
| Outdoor sales area                                 | 4.5 W/m <sup>2</sup>                         |

### **6.3.6 Controls for ECBC+ and SuperECBC Buildings**

ECBC+ and SuperECBC Buildings shall comply with requirements of § 6.3.6 in addition to complying with requirements of § 6.2.

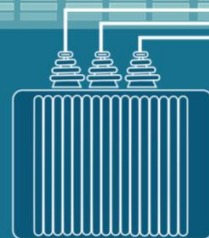
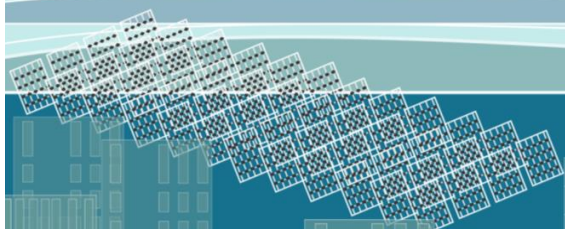
#### **6.3.6.1 Centralized Controls**

ECBC+ and SuperECBC building shall have centralized control system for schedule based automatic lighting shutoff switches.

#### **6.3.6.2 Exterior Lighting Controls**

Lighting for all exterior applications, shall have lamp efficacy not less than 80 lumens per watt, 90 lumens per watt, and 100 lumens per watt, for ECBC, ECBC+, and SuperECBC Buildings respectively, unless the luminaire is controlled by a motion sensor or exempt under §6.1.

# 7 Electrical & Renewable Energy Systems



# 7. Electrical and Renewable Energy Systems

## 7.1 General

All electric and renewable energy equipment and systems shall comply with the mandatory requirements of §7.2.

## 7.2 Mandatory Requirements

### 7.2.1 Transformers

#### 7.2.1.1 Maximum Allowable Power Transformer Losses

Power transformers of the proper ratings and design must be selected to satisfy the minimum acceptable efficiency at 50% and full load rating. The permissible loss shall not exceed to values listed in Table 7-1 for dry type transformers and Table 7-2 for oil type transformers.

Table 7-1 Permissible Losses for Dry Type Transformers

| Rating<br>kVA | Max. Losses at<br>50% loading<br>W* | Max. Losses at<br>100% loading<br>W* | Max. Losses at<br>50% loading<br>W* | Max. Losses at<br>100% loading<br>W* |
|---------------|-------------------------------------|--------------------------------------|-------------------------------------|--------------------------------------|
|               | Up to 22 kV class                   |                                      | 33 kV class                         |                                      |
| 100           | 940                                 | 2,400                                | 1,120                               | 2,400                                |
| 160           | 1,290                               | 3,300                                | 1,420                               | 3,300                                |
| 200           | 1,500                               | 3,800                                | 1,750                               | 4,000                                |
| 250           | 1,700                               | 4,320                                | 1,970                               | 4,600                                |
| 315           | 2,000                               | 5,040                                | 2,400                               | 5,400                                |
| 400           | 2,380                               | 6,040                                | 2,900                               | 6,800                                |
| 500           | 2,800                               | 7,250                                | 3,300                               | 7,800                                |
| 630           | 3,340                               | 8,820                                | 3,950                               | 9,200                                |
| 800           | 3,880                               | 10,240                               | 4,650                               | 11,400                               |
| 1,000         | 4,500                               | 12,000                               | 5,300                               | 12,800                               |
| 1,250         | 5,190                               | 13,870                               | 6,250                               | 14,500                               |
| 1,600         | 6,320                               | 16,800                               | 7,500                               | 18,000                               |
| 2,000         | 7,500                               | 20,000                               | 8,880                               | 21,400                               |
| 2,500         | 9,250                               | 24,750                               | 10,750                              | 26,500                               |

\* The values as per Indian Standard/BEE Standard & Labeling notification for dry type transformer corresponding to values in this table will supersede as and when the Indian standards/ BEE Standard & Labeling notification are published.

Table 7-2 Permissible Losses for Oil Type Transformers.

| Rating (kVA) | Impedance (%) | Max. Total Loss (W) for transformers up to 11 kV class |           |                |           |                    |           |
|--------------|---------------|--|-----------|----------------|-----------|--------------------|-----------|
|              |               | ECBC Building  |           | ECBC+ Building |           | SuperECBC Building |           |
|              |               | 50 % Load  | 100% Load | 50 % Load      | 100% Load | 50 % Load          | 100% Load |
| 16           | 4.5           | 135  | 440       | 108            | 364       | 87                 | 301       |
| 25           | 4.5           | 190  | 635       | 158            | 541       | 128                | 448       |
| 63           | 4.5           | 340  | 1,140     | 270            | 956       | 219                | 791       |
| 100          | 4.5           | 475  | 1,650     | 392            | 1,365     | 317                | 1,130     |
| 160          | 4.5           | 670  | 1,950     | 513            | 1,547     | 416                | 1,281     |
| 200          | 4.5           | 780  | 2,300     | 603            | 1,911     | 488                | 1,582     |
| 250          | 4.5           | 980  | 2,930     | 864            | 2,488     | 761                | 2,113     |
| 315          | 4.5           | 1,025  | 3,100     | 890            | 2,440     | 772                | 1,920     |
| 400          | 4.5           | 1,225  | 3,450     | 1,080          | 3,214     | 951                | 2,994     |
| 500          | 4.5           | 1,510  | 4,300     | 1,354          | 3,909     | 1,215              | 3,554     |
| 630          | 4.5           | 1,860  | 5,300     | 1,637          | 4,438     | 1,441              | 3,717     |
| 1,000        | 5             | 2,790  | 7,700     | 2,460          | 6,364     | 2,170              | 5,259     |
| 1,250        | 5             | 3,300  | 9,200     | 3,142          | 7,670     | 2,991              | 6,394     |
| 1,600        | 6.25          | 4,200  | 11,800    | 3,753          | 10,821    | 3,353              | 9,924     |
| 2,000        | 6.25          | 5,050  | 15,000    | 4,543          | 13,254    | 4,088              | 11,711    |
| 2,500        | 6.25          | 6,150  | 18,500    | 5,660          | 16,554    | 5,209              | 14,813    |

Total loss values given in above table are applicable for thermal classes E, B and F and have component of load loss at reference temperature according to Clause 17 of IS 1180 i.e., average winding temperature rise as given in Column 2 of Table 8.2 plus 300C. An increase of 7% on total for thermal class H is allowed.

Permissible total loss values shall not exceed:

- 5% of the maximum total loss values mentioned in IS 1180 for oil type transformers in voltage class above 11 kV but not more than 22 kV
- 7.5% of the maximum total loss values mentioned in above IS 1180 for oil type transformers in voltage class above 22 kV and up to and including 33 kV

### 7.2.1.2 Measurement and Reporting of Transformer Losses

All measurement of losses shall be carried out by using calibrated digital meters of class 0.5 or better accuracy and certified by the manufacturer. All transformers of capacity of 500 kVA and above would be equipped with additional metering class current transformers (CTs) and potential transformers (PTs) additional to requirements of Utilities so that periodic loss monitoring study may be carried out.

### 7.2.1.3 Voltage Drop

Voltage drop for feeders shall not exceed 2% at design load. Voltage drop for branch circuit shall not exceed 3% at design load.

## 7.2.2 Energy Efficient Motors

Motors shall comply with the following:

- (a) Three phase induction motors shall conform to Indian Standard (IS) 12615 and shall fulfil the following efficiency requirements:
  - i. ECBC Buildings shall have motors of IE 2 (high efficiency) class or a higher class
  - ii. ECBC+ Buildings shall have IE 3 (premium efficiency) class motors or higher class
  - iii. SuperECBC Buildings shall have IE 4 (super premium efficiency) class motors
- (b) Motors of horsepower differing from those listed in the table shall have efficiency greater than that of the next listed kW motor.
- (c) Motor horsepower ratings shall not exceed 20% of the calculated maximum load being served.
- (d) Motor nameplates shall list the nominal full-load motor efficiencies and the full-load power factor.

## 7.2.3 Diesel Generator (DG) Sets

BEE star rated DG sets shall be used in all compliant buildings. DG sets in buildings greater than 20,000 m<sup>2</sup> BUA shall have:

- (a) minimum 3 stars rating in ECBC Buildings
- (b) minimum 4 stars rating in ECBC+ Buildings
- (c) 5 stars rating in SuperECBC Buildings

## 7.2.4 Check-Metering and Monitoring

At Building mains, installed meters must be capable of monitoring Energy use (kWh), Energy Demand (kW) and total Power Factor on an hourly basis. For sub-meters installed at building services, the following metering requirements must be complied with:

- (a) Services exceeding 1,000 kVA shall have permanently installed electrical metering to record demand (kVA), energy (kWh), and total power factor on hourly basis. The metering shall also display current (in each phase and the neutral), voltage (between phases and between each phase and neutral), and total harmonic distortion (THD) as a percentage of total current.
- (b) Services not exceeding 1,000 kVA but over 65 kVA shall have permanently installed electric metering to record demand (kW), energy (kWh), and total power factor (or kVARh) on hourly basis.

- (c) Services not exceeding 65 kVA shall have permanently installed electrical metering to record energy (kWh) on hourly basis.

Sub-metering requirements for different services are outlined in Table 7-3.

Table 7-3 Sub Metering: Minimum requirement for separation of electrical load

|                                | Building Contract Demand |                      |
|--------------------------------|--------------------------|----------------------|
|                                | 120 kVA to 250 kVA       | Greater than 250 kVA |
| HVAC system and components     | Required                 | Required             |
| Interior and Exterior Lighting | Not required             | Required             |
| Domestic hot water             | Not required             | Required             |
| Plug loads                     | Not required             | Required             |
| Renewable power source         | Required                 | Required             |

In addition to requirements stated above, for building types identified in Table 7-4, respective services must be sub-metered.

Table 7-4 Additional sub-metering requirements for specific building types

| Mandatory requirement of sub- metering of services for specific building types |                                    |
|--|------------------------------------|
| Shopping Complex   | Façade lighting                    |
| Shopping Complex   | Elevator, escalators, moving walks |
| Business   | Data centers                       |
| Hospitality  | Commercial kitchens                |

For tenant-based building, tenants must be provided with tap-off points to install electrical sub-meters.

### 7.2.5 Power Factor Correction

All 3 phase shall maintain their power factor at the point of connection as follows:

- (a) 0.97 for ECBC Building
- (b) 0.98 for ECBC+ building
- (c) 0.99 for SuperECBC building

### 7.2.6 Power Distribution Systems

The power cabling shall be sized so that the distribution losses do not exceed

- (a) 3% of the total power usage in ECBC Buildings
- (b) 2% of the total power usage in ECBC+ Buildings

## (c) 1% of total power usage in SuperECBC Buildings

Record of design calculation for the losses shall be maintained. Load calculation shall be calculated up to the panel level.

## 7.2.7 Uninterruptible Power Supply (UPS)

In all buildings, UPS shall meet or exceed the energy efficiency requirements listed in Table 7-5. Any Standards and Labeling program by BEE shall take precedence over requirements listed in this section.

Table 7-5 Energy Efficiency Requirements for UPS for ECBC, ECBC+, SuperECBC building

| UPS Size       | Energy Efficiency Requirements at 100% Load |
|----------------|---|
| kVA < 20       | 90.2%                                       |
| 20 ≤ kVA ≤ 100 | 91.9%                                       |
| kVA > 100      | 93.8%                                       |

## 7.2.8 Renewable Energy Systems

All buildings shall have provisions for installation of renewable energy systems in the future on rooftops or the site.

### 7.2.8.1 Renewable Energy Generating Zone (REGZ)

- A dedicated REGZ equivalent to at least 25 % of roof area or area required for generation of energy equivalent to 1% of total peak demand or connected load of the building, whichever is less, shall be provided in all buildings.
- The REGZ shall be free of any obstructions within its boundaries and from shadows cast by objects adjacent to the zone
- ECBC+ and SuperECBC building shall fulfil the additional requirements listed in Table 7-6 and Table 7-7 respectively.

Table 7-6 Minimum Renewable Contribution towards meeting Contract Demand in ECBC+ Building

| Building Type                          | Minimum Capacity to be Installed in REGZ |
|--|--|
| All building types except below        | Minimum 2% of total Contract Demand      |
| Star Hotel > 20,000 m <sup>2</sup> AGA | Minimum 3% of total Contract Demand      |
| Resort > 12,500 m <sup>2</sup> AGA     |  |
| University > 20,000 m <sup>2</sup> AGA |  |
| Business > 20,000 m <sup>2</sup> AGA   |  |



Table 7-7 Minimum Renewable Contribution towards meeting Contract Demand in SuperECBC Building

| <i>Building Type</i>                   | <i>Minimum Capacity to be Installed in REGZ</i> |
|--|---|
| All Building types except below        | Minimum 4% of total Contract Demand             |
| Star Hotel > 20,000 m <sup>2</sup> AGA | Minimum 6% of total Contract Demand             |
| Resort > 12,500 m <sup>2</sup> AGA     |   |
| University > 20,000 m <sup>2</sup> AGA |   |
| Business > 20,000 m <sup>2</sup> AGA   |   |

#### 7.2.8.2 Main Electrical Service Panel

Minimum rating shall be displayed on the main electrical service panel. Space shall be reserved for the installation of a double pole circuit breaker for a future renewable electric installation.

#### 7.2.8.3 Demarcation on Documents

The following shall be indicated in design and construction documents:

- Location for inverters and metering equipment,
- Pathway for routing of conduit from the REGZ to the point of interconnection with the electrical service,
- Routing of plumbing from the REGZ to the water-heating system and,
- Structural design loads for roof dead and live load.

# 8 Definitions, Abbreviations & Acronyms

## 8. Definitions, Abbreviations, and Acronyms

### 8.1 General

Certain terms, abbreviations, and acronyms are defined in this section for the purposes of this code. These definitions are applicable to all sections of this code. Terms that are not defined shall have their ordinarily accepted meanings within the context in which they are used.

### 8.2 Definitions

#### A

**Above grade area (AGA):** AGA is the cumulative floor area of all the floor levels of a building that are above the ground level. Ground level shall be as defined in building site plan. A floor level is above grade if one-third of the total external surface area of only the said floor level is above the ground level.

**Accredited independent laboratory:** testing laboratory not affiliated with producer or consumer of goods or products tested at the laboratory and accredited by national or international organizations for technical competence

**Addition:** an extension or increase in floor area or height of a building outside of the existing building envelope.

**Air conditioning and condensing units serving computer rooms:** air conditioning equipment that provides cooling by maintaining space temperature and humidity within a narrow range. Major application is in data centers where dissipating heat generated by equipment takes precedence over comfort cooling for occupants.

**Alteration:** any change, rearrangement, replacement, or addition to a building or its systems and equipment; any modification in construction or building equipment.

**Area weighted average (AWA) method:** AWA method is based on the concept of weighted arithmetic mean where instead of each data point contributing equally to the final mean; each data point contributes more “weight” than others based on the size of the area the said data point is applicable to. To calculate the area weighted average mean, a summation of each data point multiplied with its respective area is divided with the total area.

$$AWA = \sum \frac{(\text{Data point } X \text{ area})}{\text{Total area}}$$

**Astronomical time switch:** an automatic time switch that makes an adjustment for the length of the day as it varies over the year.

**Authority having jurisdiction:** the agency or agent responsible for enforcing this code.

## B

**Balancing, air system:** adjusting airflow rates through air distribution system devices, such as fans and diffusers, by manually adjusting the position of dampers, splitters vanes, extractors, etc., or by using automatic control devices, such as constant air volume or variable air volume boxes.

**Balancing, hydronic system:** adjusting water flow rates through hydronic distribution system devices, such as pumps and coils, by manually adjusting the position valves, or by using automatic control devices, such as automatic flow control valves.

**Ballast:** a device used in conjunction with an electric-discharge lamp to cause the lamp to start and operate under proper circuit conditions of voltage, current, waveform, electrode heat, etc.

**Standard Design:** a computer model of a hypothetical building, based on actual building design, that fulfils all the mandatory requirements and minimally complies with the prescriptive requirements of ECBC.

**Boiler:** a self-contained low-pressure appliance for supplying steam or hot water

**Building or building complex or complex:** a structure wholly or partially enclosed within exterior walls, or within exterior and party walls, and a roof, affording shelter to persons, animals, or property. Building complex means a building or group of buildings constructed in a contiguous area for business, commercial, institutional, healthcare, hospitality purposes or assembly buildings under the single ownership of individuals or group of individuals or under the name of a co-operative group society or on lease and sold as shops or office space or space for other commercial purposes, having a connected load of 100 kW or contract demand of 120 kVA and above.

**Building, base:** includes building structure, building envelope, common areas, circulation areas, parking, basements, services area, plant room and its supporting areas and, open project site area.

**Building, core and shell:** buildings where the developer or owner will only provide the base building and its services.

**Building, existing:** a building or portion thereof that was previously occupied or approved for occupancy by the authority having jurisdiction.

**Building envelope:** the exterior plus the semi-exterior portions of a building. For the purposes of determining building envelope requirements, the classifications are defined as follows:

- (a) **Building envelope, exterior:** the elements of a building that separate conditioned spaces from the exterior
- (b) **Building envelope, semi-exterior:** the elements of a building that separate conditioned space from unconditioned space or that enclose semi-heated spaces through which thermal energy may be transferred to or from the exterior, or to or from unconditioned spaces, or to or from conditioned spaces

**Building grounds lighting:** lighting provided through a building's electrical service for parking lot, site, roadway, pedestrian pathway, loading dock, and security applications

**Building material:** any element of the building envelope through which heat flows and that heat is included in the component U-factor calculations other than air films and insulation

**Built up area (BUA):** sum of the covered areas of all floors of a building, other than the roof, and areas covered by external walls and parapet on these floors.

**24-hour Business Building:** Business building operated and occupied for more than 12 hours on each weekday. Intensity of occupancy may vary.

## C

**Cardinal direction:** cardinal directions or cardinal points are the four main directional points of a compass: north, south, east, and west **Centralized control:** single hardware/ software for observing and controlling operations of a group of equipment and devices with similar or different functions

**Circuit breaker:** a safety device that automatically stops flow of current in electrical circuits. It protects the circuit from current surge.

**Class of construction:** classification that determines the construction materials for the building envelope, roof, wall, floor, slab-on-grade floor, opaque door, vertical fenestration, skylight

**Daylight window:** fenestration 2.2 meter above floor level, with an interior light shelf at bottom of this fenestration

**Coefficient of Performance (COP) – cooling:** the ratio of the rate of heat removal to the rate of energy input, in consistent units, for a complete refrigerating system or some specific portion of that system under designated operating conditions

**Coefficient of Performance (COP) – heating:** the ratio of the rate of heat delivered to the rate of energy input, in consistent units, for a complete heat pump system, including the compressor and, if applicable, auxiliary heat, under designated operating conditions

**Common area:** areas within a building that are available for use by all tenants in a building (i.e. lobbies, corridors, restrooms, etc.)

**Commercial building:** a building or a part of building or building complex which are used or intended to be used for commercial purposes and classified as per the time of the day the

building is operational and sub classified, as per the functional requirements of its design, construction, and use as per following details:

- a) Group I – 24 hours building covering Type A Hospitality, Type B Health Care and Type C Assembly, Type D Business and,
- b) Group II – Regular building covering Type D Business, Type E Educational and Type F Shopping Complexes.

**Compliance documents:** the forms specified in ECBC Rules and Regulations to record and check compliance with these rules. These include but are not limited to EPI Ratio Compliance Report, Building Envelope Compliance Form, Mechanical Systems Compliance Form and Permit Checklist, Lighting System Compliance Form and Permit Checklist and certificates from Certified Energy Auditor for existing or proposed buildings.

**Connected load:** the sum of the rated wattage of all equipment, appliances and devices to be installed in the building or part of building or building complexes, in terms of kilowatt (kW) that will be allocated to all applicants for electric power consumption in respect of the proposed building or building complexes on their completion.

Demand factor is the ratio of the sum of the maximum demand of a system (or part of a system) to the total connected load on the system (or part of the system) under consideration. Demand factor is always less than one.

**Contract demand:** the maximum demand in kilo Volt Ampere (kVA) (within a consumer's sanctioned load) agreed to be supplied by the electricity provider or utility in the agreement executed between the user and the utility or electricity provider.

**Construction documents:** drawings or documents, containing information pertaining to building construction processes and approvals, building materials and equipment specification, architectural details etc. required by the authority having jurisdiction.

**Controls or control device:** manually operated or automatic device or software to regulate the operation of building equipment

**Cool roof:** roof with top layer of material that has high solar reflectance and high thermal emittance properties. Cool roof surfaces are characterized by light colors so that heat can be rejected back to the environment.

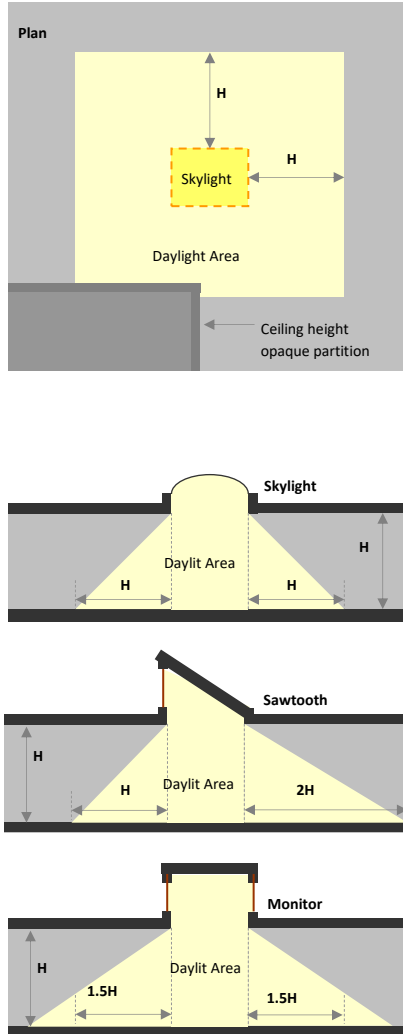
**Cumulative design EPI:** energy performance index for a building having two or more different functional uses and calculated based on the area weighted average (AWA) method

## D

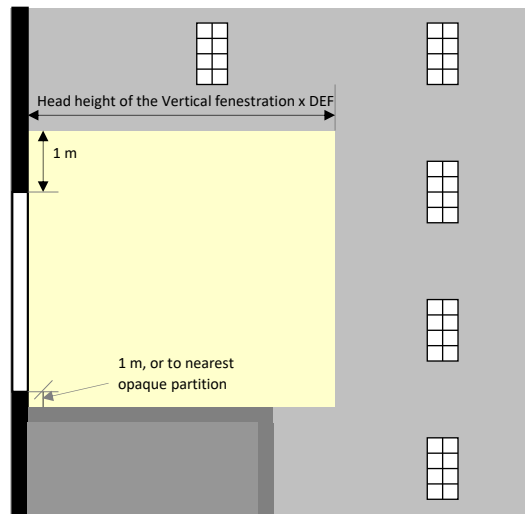
**Daylight area:** the daylight illuminated floor area under horizontal fenestration (skylight) or adjacent to vertical fenestration (window), described as follows:

- (a) Horizontal Fenestration: the area under a skylight, monitor, or sawtooth configuration with an effective aperture greater than 0.001 (0.1%). The daylight area is calculated as the horizontal dimension in each direction equal to the top

aperture dimension in that direction plus either the floor-to-ceiling height ( $H$ ) for skylights, or  $1.5H$  for monitors, or  $H$  or  $2H$  for the sawtooth configuration, or the distance to the nearest 1 meter or higher opaque partition, or one-half the distance to an adjacent skylight or vertical glazing, whichever is least, as shown in the plan and section figures below.



- (b) Vertical Fenestration: the floor area adjacent to side apertures (vertical fenestration in walls) with an effective aperture greater than 0.06 (6%). The daylight area extends into the space perpendicular to the side aperture a distance equal to daylight extension factor (DEF) multiplied by the head height of the side aperture or till higher opaque partition, whichever is less. In the direction parallel to the window, the daylight area extends a horizontal dimension equal to the width of the window plus either 1 meter on each side of the aperture, or the distance to an opaque partition, or one-half the distance to an adjacent skylight or window, whichever is least.



**Daylight Extension Factor (DEF):** factor to manually calculate the daylight area on floor plates. It is to be multiplied by the head height of windows. It is dependent on orientation and glazing VLT, shading devices adjacent to it and building location.

**Daytime Business Building:** Business building operated typically only during daytime on weekdays upto 12 hours each day.

**Deadband:** the range of values within which a sensed variable can vary without initiating a change in the controlled process.

**Demand:** maximum rate of electricity (kW) consumption recorded for a building or facility during a selected time frame.

**Demand control ventilation (DCV):** a ventilation system capability that provides automatic reduction of outdoor air intake below design rates when the actual occupancy of spaces served by the system is less than design occupancy

**Design capacity:** output capacity of a mechanical or electrical system or equipment at design conditions

**Design conditions:** specified indoor environmental conditions, such as temperature, humidity and light intensity, required to be produced and maintained by a system and under which the system must operate

**Distribution system:** network or system comprising controlling devices or equipment and distribution channels (cables, coils, ducts, pipes etc.) for delivery of electrical power or, cooled or heated water or air in buildings

**Door:** all operable opening areas, that are not more than one half glass, in the building envelope, including swinging and roll-up doors, fire doors, and access hatches.

**Door area:** total area of the door measured using the rough opening and including the door slab and the frame.



## E

**Economizer, air:** a duct and damper arrangement with automatic controls that allow a cooling system to supply outdoor air to reduce or eliminate the need for mechanical cooling during mild or cold weather

**Economizer, water:** a system by which the supply air of a cooling system is cooled indirectly with water that is itself cooled by heat or mass transfer to the environment without the use of mechanical cooling

**ECBC Building:** a building that complies with the mandatory requirements of §4 to §7 and also complies either with the prescriptive requirements stated under the ECBC Building categories of §4 to §7, or, with the whole building performance compliance method of §9.

**ECBC+ Building:** a building that complies with the mandatory requirements of §4 to §7 and also complies either with the prescriptive requirements stated under the ECBC+ Building categories of §4 to §7, or, with the whole building performance compliance method of §9. This is a voluntary level of compliance with ECBC.

**Effective aperture:** Visible light transmittance x window-to-wall Ratio. ( $EA = VLT \times WWR$ )

**Efficacy:** the lumens produced by a lamp plus ballast system divided by the total watts of input power (including the ballast), expressed in lumens per watt

**Efficiency:** performance at a specified rating condition

**Efficiency, thermal:** ratio of work output to heat input

**Efficiency, combustion:** efficiency with which fuel is burned during the combustion process in equipment

**Emittance:** the ratio of the radiant heat flux emitted by a specimen to that emitted by a blackbody at the same temperature and under the same conditions

**Energy:** power derived from renewable or non-renewable resources to provide heating, cooling and light to a building or operate any building equipment and appliances. It has various forms such as thermal (heat), mechanical (work), electrical, and chemical that may be transformed from one into another. Customary unit of measurement is watts (W)

**Energy Conservation Building Code (ECBC):** the Energy Conservation Building Code as updated from time to time by the Bureau and displayed on its website ([www.beeindia.gov.in](http://www.beeindia.gov.in)).

**Energy Efficiency Ratio (EER):** the ratio of net cooling capacity in watt to total rate of electric input in watts under design operating conditions

**Energy recovery system:** equipment to recover energy from building or space exhaust air and use it to treat (pre-heat or pre-cool) outdoor air taken inside the building or space by ventilation systems

**Envelope Performance Factor (EPF):** value for the building envelope performance compliance option calculated using the procedures specified in 4.3.5 and 4.3.5.1.1. For the purposes of determining building envelope requirements the classifications are defined as follows:

- (a) Standard Building EPF: envelope performance factor calculated for the Standard Building using prescriptive requirements for walls, vertical fenestrations and roofs
- (b) Proposed Building EPF: the building envelope performance factor for the Proposed Building using proposed values for walls, vertical fenestrations and roofs

**Energy Performance Index (EPI):** of a building means its annual energy consumption in kilowatt-hours per square meter of the area of the building which shall be calculated in the existing or proposed building as per the formula below,

$$= \frac{\text{annual energy consumption in kWh}}{\text{total built – up area (excluding storage area and the parking in the basement) in m}^2}$$

**EPI Ratio:** of a building means the ratio of the EPI of the Proposed Building to the EPI of the Standard Building.

**Equipment:** mechanical, electrical or static devices for operating a building, including but not limited to those required for providing cooling, heating, ventilation, lighting, service hot water, vertical circulation

**Equipment, existing:** equipment previously installed in an existing building

**Equivalent SHGC:** SHGC for a fenestration with a permanent external shading projection. It is calculated using the Projection Factor (PF) of the permanent external shading projection and Shading Equivalent Factor (SEF) listed in §4.3.1.

**Exemption:** any exception allowed to compliance with ECBC requirements

## F

**Fan system power:** sum of the nominal power demand (nameplate W or HP) of motors of all fans that are required to operate at design conditions to supply air from the heating or cooling source to the conditioned space(s) and return it to the point where it can be exhausted to outside the building.

**Fenestration:** all areas (including the frames) in the building envelope that let in light, including windows, plastic panels, clerestories, skylights, glass doors that are more than one-half glass, and glass block walls.

- (a) Skylight: a fenestration surface having a slope of less than 60 degrees from the horizontal plane. Other fenestration, even if mounted on the roof of a building, is considered vertical fenestration.
- (b) Vertical fenestration: all fenestration other than skylights. Trombe wall assemblies, where glazing is installed within 300 mm of a mass wall, are considered walls, not fenestration.

**Fenestration area:** total area of the fenestration measured using the rough opening and including the glazing, sash, and frame. For doors where the glazed vision area is less than 50% of the door area, the fenestration area is the glazed vision area. For all other doors, the fenestration area is the door area.

**Finished floor level:** level of floor achieved after finishing materials have been added to the subfloor or rough floor or concrete floor slab.

**Fossil fuel:** fuel derived from a hydrocarbon deposit such as petroleum, coal, or natural gas derived from living matter of a previous geologic time

**Fuel:** a material that may be used to produce heat or generate power by combustion

**Fuel utilization efficiency (FUE):** a thermal efficiency measure of combustion equipment like furnaces, boilers, and water heaters

## G

**Gathering hall (Type of Assembly):** any building, its lobbies, rooms and other spaces connected thereto, primarily intended for assembly of people, but which has no theatrical stage or permanent theatrical and/or cinematographic accessories and has gathering space for greater or equal to 100 persons, for example, stand-alone dance halls, stand-alone night clubs, halls for incidental picture shows, dramatic, theatrical or educational presentation, lectures or other similar purposes having no theatrical stage except a raised platform and used without permanent seating arrangement; art galleries, community halls, marriage halls, places of worship, museums, stand-alone lecture halls, passenger terminals and heritage and archeological monuments, pool and billiard parlors, bowling alleys, community halls, courtrooms, gymnasiums, indoor swimming pools, indoor tennis court, any indoor stadium for sports and culture, auditoriums

**Grade:** finished ground level adjoining a building at all exterior walls

**Guest room:** any room or rooms used or intended to be used by a guest for sleeping purposes

## H

**Habitable spaces:** space in a building or structure intended or used for working, meeting, living, sleeping, eating, or cooking. Bathrooms, water closet compartments, closets, halls, storage or utility space, and similar areas are not considered habitable spaces.

**Hospitals and sanatoria (Healthcare):** Any building or a group of buildings under single management, which is used for housing persons suffering from physical limitations because of health or age and those incapable of self-preservation, for example, any hospitals, infirmaries, sanatoria and nursing homes.

**HVAC system:** equipment, distribution systems, and terminal devices that provide, either collectively or individually, the processes of heating, ventilating, or air conditioning to a building or parts of a building.

**Hyper Markets (Type F of Shopping Complex):** large retail establishments that are a combination of supermarket and department stores. They are considered as a one-stop shop for all needs of the customer.

## I

**Infiltration:** uncontrolled inward air leakage through cracks and crevices in external surfaces of buildings, around windows and doors due to pressure differences across these caused by factors such as wind or indoor and outside temperature differences (stack effect), and imbalance between supply and exhaust air systems

**Installed interior lighting power:** power in watts of all permanently installed general, task, and furniture lighting systems and luminaires

**Integrated part-load value (IPLV):** weighted average efficiency of chillers measured when they are operating at part load conditions (less than design or 100% conditions). It is more realistic measurement of chiller efficiency during its operational life.

## K

**Kilovolt-ampere (kVA):** where the term “kilovolt-ampere” (kVA) is used in this Code, it is the product of the line current (amperes) times the nominal system voltage (kilovolts) times 1.732 for three-phase currents. For single-phase applications, kVA is the product of the line current (amperes) times the nominal system voltage (kilovolts).

**Kilowatt (kW):** the basic unit of electric power, equal to 1000 W.

## L

**Labeled:** equipment or materials to which a symbol or other identifying mark has been attached by the manufacturer indicating compliance with specified standard or performance in a specified manner.

**Lamp:** a device for giving light consisting of electric bulb with its holder and shade or cover.

**Lighted floor area, gross:** gross area of lighted floor spaces

**Lighting, emergency:** battery backed lighting that provides illumination only when there is a power outage and general lighting luminaires are unable to function.

**Lighting, general:** lighting that provides a substantially uniform level of illumination throughout an area. General lighting shall not include decorative lighting or lighting that provides a dissimilar level of illumination to serve a specialized application or feature within such area.

**Lighting system:** a group of luminaires circuited or controlled to perform a specific function.

**Lighting power allowance:**

- (a) Interior lighting power allowance: the maximum lighting power in watts allowed for

the interior of a building

- (b) Exterior lighting power allowance: the maximum lighting power in watts allowed for the exterior of a building

**Lighting Power Density (LPD):** maximum lighting power per unit area of a space as per its function or building as per its classification.

**Low energy comfort systems:** space conditioning or ventilation systems that are less energy intensive than vapor compression based space condition systems. These primarily employ alternate heat transfer methods or materials (adiabatic cooling, radiation, desiccant, etc.), or renewable sources of energy (solar energy, geo-thermal) so that minimal electrical energy input is required to deliver heating or cooling to spaces.

**Luminaires:** a complete lighting unit consisting of a lamp or lamps together with the housing designed to distribute the light, position and protect the lamps, and connect the lamps to the power supply.

## M

**Man-made daylight obstruction:** any permanent man-made object (equipment, adjacent building) that obstructs sunlight or solar radiation from falling on a portion or whole of a building's external surface at any point of time during a year is called as a man-made sunlight obstructer.

**Manual (non-automatic):** requiring personal intervention for control. Non-automatic does not necessarily imply a manual controller, only that personal intervention is necessary.

**Manufacturing processes:** processes through which raw material is converted into finished goods for commercial sale using machines, labor, chemical or biological processes, etc.

**Manufacturer:** company or person or group of persons who produce and assemble goods or purchases goods manufactured by a third party in accordance with their specifications.

**Mean temperature:** average of the minimum daily temperature and maximum daily temperature.

**Mechanical cooling:** reducing the temperature of a gas or liquid by using vapor compression, absorption, and desiccant dehumidification combined with evaporative cooling, or another energy-driven thermodynamic cycle. Indirect or direct evaporative cooling alone is not considered mechanical cooling.

**Metering:** practice of installing meters in buildings to acquire data for energy consumption and other operational characteristics of individual equipment or several equipment grouped on basis of their function (lighting, appliances, chillers, etc.). Metering is done in buildings to monitor their energy performance.

**Mixed mode air-conditioned building:** building in which natural ventilation is employed as the primary mode of ventilating the building, and air conditioning is deployed as and when required.

**Mixed use development:** a single building or a group of buildings used for a combination of residential, commercial, business, educational, hospitality and assembly purposes

## N

**National Building Code 2016 (NBC):** model building code that provides guidelines for design and construction of buildings. In this code, National Building Code 2016 refers to the latest version by the Bureau of Indian Standards.

**Natural daylight obstruction:** any natural object, like tree, hill, etc., that obstructs sunlight from falling on part or whole of a building's external surface at any point of time during a year and casts a shadow on the building surface.

**Naturally ventilated building:** a building that does not use mechanical equipment to supply air to and exhaust air from indoor spaces. It is primarily ventilated by drawing and expelling air through operable openings in the building envelope.

**Non-cardinal directions:** any direction which is not a cardinal direction, i.e. perfect north, south, east, or west, is termed as non-cardinal direction.

**No Star hotel (Type of Hospitality):** any building or group of buildings under the same management, in which separate sleeping accommodation on commercial basis, with or without dining facilities or cooking facilities, is provided for individuals. This includes lodging rooms, inns, clubs, motels, no star hotel and guest houses and excludes residential apartments rented on a lease agreement of 4 months or more. These shall also include any building in which group sleeping accommodation is provided, with or without dining facilities for persons who are not members of the same family, in one room or a series of adjoining rooms under joint occupancy and single management, for example, school and college dormitories, students, and other hostels and military barracks.

## O

**Occupant sensor:** a device that detects the presence or absence of people within an area and causes lighting, equipment, or appliances to be dimmed, or switched on or off accordingly.

**Opaque assembly or opaque construction:** surface of the building roof or walls other than fenestration and building service openings such as vents and grills.

**Opaque external wall:** external wall composed of materials which are not transparent or translucent, usually contains the structural part of the building, and supports the glazed façade. This type may be composed of one or more materials.

**Open Gallery Mall (Type of Shopping Complex):** a large retail complex containing a variety of stores and often restaurants and other business establishments housed in a series of connected or adjacent buildings or in a single large building. The circulation area and atrium of the open gallery mall is an unconditioned space and is open to sky.

**Orientation:** the direction a building facade faces, i.e., the direction of a vector perpendicular to and pointing away from the surface of the facade. For vertical fenestration, the two categories are north-oriented and all other.

**Outdoor (outside) air:** air taken from the outside the building and has not been previously circulated through the building.

**Out-patient Healthcare (Type of Healthcare):** any building or a group of buildings under single management, which is used only for treating persons requiring treatment or diagnosis of disease but not requiring overnight or longer accommodation in the building during treatment or diagnosis.

**Overcurrent:** any current in excess of the rated current of the equipment of the ampacity of the conductor. It may result from overload, short circuit, or ground fault.

**Owner:** a person, group of persons, company, trust, institute, Registered Body, state or central Government and its attached or sub-ordinate departments, undertakings and like agencies or organization in whose name the property stands registered in the revenue records for the construction of a building or building complex

## P

**Party wall:** a firewall on an interior lot line used or adapted for joint service between two buildings.

**Permanently installed:** equipment that is fixed in place and is not portable or movable.

**Plenum:** a compartment or chamber to which one or more ducts are connected, that forms a part of the air distribution system, and that is not used for occupancy or storage.

**Plug loads:** energy used by products that are powered by means of an AC plug. This term excludes building energy that is attributed to major end uses specified in § 5, § 6, § 7 (like HVAC, lighting, water heating, etc.).

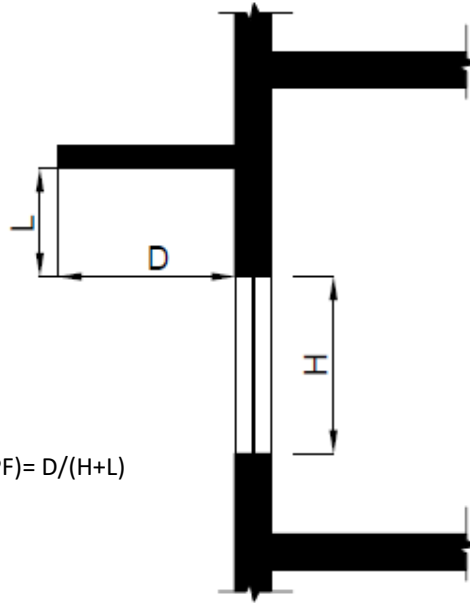
**Pool:** any structure, basin, or tank containing an artificial body of water for swimming, diving, or recreational bathing. The terms include, but no limited to, swimming pool, whirlpool, spa, hot tub.

**Potential daylight time:** amount of time in a day when there is daylight to light a space adequately without using artificial lighting. Potential daylight time is fixed for 8 hours per day i.e. from 09:00 AM to 5:00 PM local time, resulting 2920 hours in total for all building types except for Type E-1 - Educational, which shall be analyzed for 7 hours per day i.e. from 08:00 AM to 3:00 PM local time.

**Primary inter-cardinal direction:** any of the four points of the compass, midway between the cardinal points; northeast, southeast, southwest, or northwest are called primary inter-cardinal direction.

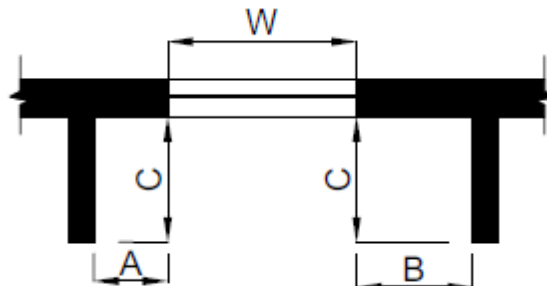
**Process load:** building loads resulting from the consumption or release of energy due to industrial processes or processes other than those for providing space conditioning, lighting, ventilation, or service hot water heating.

**Projection factor, overhang:** It is the ratio of the horizontal depth of the external shading projection to the sum of the height of the fenestration and the distance from the top of the fenestration to the bottom of the farthest point of the external shading projection, in consistent units.



Projection factor (PF) =  $D / (H + L)$

**Projection factor, side fin:** It is the ratio of the horizontal depth of the external shading projection to the distance from the window jamb to the farthest point of the external shading projection, in consistent units.



Projection factor Left Fin(PF<sub>L</sub>) =  $C / (A + W)$

Projection factor Right Fin(PF<sub>R</sub>) =  $C / (B + W)$



**Projection Factor, overhang and side fin:** average of ratio projection factor for overhang only and projection factor of side fin only.

**Proposed Building:** is consistent with the actual design of the building and complies with all the mandatory requirements of ECBC.

**Proposed Design:** a computer model of the proposed building, consistent with its actual design, which complies with all the mandatory requirements of ECBC.

R

**R-value (thermal resistance):** the reciprocal of the time rate of heat flow through a unit area induced by a unit temperature difference between two defined surfaces of material or construction under steady-state conditions. Units of R value are  $m^2.K / W$ .

**Readily accessible:** capable of being reached quickly for operation, renewal, or inspections without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, chairs, etc. In public facilities, accessibility may be limited to certified personnel through locking covers or by placing equipment in locked rooms.

**Recirculating system:** a domestic or service hot water distribution system that includes a close circulation circuit designed to maintain usage temperatures in hot water pipes near terminal devices (e.g., lavatory faucets, shower heads) in order to reduce the time required to obtain hot water when the terminal device valve is opened. The motive force for circulation is either natural (due to water density variations with temperature) or mechanical (recirculation pump).

**Renewable Energy Generating Zone:** a contiguous or semi-contiguous area, either on rooftop or elsewhere within site boundary, dedicated for installation of renewable energy systems.

**Resort (Type of Hospitality):** commercial establishments that provide relaxation and recreation over and above the accommodation, meals and other basic amenities. The characteristics of resort are as below –

- i. Includes 1 or more recreation(s) facility like spa, swimming pool, or any sport;
- ii. Is located in the midst of natural and picturesque surroundings outside the city;
- iii. Comprises of 2 or more blocks of buildings within the same site less than or equal to 3 floors (including the ground floor).

**Reset:** automatic adjustment of the controller set point to a higher or lower value.

**Roof:** the upper portion of the building envelope, including opaque areas and fenestration, that is horizontal or tilted at an angle of less than 60° from horizontal. This includes podium roof as well which are exposed to direct sun rays.

**Roof area, gross:** the area of the roof measured from the exterior faces of walls or from the centerline of party walls

## S

**Service:** the equipment for delivering energy from the supply or distribution system to the premises served.

**Service water heating equipment:** equipment for heating water for domestic or commercial purposes other than space heating and process requirements.

**Set point:** the desired temperature (°C) of the heated or cooled space that must be maintained by mechanical heating or cooling equipment.

**Shading Coefficient (SC):** measure of thermal performance of glazing. It is the ratio of solar heat gain through glazing due to solar radiation at normal incidence to that occurring through 3 mm thick clear, double-strength glass. Shading coefficient, as used herein, does not include interior, exterior, or integral shading devices.

**Shading Equivalent Factor:** coefficient for calculating effective SHGC of fenestrations shaded by overhangs or side fins.

**Shopping Mall (Shopping Complex):** a large retail complex containing a variety of stores and often restaurants and other business establishments housed in a series of connected or adjacent buildings or in a single large building. The circulation area and atrium of the mall is an enclosed space covered completely by a permanent or temporary structure.

**Simulation program:** software in which virtual building models can be developed to simulate the energy performance of building systems and daylighting analysis

**Single-zone system:** an HVAC system serving a single HVAC zone.

**Site-recovered energy:** waste energy recovered at the building site that is used to offset consumption of purchased fuel or electrical energy supplies.

**Slab-on-grade floor:** floor slab of the building that is in contact with ground and that is either above grade or is less than or equal to 300 mm below the final elevation of the nearest exterior grade. **Solar energy source:** source of thermal, chemical, or electrical energy derived from direction conversion of incident solar radiation at the building site.

**Solar Heat Gain Coefficient (SHGC):** the ratio of the solar heat gain entering the space through the fenestration area to the incident solar radiation. Solar heat gain includes directly transmitted solar heat and absorbed solar radiation, which is then reradiated, conducted, or convected into the space.

**Solar Reflectance:** ratio of the solar radiation reflected by a surface to the solar radiation incident upon it.

**Space:** an enclosed area within a building. The classifications of spaces are as follows for purpose of determining building envelope requirements:

- (a) Conditioned space: a cooled space, heated space, or directly conditioned space.
- (b) Semi-heated space: an enclosed space within a building that is heated by a heating

system whose output capacity is greater or equal to  $10.7 \text{ W/m}^2$  but is not a conditioned space.

- (c) Non-conditioned space: an enclosed space within a building that is not conditioned space or a semi-heated space. Crawlspace, attics, and parking garages with natural or mechanical ventilation are not considered enclosed spaces.

**Star Hotels/motels (Star Hotel):** any building or group of buildings under single management and accredited as a starred hotel by the Hotel and Restaurant Approval and Classification Committee, Ministry of Tourism, in which sleeping accommodation, with or without dining facilities is provided.

**Stand-alone Retail (Shopping Complex):** a large retail store owned or sublet to a single management which may offer customers a variety of products under self-branding or products of different brands. The single management shall have a complete ownership of all the spaces of the building and no space within the building is further sold or sublet to a different management.

**Standard Building:** a building that minimally complies with all the mandatory and prescriptive requirements of Energy Conservation Building Code and has same floor area, gross wall area, and gross roof area of the Proposed Building.

**Standard Design:** a computer model of a hypothetical building, based on actual building design, that fulfils all the mandatory requirements and minimally complies with the prescriptive requirements of ECBC, as described in the Whole Building Performance method.

**Story:** portion of a building that is between one finished floor level and the next higher finished floor level or building roof. Basement and cellar shall not be considered a story.

**Summer Solar Insolation:** measure of solar radiation energy received on a given surface area from the month of March to October within the same calendar year. Units of measurement are watts per square meter ( $\text{W/m}^2$ ) or kilowatt-hours per square meter per day ( $\text{kW}\cdot\text{h}/(\text{m}^2\cdot\text{day})$ ) (or hours/day).

**SuperECBC Building:** a building that complies with the mandatory requirements of §4 to §7 and also complies either with the prescriptive requirements stated under the SuperECBC Building categories of §4 to §7, or, with the whole building performance compliance method of §9. This is a voluntary level of compliance with ECBC.

**Super Market (Shopping Complex):** supermarkets are large self-service grocery stores that offer customers a variety of foods and household supplies. The merchandise is organized into an organized aisle format, where each aisle has only similar goods placed together.

**System:** a combination of equipment and auxiliary devices (e.g., controls, accessories, interconnecting means, and terminal elements) by which energy is transformed so it performs a specific function such as HVAC, service water heating, or lighting.

**System Efficiency:** the system efficiency is the ratio of annual kWh electricity consumption of equipment of water cooled chilled water plant (i.e. chillers, chilled and condenser water pumps, cooling tower) to chiller thermal kWh used in a building.

**System, existing:** a system or systems previously installed in an existing building.

## T

**Tenant lease agreement:** The formal legal document entered into between a Landlord and a Tenant to reflect the terms of the negotiations between them; that is, the lease terms have been negotiated and agreed upon, and the agreement has been reduced to writing. It constitutes the entire agreement between the parties and sets forth their basic legal rights.

**Tenant leased area:** area of a building that is leased to tenant(s) as per the tenant lease agreement.

**Terminal device:** a device through which heated or cooled air is supplied to a space to maintain its temperature. It usually contains dampers and heating and cooling coils. Or a device by which energy from a system is finally delivered, e.g., registers, diffusers, lighting fixtures, faucets, etc.

**Theater or motion picture hall (Type of Assembly):** any building primarily meant for theatrical or operatic performances and which has a stage, proscenium curtain, fixed or portable scenery or scenery loft, lights, mechanical appliances or other theatrical accessories and equipment for example, theaters, motion picture houses, auditoria, concert halls, television and radio studios admitting an audience and which are provided with fixed seats.

**Thermal block:** a collection of one or more HVAC zones grouped together for simulation purposes. Spaces need not be contiguous to be combined within a single thermal block.

**Thermal comfort conditions:** conditions that influence thermal comfort of occupants. Environmental conditions that influence thermal comfort air and radiant temperature, humidity, and air speed.

**Thermostat:** device containing a temperature sensor used to automatically maintain temperature at a desirable fixed or adjustable set point in a space.

**Tinted:** (as applied to fenestration) bronze, green, or grey coloring that is integral with the glazing material. Tinting does not include surface applied films such as reflective coatings, applied either in the field or during the manufacturing process.

**Transformer:** a piece of electrical equipment used to convert electric power from one voltage to another voltage.

**Transformer losses:** electrical losses in a transformer that reduces its efficiency.

**Transport Buildings (Assembly):** any building or structure used for the purpose of transportation and transit like airports, railway stations, bus stations, and underground and elevated mass rapid transit system example, underground or elevated railways.

## U

**Unconditioned buildings:** building in which more than 90% of spaces are unconditioned spaces.

**Unconditioned space:** mechanically or naturally ventilated space that is not cooled or heated by mechanical equipment.

**Universities and all others coaching/training institutions (Educational):** a building or a group of buildings, under single management, used for imparting education to students numbering more than 100 or public or private training institution built to provide training/coaching etc.

**Useful Daylight Illuminance:** percentage of annual daytime hours that a given point on a work plane height of 0.8 m above finished floor level receives daylight between 100 lux to 2,000 lux.

**U-factor (Thermal Transmittance):** heat transmission in unit time through unit area of a material or construction and the boundary air films, induced by unit temperature difference between the environments on each side. Unit of U value is  $W/m^2.K$ .

## V

**Variable Air Volume (VAV) system:** HVAC system that controls the dry-bulb temperature within a space by varying the volumetric flow of heated or cooled air supplied to the space

**Vegetative roofs:** also known as green roofs, they are thin layers of living vegetation installed on top of conventional flat or sloping roofs.

**Ventilation:** the process of supplying or removing air by natural or mechanical means to or from any space. Such air is not required to have been conditioned.

**Vision Windows:** windows or area of large windows that are primarily for both daylight and exterior views. Typically, their placement in the wall is between 1 meter and 2.2 meter above the floor level.

## W

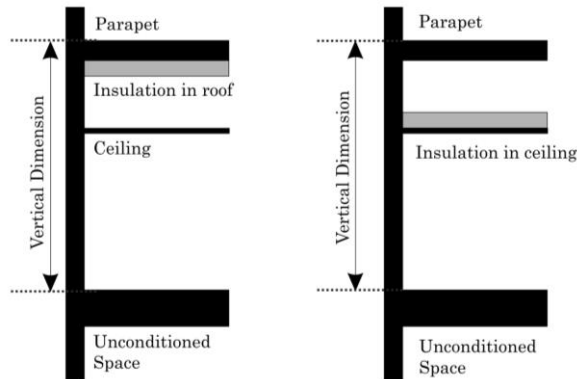
**Wall:** that portion of the building envelope, including opaque area and fenestration, that is vertical or tilted at an angle of  $60^\circ$  from horizontal or greater. This includes above- and below-grade walls, between floor spandrels, peripheral edges of floors, and foundation walls.

(a) Wall, above grade: a wall that is not below grade

(b) Wall, below grade: that portion of a wall in the building envelope that is entirely below the finish grade and in contact with the ground

**Wall area, gross:** the overall area off a wall including openings such as windows and doors measured horizontally from outside surface to outside surface and measured vertically from the top of the floor to the top of the roof. If roof insulation is installed at the ceiling level

rather than the roof, then the vertical measurement is made to the top of the ceiling. The gross wall area includes the area between the ceiling and the floor for multi-story buildings.



**Water heater:** vessel in which water is heated and withdrawn for use external to the system.

## Z

**Zone, HVAC:** a space or group of spaces within a building with heating and cooling requirements that are sufficiently similar so that desired conditions (e.g., temperature) can be maintained throughout using a single sensor (e.g., thermostat or temperature sensor).

**Zone, Critical:** a zone serving a process where reset of the zone temperature setpoint during a demand shed event might disrupt the process, including but not limited to data centers, telecom and private branch exchange (PBX) rooms, and laboratories.

**Zone, Non-Critical:** a zone that is not a critical zone.

### 8.3 SI to IP Conversion Factors

| SI Unit                | IP Unit                           |
|------------------------|-----------------------------------|
| 1 cmh                  | 1.7 cfm                           |
| 1 Pa                   | 0.0040 inch of water gauge        |
| 1m                     | 3.28 ft                           |
| 1m                     | 39.37 in                          |
| 1mm                    | 0.039 in                          |
| 1 l/s                  | 2.12 cfm                          |
| 1 m <sup>2</sup>       | 10.76 ft <sup>2</sup>             |
| 1 W/m <sup>2</sup>     | 10.76 W/ ft <sup>2</sup>          |
| 1 W/ lin m             | 3.28 W/ ft                        |
| 1 W/m <sup>2</sup> .K  | 5.678 Btu/ h-ft <sup>2</sup> -°F  |
| 1 W/ l-s <sup>-1</sup> | 0.063 W/ gpm                      |
| 1 m <sup>2</sup> .K/W  | 0.1761 ft <sup>2</sup> -h-°F/ Btu |
| 1 °C                   | ((°C X 9/5) + 32) °F              |
| 1 kW <sub>r</sub>      | 0.284 TR                          |
| 1 kW                   | 1.34 hp                           |
| 1 kW                   | 3412.142 Btu/hr                   |

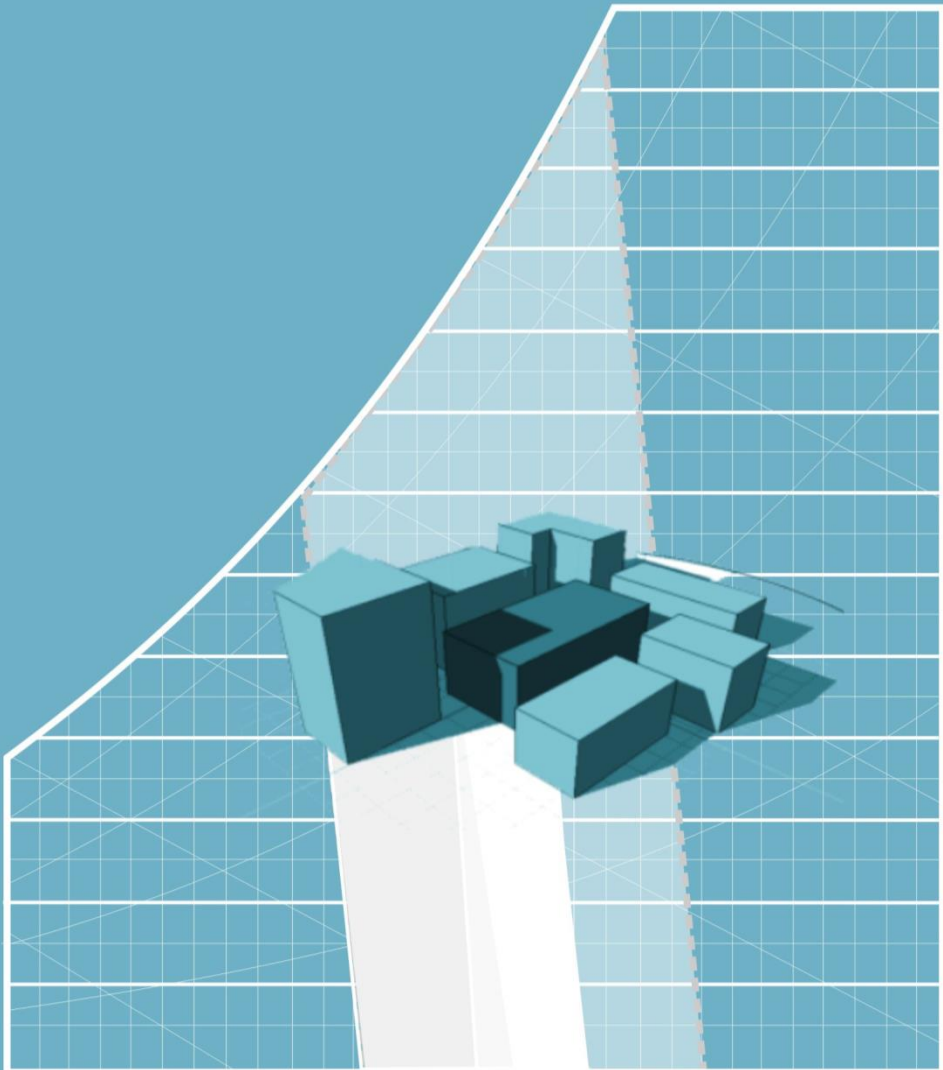
## 8.4 Abbreviations and Acronyms

|                           |   |
|---------------------------|---|
| AFUE                      | Annual fuel utilization efficiency  |
| AHRI                      | Air-conditioning, Heating and Refrigeration Institute                     |
| ANSI                      | American National Standards Institute                                     |
| ARI                       | Air-Conditioning and Refrigeration Institute                              |
| ASHRAE                    | American Society of Heating, Refrigerating and Air-Conditioning Engineers |
| ASTM                      | American Society for Testing and Materials                                |
| BIS                       | Bureau of Indian Standards  |
| Btu                       | British thermal unit  |
| Btu/h                     | British thermal units per hour  |
| Btu/h-ft <sup>2</sup> -°F | British thermal units per hour per square foot per degree Fahrenheit      |
| BUA                       | Built up area   |
| C                         | Celsius   |
| cmh                       | cubic meter per hour  |
| cm                        | centimeter  |
| COP                       | coefficient of performance  |
| DEF                       | daylight extent factor  |
| EER                       | energy efficiency ratio   |
| EPI                       | energy performance index  |
| F                         | Fahrenheit  |
| ft                        | foot  |
| h                         | hour  |
| h-ft <sup>2</sup> -°F/Btu | hour per square foot per degree Fahrenheit per British thermal unit       |
| h-m <sup>2</sup> -°C/W    | hour per square meter per degree Celsius per Watt                         |
| hp                        | horsepower  |
| HVAC                      | heating, ventilation, and air conditioning                                |
| I-P                       | inch-pound  |
| in.                       | inch  |
| IPLV                      | integrated part-load value  |
| IS                        | Indian Standard   |
| ISO                       | International Organization for Standardization                            |
| kVA                       | kilovolt-ampere   |
| kW                        | Kilowatt of electricity   |
| kW <sub>r</sub>           | kilowatt of refrigeration   |
| kWh                       | kilowatt-hour   |
| l/s                       | liter per second  |



|                      |                                   |
|----------------------|-----------------------------------|
| LE                   | luminous efficacy                 |
| lin                  | linear                            |
| lin ft               | linear foot                       |
| lin m                | linear meter                      |
| lm                   | lumens                            |
| Lm/W                 | lumens per watt                   |
| LPD                  | lighting power density            |
| m                    | meter                             |
| mm                   | millimeter                        |
| m <sup>2</sup>       | square meter                      |
| m <sup>2</sup> .K/W  | square meter Kelvin per watt      |
| NBC                  | National Building Code 2016       |
| Pa                   | pascal                            |
| PF                   | projection factor                 |
| R                    | R-value (thermal resistance)      |
| SC                   | shading coefficient               |
| SEF                  | Shading equivalent factor         |
| SHGC                 | solar heat gain coefficient       |
| TR                   | tons of refrigeration             |
| UPS                  | uninterruptible power supply      |
| VAV                  | variable air volume               |
| VLT                  | visible light transmission        |
| W                    | watt                              |
| W/ l-s <sup>-1</sup> | watt per litre per second         |
| W/m <sup>2</sup>     | watts per square meter            |
| W/m <sup>2</sup> .K  | watts per square meter per Kelvin |
| W/m <sup>2</sup>     | watts per hour per square meter   |
| W/m.K                | watts per lineal meter per Kelvin |
| Wh                   | watthour                          |

# 9 Whole Building Performance Method



## 9. Whole Building Performance Method

### 9.1 General

#### 9.1.1 Scope

The Whole Building Performance Method is an alternative to the Prescriptive Method compliance path contained in §4 through §7 of this Code. It applies to all building types covered by the Code as mentioned in §2.5.

#### 9.1.2 Compliance

A building complies with the Code using the Whole Building Performance (WBP) Method, when the estimated EPI Ratio is equal to or less than 1, even though it may not comply with the specific provisions of the prescriptive requirements in §4 through §7. The mandatory requirements of §4 through §7 (§4.2, §5.2, §6.2, and §7.2) shall be met when using the WBP Method.

#### 9.1.3 Annual Energy Use

Annual energy use for the purposes of the WBP Method shall be calculated in kilowatt-hours (kWh) of electricity use per year per unit area. Energy sources other than electricity that are used in the building shall be converted to kWh of electric energy at the rate of 0.75 kWh per megajoule.

**Note:** *The annual energy use calculation as per the Whole Building Performance Method is not a prediction of the actual energy use of the building once it gets operational. Actual energy performance of a building depends on a number of factors like weather, occupant behaviour, equipment performance and maintenance, among others, which are not covered by this Code.*

#### 9.1.4 Trade-offs Limited to Building Permit

The WBP Method may be used for building permit applications that include less than the whole building; however, any design parameters that are not part of the building permit application shall be identical for both the Proposed Design and the Standard Design. Future improvements to the building shall comply with both the mandatory and prescriptive requirements of concurrent code.

#### 9.1.5 Documentation Requirements

Compliance shall be documented and compliance forms shall be submitted to the authority having jurisdiction. The information submitted shall include, at a minimum, the following:

- (a) Summary describing the results of the analysis, including the annual energy use for the Proposed Design and the Standard Design, and software used.
- (b) Brief description of the project with location, number of stories, space types, conditioned and unconditioned areas, hours of operation.
- (c) List of the energy-related building features of the Proposed Design. This list shall also document features different from the Standard Design.
- (d) List showing compliance with the mandatory requirements of this code.
- (e) The input and output report(s) from the simulation program including a breakdown of energy usage by at least the following components: lights, internal equipment loads, service water heating equipment, space heating equipment, space cooling and heat rejection equipment, fans, and other HVAC equipment (such as pumps). The output reports shall also show the number of hours any loads are not met by the HVAC system for both the Proposed Design and Standard Design.
- (f) Explanation of any significant modelling assumptions made.
- (g) Explanation of any error messages noted in the simulation program output.
- (h) Building floor plans, building elevations, and site plan.

## 9.2 Mandatory Requirements

All requirements of §4.2, §5.2, §6.2, and §7.2 shall be met. These sections contain the mandatory provisions of the Code and are prerequisites for demonstrating compliance using the WBP Method.

## 9.3 Simulation Requirements

### 9.3.1 Energy Simulation Program

The simulation software shall be a computer-based program for the analysis of energy consumption in buildings and be approved by the authority having jurisdiction. The simulation program shall, at a minimum, have the ability to model the following:

- (a) Energy flows on an hourly basis for all 8,760 hours of the year,
- (b) Hourly variations in occupancy, lighting power, miscellaneous equipment power, thermostat set points, and HVAC system operation, defined separately for each day of the week and holidays,
- (c) Thermal mass effects,
- (d) Ten or more thermal zones,
- (e) Part-load and temperature dependent performance of heating and cooling equipment,
- (f) Air-side and water-side economizers with integrated control.

In addition to the above, the simulation tool shall be able to produce hourly reports of energy use by energy source and shall have the capability to performing design load calculations to determine required HVAC equipment capacities, air, and water flow rates in accordance with §5 for both the proposed and Standard building designs.

The simulation program shall be tested according to ASHRAE Standard 140 Method of Test

for the Evaluation of Building Energy Analysis Computer Programs (ANSI approved) and the results shall be furnished by the software provider.

### 9.3.2 Climate Data

The simulation program shall use hourly values of climatic data, such as temperature and humidity, from representative climatic data for the city in which the Proposed Design is to be located. For cities or urban regions with several climate data entries, and for locations where weather data are not available, the designer shall select available weather data that best represent the climate at the construction site.

### 9.3.3 Compliance Calculations

The Proposed Design and Standard Design shall be calculated using the following:

- (a) Same simulation program,
- (b) Same weather data, and
- (c) Identical building operation assumptions (thermostat set points, schedules, equipment and occupant loads, etc.) unless an exception is allowed by this Code or the authority having jurisdiction for a given category.

## 9.4 Calculating Energy Consumption of Proposed Design and Standard Design

### 9.4.1 Energy Simulation Model

The simulation model for calculating the Proposed Design and the Standard Design shall be developed in accordance with the requirements in Table 9-1. The Standard Design is based on the mandatory and prescriptive requirements of the ECBC compliant building. The Standard Design will be the same for all compliance levels (ECBC, ECBC+, Super ECBC).

Table 9-1 Modelling Requirements for Calculating Proposed and Standard Design

| Case               | Proposed Design  | Standard Design  |
|--------------------|--|--|
| 1.<br>Design Model | <p>(a) The simulation model of the Proposed Design shall be consistent with the design documents, including proper accounting of fenestration and opaque envelope types and area; interior lighting power and controls; HVAC system types, sizes, and controls; and service water heating systems and controls.</p> <p>(b) When the whole building performance method is applied to buildings in which energy-related features have not been designed yet (e.g., a lighting system), those yet-to-be-designed features shall be described in the Proposed Design so that</p> | <p>The Standard Design shall be developed by modifying the Proposed Design as described in this table. Unless specified in this table, all building systems and equipment shall be modeled identically in the Standard Design and Proposed Design.</p> |

|                                   |   |  |
|-----------------------------------|---|--|
|                                   | they minimally comply with applicable mandatory and prescriptive requirements of §4.2, §5.2, §6.2, and §7.2 and §4.3, §5.3, and §6.3 respectively.  |  |
| 2.<br>Space Use<br>Classification | The building type or space type classifications shall be chosen in accordance with §2.5. More than one building type category may be used in a building if it is a mixed-use facility.  | Same as Proposed Design.   |
| 3.<br>Schedules                   | Operational schedules (hourly variations in occupancy, lighting power, equipment power, HVAC equipment operation, etc.) suitable for the building and/or space type shall be modeled for showing compliance. Schedules must be modeled as per §9.6. In case a schedule for an occupancy type is missing in §9.6, appropriate schedule may be used. Temperature and humidity schedules and set points shall be identical in the Standard and Proposed Designs. Temperature control/thermostat throttling ranges shall also be modeled identically in both the Designs.   | Same as Proposed Design.<br>Exception: Schedules may be allowed to differ between the Standard and Proposed models wherever it is necessary to model nonstandard efficiency measures and/or measures which can be best approximated by a change in schedule. Measures that may warrant a change in operating schedules include but are not limited to automatic controls for lighting, natural ventilation, demand controlled ventilation systems, controls for service water heating load reduction. Schedule change is not allowed for manual controls under any category. This is subject to approval by the authority having jurisdiction.   |
| 4.<br>Building<br>Envelope        | All components of the building envelope in the Proposed Design shall be modeled as shown on architectural drawings or as installed for existing building envelopes. Exceptions: The following building elements are permitted to differ from architectural drawings.<br>(a) Any envelope assembly that covers less than 5% of the total area of that assembly type (e.g., exterior walls) need not be separately described. If not separately described, the area of an envelope assembly must be added to the area of the adjacent assembly of that same type.<br>(b) Exterior surfaces whose azimuth orientation and tilt differ by no more than 45 degrees and are otherwise the same may be described as either a single surface or by using multipliers.<br>(c) For exterior roofs, other than roofs with ventilated attics, the reflectance and emittance of the roof surface shall be modeled in accordance with §4.3.1.1.<br>(d) Manually operated fenestration shading devices such as blinds or shades shall not be | The Standard Design shall have identical conditioned floor area and identical exterior dimensions and orientations as the Proposed Design, except as noted in (a), (b), (c),(d) and (e) below.<br>(a) Orientation. The Standard Design performance shall be generated by simulating the building with its actual orientation and again after rotating the entire building 90, 180, 270 degrees, then averaging the results. The building shall be modeled so that it does not shade itself<br>(b) Opaque assemblies such as roof, floors, doors, and walls shall be modeled with the maximum U-factor allowed in §4.3.1 and §4.3.2.<br>(c) Fenestration. Fenestration areas shall equal that in the Proposed Design or 40% of gross above grade wall area, whichever is smaller, and shall be distributed on each face in the same proportions as in the Proposed Design No shading projections are to be modeled; fenestration shall be assumed to be flush |

|                               |   |
|-------------------------------|---|
| <p><b>5.</b><br/>Lighting</p> | <p>modeled. Permanent shading devices such as fins, overhangs, and light shelves shall be modeled.</p> <p>(e) The exterior roof surface shall be modeled using the solar reflectance in accordance with ASTM E903-96 and thermal emittance determined in accordance with ASTM E408-71. Where cool roof is proposed, emittance and reflectance shall be modeled as per ASTM E408-71 and ASTM E903-96 respectively. Where cool roof is not proposed, the exterior roof surfaces shall be modeled as per §4.3.1.1 i.e. the exterior roof surface shall be modeled with a solar reflectance of 0.70 and a thermal emittance of 0.75.</p> <p>Lighting power in the Proposed Design shall be determined as follows:</p> <p>Where a complete lighting system exists, the actual lighting power shall be used in the model.</p> <p>Where a lighting system has been designed, lighting power shall be determined in accordance with either §6.3.4.</p> <p>Where no lighting exists, or is specified, lighting power shall be determined in accordance with the §6.3.2 or §6.3.3 for the appropriate building type.</p> <p>Lighting system power shall include all lighting system components shown or provided for on plans (including lamps, ballasts, task fixtures, and furniture-mounted fixtures).</p> <p>Lighting power for parking garages, exterior spaces and building facades shall be modeled</p> <p>Minimum Lighting controls, as per the ECBC requirements of §6.2.1, shall be modeled in the Proposed case.</p> <p>Automatic daylighting controls shall be modeled directly in the software or through schedule adjustments determined by a separate daylight analysis approved by the authority having jurisdiction.</p> <p>Other automatic lighting controls shall be modeled directly in the software by adjusting the lighting power as per Table 9-3.</p> <p>with the exterior wall or roof. Manually operated fenestration shading devices such as blinds or shades shall not be modeled. Fenestration U-factor shall be the maximum allowed for the climate, and the solar heat gain coefficient shall be the maximum allowed for the climate and orientation.</p> <p>(d) Skylight areas shall equal that in the Proposed Design or 5% of gross roof area, whichever is smaller.</p> <p>(e) Roof Solar Reflectance and Thermal Emittance: The exterior roof surfaces shall be modeled using a solar reflectance of 0.70 and a thermal emittance of 0.75.as per §4.3.1.1</p> <p>Interior lighting power in the Standard Design shall be determined using the same categorization procedure (building area or space function) and categories as the Proposed Design with lighting power set equal to the maximum allowed for the corresponding method and category in either §6.3.2 or §6.3.3. Power for fixtures not included in the lighting power density calculation shall be modeled identically in the Proposed Design and Standard Design. Lighting controls shall be as per the ECBC requirements of §6.2.1.</p> <p>Exterior lighting power in the standard design shall be set equal to the maximum allowed in §6.3.5</p> |
|-------------------------------|---|

|   |  |
|---|--|
| <div>6.</div> <div>HVAC Thermal Zones</div> | <div><p>HVAC Zones Designed: Where HVAC zones are defined on design drawings, each HVAC zone shall be modeled as a separate thermal block.</p><p>Exception: Identical zones (similar occupancy and usage, similar internal loads, similar set points and type of HVAC system, glazed exterior walls face the same orientation or vary by less than 45°) may be combined for simplicity.</p><p>HVAC Zones Not Designed: Where HVAC zones are not defined on design drawings, HVAC zones shall be defined based on similar occupancy and usage, similar internal loads, similar set points and type of HVAC system, glazed exterior walls that face the same orientation or vary by less than 45° in combination with the following rules:</p><p>Perimeter Core Zoning: Separate thermal block shall be modeled for perimeter and core spaces. Perimeter spaces are defined as spaces located within 5 meters of an exterior or semi exterior wall. Core spaces are defined as spaces located greater than 5 meters of an exterior or semi exterior wall. Separate thermal blocks shall be modeled for floors in contact with ground and for floors which have a ceiling/roof exposure to the ambient.</p></div>   |
| <div>7.</div> <div>HVAC Systems</div>       | <div><p>The HVAC system type and all related performance parameters, such as equipment capacities and efficiencies, in the Proposed Design shall be determined as follows:</p><p>(a) Where a complete HVAC system exists, the model shall reflect the actual system type using actual component capacities and efficiencies.</p><p>(b) Where an HVAC system has been designed, the HVAC model shall be consistent with design documents.</p><p>Mechanical equipment efficiencies shall be adjusted from actual design conditions to the rating conditions specified in §5, if required by the simulation model.</p><p>(c) Where no heating system has been specified, the heating system shall be assumed to be electric. The system characteristics shall be identical to the system modeled in the Standard Design.</p><p>(d) Where no cooling system has been specified, the cooling system and its</p></div> <div><p>Same as Proposed Design</p><p>The HVAC system type shall be as per Table 9-2 and related performance parameters for the Standard Design shall be determined from requirements of §9.4.2. Equipment performance shall meet the requirements of §5 for code compliant building.</p></div> |



|   |   |  |
|---|---|--|
|   | characteristics shall be identical to the system modeled in the Standard Design.  |  |
| <b>8.</b><br>Service Hot Water                                | <p>The service hot water system type and all related performance parameters, such as equipment capacities and efficiencies, in the Proposed Design shall be determined as follows:</p> <p>(a) Where a complete service hot water system exists, the model shall reflect the actual system type using actual component capacities and efficiencies.</p> <p>(b) Where a service hot water system has been designed, the service hot water model shall be consistent with design documents.</p> <p>(c) Where no service hot water system exists, or is specified, no service hot water heating shall be modeled.</p>   | <p>The service water heating system shall be of the same type as the Proposed Design. For residential facilities, hotels and hospitals the Standard Design shall have a solar hot water system capable of meeting 20% of the hot water demand. Systems shall meet the efficiency requirements of §5.2.7.2.</p> |
| <b>9.</b><br>Miscellaneous Loads                              | <p>Receptacle, motor, and process loads shall be modeled and estimated based on the building type or space type category. These loads shall be included in simulations of the building and shall be included when calculating the Standard Design and Proposed Design. All end-use load components within and associated with the building shall be modeled, unless specifically excluded by this Table, but not limited to, exhaust fans, parking garage ventilation fans, exterior building lighting, swimming pool heaters and pumps, elevators and escalators, refrigeration equipment, and cooking equipment.</p>  | <p>Receptacle, motor and process loads shall be modeled the same as the Proposed Design.</p>   |
| <b>10.</b><br>Modelling Limitations to the Simulation Program | <p>If the simulation program cannot model a component or system included in the Proposed Design, one of the following methods shall be used with the approval of the authority having jurisdiction:</p> <p>(a) Ignore the component if the energy impact on the trade-offs being considered is not significant.</p> <p>(b) Model the component substituting a thermodynamically similar component model.</p> <p>(c) Model the HVAC system components or systems using the HVAC system of the Standard Design in accordance with Section 6 of this table.</p> <p>Whichever method is selected, the component shall be modeled identically for both the Proposed Design and Standard Design models.</p> | <p>Same as Proposed Design.</p>  |

Table 9-2 HVAC Systems Map for Standard Design

|                          |   |  |  |  |
|--------------------------|---|--|--|--|
|                          | Hotel/Motel, Hospital Patient Rooms, Hotel Guest Rooms, Resorts, Villas, Sleeping Quarters in Mixed-use Buildings, Schools, Classrooms/Lecture Rooms <sup>1</sup>   | Buildings with Less than or Equal to 12,500 m <sup>2</sup> of Conditioned Area   | Buildings with More than 12,500 m <sup>2</sup> of Conditioned Area   | Data Centre/ Server/Computer Rooms         |
| Name                     | <b>System A</b>   | <b>System B</b>  | <b>System C</b>  | <b>System D</b>                            |
| System Type <sup>2</sup> | Split AC  | VRF: Variable Refrigerant Flow   | VAV: Central cooling plant with variable volume AHU <sup>3</sup>   | Computer Room air conditioners             |
| Fan Control              | Constant Volume   | Constant volume  | Variable volume  | Constant volume                            |
| Cooling Type             | Direct expansion with air cooled condenser  | Direct expansion with air cooled condenser   | Chilled Water with water cooled condenser  | Direct expansion with air cooled condenser |
| Heating Type             | 1. Heat Pump: Where no heating system has been specified or where an electric heating system has been specified in the Proposed Design<br>2. Fossil Fuel Boiler, Fossil/Electric Hybrid: Where a heating system exists and a fossil fuel hot water boiler has been specified in the Proposed Design | 1. Heat Pump: Where no heating system has been specified or where an electric heating system has been specified in the Proposed Design<br>2. Fossil Fuel Boiler Fossil/Electric Hybrid: Where a heating system exists and a fossil fuel hot water boiler has been specified in the Proposed Design | 1. Electric resistance: Where no heating system has been specified or where an electric heating system has been specified in the Proposed Design<br>2. Fossil Fuel Boiler Fossil/Electric Hybrid: Where a heating system exists and a fossil fuel hot water boiler has been specified in the Proposed Design | NA   |

## Notes:

1. Buildings of the listed occupancy types or spaces in Mixed-use Buildings with the listed occupancy types.

2. Where attributes make a building eligible for more than one system type; use the predominant condition to determine the Standard Design system type provided the non-predominant conditions apply to less than 1,000 m<sup>2</sup> of conditioned floor area. Use additional system type for non-predominant conditions if those conditions apply to more than 1,000 m<sup>2</sup> of conditioned floor area. Use additional system type for any space which has a substantial difference in peak loads and/or operational hours compared to the predominant space type. Such spaces may include but are not limited to computer/server rooms, retail areas in residential, or office buildings.

3. One AHU per floor at a minimum.

Table 9-3 Power Adjustment Factors for Automatic Lighting Controls

| <i>Automatic Control Device</i>                  | <i>Daytime occupancy and area &lt;300 m<sup>2</sup></i> | <i>All Others</i> |
|--|---|-------------------|
| Programmable Timing Control                      | 10%   | 0%                |
| Occupancy Sensor                                 | 10%   | 10%               |
| Occupancy Sensor and Programmable Timing Control | 15%   | 10%               |

## 9.4.2 HVAC Systems

The HVAC system type and related performance parameters for the Standard Design shall be determined from Table 9-2 and the following rules:

- (a) Other components: Components and parameters not listed in Table 9-2 or otherwise specifically addressed in this subsection shall be identical to those in the Proposed Design.

Exception to § 9.4.2(a): Where there are specific requirements in §5.2.2, the component efficiency in the Standard Design shall be adjusted to the lowest efficiency level allowed by the requirement for that component type.

- (b) All HVAC and service water heating equipment in the Standard Design shall be modeled at the minimum efficiency levels, both part load and full load, in accordance with §5.2.2.
- (c) Where efficiency ratings, such as EER and COP, include fan energy, the descriptor shall be broken down into its components so that supply fan energy can be modeled separately.
- (d) Minimum outdoor air ventilation rates shall be the same for both the Standard Design and the Proposed Design except for conditions specified in §9.4.2.1.
- (e) The equipment capacity for the standard design shall be based on sizing runs for each orientation and shall be oversized by 15% for cooling and 25% for heating, i.e., the ratio between the capacities determined by the sizing runs shall be 1.15 for cooling and 1.25 for heating.
- (f) Unmet load hours for the Proposed Design shall not differ from unmet load hours for the Standard Design by more than 50 hours. Maximum number of unmet hours shall not exceed 300 for either case.

### 9.4.2.1 Minimum Outdoor air rates:

Minimum outdoor air rates shall be identical for both the Standard Design and Proposed Design, except

- (a) when modeling demand controlled ventilation (DCV) in the Proposed Design (DCV is not required in the Standard Design as per §5.2.1.3.
- (b) when the Proposed Design has a ventilation flow higher than the minimum required by the applicable code, the Standard Design shall be modeled as per the minimum

ventilation rate required by the applicable code and the Proposed Design shall be modeled as per actual design (higher than Standard Design)

#### 9.4.2.2 Fan Schedules

Supply and return fans shall operate continuously whenever the spaces are occupied and shall be cycled to meet heating and cooling loads during unoccupied hours.

#### 9.4.2.3 Fan Power

(a) For Systems Types A, B and D,

$$P_{fan} = cmh \times .51$$

Where  $P_{fan}$  = Standard Design fan power in watts

cmh = Standard Design supply airflow rate auto-sized by the simulation software

(b) For System Type C

Fan power shall be modeled as per efficiency limits specified in Table 5-11 using a static pressure of 622 Pa or the design static pressure, whichever is higher. The simulation software shall automatically calculate the Standard Design fan power based on the above inputs.

#### 9.4.2.4 Design Airflow Rates

Design airflow rates for the Standard Design shall be sized based on a supply air to room air temperature difference of 11 °C for cooling and 18°C for heating. The Proposed Design airflow rates shall be as per design.

#### 9.4.2.5 Economizers (airside and waterside)

Airside economizers shall be modeled in the Standard Design as per the requirements of §5.3.5.

Exception to §9.4.2.5: Airside economizer shall not be modeled for Standard Design HVAC System Type A.

#### 9.4.2.6 Energy Recovery

Energy recovery shall be modeled in the Standard Design as per the requirements of §5.3.

#### 9.4.2.7 Chilled Water Design Supply Temperatures

Chilled water design supply temperature shall be modeled at 6.7°C and return temperature at 13.3°C.

#### 9.4.2.8 Chillers

Only electric chillers shall be modeled in the Standard Design for System C. Chillers shall meet the minimum efficiency requirements indicated in Table 5-1 and Table 5-2. Chillers in the Standard Design shall be selected as per Table 9-4 below:

Table 9-4 Types and Number of Chillers for Standard Design

| Peak Building Cooling Load (kW <sub>r</sub> ) | Chiller Type  |
|---|---|
| < 1,055                                       | 1 Water Cooled Screw Chiller  |
| 1,055 to 2,110                                | 2 Water Cooled Screw Chillers equally sized   |
| > 2,110                                       | 2 or more Water Cooled Centrifugal Chillers, equally sized such that no Chiller is greater than 2,813 kW <sub>r</sub> |

Exception to 9.4.2.8: Air cooled chillers are allowed to be modeled in the Standard Design if the Proposed Design has air cooled chillers. If the proposed building has a mix of air and water cooled chillers, then the Standard Design shall be modeled with a mix of air and water cooled chillers in the same proportion as in the Proposed Design.

#### 9.4.2.9 Chilled Water Pumps

*Chilled and condenser water pumps for the Standard Design shall be modeled as per power and efficiency limits specified in*

Table 5-16. Standard Design chilled water pumps shall be modeled as primary-secondary with variable secondary flow.

#### 9.4.2.10 Cooling Tower

Standard Design cooling tower shall be modeled as an open circuit axial flow tower with power and efficiency as per §5.3.3. The fans shall be modeled as two speed.

Condenser water design supply temperature shall be 29.4°C or 5.6°C approach to wet bulb temperature, whichever is lower, with a design temperature rise of 5.6°C.

#### 9.4.2.11 Boiler

Standard Design boilers shall be modeled as natural draft boilers and shall use the same fuel as the Proposed Design. Boiler efficiency shall be modeled as per Table 5-6.

#### 9.4.2.12 Hot Water Design Supply Temperatures

Hot water design supply temperature shall be modeled at 82°C and return temperature at 54°C.

#### 9.4.2.13 Hot Water Pumps

The Standard Design hot water pumps shall be modeled with a minimum efficiency of 70% and a pump power of 300 W/l-s<sup>-1</sup>.

Standard Design hot water pumps shall be modeled as primary-secondary with variable secondary flow.

#### 9.4.2.14 Campus/District Cooling Systems

All district cooling plants shall be assumed to be on grid electricity, unless otherwise specified and supported through pertinent documents. New district plants shall comply with

the mandatory requirements of ECBC irrespective of who owns and/or operates the district plant.

Projects may choose either option A or option B given below for modelling campus/district cooling systems.

#### **Option A**

The cooling source shall be modeled as purchased chilled water in both the Standard Design and Proposed Design. For the Standard Design, Table 9-2, shall be modified as follows:

- (a) For System Type C; purchased chilled water shall be modeled as the cooling source.
- (b) System Types A and B shall be replaced with a two-pipe fan coil system with purchased chilled water as the cooling source.

The chilled water/thermal energy consumption simulated by the software shall be converted to units of kWh and added to the overall building energy consumption. The following conversion factors shall be used to convert chilled water/thermal energy consumption to units of kWh.

$$1 \text{ ton hour} = 0.85 \text{ kWh}$$

$$1 \text{ MBtu} = 1,000,000 \text{ Btu} = 293 \text{ kWh}$$

#### **Option B**

The Standard Design shall be modeled as per Table 9-2 HVAC Systems Map.

For the Proposed Design, model a virtual onsite chilled water plant with Chiller, Pumps and cooling towers modeled at minimum efficiency levels as per §9.4.2.7 to §9.4.2.10.

Airside/low side capacities shall be modeled as per design and the plant capacities shall be auto-sized by the software.

### **9.4.3 Compliance Thresholds for ECBC compliant, ECBC+ and SuperECBC Buildings**

For buildings to qualify as ECBC+ and SuperECBC Buildings, the WBP Method shall be followed for the Standard Design as detailed above. The Proposed Design for ECBC+ and SuperECBC Buildings shall meet the mandatory provisions of §4.2, §5.2, §6.2, and §7.2.

The EPI Ratio for ECBC+ and SuperECBC Buildings shall be equal to or less than the EPI Ratios listed under the applicable climate zone in Table 9-5 through Table 9-9 of §9.5.

## 9.5 Maximum Allowed EPI Ratios

Table 9-5 Maximum Allowed EPI Ratios for Building in Composite Climate

| Building Type            | Composite |       |           |
|--------------------------|-----------|-------|-----------|
|                          | ECBC      | ECBC+ | SuperECBC |
| Hotel (No Star and Star) | 1         | 0.91  | 0.81      |
| Resort                   | 1         | 0.88  | 0.76      |
| Hospital                 | 1         | 0.85  | 0.77      |
| Outpatient               | 1         | 0.85  | 0.75      |
| Assembly                 | 1         | 0.86  | 0.77      |
| Office (Regular Use)     | 1         | 0.86  | 0.78      |
| Office (24Hours)         | 1         | 0.88  | 0.76      |
| Schools and University   | 1         | 0.77  | 0.66      |
| Open Gallery Mall        | 1         | 0.85  | 0.76      |
| Shopping Mall            | 1         | 0.86  | 0.74      |
| Supermarket              | 1         | 0.81  | 0.70      |
| Strip retail             | 1         | 0.82  | 0.68      |

Table 9-6 Maximum Allowed EPI Ratios for Buildings in Hot and Dry Climate

| Building Type            | Hot and Dry |       |           |
|--------------------------|-------------|-------|-----------|
|                          | ECBC        | ECBC+ | SuperECBC |
| Hotel (No Star and Star) | 1           | 0.90  | 0.81      |
| Resort                   | 1           | 0.88  | 0.76      |
| Hospital                 | 1           | 0.84  | 0.76      |
| Outpatient               | 1           | 0.85  | 0.75      |
| Assembly                 | 1           | 0.86  | 0.78      |
| Office (Regular Use)     | 1           | 0.86  | 0.78      |
| Office (24Hours)         | 1           | 0.88  | 0.76      |
| Schools and University   | 1           | 0.77  | 0.66      |
| Open Gallery Mall        | 1           | 0.85  | 0.77      |
| Shopping Mall            | 1           | 0.84  | 0.72      |
| Supermarket              | 1           | 0.73  | 0.69      |
| Strip retail             | 1           | 0.82  | 0.68      |

Table 9-7 Maximum Allowed EPI Ratios for Buildings in Temperate Climate

| Building Type            | Temperate |       |           |
|--------------------------|-----------|-------|-----------|
|                          | ECBC      | ECBC+ | SuperECBC |
| Hotel (No Star and Star) | 1         | 0.90  | 0.80      |
| Resort                   | 1         | 0.88  | 0.75      |
| Hospital                 | 1         | 0.82  | 0.73      |
| Outpatient               | 1         | 0.85  | 0.75      |
| Assembly                 | 1         | 0.85  | 0.76      |
| Office (Regular Use)     | 1         | 0.85  | 0.75      |
| Office (24Hours)         | 1         | 0.87  | 0.74      |
| Schools and University   | 1         | 0.77  | 0.66      |
| Open Gallery Mall        | 1         | 0.83  | 0.74      |
| Shopping Mall            | 1         | 0.84  | 0.71      |
| Supermarket              | 1         | 0.81  | 0.69      |
| Strip retail             | 1         | 0.81  | 0.67      |

Table 9-8 Maximum Allowed EPI Ratios for Buildings in Warm and Humid Climate

| Building Type            | Warm and Humid |       |           |
|--------------------------|----------------|-------|-----------|
|                          | ECBC           | ECBC+ | SuperECBC |
| Hotel (No Star and Star) | 1              | 0.91  | 0.81      |
| Resort                   | 1              | 0.88  | 0.75      |
| Hospital                 | 1              | 0.86  | 0.77      |
| Outpatient               | 1              | 0.86  | 0.76      |
| Assembly                 | 1              | 0.88  | 0.80      |
| Office (Regular Use)     | 1              | 0.86  | 0.76      |
| Office (24Hours)         | 1              | 0.88  | 0.76      |
| Schools and University   | 1              | 0.77  | 0.66      |
| Open Gallery Mall        | 1              | 0.86  | 0.77      |
| Shopping Mall            | 1              | 0.85  | 0.72      |
| Supermarket              | 1              | 0.82  | 0.70      |
| Strip retail             | 1              | 0.83  | 0.68      |



Table 9-9 Maximum Allowed EPI Ratios for Buildings in Cold Climate

| Building Type            | Cold |       |           |
|--------------------------|------|-------|-----------|
|                          | ECBC | ECBC+ | SuperECBC |
| Hotel (No Star and Star) | 1    | 0.91  | 0.82      |
| Resort                   | 1    | 0.88  | 0.75      |
| Hospital                 | 1    | 0.88  | 0.80      |
| Outpatient               | 1    | 0.85  | 0.75      |
| Assembly                 | 1    | 0.87  | 0.81      |
| Office (Regular Use)     | 1    | 0.88  | 0.80      |
| Office (24Hours)         | 1    | 0.87  | 0.75      |
| Schools and University   | 1    | 0.85  | 0.73      |
| Open Gallery Mall        | 1    | 0.82  | 0.73      |
| Shopping Mall            | 1    | 0.96  | 0.93      |
| Supermarket              | 1    | 0.80  | 0.68      |
| Strip retail             | 1    | 0.80  | 0.66      |

## 9.6 Schedules

Table 9-10 Schedules for Business - Office Buildings

| Business - Office |                    |                   |                            |                      |                   |                   |                   |
|-------------------|--------------------|-------------------|----------------------------|----------------------|-------------------|-------------------|-------------------|
| Time Period       | Elevator Schedules |                   | External Lighting Schedule | Basement Ventilation |                   | Basement Lighting |                   |
|                   | Daytime Business   | 24 Hours Business | 7 Days / week              | Daytime Business     | 24 Hours Business | Daytime Business  | 24 Hours Business |
| 00:00-01:00       | 0.05               | 0.55              | 0.80                       | 0.00                 | 1.00              | 0.05              | 1.00              |
| 01:00-02:00       | 0.05               | 0.25              | 0.80                       | 0.00                 | 1.00              | 0.05              | 1.00              |
| 02:00-03:00       | 0.05               | 0.25              | 0.80                       | 0.00                 | 1.00              | 0.05              | 1.00              |
| 03:00-04:00       | 0.05               | 0.15              | 0.80                       | 0.00                 | 1.00              | 0.05              | 1.00              |
| 04:00-05:00       | 0.05               | 0.35              | 0.80                       | 0.00                 | 1.00              | 0.05              | 1.00              |
| 05:00-06:00       | 0.05               | 0.50              | 0.80                       | 0.00                 | 1.00              | 0.05              | 1.00              |
| 06:00-07:00       | 0.20               | 0.20              | 0.00                       | 0.00                 | 1.00              | 0.05              | 1.00              |
| 07:00-08:00       | 0.40               | 0.40              | 0.00                       | 0.00                 | 1.00              | 0.05              | 1.00              |
| 08:00-09:00       | 0.80               | 0.80              | 0.00                       | 1.00                 | 1.00              | 1.00              | 1.00              |
| 09:00-10:00       | 0.80               | 0.80              | 0.00                       | 1.00                 | 1.00              | 1.00              | 1.00              |
| 10:00-11:00       | 0.55               | 0.55              | 0.00                       | 1.00                 | 1.00              | 1.00              | 1.00              |
| 11:00-12:00       | 0.35               | 0.35              | 0.00                       | 1.00                 | 1.00              | 1.00              | 1.00              |
| 12:00-13:00       | 0.25               | 0.25              | 0.00                       | 1.00                 | 1.00              | 1.00              | 1.00              |
| 13:00-14:00       | 0.95               | 0.95              | 0.00                       | 1.00                 | 1.00              | 1.00              | 1.00              |
| 14:00-15:00       | 0.95               | 0.95              | 0.00                       | 1.00                 | 1.00              | 1.00              | 1.00              |
| 15:00-16:00       | 0.35               | 0.35              | 0.00                       | 1.00                 | 1.00              | 1.00              | 1.00              |
| 16:00-17:00       | 0.15               | 0.35              | 0.00                       | 1.00                 | 1.00              | 1.00              | 1.00              |
| 17:00-18:00       | 0.75               | 0.70              | 0.00                       | 1.00                 | 1.00              | 1.00              | 1.00              |
| 18:00-19:00       | 0.95               | 0.95              | 0.80                       | 1.00                 | 1.00              | 1.00              | 1.00              |
| 19:00-20:00       | 0.50               | 0.50              | 0.80                       | 1.00                 | 1.00              | 1.00              | 1.00              |
| 20:00-21:00       | 0.30               | 0.35              | 0.80                       | 1.00                 | 1.00              | 1.00              | 1.00              |
| 21:00-22:00       | 0.20               | 0.25              | 0.80                       | 0.00                 | 1.00              | 0.05              | 1.00              |
| 22:00-23:00       | 0.05               | 0.25              | 0.80                       | 0.00                 | 1.00              | 0.05              | 1.00              |
| 23:00-24:00       | 0.05               | 0.55              | 0.80                       | 0.00                 | 1.00              | 0.05              | 1.00              |

Table 9-11: Schedules for Business - Office Building Daytime Business

| Business – Office Daytime Business |                    |                    |                         |                   |                    |                         |                    |                         |                                    |         |
|------------------------------------|--------------------|--------------------|-------------------------|-------------------|--------------------|-------------------------|--------------------|-------------------------|------------------------------------|---------|
| Time Period                        | Occupancy Schedule |                    |                         | Lighting Schedule |                    |                         | Equipment Schedule |                         | HVAC Fan Schedule (On/Off)         |         |
|                                    | Office             | Corridor/<br>Lobby | Conference<br>/ Meeting | Office            | Corridor/<br>Lobby | Conference<br>/ Meeting | Office             | Conference<br>/ Meeting | Office/<br>Corridor/<br>Conference | Meeting |
| 00:00-01:00                        | 0.00               | 0.00               | 0.00                    | 0.10              | 0.10               | 0.00                    | 0.00               | 0.00                    | 0                                  | 0       |
| 01:00-02:00                        | 0.00               | 0.00               | 0.00                    | 0.10              | 0.10               | 0.00                    | 0.00               | 0.00                    | 0                                  | 0       |
| 02:00-03:00                        | 0.00               | 0.00               | 0.00                    | 0.10              | 0.10               | 0.00                    | 0.00               | 0.00                    | 0                                  | 0       |
| 03:00-04:00                        | 0.00               | 0.00               | 0.00                    | 0.10              | 0.10               | 0.00                    | 0.00               | 0.00                    | 0                                  | 0       |
| 04:00-05:00                        | 0.00               | 0.00               | 0.00                    | 0.10              | 0.10               | 0.00                    | 0.00               | 0.00                    | 0                                  | 0       |
| 05:00-06:00                        | 0.00               | 0.00               | 0.00                    | 0.10              | 0.10               | 0.00                    | 0.00               | 0.00                    | 0                                  | 0       |
| 06:00-07:00                        | 0.00               | 0.00               | 0.00                    | 0.10              | 0.10               | 0.00                    | 0.00               | 0.00                    | 0                                  | 0       |
| 07:00-08:00                        | 0.00               | 0.00               | 0.00                    | 0.10              | 0.10               | 0.00                    | 0.00               | 0.00                    | 1                                  | 0       |
| 08:00-09:00                        | 0.20               | 0.70               | 0.00                    | 0.90              | 0.90               | 0.00                    | 0.10               | 0.00                    | 1                                  | 1       |
| 09:00-10:00                        | 0.95               | 0.80               | 0.00                    | 0.90              | 0.90               | 0.00                    | 0.90               | 0.00                    | 1                                  | 1       |
| 10:00-11:00                        | 0.95               | 0.70               | 0.75                    | 0.90              | 0.90               | 0.90                    | 0.90               | 0.90                    | 1                                  | 1       |
| 11:00-12:00                        | 0.95               | 0.30               | 0.75                    | 0.90              | 0.90               | 0.90                    | 0.90               | 0.90                    | 1                                  | 1       |
| 12:00-13:00                        | 0.95               | 0.30               | 0.75                    | 0.90              | 0.90               | 0.90                    | 0.90               | 0.90                    | 1                                  | 1       |
| 13:00-14:00                        | 0.50               | 0.80               | 0.5                     | 0.50              | 0.90               | 0.50                    | 0.80               | 0.50                    | 1                                  | 1       |
| 14:00-15:00                        | 0.95               | 0.50               | 0.75                    | 0.90              | 0.90               | 0.90                    | 0.90               | 0.90                    | 1                                  | 1       |
| 15:00-16:00                        | 0.95               | 0.30               | 0.75                    | 0.90              | 0.90               | 0.90                    | 0.90               | 0.90                    | 1                                  | 1       |
| 16:00-17:00                        | 0.95               | 0.30               | 0.75                    | 0.90              | 0.90               | 0.90                    | 0.90               | 0.90                    | 1                                  | 1       |
| 17:00-18:00                        | 0.95               | 0.80               | 0.75                    | 0.95              | 0.90               | 0.90                    | 0.90               | 0.90                    | 1                                  | 1       |
| 18:00-19:00                        | 0.30               | 0.70               | 0.50                    | 0.50              | 0.90               | 0.90                    | 0.50               | 0.90                    | 1                                  | 1       |
| 19:00-20:00                        | 0.00               | 0.30               | 0.00                    | 0.30              | 0.90               | 0.00                    | 0.10               | 0.00                    | 1                                  | 0       |
| 20:00-21:00                        | 0.00               | 0.00               | 0.00                    | 0.10              | 0.10               | 0.00                    | 0.10               | 0.00                    | 1                                  | 0       |
| 21:00-22:00                        | 0.00               | 0.00               | 0.00                    | 0.10              | 0.10               | 0.00                    | 0.00               | 0.00                    | 0                                  | 0       |
| 22:00-23:00                        | 0.00               | 0.00               | 0.00                    | 0.10              | 0.10               | 0.00                    | 0.00               | 0.00                    | 0                                  | 0       |
| 23:00-24:00                        | 0.00               | 0.00               | 0.00                    | 0.10              | 0.10               | 0.00                    | 0.00               | 0.00                    | 0                                  | 0       |

Table 9-12: Schedules for Business - Office Building 24-hours Business

| Business – Office 24-hour Business |                    |                 |                     |                   |                 |                     |                    |                     |  |
|------------------------------------|--------------------|-----------------|---------------------|-------------------|-----------------|---------------------|--------------------|---------------------|--|
| Time Period                        | Occupancy Schedule |                 |                     | Lighting Schedule |                 |                     | Equipment Schedule |                     | HVAC Fan Schedule (On/Off)                   |
|                                    | Office             | Corridor/ Lobby | Conference/ Meeting | Office            | Corridor/ Lobby | Conference/ Meeting | Office             | Conference/ Meeting | Office/ Corridor/ Lobby/ Conference/ Meeting |
| 00:00-01:00                        | 0.90               | 0.20            | 0.00                | 0.90              | 0.90            | 0.00                | 0.95               | 0.00                | 1  |
| 01:00-02:00                        | 0.90               | 0.50            | 0.00                | 0.90              | 0.90            | 0.00                | 0.95               | 0.00                | 1  |
| 02:00-03:00                        | 0.90               | 0.20            | 0.00                | 0.90              | 0.90            | 0.00                | 0.95               | 0.00                | 1  |
| 03:00-04:00                        | 0.90               | 0.20            | 0.00                | 0.90              | 0.90            | 0.00                | 0.95               | 0.00                | 1  |
| 04:00-05:00                        | 0.50               | 0.20            | 0.50                | 0.50              | 0.90            | 0.50                | 0.00               | 0.90                | 1  |
| 05:00-06:00                        | 0.20               | 0.50            | 0.50                | 0.05              | 0.90            | 0.50                | 0.00               | 0.90                | 1  |
| 06:00-07:00                        | 0.10               | 0.50            | 0.50                | 0.05              | 0.50            | 0.50                | 0.00               | 0.90                | 1  |
| 07:00-08:00                        | 0.10               | 0.50            | 0.00                | 0.90              | 0.50            | 0.00                | 0.95               | 0.00                | 1  |
| 08:00-09:00                        | 0.90               | 0.70            | 0.00                | 0.90              | 0.90            | 0.00                | 0.95               | 0.00                | 1  |
| 09:00-10:00                        | 0.90               | 0.80            | 0.50                | 0.90              | 0.90            | 0.50                | 0.95               | 0.90                | 1  |
| 10:00-11:00                        | 0.90               | 0.70            | 0.75                | 0.90              | 0.90            | 0.90                | 0.95               | 0.90                | 1  |
| 11:00-12:00                        | 0.90               | 0.30            | 0.75                | 0.90              | 0.90            | 0.90                | 0.95               | 0.90                | 1  |
| 12:00-13:00                        | 0.90               | 0.30            | 0.75                | 0.90              | 0.90            | 0.90                | 0.95               | 0.90                | 1  |
| 13:00-14:00                        | 0.20               | 0.80            | 0.25                | 0.50              | 0.50            | 0.50                | 0.20               | 0.50                | 1  |
| 14:00-15:00                        | 0.90               | 0.50            | 0.75                | 0.90              | 0.90            | 0.90                | 0.95               | 0.90                | 1  |
| 15:00-16:00                        | 0.90               | 0.30            | 0.75                | 0.90              | 0.90            | 0.90                | 0.95               | 0.90                | 1  |
| 16:00-17:00                        | 0.90               | 0.30            | 0.75                | 0.90              | 0.90            | 0.90                | 0.95               | 0.90                | 1  |
| 17:00-18:00                        | 0.90               | 0.80            | 0.75                | 0.90              | 0.90            | 0.90                | 0.95               | 0.90                | 1  |
| 18:00-19:00                        | 0.90               | 0.70            | 0.50                | 0.90              | 0.90            | 0.90                | 0.20               | 0.90                | 1  |
| 19:00-20:00                        | 0.20               | 0.30            | 0.00                | 0.90              | 0.90            | 0.00                | 0.95               | 0.00                | 1  |
| 20:00-21:00                        | 0.90               | 0.20            | 0.00                | 0.90              | 0.90            | 0.00                | 0.95               | 0.00                | 1  |
| 21:00-22:00                        | 0.90               | 0.20            | 0.50                | 0.90              | 0.90            | 0.50                | 0.95               | 0.90                | 1  |
| 22:00-23:00                        | 0.90               | 0.20            | 0.50                | 0.90              | 0.90            | 0.50                | 0.95               | 0.90                | 1  |
| 23:00-24:00                        | 0.90               | 0.20            | 0.50                | 0.90              | 0.90            | 0.50                | 0.20               | 0.90                | 1  |

Table 9-13: Schedules for Business - Server Room

| Business Building - Server Room |                    |                  |                   |                  |                    |                            |
|---------------------------------|--------------------|------------------|-------------------|------------------|--------------------|----------------------------|
| Time Period                     | Occupancy Schedule |                  | Lighting Schedule |                  | Equipment Schedule | HVAC Fan Schedule (ON/OFF) |
|                                 | Daytime Business   | 24-hour business | Daytime Business  | 24-hour business | All time running   |                            |
| 00:00-01:00                     | 0.00               | 0.00             | 0.10              | 0.10             | 1.00               | 1                          |
| 01:00-02:00                     | 0.00               | 0.00             | 0.10              | 0.10             | 1.00               | 1                          |
| 02:00-03:00                     | 0.00               | 0.00             | 0.10              | 0.10             | 1.00               | 1                          |
| 03:00-04:00                     | 0.00               | 0.00             | 0.10              | 0.10             | 1.00               | 1                          |
| 04:00-05:00                     | 0.00               | 0.00             | 0.10              | 0.10             | 1.00               | 1                          |
| 05:00-06:00                     | 0.00               | 1.00             | 0.10              | 0.10             | 1.00               | 1                          |
| 06:00-07:00                     | 0.00               | 1.00             | 0.10              | 0.10             | 1.00               | 1                          |
| 07:00-08:00                     | 0.00               | 1.00             | 0.10              | 0.10             | 1.00               | 1                          |
| 08:00-09:00                     | 1.00               | 1.00             | 0.10              | 0.10             | 1.00               | 1                          |
| 09:00-10:00                     | 1.00               | 1.00             | 0.50              | 0.50             | 1.00               | 1                          |
| 10:00-11:00                     | 1.00               | 1.00             | 0.50              | 0.50             | 1.00               | 1                          |
| 11:00-12:00                     | 1.00               | 1.00             | 0.50              | 0.50             | 1.00               | 1                          |
| 12:00-13:00                     | 1.00               | 1.00             | 0.50              | 0.50             | 1.00               | 1                          |
| 13:00-14:00                     | 1.00               | 1.00             | 0.50              | 0.50             | 1.00               | 1                          |
| 14:00-15:00                     | 1.00               | 1.00             | 0.50              | 0.50             | 1.00               | 1                          |
| 15:00-16:00                     | 1.00               | 1.00             | 0.50              | 0.50             | 1.00               | 1                          |
| 16:00-17:00                     | 1.00               | 1.00             | 0.50              | 0.50             | 1.00               | 1                          |
| 17:00-18:00                     | 1.00               | 1.00             | 0.50              | 0.50             | 1.00               | 1                          |
| 18:00-19:00                     | 0.00               | 1.00             | 0.10              | 0.50             | 1.00               | 1                          |
| 19:00-20:00                     | 0.00               | 1.00             | 0.10              | 0.50             | 1.00               | 1                          |
| 20:00-21:00                     | 0.00               | 1.00             | 0.10              | 0.50             | 1.00               | 1                          |
| 21:00-22:00                     | 0.00               | 1.00             | 0.10              | 0.50             | 1.00               | 1                          |
| 22:00-23:00                     | 0.00               | 0.00             | 0.10              | 0.10             | 1.00               | 1                          |
| 23:00-24:00                     | 0.00               | 0.00             | 0.10              | 0.10             | 1.00               | 1                          |

Table 9-14: Schedules for Assembly Buildings (A)

| Assembly Buildings – Common Areas |                   |                            |               |                          |                            |                      |                   |
|-----------------------------------|-------------------|----------------------------|---------------|--------------------------|----------------------------|----------------------|-------------------|
| Time Period                       | Elevator Schedule | HVAC Fan Schedule (On/Off) |               |                          | External Lighting Schedule | Basement Ventilation | Basement Lighting |
|                                   |                   | Seating / Public Space     | Exhibit Space | Meeting/ Conference Room |                            |                      |                   |
| 00:00-01:00                       | 0.00              | 0                          | 0             | 0                        | 0.80                       | 0.00                 | 0.05              |
| 01:00-02:00                       | 0.00              | 0                          | 0             | 0                        | 0.80                       | 0.00                 | 0.05              |
| 02:00-03:00                       | 0.00              | 0                          | 0             | 0                        | 0.80                       | 0.00                 | 0.05              |
| 03:00-04:00                       | 0.00              | 0                          | 0             | 0                        | 0.80                       | 0.00                 | 0.05              |
| 04:00-05:00                       | 0.00              | 0                          | 0             | 0                        | 0.80                       | 0.00                 | 0.05              |
| 05:00-06:00                       | 0.00              | 0                          | 0             | 0                        | 0.80                       | 0.00                 | 0.05              |
| 06:00-07:00                       | 0.00              | 0                          | 0             | 1                        | 0.00                       | 0.00                 | 0.05              |
| 07:00-08:00                       | 0.00              | 1                          | 1             | 1                        | 0.00                       | 0.00                 | 0.05              |
| 08:00-09:00                       | 0.20              | 1                          | 1             | 1                        | 0.00                       | 1.00                 | 1.00              |
| 09:00-10:00                       | 0.50              | 1                          | 1             | 1                        | 0.00                       | 1.00                 | 1.00              |
| 10:00-11:00                       | 0.50              | 1                          | 1             | 1                        | 0.00                       | 1.00                 | 1.00              |
| 11:00-12:00                       | 0.50              | 1                          | 1             | 1                        | 0.00                       | 1.00                 | 1.00              |
| 12:00-13:00                       | 0.50              | 1                          | 1             | 1                        | 0.00                       | 1.00                 | 1.00              |
| 13:00-14:00                       | 0.50              | 1                          | 1             | 1                        | 0.00                       | 1.00                 | 1.00              |
| 14:00-15:00                       | 0.50              | 0                          | 1             | 1                        | 0.00                       | 1.00                 | 1.00              |
| 15:00-16:00                       | 0.50              | 0                          | 1             | 0                        | 0.00                       | 1.00                 | 1.00              |
| 16:00-17:00                       | 0.50              | 0                          | 1             | 0                        | 0.00                       | 1.00                 | 1.00              |
| 17:00-18:00                       | 0.50              | 0                          | 0             | 0                        | 0.00                       | 1.00                 | 0.50              |
| 18:00-19:00                       | 0.50              | 0                          | 0             | 0                        | 0.80                       | 0.00                 | 0.05              |
| 19:00-20:00                       | 0.40              | 0                          | 0             | 0                        | 0.80                       | 0.00                 | 0.05              |
| 20:00-21:00                       | 0.20              | 0                          | 0             | 0                        | 0.80                       | 0.00                 | 0.05              |
| 21:00-22:00                       | 0.20              | 0                          | 0             | 0                        | 0.80                       | 0.00                 | 0.05              |
| 22:00-23:00                       | 0.00              | 0                          | 0             | 0                        | 0.80                       | 0.00                 | 0.05              |
| 23:00-24:00                       | 0.00              | 0                          | 0             | 0                        | 0.80                       | 0.00                 | 0.05              |

Table 9-15: Schedules for Assembly Buildings (B)

| Assembly Buildings |                       |               |                     |                       |               |                     |                    |                     |
|--------------------|-----------------------|---------------|---------------------|-----------------------|---------------|---------------------|--------------------|---------------------|
| Time Period        | Occupancy Schedule    |               |                     | Lighting Schedule     |               |                     | Equipment Schedule |                     |
|                    | Seating/ Public Space | Exhibit Space | Meeting/ Conference | Seating/ Public Space | Exhibit Space | Meeting/ Conference | Exhibit Space      | Meeting/ Conference |
| 00:00-01:00        | 0.00                  | 0.00          | 0.00                | 0.10                  | 0.10          | 0.10                | 0.00               | 0.00                |
| 01:00-02:00        | 0.00                  | 0.00          | 0.00                | 0.10                  | 0.10          | 0.10                | 0.00               | 0.00                |
| 02:00-03:00        | 0.00                  | 0.00          | 0.00                | 0.10                  | 0.10          | 0.10                | 0.00               | 0.00                |
| 03:00-04:00        | 0.00                  | 0.00          | 0.00                | 0.10                  | 0.10          | 0.10                | 0.00               | 0.00                |
| 04:00-05:00        | 0.00                  | 0.00          | 0.00                | 0.10                  | 0.10          | 0.10                | 0.00               | 0.00                |
| 05:00-06:00        | 0.00                  | 0.00          | 0.00                | 0.10                  | 0.10          | 0.10                | 0.00               | 0.00                |
| 06:00-07:00        | 0.00                  | 0.00          | 0.00                | 0.10                  | 0.10          | 0.10                | 0.00               | 0.00                |
| 07:00-08:00        | 0.00                  | 0.00          | 0.00                | 0.10                  | 0.10          | 0.10                | 0.00               | 0.00                |
| 08:00-09:00        | 0.50                  | 0.50          | 0.00                | 0.90                  | 0.90          | 0.10                | 0.00               | 0.00                |
| 09:00-10:00        | 0.60                  | 0.50          | 0.50                | 0.90                  | 0.90          | 0.90                | 0.90               | 0.80                |
| 10:00-11:00        | 0.70                  | 0.80          | 0.75                | 0.90                  | 0.90          | 0.90                | 0.90               | 0.80                |
| 11:00-12:00        | 0.70                  | 0.80          | 0.75                | 0.90                  | 0.90          | 0.90                | 0.90               | 0.80                |
| 12:00-13:00        | 0.70                  | 0.80          | 0.75                | 0.90                  | 0.90          | 0.90                | 0.90               | 0.80                |
| 13:00-14:00        | 0.90                  | 0.25          | 0.50                | 0.90                  | 0.50          | 0.50                | 0.50               | 0.50                |
| 14:00-15:00        | 0.90                  | 0.25          | 0.75                | 0.90                  | 0.50          | 0.90                | 0.90               | 0.80                |
| 15:00-16:00        | 0.70                  | 0.80          | 0.75                | 0.90                  | 0.90          | 0.90                | 0.90               | 0.80                |
| 16:00-17:00        | 0.70                  | 0.80          | 0.75                | 0.90                  | 0.90          | 0.90                | 0.90               | 0.80                |
| 17:00-18:00        | 0.70                  | 0.80          | 0.75                | 0.90                  | 0.90          | 0.90                | 0.90               | 0.80                |
| 18:00-19:00        | 0.80                  | 0.50          | 0.50                | 0.90                  | 0.90          | 0.50                | 0.00               | 0.00                |
| 19:00-20:00        | 0.80                  | 0.00          | 0.00                | 0.90                  | 0.10          | 0.10                | 0.00               | 0.00                |
| 20:00-21:00        | 0.80                  | 0.00          | 0.00                | 0.90                  | 0.10          | 0.10                | 0.00               | 0.00                |
| 21:00-22:00        | 0.70                  | 0.00          | 0.00                | 0.90                  | 0.10          | 0.10                | 0.00               | 0.00                |
| 22:00-23:00        | 0.60                  | 0.00          | 0.00                | 0.90                  | 0.10          | 0.10                | 0.00               | 0.00                |
| 23:00-24:00        | 0.50                  | 0.00          | 0.00                | 0.90                  | 0.10          | 0.10                | 0.00               | 0.00                |

Table 9-16: Schedules for Assembly Buildings (C)

| Assembly Buildings - Museum |                    |                    |                   |                    |                    |                    |                            |                    |
|-----------------------------|--------------------|--------------------|-------------------|--------------------|--------------------|--------------------|----------------------------|--------------------|
| Time Period                 | Occupancy Schedule |                    | Lighting Schedule |                    | Equipment Schedule |                    | HVAC Fan Schedule (ON/OFF) |                    |
|                             | Museum Exhibition  | Museum Restoration | Museum Exhibition | Museum Restoration | Museum Exhibition  | Museum Restoration | Museum Exhibition          | Museum Restoration |
| 00:00-01:00                 | 0.00               | 0.00               | 0.10              | 0.10               | 0.00               | 0.00               | 0                          | 0                  |
| 01:00-02:00                 | 0.00               | 0.00               | 0.10              | 0.10               | 0.00               | 0.00               | 0                          | 0                  |
| 02:00-03:00                 | 0.00               | 0.00               | 0.10              | 0.10               | 0.00               | 0.00               | 0                          | 0                  |
| 03:00-04:00                 | 0.00               | 0.00               | 0.10              | 0.10               | 0.00               | 0.00               | 0                          | 0                  |
| 04:00-05:00                 | 0.00               | 0.00               | 0.10              | 0.10               | 0.00               | 0.00               | 0                          | 0                  |
| 05:00-06:00                 | 0.00               | 0.00               | 0.10              | 0.10               | 0.00               | 0.00               | 0                          | 0                  |
| 06:00-07:00                 | 0.00               | 0.00               | 0.10              | 0.10               | 0.00               | 0.00               | 0                          | 0                  |
| 07:00-08:00                 | 0.00               | 0.00               | 0.10              | 0.10               | 0.00               | 0.00               | 1                          | 1                  |
| 08:00-09:00                 | 0.50               | 0.80               | 0.90              | 0.90               | 0.00               | 0.90               | 1                          | 1                  |
| 09:00-10:00                 | 0.50               | 0.25               | 0.90              | 0.50               | 0.90               | 0.25               | 1                          | 1                  |
| 10:00-11:00                 | 0.80               | 0.25               | 0.90              | 0.50               | 0.90               | 0.25               | 1                          | 1                  |
| 11:00-12:00                 | 0.80               | 0.25               | 0.90              | 0.50               | 0.90               | 0.25               | 1                          | 1                  |
| 12:00-13:00                 | 0.80               | 0.25               | 0.90              | 0.50               | 0.90               | 0.25               | 1                          | 1                  |
| 13:00-14:00                 | 0.25               | 0.80               | 0.50              | 0.90               | 0.50               | 0.90               | 1                          | 1                  |
| 14:00-15:00                 | 0.25               | 0.80               | 0.50              | 0.90               | 0.90               | 0.90               | 1                          | 1                  |
| 15:00-16:00                 | 0.80               | 0.25               | 0.90              | 0.50               | 0.90               | 0.25               | 1                          | 1                  |
| 16:00-17:00                 | 0.80               | 0.25               | 0.90              | 0.50               | 0.90               | 0.25               | 1                          | 1                  |
| 17:00-18:00                 | 0.80               | 0.25               | 0.90              | 0.50               | 0.90               | 0.25               | 1                          | 1                  |
| 18:00-19:00                 | 0.25               | 0.80               | 0.90              | 0.90               | 0.00               | 0.90               | 1                          | 1                  |
| 19:00-20:00                 | 0.00               | 0.00               | 0.10              | 0.10               | 0.00               | 0.00               | 1                          | 1                  |
| 20:00-21:00                 | 0.00               | 0.00               | 0.10              | 0.10               | 0.00               | 0.00               | 0                          | 0                  |
| 21:00-22:00                 | 0.00               | 0.00               | 0.10              | 0.10               | 0.00               | 0.00               | 0                          | 0                  |
| 22:00-23:00                 | 0.00               | 0.00               | 0.10              | 0.10               | 0.00               | 0.00               | 0                          | 0                  |
| 23:00-24:00                 | 0.00               | 0.00               | 0.10              | 0.10               | 0.00               | 0.00               | 0                          | 0                  |



[illegible]

Table 9-18: Schedules for Healthcare - Hospital Buildings (A)

| Healthcare - Hospital |                    |               |               |                            |                   |                  |                            |               |                    |                            |               |
|-----------------------|--------------------|---------------|---------------|----------------------------|-------------------|------------------|----------------------------|---------------|--------------------|----------------------------|---------------|
| Time Period           | Occupancy Schedule |               |               |                            | Lighting Schedule |                  |                            |               | Equipment Schedule |                            |               |
|                       | In Patient & ICU   | Public Spaces | OPD & Offices | Diagnostic, emergency & OT | Public Spaces     | In Patient & ICU | Diagnostic, emergency & OT | OPD & Offices | In Patient & ICU   | Diagnostic, emergency & OT | OPD & Offices |
|                       | 7 Days/ week       | 7 Days/ week  | 7 Days/ week  | 7 Days/ week               | 7 Days/ week      | 7 Days/ week     | 7 Days/ week               | 7 Days/ week  | 7 Days/ week       | 7 Days/ week               | 7 Days/ week  |
| 00:00-01:00           | 0.90               | 0.00          | 0.00          | 0.50                       | 0.10              | 0.10             | 0.50                       | 0.05          | 0.40               | 0.00                       | 0.00          |
| 01:00-02:00           | 0.90               | 0.00          | 0.00          | 0.40                       | 0.10              | 0.10             | 0.50                       | 0.05          | 0.40               | 0.00                       | 0.00          |
| 02:00-03:00           | 0.90               | 0.00          | 0.00          | 0.40                       | 0.10              | 0.10             | 0.50                       | 0.05          | 0.40               | 0.00                       | 0.00          |
| 03:00-04:00           | 0.90               | 0.00          | 0.00          | 0.40                       | 0.10              | 0.10             | 0.50                       | 0.05          | 0.40               | 0.00                       | 0.00          |
| 04:00-05:00           | 0.90               | 0.00          | 0.00          | 0.40                       | 0.10              | 0.10             | 0.50                       | 0.05          | 0.40               | 0.00                       | 0.00          |
| 05:00-06:00           | 0.90               | 0.00          | 0.00          | 0.40                       | 0.10              | 0.10             | 0.50                       | 0.05          | 0.40               | 0.00                       | 0.00          |
| 06:00-07:00           | 0.90               | 0.00          | 0.00          | 0.50                       | 0.10              | 0.10             | 0.50                       | 0.10          | 0.40               | 0.00                       | 0.00          |
| 07:00-08:00           | 0.90               | 0.10          | 0.10          | 0.70                       | 0.50              | 0.20             | 0.50                       | 0.30          | 0.70               | 0.70                       | 0.70          |
| 08:00-09:00           | 0.90               | 0.50          | 0.30          | 0.70                       | 0.90              | 0.20             | 0.90                       | 0.90          | 0.90               | 0.90                       | 0.90          |
| 09:00-10:00           | 0.90               | 0.95          | 0.90          | 0.95                       | 0.90              | 0.20             | 0.90                       | 0.90          | 0.90               | 0.90                       | 0.90          |
| 10:00-11:00           | 0.90               | 0.95          | 0.90          | 0.95                       | 0.90              | 0.20             | 0.90                       | 0.90          | 0.90               | 0.90                       | 0.90          |
| 11:00-12:00           | 0.90               | 0.95          | 0.50          | 0.95                       | 0.90              | 0.20             | 0.90                       | 0.90          | 0.90               | 0.90                       | 0.90          |
| 12:00-13:00           | 0.90               | 0.95          | 0.20          | 0.95                       | 0.90              | 0.20             | 0.90                       | 0.90          | 0.90               | 0.90                       | 0.90          |
| 13:00-14:00           | 0.90               | 0.95          | 0.50          | 0.95                       | 0.90              | 0.20             | 0.90                       | 0.50          | 0.90               | 0.90                       | 0.90          |
| 14:00-15:00           | 0.90               | 0.95          | 0.90          | 0.95                       | 0.90              | 0.20             | 0.90                       | 0.90          | 0.90               | 0.90                       | 0.90          |
| 15:00-16:00           | 0.90               | 0.95          | 0.90          | 0.95                       | 0.90              | 0.20             | 0.90                       | 0.90          | 0.90               | 0.90                       | 0.90          |
| 16:00-17:00           | 0.90               | 0.95          | 0.90          | 0.95                       | 0.30              | 0.20             | 0.90                       | 0.90          | 0.60               | 0.60                       | 0.90          |
| 17:00-18:00           | 0.90               | 0.70          | 0.90          | 0.95                       | 0.30              | 0.70             | 0.90                       | 0.90          | 0.60               | 0.60                       | 0.90          |
| 18:00-19:00           | 0.90               | 0.50          | 0.50          | 0.95                       | 0.30              | 0.90             | 0.90                       | 0.50          | 0.60               | 0.60                       | 0.60          |
| 19:00-20:00           | 0.90               | 0.30          | 0.50          | 0.95                       | 0.30              | 0.90             | 0.90                       | 0.50          | 0.60               | 0.60                       | 0.60          |
| 20:00-21:00           | 0.90               | 0.10          | 0.50          | 0.70                       | 0.30              | 0.90             | 0.50                       | 0.30          | 0.60               | 0.60                       | 0.60          |
| 21:00-22:00           | 0.90               | 0.00          | 0.10          | 0.70                       | 0.30              | 0.90             | 0.50                       | 0.20          | 0.60               | 0.00                       | 0.00          |
| 22:00-23:00           | 0.90               | 0.00          | 0.00          | 0.50                       | 0.30              | 0.70             | 0.50                       | 0.10          | 0.60               | 0.00                       | 0.00          |
| 23:00-24:00           | 0.90               | 0.00          | 0.00          | 0.50                       | 0.10              | 0.10             | 0.50                       | 0.05          | 0.40               | 0.00                       | 0.00          |

Table 9-19: Schedules for Healthcare - Hospital Buildings (B)

| Healthcare - Hospital |                            |              |                    |               |                            |           |                   |                  |                      |                   |
|-----------------------|----------------------------|--------------|--------------------|---------------|----------------------------|-----------|-------------------|------------------|----------------------|-------------------|
| Time Period           | HVAC Fan Schedule (On/Off) |              |                    |               | External Lighting Schedule | Elevators | Service Hot Water |                  | Basement Ventilation | Basement Lighting |
|                       | Public Spaces              | Beds & ICU   | Diagn, emerg, & OT | OPD & Offices |                            |           | Building Summer   | Building Winters |                      |                   |
|                       | 7 Days/ week               | 7 Days/ week | 7 Days/ week       | 7 Days/ week  |                            |           | 7 Days/ week      | 7 Days/ week     |                      |                   |
| 00:00-01:00           | 0                          | 1            | 1                  | 0             | 1.00                       | 0.20      | 0.00              | 0.30             | 0.50                 | 0.50              |
| 01:00-02:00           | 0                          | 1            | 1                  | 0             | 1.00                       | 0.20      | 0.00              | 0.30             | 0.50                 | 0.50              |
| 02:00-03:00           | 0                          | 1            | 1                  | 0             | 1.00                       | 0.20      | 0.00              | 0.30             | 0.50                 | 0.50              |
| 03:00-04:00           | 0                          | 1            | 1                  | 0             | 1.00                       | 0.20      | 0.00              | 0.30             | 0.50                 | 0.50              |
| 04:00-05:00           | 0                          | 1            | 1                  | 0             | 1.00                       | 0.20      | 0.00              | 0.30             | 0.50                 | 0.50              |
| 05:00-06:00           | 0                          | 1            | 1                  | 0             | 1.00                       | 0.20      | 0.00              | 0.30             | 0.50                 | 0.50              |
| 06:00-07:00           | 0                          | 1            | 1                  | 0             | 0.00                       | 0.20      | 0.00              | 0.30             | 0.50                 | 0.50              |
| 07:00-08:00           | 1                          | 1            | 1                  | 0             | 0.00                       | 0.50      | 0.00              | 0.20             | 0.50                 | 0.50              |
| 08:00-09:00           | 1                          | 1            | 1                  | 1             | 0.00                       | 0.75      | 0.20              | 0.60             | 1.00                 | 1.00              |
| 09:00-10:00           | 1                          | 1            | 1                  | 1             | 0.00                       | 1.00      | 0.30              | 0.60             | 1.00                 | 1.00              |
| 10:00-11:00           | 1                          | 1            | 1                  | 1             | 0.00                       | 1.00      | 0.30              | 0.80             | 1.00                 | 1.00              |
| 11:00-12:00           | 1                          | 1            | 1                  | 1             | 0.00                       | 1.00      | 0.30              | 0.80             | 1.00                 | 1.00              |
| 12:00-13:00           | 1                          | 1            | 1                  | 1             | 0.00                       | 0.75      | 0.25              | 0.70             | 1.00                 | 1.00              |
| 13:00-14:00           | 1                          | 1            | 1                  | 1             | 0.00                       | 1.00      | 0.25              | 0.80             | 1.00                 | 1.00              |
| 14:00-15:00           | 1                          | 1            | 1                  | 1             | 0.00                       | 1.00      | 0.25              | 0.80             | 1.00                 | 1.00              |
| 15:00-16:00           | 1                          | 1            | 1                  | 1             | 0.00                       | 1.00      | 0.25              | 0.70             | 1.00                 | 1.00              |
| 16:00-17:00           | 1                          | 1            | 1                  | 1             | 0.00                       | 1.00      | 0.25              | 0.70             | 1.00                 | 1.00              |
| 17:00-18:00           | 1                          | 1            | 1                  | 1             | 0.00                       | 1.00      | 0.10              | 0.50             | 1.00                 | 1.00              |
| 18:00-19:00           | 1                          | 1            | 1                  | 1             | 1.00                       | 0.50      | 0.00              | 0.35             | 1.00                 | 1.00              |
| 19:00-20:00           | 1                          | 1            | 1                  | 1             | 1.00                       | 0.50      | 0.00              | 0.35             | 1.00                 | 1.00              |
| 20:00-21:00           | 1                          | 1            | 1                  | 1             | 1.00                       | 0.50      | 0.00              | 0.35             | 1.00                 | 1.00              |
| 21:00-22:00           | 1                          | 1            | 1                  | 0             | 1.00                       | 0.30      | 0.00              | 0.30             | 0.50                 | 0.50              |
| 22:00-23:00           | 0                          | 1            | 1                  | 0             | 1.00                       | 0.20      | 0.00              | 0.30             | 0.50                 | 0.50              |
| 23:00-24:00           | 0                          | 1            | 1                  | 0             | 1.00                       | 0.20      | 0.00              | 0.30             | 0.50                 | 0.50              |

Table 9-20: Schedules for Healthcare – Out-patient Healthcare Buildings (A)

| Healthcare – Out-patient Healthcare |                    |                        |                   |                        |                   |                        |                   |
|-------------------------------------|--------------------|------------------------|-------------------|------------------------|-------------------|------------------------|-------------------|
| Time Period                         | Occupancy Schedule |                        |                   | Lighting Schedule      |                   | Equipment Schedule     |                   |
|                                     | Lobby              | Diagnostic & Emergency | OPD & Back Office | Diagnostic & Emergency | OPD & Back Office | Diagnostic & Emergency | OPD & Back Office |
|                                     | 6 days/ week       | 6 days/ week           | 6 days/ week      | 6 days/ week           | 6 days/ week      | 6 days/ week           | 6 days/ week      |
| 00:00-01:00                         | 0.00               | 0.00                   | 0.00              | 0.10                   | 0.00              | 0.00                   | 0.00              |
| 01:00-02:00                         | 0.00               | 0.00                   | 0.00              | 0.10                   | 0.00              | 0.00                   | 0.00              |
| 02:00-03:00                         | 0.00               | 0.00                   | 0.00              | 0.10                   | 0.00              | 0.00                   | 0.00              |
| 03:00-04:00                         | 0.00               | 0.00                   | 0.00              | 0.10                   | 0.00              | 0.00                   | 0.00              |
| 04:00-05:00                         | 0.00               | 0.00                   | 0.00              | 0.10                   | 0.00              | 0.00                   | 0.00              |
| 05:00-06:00                         | 0.00               | 0.00                   | 0.00              | 0.10                   | 0.00              | 0.00                   | 0.00              |
| 06:00-07:00                         | 0.00               | 0.20                   | 0.20              | 0.10                   | 0.10              | 0.00                   | 0.00              |
| 07:00-08:00                         | 0.10               | 0.20                   | 0.20              | 0.50                   | 0.30              | 0.50                   | 0.00              |
| 08:00-09:00                         | 0.50               | 0.30                   | 0.20              | 0.90                   | 0.90              | 0.95                   | 0.95              |
| 09:00-10:00                         | 0.80               | 0.90                   | 0.90              | 0.90                   | 0.90              | 0.95                   | 0.95              |
| 10:00-11:00                         | 0.80               | 0.90                   | 0.90              | 0.90                   | 0.90              | 0.95                   | 0.95              |
| 11:00-12:00                         | 0.80               | 0.90                   | 0.90              | 0.90                   | 0.90              | 0.95                   | 0.95              |
| 12:00-13:00                         | 0.80               | 0.90                   | 0.50              | 0.90                   | 0.90              | 0.95                   | 0.95              |
| 13:00-14:00                         | 0.80               | 0.90                   | 0.20              | 0.90                   | 0.50              | 0.95                   | 0.95              |
| 14:00-15:00                         | 0.80               | 0.90                   | 0.50              | 0.90                   | 0.90              | 0.95                   | 0.95              |
| 15:00-16:00                         | 0.80               | 0.90                   | 0.90              | 0.90                   | 0.90              | 0.95                   | 0.95              |
| 16:00-17:00                         | 0.80               | 0.90                   | 0.90              | 0.90                   | 0.90              | 0.95                   | 0.95              |
| 17:00-18:00                         | 0.80               | 0.90                   | 0.90              | 0.90                   | 0.95              | 0.95                   | 0.95              |
| 18:00-19:00                         | 0.80               | 0.90                   | 0.50              | 0.90                   | 0.95              | 0.95                   | 0.95              |
| 19:00-20:00                         | 0.80               | 0.90                   | 0.50              | 0.90                   | 0.30              | 0.95                   | 0.95              |
| 20:00-21:00                         | 0.20               | 0.65                   | 0.20              | 0.90                   | 0.30              | 0.80                   | 0.80              |
| 21:00-22:00                         | 0.20               | 0.20                   | 0.20              | 0.50                   | 0.20              | 0.00                   | 0.00              |
| 22:00-23:00                         | 0.00               | 0.00                   | 0.00              | 0.30                   | 0.00              | 0.00                   | 0.00              |
| 23:00-24:00                         | 0.00               | 0.00                   | 0.00              | 0.10                   | 0.00              | 0.00                   | 0.00              |

Table 9-21: Schedules for Healthcare – Out-patient Healthcare Buildings (B)

| Healthcare - Out-patient Healthcare |                   |                            |                            |                         |                  |                      |                   |
|-------------------------------------|-------------------|----------------------------|----------------------------|-------------------------|------------------|----------------------|-------------------|
| Time Period                         | Elevator Schedule | HVAC Fan Schedule (On/Off) | External Lighting Schedule | Service Hot Water (SHW) |                  | Basement Ventilation | Basement Lighting |
|                                     |                   | All Spaces                 |                            | Building Summer         | Building Winters |                      |                   |
|                                     | 6 days/ week      | 6 days/ week               | 7 Days/ week               | 6 days/ week            | 6 days/ week     | 6 days/ week         | 6 days/ week      |
| 00:00-01:00                         | 0.05              | 0                          | 0.20                       | 0.00                    | 0.00             | 0.00                 | 0.00              |
| 01:00-02:00                         | 0.05              | 0                          | 0.20                       | 0.00                    | 0.00             | 0.00                 | 0.00              |
| 02:00-03:00                         | 0.05              | 0                          | 0.20                       | 0.00                    | 0.00             | 0.00                 | 0.00              |
| 03:00-04:00                         | 0.05              | 0                          | 0.20                       | 0.00                    | 0.00             | 0.00                 | 0.00              |
| 04:00-05:00                         | 0.05              | 0                          | 0.20                       | 0.00                    | 0.00             | 0.00                 | 0.00              |
| 05:00-06:00                         | 0.05              | 0                          | 0.20                       | 0.00                    | 0.00             | 0.00                 | 0.00              |
| 06:00-07:00                         | 0.05              | 0                          | 0.00                       | 0.00                    | 0.00             | 0.00                 | 0.00              |
| 07:00-08:00                         | 0.50              | 0                          | 0.00                       | 0.00                    | 0.20             | 0.00                 | 0.00              |
| 08:00-09:00                         | 0.75              | 1                          | 0.00                       | 0.20                    | 0.60             | 1.00                 | 1.00              |
| 09:00-10:00                         | 1.00              | 1                          | 0.00                       | 0.30                    | 0.60             | 1.00                 | 1.00              |
| 10:00-11:00                         | 1.00              | 1                          | 0.00                       | 0.30                    | 0.80             | 1.00                 | 1.00              |
| 11:00-12:00                         | 1.00              | 1                          | 0.00                       | 0.30                    | 0.80             | 1.00                 | 1.00              |
| 12:00-13:00                         | 0.75              | 1                          | 0.00                       | 0.25                    | 0.70             | 1.00                 | 1.00              |
| 13:00-14:00                         | 1.00              | 1                          | 0.00                       | 0.25                    | 0.80             | 1.00                 | 1.00              |
| 14:00-15:00                         | 1.00              | 1                          | 0.00                       | 0.25                    | 0.80             | 1.00                 | 1.00              |
| 15:00-16:00                         | 1.00              | 1                          | 0.00                       | 0.25                    | 0.70             | 1.00                 | 1.00              |
| 16:00-17:00                         | 1.00              | 1                          | 0.00                       | 0.25                    | 0.70             | 1.00                 | 1.00              |
| 17:00-18:00                         | 1.00              | 1                          | 0.00                       | 0.10                    | 0.50             | 1.00                 | 1.00              |
| 18:00-19:00                         | 0.50              | 1                          | 0.50                       | 0.01                    | 0.20             | 1.00                 | 1.00              |
| 19:00-20:00                         | 0.50              | 1                          | 0.50                       | 0.01                    | 0.20             | 1.00                 | 1.00              |
| 20:00-21:00                         | 0.50              | 1                          | 0.50                       | 0.01                    | 0.20             | 1.00                 | 1.00              |
| 21:00-22:00                         | 0.30              | 0                          | 0.50                       | 0.01                    | 0.10             | 1.00                 | 1.00              |
| 22:00-23:00                         | 0.05              | 0                          | 0.20                       | 0.01                    | 0.01             | 0.00                 | 0.00              |
| 23:00-24:00                         | 0.05              | 0                          | 0.20                       | 0.01                    | 0.01             | 0.00                 | 0.00              |

Table 9-22: Schedules for Educational School Building (A)

| Educational – School Building |                   |                            |             |                  |                            |                      |                   |
|-------------------------------|-------------------|----------------------------|-------------|------------------|----------------------------|----------------------|-------------------|
| Time Period                   | Elevator Schedule | HVAC Fan Schedule (On/Off) |             |                  | External Lighting Schedule | Basement Ventilation | Basement Lighting |
|                               | 7 Days/<br>week   | Student Area               | Back Office | Corridor / Lobby | 7 Days/<br>week            | 7 Days/<br>week      | 7 Days/<br>week   |
| 00:00-01:00                   | 0.00              | 0                          | 0           | 0                | 0.80                       | 0.00                 | 0.05              |
| 01:00-02:00                   | 0.00              | 0                          | 0           | 0                | 0.80                       | 0.00                 | 0.05              |
| 02:00-03:00                   | 0.00              | 0                          | 0           | 0                | 0.80                       | 0.00                 | 0.05              |
| 03:00-04:00                   | 0.00              | 0                          | 0           | 0                | 0.80                       | 0.00                 | 0.05              |
| 04:00-05:00                   | 0.00              | 0                          | 0           | 0                | 0.80                       | 0.00                 | 0.05              |
| 05:00-06:00                   | 0.00              | 0                          | 0           | 0                | 0.80                       | 0.00                 | 0.05              |
| 06:00-07:00                   | 0.05              | 0                          | 0           | 1                | 0.00                       | 0.00                 | 0.05              |
| 07:00-08:00                   | 0.80              | 1                          | 1           | 1                | 0.00                       | 0.00                 | 0.05              |
| 08:00-09:00                   | 0.80              | 1                          | 1           | 1                | 0.00                       | 1.00                 | 1.00              |
| 09:00-10:00                   | 0.25              | 1                          | 1           | 1                | 0.00                       | 1.00                 | 1.00              |
| 10:00-11:00                   | 0.25              | 1                          | 1           | 1                | 0.00                       | 1.00                 | 1.00              |
| 11:00-12:00                   | 0.25              | 1                          | 1           | 1                | 0.00                       | 1.00                 | 1.00              |
| 12:00-13:00                   | 0.25              | 1                          | 1           | 1                | 0.00                       | 1.00                 | 1.00              |
| 13:00-14:00                   | 0.90              | 1                          | 1           | 1                | 0.00                       | 1.00                 | 1.00              |
| 14:00-15:00                   | 0.60              | 0                          | 1           | 1                | 0.00                       | 1.00                 | 1.00              |
| 15:00-16:00                   | 0.20              | 0                          | 1           | 0                | 0.00                       | 1.00                 | 1.00              |
| 16:00-17:00                   | 0.30              | 0                          | 1           | 0                | 0.00                       | 1.00                 | 1.00              |
| 17:00-18:00                   | 0.40              | 0                          | 0           | 0                | 0.00                       | 1.00                 | 0.50              |
| 18:00-19:00                   | 0.00              | 0                          | 0           | 0                | 0.80                       | 0.00                 | 0.05              |
| 19:00-20:00                   | 0.00              | 0                          | 0           | 0                | 0.80                       | 0.00                 | 0.05              |
| 20:00-21:00                   | 0.00              | 0                          | 0           | 0                | 0.80                       | 0.00                 | 0.05              |
| 21:00-22:00                   | 0.00              | 0                          | 0           | 0                | 0.80                       | 0.00                 | 0.05              |
| 22:00-23:00                   | 0.00              | 0                          | 0           | 0                | 0.80                       | 0.00                 | 0.05              |
| 23:00-24:00                   | 0.00              | 0                          | 0           | 0                | 0.80                       | 0.00                 | 0.05              |

[illegible]

Table 9-24: Schedules for Educational - University Building (A)

| Educational – University Buildings |                        |                         |                            |              |                        |                 |                            |                      |                   |
|------------------------------------|------------------------|-------------------------|----------------------------|--------------|------------------------|-----------------|----------------------------|----------------------|-------------------|
| Time Period                        | Elevator Schedule      |                         | HVAC Fan Schedule (On/Off) |              |                        |                 | External Lighting Schedule | Basement Ventilation | Basement Lighting |
|                                    | Library & Comp. Centre | Student and Back office | Student Area               | Back Office  | Library & Comp. Centre | Corridor/ Lobby |                            |                      |                   |
|                                    | 7 days/ week           | 7 days/ week            | 5 days/ week               | 5 days/ week | 7 days/ week           | 5 days/ week    |                            |                      |                   |
| 00:00-01:00                        | 0.00                   | 0.00                    | 0                          | 0            | 0                      | 0               | 0.80                       | 0.00                 | 0.05              |
| 01:00-02:00                        | 0.00                   | 0.00                    | 0                          | 0            | 0                      | 0               | 0.80                       | 0.00                 | 0.05              |
| 02:00-03:00                        | 0.00                   | 0.00                    | 0                          | 0            | 0                      | 0               | 0.80                       | 0.00                 | 0.05              |
| 03:00-04:00                        | 0.00                   | 0.00                    | 0                          | 0            | 0                      | 0               | 0.80                       | 0.00                 | 0.05              |
| 04:00-05:00                        | 0.00                   | 0.00                    | 0                          | 0            | 0                      | 0               | 0.80                       | 0.00                 | 0.05              |
| 05:00-06:00                        | 0.00                   | 0.00                    | 0                          | 0            | 0                      | 0               | 0.80                       | 0.00                 | 0.05              |
| 06:00-07:00                        | 0.00                   | 0.05                    | 0                          | 0            | 0                      | 0               | 0.00                       | 0.00                 | 0.05              |
| 07:00-08:00                        | 0.00                   | 0.25                    | 1                          | 1            | 1                      | 1               | 0.00                       | 0.00                 | 0.05              |
| 08:00-09:00                        | 0.50                   | 0.85                    | 1                          | 1            | 1                      | 1               | 0.00                       | 1.00                 | 1.00              |
| 09:00-10:00                        | 0.50                   | 0.25                    | 1                          | 1            | 1                      | 1               | 0.00                       | 1.00                 | 1.00              |
| 10:00-11:00                        | 0.30                   | 0.25                    | 1                          | 1            | 1                      | 1               | 0.00                       | 1.00                 | 1.00              |
| 11:00-12:00                        | 0.20                   | 0.25                    | 1                          | 1            | 1                      | 1               | 0.00                       | 1.00                 | 1.00              |
| 12:00-13:00                        | 0.20                   | 0.25                    | 1                          | 1            | 1                      | 1               | 0.00                       | 1.00                 | 1.00              |
| 13:00-14:00                        | 0.40                   | 0.90                    | 1                          | 1            | 1                      | 1               | 0.00                       | 1.00                 | 1.00              |
| 14:00-15:00                        | 0.30                   | 0.60                    | 1                          | 1            | 1                      | 1               | 0.00                       | 1.00                 | 1.00              |
| 15:00-16:00                        | 0.30                   | 0.25                    | 1                          | 1            | 1                      | 1               | 0.00                       | 1.00                 | 1.00              |
| 16:00-17:00                        | 0.30                   | 0.25                    | 1                          | 1            | 1                      | 1               | 0.00                       | 1.00                 | 1.00              |
| 17:00-18:00                        | 0.50                   | 0.90                    | 1                          | 0            | 1                      | 1               | 0.00                       | 1.00                 | 1.00              |
| 18:00-19:00                        | 0.50                   | 0.15                    | 0                          | 0            | 1                      | 1               | 0.80                       | 1.00                 | 1.00              |
| 19:00-20:00                        | 0.50                   | 0.05                    | 0                          | 0            | 1                      | 0               | 0.80                       | 1.00                 | 1.00              |
| 20:00-21:00                        | 0.50                   | 0.00                    | 0                          | 0            | 1                      | 0               | 0.80                       | 0.00                 | 0.50              |
| 21:00-22:00                        | 0.50                   | 0.00                    | 0                          | 0            | 1                      | 0               | 0.80                       | 0.00                 | 0.05              |
| 22:00-23:00                        | 0.50                   | 0.00                    | 0                          | 0            | 1                      | 0               | 0.80                       | 0.00                 | 0.05              |
| 23:00-24:00                        | 0.00                   | 0.00                    | 0                          | 0            | 0                      | 0               | 0.80                       | 0.00                 | 0.05              |



[illegible]

Table 9-26: Schedules for Hospitality Buildings (A)

| Hospitality |                   |          |                            |                         |          |              |                      |                   |              |
|-------------|-------------------|----------|----------------------------|-------------------------|----------|--------------|----------------------|-------------------|--------------|
| Time Period | Elevator Schedule |          | External Lighting Schedule | Service Hot Water (SHW) |          |              | Basement Ventilation | Basement Lighting |              |
|             |                   |          |                            | Guest rooms             |          | Kitchen      |                      |                   |              |
|             | Week Days         | Weekends | 7 Days/ week               | Week Days               | Weekends | 7 Days/ week | 7 Days/ week         | 7 Days/ week      | 7 Days/ week |
| 00:00-01:00 | 0.10              | 0.10     | 1.00                       | 0.01                    | 0.01     | 0.00         | 0.00                 | 0.50              | 0.50         |
| 01:00-02:00 | 0.10              | 0.10     | 1.00                       | 0.01                    | 0.01     | 0.00         | 0.00                 | 0.50              | 0.50         |
| 02:00-03:00 | 0.10              | 0.10     | 1.00                       | 0.01                    | 0.01     | 0.00         | 0.00                 | 0.50              | 0.50         |
| 03:00-04:00 | 0.10              | 0.10     | 1.00                       | 0.01                    | 0.01     | 0.00         | 0.00                 | 0.50              | 0.50         |
| 04:00-05:00 | 0.10              | 0.10     | 1.00                       | 0.01                    | 0.01     | 0.00         | 0.00                 | 0.50              | 0.50         |
| 05:00-06:00 | 0.20              | 0.20     | 1.00                       | 0.01                    | 0.01     | 0.00         | 0.00                 | 0.50              | 0.50         |
| 06:00-07:00 | 0.40              | 0.50     | 0.00                       | 0.50                    | 0.70     | 0.60         | 0.00                 | 0.50              | 0.50         |
| 07:00-08:00 | 0.50              | 0.60     | 0.00                       | 0.50                    | 0.70     | 0.80         | 0.00                 | 0.50              | 0.50         |
| 08:00-09:00 | 0.50              | 0.60     | 0.00                       | 0.30                    | 0.50     | 0.80         | 1.00                 | 1.00              | 1.00         |
| 09:00-10:00 | 0.35              | 0.40     | 0.00                       | 0.15                    | 0.30     | 0.60         | 1.00                 | 1.00              | 1.00         |
| 10:00-11:00 | 0.15              | 0.20     | 0.00                       | 0.15                    | 0.20     | 0.60         | 1.00                 | 1.00              | 1.00         |
| 11:00-12:00 | 0.15              | 0.20     | 0.00                       | 0.15                    | 0.20     | 0.80         | 1.00                 | 1.00              | 1.00         |
| 12:00-13:00 | 0.15              | 0.20     | 0.00                       | 0.15                    | 0.20     | 0.80         | 1.00                 | 1.00              | 1.00         |
| 13:00-14:00 | 0.15              | 0.20     | 0.00                       | 0.15                    | 0.20     | 0.80         | 1.00                 | 1.00              | 1.00         |
| 14:00-15:00 | 0.15              | 0.20     | 0.00                       | 0.15                    | 0.20     | 0.60         | 1.00                 | 1.00              | 1.00         |
| 15:00-16:00 | 0.15              | 0.20     | 0.00                       | 0.15                    | 0.20     | 0.60         | 1.00                 | 1.00              | 1.00         |
| 16:00-17:00 | 0.35              | 0.40     | 0.00                       | 0.15                    | 0.20     | 0.60         | 0.00                 | 1.00              | 1.00         |
| 17:00-18:00 | 0.50              | 0.60     | 0.00                       | 0.30                    | 0.30     | 0.80         | 0.00                 | 1.00              | 1.00         |
| 18:00-19:00 | 0.50              | 0.60     | 1.00                       | 0.50                    | 0.50     | 0.80         | 0.00                 | 1.00              | 1.00         |
| 19:00-20:00 | 0.50              | 0.60     | 1.00                       | 0.50                    | 0.70     | 0.80         | 0.00                 | 1.00              | 1.00         |
| 20:00-21:00 | 0.50              | 0.60     | 1.00                       | 0.65                    | 0.70     | 0.80         | 0.00                 | 1.00              | 1.00         |
| 21:00-22:00 | 0.30              | 0.40     | 1.00                       | 0.65                    | 0.90     | 0.80         | 0.00                 | 0.50              | 0.50         |
| 22:00-23:00 | 0.20              | 0.30     | 1.00                       | 0.01                    | 0.01     | 0.60         | 0.00                 | 0.50              | 0.50         |
| 23:00-24:00 | 0.10              | 0.10     | 1.00                       | 0.01                    | 0.01     | 0.60         | 0.00                 | 0.50              | 0.50         |

Table 9-27: Schedules for Hospitality Buildings (B)

| Hospitality - Occupancy |                    |              |              |              |               |              |              |              |              |              |                             |                 |
|-------------------------|--------------------|--------------|--------------|--------------|---------------|--------------|--------------|--------------|--------------|--------------|-----------------------------|-----------------|
| Time Period             | Occupancy Schedule |              |              |              |               |              |              |              |              |              |                             |                 |
|                         | Guest Room         |              | Lobby        |              | Public Spaces |              | Restaurant   |              | Back Office  |              | Conference/<br>Banquet Room | Kitchen         |
|                         | Week<br>Days       | Week<br>ends | Week<br>Days | Week<br>ends | Week<br>Days  | Week<br>ends | Week<br>Days | Week<br>ends | Week<br>Days | Week<br>ends | 7 Days/<br>week             | 7 Days/<br>week |
| 00:00-01:00             | 0.65               | 0.90         | 0.10         | 0.10         | 0.00          | 0.00         | 0.00         | 0.00         | 0.20         | 0.20         | 0.00                        | 0.00            |
| 01:00-02:00             | 0.65               | 0.90         | 0.10         | 0.10         | 0.00          | 0.00         | 0.00         | 0.00         | 0.20         | 0.20         | 0.00                        | 0.00            |
| 02:00-03:00             | 0.65               | 0.90         | 0.10         | 0.10         | 0.00          | 0.00         | 0.00         | 0.00         | 0.20         | 0.20         | 0.00                        | 0.00            |
| 03:00-04:00             | 0.65               | 0.90         | 0.10         | 0.10         | 0.00          | 0.00         | 0.00         | 0.00         | 0.20         | 0.20         | 0.00                        | 0.00            |
| 04:00-05:00             | 0.65               | 0.90         | 0.10         | 0.10         | 0.00          | 0.00         | 0.00         | 0.00         | 0.20         | 0.20         | 0.00                        | 0.00            |
| 05:00-06:00             | 0.65               | 0.90         | 0.10         | 0.10         | 0.20          | 0.50         | 0.00         | 0.00         | 0.20         | 0.20         | 0.00                        | 0.00            |
| 06:00-07:00             | 0.50               | 0.70         | 0.20         | 0.20         | 0.40          | 0.70         | 0.00         | 0.00         | 0.20         | 0.20         | 0.00                        | 0.50            |
| 07:00-08:00             | 0.50               | 0.70         | 0.30         | 0.40         | 0.40          | 0.70         | 0.30         | 0.30         | 0.20         | 0.20         | 0.00                        | 0.80            |
| 08:00-09:00             | 0.30               | 0.50         | 0.40         | 0.70         | 0.40          | 0.70         | 0.30         | 0.30         | 0.20         | 0.20         | 0.20                        | 0.80            |
| 09:00-10:00             | 0.15               | 0.30         | 0.40         | 0.70         | 0.40          | 0.70         | 0.30         | 0.30         | 0.95         | 0.50         | 0.50                        | 0.50            |
| 10:00-11:00             | 0.15               | 0.20         | 0.40         | 0.70         | 0.40          | 0.70         | 0.30         | 0.30         | 0.95         | 0.50         | 0.90                        | 0.50            |
| 11:00-12:00             | 0.15               | 0.20         | 0.40         | 0.70         | 0.20          | 0.30         | 0.30         | 0.30         | 0.95         | 0.50         | 0.90                        | 0.80            |
| 12:00-13:00             | 0.15               | 0.20         | 0.40         | 0.70         | 0.20          | 0.30         | 0.80         | 0.80         | 0.95         | 0.50         | 0.90                        | 0.80            |
| 13:00-14:00             | 0.15               | 0.20         | 0.20         | 0.20         | 0.20          | 0.30         | 0.80         | 0.80         | 0.50         | 0.30         | 0.90                        | 0.80            |
| 14:00-15:00             | 0.15               | 0.20         | 0.20         | 0.20         | 0.20          | 0.30         | 0.80         | 0.80         | 0.95         | 0.50         | 0.90                        | 0.50            |
| 15:00-16:00             | 0.15               | 0.20         | 0.20         | 0.20         | 0.40          | 0.70         | 0.30         | 0.30         | 0.95         | 0.50         | 0.90                        | 0.50            |
| 16:00-17:00             | 0.15               | 0.20         | 0.20         | 0.20         | 0.40          | 0.70         | 0.30         | 0.30         | 0.95         | 0.50         | 0.90                        | 0.50            |
| 17:00-18:00             | 0.30               | 0.30         | 0.40         | 0.40         | 0.40          | 0.70         | 0.30         | 0.30         | 0.95         | 0.50         | 0.50                        | 0.80            |
| 18:00-19:00             | 0.50               | 0.50         | 0.40         | 0.40         | 0.50          | 0.70         | 0.50         | 0.50         | 0.30         | 0.30         | 0.20                        | 0.80            |
| 19:00-20:00             | 0.50               | 0.70         | 0.40         | 0.40         | 0.80          | 0.70         | 0.80         | 0.90         | 0.20         | 0.20         | 0.20                        | 0.80            |
| 20:00-21:00             | 0.65               | 0.70         | 0.30         | 0.30         | 0.90          | 0.70         | 0.80         | 0.90         | 0.20         | 0.20         | 0.00                        | 0.80            |
| 21:00-22:00             | 0.65               | 0.90         | 0.20         | 0.20         | 0.80          | 0.70         | 0.80         | 0.90         | 0.20         | 0.20         | 0.00                        | 0.80            |
| 22:00-23:00             | 0.65               | 0.90         | 0.10         | 0.10         | 0.60          | 0.60         | 0.80         | 0.90         | 0.20         | 0.20         | 0.00                        | 0.50            |
| 23:00-24:00             | 0.65               | 0.90         | 0.10         | 0.10         | 0.30          | 0.30         | 0.50         | 0.90         | 0.20         | 0.20         | 0.00                        | 0.50            |

Table 9-28: Schedules for Hospitality Buildings (C)

| Hospitality – Lighting |                   |              |              |              |               |              |              |              |              |              |                             |                 |
|------------------------|-------------------|--------------|--------------|--------------|---------------|--------------|--------------|--------------|--------------|--------------|-----------------------------|-----------------|
| Time Period            | Lighting Schedule |              |              |              |               |              |              |              |              |              |                             |                 |
|                        | Guest Room        |              | Lobby        |              | Public Spaces |              | Restaurant   |              | Back Office  |              | Conference/<br>Banquet Room | Kitchen         |
|                        | Week<br>Days      | Week<br>ends | Week<br>Days | Week<br>ends | Week<br>Days  | Week<br>ends | Week<br>Days | Week<br>ends | Week<br>Days | Week<br>ends | 7 Days/<br>week             | 7 Days/<br>week |
| 00:00-01:00            | 0.20              | 0.30         | 0.30         | 0.30         | 0.20          | 0.20         | 0.50         | 0.50         | 0.05         | 0.05         | 0.00                        | 0.50            |
| 01:00-02:00            | 0.20              | 0.25         | 0.30         | 0.30         | 0.15          | 0.20         | 0.10         | 0.10         | 0.05         | 0.05         | 0.00                        | 0.05            |
| 02:00-03:00            | 0.10              | 0.10         | 0.30         | 0.30         | 0.10          | 0.10         | 0.10         | 0.10         | 0.05         | 0.05         | 0.00                        | 0.05            |
| 03:00-04:00            | 0.10              | 0.10         | 0.30         | 0.30         | 0.10          | 0.10         | 0.10         | 0.10         | 0.05         | 0.05         | 0.00                        | 0.05            |
| 04:00-05:00            | 0.10              | 0.10         | 0.30         | 0.30         | 0.10          | 0.10         | 0.10         | 0.10         | 0.05         | 0.05         | 0.00                        | 0.05            |
| 05:00-06:00            | 0.20              | 0.10         | 0.30         | 0.30         | 0.20          | 0.10         | 0.10         | 0.10         | 0.05         | 0.05         | 0.00                        | 0.05            |
| 06:00-07:00            | 0.45              | 0.40         | 0.40         | 0.40         | 0.40          | 0.30         | 0.10         | 0.10         | 0.10         | 0.10         | 0.00                        | 0.10            |
| 07:00-08:00            | 0.55              | 0.40         | 0.30         | 0.40         | 0.50          | 0.30         | 0.50         | 0.50         | 0.30         | 0.30         | 0.00                        | 0.30            |
| 08:00-09:00            | 0.45              | 0.55         | 0.40         | 0.70         | 0.40          | 0.40         | 0.50         | 0.50         | 0.90         | 0.60         | 0.50                        | 0.90            |
| 09:00-10:00            | 0.20              | 0.20         | 0.40         | 0.70         | 0.20          | 0.40         | 0.50         | 0.50         | 0.90         | 0.60         | 0.80                        | 0.90            |
| 10:00-11:00            | 0.20              | 0.20         | 0.40         | 0.70         | 0.20          | 0.40         | 0.50         | 0.50         | 0.90         | 0.60         | 0.90                        | 0.90            |
| 11:00-12:00            | 0.20              | 0.20         | 0.40         | 0.70         | 0.20          | 0.40         | 0.50         | 0.50         | 0.90         | 0.60         | 0.90                        | 0.90            |
| 12:00-13:00            | 0.20              | 0.20         | 0.40         | 0.70         | 0.20          | 0.40         | 0.90         | 0.90         | 0.90         | 0.60         | 0.90                        | 0.90            |
| 13:00-14:00            | 0.20              | 0.20         | 0.40         | 0.40         | 0.20          | 0.40         | 0.90         | 0.90         | 0.50         | 0.50         | 0.90                        | 0.50            |
| 14:00-15:00            | 0.20              | 0.20         | 0.40         | 0.40         | 0.20          | 0.40         | 0.90         | 0.90         | 0.90         | 0.60         | 0.90                        | 0.90            |
| 15:00-16:00            | 0.20              | 0.20         | 0.40         | 0.40         | 0.20          | 0.40         | 0.50         | 0.50         | 0.90         | 0.60         | 0.90                        | 0.90            |
| 16:00-17:00            | 0.20              | 0.20         | 0.40         | 0.40         | 0.20          | 0.40         | 0.50         | 0.50         | 0.90         | 0.60         | 0.90                        | 0.90            |
| 17:00-18:00            | 0.30              | 0.30         | 0.40         | 0.40         | 0.25          | 0.40         | 0.50         | 0.50         | 0.95         | 0.60         | 0.50                        | 0.95            |
| 18:00-19:00            | 0.70              | 0.85         | 0.40         | 0.40         | 0.60          | 0.60         | 0.90         | 0.90         | 0.50         | 0.50         | 0.50                        | 0.95            |
| 19:00-20:00            | 0.90              | 1.00         | 0.40         | 0.40         | 0.80          | 0.70         | 0.90         | 0.90         | 0.30         | 0.30         | 0.50                        | 0.95            |
| 20:00-21:00            | 1.00              | 1.00         | 0.30         | 0.30         | 0.90          | 0.70         | 0.90         | 0.90         | 0.30         | 0.30         | 0.00                        | 0.95            |
| 21:00-22:00            | 0.90              | 1.00         | 0.40         | 0.40         | 0.80          | 0.70         | 0.90         | 0.90         | 0.20         | 0.20         | 0.00                        | 0.95            |
| 22:00-23:00            | 0.70              | 0.85         | 0.30         | 0.30         | 0.60          | 0.60         | 0.90         | 0.90         | 0.10         | 0.10         | 0.00                        | 0.95            |
| 23:00-24:00            | 0.30              | 0.40         | 0.30         | 0.30         | 0.30          | 0.30         | 0.90         | 0.90         | 0.05         | 0.05         | 0.00                        | 0.95            |

Table 9-29: Schedules for Hospitality Buildings (D)

| Hospitality – Equipment |                    |          |               |            |          |             |          |                             |              |
|-------------------------|--------------------|----------|---------------|------------|----------|-------------|----------|-----------------------------|--------------|
| Time Period             | Equipment Schedule |          |               |            |          |             |          |                             |              |
|                         | Guest Room         |          | Public Spaces | Restaurant |          | Back Office |          | Conference/<br>Banquet Room | Kitchen      |
|                         | Week Days          | Weekends | 7 Days/ week  | Week Days  | Weekends | Week Days   | Weekends | 7 Days/ week                | 7 Days/ week |
| 00:00-01:00             | 0.20               | 0.20     | 0.30          | 0.50       | 0.50     | 0.05        | 0.05     | 0.00                        | 0.30         |
| 01:00-02:00             | 0.20               | 0.20     | 0.20          | 0.00       | 0.00     | 0.05        | 0.05     | 0.00                        | 0.10         |
| 02:00-03:00             | 0.20               | 0.20     | 0.20          | 0.00       | 0.00     | 0.05        | 0.05     | 0.00                        | 0.10         |
| 03:00-04:00             | 0.20               | 0.20     | 0.20          | 0.00       | 0.00     | 0.05        | 0.05     | 0.00                        | 0.10         |
| 04:00-05:00             | 0.20               | 0.20     | 0.20          | 0.00       | 0.00     | 0.05        | 0.05     | 0.00                        | 0.10         |
| 05:00-06:00             | 0.20               | 0.20     | 0.30          | 0.00       | 0.00     | 0.05        | 0.05     | 0.00                        | 0.10         |
| 06:00-07:00             | 0.30               | 0.30     | 0.50          | 0.00       | 0.00     | 0.05        | 0.05     | 0.00                        | 0.30         |
| 07:00-08:00             | 0.40               | 0.60     | 0.50          | 0.60       | 0.60     | 0.10        | 0.10     | 0.00                        | 0.30         |
| 08:00-09:00             | 0.70               | 0.90     | 0.50          | 0.60       | 0.60     | 0.30        | 0.30     | 0.50                        | 0.30         |
| 09:00-10:00             | 0.20               | 0.20     | 0.50          | 0.60       | 0.60     | 0.95        | 0.70     | 0.50                        | 0.30         |
| 10:00-11:00             | 0.20               | 0.20     | 0.35          | 0.60       | 0.60     | 0.95        | 0.70     | 0.90                        | 0.30         |
| 11:00-12:00             | 0.20               | 0.20     | 0.35          | 0.60       | 0.60     | 0.95        | 0.70     | 0.90                        | 0.30         |
| 12:00-13:00             | 0.20               | 0.20     | 0.35          | 0.80       | 0.80     | 0.95        | 0.70     | 0.90                        | 0.30         |
| 13:00-14:00             | 0.20               | 0.20     | 0.35          | 0.80       | 0.80     | 0.50        | 0.70     | 0.90                        | 0.30         |
| 14:00-15:00             | 0.20               | 0.20     | 0.35          | 0.80       | 0.80     | 0.95        | 0.70     | 0.90                        | 0.30         |
| 15:00-16:00             | 0.20               | 0.20     | 0.35          | 0.60       | 0.60     | 0.95        | 0.70     | 0.90                        | 0.30         |
| 16:00-17:00             | 0.20               | 0.20     | 0.35          | 0.60       | 0.60     | 0.95        | 0.70     | 0.90                        | 0.30         |
| 17:00-18:00             | 0.30               | 0.30     | 0.35          | 0.60       | 0.60     | 0.95        | 0.70     | 0.50                        | 0.30         |
| 18:00-19:00             | 0.50               | 0.50     | 0.70          | 0.80       | 0.80     | 0.30        | 0.30     | 0.50                        | 0.30         |
| 19:00-20:00             | 0.50               | 0.50     | 0.90          | 0.80       | 0.90     | 0.10        | 0.10     | 0.50                        | 0.30         |
| 20:00-21:00             | 0.50               | 0.70     | 0.90          | 0.80       | 0.90     | 0.10        | 0.10     | 0.00                        | 0.30         |
| 21:00-22:00             | 0.70               | 0.70     | 0.90          | 0.80       | 0.90     | 0.10        | 0.10     | 0.00                        | 0.30         |
| 22:00-23:00             | 0.40               | 0.40     | 0.70          | 0.80       | 0.90     | 0.05        | 0.05     | 0.00                        | 0.30         |
| 23:00-24:00             | 0.20               | 0.20     | 0.40          | 0.80       | 0.90     | 0.05        | 0.05     | 0.00                        | 0.30         |

Table 9-30: Schedules for Hospitality Buildings (E)

| Hospitality – HVAC Fan Schedules |                   |                 |                 |                 |                 |                           |                 |
|----------------------------------|-------------------|-----------------|-----------------|-----------------|-----------------|---------------------------|-----------------|
| Time Period                      | HVAC Fan Schedule |                 |                 |                 |                 |                           |                 |
|                                  | Guest Room        | Lobby           | Public Spaces   | Restaurants     | Back Office     | Conference / Banquet Room | Kitchen         |
|                                  | 7 Days/<br>week   | 7 Days/<br>week | 7 Days/<br>week | 7 Days/<br>week | 7 Days/<br>week | 7 Days/<br>week           | 7 Days/<br>week |
| 00:00-01:00                      | 1                 | 0               | 0               | 0               | 0               | 0                         | 0               |
| 01:00-02:00                      | 1                 | 0               | 0               | 0               | 0               | 0                         | 0               |
| 02:00-03:00                      | 1                 | 0               | 0               | 0               | 0               | 0                         | 0               |
| 03:00-04:00                      | 1                 | 0               | 0               | 0               | 0               | 0                         | 0               |
| 04:00-05:00                      | 1                 | 0               | 0               | 0               | 0               | 0                         | 0               |
| 05:00-06:00                      | 1                 | 1               | 1               | 0               | 0               | 0                         | 1               |
| 06:00-07:00                      | 1                 | 1               | 1               | 1               | 0               | 0                         | 1               |
| 07:00-08:00                      | 1                 | 1               | 1               | 1               | 0               | 0                         | 1               |
| 08:00-09:00                      | 1                 | 1               | 1               | 1               | 1               | 1                         | 1               |
| 09:00-10:00                      | 1                 | 1               | 1               | 1               | 1               | 1                         | 1               |
| 10:00-11:00                      | 1                 | 1               | 1               | 1               | 1               | 1                         | 1               |
| 11:00-12:00                      | 1                 | 1               | 1               | 1               | 1               | 1                         | 1               |
| 12:00-13:00                      | 1                 | 1               | 1               | 1               | 1               | 1                         | 1               |
| 13:00-14:00                      | 1                 | 1               | 1               | 1               | 1               | 1                         | 1               |
| 14:00-15:00                      | 1                 | 1               | 1               | 1               | 1               | 1                         | 1               |
| 15:00-16:00                      | 1                 | 1               | 1               | 1               | 1               | 1                         | 1               |
| 16:00-17:00                      | 1                 | 1               | 1               | 1               | 1               | 1                         | 1               |
| 17:00-18:00                      | 1                 | 1               | 1               | 1               | 1               | 1                         | 1               |
| 18:00-19:00                      | 1                 | 1               | 1               | 1               | 1               | 1                         | 1               |
| 19:00-20:00                      | 1                 | 1               | 1               | 1               | 0               | 1                         | 1               |
| 20:00-21:00                      | 1                 | 1               | 1               | 1               | 0               | 1                         | 1               |
| 21:00-22:00                      | 1                 | 1               | 1               | 1               | 0               | 0                         | 1               |
| 22:00-23:00                      | 1                 | 0               | 1               | 1               | 0               | 0                         | 1               |
| 23:00-24:00                      | 1                 | 0               | 1               | 1               | 0               | 0                         | 1               |

Table 9-31: Schedules for Shopping Complexes Buildings (A)

| Shopping Complex |                            |                   |               |                            |                      |                   |                   |          |
|------------------|----------------------------|-------------------|---------------|----------------------------|----------------------|-------------------|-------------------|----------|
| Time Period      | HVAC Fan Schedule (ON/OFF) |                   |               | External Lighting Schedule | Basement Ventilation | Basement Lighting | Elevator Schedule |          |
|                  | Retail                     | Corridor & Atrium | Special Zones |                            |                      |                   | Weekdays          | Weekends |
|                  | 7 Days/ week               | 7 Days/ week      | 7 Days/ week  |                            |                      |                   |                   |          |
| 00:00-01:00      | 0                          | 0                 | 0             | 1.00                       | 1.00                 | 1.00              | 0.20              | 0.20     |
| 01:00-02:00      | 0                          | 0                 | 0             | 0.50                       | 0.00                 | 0.05              | 0.05              | 0.20     |
| 02:00-03:00      | 0                          | 0                 | 0             | 0.50                       | 0.00                 | 0.05              | 0.05              | 0.05     |
| 03:00-04:00      | 0                          | 0                 | 0             | 0.50                       | 0.00                 | 0.05              | 0.05              | 0.05     |
| 04:00-05:00      | 0                          | 0                 | 0             | 0.50                       | 0.00                 | 0.05              | 0.05              | 0.05     |
| 05:00-06:00      | 0                          | 0                 | 0             | 0.50                       | 0.00                 | 0.05              | 0.05              | 0.05     |
| 06:00-07:00      | 0                          | 0                 | 0             | 0.00                       | 0.00                 | 0.05              | 0.05              | 0.05     |
| 07:00-08:00      | 0                          | 0                 | 0             | 0.00                       | 0.00                 | 0.05              | 0.10              | 0.10     |
| 08:00-09:00      | 0                          | 0                 | 0             | 0.00                       | 0.00                 | 0.05              | 0.10              | 0.10     |
| 09:00-10:00      | 0                          | 1                 | 1             | 0.00                       | 1.00                 | 1.00              | 0.20              | 0.20     |
| 10:00-11:00      | 1                          | 1                 | 1             | 0.00                       | 1.00                 | 1.00              | 0.40              | 0.40     |
| 11:00-12:00      | 1                          | 1                 | 1             | 0.00                       | 1.00                 | 1.00              | 0.70              | 0.70     |
| 12:00-13:00      | 1                          | 1                 | 1             | 0.00                       | 1.00                 | 1.00              | 0.70              | 0.80     |
| 13:00-14:00      | 1                          | 1                 | 1             | 0.00                       | 1.00                 | 1.00              | 0.70              | 0.95     |
| 14:00-15:00      | 1                          | 1                 | 1             | 0.00                       | 1.00                 | 1.00              | 0.70              | 0.95     |
| 15:00-16:00      | 1                          | 1                 | 1             | 0.00                       | 1.00                 | 1.00              | 0.70              | 0.95     |
| 16:00-17:00      | 1                          | 1                 | 1             | 0.00                       | 1.00                 | 1.00              | 0.70              | 0.95     |
| 17:00-18:00      | 1                          | 1                 | 1             | 0.00                       | 1.00                 | 1.00              | 0.80              | 0.95     |
| 18:00-19:00      | 1                          | 1                 | 1             | 1.00                       | 1.00                 | 1.00              | 0.80              | 0.95     |
| 19:00-20:00      | 1                          | 1                 | 1             | 1.00                       | 1.00                 | 1.00              | 0.80              | 0.95     |
| 20:00-21:00      | 1                          | 1                 | 1             | 1.00                       | 1.00                 | 1.00              | 0.80              | 0.95     |
| 21:00-22:00      | 0                          | 1                 | 1             | 1.00                       | 1.00                 | 1.00              | 0.80              | 0.80     |
| 22:00-23:00      | 0                          | 1                 | 1             | 1.00                       | 1.00                 | 1.00              | 0.50              | 0.60     |
| 23:00-24:00      | 0                          | 1                 | 1             | 1.00                       | 1.00                 | 1.00              | 0.30              | 0.40     |

Table 9-32: Schedules for Shopping Complexes Buildings (B)

| Shopping Complex |                    |         |                    |         |              |         |                   |                    |              |                    |              |
|------------------|--------------------|---------|--------------------|---------|--------------|---------|-------------------|--------------------|--------------|--------------------|--------------|
| Time Period      | Occupancy Schedule |         |                    |         |              |         | Lighting Schedule |                    |              | Equipment Schedule |              |
|                  | Retail             |         | Corridors & Atrium |         | Special Zone |         | Retail            | Corridors & Atrium | Special Zone | Retail             | Special Zone |
|                  | Weekday            | Weekend | Weekday            | Weekend | Weekday      | Weekend | 7 Days/ week      | 7 Days/ week       | 7 Days/ week | 7 Days/ week       | 7 Days/ week |
| 00:00-01:00      | 0.00               | 0.00    | 0.00               | 0.10    | 0.00         | 0.00    | 0.05              | 0.05               | 0.05         | 0.05               | 0.05         |
| 01:00-02:00      | 0.00               | 0.00    | 0.00               | 0.00    | 0.00         | 0.00    | 0.05              | 0.05               | 0.05         | 0.05               | 0.05         |
| 02:00-03:00      | 0.00               | 0.00    | 0.00               | 0.00    | 0.00         | 0.00    | 0.05              | 0.05               | 0.05         | 0.05               | 0.05         |
| 03:00-04:00      | 0.00               | 0.00    | 0.00               | 0.00    | 0.00         | 0.00    | 0.05              | 0.05               | 0.05         | 0.05               | 0.05         |
| 04:00-05:00      | 0.00               | 0.00    | 0.00               | 0.00    | 0.00         | 0.00    | 0.05              | 0.05               | 0.05         | 0.05               | 0.05         |
| 05:00-06:00      | 0.00               | 0.00    | 0.00               | 0.00    | 0.00         | 0.00    | 0.05              | 0.05               | 0.05         | 0.05               | 0.05         |
| 06:00-07:00      | 0.00               | 0.00    | 0.00               | 0.00    | 0.00         | 0.00    | 0.05              | 0.05               | 0.05         | 0.05               | 0.05         |
| 07:00-08:00      | 0.00               | 0.00    | 0.00               | 0.00    | 0.00         | 0.00    | 0.05              | 0.05               | 0.05         | 0.05               | 0.05         |
| 08:00-09:00      | 0.00               | 0.00    | 0.00               | 0.00    | 0.00         | 0.00    | 0.05              | 0.05               | 0.05         | 0.05               | 0.50         |
| 09:00-10:00      | 0.20               | 0.20    | 0.20               | 0.20    | 0.20         | 0.20    | 0.20              | 0.20               | 0.20         | 0.05               | 0.50         |
| 10:00-11:00      | 0.40               | 0.40    | 0.40               | 0.40    | 0.20         | 0.20    | 0.50              | 0.50               | 0.40         | 0.90               | 0.90         |
| 11:00-12:00      | 0.60               | 0.60    | 0.60               | 0.60    | 0.30         | 0.50    | 0.95              | 0.50               | 0.60         | 0.90               | 0.90         |
| 12:00-13:00      | 0.60               | 0.70    | 0.60               | 0.70    | 0.50         | 0.70    | 0.95              | 0.50               | 0.60         | 0.90               | 0.90         |
| 13:00-14:00      | 0.60               | 0.90    | 0.60               | 0.90    | 0.50         | 0.70    | 0.95              | 0.50               | 0.60         | 0.90               | 0.90         |
| 14:00-15:00      | 0.70               | 0.90    | 0.70               | 0.90    | 0.50         | 0.70    | 0.95              | 0.50               | 0.60         | 0.90               | 0.90         |
| 15:00-16:00      | 0.70               | 0.90    | 0.70               | 0.90    | 0.50         | 0.80    | 0.95              | 0.50               | 0.40         | 0.90               | 0.90         |
| 16:00-17:00      | 0.70               | 0.90    | 0.70               | 0.90    | 0.50         | 0.80    | 0.95              | 0.70               | 0.40         | 0.90               | 0.90         |
| 17:00-18:00      | 0.70               | 0.90    | 0.70               | 0.90    | 0.50         | 0.80    | 0.95              | 0.95               | 0.40         | 0.90               | 0.90         |
| 18:00-19:00      | 0.90               | 0.95    | 0.90               | 0.95    | 0.60         | 0.95    | 0.95              | 0.95               | 0.80         | 0.90               | 0.90         |
| 19:00-20:00      | 0.90               | 0.95    | 0.90               | 0.95    | 0.60         | 0.95    | 0.95              | 0.95               | 0.80         | 0.90               | 0.90         |
| 20:00-21:00      | 0.90               | 0.95    | 0.90               | 0.95    | 0.60         | 0.95    | 0.95              | 0.95               | 0.80         | 0.50               | 0.90         |
| 21:00-22:00      | 0.00               | 0.00    | 0.40               | 0.40    | 0.60         | 0.95    | 0.05              | 0.50               | 0.80         | 0.05               | 0.90         |
| 22:00-23:00      | 0.00               | 0.00    | 0.30               | 0.30    | 0.60         | 0.95    | 0.05              | 0.30               | 0.80         | 0.05               | 0.90         |
| 23:00-24:00      | 0.00               | 0.00    | 0.10               | 0.10    | 0.30         | 0.95    | 0.05              | 0.30               | 0.80         | 0.05               | 0.90         |



Table 9-33: Schedules for Shopping Complexes Buildings – Food Court

| Shopping Complex - Food Court |                    |                  |            |                   |                  |            |                    |                  |            |                   |                  |            |
|-------------------------------|--------------------|------------------|------------|-------------------|------------------|------------|--------------------|------------------|------------|-------------------|------------------|------------|
| Time Period                   | Occupancy Schedule |                  |            | Lighting Schedule |                  |            | Equipment Schedule |                  |            | HVAC Fan Schedule |                  |            |
|                               | Family Dining      | Food Preparation | Bar Lounge | Family Dining     | Food Preparation | Bar Lounge | Family Dining      | Food Preparation | Bar Lounge | Family Dining     | Food Preparation | Bar Lounge |
| 00:00-01:00                   | 0.00               | 0.50             | 0.70       | 0.50              | 0.70             | 0.70       | 0.50               | 0.60             | 0.70       | 1                 | 0                | 1          |
| 01:00-02:00                   | 0.00               | 0.00             | 0.00       | 0.00              | 0.00             | 0.00       | 0.00               | 0.00             | 0.00       | 0                 | 0                | 0          |
| 02:00-03:00                   | 0.00               | 0.00             | 0.00       | 0.00              | 0.00             | 0.00       | 0.00               | 0.00             | 0.00       | 0                 | 0                | 0          |
| 03:00-04:00                   | 0.00               | 0.00             | 0.00       | 0.00              | 0.00             | 0.00       | 0.00               | 0.00             | 0.00       | 0                 | 0                | 0          |
| 04:00-05:00                   | 0.00               | 0.00             | 0.00       | 0.00              | 0.00             | 0.00       | 0.00               | 0.00             | 0.00       | 0                 | 0                | 0          |
| 05:00-06:00                   | 0.00               | 0.00             | 0.00       | 0.00              | 0.00             | 0.00       | 0.00               | 0.00             | 0.00       | 0                 | 0                | 0          |
| 06:00-07:00                   | 0.00               | 0.00             | 0.00       | 0.00              | 0.00             | 0.00       | 0.00               | 0.00             | 0.00       | 0                 | 0                | 0          |
| 07:00-08:00                   | 0.00               | 0.00             | 0.00       | 0.00              | 0.00             | 0.00       | 0.00               | 0.00             | 0.00       | 0                 | 0                | 0          |
| 08:00-09:00                   | 0.00               | 0.00             | 0.00       | 0.00              | 0.00             | 0.00       | 0.00               | 0.00             | 0.00       | 0                 | 0                | 0          |
| 09:00-10:00                   | 0.00               | 0.20             | 0.00       | 0.00              | 0.50             | 0.00       | 0.00               | 0.60             | 0.00       | 0                 | 0                | 0          |
| 10:00-11:00                   | 0.20               | 0.50             | 0.00       | 0.50              | 0.70             | 0.00       | 0.60               | 0.70             | 0.00       | 0                 | 1                | 0          |
| 11:00-12:00                   | 0.20               | 0.80             | 0.00       | 0.50              | 0.90             | 0.00       | 0.60               | 0.70             | 0.00       | 1                 | 1                | 0          |
| 12:00-13:00                   | 0.70               | 0.80             | 0.00       | 0.90              | 0.90             | 0.00       | 0.80               | 0.70             | 0.00       | 1                 | 1                | 0          |
| 13:00-14:00                   | 0.70               | 0.80             | 0.00       | 0.90              | 0.90             | 0.00       | 0.80               | 0.70             | 0.00       | 1                 | 1                | 0          |
| 14:00-15:00                   | 0.70               | 0.80             | 0.00       | 0.90              | 0.90             | 0.00       | 0.80               | 0.70             | 0.00       | 1                 | 1                | 0          |
| 15:00-16:00                   | 0.20               | 0.50             | 0.00       | 0.50              | 0.70             | 0.00       | 0.60               | 0.40             | 0.00       | 1                 | 1                | 0          |
| 16:00-17:00                   | 0.20               | 0.30             | 0.00       | 0.50              | 0.50             | 0.00       | 0.60               | 0.40             | 0.00       | 1                 | 1                | 1          |
| 17:00-18:00                   | 0.20               | 0.30             | 0.50       | 0.50              | 0.50             | 0.70       | 0.60               | 0.40             | 0.70       | 1                 | 1                | 1          |
| 18:00-19:00                   | 0.50               | 0.50             | 0.70       | 0.90              | 0.70             | 0.80       | 0.80               | 0.40             | 0.70       | 1                 | 1                | 1          |
| 19:00-20:00                   | 0.80               | 0.90             | 0.80       | 0.90              | 0.90             | 0.80       | 0.80               | 0.70             | 0.70       | 1                 | 1                | 1          |
| 20:00-21:00                   | 0.80               | 0.90             | 0.80       | 0.90              | 0.90             | 0.80       | 0.80               | 0.70             | 0.70       | 1                 | 1                | 1          |
| 21:00-22:00                   | 0.80               | 0.90             | 0.80       | 0.90              | 0.90             | 0.80       | 0.80               | 0.70             | 0.70       | 1                 | 1                | 1          |
| 22:00-23:00                   | 0.80               | 0.90             | 0.80       | 0.90              | 0.90             | 0.80       | 0.80               | 0.70             | 0.70       | 1                 | 1                | 1          |
| 23:00-24:00                   | 0.50               | 0.50             | 0.80       | 0.90              | 0.90             | 0.80       | 0.80               | 0.40             | 0.70       | 1                 | 1                | 1          |

Table 9-34: Schedules for Shopping Complex- Strip Retail &amp; Supermall Buildings

| Strip Retail & Supermall |                      |          |                   |                    |                            |                   |          |                            |                      |                   |
|--------------------------|----------------------|----------|-------------------|--------------------|----------------------------|-------------------|----------|----------------------------|----------------------|-------------------|
| Time Period              | Occupancy Schedule   |          | Lighting Schedule | Equipment Schedule | HVAC Fan Schedule (On/Off) | Elevator Schedule |          | External Lighting Schedule | Basement Ventilation | Basement Lighting |
|                          | Retail & Circulation |          | All Spac          | All Spac           |                            |                   |          |                            |                      |                   |
|                          | Weekdays             | Weekends | 7 Days/ week      | 7 Days/ week       | 7 Days/ week               | Weekdays          | Weekends | 7 Days/ week               | 7 Days/ week         | 7 Days/ week      |
| 00:00-01:00              | 0.00                 | 0.00     | 0.05              | 0.05               | 0                          | 0.00              | 0.00     | 0.20                       | 0.00                 | 0.05              |
| 01:00-02:00              | 0.00                 | 0.00     | 0.05              | 0.05               | 0                          | 0.00              | 0.00     | 0.20                       | 0.00                 | 0.05              |
| 02:00-03:00              | 0.00                 | 0.00     | 0.05              | 0.05               | 0                          | 0.00              | 0.00     | 0.20                       | 0.00                 | 0.05              |
| 03:00-04:00              | 0.00                 | 0.00     | 0.05              | 0.05               | 0                          | 0.00              | 0.00     | 0.20                       | 0.00                 | 0.05              |
| 04:00-05:00              | 0.00                 | 0.00     | 0.05              | 0.05               | 0                          | 0.00              | 0.00     | 0.20                       | 0.00                 | 0.05              |
| 05:00-06:00              | 0.00                 | 0.00     | 0.05              | 0.05               | 0                          | 0.00              | 0.00     | 0.20                       | 0.00                 | 0.05              |
| 06:00-07:00              | 0.00                 | 0.00     | 0.05              | 0.05               | 0                          | 0.00              | 0.00     | 0.00                       | 0.00                 | 0.05              |
| 07:00-08:00              | 0.00                 | 0.00     | 0.05              | 0.05               | 0                          | 0.10              | 0.10     | 0.00                       | 0.00                 | 0.05              |
| 08:00-09:00              | 0.00                 | 0.00     | 0.05              | 0.05               | 0                          | 0.10              | 0.10     | 0.00                       | 0.00                 | 0.05              |
| 09:00-10:00              | 0.20                 | 0.20     | 0.20              | 0.05               | 1                          | 0.20              | 0.20     | 0.00                       | 1.00                 | 1.00              |
| 10:00-11:00              | 0.40                 | 0.40     | 0.50              | 0.90               | 1                          | 0.40              | 0.40     | 0.00                       | 1.00                 | 1.00              |
| 11:00-12:00              | 0.60                 | 0.60     | 0.95              | 0.90               | 1                          | 0.70              | 0.70     | 0.00                       | 1.00                 | 1.00              |
| 12:00-13:00              | 0.60                 | 0.70     | 0.95              | 0.90               | 1                          | 0.70              | 0.80     | 0.00                       | 1.00                 | 1.00              |
| 13:00-14:00              | 0.60                 | 0.90     | 0.95              | 0.90               | 1                          | 0.70              | 0.95     | 0.00                       | 1.00                 | 1.00              |
| 14:00-15:00              | 0.70                 | 0.90     | 0.95              | 0.90               | 1                          | 0.70              | 0.95     | 0.00                       | 1.00                 | 1.00              |
| 15:00-16:00              | 0.70                 | 0.90     | 0.95              | 0.90               | 1                          | 0.70              | 0.95     | 0.00                       | 1.00                 | 1.00              |
| 16:00-17:00              | 0.70                 | 0.90     | 0.95              | 0.90               | 1                          | 0.70              | 0.95     | 0.00                       | 1.00                 | 1.00              |
| 17:00-18:00              | 0.70                 | 0.90     | 0.95              | 0.90               | 1                          | 0.80              | 0.95     | 0.00                       | 1.00                 | 1.00              |
| 18:00-19:00              | 0.90                 | 0.95     | 0.95              | 0.90               | 1                          | 0.80              | 0.95     | 1.00                       | 1.00                 | 1.00              |
| 19:00-20:00              | 0.90                 | 0.95     | 0.95              | 0.90               | 1                          | 0.80              | 0.95     | 1.00                       | 1.00                 | 1.00              |
| 20:00-21:00              | 0.90                 | 0.95     | 0.95              | 0.50               | 1                          | 0.80              | 0.95     | 1.00                       | 1.00                 | 1.00              |
| 21:00-22:00              | 0.00                 | 0.00     | 0.05              | 0.05               | 0                          | 0.00              | 0.00     | 1.00                       | 0.20                 | 0.50              |
| 22:00-23:00              | 0.00                 | 0.00     | 0.05              | 0.05               | 0                          | 0.00              | 0.00     | 0.20                       | 0.00                 | 0.05              |
| 23:00-24:00              | 0.00                 | 0.00     | 0.05              | 0.05               | 0                          | 0.00              | 0.00     | 0.20                       | 0.00                 | 0.05              |

# Appendices

## 10. Appendix A: Default Values for Typical Constructions

### 10.1 Procedure for Determining Fenestration Product U-factor and Solar Heat Gain Coefficient

§ 4.2.1.1 and § 4.2.1.2 require that U-factors and solar heat gain coefficients (SHGC) be determined for the overall fenestration product (including the sash and frame) in accordance with ISO 15099.

In several cases, ISO 15099 suggests that individual national standards will need to be more specific and in other cases the ISO document gives users the choice of two options. This section clarifies these specific issues as they are to be implemented for this code:

- (a) § 4.1 of ISO 15099: For calculating the overall U-factor, ISO 15099 offers a choice between the linear thermal transmittance (4.1.2) and the area weighted method (4.1.3). The area weighted method (4.1.3) shall be used.
- (b) § 4.2.2 of ISO 15099: Frame and divider SHGC's shall be calculated in accordance with § 4.2.2. The alternate approach in § 8.6 shall not be used.
- (c) § 6.4 of ISO 15099 refers the issue of material properties to national standards. Material conductivities and emissivity shall be determined in accordance with Indian standards.
- (d) § 7 of ISO 15099 on shading systems is currently excluded.
- (e) § 8.2 of ISO 15099 addresses environmental conditions. The following are defined for India:

For U-factor calculations:

$$T_{in} = 24 \text{ }^{\circ}\text{C}$$

$$T_{out} = 32 \text{ }^{\circ}\text{C}$$

$$V = 3.35 \text{ m/s}$$

$$T_{rm,out}=T_{out}$$

$$T_{rm,in}=T_{in}$$

$$I_s=0 \text{ W/m}^2$$

For SHGC calculations:

$$T_{in} = 24 \text{ }^{\circ}\text{C}$$

$$T_{out} = 32 \text{ }^{\circ}\text{C}$$

$$V = 2.75 \text{ m/s}$$

$$T_{rm,out}=T_{out}$$

$$T_{rm,in}=T_{in}$$

$$I_s=783 \text{ W/m}^2$$

- (f) § 8.3 of ISO 15099 addresses convective film coefficients on the interior and exterior of the window product. In § 8.3.1 of ISO 15099, simulations shall use the

heat transfer coefficient based on the center of glass temperature and the entire window height; this film coefficient shall be used on all indoor surfaces, including frame sections. In § 8.3.2 of ISO 15099, the formula from this section shall be applied to all outdoor exposed surfaces.

- (g) § 8.4.2 of ISO 15099 presents two possible approaches for incorporating the impacts of self-viewing surfaces on interior radiative heat transfer calculations. Products shall use the method in § 8.4.2.1 of ISO 15099 (Two-Dimensional Element to Element View Factor Based Radiation Heat Transfer Calculation). The alternate approach in § 8.4.3 of ISO 15099 shall not be used.

## 10.2 Default U-factors, Visible Light Transmittance and Solar Heat Gain Coefficients for Unrated Fenestration Products

All fenestration with U-factors, SHGC, or visible light transmittance determined, certified, and labeled in accordance ISO 15099 shall be assigned those values.

### 10.2.1 Unrated Vertical Fenestration.

For unrated vertical fenestration, both operable and fixed, the glass VLT reported by manufacturer must meet or exceed 0.37 (as it accounts for framing). The SHGC values reported by glass manufacturer must meet or exceed the prescriptive requirements in Table 4-10 and Table 4-11 for compliance.

U-factors for unrated vertical fenestration, both operable and fixed, shall be assigned as per Table 10-1.

*Table 10-1 Defaults for Unrated Fenestration (Overall Assembly including the Sash and Frame)*

| <i>Frame Type</i>  | <i>Glazing Type</i>                                   | <i>U-Factor<br/>(W/m<sup>2</sup>.K)</i> |
|--|---|---|
| All frame types  | Single Glazing  | 7.1                                     |
| Wood, vinyl, or fiberglass frame or metal frame with thermal break | Double Glazing (COG U value >1.6 W/m <sup>2</sup> .K) | 3.4                                     |
| Wood, vinyl, or fiberglass frame or metal frame with thermal break | Double Glazing (COG U value <1.6 W/m <sup>2</sup> .K) | 3.0                                     |
| Metal and other frame type   | Double Glazing  | 5.1                                     |

## 10.3 Typical Roof Constructions

For calculating the overall U-factor of a typical roof construction, the U-factors from the typical wall construction type and effective U-factor for insulation shall be combined according to the following equation:

$$U_{TotalRoof} = \frac{1}{\frac{1}{U_{TypicalRoof}} + \frac{1}{U_{TyipcalInsulation}}}$$

where

|                                 |  |
|---------------------------------|--|
| U <sub>TotalRoof</sub>          | Total U-factor of the roof with insulation |
| U <sub>Typical Roof</sub>       | U-factor of the roof                       |
| U <sub>Typical Insulation</sub> | U-factor of the effective insulation       |

10.4 Typical Wall Constructions

For calculating the overall U-factor of a typical wall construction, the U-factors from the typical wall construction type and effective U-factor for insulation shall be combined according to the following equation:

$$U_{TotalWall} = \frac{1}{\frac{1}{U_{TypicalWall}} + \frac{1}{U_{TyipcalInsulation}}}$$

where

|                                 |  |
|---------------------------------|--|
| U <sub>TotalWall</sub>          | Total U-factor of the wall with insulation |
| U <sub>Typical Wall</sub>       | U-factor of the wall                       |
| U <sub>Typical Insulation</sub> | U-factor of the effective insulation       |

Table 10-2 Typical Thermal Properties of Common Building and Insulating Materials<sup>2,a</sup>

| Description                                     | Density<br>kg/m <sup>3</sup> | Conductivity <sup>b</sup> k,<br>W/(m·K) | Resistance R,<br>(m <sup>2</sup> ·K)/W | Specific<br>Heat,<br>kJ/(kg·K) |
|---|------------------------------|---|--|--------------------------------|
| <b>Building Board and Siding</b>                |                              |   |  |                                |
| <b>Board</b>                                    |                              |   |  |                                |
| Asbestos/cement board                           | 1900                         | 0.57                                    | -                                      | 1                              |
| Cement board                                    | 1150                         | 0.25                                    | -                                      | 0.84                           |
| Fiber/cement board                              | 1400                         | 0.25                                    | -                                      | 0.84                           |
|   | 1000                         | 0.19                                    | -                                      | 0.84                           |
|   | 400                          | 0.07                                    | -                                      | 1.88                           |
|   | 300                          | 0.06                                    | -                                      | 1.88                           |
| Gypsum or plaster board                         | 640                          | 0.16                                    | -                                      | 1.15                           |
| Oriented strand board (OSB) 9 to 11 mm          | 650                          | -                                       | 0.11                                   | 1.88                           |
| Oriented strand board (OSB) 12.7 mm             | 650                          | -                                       | 0.12                                   | 1.88                           |
| Plywood (douglas fir) 12.7 mm                   | 460                          | -                                       | 0.14                                   | 1.88                           |
| Plywood (douglas fir) 15.9 mm                   | 540                          | -                                       | 0.15                                   | 1.88                           |
| Plywood/wood panels 19.0 mm                     | 550                          | -                                       | 0.19                                   | 1.88                           |
| <i>Vegetable fiber board</i>                    |                              |   |  | -                              |
| Sheathing, regular density <sup>e</sup> 12.7 mm | 290                          | -                                       | 0.23                                   | 1.3                            |
| Intermediate density <sup>e</sup> .. 12.7 mm    | 350                          | -                                       | 0.19                                   | 1.3                            |
| Nail-base sheathing <sup>e</sup> 12.7 mm        | 400                          | -                                       | 0.19                                   | 1.3                            |
| Shingle backer 9.5 mm                           | 290                          | -                                       | 0.17                                   | 1.3                            |
| Sound deadening board. 12.7 mm                  | 240                          | -                                       | 0.24                                   | 1.26                           |
| Tile and lay-in panels, plain or acoustic       | 290                          | 0.058                                   | -                                      | 0.59                           |
| Laminated paperboard                            | 480                          | 0.072                                   | -                                      | 1.38                           |
| Homogeneous board from repulped paper           | 480                          | 0.072                                   | -                                      | 1.17                           |
| <b>Hardboard<sup>e</sup></b>                    |                              |   |  |                                |
| Medium density                                  | 800                          | 0.105                                   | -                                      | 1.3                            |
| High density, service-tempered                  | 880                          | 0.12                                    | -                                      | 1.34                           |
| <b>Grade and service grade</b>                  |                              |   |  |                                |
| High density, standard-tempered grade           | 1010                         | 0.144                                   | -                                      | 1.34                           |
| <b>Particleboard<sup>e</sup></b>                |                              |   |  |                                |

<sup>2</sup> ASHRAE- Handbook of Fundamentals

|  |      |       |            |      |
|--|------|-------|------------|------|
| Low density  | 590  | 0.102 | -          | 1.3  |
| Medium density   | 800  | 0.135 | -          | 1.3  |
| High density   | 1000 | 0.18  | -          | -    |
| Underlayment 15.9 mm   | 640  | -     | 1.22       | 1.21 |
| Waferboard   | 700  | 0.072 | -          | 1.88 |
| <i>Shingles</i>  |      |       |            |      |
| Asbestos/cement  | 1900 | -     | 0.37       | -    |
| Wood, 400 mm, 190 mm exposure  | -    | -     | 0.015      | 1.3  |
| Wood, double, 400 mm, 300 mm exposure  | -    | -     | 0.21       | 1.17 |
| Wood, plus ins. backer board 8 mm  | -    | -     | 0.25       | 1.3  |
| Siding   | -    | -     | -          | -    |
| Asbestos/cement, lapped 6.4 mm   | -    | -     | 0.037      | 1.01 |
| Asphalt roll siding  | -    | -     | 0.026      | 1.47 |
| <i>Siding</i>  |      |       |            |      |
| Asphalt insulating siding (12.7 mm bed)  | -    | -     | 0.26       | 1.47 |
| Hardboard siding 11 mm   | -    | -     | 0.12       | 1.17 |
| Wood, drop, 200 mm 25 mm   | -    | -     | 0.14       | 1.17 |
| Wood, bevel 200 mm, lapped 13 mm   | -    | -     | 0.14       | 1.17 |
| Wood, bevel 250 mm, lapped 19 mm   | -    | -     | 0.18       | 1.17 |
| Wood, plywood, lapped 9.5 mm   | -    | -     | 0.1        | 1.22 |
| Aluminum, steel, or vinyl, <sup>j,k</sup> over sheathing<br>Hollow-backed                  | -    | -     | 0.11       | 1.22 |
| Aluminum, steel, or vinyl, <sup>j,k</sup> over sheathing<br>Insulating-board-backed 9.5 mm | -    | -     | 0.32       | 1.34 |
| Aluminum, steel, or vinyl, <sup>j,k</sup> over sheathing<br>Foil-backed 9.5 mm             | -    | -     | 0.52       | -    |
| Architectural (soda-lime float) glass  | 2500 | 1     | -          | 0.84 |
| Building Membrane  |      |       |            |      |
| Vapor-permeable felt   | -    | -     | 0.011      | -    |
| Vapor: seal, 2 layers of mopped 0.73 kg/m <sup>2</sup><br>felt                             | -    | -     | 0.21       | -    |
| Vapor: seal, plastic film  | -    | -     | Negligible | -    |
| Finish Flooring Materials  |      |       |            |      |
| Carpet and rebounded urethane pad 19<br>mm   | 110  | -     | 0.42       | -    |
| Carpet and rubber pad (one-piece) 9.5 mm   | 320  | -     | 0.12       | -    |
| Pile carpet with rubber pad 9.5 to 12.7<br>mm  | 290  | -     | 0.28       | -    |
| Linoleum/cork tile 6.4 mm  | 465  | -     | 0.09       | -    |
| PVC/Rubber floor covering  | -    | 0.4   | -          | -    |
| Rubber tile 25 mm  | 1900 | -     | 0.06       | -    |



|   |            |                |       |      |
|---|------------|----------------|-------|------|
| Terrazzo 25 mm  | -          | -              | 0.014 | 0.8  |
| Insulating Materials  |            |                |       |      |
| <i>Blanket and batt<sup>c,d</sup></i>                             |            |                |       |      |
| Glass-fiber batts 85 to 90 mm                                     | 10 to 14   | 0.043          | -     | 0.84 |
| Glass-fiber batts 50 mm   | 8 to 13    | 0.045 to 0.048 | -     | 0.84 |
| Mineral fiber 140 mm  | 30         | 0.036          | -     | 0.84 |
| Mineral wool, felted  | 16 to 48   | 0.04           | -     | -    |
|   | 65 to 130  | 0.035          | -     | -    |
| Slag wool .   | 50 to 190  | 0.038          | -     | -    |
|   | 255        | 0.04           | -     | -    |
|   | 305        | 0.043          | -     | -    |
|   | 350        | 0.048          | -     | -    |
|   | 400        | 0.05           | -     | -    |
| <i>Board and slabs</i>  |            |                |       |      |
| Cellular glass.   | 130        | 0.048          | -     | 0.75 |
| Cement fiber slabs, shredded wood with Portland cement binder     | 400 to 430 | 0.072 to 0.076 | -     | -    |
|   |            |                | -     |      |
| Cement fiber slabs, shredded wood with magnesia oxysulfide binder | 350        | 0.082          | -     | 1.3  |
| Glass fiber board   | 160        | 0.032 to 0.040 | -     | 0.84 |
| Expanded rubber (rigid)   | 70         | 0.032          | -     | 1.67 |
| Expanded polystyrene extruded (smooth skin)                       | 25 to 40   | 0.022 to 0.030 | -     | 1.47 |
| Expanded polystyrene, molded beads                                | 15 to 25   | 0.032 to 0.039 | -     | 1.47 |
| Mineral fiberboard, wet felted                                    | 160        | 0.038          | -     | 0.84 |
| Mineral fiberboard, core or roof insulation                       | 255 to 270 | 0.049          | -     | -    |
| Mineral fiberboard, acoustical tile <sup>g</sup>                  | 290        | 0.05           | -     | 0.8  |
|   | 335        | 0.053          | -     | -    |
| Mineral fiberboard, wet-molded, acoustical tile.                  | 370        | 0.061          | -     | 0.59 |
| Perlite board   | 160        | 0.052          | -     | -    |
| Polyisocyanurate, aged unfaced                                    | 25 to 35   | 0.020 to 0.027 | -     | -    |
| Polyisocyanurate, aged with facers                                | 65         | 0.019          | -     | 1.47 |
| Phenolic foam board with facers, aged                             | 65         | 0.019          | -     | -    |
| <i>Loose fill</i>   |            |                |       |      |

|   |            |                |            |      |
|---|------------|----------------|------------|------|
| Cellulosic (milled paper or wood pulp)  | 35 to 50   | 0.039 to 0.045 | -          | 1.38 |
| Perlite, expanded   | 30 to 65   | 0.039 to 0.046 | -          | 1.09 |
|   | 65 to 120  | 0.045 to 0.052 | -          | -    |
|   | 120 to 180 | 0.052 to 0.061 | -          | -    |
| Mineral fiber (rock, slag, or glass) <sup>d</sup> approx. 95 to 130 mm                | 10 to 30   | -              | 1.92       | 0.71 |
| Mineral fiber (rock, slag, or glass) <sup>d</sup> approx. 170 to 220 mm               | 11 to 30   | -              | 3.33       | -    |
| Mineral fiber (rock, slag, or glass) <sup>d</sup> approx. 190 to 250 mm               | 12 to 30   | -              | 3.85       | -    |
| Mineral fiber (rock, slag, or glass) <sup>d</sup> approx. 260 to 350 mm               | 13 to 30   | -              | 5.26       | -    |
| Mineral fiber (rock, slag, or glass) <sup>d</sup> 90 mm (closed sidewall application) | 30 to 55   | -              | 2.1 to 2.5 | -    |
| Vermiculite, exfoliated   | 110 to 130 | 0.068          | -          | 1.34 |
|   | 64 to 96   | 0.063          | -          | -    |
| <i>Spray-applied</i>  |            |                |            |      |
| Cellulosic fiber  | 55 to 95   | 0.042 to 0.049 | -          | -    |
| Glass fiber   | 55 to 70   | 0.038 to 0.039 | -          | -    |
| Polyurethane foam (low density)   | 6 to 8     | 0.042          | -          | 1.47 |
|   | 40         | 0.026          | -          | 1.47 |
| Polyurethane foam (low density) aged and dry 40 mm                                    | 30         | -              | 1.6        | 1.47 |
| Polyurethane foam (low density) 50 mm   | 55         | -              | 1.92       | 1.47 |
| Polyurethane foam (low density) 120 mm  | 30         | -              | 3.69       | -    |
| Ureaformaldehyde foam, dry  | 8 to 20    | 0.030 to 0.032 | -          | -    |
| Roofing   |            |                |            |      |
| Asbestos/cement shingles  | 1120       | -              | 0.037      | 1    |
| Asphalt (bitumen with inert fill)   | 1600       | 0.43           | -          | -    |
|   | 1900       | 0.58           | -          | -    |
|   | 2300       | 1.15           | -          | -    |
| Asphalt roll roofing  | 920        | -              | 0.027      | 1.51 |
| Asphalt shingles  | 920        | -              | 0.078      | 1.26 |
| Built-up roofing  | 920        | -              | 0.059      | 1.47 |
| Mastic asphalt (heavy, 20% grit)  | 950        | 0.19           | -          | -    |
| Reed thatch   | 270        | 0.09           | -          | -    |
| Roofing felt  | 2250       | 1.2            | -          | -    |

|   |      |              |       |      |
|---|------|--------------|-------|------|
| Slate 13 mm                                 | -    | -            | 0.009 | 1.26 |
| Straw thatch                                | 240  | 0.07         | -     | -    |
| Wood shingles, plain and plastic-film-faced | -    | -            | 0.166 | 1.3  |
| Plastering Materials                        |      |              |       |      |
| Cement plaster, sand aggregate              | 1860 | 0.72         | -     | 0.84 |
| Sand aggregate 10 mm                        | -    | -            | 0.013 | 0.84 |
| Sand aggregate 20 mm                        | -    | -            | 0.026 | 0.84 |
| Gypsum plaster                              | 1120 | 0.38         | -     | -    |
|   | 1280 | 0.46         | -     | -    |
| Lightweight aggregate                       | 720  | -            | 0.056 | -    |
| Lightweight aggregate                       | 720  | -            | 0.066 | -    |
| Lightweight aggregate                       | -    | -            | 0.083 | -    |
| Perlite aggregate                           | 720  | 0.22         | -     | 1.34 |
| Sand aggregate                              | 1680 | 0.81         | -     | 0.84 |
| Sand aggregate on metal lath 19 mm          | -    | -            | 0.023 | -    |
| Vermiculite aggregate                       | 480  | 0.14         | -     | -    |
|   | 600  | 0.2          | -     | -    |
|   | 720  | 0.25         | -     | -    |
|   | 840  | 0.26         | -     | -    |
|   | 960  | 0.3          | -     | -    |
| Perlite plaster                             | 400  | 0.08         | -     | -    |
|   | 600  | 0.19         | -     | -    |
| Pulpboard or paper plaster                  | 600  | 0.07         | -     | -    |
| Sand/cement plaster, conditioned            | 1560 | 0.63         | -     | -    |
| Sand/cement/lime plaster, conditioned       | 1440 | 0.48         | -     | -    |
| Sand/gypsum (3:1) plaster, conditioned      | 1550 | 0.65         | -     | -    |
| Masonry Materials                           |      |              |       |      |
| <i>Masonry units</i>                        |      |              |       |      |
| Brick, fired clay                           | 2400 | 1.21 to 1.47 | -     | -    |
|   | 2240 | 1.07 to 1.30 | -     | -    |
|   | 2080 | 0.92 to 1.12 | -     | -    |
|   | 1920 | 0.81 to 0.98 | -     | 0.8  |
|   | 1760 | 0.71 to 0.85 | -     | -    |
|   | 1600 | 0.61 to 0.74 | -     | -    |
|   | 1440 | 0.52 to 0.62 | -     | -    |
|   | 1280 | 0.43 to 0.53 | -     | -    |
|   | 1120 | 0.36 to 0.45 | -     | -    |
| Clay tile, hollow 1 cell deep 75 mm         | -    | -            | 0.14  | 0.88 |

|   |     |      |              |      |
|---|-----|------|--------------|------|
| Clay tile, hollow 1 cell deep 100 mm  | -   | -    | 0.2          | -    |
| Clay tile, hollow 2 cells deep 150 mm   | -   | -    | 0.27         | -    |
| Clay tile, hollow 2 cells deep 200 mm   | -   | -    | 0.33         | -    |
| Clay tile, hollow 2 cells deep 250 mm   | -   | -    | 0.39         | -    |
| Clay tile, hollow 3 cells deep 300 mm   | -   | -    | 0.44         | -    |
| Lightweight brick   | 800 | 0.2  | -            | -    |
|   | 770 | 0.22 | -            | -    |
| Concrete blocks <sup>h,i</sup> Limestone aggregate<br>~200 mm, 16.3 kg, 2200 kg/m <sup>3</sup> concrete, 2<br>cores ..  | -   | -    | -            | -    |
| Concrete blocks <sup>h,i</sup> Limestone aggregate<br>~200 mm, 16.3 kg, 2200 kg/m <sup>3</sup> concrete<br>with perlite-filled cores                                    | -   | -    | 0.37         | -    |
| Concrete blocks <sup>h,i</sup> Limestone aggregate<br>~300 mm, 25 kg, 2200 kg/m <sup>3</sup> concrete, 2<br>cores   | -   | -    | -            | -    |
| Normal-weight aggregate (sand and<br>gravel)~200 mm, 16 kg, 2100 kg/m <sup>3</sup><br>concrete, 2 or 3 cores ..   | -   | -    | 0.20 to 0.17 | 0.92 |
| Normal-weight aggregate (sand and<br>gravel)~200 mm, 16 kg, 2100 kg/m <sup>3</sup> with<br>perlite-filled cores   | -   | -    | 0.35         | -    |
| Normal-weight aggregate (sand and<br>gravel)~200 mm, 16 kg, 2100 kg/m <sup>3</sup> with<br>vermiculite-filled cores   | -   | -    | 0.34 to 0.24 | -    |
| Normal-weight aggregate (sand and<br>gravel)~200 mm, 16 kg, 2100 kg/m <sup>3</sup> ~300<br>mm, 22.7 kg, 2000 kg/m <sup>3</sup> concrete, 2 cores<br>..                  | -   | -    | 0.217        | 0.92 |
| Medium-weight aggregate (combinations<br>of normal and lightweight aggregate) ~200<br>mm, 13 kg, 1550 to 1800 kg/m <sup>3</sup> concrete, 2<br>or 3 cores               | -   | -    | 0.30 to 0.22 | -    |
| Medium-weight aggregate (combinations<br>of normal and lightweight aggregate) ~200<br>mm, 13 kg, 1550 to 1800 kg/m <sup>3</sup> with<br>perlite-filled cores            | -   | -    | 0.65 to 0.41 | -    |
| Medium-weight aggregate (combinations<br>of normal and lightweight aggregate) ~200<br>mm, 13 kg, 1550 to 1800 kg/m <sup>3</sup> with<br>vermiculite-filled cores        | -   | -    | 0.58         | -    |
| Medium-weight aggregate (combinations<br>of normal and lightweight aggregate) ~200<br>mm, 13 kg, 1550 to 1800 kg/m <sup>3</sup> with<br>molded-EPS-filled (beads) cores | -   | -    | 0.56         | -    |
| Medium-weight aggregate (combinations<br>of normal and lightweight aggregate) ~200<br>mm, 13 kg, 1550 to 1800 kg/m <sup>3</sup> with<br>molded EPS inserts in cores     | -   | -    | 0.47         | -    |

|   |      |      |              |      |
|---|------|------|--------------|------|
| Low-mass aggregate (expanded shale, clay, slate or slag, pumice) ~150 mm, 7 1/2 kg, 1400 kg/m <sup>2</sup> concrete, 2 or 3 cores                                 | -    | -    | 0.34 to 0.29 | -    |
| Low-mass aggregate (expanded shale, clay, slate or slag, pumice) ~150 mm, 7 1/2 kg, 1400 kg/m <sup>2</sup> with perlite-filled cores                              | -    | -    | 0.74         | -    |
| Low-mass aggregate (expanded shale, clay, slate or slag, pumice) ~150 mm, 7 1/2 kg, 1400 kg/m <sup>2</sup> with vermiculite-filled cores                          | -    | -    | 0.53         | -    |
| Low-mass aggregate (expanded shale, clay, slate or slag, pumice) 200 mm, 8 to 10 kg, 1150 to 1380 kg/m <sup>2</sup> concrete                                      | -    | -    | 0.56 to 0.33 | 0.88 |
| Low-mass aggregate (expanded shale, clay, slate or slag, pumice) 200 mm, 8 to 10 kg, 1150 to 1380 kg/m <sup>2</sup> concrete with perlite-filled cores            | -    | -    | 1.20 to 0.77 | -    |
| Low-mass aggregate (expanded shale, clay, slate or slag, pumice) 200 mm, 8 to 10 kg, 1150 to 1380 kg/m <sup>2</sup> concrete with vermiculite-filled cores        | -    | -    | 0.93 to 0.69 | -    |
| Low-mass aggregate (expanded shale, clay, slate or slag, pumice) 200 mm, 8 to 10 kg, 1150 to 1380 kg/m <sup>2</sup> concrete with molded-EPS-filled (beads) cores | -    | -    | 0.85         | -    |
| Low-mass aggregate (expanded shale, clay, slate or slag, pumice) 200 mm, 8 to 10 kg, 1150 to 1380 kg/m <sup>2</sup> concrete with UF foam-filled cores            | -    | -    | 0.79         | -    |
| Low-mass aggregate (expanded shale, clay, slate or slag, pumice) 200 mm, 8 to 10 kg, 1150 to 1380 kg/m <sup>2</sup> concrete with molded EPS inserts in cores     | -    | -    | 0.62         | -    |
| Low-mass aggregate (expanded shale, clay, slate or slag, pumice) 300 mm, 16 kg, 1400 kg/m <sup>3</sup> ,concrete, 2 or 3 cores                                    | -    | -    | 0.46 to 0.40 | -    |
| Low-mass aggregate (expanded shale, clay, slate or slag, pumice) 300 mm, 16 kg, 1400 kg/m <sup>3</sup> ,with perlite-filled cores                                 | -    | -    | 1.6 to 1.1   | -    |
| Low-mass aggregate (expanded shale, clay, slate or slag, pumice) 300 mm, 16 kg, 1400 kg/m <sup>3</sup> ,with vermiculite-filled cores                             | -    | -    | 1            | -    |
| Stone, lime, or sand  | 2800 | 10.4 | -            | -    |
| Quartzitic and sandstone  | 2560 | 6.2  | -            | -    |
|   | 2240 | 3.46 | -            | -    |
|   | 1920 | 1.88 | -            | 0.88 |
| Calcitic, dolomitic, limestone, marble, and granite   | 2880 | 4.33 | -            | -    |
|   | 2560 | 3.17 | -            | -    |
|   | 2240 | 2.31 | -            | -    |
|   | 1920 | 1.59 | -            | 0.88 |

|  |            |              |       |              |
|--|------------|--------------|-------|--------------|
|  | 1600       | 1.15         | -     | -            |
| Gypsum partition tile .75 by 300 by 760 mm, solid  | -          | -            | 0.222 | 0.79         |
| Gypsum partition tile .4 cells   | -          | -            | 0.238 | -            |
| Gypsum partition tile .100 by 300 by 760 mm, 3 cells   | -          | -            | 0.294 | -            |
| Limestone  | 2400       | 0.57         | -     | 0.84         |
|  | 2600       | 0.93         | -     | 0.84         |
| <b>Concretes</b>   |            |              |       |              |
| Sand and gravel or stone aggregate concretes (concretes with >50% quartz or quartzite sand have conductivities in higher end of range)   | 2400       | 1.4 to 2.9   | -     | -            |
|  | 2240       | 1.3 to 2.6   | -     | 0.80 to 1.00 |
|  | 2080       | 1.0 to 1.9   | -     | -            |
| Low-mass aggregate or limestone concretes  | 1920       | 0.9 to 1.3   | -     | -            |
| Low-mass aggregate or limestone concretes Expanded shale, clay, or slate; expanded slags ;cinders; pumice (with density up to 1600 kg/m <sup>3</sup> ); scoria (sanded concretes have conductivities in higher end of range) | 1600       | 0.68 to 0.89 | -     | 0.84         |
|  | 1280       | 0.48 to 0.59 | -     | 0.84         |
|  | 960        | 0.30 to 0.36 | -     | -            |
|  | 640        | 0.18         | -     | -            |
| Gypsum/fiber concrete (87.5% gypsum, 12.5% wood chips)   | 800        | 0.24         | -     | 0.84         |
| Cement/lime, mortar, and stucco  | 1920       | 1.4          | -     | -            |
|  | 1600       | 0.97         | -     | -            |
|  | 1280       | 0.65         | -     | -            |
| Perlite, vermiculite, and polystyrene beads  | 800        | 0.26 to 0.27 | -     | -            |
|  | 640        | 0.20 to 0.22 | -     | 0.63 to 0.96 |
|  | 480        | 0.16         | -     | -            |
|  | 320        | 0.12         | -     | -            |
| Foam concretes   | 1920       | 0.75         | -     | -            |
|  | 1600       | 0.6          | -     | -            |
|  | 1280       | 0.44         | -     | -            |
|  | 1120       | 0.36         | -     | -            |
| Foam concretes and cellular concretes  | 960        | 0.3          | -     | -            |
|  | 640        | 0.2          | -     | -            |
|  | 320        | 0.12         | -     | -            |
| Aerated concrete (oven-dried)  | 430 to 800 | 0.2          | -     | 0.84         |
| Polystyrene concrete (oven-dried)  | 255 to 800 | 0.37         | -     | 0.84         |
| Polymer concrete   | 1950       | 1.64         | -     | -            |
|  | 2200       | 1.03         | -     | -            |

|                                     |            |              |   |      |
|-------------------------------------|------------|--------------|---|------|
| Polymer cement                      | 1870       | 0.78         | - | -    |
| Slag concrete                       | 960        | 0.22         | - | -    |
|                                     | 1280       | 0.32         | - | -    |
|                                     | 1600       | 0.43         | - | -    |
|                                     | 2000       | 1.23         | - | -    |
| <b>Woods (12% moisture content)</b> |            |              |   |      |
| <i>Hardwoods</i>                    | -          | -            | - | 1.63 |
| Oak                                 | 660 to 750 | 0.16 to 0.18 | - | -    |
| Birch                               | 680 to 725 | 0.17 to 0.18 | - | -    |
| Maple                               | 635 to 700 | 0.16 to 0.17 | - | -    |
| Ash                                 | 615 to 670 | 0.15 to 0.16 | - | -    |
| <i>Softwoods</i>                    | -          | -            | - | 1.63 |
| Southern pine                       | 570 to 660 | 0.14 to 0.16 | - | -    |
| Southern yellow pine                | 500        | 0.13         | - | -    |
| Eastern white pine                  | 400        | 0.1          | - | -    |
| Douglas fir/larch                   | 535 to 580 | 0.14 to 0.15 | - | -    |
| Southern cypress                    | 500 to 515 | 0.13         | - | -    |
| Hem/fir, spruce/pine/fir            | 390 to 500 | 0.11 to 0.13 | - | -    |
| Spruce                              | 400        | 0.09         | - | -    |
| Western red cedar                   | 350        | 0.09         | - | -    |
| West coast woods, cedars            | 350 to 500 | 0.10 to 0.13 | - | -    |
| Eastern white cedar                 | 360        | 0.1          | - | -    |
| California redwood                  | 390 to 450 | 0.11 to 0.12 | - | -    |
| Pine (oven-dried)                   | 370        | 0.092        | - | 1.88 |
| Spruce (oven-dried)                 | 395        | 0.1          | - | 1.88 |

<sup>a</sup>Values are for mean temperature of 24°C. Representative values for dry materials are intended as design (not specification) values for materials in normal use. Thermal values of insulating materials may differ from design values depending on in-situ properties (e.g., density and moisture content, orientation, etc.) and manufacturing variability. For properties of specific product, use values supplied by manufacturer or unbiased tests.

<sup>b</sup>Symbol  $\lambda$  also used to represent thermal conductivity.

<sup>c</sup>Does not include paper backing and facing, if any. Where insulation forms boundary (reflective or otherwise) of airspace

<sup>d</sup>Conductivity varies with fiber diameter. Batt, blanket, and loose-fill mineral fiber insulations are manufactured to achieve specified R-values, the most common of which are listed in the table. Because of differences in manufacturing processes and materials, the product thicknesses, densities, and thermal conductivities vary over considerable ranges for a specified R-value.

<sup>e</sup>Values are for aged products with gas-impermeable facers on the two major surfaces. An aluminum foil facer of 25  $\mu$ m thickness or greater is generally considered impermeable to gases. For change in conductivity with age of expanded polyisocyanurate.

<sup>f</sup>Cellular phenolic insulation may no longer be manufactured. Thermal conductivity and resistance values do not represent aged insulation, which may have higher thermal conductivity and lower thermal resistance.

<sup>g</sup>Insulating values of acoustical tile vary, depending on density of board and on type, size, and depth of perforations.

---

<sup>b</sup>Values for fully grouted block may be approximated using values for concrete with similar unit density.

<sup>c</sup>Values for concrete block and concrete are at moisture contents representative of normal use.

<sup>d</sup>Values for metal or vinyl siding applied over flat surfaces vary widely, depending on ventilation of the airspace beneath the siding; whether airspace is reflective or nonreflective; and on thickness, type, and application of insulating backing-board used. Values are averages for use as design guides, and were obtained from several guarded hot box tests (ASTM *Standard C236*) or calibrated hot box (ASTM *Standard C976*) on hollow-backed types and types made using backing of wood fiber, foamed plastic, and glass fiber. Departures of  $\pm 50\%$  or more from these values may occur.

<sup>e</sup>Vinyl specific heat =  $1.0 \text{ kJ}/(\text{kg}\cdot\text{K})$

<sup>f</sup>See Adams (1971), MacLean (1941), and Wilkes (1979). Conductivity values listed are for heat transfer across the grain. Thermal conductivity of wood varies linearly with density, and density ranges listed are those normally found for wood species given. If density of wood species is not known, use mean conductivity value. For extrapolation to other moisture contents, the following empirical equation developed by Wilkes (1979) may be used:

$$k = 0.1791 + \frac{(1.874 \times 10^{-2} + 5.733 \times 10^{-4} M)\rho}{1 + 0.01 M}$$

where  $\rho$  is density of moist wood in  $\text{kg}/\text{m}^3$ , and  $M$  is moisture content in percent.

<sup>g</sup>From Wilkes (1979), an empirical equation for specific heat of moist wood at  $24^\circ\text{C}$  is as follows:

$$C_p = \frac{(0.299 + 0.01 M)}{(1 + 0.01 M)} + \Delta C_p$$

where  $\Delta C_p$  accounts for heat of sorption and is denoted by

$$\Delta C_p = M(1.921 \times 10^{-3} - 3.168 \times 10^{-5} M)$$

where  $M$  is moisture content in percent by mass.

<sup>h</sup>Blank space in reference column indicates historical values from previous volumes of *ASHRAE Handbook*. Source of information could not be determined.

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## 11. Appendix B: Climate Zone Map of India

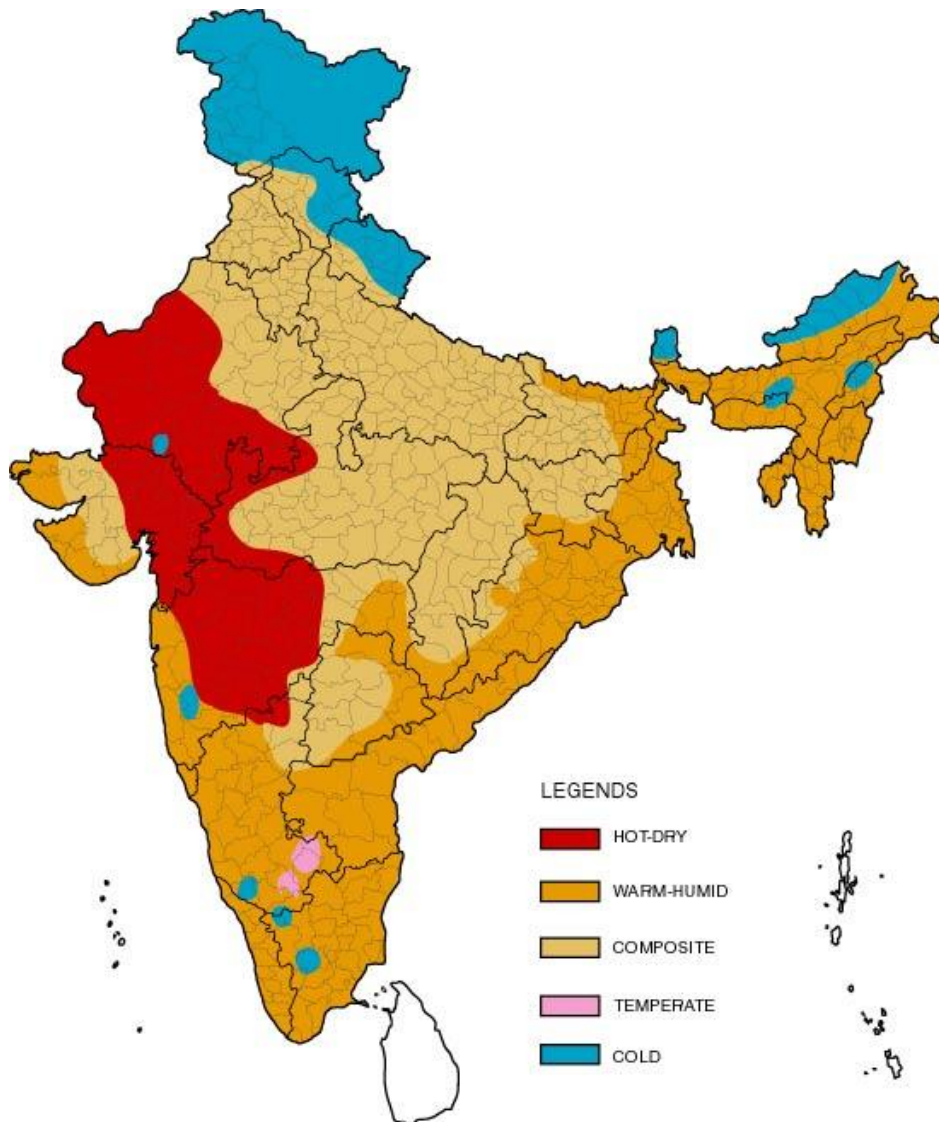


Table 11-1 Climate Zone for Major Indian Cities

| City        | Climate Type | City            | Climate Type |
|-------------|--------------|-----------------|--------------|
| Ahmedabad   | Hot & Dry    | Kurnool         | Warm & Humid |
| Allahabad   | Composite    | Leh             | Cold         |
| Amritsar    | Composite    | Lucknow         | Composite    |
| Aurangabad  | Hot & Dry    | Ludhiana        | Composite    |
| Bangalore   | Temperate    | Chennai         | Warm & Humid |
| Barmer      | Hot & Dry    | Manali          | Cold         |
| Belgaum     | Warm & Humid | Mangalore       | Warm & Humid |
| Bhagalpur   | Warm & Humid | Mumbai          | Warm & Humid |
| Bhopal      | Composite    | Nagpur          | Composite    |
| Bhubaneswar | Warm & Humid | Nellore         | Warm & Humid |
| Bikaner     | Hot & Dry    | New Delhi       | Composite    |
| Chandigarh  | Composite    | Panjim          | Warm & Humid |
| Chitradurga | Warm & Humid | Patna           | Composite    |
| Dehradun    | Composite    | Pune            | Warm & Humid |
| Dibrugarh   | Warm & Humid | Raipur          | Composite    |
| Guwahati    | Warm & Humid | Rajkot          | Composite    |
| Gorakhpur   | Composite    | Ramgundam       | Warm & Humid |
| Gwalior     | Composite    | Ranchi          | Composite    |
| Hissar      | Composite    | Ratnagiri       | Warm & Humid |
| Hyderabad   | Composite    | Raxaul          | Warm & Humid |
| Imphal      | Warm & Humid | Saharanpur      | Composite    |
| Indore      | Composite    | Shillong        | Cold         |
| Jabalpur    | Composite    | Sholapur        | Hot & Dry    |
| Jagdelpur   | Warm & Humid | Srinagar        | Cold         |
| Jaipur      | Composite    | Sundernagar     | Cold         |
| Jaisalmer   | Hot & Dry    | Surat           | Hot & Dry    |
| Jalandhar   | Composite    | Tezpur          | Warm & Humid |
| Jamnagar    | Warm & Humid | Tiruchirappalli | Warm & Humid |
| Jodhpur     | Hot & Dry    | Trivandrum      | Warm & Humid |
| Jorhat      | Warm & Humid | Tuticorin       | Warm & Humid |
| Kochi       | Warm & Humid | Udhagamandalam  | Cold         |
| Kolkata     | Warm & Humid | Vadodara        | Hot & Dry    |
| Kota        | Hot & Dry    | Veraval         | Warm & Humid |
| Kullu       | Cold         | Vishakhapatnam  | Warm & Humid |

## 12. Appendix C: Air-Side Economizer Acceptance Procedures

### 12.1 Construction Inspection

Prior to Performance Testing, verify and document the following:

- (a) System controls are wired correctly to ensure economizer is fully integrated (i.e. economizer will operate when mechanical cooling is enabled).
- (b) Economizer lockout control sensor location is adequate (open to air but not exposed to direct sunlight nor in an enclosure; away from sources of building exhaust; at least 8 meters away from cooling towers).
- (c) System is provided with barometric relief, relief fan or return fan to control building pressure.

### 12.2 Equipment Testing

Step 1: Simulate a cooling load and enable the economizer by adjusting the lockout control set point. Verify and document the following:

- (a) Economizer damper modulates opens to 100% outside air.
- (b) Return air damper modulates closed and is completely closed when economizer damper is 100% open.
- (c) Economizer damper is 100% open before mechanical cooling is enabled.
- (d) Relief fan or return fan (if applicable) is operating or barometric relief dampers freely swing open.

Step 2: Continue from Step 1 and disable the economizer by adjusting the lockout control set point. Verify and document the following:

- (a) Economizer damper closes to minimum ventilation position.
- (b) Return air damper opens to at or near 100%.
- (c) Relief fan (if applicable) shuts off or barometric relief dampers close. Return fan (if applicable) may still operate even when economizer is disabled.

## 13. Appendix D: Compliance Forms

## Envelope Summary

Energy Conservation Building Code 2017 Compliance Forms

|                       |  |                             |
|-----------------------|--|-----------------------------|
| Project Info          | Project Address                            | Date                        |
|                       |  | For Building Department Use |
|                       | Project Built-up Area [m <sup>2</sup> ]    |                             |
|                       | Project Above-grade Area [m <sup>2</sup> ] |                             |
|                       | Project Conditioned Area [m <sup>2</sup> ] |                             |
|                       | Applicant Name and Address                 |                             |
|                       |  |                             |
| Project Climatic Zone |  |                             |

|                         |                                      |   |
|-------------------------|--------------------------------------|---|
| Building Classification | <input type="checkbox"/> Hospitality | <input type="checkbox"/> Business         |
|                         | <input type="checkbox"/> Health Care | <input type="checkbox"/> Educational      |
|                         | <input type="checkbox"/> Assembly    | <input type="checkbox"/> Shopping Complex |

|  |  |   |   |
|--|--|---|---|
| Project Description                              | <input type="checkbox"/> New Building  | <input type="checkbox"/> Addition       | <input type="checkbox"/> Alteration       |
|  | <input type="checkbox"/> Self-occupied | <input type="checkbox"/> Core and Shell | <input type="checkbox"/> Mixed-Use        |
| Compliance is sought for Energy efficiency level | <input type="radio"/> ECBC Compliant   | <input type="radio"/> ECBC+ Compliant   | <input type="radio"/> SuperECBC Compliant |
| EPI Ratio  |  |   |   |

|                     |                     |                                   |   |
|---------------------|---------------------|-----------------------------------|---|
| Compliance Approach | Prescriptive Method | Whole Building Performance Method | Building Trade-off Method-Envelope Compliance |
|---------------------|---------------------|-----------------------------------|---|

|  |  |         |                                      |
|--|--|---------|--------------------------------------|
| Building Envelope                      |  |         |                                      |
| Vertical Fenestration Area Calculation | Total Vertical Fenestration Area (rough opening) | /       | Gross Exterior Wall Area             |
|  |  |         | X 100 = % Window to Wall Ratio (WWR) |
|  |  | X 100 = |                                      |

|                                    |  |                   |   |                                |
|------------------------------------|--|-------------------|---|--------------------------------|
| Skylight Area Calculation          | Total Skylight Area (rough opening) / Gross Exterior Roof Area |                   | times 100 equals  | % Skylight to roof ratio (SRR) |
|                                    | ÷  |                   | X 100 =   |                                |
| Opaque Assembly                    |  |                   | Daylighting Summary   |                                |
| Wall (Minimum Insulation U-factor) |  |                   | % above-grade floor area meeting the UDI requirement for 90% of the potential daylit time in a year |                                |
| Roof (Minimum Insulation U-factor) |  |                   |   |                                |
|                                    |  |                   |   |                                |
| Cool Roof                          |  |                   | Fenestration  |                                |
| Solar Reflectance                  |  |                   | Vertical  |                                |
| Emittance                          |  |                   | Maximum U-factor  |                                |
|                                    |  |                   | Maximum SHGC (or SC)  |                                |
| Wall Assembly                      |  |                   | Minimum VLT   |                                |
| Material                           | R-value  | Assembly U-Factor | Overhang / Sidefins / Box Frame Projection (yes or no)  |                                |
|                                    |  |                   | If yes, enter Projection Factor for each orientation and effective SHGC                             |                                |
|                                    |  |                   | Skylight  |                                |
|                                    |  |                   | Maximum U-factor  |                                |
|                                    |  |                   | Maximum SHGC (or SC)  |                                |

## Envelope Checklist

Energy Conservation Building Code 2017 Compliance Forms

|                 |  |      |  |
|-----------------|--|------|--|
| Project Address |  | Date |  |
|-----------------|--|------|--|

| Applicability                      |    |     | Code Section | Component                   | Information Required   | Location on Plans | Building Department Notes |
|------------------------------------|----|-----|--------------|-----------------------------|--|-------------------|---------------------------|
| Yes                                | No | N/A |              |                             |  |                   |                           |
| Mandatory Provisions (Section 4.2) |    |     |              |                             |  |                   |                           |
|                                    |    |     | 4.2.1        | Fenestration                |  |                   |                           |
|                                    |    |     | 4.2.1.1      | U-factor                    | Specify reference standard                                   |                   |                           |
|                                    |    |     | 4.2.1.2      | SHGC                        | Specify reference standard                                   |                   |                           |
|                                    |    |     | 4.2.1.3      | Visible light transmittance | Specify reference standard                                   |                   |                           |
|                                    |    |     | 4.2.2        | Opaque Construction         |  |                   |                           |
|                                    |    |     | 4.2.2.1      | U-factors                   | Specify reference standard                                   |                   |                           |
|                                    |    |     | 4.2.2.2      | Solar Reflectance           | Specify reference standard                                   |                   |                           |
|                                    |    |     | 4.2.2.3      | Emittance                   | Specify reference standard                                   |                   |                           |
|                                    |    |     | 4.2.3        | Daylighting                 | Specify simulation approach or prescriptive                  |                   |                           |
|                                    |    |     | 4.2.4        | Building envelope sealing   | Indicate sealing, caulking, gasketing, and weather stripping |                   |                           |

| Prescriptive Compliance Option (Section 4.3) |  |  |         |                       |  |  |  |
|--|--|--|---------|-----------------------|--|--|--|
|  |  |  | 4.3.1   | Roofs                 | Specify implemented U factor   |  |  |
|  |  |  | 4.3.1.1 | Vegetative cool roof  | Specify the solar reflectance, emittance, and reference standards  |  |  |
|  |  |  | 4.3.2   | Opaque External Wall  | Specify implemented U factor   |  |  |
|  |  |  | 4.3.3   | Vertical fenestration | (1) Indicate U-factors on fenestration schedule. Indicate if values are rated or default. If values are default, then specify frame type, glazing layers, gapwidth, low-e.<br>(2) Indicate SHGC or SC on fenestration schedule. Indicate if values are rated or default.<br>(3) Indicate VLT of fenestration schedule. Indicate if values are rated or default.<br>(4) Indicate if overhangs or side fins or box-frame projection are used for compliance purposes. If so, provide projection factor calculation and equivalent SHGC calculation |  |  |

|  |  |  |              |                                       |   |  |  |
|--|--|--|--------------|---------------------------------------|---|--|--|
|  |  |  | 4.3.3<br>(a) | fenestration U<br>factor<br>exemption | Specify if applicable, specify<br>unconditioned space percentage,<br>and specify incorporated<br>specifications   |  |  |
|  |  |  | 4.3.4        | Skylights                             | (1) Indicate U-factors on<br>fenestration schedule. Indicate if<br>values are rated or default. If values<br>are default, then specify frame type,<br>glazing layers, gap width, low-e. (2)<br>Indicate SHGC or SC on fenestration<br>schedule. Indicate if values are<br>rated or default. |  |  |
|  |  |  |              |                                       |   |  |  |

|  |  |  |  |  |                      |  |  |
|--|--|--|--|--|----------------------|--|--|
| Building Envelope Trade-Off Option (Section 4.3.4) |  |  |  |  |                      |  |  |
|  |  |  |  |  | Provide calculations |  |  |



## Comfort System and Control Summary

Energy Conservation Building Code 2017 Compliance Forms

|              |                                  |                             |
|--------------|----------------------------------|-----------------------------|
| Project Info | Project Address:                 | Date                        |
|              |                                  | For Building Department Use |
|              | Project Built-up Area (sq.m):    |                             |
|              | Project Above-grade area (sq.m): |                             |
|              | Project Conditioned Area (sq.m): |                             |
|              | Applicant Name and Address:      |                             |
|              |                                  |                             |
|              | Project Climatic Zone:           |                             |

### Project Description

|  |  |
|--|--|
| Briefly describe comfort system type and features. | Natural ventilation, mechanical Ventilation, Low energy comfort system, heating and cooling mechanical equipment. percentage area distribution for the installed system, and related information |
|  |  |
|  |  |

|                   |                   |                     |                                   |
|-------------------|-------------------|---------------------|-----------------------------------|
| Compliance Option | System efficiency | Prescriptive Method | Whole Building Performance Method |
|-------------------|-------------------|---------------------|-----------------------------------|

|                     |  |
|---------------------|--|
| Equipment Schedules | The following information is required to be incorporated with the mechanical equipment schedules on the plans. For projects without plans, fill in the required information below. |
|---------------------|--|

### Cooling Equipment Schedule

| Equip. ID | Brand Name | Model No. | Capacity kW | Testing Standards | OSA CFM or Economizer? | COP | IPLV | Location |
|-----------|------------|-----------|-------------|-------------------|------------------------|-----|------|----------|
|           |            |           |             |                   |                        |     |      |          |
|           |            |           |             |                   |                        |     |      |          |
|           |            |           |             |                   |                        |     |      |          |
|           |            |           |             |                   |                        |     |      |          |
|           |            |           |             |                   |                        |     |      |          |
|           |            |           |             |                   |                        |     |      |          |

### Heating Equipment Schedule

| Equip. ID | Brand Name | Model No. | Capacity kW | Testing Standards | OSA CFM | Input kW | Output kW | Efficiency |
|-----------|------------|-----------|-------------|-------------------|---------|----------|-----------|------------|
|-----------|------------|-----------|-------------|-------------------|---------|----------|-----------|------------|

[illegible][illegible]

# Comfort System & Controls Checklist

Energy Conservation Building Code 2017 Compliance Forms

| Project Address   |    |     |              |   | Date   |                   |                           |
|---|----|-----|--------------|---|--|-------------------|---------------------------|
| The following information is necessary to check a building permit application for compliance with the mechanical requirements in the Energy Conservation Building Code. |    |     |              |   |  |                   |                           |
| Applicability   |    |     | Code Section | Component   | Information Required   | Location on Plans | Building Department Notes |
| Yes   | No | N/A |              |   |  |                   |                           |
| Comfort Systems and Control   |    |     |              |   |  |                   |                           |
| Mandatory Provisions (Section 5.2)  |    |     |              |   |  |                   |                           |
|   |    |     | 5.2.1        | Ventilation                                       | Indicate all habitable spaces are ventilated with outdoor air in accordance with § 5.2.1 and guidelines specified in NBC   |                   |                           |
|   |    |     | 5.2.2        | Minimum Space Conditioning Equipment Efficiencies | Provide equipment schedule with type, capacity, efficiency   |                   |                           |
|   |    |     | 5.2.3        | Controls  |  |                   |                           |
|   |    |     | 5.2.3.1      | Timeclock   | Indicate thermostat with night setback, 3 different day types per week, and 2-hour manual override, capable of retaining programming and time setting during loss of power for a period of at least 10 hours |                   |                           |
|   |    |     | 5.2.3.2      | Temperature Controls                              | Indicate temperature control with 3°C deadband minimum if the system provides both heating and cooling.  |                   |                           |
|   |    |     |              |   | Indicate thermostats are interlocked to prevent simultaneous heating and cooling, where separate heating and cooling systems are there   |                   |                           |
|   |    |     |              |   | Indicate separate thermostat control for space types mentioned in § 5.2.3.2.(c)  |                   |                           |
|   |    |     | 5.2.3.3      | Occupancy Controls                                | Indicate occupancy controls for space types mentioned in § 5.2.3.3   |                   |                           |
|   |    |     | 5.2.3.4      | Fan Controls                                      | Indicate two-speed motor, pony motor, or variable speed drive to control the fans and controls shall be capable to reduce the fan speed to at least two third of installed fan power                         |                   |                           |
|   |    |     | 5.2.3.5      | Dampers   | Indicate all air supply and exhaust equipment's having VFD shall have dampers that automatically close upon the situations mentioned in § 5.2.3.5  |                   |                           |
|   |    |     | 5.2.4        | Piping & ductwork                                 | Indicate sealing, caulking, gasketing, and weatherstripping  |                   |                           |
|   |    |     | 5.2.4.1      | Piping insulation                                 | Indicate R-value of insulation   |                   |                           |
|   |    |     | 5.2.4.2      | Ductwork and Plenum insulation                    | Indicate R-value of insulation   |                   |                           |
|   |    |     | 5.2.5        | System Balancing                                  | Show written balance report for HVAC systems serving zones with a total conditioned area exceeding 500 m <sup>2</sup>  |                   |                           |
|   |    |     | 5.2.6        | Condensers  | Indicate location of condenser and source of water used for condenser  |                   |                           |
|   |    |     | 5.2.7        | Service Hot Water Heating                         |  |                   |                           |
|   |    |     | 5.2.7.1      | Solar Water Heating                               | Indicate all Hotels and hospitals have solar water heating equipment installed for hot water design capacity as per § 5.2.9.1  |                   |                           |

|  |  |  |         |                              |   |
|--|--|--|---------|------------------------------|---|
|  |  |  | 5.2.7.2 | Heating Equipment Efficiency | Indicate service water heating equipment shall meet the performance and efficiency as per § 5.2.9.2   |
|  |  |  | 5.2.7.3 | Other Water Heating System   | Indicate supplementary heating system is designed in consideration with § 5.2.9.3   |
|  |  |  | 5.2.7.4 | Piping Insulation            | Indicate the Piping insulation is compliant with § 5.2.6.1.   |
|  |  |  | 5.2.7.5 | Heat Traps                   | Indicate vertical pipe risers serving water heaters and storage tanks are as per § 5.2.9.5  |
|  |  |  | 5.2.7.6 | Swimming Pools               | Indicate the heated pools are provided with a vapor retardent pool cover on the water surface and temperature control and minimum insulation value as per § 5.2.9.6 |

#### Prescriptive Compliance Option (Section 5.3)

|  |  |  |         |   |  |
|--|--|--|---------|---|--|
|  |  |  | 5.3.1   | Chillers                                  | Indicate chiller type, capacity, COP & IPLV  |
|  |  |  | 5.3.2   | Pumps                                     | Indicate pump type (Primary, secondary, and condenser), its total installed capacity and efficiency  |
|  |  |  | 5.3.3   | Cooling Towers                            | Indicate cooling tower type and installed capacity   |
|  |  |  | 5.3.4   | Boilers                                   | Indicate boiler type, capacity and efficiency  |
|  |  |  | 5.3.5.1 | Air-Economizer (ECBC/ECBC+/SuperECBC)     | Indicate air economizer is capable of modulating outside-air and return-air dampers to supply 50% of design supply air quantity as outside-air for respective building type.   |
|  |  |  | 5.3.5.1 | Water-economizer (ECBC/ECBC+/SuperECBC)   | Indicate water economizer is capable of providing 50% of the expected system cooling load at outside air temperatures of 10°C dry-bulb/7.2°C wet-bulb and below, if the designed building is a respective building type. |
|  |  |  | 5.3.5.2 | Partial Cooling                           | Indicate where required by § 5.3.4 economizers shall be capable of providing partial cooling even when additional mechanical cooling is required to meet the cooling load.   |
|  |  |  | 5.3.5.3 | Economizer Controls                       | Indicate air economizers are equipped with controls as specified in § 5.3.4.4  |
|  |  |  | 5.3.5.4 | Testing                                   | Indicate air-side economizers have been tested as per the requirement specified  |
|  |  |  | 5.3.6   | Variable Flow Hydronic Systems            |  |
|  |  |  | 5.3.6.1 | Variable Fluid Flow                       | Indicate design flow rate of HVAC pumping system   |
|  |  |  | 5.3.6.2 | Isolation Valves                          | Indicate water cooled air-conditioning have two-way automatic isolation valves and pump motors greater than or equal to 3.7 kW is controlled by variable speed drives  |
|  |  |  | 5.3.6.3 | Variable Speed Drives                     | Indicate Chilled water or condenser water systems comply with either § 5.3.5.1 or § 5.3.5.2  |
|  |  |  | 5.3.7   | Unitary, Split, Packaged Air-Conditioners | Indicate the type of system, cooling capacity.   |
|  |  |  | 5.3.8   | Controls for ECBC+ & SuperECBC Building   |  |
|  |  |  | 5.3.8.1 | Centralized Demand Shed Controls          | Indicate the building has a Building Management System, with all Mechanical cooling and heating systems having PLC to the zone level shall have the control capabilities mentioned in § 5.2.4.1                          |
|  |  |  | 5.3.8.2 | Supply Air temperature reset              | Indicate multi zone mechanical cooling and heating systems shall have controls to automatically reset supply air temperature in response to building loads or outdoor air  |

|  |  |  |         |   |   |
|--|--|--|---------|---|---|
|  |  |  |         |   | temperature by at least 25% of the difference between design supply air temperature and the design room air temperature.  |
|  |  |  | 5.3.8.3 | Chilled Water Temperature                             | Indicate chilled water systems exceeding 350 kW shall have controls to automatically reset supply water temperatures by representative building loads or by outdoor air temperature |
|  |  |  | 5.3.9   | Controls for SuperECBC Building                       | Indicate that the mechanical systems comply with § 5.2.4 and § 5.2.5  |
|  |  |  | 5.3.9.1 | Variable Air Volume Fan Control                       | Indicate Fans in VAV systems shall have controls or devices to limit fan motor demand as per § 5.2.5.1  |
|  |  |  | 5.3.10  | Heat Recovery   | Indicate for all Hospitality and Healthcare, heat recovery effectiveness, and efficiency of oil and gas fired boilers   |
|  |  |  | 5.3.11  | Service Water Heating                                 | Indicate all Buildings, Hotels and hospitals have solar water heating equipment installed for hot water design capacity as per § 5.3.11   |
|  |  |  | 5.3.12  | Total System Efficiency-Alternate Compliance approach | Attach simulation report  |
|  |  |  | 5.3.13  | Low Energy Comfort Systems                            | Indicate system type and list the exemption claimed   |

Lighting and Controls Summary

Energy Conservation Building Code 2017 Compliance Forms

|              |                                |                                |
|--------------|--------------------------------|--------------------------------|
| Project Info | Project Address:               | Date                           |
|              |                                | For Building<br>Department Use |
|              | Project Built-up Area (m²):    |                                |
|              | Project Above-grade area (m²): |                                |
|              | Project Conditioned Area (m²): |                                |
|              | Applicant Name and Address:    |                                |
|              | Project Climatic Zone:         |                                |

|                   |   |  |
|-------------------|---|--|
| Compliance Option | <input type="checkbox"/> Space by Space<br>method | <input type="checkbox"/> Whole Building Method |
|-------------------|---|--|

Maximum Allowed Lighting Power (Interior, Section 6.3.2 or 6.3.3)

| Location<br>(floor/room no.) | Occupancy Description | Allowed<br>Watts per<br>m² ** | Area in m²          | Allowed<br>x Area |
|------------------------------|-----------------------|-------------------------------|---------------------|-------------------|
|                              |                       |                               |                     |                   |
|                              |                       |                               |                     |                   |
|                              |                       |                               |                     |                   |
| ** Document all exceptions   |                       |                               | Total Allowed Watts |                   |

Proposed Lighting Power (Interior)

| Location<br>(floor/room no.)  | Fixture Description | Number of<br>Fixtures | Watts/<br>Fixture    | Watts<br>Proposed |
|---|---------------------|-----------------------|----------------------|-------------------|
|   |                     |                       |                      |                   |
|   |                     |                       |                      |                   |
|   |                     |                       |                      |                   |
| Total Proposed Watts may not exceed Total Allowed Watts<br>for Interior |                     |                       | Total Proposed Watts |                   |

Maximum Allowed Lighting Wattage (Exterior, Section 6.3.5)

| Location            | Description | Allowed<br>Watts<br>per m² or<br>per lm | Area in m²<br>(or lm for<br>perimeter) | Allowed<br>Watts<br>x m² (or x<br>lm) |
|---------------------|-------------|---|--|---------------------------------------|
|                     |             |   |  |                                       |
|                     |             |   |  |                                       |
|                     |             |   |  |                                       |
|                     |             |   |  |                                       |
|                     |             |   |  |                                       |
| Total Allowed Watts |             |   |  |                                       |

Proposed Lighting Wattage (Exterior)

| Location | Fixture Description | Number of<br>Fixtures | Watts/<br>Fixture | Watts<br>Proposed |
|----------|---------------------|-----------------------|-------------------|-------------------|
|          |                     |                       |                   |                   |
|          |                     |                       |                   |                   |

|  |    |     |              |  |  |                   |                           |
|--|----|-----|--------------|--|--|-------------------|---------------------------|
|  |    |     |              |  |  |                   |                           |
| Total Proposed Watts may not exceed Total Allowed Watts for Exterior   |    |     |              | Total Proposed Watts                   |  |                   |                           |
| <b>Lighting &amp; Controls Checklist</b>   |    |     |              |  |  |                   |                           |
| Energy Conservation Building Code 2017 Compliance Forms  |    |     |              |  |  |                   |                           |
| Project Address  |    |     |              |  |  | Date              |                           |
| The following information is necessary to check a building permit application for compliance with the lighting requirements in the Energy Conservation Building Code 2017. |    |     |              |  |  |                   |                           |
| Applicability  |    |     | Code Section | Component                              | Information Required   |                   |                           |
| Yes  | No | N/A |              |  |  | Location on Plans | Building Department Notes |
|  |    |     |              |  |  |                   |                           |
| <b>Lighting and Controls</b>   |    |     |              |  |  |                   |                           |
| Mandatory Provisions (Section 6.2)   |    |     |              |  |  |                   |                           |
|  |    |     | 6.2.1        | Lighting Controls                      |  |                   |                           |
|  |    |     | 6.2.1.1      | Automatic shutoff                      | Indicate automatic shutoff locations or occupancy sensors  |                   |                           |
|  |    |     | 6.2.1.2      | Space control                          | Provide schedule with type, indicate locations   |                   |                           |
|  |    |     | 6.2.1.3      | Control in Daylight Areas              | Provide manual or automatic control device schedule with type and features, indicate locations   |                   |                           |
|  |    |     | 6.2.1.4      | Ext. lighting control                  | Indicate photosensor or astronomical time switch   |                   |                           |
|  |    |     | 6.2.1.5      | Additional control                     | Provide schedule with type, indicate locations   |                   |                           |
|  |    |     | 6.2.2        | Exit signs                             | Indicate wattage per face of Exit signs  |                   |                           |
| Prescriptive Interior Lighting Power Compliance Option (Section 6.3)   |    |     |              |  |  |                   |                           |
|  |    |     | 6.3.1        | LPD compliance                         | Indicate whether project is complying with the Building Area Method (6.3.2) or the Space Function Method (6.3.3)   |                   |                           |
|  |    |     | 6.3.2        | Building area method                   | Provide lighting schedule with wattage of lamp and ballast and number of fixtures. Document all exceptions.  |                   |                           |
|  |    |     | 6.3.3        | Space function method                  | Provide lighting schedule with wattage of lamp and ballast and number of fixtures. Document all exceptions.  |                   |                           |
|  |    |     | 6.3.4.1      | Luminaire wattage                      | Indicate the wattage of installed luminaires on the floor plan. In case of luminaires containing permanently installed ballasts, the operating input wattage has to be provided, either from manufacturers catalogs or values from independent testing laboratory reports. |                   |                           |
|  |    |     | 6.3.6        | Controls_ECBC+ and SuperECBC Buildings | Provide centralized control system schedule with type and features, indicate locations   |                   |                           |
| Prescriptive Exterior Lighting Power Compliance Option (Section 6.3.5)   |    |     |              |  |  |                   |                           |
|  |    |     | 6.3.5        | External light power                   | Provide lighting schedule with wattage of lamp and ballast and number of fixtures. Document all exceptions.  |                   |                           |

Electrical and Renewable Energy Systems Summary

Energy Conservation Building Code 2017 Compliance Forms

|              |                               |                             |
|--------------|-------------------------------|-----------------------------|
| Project Info | Project Address               | Date                        |
|              |                               | For Building Department Use |
|              | Project Built-up Area [m²]    |                             |
|              | Project Above-grade Area [m²] |                             |
|              | Project Conditioned Area [m²] |                             |
|              | Applicant Name and Address    |                             |
|              |                               |                             |
|              | Project Climatic Zone         |                             |

|  |   |
|--|---|
| <b>Project Description</b><br>Briefly describe electrical systems and renewable energy installed in the facility | Transformers, Diesel Generator sets, Uninterruptible Power Supply, Renewable Energy Systems and related information |
|  |   |
|  |   |

|                     |                     |                                   |
|---------------------|---------------------|-----------------------------------|
| Compliance Approach | Prescriptive Method | Whole Building Performance Method |
|---------------------|---------------------|-----------------------------------|

|   |  |                               |                                |
|---|--|-------------------------------|--------------------------------|
| Transformers                                    |  |                               |                                |
| Type of Transformer                             | Dry Type Transformer/ Oil Type Transformer |                               |                                |
|   | X 100 =                                    |                               |                                |
| Transformer Losses                              | kVA Rating of Transformer                  | / Losses at 50% Loading in kW | / Losses at 100% Loading in kW |
| Diesel Generator Sets                           |  |                               |                                |
| Star Rating of DG set                           | 3 Star / 4 Star / 5 Star                   |                               |                                |
| Uninterruptible Power Supply                    |  |                               |                                |
| Efficiency at 100% Load                         |  |                               |                                |
| Renewable Energy Systems                        |  |                               |                                |
| Capacity and Type of Renewable Energy Installed |  |                               |                                |



# Electrical and Renewable Energy Systems Checklist

Energy Conservation Building Code 2017 Compliance Forms

|  |    |     |              |   |   |                           |
|--|----|-----|--------------|---|---|---------------------------|
| Project Address  |    |     |              |   | Date  |                           |
| The following information is necessary to check a building permit application for compliance with the Electrical and Renewable Energy requirements in the Energy Conservation Building Code. |    |     |              |   |   |                           |
| Applicability  |    |     | Code Section | Component                                       | Information Required  | Location on Plans         |
| Yes  | No | N/A |              |   |   | Building Department Notes |
| Electrical and Renewable Energy Systems  |    |     |              |   |   |                           |
| Mandatory Provisions (Section 5.2)   |    |     |              |   |   |                           |
|  |    |     | 7.2.1        | Transformers                                    |   |                           |
|  |    |     | 7.2.1.1      | Maximum Allowable Power Transformer Losses      | Provide losses at 50% load and 100% load, capacity and efficiency   |                           |
|  |    |     | 7.2.1.2      | Measurement and Reporting of Transformer Losses | For less than 500 kVA transformer meters are calibrated of 0.5 class accuracy and digital meters  |                           |
|  |    |     |              |   | For above 500 kVA additional Ct's and PT's are installed  |                           |
|  |    |     | 7.2.1.3      | Voltage Drop                                    | Indicate the Voltage drop for feeders shall not exceed 2% at design load. Voltage drop for branch circuit shall not exceed 3% at design load.   |                           |
|  |    |     | 7.2.2        | Energy Efficient Motors                         | Indicate the motor class IE2/IE3/IE4.   |                           |
|  |    |     |              |   | Indicate the motors capacity more than 0.375 kW have efficiency according to the latest version of IS 12615.  |                           |
|  |    |     |              |   | Motor nameplate indicates nominal full-load motor efficiencies and full-load power factor.  |                           |
|  |    |     |              |   | Indicate the motor horsepower ratings does not exceed 20% of the calculated maximum load being served.  |                           |
|  |    |     | 7.2.3        | Diesel Generator Sets                           | Indicate the star rating of the Diesel Generator Set  |                           |
|  |    |     | 7.2.4        | Check-Metering and Monitoring                   | Indicate the services exceeding 1000 kVA have permanently installed electrical metring to record kVA, kWh and total power factor. And provision for display of current in each phase, voltage between each phase and between each phase and neutral and total harmonic distortion as a percentage of total current. |                           |

|  |  |  |         |                                  |   |
|--|--|--|---------|----------------------------------|---|
|  |  |  |         |                                  | Indicate the services not exceeding 1000 kVA but over 65 kVA shall have permanently installed electric metering to record kW, kWh and power factor or kVARh on hourly basis.  |
|  |  |  |         |                                  | Indicate the services not exceeding 65 kVA shall have permanently installed electric metering to record kWh on hourly basis.  |
|  |  |  |         |                                  | Indicate in case of tenant based building, for recording metering should be provided at a location from where each tenant could attach the services.  |
|  |  |  | 7.2.5   | Power Factor Correction          | Indicate that the power factor correction has been maintained at the point of connection.   |
|  |  |  | 7.2.6   | Power Distribution System        | Indicate the power cable has been sized so that the distribution losses do not exceed the values mentioned in the code.   |
|  |  |  | 7.2.7   | Uninterruptible Power Supply     | Indicate the UPS meets or exceed the energy efficiency requirements listed in the table 7-4.  |
|  |  |  | 7.2.8   | Renewable Energy Systems         | Indicate the buildings have provision for installation of renewable energy systems in the future on rooftop or the site.  |
|  |  |  | 7.2.8.1 | Renewable Energy Generating Zone | Indicate a dedicated REGZ equivalent to at least 25 % of roof area or area required for generation of energy equivalent to 1% of total peak demand or connected load of the building, whichever is less, shall be provided in all buildings.  |
|  |  |  |         |                                  | Indicate the REGZ shall is free of any obstructions within its boundaries and from shadows cast by objects adjacent to the zone   |
|  |  |  | 7.2.8.2 | Main Electrical Service Panel    | Indicate the minimum rating is displayed on the main electrical service panel. And space is reserved for the installation of double pole circuit breaker for future solar electric installation.  |
|  |  |  | 7.2.8.3 | Demarcation on Documents         | Location for inverters and metering equipment,<br>Pathway for routing of conduit from the REGZ to the point of interconnection with the electrical service,<br>Routing of plumbing from the REGZ to the water-heating system and,<br>Structural design loads for roof dead and live load. |

## 14. Appendix E: BEE approved list of software to show compliance<sup>3</sup>

Table 14-1 Bureau of Energy Efficiency Approved Software for Demonstrating Compliance with ECBC

| Analysis                          | Software   |
|-----------------------------------|--|
| Whole Building Performance Method | AECOSim  |
|                                   | Design Builder                                     |
|                                   | DOE2   |
|                                   | EnergyPlus   |
|                                   | eQUEST   |
|                                   | HAP  |
|                                   | IDA-ICE  |
|                                   | IES-VE   |
|                                   | OpenStudio   |
|                                   | Simergy  |
|                                   | Trace700   |
|                                   | TRNSYS   |
|                                   | Visual DOE   |
|                                   | BEP-EMIS   |
| Daylighting                       | AGI32 (Licaso)                                     |
|                                   | Daysim   |
|                                   | Design Builder                                     |
|                                   | DIVA   |
|                                   | Groundhog  |
|                                   | IES-VE   |
|                                   | OpenStudio   |
|                                   | RadianceRhino-Grasshopper with Daylighting Plugins |
|                                   | Sefaira  |
|                                   | Sensor Placement + Optimization Tool (SPOT)        |

<sup>3</sup> This is not an all-inclusive list. The current list of approved software is available at BEE website (<https://www.beeindia.gov.in/>).

परिशिष्ट बी-१  
महाराष्ट्र राज्याचे हवामान वर्गीकरण

## 1. Climate Map for Maharashtra



**2. Districtwise classification of climatic data for Maharashtra State :**

| A) NASHIK DIVISION  |          |               |   |              |                                |
|---------------------|----------|---------------|---|--------------|--------------------------------|
| 1. Nashik District  |          |               |   |              |                                |
| Sr. No.             | District | Talukas       | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
| 1.                  | Nashik   | Baglan        | Satana                                  | Hot and Dry  | Pune/Mumbai                    |
| 2.                  | Nashik   | Chandvad      | -                                       | Hot and Dry  | Pune/Mumbai                    |
| 3.                  | Nashik   | Deola         | -                                       | Hot and Dry  | Pune/Mumbai                    |
| 4.                  | Nashik   | Dindori       | -                                       | Composite    | Pune/Mumbai                    |
| 5.                  | Nashik   | Igatpuri      | Igatpuri                                | Composite    | Pune/Mumbai                    |
| 6.                  | Nashik   | Kalwan        | Saptashrungigad                         | Hot and Dry  | Pune/Mumbai                    |
| 7.                  | Nashik   | Malegaon      | Malegaon                                | Hot and Dry  | Pune/Mumbai                    |
| 8.                  | Nashik   | Nandgaon      | Manmad                                  | Hot and Dry  | Pune/Mumbai                    |
|                     | Nashik   |               | Nandgaon                                |              | Pune/Mumbai                    |
| 9.                  | Nashik   | Nashik        | Nashik                                  | Composite    | Pune/Mumbai                    |
|                     | Nashik   |               | Bhagur                                  |              | Pune/Mumbai                    |
| 10.                 | Nashik   | Niphad        | -                                       | Composite    | Pune/Mumbai                    |
| 11.                 | Nashik   | Peint         | -                                       | Composite    | Pune/Mumbai                    |
| 12.                 | Nashik   | Sinnar        | Sinnar                                  | Composite    | Pune/Mumbai                    |
| 13.                 | Nashik   | Surgana       | -                                       | Composite    | Pune/Mumbai                    |
| 14.                 | Nashik   | Trimbakeshwar | Tryambakeshwar                          | Composite    | Pune/Mumbai                    |
| 15.                 | Nashik   | Yeola         | Yeola                                   | Hot and Dry  | Pune/Mumbai                    |
| 2. Jalgaon District |          |               |   |              |                                |
| Sr. No.             | District | Talukas       | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
| 1.                  | Jalgaon  | Amalner       | Amalner                                 | Hot and Dry  | Nagpur                         |
| 2.                  | Jalgaon  | Bhadgaon      | -                                       | Hot and Dry  | Nagpur                         |
| 3.                  | Jalgaon  | Bhusaval      | Bhusaval                                | Hot and Dry  | Nagpur                         |
| 4.                  | Jalgaon  | Bodvad        | -                                       | Hot and Dry  | Nagpur                         |
| 5.                  | Jalgaon  | Chalisgaon    | Chalisgaon                              | Hot and Dry  | Nagpur                         |
| 6.                  | Jalgaon  | Chopda        | Chopda                                  | Hot and Dry  | Nagpur                         |
| 7.                  | Jalgaon  | Dharangaon    | Dharangaon                              | Hot and Dry  | Nagpur                         |
| 8.                  | Jalgaon  | Erandol       | Erandol                                 | Hot and Dry  | Nagpur                         |
| 9.                  | Jalgaon  | Jalgaon       | Jalgaon                                 | Hot and Dry  | Nagpur                         |
| 10.                 | Jalgaon  | Jamner        | -                                       | Hot and Dry  | Nagpur                         |
| 11.                 | Jalgaon  | Muktainagar   | -                                       | Hot and Dry  | Nagpur                         |

| 12.                           | Jalgaon    | Pachora    | Pachora                                 | Hot and Dry  | Nagpur                         |
|-------------------------------|------------|------------|---|--------------|--------------------------------|
| 13.                           | Jalgaon    | Parola     | Parola                                  | Hot and Dry  | Nagpur                         |
| 14.                           | Jalgaon    | Raver      | Raver                                   | Hot and Dry  | Nagpur                         |
|                               | Jalgaon    |            | Savda                                   |              | Nagpur                         |
| 15.                           | Jalgaon    | Yawal      | Yawal                                   | Hot and Dry  | Nagpur                         |
|                               | Jalgaon    |            | Faizpur                                 |              | Nagpur                         |
| <b>3. Nandurbar District</b>  |            |            |   |              |                                |
| Sr. No.                       | District   | Talukas    | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
| 1.                            | Nandurbar  | Akkalkuwa  | -                                       | Hot and Dry  | Nagpur                         |
| 2.                            | Nandurbar  | Akrani     | -                                       | Hot and Dry  | Nagpur                         |
| 3.                            | Nandurbar  | Nandurbar  | Nandurbar                               | Hot and Dry  | Nagpur                         |
| 4.                            | Nandurbar  | Navapur    | Navapur                                 | Hot and Dry  | Nagpur                         |
| 5.                            | Nandurbar  | Shahada    | Shahada                                 | Hot and Dry  | Nagpur                         |
| 6.                            | Nandurbar  | Taloda     | Taloda                                  | Hot and Dry  | Nagpur                         |
| <b>4. Dhule District</b>      |            |            |   |              |                                |
| Sr. No.                       | District   | Talukas    | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
| 1.                            | Dhule      | Dhule      | -                                       | Hot and Dry  | Nagpur                         |
| 2.                            | Dhule      | Sakri      | -                                       | Hot and Dry  | Nagpur                         |
| 3.                            | Dhule      | Shirpur    | Shirpur-Warwade                         | Hot and Dry  | Nagpur                         |
| 4.                            | Dhule      | Sindkheda  | Dondaicha-Warwade                       | Hot and Dry  | Nagpur                         |
| <b>5. Ahmednagar District</b> |            |            |   |              |                                |
| Sr. No.                       | District   | Talukas    | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
| 1.                            | Ahmednagar | Ahmednagar | Ahmednagar                              | Composite    | Pune                           |
| 2.                            | Ahmednagar | Akola      | -                                       | Composite    | Pune                           |
| 3.                            | Ahmednagar | Jamkhed    | -                                       | Composite    | Pune                           |
| 4.                            | Ahmednagar | Karjat     | -                                       | Composite    | Pune                           |
| 5.                            | Ahmednagar | Kopergaon  | Kopergaon                               | Hot and Dry  | Pune                           |
| 6.                            | Ahmednagar | Nevasa     | Nevasa-Khurd                            | Hot and Dry  | Pune                           |
| 7.                            | Ahmednagar | Parner     | -                                       | Hot and Dry  | Pune                           |
| 8.                            | Ahmednagar | Pathardi   | Pathardi                                | Hot and Dry  | Pune                           |
| 9.                            | Ahmednagar | Rahta      | Rahta                                   | Composite    | Pune                           |
|                               | Ahmednagar |            | Shirdi                                  |              | Pune                           |
| 10.                           | Ahmednagar | Rahuri     | Rahuri                                  | Composite    | Pune                           |
|                               | Ahmednagar |            | Deolali-Pravara                         |              | Pune                           |
| 11.                           | Ahmednagar | Sangamner  | Sangamner                               | Composite    | Pune                           |

|     |            |           |           |             |      |
|-----|------------|-----------|-----------|-------------|------|
| 12. | Ahmednagar | Shevgaon  | Shevgaon  | Hot and Dry | Pune |
| 13. | Ahmednagar | Shrigonda | Shrigonda | Hot and Dry | Pune |
| 14. | Ahmednagar | Srirampur | Srirampur | Hot and Dry | Pune |
|     | Ahmednagar |           | Belapur   |             | Pune |

**B) AURANGABAD DIVISION****1. Aurangabad District**

| Sr. No. | District   | Talukas    | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
|---------|------------|------------|---|--------------|--------------------------------|
| 1.      | Aurangabad | Aurangabad | Aurangabad                              | Hot and dry  | Aurangabad                     |
| 2.      | Aurangabad | Gangapur   | Gangapur                                | Hot and Dry  | Aurangabad                     |
| 3.      | Aurangabad | Kannad     | Kannad                                  | Hot and Dry  | Aurangabad                     |
| 4.      | Aurangabad | Khuldabad  | -                                       | Hot and Dry  | Aurangabad                     |
| 5.      | Aurangabad | Paithan    | Paithan                                 | Hot and Dry  | Aurangabad                     |
| 6.      | Aurangabad | Phulambri  | -                                       | Hot and Dry  | Aurangabad                     |
| 7.      | Aurangabad | Sillod     | Sillod                                  | Hot and Dry  | Aurangabad                     |
| 8.      | Aurangabad | Soegaon    | -                                       | Hot and Dry  | Aurangabad                     |
| 9.      | Aurangabad | Vaijapur   | Vaijapur                                | Hot and Dry  | Aurangabad                     |

**2. Hingoli District**

| Sr. No. | District | Talukas          | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
|---------|----------|------------------|---|--------------|--------------------------------|
| 1.      | Hingoli  | Aundha (Nagnath) | -                                       | Hot and Dry  | Aurangabad                     |
| 2.      | Hingoli  | Basmatnagar      | Basmatnagar                             | Hot and Dry  | Aurangabad                     |
| 3.      | Hingoli  | Hingoli          | Hingoli                                 | Hot and Dry  | Aurangabad                     |
| 4.      | Hingoli  | Kalamnuri        | Kalamnuri                               | Hot and Dry  | Aurangabad                     |
| 5.      | Hingoli  | Sengaon          | -                                       | Hot and Dry  | Aurangabad                     |

**3. Parbhani District**

| Sr. No. | District | Talukas   | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
|---------|----------|-----------|---|--------------|--------------------------------|
| 1.      | Parbhani | Gangakhed | Gangakhed                               | Hot and Dry  | Aurangabad                     |
| 2.      | Parbhani | Jintur    | Jintur                                  | Hot and Dry  | Aurangabad                     |
| 3.      | Parbhani | Manvat    | Manvat                                  | Hot and Dry  | Aurangabad                     |
| 4.      | Parbhani | Palam     | -                                       | Hot and Dry  | Aurangabad                     |
| 5.      | Parbhani | Parbhani  | Parbhani                                | Hot and Dry  | Aurangabad                     |
| 6.      | Parbhani | Pathri    | Pathri                                  | Hot and Dry  | Aurangabad                     |
| 7.      | Parbhani | Purna     | Purna                                   | Hot and Dry  | Aurangabad                     |
| 8.      | Parbhani | Sailu     | Sailu                                   | Hot and Dry  | Aurangabad                     |
| 9.      | Parbhani | Sonepath  | Sonpeth                                 | Hot and Dry  | Aurangabad                     |



| 4. Latur District     |           |                   |   |              |                                |
|-----------------------|-----------|-------------------|---|--------------|--------------------------------|
| Sr. No.               | District  | Talukas           | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
| 1.                    | Latur     | Ahemadpur         | Ahemadpur                               | Hot and Dry  | Aurangabad                     |
| 2.                    | Latur     | Ausa              | Ausa (R)                                | Composite    | Aurangabad                     |
| 3.                    | Latur     | Chakur            | -                                       | Composite    | Aurangabad                     |
| 4.                    | Latur     | Deoni             | -                                       | Hot and Dry  | Aurangabad                     |
| 5.                    | Latur     | Jalkot            | -                                       | Hot and Dry  | Aurangabad                     |
| 6.                    | Latur     | Latur             | Latur                                   | Hot and Dry  | Aurangabad                     |
| 7.                    | Latur     | Nilanga           | Nilanga                                 | Hot and Dry  | Aurangabad                     |
| 8.                    | Latur     | Renapur           | -                                       | Hot and Dry  | Aurangabad                     |
| 9.                    | Latur     | Shirur – Anantpal | -                                       | Composite    | Aurangabad                     |
| 10.                   | Latur     | Udgir             | Udgir                                   | Hot and Dry  | Aurangabad                     |
| 5. Jalna District     |           |                   |   |              |                                |
| Sr. No.               | District  | Talukas           | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
| 1.                    | Jalna     | Ambad             | Ambad                                   | Composite    | Aurangabad                     |
| 2.                    | Jalna     | Badnapur          | -                                       | Hot and Dry  | Aurangabad                     |
| 3.                    | Jalna     | Bhokardan         | Bhokardan                               | Hot and Dry  | Aurangabad                     |
| 4.                    | Jalna     | Ghansawangi       | -                                       | Composite    | Aurangabad                     |
| 5.                    | Jalna     | Jafferabad        | -                                       | Composite    | Aurangabad                     |
| 6.                    | Jalna     | Jalna             | Jalna                                   | Hot and dry  | Aurangabad                     |
| 7.                    | Jalna     | Mantha            | -                                       | Hot and Dry  | Aurangabad                     |
| 8.                    | Jalna     | Partur            | Partur                                  | Composite    | Aurangabad                     |
| 6. Osmanabad District |           |                   |   |              |                                |
| Sr. No.               | District  | Talukas           | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
| 1.                    | Osmanabad | Bhum              | Bhum                                    | Composite    | Aurangabad                     |
| 2.                    | Osmanabad | Kalamb            | Kalamb                                  | Hot and Dry  | Aurangabad                     |
| 3.                    | Osmanabad | Lohara            | -                                       | Composite    | Aurangabad                     |
| 4.                    | Osmanabad | Osmanabad         | Osmanabad                               | Composite    | Aurangabad                     |
| 5.                    | Osmanabad | Paranda           | Paranda                                 | Hot and Dry  | Aurangabad                     |
| 6.                    | Osmanabad | Tuljapur          | Tuljapur                                | Composite    | Aurangabad                     |
|                       | Osmanabad |                   | Naldurg                                 |              | Aurangabad                     |
| 7.                    | Osmanabad | Umerga            | Umerga                                  | Hot and Dry  | Aurangabad                     |
|                       | Osmanabad |                   | Murum                                   |              | Aurangabad                     |
| 8.                    | Osmanabad | Washi             | -                                       | Composite    | Aurangabad                     |

| 7. Nanded District |          |                     |   |              |                                |
|--------------------|----------|---------------------|---|--------------|--------------------------------|
| Sr. No.            | District | Talukas             | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
| 1.                 | Nanded   | Ardhapur            | -                                       | Hot and Dry  | Aurangabad                     |
| 2.                 | Nanded   | Bhokar              | Bhokar                                  | Composite    | Aurangabad                     |
| 3.                 | Nanded   | Biloli              | Biloli                                  | Composite    | Aurangabad                     |
|                    | Nanded   |                     | Kundalwadi                              |              | Aurangabad                     |
| 4.                 | Nanded   | Deglur              | Deglur                                  | Composite    | Aurangabad                     |
| 5.                 | Nanded   | Dharmabad           | Dharmabad                               | Composite    | Aurangabad                     |
| 6.                 | Nanded   | Hadgaon             | Hadgaon                                 | Hot and Dry  | Aurangabad                     |
| 7.                 | Nanded   | Himayatnagar        | -                                       | Composite    | Aurangabad                     |
| 8.                 | Nanded   | Kandhar             | Kandhar                                 | Composite    | Aurangabad                     |
| 9.                 | Nanded   | Kinwat              | Kinwat                                  | Composite    | Aurangabad                     |
| 10.                | Nanded   | Loha                | Loha                                    | Composite    | Aurangabad                     |
| 11.                | Nanded   | Mahur               | Mahur                                   | Composite    | Aurangabad                     |
| 12.                | Nanded   | Mudkhed             | Mudkhed                                 | Composite    | Aurangabad                     |
| 13.                | Nanded   | Mukhed              | Mukhed                                  | Composite    | Aurangabad                     |
| 14.                | Nanded   | Naigaon (Khaurgaon) | Naigaon                                 | Composite    | Aurangabad                     |
| 15.                | Nanded   | Nanded              | -                                       | Composite    | Aurangabad                     |
| 16.                | Nanded   | Umri                | Umri                                    | Composite    | Aurangabad                     |
| 8. Beed District   |          |                     |   |              |                                |
| Sr. No.            | District | Talukas             | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
| 1.                 | Beed     | Ambejogai           | Ambejogai                               | Composite    | Aurangabad                     |
| 2.                 | Beed     | Ashti               | Ashti                                   | Composite    | Aurangabad                     |
| 3.                 | Beed     | Beed                | Beed                                    | Hot and Dry  | Aurangabad                     |
| 4.                 | Beed     | Dharur              | KilleDharur                             | Composite    | Aurangabad                     |
| 5.                 | Beed     | Georai              | Georai                                  | Hot and Dry  | Aurangabad                     |
| 6.                 | Beed     | Kaij                | Kaij                                    | Composite    | Aurangabad                     |
| 7.                 | Beed     | Majalgaon           | Majalgaon                               | Hot and Dry  | Aurangabad                     |
| 8.                 | Beed     | Parli               | Parali-Waijanath                        | Composite    | Aurangabad                     |
| 9.                 | Beed     | Patoda              | Patoda                                  | Composite    | Aurangabad                     |
| 10.                | Beed     | Shirur (Kasar)      | -                                       | Composite    | Aurangabad                     |
| 11.                | Beed     | Wadwani             | -                                       | Composite    | Aurangabad                     |

**C) AMRAVATI DIVISION****1. Amravati District**

| Sr. No. | District | Talukas              | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
|---------|----------|----------------------|---|--------------|--------------------------------|
| 1.      | Amravati | Achalpur             | Achalpur                                | Hot and Dry  | Nagpur                         |
| 2.      | Amravati | Amravati             | Amravati                                | Hot and Dry  | Nagpur                         |
| 3.      | Amravati | AnjangaonSurji       | AnjangaonSurji                          | Hot and Dry  | Nagpur                         |
| 4.      | Amravati | Bhatkuli             | -                                       | Hot and Dry  | Nagpur                         |
| 5.      | Amravati | Chandur Railway      | Chandur Rly                             | Composite    | Nagpur                         |
| 6.      | Amravati | Chandurbazar         | Chandur Bazar                           | Composite    | Nagpur                         |
| 7.      | Amravati | Chilkhaldera         | -                                       | Hot and Dry  | Nagpur                         |
| 8.      | Amravati | Daryapur             | Daryapur                                | Hot and Dry  | Nagpur                         |
| 9.      | Amravati | Dhamangaon Railway   | Dhamangaon Railway                      | Composite    | Nagpur                         |
| 10.     | Amravati | Dharni               | -                                       | Hot and Dry  | Nagpur                         |
| 11.     | Amravati | Morshi               | Morshi                                  | Composite    | Nagpur                         |
| 12.     | Amravati | Nandgaon-Khandeshwar | -                                       | Composite    | Nagpur                         |
| 13.     | Amravati | Teosa                | -                                       | Composite    | Nagpur                         |
| 14.     | Amravati | Warud                | Warud                                   | Composite    | Nagpur                         |

**2. Akola District**

| Sr. No. | District | Talukas     | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
|---------|----------|-------------|---|--------------|--------------------------------|
| 1.      | Akola    | Akola       | Akola                                   | Hot and Dry  | Nagpur                         |
| 2.      | Akola    | Akot        | Akot                                    | Hot and Dry  | Nagpur                         |
| 3.      | Akola    | Balapur     | Balapur (partly)                        | Hot and Dry  | Nagpur                         |
| 4.      | Akola    | BarshiTakli | BarshiTakali                            | Hot and Dry  | Nagpur                         |
| 5.      | Akola    | Murtizapur  | Murtizapur                              | Hot and Dry  | Nagpur                         |
| 6.      | Akola    | Patur       | Patur                                   | Hot and Dry  | Nagpur                         |
| 7.      | Akola    | Telhara     | Telhara                                 | Hot and Dry  | Nagpur                         |

**3. Washim District**

| Sr. No. | District | Talukas    | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
|---------|----------|------------|---|--------------|--------------------------------|
| 1.      | Washim   | Karanja    | Karanja                                 | Hot and Dry  | Nagpur                         |
| 2.      | Washim   | Malegaon   | Malegaon                                | Hot and Dry  | Nagpur                         |
| 3.      | Washim   | Mangrulpir | Mangrulpir                              | Hot and Dry  | Nagpur                         |
| 4.      | Washim   | Manora     | -                                       | Hot and Dry  | Nagpur                         |
| 5.      | Washim   | Risod      | Risod                                   | Hot and Dry  | Nagpur                         |
| 6.      | Washim   | Washim     | Washim                                  | Hot and Dry  | Nagpur                         |

| 4. Buldhana District |          |                 |   |              |                                |
|----------------------|----------|-----------------|---|--------------|--------------------------------|
| Sr. No.              | District | Talukas         | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
| 1.                   | Buldhana | Buldhana        | Buldhana                                | Hot and Dry  | Nagpur                         |
| 2.                   | Buldhana | Chikhali        | Chikhali                                | Hot and Dry  | Nagpur                         |
| 3.                   | Buldhana | Deolgaon Raja   | Deulgaon Raja                           | Hot and Dry  | Nagpur                         |
| 4.                   | Buldhana | Jalgaon (Jamod) | JalgaonJamod                            | Hot and Dry  | Nagpur                         |
| 5.                   | Buldhana | Khamgaon        | Khamgaon                                | Hot and Dry  | Nagpur                         |
| 6.                   | Buldhana | Lonar           | Lonar                                   | Hot and Dry  | Nagpur                         |
| 7.                   | Buldhana | Malkapur        | Malkapur                                | Hot and Dry  | Nagpur                         |
| 8.                   | Buldhana | Mehekar         | Mehekar                                 | Hot and Dry  | Nagpur                         |
| 9.                   | Buldhana | Motala          | -                                       | Hot and Dry  | Nagpur                         |
| 10.                  | Buldhana | Nandura         | Nandura                                 | Hot and Dry  | Nagpur                         |
| 11.                  | Buldhana | Sangrampur      | -                                       | Hot and Dry  | Nagpur                         |
| 12.                  | Buldhana | Shegaon         | Shegaon                                 | Hot and Dry  | Nagpur                         |
| 13.                  | Buldhana | Sindkhed Raja   | Sindkhed Raja                           | Hot and Dry  | Nagpur                         |
| 5. Yavatmal District |          |                 |   |              |                                |
| Sr. No.              | District | Talukas         | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
| 1.                   | Yavatmal | Arni            | -                                       | Composite    | Nagpur                         |
| 2.                   | Yavatmal | Babulgaon       | -                                       | Composite    | Nagpur                         |
| 3.                   | Yavatmal | Darwha          | Darwha                                  | Hot and Dry  | Nagpur                         |
| 4.                   | Yavatmal | Digras          | Digras                                  | Hot and Dry  | Nagpur                         |
| 5.                   | Yavatmal | Ghatanji        | Ghatanji                                | Composite    | Nagpur                         |
| 6.                   | Yavatmal | Kalamb          | -                                       | Hot and Dry  | Nagpur                         |
| 7.                   | Yavatmal | Kelapur         | Pandharkavda                            | Composite    | Nagpur                         |
| 8.                   | Yavatmal | Mahagaon        | -                                       | Composite    | Nagpur                         |
| 9.                   | Yavatmal | Maregaon        | -                                       | Composite    | Nagpur                         |
| 10.                  | Yavatmal | Ner             | Ner Nawabpur                            | Hot and Dry  | Nagpur                         |
| 11.                  | Yavatmal | Pusad           | Pusad                                   | Hot and Dry  | Nagpur                         |
| 12.                  | Yavatmal | Ralegaon        | -                                       | Composite    | Nagpur                         |
| 13.                  | Yavatmal | Umarkhed        | Umarkhed                                | Hot and Dry  | Nagpur                         |
| 14.                  | Yavatmal | Wani            | Wani                                    | Composite    | Nagpur                         |
| 15.                  | Yavatmal | Yavatmal        | Yavatmal                                | Hot and Dry  | Nagpur                         |
| 16.                  | Yavatmal | Zari-Jamani     | -                                       | Composite    | Nagpur                         |

**D) PUNE DIVISION****1. Pune District**

| Sr. No. | District | Talukas          | Name of Municipal Council / Corporation | Climate Zone   | Closest available weather file |
|---------|----------|------------------|---|----------------|--------------------------------|
| 1.      | Pune     | Ambegaon         | -                                       | Composite      | Pune                           |
| 2.      | Pune     | Baramati         | Baramati                                | Hot and Dry    | Pune                           |
| 3.      | Pune     | Bhor             | Bhor                                    | Composite      | Pune                           |
| 4.      | Pune     | Daund            | Daund                                   | Hot and Dry    | Pune                           |
| 5.      | Pune     | Indapur          | Indapur                                 | Hot and Dry    | Pune                           |
| 6.      | Pune     | Junnar           | Junnar                                  | Composite      | Pune                           |
| 7.      | Pune     | Khed             | Alandi                                  | Composite      | Pune                           |
| 8.      | Pune     | Mawal            | Talegaon-Dhabhade                       | Warm and Humid | Pune                           |
| 9.      | Pune     | Mulshi           | -                                       | Warm and Humid | Pune                           |
| 10.     | Pune     | Pune City Haveli | Pune                                    | Composite      | Pune                           |
|         | Pune     |                  | Pimpri Chinchwad                        |                | Pune                           |
|         | Pune     |                  | Loni-Kalbhor                            |                | Pune                           |
| 11.     | Pune     | Purandar         | Jejuri                                  | Composite      | Pune                           |
|         | Pune     |                  | Saswad                                  |                | Pune                           |
| 12.     | Pune     | Shirur           | Shirur                                  | Hot and Dry    | Pune                           |
| 13.     | Pune     | Velhe            | -                                       | Warm and Humid | Pune                           |

**2. Kolhapur District**

| Sr. No. | District | Talukas     | Name of Municipal Council / Corporation | Climate Zone   | Closest available weather file |
|---------|----------|-------------|---|----------------|--------------------------------|
| 1.      | Kolhapur | Ajra        | -                                       | Composite      | Pune                           |
| 2.      | Kolhapur | Bavda       | -                                       | Warm and Humid | Pune                           |
| 3.      | Kolhapur | Bhudargad   | -                                       | Composite      | Pune                           |
| 4.      | Kolhapur | Chandgad    | -                                       | Warm and Humid | Pune                           |
| 5.      | Kolhapur | Gandhinglaj | Gandhinglaj                             | Composite      | Pune                           |
| 6.      | Kolhapur | Hatkanangle | Ichalkarnji                             | Composite      | Pune                           |
|         | Kolhapur |             | Vadgaon                                 |                | Pune                           |
| 7.      | Kolhapur | Kagal       | Kagal                                   | Composite      | Pune                           |
|         | Kolhapur |             | Murgud                                  |                | Pune                           |
| 8.      | Kolhapur | Karvir      | -                                       | Composite      | Pune                           |
| 9.      | Kolhapur | Kolhapur    | -                                       | Composite      | Pune                           |
| 10.     | Kolhapur | Panhala     | -                                       | Composite      | Pune                           |
| 11.     | Kolhapur | Radhanagari | -                                       | Warm and Humid | Pune                           |
| 12.     | Kolhapur | Shahuwadi   | Malkapur                                | Composite      | Pune                           |
| 13.     | Kolhapur | Shirol      | Jaysingpur                              | Composite      | Pune                           |
|         |          |             | Kurundwad                               |                | Pune                           |

| 3. Satara District  |          |                 |   |                |                                |
|---------------------|----------|-----------------|---|----------------|--------------------------------|
| Sr. No.             | District | Talukas         | Name of Municipal Council / Corporation | Climate Zone   | Closest available weather file |
| 1.                  | Satara   | Jaoli           | -                                       | Hot and Dry    | Pune                           |
| 2.                  | Satara   | Karad           | Karad                                   | Composite      | Pune                           |
| 3.                  | Satara   | Khandala        | Lonand                                  | Composite      | Pune                           |
| 4.                  | Satara   | Khataav         | -                                       | Warm and Humid | Pune                           |
| 5.                  | Satara   | Koregaon        | Koregaon                                | Warm and Humid | Pune                           |
|                     | Satara   |                 | Rahimatpur                              |                | Pune                           |
| 6.                  | Satara   | Man             | Mhaswad                                 | Composite      | Pune                           |
| 7.                  | Satara   | Mahabaleshwar   | -                                       | Warm and Humid | Pune                           |
| 8.                  | Satara   | Patan           | -                                       | Hot and Dry    | Pune                           |
| 9.                  | Satara   | Phaltan         | Phaltan                                 | Composite      | Pune                           |
| 10.                 | Satara   | Satara          | Satara                                  | Composite      | Pune                           |
| 11.                 | Satara   | Wai             | Wai                                     | Composite      | Pune                           |
| 4. Solapur District |          |                 |   |                |                                |
| Sr. No.             | District | Talukas         | Name of Municipal Council / Corporation | Climate Zone   | Closest available weather file |
| 1.                  | Solapur  | Akkalkot        | Akkalkot                                | Hot and Dry    | Pune                           |
|                     | Solapur  |                 | Dudhani                                 |                | Pune                           |
|                     | Solapur  |                 | Maindargi                               |                | Pune                           |
| 2.                  | Solapur  | Barshi          | Barshi                                  | Hot and Dry    | Pune                           |
| 3.                  | Solapur  | Karmala         | Karmala                                 | Hot and Dry    | Pune                           |
| 4.                  | Solapur  | Madha           | Kurduwadi                               | Hot and Dry    | Pune                           |
| 5.                  | Solapur  | Malshiras       | Akluj                                   | Hot and Dry    | Pune                           |
| 6.                  | Solapur  | Mangalwedha     | Mangalwedha                             | Hot and Dry    | Pune                           |
| 7.                  | Solapur  | Mohol           | -                                       | Hot and Dry    | Pune                           |
| 8.                  | Solapur  | Pandharpur      | Pandharpur                              | Hot and Dry    | Pune                           |
| 9.                  | Solapur  | Sangola         | Sangola                                 | Hot and Dry    | Pune                           |
| 10.                 | Solapur  | Solapur North   | Solapur                                 | Hot and Dry    | Pune                           |
| 11.                 | Solapur  | Solapur South   |   | Hot and Dry    | Pune                           |
| 5. Sangli District  |          |                 |   |                |                                |
| Sr. No.             | District | Talukas         | Name of Municipal Council / Corporation | Climate Zone   | Closest available weather file |
| 1.                  | Sangli   | Atpadi          | -                                       | Hot and Dry    | Pune                           |
| 2.                  | Sangli   | Jat             | -                                       | Composite      | Pune                           |
| 3.                  | Sangli   | Kadegaon        | -                                       | Composite      | Pune                           |
| 4.                  | Sangli   | Kavathe Mahakal | -                                       | Composite      | Pune                           |
| 5.                  | Sangli   | Khanapur        | Vita                                    | Composite      | Pune                           |
| 6.                  | Sangli   | Miraj           | -                                       | Composite      | Pune                           |
| 7.                  | Sangli   | Palus           | -                                       | Composite      | Pune                           |

|     |        |         |          |           |      |
|-----|--------|---------|----------|-----------|------|
| 8.  | Sangli | Sangli  | -        | Composite | Pune |
| 9.  | Sangli | Shirala | -        | Composite | Pune |
| 10. | Sangli | Tasgaon | Tasgaon  | Composite | Pune |
| 11. | Sangli | Walwa   | Ashta    | Composite | Pune |
|     |        |         | Islampur |           | Pune |

#### E) NAGPUR DIVISION

##### 1. Nagpur District

| Sr. No. | District | Talukas        | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
|---------|----------|----------------|---|--------------|--------------------------------|
| 1.      | Nagpur   | Bhiwapur       | Bhiwapur                                | Composite    | Nagpur                         |
| 2.      | Nagpur   | Hingna         | -                                       | Composite    | Nagpur                         |
| 3.      | Nagpur   | Kalameshwar    | Kalameshwar                             | Composite    | Nagpur                         |
|         | Nagpur   |                | Mohpa                                   |              | Nagpur                         |
| 4.      | Nagpur   | Kamthi         | Kamthi                                  | Composite    | Nagpur                         |
| 5.      | Nagpur   | Katol          | Katol                                   | Composite    | Nagpur                         |
| 6.      | Nagpur   | Kuhi           | -                                       | Composite    | Nagpur                         |
| 7.      | Nagpur   | Mauda          | -                                       | Composite    | Nagpur                         |
| 8.      | Nagpur   | Nagpur (Rural) |   | Composite    | Nagpur                         |
| 9.      | Nagpur   | Nagpur (Urban) | Nagpur                                  | Composite    | Nagpur                         |
| 10.     | Nagpur   | Narkhed        | Narkhed                                 | Composite    | Nagpur                         |
|         | Nagpur   |                | Mowad (R)                               |              | Nagpur                         |
| 11.     | Nagpur   | Parseoni       | -                                       | Composite    | Nagpur                         |
| 12.     | Nagpur   | Ramtek         | Ramtek                                  | Composite    | Nagpur                         |
| 13.     | Nagpur   | Saoner         | Saoner                                  | Composite    | Nagpur                         |
|         | Nagpur   |                | Khapa                                   |              | Nagpur                         |
| 14.     | Nagpur   | Umred          | Umred                                   | Composite    | Nagpur                         |

##### 2. Wardha District

| Sr. No. | District | Talukas    | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
|---------|----------|------------|---|--------------|--------------------------------|
| 1.      | Wardha   | Arvi       | Arvi                                    | Composite    | Nagpur                         |
| 2.      | Wardha   | Ashti      | -                                       | Composite    | Nagpur                         |
| 3.      | Wardha   | Deoli      | Deoli                                   | Composite    | Nagpur                         |
|         | Wardha   |            | Pulgaon                                 |              | Nagpur                         |
| 4.      | Wardha   | Hinganghat | Hinganghat                              | Composite    | Nagpur                         |
| 5.      | Wardha   | Karanja    | -                                       | Composite    | Nagpur                         |
| 6.      | Wardha   | Samudrapur | -                                       | Composite    | Nagpur                         |
| 7.      | Wardha   | Seloo      | Sindi (Rly)                             | Composite    | Nagpur                         |
| 8.      | Wardha   | Wardha     | Wardha                                  | Composite    | Nagpur                         |
|         |          |            | Sevagram                                |              | Nagpur                         |

| 3. Gadchiroli District |            |                    |   |                |                                |
|------------------------|------------|--------------------|---|----------------|--------------------------------|
| Sr. No.                | District   | Talukas            | Name of Municipal Council / Corporation | Climate Zone   | Closest available weather file |
| 1.                     | Gadchiroli | Aheri              | -                                       | Warm and Humid | Nagpur                         |
| 2.                     | Gadchiroli | Armori             | Armori                                  | Warm and Humid | Nagpur                         |
| 3.                     | Gadchiroli | Bhamragad          | -                                       | Warm and Humid | Nagpur                         |
| 4.                     | Gadchiroli | Chamorshi          | -                                       | Warm and Humid | Nagpur                         |
| 5.                     | Gadchiroli | Desaiganj (Vadasa) | Desaiganj                               | Warm and Humid | Nagpur                         |
| 6.                     | Gadchiroli | Dhanora            | -                                       | Warm and Humid | Nagpur                         |
| 7.                     | Gadchiroli | Etapalli           | -                                       | Warm and Humid | Nagpur                         |
| 8.                     | Gadchiroli | Gadchiroli         | Gadchiroli                              | Warm and Humid | Nagpur                         |
| 9.                     | Gadchiroli | Korchi             | -                                       | Warm and Humid | Nagpur                         |
| 10.                    | Gadchiroli | Kurkheda           | -                                       | Warm and Humid | Nagpur                         |
| 11.                    | Gadchiroli | Mulchera           | -                                       | Warm and Humid | Nagpur                         |
| 12.                    | Gadchiroli | Sironcha           | -                                       | Warm and Humid | Nagpur                         |
| 4. Bhandara District   |            |                    |   |                |                                |
| Sr. No.                | District   | Talukas            | Name of Municipal Council / Corporation | Climate Zone   | Closest available weather file |
| 1.                     | Bhandara   | Bhandara           | Bhandara                                | Composite      | Nagpur                         |
| 2.                     | Bhandara   | Lakhandur          | -                                       | Warm and Humid | Nagpur                         |
| 3.                     | Bhandara   | Lakhani            | Lakhani                                 | Warm and Humid | Nagpur                         |
| 4.                     | Bhandara   | Mohadi             | -                                       | Composite      | Nagpur                         |
| 5.                     | Bhandara   | Paoni              | Paoni                                   | Warm and Humid | Nagpur                         |
| 6.                     | Bhandara   | Sakoli             | Sakoli                                  | Warm and Humid | Nagpur                         |
| 7.                     | Bhandara   | Tumsar             | Tumsar                                  | Composite      | Nagpur                         |



| 5. Chandrapur District |            |                 |   |                |                                |
|------------------------|------------|-----------------|---|----------------|--------------------------------|
| Sr. No.                | District   | Talukas         | Name of Municipal Council / Corporation | Climate Zone   | Closest available weather file |
| 1.                     | Chandrapur | Ballarpur       | Ballarpur                               | Warm and Humid | Nagpur                         |
| 2.                     | Chandrapur | Bhadravati      | -                                       | Warm and Humid | Nagpur                         |
| 3.                     | Chandrapur | Brahmapuri      | Bramhapuri                              | Warm and Humid | Nagpur                         |
| 4.                     | Chandrapur | Chandrapur      | Chandrapur                              | Warm and Humid | Nagpur                         |
| 5.                     | Chandrapur | Chimur          | -                                       | Warm and Humid | Nagpur                         |
| 6.                     | Chandrapur | Gondpipri       | -                                       | Warm and Humid | Nagpur                         |
| 7.                     | Chandrapur | Jiwati          | -                                       | Warm and Humid | Nagpur                         |
| 8.                     | Chandrapur | Korpana         | -                                       | Warm and Humid | Nagpur                         |
| 9.                     | Chandrapur | Mul             | Mul                                     | Warm and Humid | Nagpur                         |
| 10.                    | Chandrapur | Nagbhir         | -                                       | Warm and Humid | Nagpur                         |
| 11.                    | Chandrapur | Pombhurna       | -                                       | Warm and Humid | Nagpur                         |
| 12.                    | Chandrapur | Rajura          | Rajura                                  | Warm and Humid | Nagpur                         |
| 13.                    | Chandrapur | Sawali          | -                                       | Warm and Humid | Nagpur                         |
| 14.                    | Chandrapur | Sindewahi       | -                                       | Warm and Humid | Nagpur                         |
| 15.                    | Chandrapur | Warora          | Warora                                  | Warm and Humid | Nagpur                         |
| 6. Gondia District     |            |                 |   |                |                                |
| Sr. No.                | District   | Talukas         | Name of Municipal Council / Corporation | Climate Zone   | Closest available weather file |
| 1.                     | Gondia     | Amgaon          | -                                       | Composite      | Nagpur                         |
| 2.                     | Gondia     | Arjuni- Morgaon | -                                       | Composite      | Nagpur                         |
| 3.                     | Gondia     | Deori           | Deori                                   | Composite      | Nagpur                         |
| 4.                     | Gondia     | Gondia          | Gondia                                  | Composite      | Nagpur                         |
| 5.                     | Gondia     | Goregaon        | -                                       | Composite      | Nagpur                         |
| 6.                     | Gondia     | Sadak-Arjuni    | -                                       | Composite      | Nagpur                         |
| 7.                     | Gondia     | Salekasa        | -                                       | Composite      | Nagpur                         |
| 8.                     | Gondia     | Tirora          | Tirora (EP)                             | Composite      | Nagpur<br>Nagpur               |

| F) KONKAN DIVISION |          |            |   |                |                                |
|--------------------|----------|------------|---|----------------|--------------------------------|
| 1. Raigad District |          |            |   |                |                                |
| Sr. No.            | District | Talukas    | Name of Municipal Council / Corporation | Climate Zone   | Closest available weather file |
| 1.                 | Raigad   | Alibaug    | Alibaug                                 | Warm and Humid | Mumbai                         |
| 2.                 | Raigad   | Karjat     | Karjat                                  | Warm and Humid | Mumbai                         |
| 3.                 | Raigad   | Khalapur   | Khopoli                                 | Warm and Humid | Mumbai                         |
| 4.                 | Raigad   | Mahad      | Mahad                                   | Warm and Humid | Mumbai                         |
| 5.                 | Raigad   | Mangaon    | -                                       | Warm and Humid | Mumbai                         |
| 6.                 | Raigad   | Mhasla     | -                                       | Warm and Humid | Mumbai                         |
| 7.                 | Raigad   | Murud      | Murud-Janjira                           | Warm and Humid | Mumbai                         |
| 8.                 | Raigad   | Panvel     | Panvel                                  | Warm and Humid | Mumbai                         |
| 9.                 | Raigad   | Pen        | Pen                                     | Warm and Humid | Mumbai                         |
| 10.                | Raigad   | Poladpur   | -                                       | Warm and Humid | Mumbai                         |
| 11.                | Raigad   | Raigad     | -                                       | Warm and Humid | Mumbai                         |
| 12.                | Raigad   | Roha       | Roha                                    | Warm and Humid | Mumbai                         |
| 13.                | Raigad   | Srivardhan | Srivardhan                              | Warm and Humid | Mumbai                         |
| 14.                | Raigad   | Sudhagad   | -                                       | Warm and Humid | Mumbai                         |
| 15.                | Raigad   | Tala       | -                                       | Warm and Humid | Mumbai                         |
| 16.                | Raigad   | Uran       | Uran                                    | Warm and Humid | Mumbai                         |
| 2. Thane District  |          |            |   |                |                                |
| Sr. No.            | District | Talukas    | Name of Municipal Council / Corporation | Climate Zone   | Closest available weather file |
| 1.                 | Thane    | Ambarnath  | Ambarnath                               | Warm and Humid | Mumbai                         |
| 2.                 | Thane    | Bhiwandi   | Bhiwandi-Nizampur                       | Warm and Humid | Mumbai                         |
| 3.                 | Thane    | Dahanu     | -                                       | Warm and Humid | Mumbai                         |
| 4.                 | Thane    | Jawhar     | Jawhar                                  | Warm and Humid | Mumbai                         |
| 5.                 | Thane    | Kalyan     | Kalyan-Dombivali                        | Warm and Humid | Mumbai                         |
|                    | Thane    |            | Kulgoan-Badalapur                       |                | Mumbai                         |
| 6.                 | Thane    | Mokhada    | -                                       | Warm and Humid | Mumbai                         |
| 7.                 | Thane    | Murbad     | -                                       | Warm and Humid | Mumbai                         |
| 8.                 | Thane    | Palghar    | Umarpada-Safala                         | Warm and Humid | Mumbai                         |
| 9.                 | Thane    | Shahapur   | -                                       | Warm and Humid | Mumbai                         |
| 10.                | Thane    | Talasari   | -                                       | Warm and Humid | Mumbai                         |
| 11.                | Thane    | Thane      | Thane                                   | Warm and Humid | Mumbai                         |
|                    |          |            | Navi Mumbai                             |                | Mumbai                         |
| 12.                | Thane    | Ulhasnagar | Ulhasnagar                              | Warm and Humid | Mumbai                         |
| 13.                | Thane    | Vada       | -                                       | Warm and Humid | Mumbai                         |

| 14.                           | Thane      | Vasai           | Vasai-Virar                             | Warm and Humid | Mumbai                         |
|-------------------------------|------------|-----------------|---|----------------|--------------------------------|
| 15.                           | Thane      | Vikramgad       | -                                       | Warm and Humid | Mumbai                         |
| <b>3. Ratnagiri District</b>  |            |                 |   |                |                                |
| Sr. No.                       | District   | Talukas         | Name of Municipal Council / Corporation | Climate Zone   | Closest available weather file |
| 1.                            | Ratnagiri  | Chiplun         | Chiplun                                 | Warm and Humid | Mumbai                         |
| 2.                            | Ratnagiri  | Dapoli          | -                                       | Warm and Humid | Mumbai                         |
| 3.                            | Ratnagiri  | Guhagar         | -                                       | Warm and Humid | Mumbai                         |
| 4.                            | Ratnagiri  | Khed            | Khed                                    | Warm and Humid | Mumbai                         |
| 5.                            | Ratnagiri  | Lanja           | -                                       | Warm and Humid | Mumbai                         |
| 6.                            | Ratnagiri  | Mandangad       | -                                       | Warm and Humid | Mumbai                         |
| 7.                            | Ratnagiri  | Rajapur         | Rajapur                                 | Warm and Humid | Mumbai                         |
| 8.                            | Ratnagiri  | Ratnagiri       | Ratnagiri                               | Warm and Humid | Mumbai                         |
| 9.                            | Ratnagiri  | Sangameshwar    | -                                       | Warm and Humid | Mumbai                         |
| <b>4. Sindhudurg District</b> |            |                 |   |                |                                |
| Sr. No.                       | District   | Talukas         | Name of Municipal Council / Corporation | Climate Zone   | Closest available weather file |
| 1.                            | Sindhudurg | Devgad          | -                                       | Warm and Humid | Mumbai                         |
| 2.                            | Sindhudurg | Dodamarg        | -                                       | Warm and Humid | Mumbai                         |
| 3.                            | Sindhudurg | Kankawali       | Kankawali                               | Warm and Humid | Mumbai                         |
| 4.                            | Sindhudurg | Kudal           | -                                       | Warm and Humid | Mumbai                         |
| 5.                            | Sindhudurg | Malvan          | Malvan                                  | Warm and Humid | Mumbai                         |
| 6.                            | Sindhudurg | Sawantwadi      | Sawantwadi                              | Warm and Humid | Mumbai                         |
| 7.                            | Sindhudurg | Sindhudurg      | -                                       | Warm and Humid | Mumbai                         |
| 8.                            | Sindhudurg | Vaibhavwadi     | -                                       | Warm and Humid | Mumbai                         |
| 9.                            | Sindhudurg | Vengurla        | Vengurla                                | Warm and Humid | Mumbai                         |
| <b>5. Mumbai District</b>     |            |                 |   |                |                                |
| Sr. No.                       | District   | Talukas         | Name of Municipal Council / Corporation | Climate Zone   | Closest available weather file |
| 1.                            | Mumbai     | Mumbai          | Municipal Corporation of Greater Mumbai | Warm and Humid | Mumbai                         |
| 2.                            | Mumbai     | Mumbai Suburban |   | Warm and Humid | Mumbai                         |

महाराष्ट्राचे राज्यपाल यांच्या आदेशानुसार व नावाने,

प्रशांत पुं. बडगेरी,  
शासनाचे उप सचिव.

**INDUSTRIES ENERGY AND LABOUR DEPARTMENT**  
Mantralaya, Madam Cama Road, Hutatma Rajguru Chowk,  
Mumbai 400 032, dated the 22nd August 2019.

**NOTIFICATION**

ENERGY CONSERVATION ACT, 2001.

No. APAU-2018/CR-87/Energy-7(Part-I). —The following draft of rules which the Government of Maharashtra propose to make in exercise of the powers conferred by clause (a) of sub-section (2) of section 57 read with clause (a) of section 15 of the Energy Conservation Act, 2001 (No. 52 of 2001), and of all other powers enabling it in that behalf, to specify and notify Energy Conservation Building Code with respect to use of energy in the commercial buildings in the State of Maharashtra, in consultation with the Bureau, is hereby published for information of all the persons likely to be affected thereby; and notice is hereby given that the said draft rules will be taken into consideration by the Government of Maharashtra on or after the expiry of period of thirty days from the date of publication of this notification in the *Maharashtra Government Gazette*.

2. Any objection or suggestions, which may be received by the General Manager (EC), Maharashtra Energy Development Agency, MHADA Commercial Complex, 2nd Floor, Opposite Tridal Nagar, Yerwada, Pune 411 006 or through e-mail [viz.ecbc@mahaurja.com](mailto:viz.ecbc@mahaurja.com), from any person with respect to the said draft on or before the aforesaid period, will be considered by the Government.

**DRAFT RULES**

1. *Short title.*— These rules may be called Maharashtra Energy Conservation Building Rules, 2019.

2. *Definitions.* — (1) In these rules, unless the context otherwise requires, —

(a) “Act” means the Energy Conservation Act, 2001 (No. 52 of 2001);

(b) “Actual Energy Performance Index” means the Energy performance index calculated as per actual energy consumption of the building;

(c) “Annexure” means an annexure appended to these rules;

(d) “Authority having jurisdiction” or “AHJ” means the local authority or any authority created or established under any law for the time being in force by the appropriate Government which exercises authority over land under its jurisdiction, and has powers to give permission for development of such immovable property;

(e) “Best practices” means those measures which optimize efficiencies in the identified components and systems based on integrated design approach that enhances the building performances or reduces the cost of construction having regard to the safety, stability of the building structure, health and environmental provisions of Central or State laws and includes energy conservation measures approved by the Designated Agency or National Energy Conservation Building Code implementation Committee;

- (f) "Board" means ECBC Board established under sub-rule (1) of rule 7 of these rules;
- (g) "Built up Area" means the total area covered by a building on all floors including cantilevered portion, mezzanine floors if any but except the areas excluded specifically from FSI under the Regulations of Authority having Jurisdiction;
- (h) "Bureau" means Bureau of Energy Efficiency, India;
- (i) "Bye-laws" means the building bye-laws notified by Authority having jurisdiction;
- (j) "Central Government" means the Government of India.
- (k) "Connected load" means sanctioned load of a building complex as defined in sub-para (2) of Chapter 8 of the ECBC.
- (l) "Construction documents" means set of documents as defined in sub-para (2) of Chapter 8 of the ECBC.
- (m) "Contract Demand" means contract demand as defined as defined in sub-para (2) of Chapter 8 of the ECBC.
- (n) "Designated Agency" means the Maharashtra Energy Development Agency, an agency designated by the State Government under clause (d) of section 15 of the Act;
- (o) "Distribution Licensee" means distribution licensee as authorized by MERC in clause (17) of section 2 of the Electricity Act, 2003 (Act 36 of 2003);
- (p) "ECBC" means "the Maharashtra Energy Conservation Building Code" issued by the Bureau of Energy Efficiency in pursuance of clause (p) of section 14 of the Act and includes Maharashtra amendment made in this behalf, from time to time;
- (q) "ECBC Inspecting Officer" means an inspecting officer appointed by State Designated Agency under sub-section (1) of section 17 of the Act;
- (r) "Empaneled Maha-ECBC Auditing Agency" means a firm consisting of Energy Auditor and Energy Auditor(Building) certified under Bureau of Energy Efficiency (Certification Procedures for Energy Auditors and Energy Managers) Regulations, 2010 and who are empaneled with the Designated Agency.
- (s) "Energy Auditor (Building)" means a person who fulfils the eligibility criteria specified in the Energy Conservation (Minimum qualification for Energy Auditors and Energy Managers) Rules, 2006 and has qualified National Examination for Energy Conservation Building Codes Compliance conducted by Bureau;
- (t) "Energy Conservation Measures" or "ECM" means the energy saving measures incorporated in the building design to meet the energy efficiency requirement of the building to the desired levels of ECBC compliance mechanism specified in rule 5 of these rules;
- (u) "Energy Performance Index" or "EPI" means Energy Performance Index as specified in sub-para (1.1) of Chapter 3 of ECBC, such as, —

|              |  |
|--------------|--|
| <b>EPI =</b> | <b>Annual Energy Consumption (in kWh)</b>                                |
|              | <b>Total built-up area (excluding unconditioned basement) (in sq.m.)</b> |

(v) “EPI Ratio” means EPI ratio as determined according to the formula laid down in sub-para (1.2) of Chapter 3 of ECBC;

(w) “Form” means the forms appended to these rules;

(x) “Fund” means the Energy Conservation Fund by State Government under the sub-section (1) of section 16 of the Act;

(y) “Nearly Zero Energy Building or NZEB” means energy efficient buildings with low EPI ratio, whose EPI is less than 10 kWh per square meter per year and total energy consumption met by renewable energy sources, buildings which generate as much clean energy on site as consumed by it annually;

(z) “Owner” means, a person, group of persons, a Company, a Trust, Institute, Registered Body, State or Central Government Departments, Undertakings and agencies or organization in whose name the property stands registered in the revenue records; or and in respect of a, —

(i) commercial building includes a person who constructs or causes to be constructed commercial building or converts an existing building or part thereof into such commercial building; and

(ii) In any other case shall include any other person who acts himself as a builder, colonizer, contractor, developer, estate developer or by any other name or claims to be acting as the holder of a power of attorney from the owner of the land on which the building is constructed;

(aa) “Proposed Design” means proposed design as defined in sub-para (2) of Chapter 8 of the ECBC.

(bb) “Standard Design” means standard design as defined in sub-para (2) of Chapter 8 of the ECBC.

(cc) “State Commission” or “MERC” means the Maharashtra Electricity Regulatory Commission constituted under sub-section (1) of section 82 of the Electricity Act, 2003 (36 of 2003), and includes a Joint Commission constituted under sub-section (1) of section 83 of the said Electricity Act;

(dd) “State Government” means the Government of Maharashtra.

(ee) “Technical Grievances Committee” or “Committee” means Maharashtra Energy Conservation Building Code Technical Grievances Committee established under sub-rule (2) of rule 8 of these rules.

(2) Words and expressions used herein but not defined herein and defined in any law for the time being in force or such other relevant laws of the Government shall have the same meaning respectively assigned to them in those laws.

**3. Applicability.**— (1) These rules shall be applicable to the every commercial building or building complex or a part of the building, which is used or intended to be used for commercial purposes having a connected load of 100 kilowatt (kW) or greater, or a contract demand of 120 kilovolt ampere (kVA) or greater, or 1000 Square Meters built up area and shall cover building components ,—

(a) building envelope;

(b) comfort systems and controls (heating, ventilation and air conditioning, service hot water system);

(c) lighting and controls;

(d) electrical and renewable energy systems; and

(e) any other system, as may be specified from time to time by the Bureau.

(2) Where the existing building undergoes additions or alteration resulting in aggregate connected load of 100 kilowatt (kW) or greater or a contract demand of 120 kilovolt ampere (kVA) or 1000 Square Meters built up area, such portion of additions or alteration shall comply with the components referred to in clauses (a) to (e) of sub –rule (1).

**4. Non-applicability.**—*These rules shall not apply to, —*

(1) buildings that do not use either electricity or fossil fuel; or

(2) equipment and portions of building systems that use energy primarily for manufacturing processes;

(3) buildings or building components wherever these rules are in conflict with safety, health, or environmental provisions of Central or State laws or building bye-laws or building regulations such provisions shall prevail over these rules.

**5. Compliance Mechanism.** — (1) *Compliance Approach, —*

(a) The owner shall classify the type of proposed commercial building as per the functional requirements of its design from the building classification specified in sub-para (5) of Chapter 2 of ECBC.

(b) The building or building complex shall comply with all the requirements related to Compliance and Approach as specified in Chapter 3 of ECBC and shall ensure that the compliance of the building is categorized as per climatic classification specified in Appendix B-1 appended to ECBC.

(2) *Energy Performance Compliance Level* : — The Designated Agency shall assign following star rating system as described in the Table -1 for compliances;

**Table 1: Levels of ECBC Compliance**

| Compliance Level |                   | Requirement   |
|------------------|-------------------|---|
| 1                | Mahaurja 1 - Star | ECBC Compliant building as per ECBC   |
| 2                | Mahaurja 2 - Star | ECBC+ Compliant Building as per ECBC  |
| 3                | Mahaurja 3 - Star | Super ECBC Building as per ECBC   |
| 4                | Mahaurja 4 - Star | 10% to 20% reduction in EPI ratio than the Super ECBC EPI ratio of the same building typology as mentioned in ECBC    |
| 5                | Mahaurja 5- Star  | more than 20% reduction in EPI ratio than the Super ECBC EPI ratio of the same building typology as mentioned in ECBC |

**6. Procedure for obtaining a Compliance Report of construction or re-construction or alteration of building.** - Every owner who intends to construct, re-construct or make alterations or addition in the building shall follow the following Stages, namely : —

(1) Design Phase,—

(a) The owner shall,—

(i) appoint the design team comprising of Energy Auditor (Building) and technical experts as specified under ECBC.

(ii) apply for the building design approval to the Designated Agency in Form I, II, and III.

(b) The Designated Agency shall,—

(i) scrutinize and verify the building design as per ECBC.

(ii) the Designated Agency shall verify that the,—

(a) identified Energy Conservation Measures have been applied in the proposed design ;

(b) findings of the compliance and construction documents of the proposed building comply with prescriptive or Whole Building Performance Method.

(c) EPI Ratio projected in the proposed design is in accordance with ECBC.

(iii) in case of any discrepancies in the design requirements, the Designated Agency shall communicate discrepancies report in FORM-IV to the owner for compliance.

(iv) the Designated Agency shall convey the compliance report specifying the UBID in FORM-V to the Authority having jurisdiction with the copy to Owner and respective Distribution Licensee.

(c) Authority having Jurisdiction shall, before issuing final design approval for construction of building, ensure that the design approval which has been approved by the



Authority having jurisdiction is the same for which the certificate of ECBC compliance have been issued by the Designated Agency.

(2) Construction Phase: —

(a) On receiving the required permission for construction from the Authority having jurisdiction, the owner shall—

(i) give an intimation before the commencement of construction work to the Designated Agency in FORM VI ;

(ii) before applying for occupancy certificate to Authority having jurisdiction, Energy Auditor (Building) shall verify the required compliance documents, checklists and on-site Inspection reports and certify that it is in consonance with the compliance report in FORM VII along with intimation of construction work in FORM VIII to the Designated Agency for verification ;

(iii) if the construction work is not in consonance with the compliance report, the owner shall obtain the fresh compliance report from the Designated Agency as per sub-rule (1) of these rules ;

(b) The Designated Agency shall :—

(i) scrutinize the information received in FORM VII and VIII from the owner and verify proposed EPI ratio of building construction ;

(ii) issue the non-compliance report specifying the reasons to the owner on scrutiny if any discrepancy found in FORM IX ;

(iii) issue the ECBC Completion Certificate in FORM X along with FORM XI.

(3) Operational Phase :—

(a) the Owner shall achieve the EPI-ratio as per compliance procedure defined in Chapter 3 of ECBC, within a period of eighteen months of issuance of occupancy certificate or from the date of full occupancy of the building, whichever is earlier.

(b) Distribution Licensee. - The Distribution Licensee shall monitor the building's energy consumption after eighteen months of issuance of Occupancy Certificate or after full occupancy of the building, whichever is earlier and shall inform to the Designated Agency every month.

(c) The Designated Agency shall,—

(i) validate the ECBC compliance of the building in its operational stage by monitoring energy performance of the building through check and comparison of Energy Performance Index (EPI) ratio and inform to owner ;

(ii) monitor energy performance of the building every year by Energy

Performance Index and compare with the proposed EPI ratio and inform to owner ;

(iii) receive and record the data of energy consumption of all the ECBC complied buildings.

(iv) If owner aggrieved by any decision under these rules then he may file his grievances to the Technical Grievances committee within thirty days.

**7. Powers, function and duties of Board. - (1) Constitution of Maha-ECBC Board,—**

(a) the board shall be established under the Chairmanship of Minister In-charge, New and Renewable Energy, Government of Maharashtra along with the members to be nominated by the State Government and shall comprise of five other nominees from relevant administrative Department, namely :—

- (i) a representative of the Energy Department ;
- (ii) a representative of the Urban Development Department ;
- (iii) Chief Town planner or a nominee of Directorate Town Planning ;
- (iv) a representative of the Distribution Licensee of State Government.
- (v) The head of the Designated Agency shall be the Member Secretary of the board.
- (b) The board shall have representative of Bureau.
- (c) The board shall have liberty to engage the services of experts if so desires.

(2) The Board shall, —

(a) promote energy efficient design in the buildings through optimization of energy efficiency in the various components and systems of the building to enhance the building performance and may assist the National Energy Conservation Building Code Implementation Committee to develop and revise Energy Consumption Standards for building ;

(b) promote construction of energy efficient buildings ensuring quality and consistency in their construction having regards to the climatic conditions and needs of the building projects ;

(c) undertake the performance review of annual work of all Empaneled Maha-Auditing Agency to check their credentials.

**8. Powers, functions and duties of Technical Grievance Committee.—**

(1) Constitution of Technical Grievance Committee ;

(a) Technical Grievance Committee shall be established under the Chairmanship of a representative head nominated by Urban Development Department but not below the rank of Deputy Director, Directorate of Town Planning.

(b) Technical Grievance Committee shall be constituted of four other nominees from administrative department of the State who are qualified by experience and training to pass judgment on matters pertaining to the construction of the building, namely :—

- (i) an ECBC technical expert nominated by the Designated Agency ;

(ii) a representative of Council of Architecture ;

(iii) Legal Officer, who may be nominated by the Designated Agency.

(2) The Committee shall, -

(a) hear the grievances by owner after giving the opportunity of hearing to the parties and pass the order within reasonable period.

(b) If any party aggrieved by the order of the committee then we may prefer an appeal before MERC with in the period of 30 days from the date of order.

**9. Duties of Energy Auditor (Building).** - Energy Auditor (Building), shall,—

(a) verify and certify the following, namely :—

(i) design of the building keeping in view the design criteria, energy goals of the project, integrated energy design approach, energy systems performance verification plan, and the modelling approach ;

(ii) energy conservation measures (ECMs) based on the design approach for the project under consideration ;

(iii) construction documents, compliance documents and checklists specified and any other documents desired by the Designated Agency to ensure that the building complies with these rules ;

(b) provide inputs to the Designated Agency and National Energy Conservation Building Code Committee to facilitate the implementation of ECBC and to promote norms and standards for various categories of buildings under various climatic zones of the country if required for consideration ;

(c) furnish a certificate under his seal and signature to certify that drawings, specifications, construction documents, compliance documents prepared covering ECBC related documents prepared for submission to the Designated Agency.

(d) exercise the powers of verification of the building works from the design stage to commissioning of buildings including their uses under these rules.

(e) the empaneled Maha-ECBC Auditing Agency shall ensure that none of the professional or employee working under him/her is engaged in any work in connection with the construction or alteration of concern building covered under these rules to ensure that there is no conflict of interest with his/her official duties with the interests of the authority having jurisdiction.

**10. Duties of Owner.**—The owner of the building shall have full obligation and responsibility of carrying out the construction work of the said building in accordance with the rules. Every owner shall, -

(a) engage the Energy Auditor (Building) in the development of building design, incorporation of energy conservation measures to meet the requirement of the ECBC and these rules and ensure following ;

- (i) prepare detailed electrical load calculation for the proposed building design with the help of Energy Auditor (Building) and submit it along with the declaration while submitting design approval application;
- (ii) finalize the compliance approach relevant for his building project based on the complexity of the building, budget and time constraints;
- (iii) finalize the Energy Conservation Measures (ECMs) as per ECBC having regard to the location of the proposed building;
- (iv) seek to integrate the ECMs in the building and system design so as to achieve the optimized energy efficiency in accordance with the provisions of these rules;
- (v) ensure that drawings, specifications and compliance forms are prepared and Energy Conservation Measures are reflected in the building design documents;
- (b) inform the Designated Agency before starting the construction work at the building site;
- (c) ensure that Energy Conservation Measures are reflected in the construction of the building and installation of its systems;
- (d) respond to the additional information requested, rectifications in construction or any other suggestions recommended by the Designated Agency to ensure compliance with the rules;
- (e) permit the Designated agency to enter the building or premises at any reasonable time for the purpose of verification to ensure compliance of building works with ECBC, if needed;
- (f) inform the Designated Agency in writing intimating the completion of the construction work;
- (g) inform in writing to the Designated Agency in case of termination of the services of Energy Auditor (Building) and appointment of other such professional by the Owner;
- (h) obtain an occupancy permit from the Designated Agency to any occupancy of the building or part thereof after completion of the building;
- (i) on receipt of notice, if any, from Authority having jurisdiction, he shall discontinue such use within reasonable time as specified in such notice and in no case disregards the provision of these rules;
- (j) use or install such system, material or instrument after obtaining the necessary approval of the Designated Agency before completion of the building, where the owner proposes to alter the installation of any system or material or instrument affecting the energy efficiency of the building compared to the system, material or instrument as indicated in the design approval plan.

11. *Duties and functions of Designated Agency.*— The Designated Agency shall co-ordinate with various stakeholders, regulate, and enforce the provisions of these rules in the state. The Designated Agency shall, -

- (a) create awareness about ECBC compliant buildings and procedure for erection of such building;
- (b) promote capacity building of building professionals, developers, contractors to promote energy efficient designs of buildings in the State in close co-ordination with Urban or Rural Local Bodies;
- (c) ensure that application received from the owner falling under applicability of rule 3;
- (d) create and maintain a data bank to measure the compliance rates of the buildings covered under these rules and accurately account for the energy savings resulting from the compliance of these rules during issuance of ECBC compliance certificate;
- (e) take necessary steps to make EPI ratio as a measure to comply with these rules in the various categories of buildings and send its recommendations to the Bureau for the formulation of energy consumption norms and standard in respect of various categories of buildings constructed climate zone wise;
- (f) timely reviewing empanelled Maha-ECBC Auditing Agency;
- (g) prepare a summary of violations which shall be provided by the Designated Agency to the Bureau to review such violations for the purpose of evaluating their professional skills;
- (h) assist the Bureau in developing the Energy Consumption Standards in terms of EPI ratio in respect of various categories of buildings as per its utility classification and varied nature based on statistical data of building constructed under the different climatic zones covered under these rules;
- (i) monitor the performance of Energy Auditor (Building) in the State to formulate the cadre of Empaneled Energy Auditor (Building) as effective instruments of promotion of energy efficiency in the building sector;
- (j) physical inspection, if considered necessary, to gauge the accuracy of reporting by the Energy Auditor (Building);
- (k) co-ordinate with the Authority having jurisdictions to amend their building bye-laws incorporating the provisions of these rules for the purpose of erection of buildings in compliance with these rules;
- (l) to recommend the State Government for incorporating in the buildings Bye-laws;
- (m) to file petition for penalty with the State Commission for non-compliance at any stage of ECBC in respect of order passed by the Committee.
- (n) The use of energy conservation measures or best practices or methods or design or

construction may be used by the owner in optimizing EPI ratio for compliance of ECBC, if such energy conservation measures or best practices or methods or design or construction is approved by the Designated Agency.

(o) the incentives and penalty framework shall be proposed by the Designated Agency.

**12. Duties of Distribution Licensee.**— The Distribution Licensee while granting connection to ECBC eligible building shall ensure that the,—

(a) compliance report received by the Distribution Licensee is same for the building for which permission has been granted for electrical connection.

(b) energy consumption data of the consumers of the building is regularly shared with the Designated Agency.

**13. Miscellaneous.** - ECBC shall be reviewed periodically, at least once in five years or as and when necessary to revise ECBC specified in these rules in consultation with the Bureau.

## FORMS (I –XI)

Design Stage :  
\_\_\_\_\_**FORM I**  
**(See rule 6 (1)(a)(ii))****Application for building permit of ECBC compliant building for  
Construction / Re-Construction / Addition or Alteration in existing building**

To,

(Name of the Designated Agency),

Address of the Designated Agency: \_\_\_\_\_  
\_\_\_\_\_

Date: \_\_\_\_/\_\_\_\_/\_\_\_\_

**Subject:** Application for \_\_\_\_\_ permission to construct/re-construct/ extend or alter ECBC compliant building.

Sir,

I/we the undersigned here by submit proposal to construct / re-construct / alter ECBC eligible Building under the Maha-ECB Rules, 2019.

Details of Owner/ Applicant and the Project:

| I | Details of Owner/Nominee of Owner |  |
|---|-----------------------------------|--|
|   | Name                              |  |
|   | Permanent Address                 |  |
|   |                                   |  |
|   |                                   |  |
|   | Phone no.                         |  |
|   | Mobile no.                        |  |

| II | Details of Appointed Energy Auditor (Building) |  |
|----|--|--|
|    | Appointed Energy Auditor (Building)            |  |
|    | Reg. No.                                       |  |
|    | Communication Address:                         |  |
|    | Phone no.                                      |  |



| III | Details of ECBC compliant building premises |  |
|-----|---|--|
|     | Project Name                                |  |
|     | Project description                         | <i>New/ Old/ Extension/ Alteration/ Change of Use</i>                                      |
|     | Project Address                             |  |
|     | Utility/ Building Classification            | <i>( as per Sub-para (5) of chapter 2 of ECBC as notified by Government of Maharashtra</i> |
|     | Methodology for ECBC compliance             | <i>Prescriptive / Whole Building Performance / Building trade off method</i>               |
|     | Project Climatic Zone                       |  |

| IV | Enclosure of Documents in FORM I    |   | ( ✓ / X ) |
|----|-------------------------------------|---|-----------|
| 1  | Construction Documents              | As defined in sub para (2) of chapter 8 of ECBC, as notified by Government of Maharashtra.  |           |
| 2  | Compliance documents                | Demonstrating compliance of ECBC through –<br>1. EPI ratio complying report.<br>2. Compliance approach<br>3. ECBC compliance report showing compliance - Building envelope, Mechanical Systems and equipment including Heating, Ventilation and Air-conditioning, Service Water Heating and Pumping and lighting, Electric Power compliance).<br>4. As specified in Checklist appended in ECBC, as notified by Government of Maharashtra. |           |
| 3  | Energy Conservation Measures report | Specifies the energy conservation measures taken during all phases of erection/extension of the building  |           |
| 4  | Certificate of Compliance           | Approved and signed by Certified Energy Auditor (Building)  |           |

**Declaration by the owner:**

- (i) I/ we further undertake that the information supplied in the enclosed compliance documents and the FORMS is accurate to the best of my/our knowledge and if any of the information supplied is found to be incorrect and such information result in loss to the Central or the State Government or any other authority under them. I/ we undertake to indemnify such loss.
- (ii) I/we undertake that the aforesaid building shall be constructed in accordance with the bye-laws of the Municipal Authority and the provisions of the Maha-ECB Rules, 2019. In case any deviation is noticed during the construction of the Building, I/we shall indemnify the loss to the Authority having jurisdiction.
- (iii) In case of any change in above credentials I take the responsibility to inform the same in writing to the respective Authority having jurisdiction, the Designated Agency and Committee.

- (iv) I/we undertake to inform and abide any subsequent change in design approved after having received the certificate of compliance from the Designated Agency; shall necessarily obtain revised certificate of compliance before commencement of work from the Designated Agency.
- (v) I/we inform to have flexibility in constructing the building components and the system covered in the construction document to ensure maximum energy efficiency and optimizing energy performance index ratio. with prior information to the Designated Agency.
- (vi) I/we undertake that the building will be constructed as per approved design plan by the Designated Agency.

Yours Faithfully,

(Name of the owner)

(Signature)

Date\_\_\_\_\_

**Design Stage:**

**FORM II**  
**(See rule 6 (1)(a)(ii))**

**Intimation & undertaking by Appointed Energy Auditor (Building) for providing technical assistance for ECBC compliance for the building**

To,

(Name of The Designated Agency),

Address of The Designated Agency: \_\_\_\_\_

\_\_\_\_\_

Date: \_\_\_\_/\_\_\_\_/\_\_\_\_

**Subject:** to inform the below mentioned building shall be ECBC complied under technical assistance of Energy Auditor (Building)-\_\_\_\_\_ with reg. no. \_\_\_\_\_

Sir,

I/we the undersigned here by agree on providing the technical assistance to achieve ECBC compliance for the building

Details of Energy Auditor (Building) and the Project:

| I | Details of Energy Auditor (Building) |                                      |
|---|--------------------------------------|--------------------------------------|
|   | Appointed Energy Auditor (Building)  |                                      |
|   | Reg. No.                             |                                      |
|   | Provide Assistance for :             | <i>Design and Construction Phase</i> |
|   | Communication Address:               |                                      |
|   | Phone no.                            |                                      |

|    |   |  |
|----|---|--|
| II | Details of ECBC compliant building premises |  |
|    | Project Name                                |  |
|    | Project Owner                               |  |
|    | Project description                         | <i>New/ Old/ Extension/ Alteration/ Change of Use</i>  |
|    | Project Address                             |  |
|    | Total Built up Area                         |  |
|    | Utility/ Building Classification            | <i>( as per Sub-para (5) of chapter 2 of ECBC as notified by Government of Maharashtra.)</i> |
|    | Methodology for ECBC compliance             | <i>Prescriptive / Whole Building Performance / Building trade off method</i>                 |
|    | Project Climatic Zone                       |  |

#### Declaration by the Appointed Energy Auditor (Building)

- (i) I hereby commit that all the information submitted in **FORM I and II with all documents** are true to my best knowledge and take due responsibility of confirming the ECBC compliance of the building;
- (ii) I shall abide by all the clauses in ECBC and ensure best professional ethics and conduct throughout my tenure for the project;
- (iii) I understand my responsibilities as mentioned in these rules and assure to deliver a good quality work and ensure optimum energy utilization and improve energy savings of the building;
- (iv) If at any point, I fail to continue to assist for all the compliance phases of building as per ECBC, I take responsibility to convey the same to the respective, the Designated Agency and Authority having jurisdiction and ECBC implementation Committee.

Yours Faithfully,

(Name of the Energy Auditor (Building)),

(Signature)

Date\_\_\_\_\_

**Design Stage**

**FORM III**  
**[See rule 6 (1)(a)(ii)]**

**Compliance at Design Stage by Energy Auditor (Building) with his undertaking for ECBC compliance.**

**Design Compliance/ undertaking of Compliance**

I, Energy Auditor (Building) having registration No \_\_\_\_\_ certified under Bureau of Energy Efficiency and am/are authorized as appointed by owner of the project to assist, demonstrate and verify the design of ECBC eligible Building and certify that-

- (a) I have assisted, demonstrated and verified the construction documents as per the following details showing all the pertinent data and features of the building, equipment and systems insufficient details covering Building Envelope, HVAC, Service hot water, and Lighting and Electrical power in accordance with the ECBC.

Name of Owner: \_\_\_\_\_

Address: \_\_\_\_\_

Site Address: \_\_\_\_\_

- (b) I have demonstrated the compliance forms, ECM reports and Compliance documents together with the check-lists to ensure compliance with ECBC and enclosed with this form.
- (c) The construction documents have been duly verified by me.
- (d) The Energy Performance Index Ratio of the building design as per construction documents at the design stage is in compliance with the ECBC.
- (e) I further certify that all reasonable professional skill, care, and diligence have been taken in verifying the construction document and compliance forms in respect of the various elements of the components covered in ECBC and contents thereof are at true representation of the facts and meet the requirements of ECBC.

| Sr.No | ECBC compliance of the building       |  |
|-------|---------------------------------------|--|
| 1     | Project Registered Name               |  |
| 2     | Method of compliance                  |  |
| 3     | Building Classification Category      |  |
| 4     | Operational hours of Building         |  |
| 5     | Total Built up Area ( excl. basement) |  |
| 6     | Conditioned Area                      |  |
| 7     | Unconditioned Area                    |  |

|    |   |  |
|----|---|--|
| 8  | Proposed EPI through ECBC compliance  |  |
|    | (i) Building's Base case EPI=<br>(ii) Building's proposed EPI=<br>(iii) EPI ratio to be maintained= |  |
| 9  | Total Energy Savings in percentage  |  |
| 10 | Level of ECBC compliance  |  |

**In case of Whole building performance:**

The Building shall comply with all mandatory measures and the requirements specified in the whole building performance method of the Code and the energy performance index of the proposed design under this method.

|                                    |                  |                 |      |
|------------------------------------|------------------|-----------------|------|
| Energy Auditor (Building)<br>Name: | Registration No. | Signature/Stamp | Date |
| Owner:<br>Name:                    |                  | Signature       | Date |

\*\*\*The checklist duly completed, signed and sealed by the undersigned is enclosed.

To,  
The Designated Agency

**Design Stage**

**FORM IV**  
**[See rule 6 (1)(b)(iii)]**  
**Non-Compliance Report**

To,  
 (Name of the Owner),  
 Address \_\_\_\_\_  
 \_\_\_\_\_

Subject: Non-compliance with the ECBC at design stage verification

Reference: 1) Your application No. \_\_\_\_\_ Dated: \_\_\_\_\_

**Non- Compliance with ECBC rules at Design stage verification**

Sir,

On scrutiny of the compliance documents submitted to the Designated Agency for ECBC compliance at Design stage, it is however observed that, the documents lack data/ is incorrect and requires further improvement for approval of ECBC compliance.

**Brief Summary of Documents to be re-viewed, rectified by the Owner & Design Team**

- (i) The building is Non-Compliant with respect to ECBC and is not approved for commencement of construction by the Designated Agency.
- (ii) The non-compliant design documents have to be revised and resubmitted for approval of ECBC compliance to the Designated Agency.

| Sr. No. | Document Name | Subject of non-compliance | Remarks |
|---------|---------------|---------------------------|---------|
|         |               |                           |         |
|         |               |                           |         |
|         |               |                           |         |
|         |               |                           |         |
|         |               |                           |         |
|         |               |                           |         |
|         |               |                           |         |

- (iii) The Owner shall re-submit the Compliance documents after revising the documents and ensuring compliance of the aforesaid recommendations.

|                              |   |
|------------------------------|---|
| <b>The Designated Agency</b> | <b>STAMP</b>                                |
| <b>Name:</b>                 | <b>The Designated Agency<br/>SEAL/STAMP</b> |
| <b>Signature:</b>            |   |
| <b>Date of Issuance:</b>     |   |

Copy to:

Authority having jurisdiction



**Design Stage****FORM V**  
**[See rule 6 (1)(b)(iv)]****[Compliance report from the Designated Agency enclosed with the application for Building Design for Energy Conservation Building Code compliant building]****Certificate**

The Empanelled Maha-ECBC Auditing Agency being the authority representing the Designated Agency, have scrutinized and verified the design of Energy Conservation Building Code compliant building.

I/We certify that –

- (a) I/We have scrutinized the compliance documents, undertaking given by the owner duly signed by the Energy Auditor (Building) showing all the pertinent data and features of the building, equipment and systems in sufficient details covering building envelop, heating, ventilation and air-conditioning, service hot water, lighting and electrical power in accordance with municipal bye-laws and with the ECBC in respect of building proposed to be constructed on plot on -----block no----- scheme in the city of \_\_\_\_\_ in the State of \_\_\_\_\_;
- (b) I/We have scrutinized the compliance forms with the check- lists to ensure compliance with the bye-laws and the ECBC.
- (c) The compliance documents have been duly inspected by the undersigned.
- (e) It is certified that all required scrutiny and verification of the documents submitted have been carried out diligently, truthfully and all reasonable professional skill, care and diligence have been taken in scrutinizing and verifying the drawings of the buildings and compliance forms together with check-lists covering the various components of the ECBC.
- (g) The certificate of compliance is issued on basis design submitted on such and such date, if any subsequent changes made by owner subsequent to design approval shall have to obtain revised approval from the Designated Agency.
- (h) The approval certificate is subject to ECBC Code as notified by Government of Maharashtra.– District wise classification of climatic data for Maharashtra State, for that particular division as on the date of this certificate and shall be binding on the owner to obtain revised approval before the commencement of actual work.

| (i) | Details of ECBC compliant building premises ( <i>to be filled by the Designated Agency</i> ) |   |
|-----|--|---|
|     | Project Name   |   |
|     | Project Owner  |   |
|     | Name of Appointed Energy Auditor (Building) Reg. No.   |   |
|     | Project description  | <i>New/ Old/ Extension/ Alteration/ Change of Use</i> |

|  |                                  |  |
|--|----------------------------------|--|
|  | Project Address                  |  |
|  | Total built up area              |  |
|  | Utility/ Building Classification | <i>(as per Sub-para (5) of chapter 2 of ECBC appended in Annex II)</i> |
|  | Proposed EPI ratio               |  |
|  | Level of ECBC Compliance         |  |

| (ii) | Compliance check          |  | (✓ / x) |
|------|---------------------------|--|---------|
| 1    | Construction Documents    | Compliance to existing building bye-laws                   |         |
| 2    | Compliance documents      | ECBC compliance (EPI ratio $\leq 1$ )                      |         |
| 3    | Certificate of Compliance | Approved and signed by Energy Auditor (Building)           |         |
| 4    | Certificate of Compliance | Approved and signed by Empaneled Maha-ECBC Auditing Agency |         |

- (iii) I/we have reviewed, the undertaking given by the Owner, Energy Auditor (Building) and Compliance documents.
- (iv) I/we have scrutinized, reviewed the construction drawings and documents and have approved its compliance to ECBC.
- (v) I hereby assign a Unique Building Identity Number for the Building which shall be reflected in all the documents of the building.
- (vi) The Owner shall ensure to fulfil the committed ECBC compliance measures in Construction and Operational Phase of the building. If any non-compliance of the building is observed in construction or operational phase the Authority having jurisdiction shall revoke the Building Permission for erection/re-erection.

|  |                             |
|--|-----------------------------|
| Generation of Unique Building Identity No. |                             |
| Building Name:                             | UBID No.<br>( XXXX/XX/ECBC) |

There is no objection for issue of building design in respect of the aforesaid proposed building in so far as requirements of ECBC are concerned.

|                              |   |
|------------------------------|---|
| <b>The Designated Agency</b> | <b>STAMP</b>                                |
| <b>Name:</b>                 | <b>The Designated Agency<br/>SEAL/STAMP</b> |
| <b>Signature:</b>            |   |
| <b>Date of Issuance:</b>     |   |

To,

Authority having jurisdiction

Copy to:

1. The Owner
2. The Distribution Licensee

UBID No. \_\_\_\_\_

**FORM VI**  
**(See rule 6 (2)(a)(i))**

**Intimation for commencement of construction work of ECBC compliant building**

Date: \_\_/\_\_/\_\_

To,

(Name of The Designated Agency),

Address of The Designated Agency: \_\_\_\_\_

Subject: Intimation of ECBC compliant building on approval of Design Phase Compliance by the Designated Agency and Authority having jurisdiction.

Sir,

I/We hereby give notice for commencement of building works including implementation of Energy Conservation Measures for erection of ECBC compliant building of the below mentioned details

| (i) | Details of ECBC compliant building to be constructed |  |
|-----|--|--|
| 1   | Unique Building Identity No.                         |  |
|     | Project registered Name:                             |  |
| 2   | Building Classification Category                     |  |
| 3   | Operational hours of Building                        |  |
| 4   | Total Built up Area ( excl. basement)                |  |
| 5   | Tentative time required for construction             |  |
| 6   | Level of ECBC compliance                             |  |
| 7   | Proposed EPI   |  |
| 8   | Estimated Connected Load & contract demand           |  |

- (i) I/We bring it upon an intimation to the Designated Agency that we shall commence the construction of the building in pursuance of the compliance report by the the Designated Agency/*vide* file No. / letter No..... and **FORM IV**.
- (ii) I/we undertake that the aforesaid building shall be constructed in accordance with the provisions of ECBC. In case any deviation is observed during the construction of the Building, I/we shall indemnify the loss to the Designated Agency I/we shall undertake implementation of energy conservation measures incorporated in compliance documents submitted in design phase of building approval.
- (iii) If there is any unavoidable alteration in construction work that may however not cause any non-compliance to the ECBC, I/we shall bring the same under intimation of the Designated Agency and Authority having jurisdiction and necessary compliance report shall be obtained.
- (iv) I/we further undertake that the information supplied in the enclosed drawings and application is accurate. If any of the information supplied is found to be incorrect I / we will be liable for legal action.

Yours faithfully

Name and Signature of the Owner

Copy to:

Authority having jurisdiction

**Construction Stage**

UBID No. \_\_\_\_\_

**FORM VII**

**(See rule 6 (2)(a)(ii))**

**Construction work review report by Energy Auditor (Building) for construction phase**

To

(Name of The Designated Agency),

Address of The Designated Agency: \_\_\_\_\_

- i. I..... (Name), being appointed Energy Auditor (Building) with reg. no. \_\_\_\_\_ hereby state that the designated agency having given the compliance report wider UBID No.....& the owner undertake to construct the building as per intimation by undertaking dated.....I/we have reviewed the undertaking given by the owner, energy conservation measures installed during the construction works and have reviewed the construction documents, compliance forms, check-lists, submitted along with progress in construction works in respect of the various elements of the components as referred in construction phase of these rules I have reviewed the construction work of the buildings and ensure that the building is constructed in compliance with the the compliance report of the Designated Agency
- ii. During the construction work, all the energy conservation measures have been incorporated as committed in design phase. A list of the energy conservation measures deployed in the construction of aforesaid building are enclosed.
- iii. I hereby certify the Building construction work has been constructed and verified with respect to the ECBC and the compliance report of the Designated Agency

|                                  |                                    |
|----------------------------------|------------------------------------|
| <b>Energy Auditor (Building)</b> |                                    |
| <b>Name:</b>                     | <b>Registration no. &amp; Seal</b> |
| <b>Signature:</b>                |                                    |
| <b>Date of Issuance:</b>         |                                    |

**Construction Stage**

UBID NO. \_\_\_\_\_

**FORM VIII**  
**(See rule 6 (2)(a)(ii))****Intimation of Completion of Construction Phase &  
Application for ECBC Completion Certificate**

To

The Designated Agency

Address \_\_\_\_\_,  
\_\_\_\_\_**Subject:** Intimation of completion of construction of ECBC compliant work of building with UBID  
No. \_\_\_\_\_

Sir,

I/We hereby give notice that the erection of the building with UBID No. \_\_\_\_\_ including execution and implementation of the energy conservation measures have been completed in accordance with the plans sanctioned *vide* your office communication No. \_\_\_\_\_ dated \_\_\_\_\_ and in accordance with all the construction and compliance documents submitted in Design and Construction stages of the building.

- (i) I/ we undertake that the information supplied in the enclosed compliance documents and the FORMS is accurate to the best of my/our knowledge and if any of the information supplied is found to be incorrect and such information result in loss to the Central or the State Government or any other authority under them. I/ we undertake to indemnify such loss.
- (iii) I/we undertake that the aforesaid building shall be constructed in accordance -ECBC. In case any deviation is noticed during the construction of the Building, I/we shall indemnify the loss to the Designated Agency.
- (ii) I/we assure the building is fit for use for which it has been erected/re-erected/constructed.

Energy Auditor (Building)

Signature

Yours faithfully,

(Name of the Owner)

Signature

**Construction Stage**

UBID NO. \_\_\_\_\_

**FORM IX****(See rule 6 (2)(b)(ii))****Report of Non-Compliance by the Designated Agency before completion**

To  
(Name of Owner),  
Address \_\_\_\_\_  
\_\_\_\_\_

**Subject:** Issue of Non-Compliance Certificate

Sir,

It is to bring in notice of Owner and the Designated Agency that after reviewing & scrutinizing the documents, the building with UBID no. \_\_\_\_\_ has failed to comply with the ECBC and hence a Non-Compliance Certificate is issued herewith.

The aforesaid building is not qualified for Occupancy as it lacks compliance in below mentioned areas-

This FORM is issued to inform the Owner; the following omission/non-compliance have been found on inspection –

- (i)
- (ii)
- (iii)
- (iv)
- (v)

**\*\* Details of Non-Compliance report to be enclosed with the form.**

You are directed to take corrective action within a period of forty-five days from the date of issue of this letter. Further action on your application for issue of Completion Certificate shall be taken after satisfactory compliance of the aforesaid non-compliance.

| The Designated Agency    |   |
|--------------------------|---|
| <b>Name:</b>             | <b>The Designated Agency<br/>SEAL/STAMP</b> |
| <b>Signature:</b>        |   |
| <b>Date of Issuance:</b> |   |

**Copy to Authority having jurisdiction**

**Construction Stage**

UBID NO. \_\_\_\_\_

**FORM X**  
**(See rule 6 (2)(b)(iii))****Certificate of ECBC Completion certificate format**  
(To be issued The Designated Agency)

To,  
(Authority having jurisdiction),  
Address: \_\_\_\_\_  
\_\_\_\_\_

**Subject: Issue of ECBC Completion Certificate**

Sir,  
With reference to your notice of completion of construction of building dated..... with  
building UBID No. \_\_\_\_\_

(i) I/we hereby certify that the said building having ---

|    | Details of building constructed       |  |
|----|---------------------------------------|--|
| 1  | Unique Building Identity No.          |  |
| 2  | Owner Name                            |  |
| 3  | Project registered Name:              |  |
| 4  | Project Address                       |  |
| 5  | Building Classification Category      |  |
| 6  | Operational hours of Building         |  |
| 7  | Climatic Zone                         |  |
| 8  | Total Built up Area ( excl. basement) |  |
| 9  | Compliance level of ECBC              |  |
| 10 | Proposed building EPI ratio           |  |
| 11 | Connected Load                        |  |
| 12 | Contract Demand                       |  |

for which the plans were sanctioned vide No.....dated.....has been  
inspected with reference to requirements of ECBC.





| The Designated Agency   |   |
|---|---|
| <b>Name:</b><br><br><br><b>Signature:</b><br><b>Date of Issuance:</b> | <b>The Designated Agency<br/>SEAL/STAMP</b> |

Copy to

1. Owner
2. Distribution Licensee- UBID to be tagged to the connection of this building.

**FORM XI****(See rule 6 (2)(b)(iii))****Certificate of ECBC Completion by the Designated Agency**

|   |   |   |
|---|---|---|
|    | <b>Maharashtra</b><br><b>Energy Conservation Building Code</b><br><b>Completion Certificate</b> |    |
| Date of Issue: _____ UBID NO. _____   |   |   |
| <b>Registered Name of the Building</b><br>Address _____ has successfully achieved following level of certification<br>established by Government of Maharashtra for Energy Conservation Building Code<br>compliance<br><div style="text-align: center;">  </div> <b>Mahaurja 3-Star</b><br><b>With Super ECBC Compliance</b> |   |   |
| Building Utility: _____ Validity till Date: _____   |   |   |
| <b>METHOD OF COMPLIANCE</b>   |   |   |
| <input type="radio"/> PRESCRIPTIVE <input checked="" type="radio"/> WHOLE BUILDING PERFORMANCE <input type="radio"/> BUILDING ENVELOPE TRADEOFF   |   |   |
| <b>PROJECT INFORMATION</b>  |   | <b>TECHNICAL INFORMATION</b>  |
| Applicant Name: XXXX<br>Address: XXXX<br>Project Description: XXXX<br>Project Category: XXXX<br>Site Area: XXXX<br>Built Up Area: XXXX<br>Conditioned Area: XXXX<br>Unconditioned Area: XXXX  |   | Building EPI Ratio=<br>Annual Energy Savings=____%<br><br>Project Base case EPI*: XX<br>Project Existing EPI*: XX<br>Star Category Awarded: Mahaurja- XX<br>Star (*EPI is in kWh/M2/yr) |
| This certificate is issued on the basis of analysis, compliance report and declaration duly signed<br>by Owner _____.<br>Certified Energy Auditor (building) _____ with Reg no _____  |   |   |
| Name of Licensee: _____<Post>   |   |   |
| Authority: The Designated Agency  |   | Signature & Stamp of the Licensee   |

# ECBC

Energy  
Conservation  
Building  
Code 2017



GOVERNMENT OF INDIA  
MINISTRY OF POWER



Bureau of Energy Efficiency  
Ministry of Power, Government of India



ENERGY  
CONSERVATION  
BUILDING  
CODE  
2017

# Energy Conservation Building Code

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पीयूष गोयल  
PIYUSH GOYAL



विद्युत, कोयला, नवीन और नवीकरणीय ऊर्जा एवं खान

राज्य मंत्री (स्वतंत्र प्रभार)

भारत सरकार

Minister of State (Independent Charge)  
for Power, Coal, New & Renewable Energy and Mines  
Government of India



#### Message

Indian economy has expanded aggressively in the last few decades and it is poised for greater growth in the future. However, our progress is accompanied with unique local and global challenges. Rapid economic growth, urbanization and expanding population have imposed a great strain on energy supply resources. Our economic development policies and international commitments to climate change mitigation are centred on the twin targets of spurring rapid market growth with minimal environmental impact.

India has committed to reduce emissions intensity of the national GDP by 33% to 35% by 2030 from 2005 level. Transformation of the building sector to the most advanced standards of building energy efficiency like near zero energy buildings is crucial for achieving these targets. Buildings consume about one third of the total annual electrical energy consumption in the country and are one of the largest contributors to GHG emissions. With nearly 70% of the buildings required in 2030 yet to be built, this sector will continue to impact any efforts to contain GHG emissions.

Energy Conservation Building Code (ECBC) 2017 is a powerful regulation to encourage the transition of buildings to efficient use of energy. It is one of the first building energy codes to set provisions for achieving energy neutrality in buildings.

ECBC can be leveraged with government initiatives to encourage environmental sustainability through energy efficiency and renewable energy in buildings. The Government of India's Smart Cities Mission is focused on sustainable urban infrastructure development. Energy efficient buildings is one of the metrics recommended for Smart Cities and ECBC will provide a regulatory framework for accomplishing building energy efficiency as a part of the Mission.

Regulations can only achieve so much; our response must be market based to be self-sustaining in the long term. Enforcement of ECBC can transform markets towards more efficient building materials and technologies by creating a demand for them. India is the founding member of the International Solar Alliance. Provision for renewable energy systems in buildings is one of the requirements of ECBC 2017. This offers a great opportunity to create a demand for solar energy technologies and support the objectives of the International Solar Alliance.

We have witnessed substantial progress in adoption of ECBC across all states since its launch. I congratulate the Bureau of Energy Efficiency (BEE) and state governments in the progress achieved so far. I now urge all states and BEE to continue their aggressive pursuit of energy efficiency in buildings through the code.

Piyush Goyal

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सचिव

भारत सरकार

P. K. PUJARI  
Secretary  
Government of India



सत्यमेव जयते

Ministry of Power  
Shram Shakti Bhawan  
New Delhi - 110001

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29 March, 2017



### Message

India's Nationally Determined Contributions commit to reducing emissions intensity of its GDP to 35% below 2005 levels by 2030. Any effort to achieve this target is contingent upon the increases in efficiency of energy use across all sectors, especially in the building sector.

The building sector in India consumes over 30% of the total electricity consumed in the country annually and is second only to the industrial sector as the largest emitter of greenhouse gases. Energy demand is expected to grow aggressively in the coming years with rising population and technology intensive lifestyles.

Building energy codes have been adopted as a regulatory measure for ushering energy efficiency in the building sector by many countries. In India, the Energy Conservation Act, 2001 provides the basic framework for regulating all initiatives relating to the efficient use of energy and this includes building energy codes.

India's Energy Conservation Building Code (ECBC) was first launched in 2007 as a voluntary code by the Bureau of Energy Efficiency to fulfil its mandate of effecting energy efficiency in buildings under the Energy Conservation Act of 2001.

Updating the ECBC was a priority of the government under the 12<sup>th</sup> five-year plan. The technical update of ECBC 2007 has been carried out to reflect advancements in energy efficient building technologies and building management practices as well as to streamline the compliance processes.

I am confident that the updated ECBC will establish new benchmarks for energy efficient buildings in the country. I urge all stakeholders in the building industry to support effective implementation of ECBC 2017.

  
( P. K. Pujari )





बी.पी.पाण्डेय  
विशेष सचिव  
भारत सरकार  
**B.P. Pandey**  
Special Secretary  
Government of India



सत्यमेव जयते  
Ministry of Power  
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30 March, 2017



Buildings Energy Codes stipulate the minimum energy performance levels for buildings. These codes are updated for enhancing minimum energy conservation standards and also to keep pace with the technological developments. India's Energy Conservation Building Code (ECBC) was originally launched in 2007. Subsequently, with the amendment in Energy Conservation Act, the threshold for applicability of ECBC in buildings has been brought down. Accordingly, ECBC has been updated to expand its scope, incorporate technological advancements and to respond to the changed market scenario.

This updation has been guided keeping in view the ease of implementation for enforcement officials and ease of understanding for building designers. ECBC 2017 is designed to leverage existing knowledge of building designers. Methods for demonstrating compliance with complex code requirements have been added to the code.

The Bureau of Energy Efficiency (BEE) mapped ECBC implementation systems across different states that have adopted the code. In most states, enforcement authorities for bye-law compliance are also responsible for code compliance. BEE has sought to enable greater understanding of the code and its requirements by enforcement officials by synchronizing the Code with model building bye-laws, National Building Code, and other relevant mandatory guidelines for buildings established by Government of India.

I hope that ECBC 2017 will be instrumental in swifter adoption of energy efficient practices in buildings in the country.

( B.P. Pandey )



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SHRAM SHAKTI BHAWAN, RAFI MARG

नई दिल्ली - 110001  
NEW DELHI - 110001

30<sup>th</sup> March, 2017



## MESSAGE

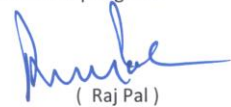
The Government of India announced the Energy Conservation Building Code (ECBC) for new commercial buildings in May 2007. ECBC sets minimum energy standards for new commercial buildings having a connected load of 100 kW or contract demand of 120 kVA and above. While the Central Government has powers under the Energy Conservation Act, 2001 to notify standards of energy consumption in commercial buildings, the state governments can amend the code to suit local or regional needs and notify the same. The major components of the building which are being addressed through the code are: envelope (walls, roofs, windows), lighting systems, HVAC systems, water heating, water pumping and electrical power system.

The enforcement of ECBC lies with the state governments and urban local bodies. A number of states have notified ECBC 2007 with amendments, and several others are in the process of amending the ECBC to suit their local requirements.

In order to facilitate implementation of ECBC, the Bureau of Energy Efficiency (BEE) carried out several enabling measures which, inter alia, included: empanelment of ECBC expert architects, development of technical reference material, development of conformance, compliance check tool, standard training modules, etc.

Keeping in view the advancements in energy efficient building technologies and building management practices and also to streamline the implementation and compliance processes, a need was felt to update the ECBC.

ECBC 2017 is now ready for adoption by the building industry. I hope that all new commercial buildings will not only be ECBC 2017 compliant, but also look to adopting the ECBC+ and Super ECBC standards specified in the new code.

  
( Raj Pal )





**BUREAU OF ENERGY EFFICIENCY**  
(Ministry of Power, Government of India)

Abhay Bakre

Director General, Bureau of Energy Efficiency



Bureau of Energy Efficiency had launched Energy Conservation Building Code (ECBC) 2007 to establish minimum energy performance standards for buildings in India. Buildings consume significant proportion of our energy resources and the ECBC is an essential regulatory tool to curb their energy footprint.

Building energy codes are updated regularly to catch up with the curve of technology maturation and to set higher benchmarks for building energy efficiency. In alignment with current market scenario and advanced technologies ECBC has been taken for update also. Energy efficient technologies and materials that were aspirational in the years preceding launch of ECBC are now commonly available in Indian markets. Accordingly, ECBC 2017 has been revised to incorporate advanced technologies.

Additional parameters included are related to renewable energy integration, ease of compliance, inclusion of passive building design strategies and, flexibility for the designers. One of the major updates to the code is inclusion of incremental, voluntary energy efficiency performance levels. ECBC 2017 is one of the first building energy codes to recognize beyond code performance. There are now three levels of energy performance standards in the code. In ascending order of efficiency, these are ECBC, ECBCPlus and SuperECBC. The adherence to the minimum requirements stipulated for ECBC level of efficiency would demonstrate compliance with the code. Other two efficiency levels are of voluntary nature. This feature was added to prepare the building industry for meeting energy efficiency standards in coming years and give sufficient time to the market to adapt.

ECBC 2017 is technology neutral. Energy efficiency requirements have been framed to provide architects and engineers artistic and technical freedom as long as minimum efficiency requirements are fulfilled.

Provisions for installation of renewable energy generation systems is mandatory in ECBC 2017. Buildings compliant with the updated code must be ready for installation of renewable energy systems. Proportion of total electricity demand to be met through renewable energy systems increases with the efficiency level the project aspires to.

Passive designs strategies like daylight and shading are mandatory in ECBC 2017. Objective for this change is to encourage design with passive strategies to be the norm for buildings in India. Building energy codes are hinged on climate responsive buildings that use local natural resources and climatic conditions to their advantage.

Passive design strategies are one of the most effective methods to ensure that building designs and technologies are sensitive to the surroundings.

ECBC update process was designed to be a participative exercise that responded to the concerns of the building sector stakeholders while maintaining the technical rigor that must accompany any enforceable building energy code. Numerous meetings and regional workshops were held to develop and review the recommendations. Tremendous participation was seen from practitioners, developers, policy makers and manufacturers during the review workshops conducted in different regions of the country.

On behalf of BEE team, I appreciate the invaluable contributions of the all working group members. Each of them is a luminary of their respective field and have numerous other crucial commitments. Yet for more than three years they worked diligently to ensure that the update process is technically rigorous and the resultant code technically consistent.

The code would not have been completed without the commitment of officials from BEE. Their efforts have ensured that the vision set for code update is embedded in ECBC 2017. I also wish to acknowledge USAID and the team from USAID's Partnership to Advance Clean Energy - Deployment (PACE-D) Technical Assistance program for assisting BEE in anchoring the code update process.

Shri Pradeep Kumar Pujari, Secretary, Ministry of Power; Shri. B P Pandey, Special Secretary, Ministry of Power and Shri Raj Pal, Economic Advisor, Ministry of Power have facilitated the update process and their guidance was instrumental in navigating inter departmental coordination between several Government agencies that oversee building regulations in the country.

I do hope that this endeavour which is evolved through collaborative efforts of many officials will be instrumental in encouraging efficiency in building sector of India. ECBC 2007 laid the foundation for energy efficient buildings in India. ECBC 2017 would aspire to strengthen it further.

**Abhay Bakre**  
Director General  
Bureau of Energy Efficiency



**BUREAU OF ENERGY EFFICIENCY**  
(Ministry of Power, Government of India)



Saurabh Diddi

Director, Bureau of Energy Efficiency

The Energy Conservation Building Code (ECBC) 2017 is now ready for launch. The technical update of the code was required to reflect technological developments that have happened over the intervening period. Also, building management systems have now enabled building energy consumption to be managed and link the same to a number of external and internal operating parameters.

Energy Conservation Building Code 2017 is the culmination of close coordination that started in 2012. This update has been made possible with the commitment and knowledge of Chairs and members of the Working Groups. Dr. N K Bansal, Late Mr. H S Mamak, Dr. R S Agarwal, Dr. Bhim Singh, and Mr. Gulshan Aghi have contributed immensely in developing a comprehensive code. They were joined in the working groups by leading sustainable building experts in India - Mr. G S Modgil, Mr. Sanjay Prakash, Mr. Anurag Bajpai, Dr. Archana Walia, Dr. Milind Rane, Mr. Rajan Rawal, Dr. Jyotirmay Mathur, and Ms. Mili Majumdar.

Energy efficiency measures in ECBC 2017 are informed by actual construction practices and existing level of energy efficiency trends in Indian construction sector. Special thanks are due to members of Refrigeration and Air-Conditioning Manufacturers Association of India, Indian Society of Heating, Refrigerating & Air-conditioning Engineers, Electric Lamp and Component Manufacturers Association of India, International Copper Promotion Council, Indian Electrical and Electronics Manufacturers Association, Central Building Research Institute Roorkee, and Indian Society of Lighting Engineers who shared data on current market trends. Experts from Central Public Works Department, Administrative Staff College of India, Ministry of New and Renewable Energy, Town & Country Planning Organization, Bureau of Indian Standards and other government agencies were instrumental in ensuring that the code is synchronized with other standards and legislation applicable to buildings.

ECBC 2017 also provides for a futuristic building performance standard which the building industry can work towards, irrespective of updates to ECBC. The updated code has defined three levels of energy performance standards. In ascending order of efficiency, these are ECBC compliant building, ECBC+ Building and Super ECBC Building. Fulfilling requirements stipulated for ECBC building level of efficiency is necessary for demonstrating compliance with the code. The other two levels are voluntary. Subsequent updates in ECBC will be focused on making ECBC+ Building and Super ECBC Building the baseline of energy efficient buildings in the country. This feature was added to give notice to the building industry of baseline building energy efficiency standards in coming years and give time to the market to adapt.

The update process was a comprehensive exercise which was able to retain its rigor and technical consistency due to efforts of Ms. Apurva Chaturvedi, Senior Clean Energy Specialist, USAID. Dr. Bhaskar Natarajan from PACE-D TA program provided constant support and guidance in management of the code development processes.

BEE acknowledges Mr. Tanmay Tathagat, Mr. Govinda Somani, Mr. Mayank Bhatnagar, Mr. Hisham Ahmad, Mr. Syed Nabeel Ahmad, Ms. Aarti Nain, Mr. Gurneet Singh, Ms. Anamika Prasad, and the team of architects, engineers and renewable energy experts from Environmental Design Solutions. The code requirements and stringency for ECBC 2017 were informed by their research and analytical studies.

ECBC 2017 would not have been possible without the commitment and support of officers from BEE beginning with the former Director General Dr. Ajay Mathur, former Energy Economist Mr. Sanjay Seth, former Assistant Energy Economist Mr. Girja Shankar, Assistant Energy Economist Mr. Arijit Sengupta and Project Engineers Ms. Anju Singh, Mr. Niraj Rajesh Modi, and Mr. Ishan Jain.

BEE also appreciates the stakeholders from the building industry in India who have provided constant feedback on improving ECBC. I do hope that an endeavour that involved collaborative efforts of so many will be instrumental in encouraging efficiency in buildings in India.

**Saurabh Diddi**

Director  
Bureau of Energy Efficiency



Mark A. White

Mission Director, USAID



Energy cooperation is a key element of the U.S.-India strategic partnership. The two countries have been working together to accelerate clean energy deployment and ensure energy security since the 1950s. The most recent partnership between the U.S. and India, the Partnership to Advance Clean Energy – Deployment (PACE-D), was initiated in 2009 to leverage skills and resources of agencies from both the U.S. and India for scaling up deployment of energy efficiency and renewable energy technologies in India.

The U.S. Agency for International Development (USAID) and the Bureau of Energy Efficiency, Ministry of Power has a long standing and fruitful partnership in enhancing energy efficiency of buildings in India. In 2007, USAID supported the development of the Energy Conservation Building Code (ECBC) in 2007 under the Energy Conservation and Commercialization (ECO) II bilateral program. With PACE-D, we have extended this partnership in a logical direction through technical assistance for update of the ECBC 2007 and its implementation in states.

ECBC 2017 supports many of the Government of India's objectives for achieving energy security, economic growth and environmental sustainability. As a primary policy driver for guiding building construction, it is a forward looking code and will push the building sector towards near zero energy targets. USAID is proud to be associated with the Bureau of Energy Efficiency and the Ministry of Power on such a progressive and innovative building energy code, ECBC 2017.

I congratulate the Bureau of Energy Efficiency and the Ministry of Power on the launch of ECBC 2017. India is in a massive construction phase and the code can be a transformative tool for integrating energy efficient design and technologies in all new commercial buildings.

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United States Agency for International Development (USAID)  
Uttarakhand Renewable Energy Development Agency  
West Bengal Renewable Energy Development Agency

The cover features a stylized illustration. At the top, a large orange crane spans the width of the page. Below it, the text 'ECBC' is written in large white letters. Underneath 'ECBC', the words 'Energy Conservation Building Code 2017' are written in black. The background is divided into three horizontal bands. The top band is solid orange. The middle band shows a landscape with wind turbines on the left, a crane in the center, and a tree on the right. The bottom band shows a city skyline with various colored buildings and a tree on the right. A vertical white line runs down the right side of the page, separating the text from the city skyline.

# ECBC

Energy  
Conservation  
Building  
Code 2017

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# 1 Purpose



# 1. Purpose

In accordance with section 14(p) of the Energy Conservation Act 2001 the purpose of the Energy Conservation Building Code (Code) is to provide minimum requirements for the energy-efficient design and construction of buildings. The Code also provides two additional sets of incremental requirements for buildings to achieve enhanced levels of energy efficiency that go beyond the minimum requirements.



## 2 Scope



## 2. Scope

The Code is applicable to buildings or building complexes that have a connected load of 100 kW or greater or a contract demand of 120 kVA or greater and are intended to be used for commercial purposes.

Buildings intended for private residential purposes only are not covered by the Code.

### 2.1 Energy Efficiency Performance Levels

The code prescribes the following three levels of energy efficiency:

(a) Energy Conservation Building Code Compliant Building (ECBC Building)

ECBC Buildings shall demonstrate compliance by adopting the mandatory and prescriptive requirements listed under ECBC Compliant Building requirements in §4 to §7, or by following the provisions of the Whole Building Performance (WBP) Method in §9.

(b) Energy Conservation Building Code Plus Building (ECBC+ Building)

ECBC+ Buildings shall demonstrate compliance by adopting the mandatory and prescriptive requirements listed under ECBC+ Compliant Building requirements in §4 to §7, or by following the provisions of the Whole Building Performance (WBP) Method in §9.

(c) Super Energy Conservation Building Code Building (SuperECBC Building)

SuperECBC Buildings shall demonstrate compliance by adopting the mandatory and prescriptive requirements listed under SuperECBC Compliant Building requirements in §4 to §7, or by following the provisions of the Whole Building Performance (WBP) Method in §9.

### 2.2 Building Systems

The provisions of this code apply to:

- (a) Building envelope,
- (b) Mechanical systems and equipment, including heating, ventilating, and air conditioning, service hot water heating,
- (c) Interior and exterior lighting, and
- (d) Electrical power and motors, and renewable energy systems.

The provisions of this code do not apply to plug loads, and equipment and parts of buildings that use energy for manufacturing processes, unless otherwise specified in the Code.

### 2.3 Precedence

The following codes, programs, and policies will take precedence over the Code in case of conflict:

- (a) Any policy notified as taking precedence over this Code, or any other rules on safety, security, health, or environment by Central, State, or Local Government.
- (b) Bureau of Energy Efficiency's Standards and Labelling for appliances and Star Rating Program for buildings, provided both or either are more stringent than the requirements of this Code.

## 2.4 Reference Standards

The National Building Code of India 2016 (NBC) is the reference standard for lighting levels, heating, ventilating, and air conditioning (HVAC), thermal comfort conditions, natural ventilation, and any other building materials and system design criteria addressed in this Code.

## 2.5 Building Classification

Any one or more building or part of a building with commercial use is classified as per the functional requirements of its design, construction, and use. The key classification is as below:

- (a) **Hospitality:** Any building in which sleeping accommodation is provided for commercial purposes, except any building classified under Health Care. Buildings and structures under Hospitality shall include the following:
  - i. No-star Hotels – like Lodging-houses, dormitories, no-star hotels/motels
  - ii. Resort
  - iii. Star Hotel
- (b) **Health Care:** Any building or part thereof, which is used for purposes such as medical or other treatment or care of persons suffering from physical or mental illness, disease, or infirmity; care of infants, convalescents, or aged persons, and for penal or correctional detention in which the liberty of the inmates is restricted. Health Care buildings ordinarily provide sleeping accommodation for the occupants. Buildings and structures like hospitals, sanatoria, out-patient healthcare, laboratories, research establishments, and test houses are included under this type.
- (c) **Assembly:** Any building or part of a building, where number of persons congregate or gather for amusement, recreation, social, religious, patriotic, civil, travel and similar purposes. Buildings like theatres or motion picture halls, gathering halls, and transport buildings like airports, railway stations, bus stations, and underground and elevated mass rapid transit system are included in this group.
- (d) **Business:** Any building or part thereof which is used for transaction of business, for keeping of accounts and records and similar purposes, professional establishments, and service facilities. There are two subcategories under Business – Daytime Business and 24-hour Business. Unless otherwise mentioned, Business buildings shall include both Daytime and 24-hour subcategories.
- (e) **Educational:** Any building used for schools, colleges, universities, and other training institutions for day-care purposes involving assembly for instruction, education, or

recreation for students. If residential accommodation is provided in the schools, colleges, or universities or coaching/ training institution, that portion of occupancy shall be classified as a No-star Hotel. Buildings and structures under Educational shall include following types-

- i. Schools
  - ii. All other types of institutes, e.g. college, university, training institutes etc.
- (f) **Shopping Complex:** Any building or part thereof, which is used as shops, stores, market, for display and sale of merchandise, either wholesale or retail. Buildings like shopping malls, stand-alone retails, open gallery malls, super markets, or hyper markets are included in this type.
- (g) **Mixed-use Building:** In a mixed-use building, each commercial part of a building must be classified separately, and –
- i. If a part of the mixed-use building has different classification and is less than 10% of the total above grade floor area, the mixed-use building shall show compliance based on the building sub-classification having higher percentage of above grade floor area.
  - ii. If a part of the mixed-use building has different classification and one or more sub-classification is more than 10% of the total above grade floor area, the compliance requirements for each sub-classification, having area more than 10% of above grade floor area of a mixed-use building shall be determined by the requirements for the respective building classification in §4 to §7.

Any building which does not fall under any of the categories defined above shall be classified in a category mentioned above that best describes the function of the building.

*Note 2-1 Building Typologies for ECBC 2017*



Energy efficiency requirements for the Code were derived after analysing 16 different non-residential building typologies (shown below), that in turn are broadly based on building classification in the National Building Code of India. Spatial layouts, material specifications, façade characteristics, and occupancy patterns have an impact on energy efficiency of a building and differ for these typologies. Potential for reducing energy use with technology and materials thus varies from building type to type. By analysing this potential.

ECBC energy efficiency requirements are now sensitive to building typologies and, to the extent possible, only requirements that are feasible have been included.



**Hospitality**

1. Star Hotel
2. No Star Hotel
3. Resort



**Educational**

1. College
2. University
3. Institution
4. School



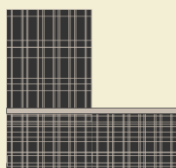
**Health Care**

1. Hospital
2. Out-patient Healthcare

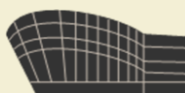


**Shopping Complex**

1. Shopping Mall
2. Stand-alone Retailers
3. Open Gallery Malls
4. Super Markets



1. Daytime use
2. 24-hours use



**Assembly**

1. Multiplex
2. Theatre
3. Building used for Transport Services



# 3 Compliance & Approach



## 3. Compliance and Approach

### 3.1 General

To comply with the Code, buildings shall

- (a) have an Energy Performance Index Ratio (EPI Ratio) as defined in §3.1.2 that is less than or equal to 1

and,

- (b) meet all mandatory requirements mentioned under §4.2, §5.2, §6.2, and §7.2.

#### 3.1.1 Energy Performance Index

The Energy Performance Index (EPI) of a building is its annual energy consumption in kilowatt-hours per square meter of the building. While calculating the EPI of a building, the area of unconditioned basements shall not be included. EPI can be determined by:

$$EPI = \frac{\text{annual energy consumption in kWh}}{\text{total builtup area (excluding unconditioned basements)}}$$

To comply with the Code, EPI value shall be rounded off to two decimal places in accordance with IS 2: 1960 'Rules for rounding off numerical values.

#### 3.1.2 Determining EPI Ratio

The EPI Ratio of a building is the ratio of the EPI of the Proposed Building to the EPI of the Standard Building:

$$EPI \text{ Ratio} = \frac{EPI \text{ of Proposed Building}}{EPI \text{ of Standard Building}}$$

where,

Proposed Building is consistent with the actual design of the building, and complies with all the mandatory requirements of ECBC.

Standard Building is a standardized building that has the same building floor area, gross wall area and gross roof area as the Proposed Building, complies with the mandatory requirements §4.2, §5.2, §6.2, and §7.2, and minimally complies with prescriptive requirements of §4.3, §5.3, and §6.3 for ECBC Buildings.

The EPI ratio of the Proposed Building shall be established through any one of the following two methods described in §3.2 –

- ( a) Prescriptive Method (see §3.2.2)
- ( b) Whole Building Performance Method (see §3.2.3)

### **3.1.3 EPI Ratio for Core and Shell Buildings**

EPI for core and shell buildings shall be calculated for the entire building based on the final design of the common areas and the relevant mandatory undertaking(s) in the tenant lease agreement for the leased areas, as per §3.2.2.1 or §3.2.3.1.

### **3.1.4 EPI Ratio for Mixed-use Development**

In a mixed-use building, each commercial part of a building must be classified separately, and EPI Ratio shall be calculated separately for each sub-classification, as per §3.2.2.1 or §3.2.3.1. The EPI Ratio of a mixed-use Proposed Building shall be calculated based on area-weighted average method. To calculate the reference maximum design EPI Ratio, listed in Table 9-5 through Table 9-9, applicable for the mixed-use building, each commercial part of mixed-use building shall be classified separately, and,

- (a) If a part of the mixed-use building has different classification and is less than 10% of the total above grade area (AGA), the EPI Ratio of the mixed-use Proposed Building shall be less than or equal to Maximum Allowed EPI ratio listed in Table 9-5 through Table 9-9 , for the building sub-classification having highest percentage of above grade floor area.
- (b) If a part of the mixed-use building has different classification and is more than 10% of the total above grade floor area, the EPI ratio of the mixed-use Proposed Building shall be less than or equal to Maximum Allowed EPI ratio for compliance calculated based on area weighted average method for all building sub-classifications listed in Table 9-5 through Table 9-9.

Exceptions to the above: Any portion of a mixed-use building classified in a category which does not fall under the scope of ECBC is exempted from demonstrating compliance.

## **3.2 Compliance Approaches**

Buildings that fall within the scope of the Code as mentioned in §2, shall comply with the Code by meeting all the mandatory requirements (see §3.2.1) and any of the compliance paths mentioned in §3.2.2, or §3.2.3.

### **3.2.1 Mandatory Requirements**

Buildings shall comply with all mandatory requirements mentioned under §4.2, §5.2 , §6.2, and §7.2, irrespective of the compliance path.



### 3.2.2 Prescriptive Method

A building complies with the Code using the Prescriptive Method if it meets the prescribed minimum (or maximum) values for envelope components (§4.3), comfort systems and controls (§5.3, §5.3.12, §5.3.13), and lighting and controls (§6.3), in addition to meeting all the mandatory requirements.

#### 3.2.2.1 EPI Ratio through Prescriptive Method

ECBC Buildings that demonstrate compliance through the Prescriptive Method (§3.2.2) shall be deemed to have an EPI equal to the Standard Building EPI, and therefore an EPI Ratio of 1. ECBC+ Buildings and SuperECBC Buildings that demonstrate compliance through the Prescriptive Method shall be deemed to have an EPI Ratio equal to the EPI Ratios listed in §9.5 under the applicable building type and climate zone.

#### 3.2.2.2 Building Envelope Trade-off Method

To comply with the Prescriptive Method of Section §4, the Building Envelope Trade-off Method may be used in place of the prescriptive criteria of §4.3.1, §4.3.2 and §4.3.3. A building complies with the Code using the Building Envelope Trade-off Method if the Envelope Performance Factor (EPF) of the Proposed Building is less than or equal to the EPF of the Standard Building, calculated as per §4.3.5.

#### 3.2.2.3 Total System Efficiency Method

For projects using central chilled water plants, the Total System Efficiency approach may be used to comply with the Prescriptive Method of §5. This approach may be used in place of the prescriptive criteria of chillers (§5.3.1 and §5.3.6), chilled water pumps (§5.3.2), condenser water pumps (§5.3.2), and cooling tower fan (§5.3.3). Per this approach, a building complies if the Total System Efficiency thresholds are met as per Table 5-23 Maximum System Efficiency Threshold for ECBC, ECBC+, and SuperECBC Buildings. Compliance with other prescriptive requirements (§5.3), as applicable, shall be met.

#### 3.2.2.4 Low Energy Comfort Systems

Low Energy Comfort Systems (§5.3.13) is a simplified approach that provides projects using Low Energy Comfort Systems an opportunity to achieve improved compliance levels of ECBC+ and SuperECBC. This approach is applicable to Prescriptive Method of Section §5. In addition to compliance with the applicable prescriptive requirements (§5.3), the projects must meet the sum of cooling and heating requirement using approved list of low energy systems as per requirements in §5.3.13.

### 3.2.3 Whole Building Performance Method

A building complies with the Code using the Whole Building Performance (WBP) Method when the estimated annual energy use of the Proposed Design is less than that of the Standard Design, even though it may not comply with the specific provisions of the prescriptive requirements in §4 through §7. The mandatory requirements of §4 through §7 (§4.2, §5.2, §6.2, and §7.2) shall be met when using the WBP Method.

### 3.2.3.1 EPI Ratio through Whole Building Performance Method

The EPI of buildings that demonstrate compliance through Whole Building Performance Method (§3.2.3) shall be calculated using the compliance path defined in §3.1.1 and detailed in §9. The EPI Ratio of a building that uses the Whole Building Performance Method to show compliance, should be less than or equal to the EPI Ratio listed in §9.5 for the applicable building type and climate zone.

## 3.3 Compliance Requirements

### 3.3.1 New Building Compliance

#### 3.3.1.1 Full building Compliance

New buildings with completed fit-outs shall comply with either the provisions of §3.2.1 and either the provision of §3.2.2 or §3.2.3.

#### 3.3.1.2 Core and Shell building Compliance

New core and shell building shall comply with the provisions of §3.2.1 and either the provision of §3.2.2 or §3.2.3 following base building systems in the common areas:

- (a) Building envelope
- (b) Thermal comfort systems and controls (only those installed by developer/ owner)
- (c) Lighting systems and controls (only those installed by developer/ owner)
- (d) Electrical systems (installed by developer/ owner)
- (e) Renewable energy systems

Additionally, the tenant lease agreement shall have a legal undertaking clause to ensure interior fit-outs made by tenant shall be Code compliant. The legal undertaking shall mandate the relevant energy efficiency compliance requirements in accordance with the provisions of §3.2.1 and §3.2.2 for all interior fit-outs within the tenant leased area.

### 3.3.2 Additions and Alterations to Existing Buildings

If any existing building after additions or alterations changes its connected load to 100 kilo-Watt (kW) or above or a contract demand of 120 kilo-Volt Ampere (kVA) or above shall comply with the provisions of §4 through §7. Compliance may be demonstrated in either of the following ways:

- (a) The addition shall comply with the applicable requirements, or
- (b) The addition, together with the entire existing building, shall comply with the requirements of this Code that shall apply to the entire building, as if it were a new building.

Exceptions to §3.3.2: When space conditioning is provided by existing systems and equipment, the existing systems and equipment need not comply with this code. However, any new equipment installed must comply with specific requirements applicable to that equipment.

### 3.4 Approved Compliance Tools

A building following the whole building performance method of §9 or Total System Efficiency – Alternate compliance approach of §5.3.12 shall show compliance through online BEP-EMIS or whole building energy simulation software endorsed by BEE.

Compliance to the daylight requirements of §4.2.3, if calculated through software tools, shall be shown through online BEP-EMIS or daylighting software approved by BEE.

### 3.5 Administrative Requirements

Administrative requirements, including but not limited to, permit requirements, enforcement, interpretations, claims of exemption, approved calculation methods, and rights of appeal are specified by the authority having jurisdiction.

### 3.6 Compliance Documents

#### 3.6.1 Compliance Documents

Construction drawings and specifications shall show all pertinent data and features of the building, equipment, and systems in sufficient detail to permit the authority having jurisdiction to verify that the building complies with the requirements of this code. Details shall include, but are not limited to:

- (a) Building Envelope: opaque construction materials and their thermal properties including thermal conductivity, specific heat, density along with thickness; fenestration U-factors, solar heat gain coefficients (SHGC), visible light transmittance (VLT) and building envelope sealing documentation; overhangs and side fins, building envelope sealing details;
- (b) Heating, Ventilation, and Air Conditioning: system and equipment types, sizes, efficiencies, and controls; economizers; variable speed drives; piping insulation; duct sealing, insulation and location; solar water heating system; requirement for balance report;
- (c) Lighting: lighting schedule showing type, number, and wattage of lamps and ballasts; automatic lighting shutoff, occupancy sensors, and other lighting controls; lamp efficacy for exterior lamps;
- (d) Electrical Power: electric schedule showing transformer losses, motor efficiencies, and power factor correction devices; electric check metering and monitoring system.
- (e) Renewable energy systems: system peak installed capacity, technical specifications, solar zone area

### 3.6.2 Supplemental Information

The authority having jurisdiction may require supplemental information necessary to verify compliance with this code, such as calculations, worksheets, compliance forms, manufacturer's literature, or other data.

# 4 Building Envelope



## 4. Building Envelope

### 4.1 General

The building envelope shall comply with the mandatory provisions of §4.2, and the prescriptive criteria of §4.3. In case alternative compliance path of Building Envelope Trade-off Method is used for compliance, requirements of §4.3.5 and relevant criteria of §4.3 shall be met.

### 4.2 Mandatory Requirements

#### 4.2.1 Fenestration

##### 4.2.1.1 U-Factor

U-factors shall be determined for the overall fenestration product (including the sash and frame) in accordance with ISO-15099 by an accredited independent laboratory, and labeled or certified by the manufacturer. U-factors for sloped glazing and skylights shall be determined at a slope of 20 degrees above the horizontal. For unrated products, use the default table in Appendix A.

##### 4.2.1.2 Solar Heat Gain Coefficient

SHGC shall be determined for the overall single or multi glazed fenestration product (including the sash and frame) in accordance with ISO-15099 by an accredited independent laboratory, and labeled or certified by the manufacturer.

Exceptions to §4.2.1.2:

- (a) Shading coefficient (SC) of the center of glass alone multiplied by 0.86 is an acceptable alternate for compliance with the SHGC requirements for the overall fenestration area.
- (b) Solar heat gain coefficient (SHGC) of the glass alone is an acceptable alternate for compliance with the SHGC requirements for the overall fenestration product.

##### 4.2.1.3 Visible light transmittance

Visible light transmittance (VLT) shall be determined for the fenestration product in accordance with ISO-15099 by an accredited independent laboratory, and labeled or certified by the manufacturer. For unrated products, VLT of the glass alone shall be de-rate by 10% for demonstrating compliance with the VLT requirements for the overall fenestration product.

## 4.2.2 Opaque Construction

### 4.2.2.1 U-Factor

U-factors shall be calculated for the opaque construction in accordance with ISO-6946. Testing shall be done in accordance with approved ISO Standard for respective insulation type by an accredited independent laboratory, and labeled or certified by the manufacturer. For unrated products, use the default tables in Appendix A.

### 4.2.2.2 Solar Reflectance

Solar reflectance for the external opaque roof construction shall be determined in accordance with ASTM E903-96 by an accredited independent laboratory, and labeled or certified by the manufacturer.

### 4.2.2.3 Emittance

Emittance for the external opaque roof construction shall be determined in accordance with ASTM E408-71 (RA 1996) by an accredited independent laboratory, and labeled or certified by the manufacturer.

## 4.2.3 Daylighting

Above grade floor areas shall meet or exceed the useful daylight illuminance (UDI) area requirements listed in Table 4-1 for 90% of the potential daylit time in a year. For the purpose of daylighting compliance, the above grade floor area may exclude the wall thickness, columns, and, lift and building shafts. Mixed-use buildings shall show compliance as per the criteria prescribed in §2.5. Compliance shall be demonstrated either through daylighting simulation method in §4.2.3.1 or the manual method in §4.2.3.2. Assembly buildings and other buildings where daylighting will interfere with the functions or processes of 50% (or more) of the building floor area, are exempted from meeting the requirements listed in Table 4-1.

Exceptions to §4.2.3:

Assembly buildings and other buildings where daylighting will interfere with the functions or processes of 50% (or more) of the building floor area, are exempted from meeting the requirements listed in Table 4-1.

Table 4-1 Daylight Requirement

| Building Category     | Percentage of above grade floor area meeting the UDI requirement |       |           |
|-----------------------|--|-------|-----------|
|                       | ECBC   | ECBC+ | SuperECBC |
| Business, Educational | 40%  | 50%   | 60%       |
| No Star Hotel         | 30%  | 40%   | 50%       |
| Star Hotel            |  |       |           |
| Healthcare            |  |       |           |
| Resort                | 45%  | 55%   | 65%       |
| Shopping Complex      | 10%  | 15%   | 20%       |
| Assembly              | Exempted   |       |           |

#### 4.2.3.1 Daylighting Simulation Method

Only BEE approved software shall be used to demonstrate compliance through the daylighting simulation method. Buildings shall achieve illuminance level between 100 lux and 2,000 lux for the minimum percentage of floor area prescribed in Table 4-1 for at least 90% of the potential daylight time. Illuminance levels for all spaces enclosed by permanent internal partitions (opaque, translucent, or transparent) with height greater or equal to 2 m from the finished floor, shall be measured as follows:

- (a) Measurements shall be taken at a work plane height of 0.8 m above the finished floor.
- (b) The period of analysis shall be fixed for continuously 8 hours per day, anytime between 7:00 AM IST to 5:00 PM IST, resulting in 2,920 hours in total for all building types except for Schools. Schools shall be analyzed for continuously 7 hours per day, anytime between 7:00 AM IST to 3:00 PM IST.
- (c) Available useful daylight across a space shall be measured based on point-by-point grid values. UDI shall be calculated for at least one point for each square meter of floor area.
- (d) Fenestration shall be modeled with actual visible light transmission (VLT) as per the details provided in the material specification sheet.
- (e) All surrounding natural or man-made daylight obstructions shall be modeled if the distance between the façade of the building (for which compliance is shown) and surrounding natural or man-made daylight obstructions is less than or equal to twice the height of the man-made or natural sunlight obstructions. If the reflectance of the surfaces is not known, default reflectance of 30% and 0% shall be used for all vertical surfaces of man-made and natural obstructions respectively.
- (f) Interior surface reflectance shall be modeled based on the actual material specification. If material specification is not available, the default values in Table 4-2 shall be used:
- (g) Documentation requirement to demonstrate compliance are:
  - i. Brief description of the project with location, number of stories, space types, hours of operation and and software used.
  - ii. Summary describing the results of the analysis and output file from simulation tool outlining point wise compliance for the analysis grid and compliance in percentage.
  - iii. Explanation of any significant modelling assumptions made.



- iv. Explanation of any error messages noted in the simulation program output.
- v. Building floor plans, building elevations & sections, and site plan with surrounding building details (if modeled).
- vi. Material reflectance, analysis grid size, total number of grid size/resolution, total number of grid points.

Table 4-2 Default Values for Surface Reflectance

| Surface Type                       | Reflectance |
|------------------------------------|-------------|
| Wall or Vertical Internal Surfaces | 50%         |
| Ceiling                            | 70%         |
| Floor                              | 20%         |
| Furniture (permanent)              | 50%         |

#### 4.2.3.2 Manual Daylighting Compliance Method

This method can be used for demonstrating compliance with daylighting requirements without simulation. Daylight extent factors (DEF) mentioned in Table 4-3 shall be used for manually calculating percentage of above grade floor area meeting the UDI requirement for 90% of the potential daylit time in a year.

Table 4-3 Daylight Extent Factors (DEF) for Manually Calculating Daylight Area

| Shading                | Latitude      | Window Type                           | VLT < 0.3 |       |      |      | VLT ≥ 0.3 |       |      |      |
|------------------------|---------------|---------------------------------------|-----------|-------|------|------|-----------|-------|------|------|
|                        |               |                                       | North     | South | East | West | North     | South | East | West |
| No shading or PF < 0.4 | ≥ 15°N        | All window types                      | 2.5       | 2.0   | 0.7  | 0.5  | 2.8       | 2.2   | 1.1  | 0.7  |
|                        | < 15°N        |                                       | 2.4       | 2.0   | 0.8  | 0.6  | 2.7       | 2.2   | 1.5  | 0.8  |
| Shading with PF ≥ 0.4  | All latitudes | All window types without light shelf* | 2.8       | 2.3   | 1.5  | 1.1  | 3.0       | 2.5   | 1.8  | 1.5  |
|                        |               | Window with light shelf*              | 3.0       | 2.5   | 1.8  | 1.6  | 3.5       | 3.0   | 2.1  | 1.8  |

\* To qualify as light shelf the internal projection shall meet the requirements specified under Exceptions to SHGC requirements in Table 4-10 and Table 4-11 (b)

(a) To calculate the daylit area:

- i. In a direction perpendicular to the fenestration, multiply daylight extent factor (DEF) by the head height of the fenestration or till an opaque partition higher than head height of the fenestration, whichever is less.

- ii. In the direction parallel to the fenestration, daylit area extends a horizontal dimension equal to the width of the fenestration plus either 1 meter on each side of the aperture, or the distance to an opaque partition of 2 m high, or one-half the distance to an adjacent fenestration, whichever is least.
- iii. For skylights, calculate the horizontal dimension in each direction equal to the top aperture dimension in that direction plus either the floor-to-ceiling height (H) for skylights, or 1.5 H for monitors, or H or 2H for the sawtooth configuration, or the distance to the nearest 1 meter or higher opaque partition, or one-half the distance to an adjacent skylight or vertical glazing, whichever is least.
- iv. Glazed façades, with non-cardinal orientation, shall be categorized under a particular cardinal direction if its orientation is within  $\pm 45$  degrees of that cardinal direction.
- v. Daylit area overlap: For overlapping daylit areas such as windows on different orientations or in case of skylights the overlapping daylit area shall be subtracted from the sum of daylit area.

(b) Documentation requirement:

- i. A separate architectural plan shall be prepared with all daylit areas marked on the floor plans.
- ii. A summary shall be provided showing compliance as per Table 4-1.

#### 4.2.4 Building Envelope Sealing

Following areas of the building envelope, of all except naturally ventilated buildings or spaces, shall be sealed, caulked, gasketed, or weather-stripped:

- (a) Joints around fenestration, skylights, and door frames
- (b) Openings between walls and foundations, and between walls and roof, and wall panels
- (c) Openings at penetrations of utility services through roofs, walls, and floors
- (d) Site-built fenestration and doors
- (e) Building assemblies used as ducts or plenums
- (f) All other openings in the building envelope
- (g) Exhaust fans shall be fitted with a sealing device such as a self-closing damper
- (h) Operable fenestration should be constructed to eliminate air leakages from fenestration frame and shutter frame

**Note 4.1 Daylight Extent Factor and Useful Daylight Illuminance**

Useful Daylight Illuminance (UDI) is defined as the annual occurrence of daylight between 100 lux to 2,000 lux on a work plane. This daylight is most useful to occupants, glare free and when available, eliminates the need for artificial lighting. Daylight extent factor provides a ratio of window sizes to floor area receiving UDI in accordance to window orientation.

**Calculating Useful Daylight Illuminance (UDI)**

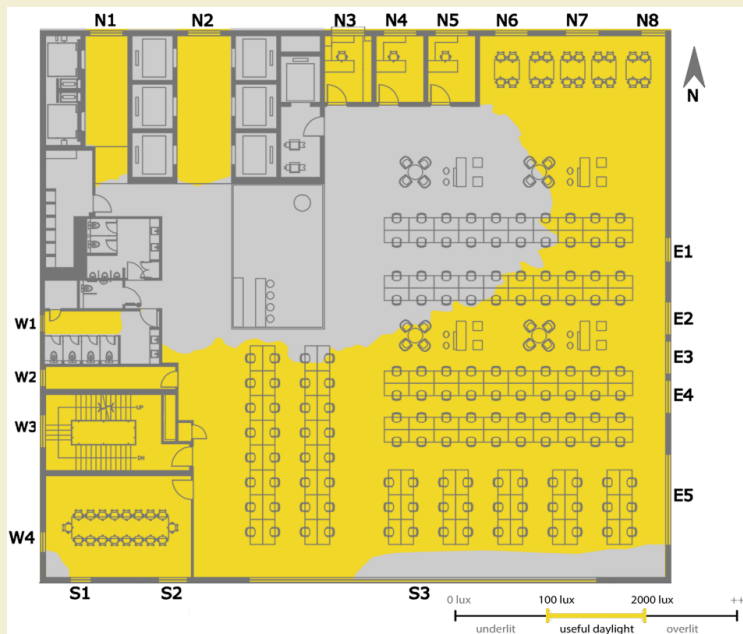
An office building located in New Delhi, India is pursuing ECBC compliance. Table 4-1 lists the minimum daylight area requirements for compliance. The table specifies that for office buildings, minimum 40% of its floor area shall receive daylight in range of 100 – 2,000 lux for at least 90% of the year.

This typical floor has a rectangular layout (33 m x 38 m) of 1,254 m<sup>2</sup>. Visible light transmission (VLT) of glazing in all orientations is 0.39. Windows have light shelves and external shading devices with Projection Factor (PF) ≥ 0.4. Head height of fenestrations is 3.0 m.

For compliance at least 502 m<sup>2</sup> (40% of 1,254 m<sup>2</sup>) of floor area shall fulfil the UDI requirements. Daylit area should be indicated in floor plans submitted to code enforcement authorities. Design guidelines on daylighting stated in NBC (Part 8: Building Services, Section 1: Lighting and Natural Ventilation, Subsection 4.2: Daylighting) should also be referred to achieve the ECBC, ECBC+, or Super ECBC requirement. Compliance with 4.2.3 Daylight Requirements can be checked for through two approaches.

**(a) Analysis through software**

If the whole building performance approach is used, compliance for daylighting requirements can be checked by analysing the façade and floor plate design in an analytical software approved by BEE (3.4). The image below, developed through an approved software, specifies the lux levels and time-period of a year during which lighting levels would be available. With this information, designers can check if the required minimum area as per 4.2.3 has the required daylight levels



*UDI Analysis with a Daylighting Analysis Software*

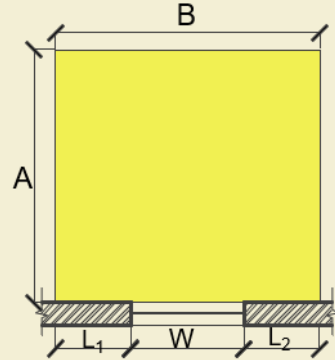
**(b) Manual calculation method**

For projects adopting the prescriptive compliance approach, manual calculation method can be used for UDI compliance.

1. From Table 4.3 determine the daylight extent factor (**DEF**) for each orientation. For a building located in Delhi (latitude > 15 degrees), with glazing of VLT  $\geq 0.39$ , shading PF  $\geq 0.4$  and light shelves in windows, DEFs for windows in North = 3.5, in South = 3.0, in East = 2.1, and in West = 1.8. Head height is 3.0 m.
2. For fenestration clear of any opaque obstructions calculate daylit floor area (**AxB**).

**A:**In the direction perpendicular to the fenestration, daylit area extends to head height of the fenestration multiplied by the daylight extent factor (DEF) or distance till an opaque partition higher than head height of the fenestration, whichever is less.

**B:**In the direction parallel to the fenestration daylit area extends a horizontal dimension equal to the width of the fenestration plus either one meter on each side of the aperture or the distance to an opaque partition, or one-half the distance to an adjacent fenestration, whichever is least.



3. For overlapping daylit areas such as corner windows. Subtract the overlapping daylit area from the sum of daylit area.



UDI Analysis with manual calculations

As per the calculations **616.5 m<sup>2</sup>** of floor area will meet the UDI requirements during 90% of the year. This is **49.2 %** of the total above grade floor area of 1,254 m<sup>2</sup>. Thus, the building floor will comply with UDI requirement. Following Tables shows calculated Daylight Area Meeting UDI Requirement.

Table 4-1-1 Manual calculation for Daylight Area Meeting UDI Requirement

| Orientation-NORTH, DEF-3.5, Fenestration Head Height H - 3m |                          |   |   |   |
|---|--------------------------|---|---|---|
| Window without opaque obstructions                          | Fenestration Width W (m) | A= H x DEF (m)                            | B= L <sub>1</sub> +W+ L <sub>2</sub> (m)<br>L <sub>1</sub> = L <sub>2</sub> =1m                                     | Area meeting the UDI requirements = AxB (m <sup>2</sup> ) |
| N7  | 2.0                      | 10.5                                      | 4.0   | 42.0  |
| N6  | 2.0                      | 10.5                                      | 4.0   | 42.0  |
| N2  | 2.0                      | 10.5                                      | 4.0   | 42.0  |
| Window with opaque obstructions                             | Fenestration Width W (m) | A= Distance till parallel Obstruction (m) | B= L <sub>1</sub> +W+ L <sub>2</sub> (m)<br>L <sub>1</sub> = L <sub>2</sub> =Distance to perpendicular Obstructions | Area meeting the UDI requirements = AxB (m <sup>2</sup> ) |
| N1  | 2.0                      | 10.5                                      | 0.3+2+0.3=2.6   | 27.3  |
| N3  | 2.0                      | 4.0                                       | 0.4+2+0.4=2.8   | 11.2  |
| N4  | 2.0                      | 4.0                                       | 0.4+2+0.4=2.8   | 11.2  |
| N5  | 2.0                      | 4.0                                       | 0.4+2+0.4=2.8   | 11.2  |
| N8  | 1.5                      | 10.5                                      | 0+1.5+1.0=2.5   | 26.3  |
| Daylit area meeting UDI requirement                         |                          |   |   | <b>213.2</b>  |
| Orientation-SOUTH, DEF-3, Fenestration Head Height H - 3m   |                          |   |   |   |
| Window without opaque obstructions                          | Fenestration Width W (m) | A= H x DEF (m)                            | B= L <sub>1</sub> +W+ L <sub>2</sub> (m)<br>L <sub>1</sub> = L <sub>2</sub> =1m                                     | Area meeting the UDI requirements = AxB (m <sup>2</sup> ) |
| S1  | 1.2                      | 6.2                                       | 1.0+1.2+1.0=3.3   | 20.1  |
| S2  | 1.7                      | 6.2                                       | 1.0+1.7+0.3=3.0   | 18.6  |
| S3  | 21.0                     | 9.0                                       | 1.0+21.0+1.0=24   | 216.0   |
| Daylit area meeting UDI requirement                         |                          |   |   | <b>254.7</b>  |

| Orientation-EAST, DEF-2.1, Fenestration Head Height H - 3m |                          |                                |  |   |
|--|--------------------------|--------------------------------|--|---|
| Window without opaque obstructions                         | Fenestration Width W (m) | $A = H \times DEF \text{ (m)}$ | $B = L_1 + W + L_2 \text{ (m)}$<br>$L_1 = L_2 = 1m$  | Area meeting the UDI requirements = $A \times B \text{ (m}^2\text{)}$ |
| E1   | 1.5                      | 6.3                            | $1.0 + 1.5 + 1.0 = 3.5$  | 22.1  |
| E5   | 5.5                      | 6.3                            | $1.0 + 5.5 + 1.0 = 7.5$  | 47.3  |
| Adjacent fenestration less than two meter apart            | Fenestration Width W (m) | $A = H \times DEF \text{ (m)}$ | $B = L_1 + W + L_2 \text{ (m)}$<br>$L_1, L_2 = \text{one half of distance to adjacent fenestration}$ | Area meeting the UDI requirements = $A \times B \text{ (m}^2\text{)}$ |
| E2   | 2                        | 6.3                            | $1.0 + 2.0 + 0.2 = 3.2$  | 20.2  |
| E3   | 2                        | 6.3                            | $0.2 + 2 + 0.2 = 2.4$  | 15.1  |
| E4   | 2                        | 6.3                            | $0.2 + 2 + 1 = 3.2$  | 20.2  |
| Daylit area meeting UDI requirement                        |                          |                                |  | <b>124.9</b>  |
| Orientation-WEST, DEF-1.8, Fenestration Head Height H - 3m |                          |                                |  |   |
| Window without opaque obstructions                         | Fenestration Width W (m) | $A = H \times DEF \text{ (m)}$ | $B = L_1 + W + L_2 \text{ (m)}$<br>$L_1 = L_2 = 1m$  | Area meeting the UDI requirements = $A \times B \text{ (m}^2\text{)}$ |
| W3   | 2.0                      | 5.4                            | $1.0 + 2.0 + 1.0 = 4.0$  | 21.6  |
| W4   | 1.4                      | 5.4                            | $1.0 + 1.2 + 1.0 = 3.2$  | 17.3  |
| Window with opaque obstructions in daylit area             | Fenestration Width W (m) | $A = H \times DEF \text{ (m)}$ | $B = L_1 + W + L_2 \text{ (m)}$<br>$L_1 = L_2 = \text{Distance to perpendicular Obstructions}$       | Area meeting the UDI requirements = $A \times B \text{ (m}^2\text{)}$ |
| W1   | 1.0                      | 5.4                            | $0.3 + 1 + 0.3 = 1.6$  | 8.6   |
| W2   | 1.0                      | 5.4                            | $0.3 + 1 + 0.3 = 1.6$  | 8.6   |
| Daylit area meeting UDI requirement                        |                          |                                |  | <b>56.1</b>   |

|  |                  |           |           |
|--|------------------|-----------|-----------|
|  |                  |           |           |
| Overlapping area calculations  |                  |           |           |
| Window with overlap areas  | Width (m)        | Depth (m) | Area (m²) |
| N4 and S1  | 3.3              | 3.3       | 10.9      |
| S3 and E5  | 3.3              | 6.5       | 21.5      |
| Overlapping daylight area (b)  |                  |           | 32.4      |
|  |                  |           |           |
| Total Daylit area  |                  |           |           |
| ORIENTATION  | Daylit area (m²) |           |           |
| NORTH  | 213.2            |           |           |
| SOUTH  | 254.7            |           |           |
| EAST   | 124.9            |           |           |
| WEST   | 56.1             |           |           |
| Total daylight area (a)  | 648.9            |           |           |
| Total Overlapping daylit area (b)                                      | 32.4             |           |           |
| Total daylit area meeting UDI requirement during 90% of the year (a-b) | 616.5            |           |           |
|  |                  |           |           |

## 4.3 Prescriptive Requirements

### 4.3.1 Roof

Roofs shall comply with the maximum assembly U-factors in Table 4-4 through Table 4-6. The roof insulation shall be applied externally as part of the roof assembly and not as a part of false ceiling.

Table 4-4 Roof Assembly U-factor ( $W/m^2.K$ ) Requirements for ECBC Compliant Building

|   | Composite | Hot and dry | Warm and humid | Temperate | Cold |
|---|-----------|-------------|----------------|-----------|------|
| All building types, except below        | 0.33      | 0.33        | 0.33           | 0.33      | 0.28 |
| School <10,000 m <sup>2</sup> AGA       | 0.47      | 0.47        | 0.47           | 0.47      | 0.33 |
| Hospitality > 10,000 m <sup>2</sup> AGA | 0.20      | 0.20        | 0.20           | 0.20      | 0.20 |

Table 4-5 Roof Assembly U-factor ( $W/m^2.K$ ) Requirements for ECBC+ Compliant Building

|                                       | Composite | Hot and dry | Warm and humid | Temperate | Cold |
|---------------------------------------|-----------|-------------|----------------|-----------|------|
| Hospitality, Healthcare Assembly      | 0.20      | 0.20        | 0.20           | 0.20      | 0.20 |
| Business Educational Shopping Complex | 0.26      | 0.26        | 0.26           | 0.26      | 0.20 |

Table 4-6 Roof Assembly U-factor ( $W/m^2.K$ ) Requirements for SuperECBC Building

|                     | Composite | Hot and dry | Warm and humid | Temperate | Cold |
|---------------------|-----------|-------------|----------------|-----------|------|
| All buildings types | 0.20      | 0.20        | 0.20           | 0.20      | 0.20 |

#### 4.3.1.1 Vegetated and Cool Roof

All roofs that are not covered by solar photovoltaics, or solar hot water, or any other renewable energy system, or utilities and services that render it unsuitable for the purpose, shall be either cool roofs or vegetated roofs.

- For qualifying as a cool roof, roofs with slopes less than 20° shall have an initial solar reflectance of no less than 0.70 and an initial emittance no less than 0.75. Solar reflectance shall be determined in accordance with ASTM E903-96 and emittance shall be determined in accordance with ASTM E408-71 (RA 1996).
- For qualifying as a vegetated roof, roof areas shall be covered by living vegetation of >50 mm high.



### 4.3.2 Opaque External Wall

Opaque above grade external walls shall comply with the maximum assembly U-factors in Table 4-7 through Table 4-9.

Table 4-7 Opaque Assembly Maximum U-factor ( $W/m^2.K$ ) Requirements for a ECBC compliant Building

|   | Composite | Hot and dry | Warm and humid | Temperate | Cold |
|---|-----------|-------------|----------------|-----------|------|
| All building types, except below          | 0.40      | 0.40        | 0.40           | 0.55      | 0.34 |
| No Star Hotel < 10,000 m <sup>2</sup> AGA | 0.63      | 0.63        | 0.63           | 0.63      | 0.40 |
| Business < 10,000 m <sup>2</sup> AGA      | 0.63      | 0.63        | 0.63           | 0.63      | 0.40 |
| School <10,000 m <sup>2</sup> AGA         | 0.85      | 0.85        | 0.85           | 1.00      | 0.40 |

Table 4-8 Opaque Assembly Maximum U-factor ( $W/m^2.K$ ) Requirements for ECBC+ Compliant Building

|   | Composite | Hot and dry | Warm and humid | Temperate | Cold |
|---|-----------|-------------|----------------|-----------|------|
| All building types, except below          | 0.34      | 0.34        | 0.34           | 0.55      | 0.22 |
| No Star Hotel < 10,000 m <sup>2</sup> AGA | 0.44      | 0.44        | 0.44           | 0.44      | 0.34 |
| Business < 10,000 m <sup>2</sup> AGA      | 0.44      | 0.44        | 0.44           | 0.55      | 0.34 |
| School <10,000 m <sup>2</sup> AGA         | 0.63      | 0.63        | 0.63           | 0.75      | 0.44 |

Table 4-9 Opaque Assembly Maximum U-factor ( $W/m^2.K$ ) Requirements for SuperECBC Building

|                    | Composite | Hot and dry | Warm and humid | Temperate | Cold |
|--------------------|-----------|-------------|----------------|-----------|------|
| All building types | 0.22      | 0.22        | 0.22           | 0.22      | 0.22 |

Exceptions to §4.3.2: Opaque external walls of an unconditioned building of No Star Hotel, Healthcare, and School categories in all climatic zones, except for cold climatic zone, shall have a maximum assembly U-factor of 0.8  $W/m^2.K$ .

### 4.3.3 Vertical Fenestration

For all climatic zones, vertical fenestration compliance requirements for all three energy efficiency levels, i.e. ECBC, ECBC+, and SuperECBC, shall comply with the following:

- Maximum allowable Window Wall Ratio (WWR) is 40% (applicable to buildings showing compliance using the Prescriptive Method, including Building Envelope Trade-off Method)
- Minimum allowable Visible light transmittance (VLT) is 0.27

- (c) Assembly U-factor shall be determined for the overall fenestration product (including the sash and frame)

Vertical fenestration shall comply with the maximum Solar Heat Gain Coefficient (SHGC) and U-factor requirements of Table 4-10 for ECBC buildings and Table 4-11 for ECBC+ buildings and SuperECBC buildings. Vertical fenestration on non-cardinal direction, shall be categorized under a particular cardinal direction if its orientation is within  $\pm 45^\circ$  of that cardinal direction.

*Table 4-10 Vertical Fenestration Assembly U-factor and SHGC Requirements for ECBC Buildings*

|  | <i>Composite</i> | <i>Hot and dry</i> | <i>Warm and humid</i> | <i>Temperate</i> | <i>Cold</i> |
|--|------------------|--------------------|-----------------------|------------------|-------------|
| Maximum U-factor (W/m <sup>2</sup> .K)                     | 3.00             | 3.00               | 3.00                  | 3.00             | 3.00        |
| Maximum SHGC Non-North                                     | 0.27             | 0.27               | 0.27                  | 0.27             | 0.62        |
| Maximum SHGC North for latitude $\geq 15^\circ\text{N}$    | 0.50             | 0.50               | 0.50                  | 0.50             | 0.62        |
| Maximum SHGC North for latitude $< 15^\circ\text{N}$       | 0.27             | 0.27               | 0.27                  | 0.27             | 0.62        |
| See Appendix A for default values of unrated fenestration. |                  |                    |                       |                  |             |

*Table 4-11 Vertical Fenestration U-factor and SHGC Requirements for ECBC+ buildings and SuperECBC buildings*

|   | <i>Composite</i> | <i>Hot and dry</i> | <i>Warm and humid</i> | <i>Temperate</i> | <i>Cold</i> |
|---|------------------|--------------------|-----------------------|------------------|-------------|
| Maximum U-factor (W/m <sup>2</sup> .K)                  | 2.20             | 2.20               | 2.20                  | 3.00             | 1.80        |
| Maximum SHGC Non-North                                  | 0.25             | 0.25               | 0.25                  | 0.25             | 0.62        |
| Maximum SHGC North for latitude $\geq 15^\circ\text{N}$ | 0.50             | 0.50               | 0.50                  | 0.50             | 0.62        |
| Maximum SHGC North for latitude $< 15^\circ\text{N}$    | 0.25             | 0.25               | 0.25                  | 0.25             | 0.62        |

Exceptions to SHGC requirements in Table 4-10 and Table 4-11:

- (a) For fenestration with a permanent external projection, including but not limited to overhangs, side fins, box frame, verandah, balcony, and fixed canopies that provide permanent shading to the fenestration, the equivalent SHGC for the proposed shaded fenestration may be determined as less than or equal to the SHGC requirements of Table 4-10 and Table 4-11. Equivalent SHGC shall be calculated by following the steps listed below:
- i. Projection factor (PF) for the external permanent projection, shall be calculated as per the applicable shading type listed in §8.2. The projection factor for using the SEF is  $PF \geq 0.25$ . The SEF is applicable for both side fins shading only other than overhangs. The projection factor shall be calculated for both side fins and the lower projection factor of each fin shall be considered. Other shading devices shall be modeled through the Whole Building Performance Method in §9.
  - ii. A shaded vertical fenestration on a non-cardinal direction, shall be categorized either under a particular cardinal direction or a primary inter-cardinal direction if its orientation is within the range of  $\pm 22.5$  degrees of the cardinal or primary inter-cardinal direction.
  - iii. Any surrounding man-made or natural sunlight obstructions shall be considered as a permanent shading of PF equal to 0.4 if
    - a. the distance between the vertical fenestration of the building, for which compliance is shown, and surrounding man-made or natural sunlight obstructions is less than or equal to twice the height of the surrounding man-made or natural sunlight obstructions; and
    - b. the surrounding man-made or natural sunlight obstructions shade the façade for at least 80% of the total time that the façade is exposed to direct sun light on a summer solstice. Compliance shall be shown using a sun path analysis for summer solstice for the vertical fenestration.
  - iv. An equivalent SHGC is calculated by dividing the SHGC of the unshaded fenestration product with a Shading Equivalent Factor (SEF). SEF shall be determined for each orientation and shading device type from Table 4-10 and Table 4-11.
  - v. The maximum allowable SHGC is calculated by multiplying the prescriptive SHGC requirement for respective compliance level from Table 4-10 and Table 4-11 with the SEF.

Table 4-12 Shading Equivalent Factors for Latitudes greater than or equal to 15°N

| Shading Equivalent Factors (SEF) for latitudes greater than or equal to 15°N |      |       |      |       |      |            |            |            |            |
|--|------|-------|------|-------|------|------------|------------|------------|------------|
| SEF  | PF   | North | East | South | West | North-East | South-East | South-West | North-West |
| Overhang + Fins  | 0.25 | 1.25  | 1.37 | 1.58  | 1.36 | 1.47       | 1.47       | 1.42       | 1.53       |
|  | 0.3  | 1.29  | 1.48 | 1.72  | 1.43 | 1.54       | 1.65       | 1.57       | 1.58       |
|  | 0.35 | 1.34  | 1.58 | 1.88  | 1.51 | 1.62       | 1.81       | 1.73       | 1.65       |
|  | 0.4  | 1.39  | 1.67 | 2.06  | 1.61 | 1.70       | 1.97       | 1.89       | 1.75       |
|  | 0.45 | 1.43  | 1.76 | 2.26  | 1.71 | 1.78       | 2.11       | 2.06       | 1.87       |
|  | 0.5  | 1.47  | 1.85 | 2.47  | 1.83 | 1.86       | 2.25       | 2.23       | 2.00       |
|  | 0.55 | 1.51  | 1.94 | 2.69  | 1.96 | 1.94       | 2.38       | 2.40       | 2.13       |
|  | 0.6  | 1.55  | 2.03 | 2.92  | 2.09 | 2.02       | 2.51       | 2.58       | 2.27       |
|  | 0.65 | 1.59  | 2.13 | 3.15  | 2.24 | 2.10       | 2.64       | 2.76       | 2.40       |
|  | 0.7  | 1.63  | 2.24 | 3.18  | 2.39 | 2.18       | 2.77       | 2.94       | 2.53       |
|  | 0.75 | 1.66  | 2.37 | 3.19  | 2.56 | 2.25       | 2.90       | 3.12       | 2.64       |
|  | 0.8  | 1.70  | 2.52 | 3.20  | 2.72 | 2.33       | 3.04       | 3.18       | 2.73       |
|  | 0.85 | 1.73  | 2.69 | 3.21  | 2.90 | 2.40       | 3.11       | 3.23       | 2.80       |
|  | 0.9  | 1.76  | 2.89 | 3.24  | 3.07 | 2.46       | 3.15       | 3.25       | 2.84       |
|  | 0.95 | 1.79  | 3.11 | 3.28  | 3.25 | 2.52       | 3.17       | 3.27       | 2.85       |
|  | ≥1   | 1.80  | 3.30 | 3.33  | 3.33 | 2.57       | 3.23       | 3.30       | 2.82       |
| Overhang   | 0.25 | 1.09  | 1.21 | 1.28  | 1.20 | 1.17       | 1.26       | 1.23       | 1.20       |
|  | 0.3  | 1.11  | 1.26 | 1.34  | 1.27 | 1.22       | 1.32       | 1.27       | 1.24       |
|  | 0.35 | 1.13  | 1.30 | 1.39  | 1.33 | 1.26       | 1.39       | 1.32       | 1.28       |
|  | 0.4  | 1.15  | 1.35 | 1.46  | 1.38 | 1.30       | 1.46       | 1.38       | 1.32       |
|  | 0.45 | 1.16  | 1.40 | 1.52  | 1.43 | 1.33       | 1.53       | 1.46       | 1.36       |
|  | 0.5  | 1.18  | 1.45 | 1.59  | 1.48 | 1.35       | 1.60       | 1.54       | 1.40       |
|  | 0.55 | 1.20  | 1.51 | 1.66  | 1.52 | 1.38       | 1.67       | 1.62       | 1.44       |
|  | 0.6  | 1.21  | 1.56 | 1.73  | 1.57 | 1.40       | 1.74       | 1.70       | 1.47       |
|  | 0.65 | 1.22  | 1.62 | 1.81  | 1.61 | 1.42       | 1.81       | 1.79       | 1.51       |
|  | 0.7  | 1.24  | 1.68 | 1.88  | 1.66 | 1.45       | 1.88       | 1.87       | 1.55       |
|  | 0.75 | 1.25  | 1.74 | 1.95  | 1.72 | 1.48       | 1.94       | 1.94       | 1.58       |
|  | 0.8  | 1.26  | 1.80 | 2.02  | 1.77 | 1.51       | 2.00       | 2.01       | 1.61       |
|  | 0.85 | 1.27  | 1.86 | 2.09  | 1.84 | 1.56       | 2.06       | 2.06       | 1.64       |
|  | 0.9  | 1.28  | 1.92 | 2.15  | 1.91 | 1.61       | 2.11       | 2.10       | 1.67       |
|  | 0.95 | 1.29  | 1.99 | 2.21  | 1.98 | 1.67       | 2.15       | 2.13       | 1.70       |
|  | ≥1   | 1.30  | 2.06 | 2.26  | 2.07 | 1.75       | 2.19       | 2.14       | 1.72       |
| Side Fins  | 0.25 | 1.13  | 1.11 | 1.18  | 1.11 | 1.21       | 1.14       | 1.16       | 1.23       |
|  | 0.3  | 1.15  | 1.13 | 1.22  | 1.13 | 1.22       | 1.17       | 1.22       | 1.27       |
|  | 0.35 | 1.17  | 1.15 | 1.26  | 1.15 | 1.24       | 1.20       | 1.26       | 1.32       |
|  | 0.4  | 1.19  | 1.17 | 1.29  | 1.17 | 1.27       | 1.23       | 1.29       | 1.36       |
|  | 0.45 | 1.21  | 1.19 | 1.32  | 1.19 | 1.30       | 1.25       | 1.31       | 1.41       |
|  | 0.5  | 1.22  | 1.20 | 1.35  | 1.20 | 1.34       | 1.27       | 1.33       | 1.46       |
|  | 0.55 | 1.24  | 1.22 | 1.38  | 1.22 | 1.38       | 1.29       | 1.34       | 1.50       |
|  | 0.6  | 1.25  | 1.23 | 1.40  | 1.23 | 1.42       | 1.31       | 1.35       | 1.55       |

|  |      |      |      |      |      |      |      |      |      |
|--|------|------|------|------|------|------|------|------|------|
|  | 0.65 | 1.27 | 1.24 | 1.42 | 1.25 | 1.47 | 1.32 | 1.36 | 1.58 |
|  | 0.7  | 1.28 | 1.26 | 1.44 | 1.26 | 1.51 | 1.34 | 1.36 | 1.61 |
|  | 0.75 | 1.30 | 1.27 | 1.46 | 1.27 | 1.55 | 1.35 | 1.37 | 1.64 |
|  | 0.8  | 1.31 | 1.28 | 1.48 | 1.29 | 1.59 | 1.37 | 1.38 | 1.65 |
|  | 0.85 | 1.32 | 1.30 | 1.49 | 1.30 | 1.62 | 1.38 | 1.39 | 1.65 |
|  | 0.9  | 1.34 | 1.31 | 1.51 | 1.31 | 1.65 | 1.40 | 1.40 | 1.64 |
|  | 0.95 | 1.35 | 1.32 | 1.53 | 1.32 | 1.67 | 1.42 | 1.42 | 1.61 |
|  | ≥1   | 1.36 | 1.33 | 1.55 | 1.33 | 1.69 | 1.44 | 1.45 | 1.57 |

Table 4-13 Shading Equivalent Factors for Latitudes less than 15 °N

| Shading Equivalent Factors (SEF) for latitudes less than 15°N |      |       |      |       |      |            |            |            |            |
|---|------|-------|------|-------|------|------------|------------|------------|------------|
| SEF   | PF   | North | East | South | West | North-East | South-East | South-West | North-West |
| Overhang + Fins   | 0.25 | 1.38  | 1.33 | 1.30  | 1.34 | 1.42       | 1.41       | 1.37       | 1.42       |
|   | 0.3  | 1.44  | 1.42 | 1.35  | 1.42 | 1.49       | 1.46       | 1.41       | 1.52       |
|   | 0.35 | 1.50  | 1.50 | 1.42  | 1.50 | 1.57       | 1.52       | 1.47       | 1.63       |
|   | 0.4  | 1.56  | 1.59 | 1.50  | 1.59 | 1.66       | 1.59       | 1.54       | 1.73       |
|   | 0.45 | 1.61  | 1.67 | 1.59  | 1.69 | 1.76       | 1.67       | 1.61       | 1.84       |
|   | 0.5  | 1.67  | 1.76 | 1.68  | 1.80 | 1.87       | 1.75       | 1.70       | 1.94       |
|   | 0.55 | 1.72  | 1.85 | 1.79  | 1.90 | 1.98       | 1.85       | 1.80       | 2.05       |
|   | 0.6  | 1.77  | 1.94 | 1.89  | 2.02 | 2.09       | 1.94       | 1.89       | 2.15       |
|   | 0.65 | 1.82  | 2.02 | 1.99  | 2.13 | 2.20       | 2.04       | 2.00       | 2.25       |
|   | 0.7  | 1.86  | 2.11 | 2.08  | 2.24 | 2.31       | 2.15       | 2.10       | 2.36       |
|   | 0.75 | 1.90  | 2.19 | 2.17  | 2.35 | 2.42       | 2.25       | 2.21       | 2.46       |
|   | 0.8  | 1.94  | 2.28 | 2.25  | 2.46 | 2.53       | 2.35       | 2.31       | 2.55       |
|   | 0.85 | 1.98  | 2.36 | 2.31  | 2.56 | 2.64       | 2.45       | 2.42       | 2.65       |
|   | 0.9  | 2.02  | 2.44 | 2.35  | 2.66 | 2.74       | 2.54       | 2.52       | 2.74       |
|   | 0.95 | 2.05  | 2.51 | 2.38  | 2.75 | 2.84       | 2.63       | 2.61       | 2.83       |
|   | ≥1   | 2.08  | 2.58 | 2.38  | 2.83 | 2.93       | 2.71       | 2.70       | 2.91       |
| Overhang  | 0.25 | 1.15  | 1.19 | 1.09  | 1.20 | 1.17       | 1.08       | 1.04       | 1.18       |
|   | 0.3  | 1.17  | 1.23 | 1.07  | 1.24 | 1.22       | 1.12       | 1.08       | 1.21       |
|   | 0.35 | 1.20  | 1.28 | 1.07  | 1.29 | 1.26       | 1.16       | 1.12       | 1.25       |
|   | 0.4  | 1.22  | 1.32 | 1.07  | 1.33 | 1.30       | 1.19       | 1.17       | 1.29       |
|   | 0.45 | 1.24  | 1.37 | 1.09  | 1.38 | 1.33       | 1.23       | 1.21       | 1.32       |
|   | 0.5  | 1.26  | 1.42 | 1.12  | 1.42 | 1.37       | 1.28       | 1.25       | 1.35       |
|   | 0.55 | 1.28  | 1.46 | 1.15  | 1.46 | 1.40       | 1.32       | 1.29       | 1.39       |
|   | 0.6  | 1.30  | 1.51 | 1.18  | 1.50 | 1.43       | 1.36       | 1.33       | 1.42       |
|   | 0.65 | 1.32  | 1.55 | 1.22  | 1.55 | 1.46       | 1.40       | 1.37       | 1.45       |
|   | 0.7  | 1.33  | 1.60 | 1.26  | 1.59 | 1.48       | 1.43       | 1.40       | 1.48       |
|   | 0.75 | 1.35  | 1.64 | 1.29  | 1.62 | 1.51       | 1.47       | 1.44       | 1.50       |
|   | 0.8  | 1.37  | 1.67 | 1.32  | 1.66 | 1.53       | 1.51       | 1.47       | 1.53       |
|   | 0.85 | 1.38  | 1.71 | 1.35  | 1.70 | 1.55       | 1.54       | 1.51       | 1.56       |
|   | 0.9  | 1.39  | 1.74 | 1.37  | 1.73 | 1.57       | 1.56       | 1.54       | 1.58       |

|           |      |      |      |      |      |      |      |      |      |
|-----------|------|------|------|------|------|------|------|------|------|
|           | 0.95 | 1.40 | 1.77 | 1.38 | 1.77 | 1.59 | 1.59 | 1.56 | 1.61 |
|           | ≥1   | 1.41 | 1.79 | 1.38 | 1.80 | 1.61 | 1.61 | 1.59 | 1.63 |
| Side Fins | 0.25 | 1.17 | 1.10 | 1.06 | 1.10 | 1.15 | 1.14 | 1.16 | 1.16 |
|           | 0.3  | 1.20 | 1.12 | 1.11 | 1.12 | 1.18 | 1.18 | 1.21 | 1.19 |
|           | 0.35 | 1.23 | 1.13 | 1.16 | 1.14 | 1.21 | 1.20 | 1.25 | 1.22 |
|           | 0.4  | 1.26 | 1.15 | 1.20 | 1.15 | 1.24 | 1.23 | 1.29 | 1.25 |
|           | 0.45 | 1.28 | 1.16 | 1.23 | 1.17 | 1.27 | 1.25 | 1.31 | 1.28 |
|           | 0.5  | 1.30 | 1.18 | 1.25 | 1.19 | 1.30 | 1.27 | 1.34 | 1.30 |
|           | 0.55 | 1.32 | 1.19 | 1.27 | 1.20 | 1.33 | 1.29 | 1.36 | 1.33 |
|           | 0.6  | 1.34 | 1.20 | 1.29 | 1.22 | 1.36 | 1.31 | 1.37 | 1.35 |
|           | 0.65 | 1.36 | 1.21 | 1.30 | 1.23 | 1.38 | 1.34 | 1.38 | 1.38 |
|           | 0.7  | 1.38 | 1.22 | 1.31 | 1.24 | 1.41 | 1.36 | 1.40 | 1.40 |
|           | 0.75 | 1.40 | 1.23 | 1.33 | 1.26 | 1.43 | 1.38 | 1.41 | 1.42 |
|           | 0.8  | 1.42 | 1.24 | 1.34 | 1.27 | 1.46 | 1.41 | 1.43 | 1.44 |
|           | 0.85 | 1.43 | 1.25 | 1.35 | 1.28 | 1.48 | 1.44 | 1.45 | 1.47 |
|           | 0.9  | 1.45 | 1.26 | 1.37 | 1.29 | 1.50 | 1.47 | 1.47 | 1.49 |
|           | 0.95 | 1.46 | 1.27 | 1.39 | 1.31 | 1.52 | 1.50 | 1.50 | 1.51 |
|           | ≥1   | 1.47 | 1.28 | 1.42 | 1.32 | 1.53 | 1.54 | 1.53 | 1.53 |

(b) Vertical fenestration, located such that its bottom is more than 2.2 m above the level of the floor, is exempt from the SHGC requirements in Table 4-10 and Table 4-11, if the following conditions are complied with:

- i. The Total Effective Aperture (WWR X VLT) for the elevation is less than 0.25, including all fenestration areas more than 1.0 meter above the floor level; and,
- ii. An interior light shelf is provided at the bottom of this fenestration area, with a projection factor on interior side not less than:
  - a. 1.0 for E-W, SE, SW, NE, and NW orientations
  - b. 0.50 for S orientation, and
  - c. 0.35 for N orientation when latitude is less than 15°N.

### Note 4-1 Equivalent SHGC and Projection Factor



A 5,400 m<sup>2</sup> two story office building in Delhi is trying to achieve ECBC level compliance. It has a rectangular layout (90 m x 30 m) with floor to floor height of 4.0 m and floor area is evenly distributed over the two floors. Windows are either east or west facing and equally distributed on the two floors. The windows are all 1.9m in length and 2.9m in height with an overhang of 0.9m, sill level is 0.9m above floor level. The overall glazing area is 374.7 m<sup>2</sup>. SHGC of the glazing in the East/West Fenestration is 0.3; area

weighted U-Factor is 3.0 W/m<sup>2</sup>.K. VLT of the glazing in all orientation is 0.5. Will the vertical fenestration comply with the ECBC through prescriptive approach?

**Solution:**

Table 4-10 and §4.3.3 lists the U-factor, SHGC and VLT requirements for vertical fenestration for ECBC compliant buildings. The building is located in Delhi (Latitude: 28°70' N, Longitude: 77°10' E), which falls under the composite climate, as per Appendix B, Table 12.1. To fulfil prescriptive requirements, Window to Wall ratio ≤ 40%, SHGC ≤ 0.27, U-factor ≤ 3.0 W/m<sup>2</sup>.K, and VLT ≥ 0.27.

Total Floor area = 5400 m<sup>2</sup>

Total wall area = 2 x (2x ((90m x 4m) + (30m x 4m))) = 1,920 m<sup>2</sup>

Total Fenestration area = 374.7 m<sup>2</sup>

Window to Wall Ratio (WWR) = 374.7/1,920 = 19.5%

As per the calculations, the building has a WWR of 19.5%, thus complying with the requirement for WWR. The U-factor is also equal to 3.0 W/m<sup>2</sup>.K. Similarly, the VLT is 0.5, which is greater than the minimum specified value of 0.27, thus complying with the U-factor and VLT requirement.

#### Equivalent SHGC Calculation

The window SHGC is 0.3 which is not meet the prescriptive requirement of Table 4-10. However, the windows have an overhang of 0.9m. As the windows have an overhang, this case will fall under the exception, and the *equivalent SHGC* value will be calculated by dividing fenestration SHGC by Shading Equivalent Factor (SEF).

For projection factor (PF) 0.3, the SEF for east, and west are taken from

Table 4-12, as the latitude is greater than 15°N.

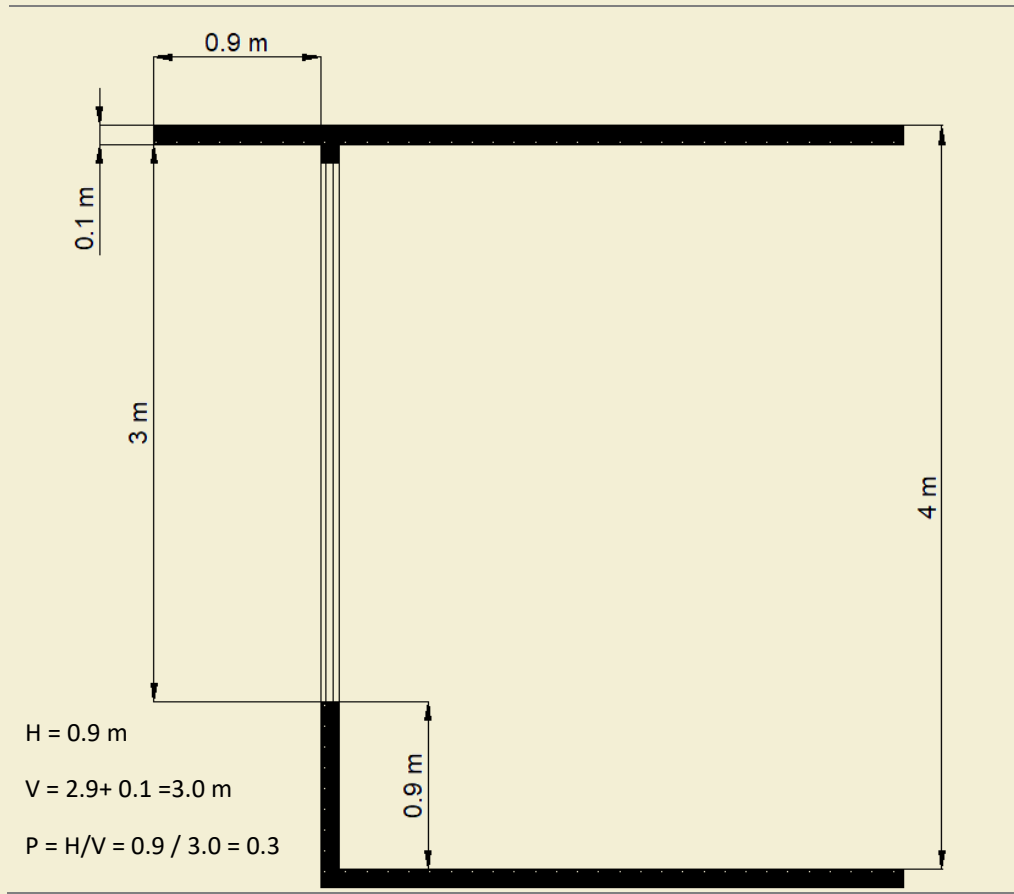
SEF for east for PF = 0.3 = 1.26

Therefore, equivalent SHGC<sub>East</sub> = 0.3 ÷ 1.26 = 0.24 Hence the vertical fenestration on the east façade will comply as per prescriptive approach, as the equivalent SHGC is less than maximum allowed.

Similarly, for the west façade:

SEF for west for PF = 0.3 = 1.27

Therefore, equivalent SHGC<sub>West</sub> = 0.3 ÷ 1.27 = 0.24, hence the vertical fenestration on the west façade will comply using the prescriptive approach, as the equivalent SHGC is less than maximum allowed.





Exceptions to U-factor requirements in Table 4-10 and Table 4-11:

Vertical fenestration on all unconditioned buildings or unconditioned spaces may have a maximum U-factor of 5 W/m<sup>2</sup>.K provided they comply with all conditions mentioned in Table 4-14.

Table 4-14 U-factor (W/m<sup>2</sup>.K) Exemption Requirements for Shaded Building

| Building Type                                   | Climate zone    | Orientation                     | Maximum Effective SHGC | Minimum VLT | PF    |
|---|-----------------|---------------------------------|------------------------|-------------|-------|
| Unconditioned buildings or unconditioned spaces | All except cold | Non-North for all latitudes and | 0.27                   | 0.27        | ≥0.40 |
|   |                 | North for latitude < 15°N       |                        |             |       |
|   |                 | North for latitude ≥ 15°N       | 0.27                   | 0.27        | ≥0.0  |

#### 4.3.4 Skylights

Skylights shall comply with the maximum U-factor and maximum SHGC requirements of Table 4-15. Skylight roof ratio (SRR), defined as the ratio of the total skylight area of the roof, measured to the outside of the frame, to the gross exterior roof area, is limited to a maximum of 5% for ECBC Building, ECBC+ Building, and SuperECBC Building, when using the Prescriptive Method for compliance.

Table 4-15 Skylight U-factor (W/m<sup>2</sup>.K) and SHGC Requirements

| Climate            | Maximum U-factor | Maximum SHGC |
|--------------------|------------------|--------------|
| All climatic zones | 4.25             | 0.35         |

Exception to §4.3.4 Skylights in temporary roof coverings or awnings over unconditioned spaces.

### 4.3.5 Building Envelope Trade-Off Method

The building envelope complies with the code if the Envelope Performance Factor (EPF) of the Proposed Building is less than the EPF of the Standard Building, where the Standard Building exactly complies with the prescriptive requirements of building envelope. This method shall not be used for buildings with WWR>40%. Trade-off is not permitted for skylights. Skylights shall meet requirements of 4.3.4. The envelope performance factor shall be calculated using the following equations.

Equation 4.1:  $EPF_{Total} = EPF_{Roof} + EPF_{Wall} + EPF_{Fenest}$

$$\begin{aligned}
 EPF_{Roof} &= c_{Roof} \sum_{s=1}^n U_s A_s \\
 EPF_{Wall} &= c_{Wall} \sum_{s=1}^n U_s A_s \\
 EPF_{Fenest} &= c_{1Fenest,North} \sum_{w=1}^n U_w A_w + c_{2Fenest,North} \sum_{w=1}^n \frac{SHGC_w}{SEF_w} A_w \\
 &+ c_{1Fenest,South} \sum_{w=1}^n U_w A_w + c_{2Fenest,South} \sum_{w=1}^n \frac{SHGC_w}{SEF_w} A_w \\
 &+ c_{1Fenest,East} \sum_{w=1}^n U_w A_w + c_{2Fenest,East} \sum_{w=1}^n \frac{SHGC_w}{SEF_w} A_w \\
 &+ c_{1Fenest,West} \sum_{w=1}^n U_w A_w + c_{2Fenest,West} \sum_{w=1}^n \frac{SHGC_w}{SEF_w} A_w
 \end{aligned}$$

$EPF_{Roof}$   
Envelope performance factor for roofs. Other subscripts include walls and fenestration.

$A_s, A_w$  The area of a specific envelope component referenced by the subscript "s" or for windows the subscript "w".

$SHGC_w$  The solar heat gain coefficient for windows (w).

$SEF_w$  A multiplier for the window SHGC that depends on the projection factor of an overhang or side fin.

$U_s$  The U-factor for the envelope component referenced by the subscript "s".

$c_{Roof}$  A coefficient for the "Roof" class of construction.

$c_{Wall}$  A coefficient for the "Wall"

$c_{1Fenest}$  A coefficient for the "Fenestration U-factor"

$c_{2Fenest}$  A coefficient for the "Fenestration SHGC"

Values of "c" are taken from Table 4-16 through Table 4-20 for each class of construction.

Table 4-16 Envelope Performance Factor Coefficients – Composite Climate

|               | <i>Daytime Business, Educational,<br/>Shopping Complex</i> |               | <i>24-hour Business, Hospitality, Health Care,<br/>Assembly</i> |               |
|---------------|--|---------------|---|---------------|
|               | C factor U-factor  | C factor SHGC | C factor U-factor   | C factor SHGC |
| Walls         | 24.3   | -             | 48.1  | -             |
| Roofs         | 40.9   | -             | 71.0  | -             |
| North Windows | 21.6   | 201.8         | 41.0  | 367.6         |
| South Windows | 19.1   | 342.5         | 41.0  | 546.3         |
| East Windows  | 18.8   | 295.6         | 38.4  | 492.2         |
| West Windows  | 19.2   | 295.4         | 38.3  | 486.1         |

Table 4-17 Envelope Performance Factor Coefficients – Hot and Dry Climate

|               | <i>Daytime Business, Educational,<br/>Shopping Complex</i> |               | <i>24-hour Business, Hospitality,<br/>Health Care, Assembly</i> |               |
|---------------|--|---------------|---|---------------|
|               | C factor U-factor  | C factor SHGC | C factor U-factor   | C factor SHGC |
| Walls         | 27.3   | -             | 55.9  | -             |
| Roofs         | 43.9   | -             | 80.7  | -             |
| North Windows | 23.7   | 238.2         | 49.1  | 414.4         |
| South Windows | 22.8   | 389.7         | 49.2  | 607.4         |
| East Windows  | 21.6   | 347.4         | 46.2  | 556.2         |
| West Windows  | 21.7   | 354.1         | 46.0  | 560.8         |

Table 4-18 Envelope Performance Factor Coefficients – Warm and Humid Climate

|               | <i>Daytime Business, Educational,<br/>Shopping Complex</i> |               | <i>24-hour Business, Hospitality, Health<br/>Care, Assembly</i> |               |
|---------------|--|---------------|---|---------------|
|               | C factor U-factor  | C factor SHGC | C factor U-factor   | C factor SHGC |
| Walls         | 24.5   | -             | 51.2  | -             |
| Roofs         | 40.1   | -             | 76.1  | -             |
| North Windows | 20.7   | 230.7         | 43.6  | 401.5         |
| South Windows | 20.1   | 347.1         | 43.9  | 546.4         |
| East Windows  | 19.0   | 301.8         | 41.1  | 490.6         |
| West Windows  | 18.7   | 303.1         | 40.5  | 483.5         |

Table 4-19 Envelope Performance Factor Coefficients – Temperate Climate

|               | Daytime Business, Educational,<br>Shopping Complex |               | 24-hour Business, Hospitality,<br>Health Care, Assembly |               |
|---------------|--|---------------|---|---------------|
|               | C factor U-factor                                  | C factor SHGC | C factor U-factor                                       | C factor SHGC |
| Walls         | 17.2   | -             | 39.1  | -             |
| Roofs         | 32.3   | -             | 76.1  | -             |
| North Windows | 12.6   | 201.4         | 32.3  | 338.41        |
| South Windows | 11.8   | 287.3         | 31.9  | 448.52        |
| East Windows  | 11.2   | 300.0         | 29.9  | 470.35        |
| West Windows  | 10.9   | 303.4         | 30.0  | 462.64        |

Table 4-20 Envelope Performance Factor Coefficients – Cold Climate

|               | Daytime Business, Educational,<br>Shopping Complex |               | 24-hour Business, Hospitality, Health<br>Care, Assembly |               |
|---------------|--|---------------|---|---------------|
|               | C factor U-factor                                  | C factor SHGC | C factor U-factor                                       | C factor SHGC |
| Walls         | 36.3   | -             | 30.7  | -             |
| Roofs         | 38.7   | -             | 46.0  | -             |
| North Windows | 21.8   | 137.6         | 28.3  | 163.86        |
| South Windows | 20.8   | 114.3         | 21.7  | 295.24        |
| East Windows  | 22.7   | 127.5         | 24.1  | 283.20        |
| West Windows  | 23.4   | 133.2         | 25.2  | 270.33        |

#### 4.3.5.1.1 Standard Building EPF Calculation

EPF of the Standard Building shall be calculated as follows:

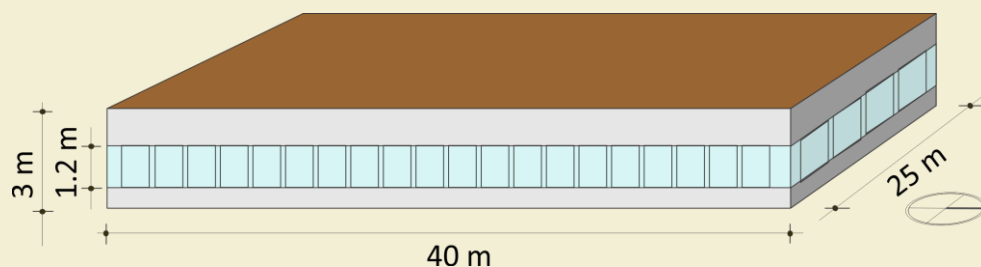
- The Standard Building shall have the same building floor area, gross wall area and gross roof area as the Proposed Building. For mixed-use building the space distribution between different typologies shall be the same as the Proposed Design.
- The U-factor of each envelope component shall be equal to the criteria from §4 for each class of construction.
- The SHGC of each window shall be equal to the criteria from §4.3.3.
- Shading devices shall not be considered for calculating EPF for Standard Building (i.e. SEF=1).

## Note 4-2 Building Envelope Trade-off Method

**Application of Building Envelope Trade-off method**

A 1,000 m<sup>2</sup> single story daytime use office building in Ahmedabad is trying to achieve ECBC level compliance. Each side has a band of windows, without shading. The materials for the envelope have already been selected, prior to opting for ECBC compliance. Their thermal properties are: roof assembly U-value = .4 W/m<sup>2</sup>.K, external wall assembly U-value = .25 W/m<sup>2</sup>.K, glazing SHGC = .25, VLT = 0.27, area weighted U-value for glazing = 1.8 W/m<sup>2</sup>.K.

Dimensions of the building envelope are as follows:



According to Table 11-1, Appendix B, Ahmedabad falls under the hot and dry climate zone. To prove compliance through the prescriptive approach, U-factor, and SHGC must comply with requirements listed in Table 4-4, Table 4-7, Table 4-10 and VLT and window to wall ratio with requirements in § 4.3.3 for a daytime use building in the hot and dry climate zone. The table below lists thermal properties of the building envelope components and the corresponding prescriptive requirements for ECBC complaint buildings.

*Table 4-3-1 Prescriptive Requirements and Proposed Thermal Properties*

|                      | Prescriptive U-factor<br>(W/m <sup>2</sup> .K) |        |        | Proposed U-factor<br>(W/m <sup>2</sup> .K) |      |      | Area<br>(m <sup>2</sup> ) |
|----------------------|--|--------|--------|--|------|------|---------------------------|
| Wall 1– North, South | =<0.63   |        |        | 0.25                                       |      |      | 90                        |
| Wall 2– East, West   | =<0.63   |        |        | 0.25                                       |      |      | 144                       |
| Roof                 | =<0.33   |        |        | 0.4  |      |      | 1000                      |
|                      | U-factor                                       | SHGC   | VLT    | U-factor                                   | SHGC | VLT  |                           |
| Window – South       | =<3.0  | =<0.27 | =>0.27 | 1.8  | 0.25 | 0.27 | 30                        |
| Window – North       | =<3.0  | =<0.5  | =>0.27 | 1.8  | 0.25 | 0.27 | 30                        |
| Window-East          | =<3.0  | =<0.27 | =>0.27 | 1.8  | 0.25 | 0.27 | 48                        |
| Window-West          | =<3.0  | =<0.27 | =>0.27 | 1.8  | 0.25 | 0.27 | 48                        |

§4.3.3 requires the WWR to be less than 40%. This condition is fulfilled in the proposed buildings as can be seen in the calculations below.

$$\text{Total Fenestration Area}_{\text{North, South}} = 2 \times (25\text{m} \times 1.2\text{m}) = 60 \text{ m}^2$$

$$\text{Wall Area}_{\text{North, South}} = 2 \times (25\text{m} \times 3\text{m}) = 150 \text{ m}^2$$

$$\text{Total Fenestration Area}_{\text{East, West}} = 2 \times (40\text{m} \times 1.2\text{m}) = 96 \text{ m}^2$$

$$\text{Total Wall Area}_{\text{East, West}} = 2 \times (40\text{m} \times 3\text{m}) = 240 \text{ m}^2$$

$$\text{Total Fenestration Area} = 156 \text{ m}^2, \text{ Total Wall Area} = 390 \text{ m}^2$$

$$\text{WWR} = 156/390 = 0.4.$$

U-value of the roof of the proposed building, at 0.4 W/m<sup>2</sup>.K does not fulfil prescriptive requirements.

Hence, this building will not be compliant if the prescriptive approach is followed. The compliance in prescriptive approach can also be demonstrated through building envelope trade-off.

#### Compliance through Building Envelope Trade-off method

Envelope performance factor (EPF) for the Standard Building and Proposed Building must be compared. As per the Building Envelope Trade-off method, the envelope performance factor (EPF) shall be calculated using the following equations:

$$\text{Equation 11.1 } EPF_{\text{Total}} = EPF_{\text{Roof}} + EPF_{\text{Wall}} + EPF_{\text{Fenest}}$$

Where,

$$EPF_{\text{Roof}} = C_{\text{Roof}} \sum_{s=1}^n U_s A_s$$

$$EPF_{\text{Wall}} = C_{\text{Wall}} \sum_{s=1}^n U_s A_s$$

$$\begin{aligned} EPF_{\text{Fenest}} = & C_{1\text{Fenest},\text{North}} \sum_{w=1}^n U_w A_w + C_{2\text{Fenest},\text{North}} \sum_{w=1}^n \frac{SHGC_w}{SEF_w} A_w \\ & + C_{1\text{Fenest},\text{South}} \sum_{w=1}^n U_w A_w + C_{2\text{Fenest},\text{South}} \sum_{w=1}^n \frac{SHGC_w}{SEF_w} A_w \\ & + C_{1\text{Fenest},\text{East}} \sum_{w=1}^n U_w A_w + C_{2\text{Fenest},\text{East}} \sum_{w=1}^n \frac{SHGC_w}{SEF_w} A_w \\ & + C_{1\text{Fenest},\text{West}} \sum_{w=1}^n U_w A_w + C_{2\text{Fenest},\text{West}} \sum_{w=1}^n \frac{SHGC_w}{SEF_w} A_w \end{aligned}$$

Standard Building EPF will be derived from U-factors, SHGCs and VLTs of walls, roofs and fenestration from Table 4-4, Table 4-7, Table 4-10 and § 4.3.3 for a daytime use building in the hot and dry climate zone. Values of C are from daytime Office building in hot and dry climatic zone for each class of construction from Table 4-17. Since There is no shading for the windows, SEF<sub>w</sub> will not be considered.

**Step 1: Calculation of EPF *Proposed Building* from actual envelope properties**

$$EPF_{Roof,Actual} = C_{Roof} \sum_{s=1}^n U_s A_s$$

$$= 43.9 \times 0.40 \times 1,000 = 17,560$$

$$EPF_{Wall,Actual} = C_{Wall} \sum_{s=1}^n U_s A_s$$

$$= (27.3 \times 0.25 \times 90) + (27.3 \times 0.25 \times 144) = 1,597.05$$

$$EPF_{Fenest} = EPF_{Fenest,North} + EPF_{Fenest,South} + EPF_{Fenest,East} + EPF_{Fenest,West}$$

$$EPF_{Fenest} = C_{1Fenest} \sum_{w=1}^n U_w A_w + C_{2Fenest} \sum_{w=1}^n \frac{SHGC_w}{SEF_w} A_w$$

Hence,

$$EPF_{Fenest,North} = 23.7 \times 1.8 \times 30 + 238.2 \times 0.25 \times 30 = 1,279.8 + 1,786.5 = 3,066.3$$

$$EPF_{Fenest,South} = 22.8 \times 1.8 \times 30 + 389.7 \times 0.25 \times 30 = 1,231.2 + 2,922.75 = 4,153.95$$

$$EPF_{Fenest,East} = 21.6 \times 1.8 \times 48 + 347.4 \times 0.25 \times 48 = 1,866.24 + 4,168.8 = 6,035.04$$

$$EPF_{Fenest,West} = 21.7 \times 1.8 \times 48 + 354.1 \times 0.25 \times 48 = 1,874.88 + 4,249.2 = 6,124.08$$

Therefore,

$$EPF_{Fenest} = 19,379.37$$

$$EPF_{Proposed} = 17,560 + 1,597.05 + 19,379.37 = 38,536.42$$

**Step 2: Calculating EPF *Standard Building* from prescriptive envelope requirements**

$$EPF_{Roof,Actual} = C_{Roof} \sum_{s=1}^n U_s A_s$$

$$= 43.9 \times 0.33 \times 1000 = 14,487$$

$$EPF_{Wall,Actual} = C_{Wall} \sum_{s=1}^n U_s A_s$$

$$= (27.3 \times 0.63 \times 90) + (27.3 \times 0.63 \times 144) = 1,547.91 + 2,476.66 = 4,024.57$$

$$EPF_{Fenest} = EPF_{Fenest,North} + EPF_{Fenest,South} + EPF_{Fenest,East} + EPF_{Fenest,West}$$

Now,

$$EPF_{Fenest, North} = 23.7 \times 3.0 \times 30 + 238.2 \times 0.5 \times 30 = 2,133 + 3,573 = 5,706$$

$$EPF_{Fenest, South} = 22.8 \times 3.0 \times 30 + 389.7 \times 0.27 \times 30 = 2,052 + 3,156.57 = 5,208.57$$

$$EPF_{Fenest, East} = 21.6 \times 3.0 \times 48 + 347.4 \times 0.27 \times 48 = 3,110.4 + 4,502.3 = 7,612.7$$

$$EPF_{Fenest, West} = 21.7 \times 3.0 \times 48 + 354.1 \times 0.27 \times 48 = 3,124.8 + 4,589.14 = 7,713.94$$

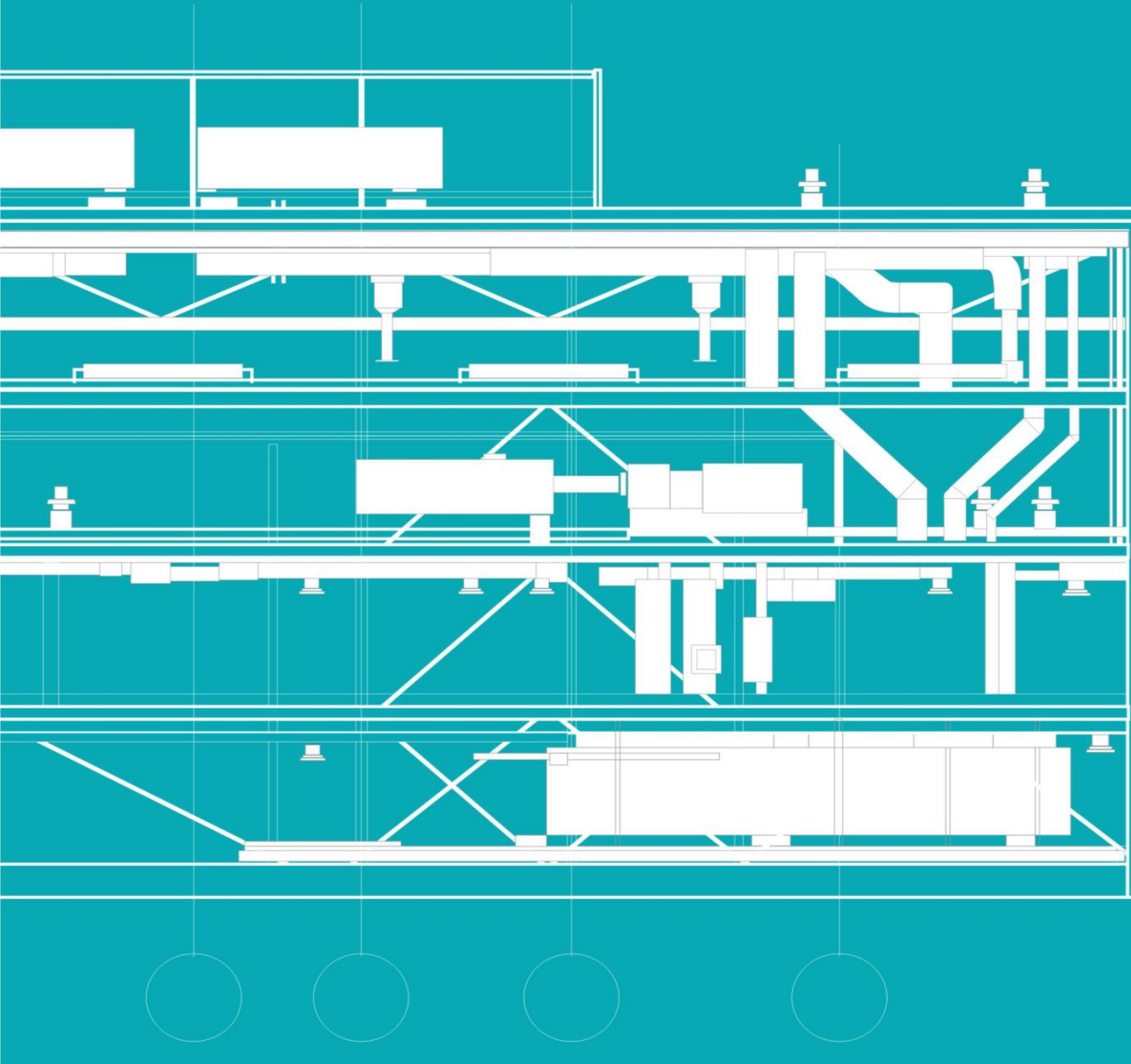
$$\text{Therefore, } EPF_{Fenest} = 26,241.21$$

$$EPF_{Baseline} = 14,487 + 4,024.57 + 26,241.21 = 44,752.78$$

Since  $EPF_{Baseline} > EPF_{Proposed}$ , therefore the building is compliant with ECBC building envelope requirements.



# 5 Comfort Systems & Controls



## 5. Comfort Systems and Controls

### 5.1 General

All heating, ventilation, air conditioning equipment and systems, and their controls shall comply with the mandatory provisions of §5.2 and the prescriptive criteria of §5.3 for the respective building energy efficiency level. In case alternative compliance path of Total System Efficiency or Low Energy Systems is used for compliance, respective requirements of §5.3.12 or §5.3.13 and relevant criteria of §5.3 shall be met.

### 5.2 Mandatory Requirements

#### 5.2.1 Ventilation

- (a) All habitable spaces shall be ventilated with outdoor air in accordance with the requirements of §5.2.1 and guidelines specified in the National Building Code 2016 (Part 8: Building Services, Section 1: Lighting and Natural Ventilation, Subsection 5: Ventilation).
- (b) Ventilated spaces shall be provided with outdoor air using one of the following:
  - i. Natural ventilation
  - ii. Mechanical ventilation

##### 5.2.1.1 Natural Ventilation Design Requirements

Naturally ventilated buildings shall:

- (a) Comply with guidelines provided for natural ventilation in NBC.
- (b) Have minimum BEE 3-star rated ceiling fans, if provided with ceiling fans.
- (c) Have exhaust fans complying with minimum efficiency requirements of fans in §5.3, if provided.

##### 5.2.1.2 Mechanical Ventilation Air Quantity Design Requirements

Buildings that are ventilated using a mechanical ventilation system that are ventilated with a mechanical system, either completely or in conjunction with natural ventilation systems, shall:

- (a) Install mechanical systems that provide outdoor air change rate as per NBC.
- (b) Have a ventilation system controlled by CO sensors for basement carpark spaces with total car park space greater than or equal to 600 m<sup>2</sup>.

### 5.2.1.3 Demand Control Ventilation

Mechanical ventilation systems shall have demand control ventilation if they provide outdoor air greater than 1,500 liters per second, to a space greater than 50 m<sup>2</sup>, with occupant density exceeding 40 people per 100 m<sup>2</sup> of the space, and are served by one or more of the following systems:

- (a) An air side economizer
- (b) Automatic outdoor modulating control of the outdoor air damper

Exceptions to § 5.2.1.3:

- (a) Classrooms in Schools, call centers category under Business
- (b) Spaces that have processes or operations that generate dust, fumes, mists, vapors, or gases and are provided with exhaust ventilation, such as indoor operation of internal combustion engines or areas designated for unvented food service preparation, or beauty salons
- (c) Systems with exhaust air energy recovering system

## 5.2.2 Minimum Space Conditioning Equipment Efficiencies

### 5.2.2.1 Chillers

- (a) Chillers shall meet or exceed the minimum efficiency requirements presented in Table 5-1 through Table 5-2 under ANSI/ AHRI 550/ 590 conditions.
- (b) The application of air-cooled chiller is allowed in all buildings with cooling load less than 530 kW. For buildings with cooling load equal to or greater than 530 kW, the capacity of air-cooled chiller shall be restricted to 33% of the total installed chilled water capacity unless the authority having jurisdiction mandates the application of air-cooled chillers.
- (c) Minimum efficiency requirements under BEE Standards and Labeling Program for chillers shall take precedence over the minimum requirements presented in Table 5-1 through Table 5-2.
- (d) To show compliance to ECBC, minimum requirement of both COP and IPLV requirement shall be met.

Table 5-1 Minimum Energy Efficiency Requirements for water cooled Chillers

| Chiller Capacity (kW <sub>r</sub> ) | COP | IPLV |
|-------------------------------------|-----|------|
| <260                                | 4.7 | 5.8  |
| ≥260 & <530                         | 4.9 | 5.9  |
| ≥530 & <1,050                       | 5.4 | 6.5  |
| ≥1,050 & <1,580                     | 5.8 | 6.8  |
| ≥1,580                              | 6.3 | 7.0  |

Table 5-2 Minimum Energy Efficiency Requirements for air cooled Chillers

| Chiller Capacity (kW <sub>r</sub> ) | COP | IPLV |
|-------------------------------------|-----|------|
| <260                                | 2.8 | 3.5  |
| ≥260                                | 3.0 | 3.7  |

### 5.2.2.2 Unitary, Split, Packaged Air-Conditioners

Unitary air-conditioners shall meet or exceed the efficiency requirements given in Table 5-3. Window and split air conditioners shall be certified under BEE's Star Labeling Program. EER shall be as per IS 8148 for all unitary, split, packaged air conditioners greater than 10 kW.

*Table 5-3 Minimum Requirements for Unitary, Split, Packaged Air Conditioners in ECBC Building*

| Cooling Capacity (kW) | Water Cooled | Air Cooled |
|-----------------------|--------------|------------|
| ≤ 10.5                | NA           | BEE 3 Star |
| > 10.5                | 3.3 EER      | 2.8 EER    |

### 5.2.2.3 Variable Refrigerant Flow

Variable Refrigerant Flow (VRF) systems shall meet or exceed the efficiency requirements specified in Table 5-4 as per the ANSI/AHRI Standard 1230 while the Indian Standard on VRF is being developed. BEE Standards and Labeling requirements for VRF shall take precedence over the current minimum requirement.

*Table 5-4 Minimum Efficiency Requirements for VRF Air conditioners for ECBC Building\**

| Type                             | Size category (kW) | For Heating or cooling or both |            |
|----------------------------------|--------------------|--------------------------------|------------|
|                                  |                    | EER (W/W)                      | IEER (W/W) |
| VRF Air Conditioners, Air cooled | < 40               | 3.28                           | 4.36       |
|                                  | ≥ 40 and < 70      | 3.26                           | 4.34       |
|                                  | ≥ 70               | 3.02                           | 4.07       |

\* The revised EER and IEER values as per Indian Standard for VRF corresponding to values in this table will supersede as and when the revised standards are published.

### 5.2.2.4 Air Conditioning and Condensing Units Serving Computer Rooms

Air conditioning and condensing units serving computer rooms shall meet or exceed the energy efficiency requirements listed in Table 5-5.

*Table 5-5 Minimum Efficiency Requirements for Computer Room Air Conditioners*

| Equipment type                                    | Net Sensible Cooling Capacity <sup>a</sup> | Minimum SCOP-127 <sup>b</sup> |        |
|---|--|-------------------------------|--------|
|   |  | Downflow                      | Upflow |
| All types of computer room ACs Air/ Water/ Glycol | All capacity                               | 2.5                           | 2.5    |

a. Net Sensible cooling capacity = Total gross cooling capacity - latent cooling capacity – Fan power

b. Sensible Coefficient of Performance (SCOP-127): A ratio calculated by dividing the net sensible cooling capacity in watts by the total power input in watts (excluding reheater and dehumidifier) at conditions defined in ASHRAE Standard 127-2012 Method of Testing for Rating Computer and Data Processing Room Unitary Air Conditioners)

### 5.2.2.5 Boilers

Gas and oil-fired boilers shall meet or exceed the minimum efficiency requirements specified in Table 5-6.

*Table 5-6 Minimum Efficiency Requirements for Oil and Gas Fired Boilers for ECBC building*

| <i>Equipment Type</i>             | <i>Sub Category</i> | <i>Size Category</i> | <i>Minimum FUE</i> |
|-----------------------------------|---------------------|----------------------|--------------------|
| Boilers, Hot Water                | Gas or oil fired    | All capacity         | 80%                |
| FUE - fuel utilization efficiency |                     |                      |                    |

## 5.2.3 Controls

To comply with the Code, buildings shall meet the requirements of §5.2.3.1 through §5.2.3.5.

### 5.2.3.1 Timeclock

Mechanical cooling and heating systems in Universities and Training Institutions of all sizes and all Shopping Complexes with built up area greater than 20,000 m<sup>2</sup> shall be controlled by timeclocks that:

- Can start and stop the system under different schedules for at least three different day-types per week,
- Are capable of retaining programming and time setting during loss of power for a period of at least 10 hours, and
- Include an accessible manual override that allows temporary operation of the system for up to 2 hours.

Exceptions to §5.2.3.1:

- Cooling systems less than 17.5 kW<sub>r</sub>
- Heating systems less than 5.0 kW<sub>r</sub>
- Unitary systems of all capacities

### 5.2.3.2 Temperature Controls

Mechanical cooling and heating equipment in all buildings shall be installed with controls to manage the temperature inside the conditioned zones. Each floor or a building block shall be installed with at least one control to manage the temperature. These controls should meet the following requirements:

- Where a unit provides both heating and cooling, controls shall be capable of providing a temperature dead band of 3.0°C within which the supply of heating and cooling energy to the zone is shut off or reduced to a minimum.

- (b) Where separate heating and cooling equipment serve the same temperature zone, temperature controls shall be interlocked to prevent simultaneous heating and cooling.
- (c) Separate thermostat control shall be installed in each
  - i. guest room of Resort and Star Hotel,
  - ii. room less than 30 m<sup>2</sup> in Business,
  - iii. air-conditioned class room, lecture room, and computer room of Educational,
  - iv. in-patient and out-patient room of Healthcare

### 5.2.3.3 Occupancy Controls

Occupancy controls shall be installed to de-energize or to throttle to minimum the ventilation and/or air conditioning systems when there are no occupants in:

- (a) Each guest room in a Resort and Star Hotel
- (b) Each public toilet in a Star Hotel or Business with built up area more than 20,000 m<sup>2</sup>
- (c) Each conference and meeting room in a Star Hotel or Business
- (d) Each room of size more than 30 m<sup>2</sup> in Educational buildings

### 5.2.3.4 Fan Controls

Cooling towers in buildings with built up area greater than 20,000 m<sup>2</sup>, shall have fan controls based on wet bulb logic, with either:

- (a) Two speed motors, pony motors, or variable speed drives controlling the fans, or
- (b) Controls capable of reducing the fan speed to at least two third of installed fan power

### 5.2.3.5 Dampers

All air supply and exhaust equipment, having a Variable Frequency Drive (VFD), shall have dampers that automatically close upon:

- (a) Fan shutdown, or,
- (b) When spaces served are not in use
- (c) Backdraft gravity damper is acceptable in the system with design outdoor air of the system is less than 150 liters per second in all climatic zones except cold climate, provided backdraft dampers for ventilation air intakes are protected from direct exposure to wind.
- (d) Dampers are not required in ventilation or exhaust systems serving naturally conditioned spaces.
- (e) Dampers are not required in exhaust systems serving kitchen exhaust hoods.

## 5.2.4 Piping and Ductwork

### 5.2.4.1 Piping Insulation

Piping for heating, space conditioning, and service hot water systems shall meet the insulation requirements listed in Table 5-7 through Table 5-9. Insulation exposed to weather

shall be protected by aluminum sheet metal, painted canvas, or plastic cover. Cellular foam insulation shall be protected as above, or be painted with water retardant paint.

Exceptions to § 5.2.4.1:

- (a) Reduction in insulation R value by 0.2 (compared to values in Table 5-7, Table 5-8 and Table 5-9) to a minimum insulation level of R-0.4 shall be permitted for any pipe located in partition within a conditioned space or buried.
- (b) Insulation R value shall be increased by 0.2 over and above the requirement stated in Table 5-7 through Table 5-9 for any pipe located in a partition outside a building with direct exposure to weather.

*Table 5-7 Insulation Requirements for Pipes in ECBC Building*

| Operating Temperature (°C)         | Pipe size (mm)              |      |
|------------------------------------|-----------------------------|------|
|                                    | <40                         | >=40 |
|                                    | Insulation R value (m².K/W) |      |
| Heating System                     |                             |      |
| >94°C and <=121°C                  | 0.9                         | 1.2  |
| >60°C and <=94°C                   | 0.7                         | 0.7  |
| >40°C and <=60°C                   | 0.4                         | 0.7  |
| Cooling System                     |                             |      |
| >4.5°C and <=15°C                  | 0.4                         | 0.7  |
| < 4.5°C                            | 0.9                         | 1.2  |
| Refrigerant Piping (Split systems) |                             |      |
| >4.5°C and <=15°C                  | 0.4                         | 0.7  |
| < 4.5°C                            | 0.9                         | 1.2  |

*Table 5-8 Insulation Requirements for Pipes in ECBC+ Building*

| Operating Temperature (°C)         | Pipe size (mm)              |      |
|------------------------------------|-----------------------------|------|
|                                    | < 40                        | >=40 |
|                                    | Insulation R value (m².K/W) |      |
| Heating System                     |                             |      |
| >94°C and <=121°C                  | 1.1                         | 1.3  |
| >60°C and <=94°C                   | 0.8                         | 0.8  |
| >40°C and <=60°C                   | 0.5                         | 0.9  |
| Cooling System                     |                             |      |
| >4.5°C and <=15°C                  | 0.5                         | 0.9  |
| < 4.5°C                            | 1.1                         | 1.3  |
| Refrigerant Piping (Split systems) |                             |      |
| >4.5°C and <=15°C                  | 0.5                         | 0.9  |
| < 4.5°C                            | 1.1                         | 1.3  |

Table 5-9 Insulation Requirements for Pipes in SuperECBC Buildings

| Operating Temperature (°C)         | Pipe size (mm)              |      |
|------------------------------------|-----------------------------|------|
|                                    | < 40                        | >=40 |
|                                    | Insulation R value (m².K/W) |      |
| Heating System                     |                             |      |
| >94°C and <=121°C                  | 1.5                         | 1.5  |
| >60°C and <=94°C                   | 1.0                         | 1.3  |
| >40°C and <=60°C                   | 0.7                         | 1.1  |
| Cooling System                     |                             |      |
| >4.5°C and <=15°C                  | 0.7                         | 1.2  |
| < 4.5°C                            | 1.5                         | 1.5  |
| Refrigerant Piping (Split systems) |                             |      |
| >4.5°C and <=15°C                  | 0.7                         | 1.1  |
| < 4.5°C                            | 1.5                         | 1.5  |

#### 5.2.4.2 Ductwork and Plenum Insulation

Ductwork and plenum shall be insulated in accordance with Table 5-10.

Table 5-10 Ductwork Insulation (R value in m<sup>2</sup>. K/W) Requirements

| Duct Location       | Supply ducts | Return ducts |
|---------------------|--------------|--------------|
| Exterior            | R -1.4       | R -0.6       |
| Unconditioned Space | R -0.6       | None         |
| Buried              | R -0.6       | None         |

### 5.2.5 System Balancing

#### 5.2.5.1 General

System balancing shall be done for systems serving zones with a total conditioned area exceeding 500 m<sup>2</sup>.

#### 5.2.5.2 Air System Balancing

Air systems shall be balanced in a manner to first minimize throttling losses; then, for fans with fan system power greater than 0.75 kW, fan speed shall be adjusted to meet design flow conditions.

#### 5.2.5.3 Hydronic System Balancing

Hydronic systems shall be proportionately balanced in a manner to first minimize throttling losses; then the pump impeller shall be trimmed or pump speed shall be adjusted to meet design flow conditions.



## 5.2.6 Condensers

### 5.2.6.1 Condenser Locations

Condensers shall be located such that the heat sink is free of interference from heat discharge by devices located in adjoining spaces, and do not interfere with other such systems installed nearby.

## 5.2.7 Service Water Heating

### 5.2.7.1 Solar Water Heating

Hospitality and Healthcare in all climatic zones and all buildings in cold climate zone with a hot water system, shall have solar water heating equipment installed to provide for:

- (a) at least 20% of the total hot water design capacity if above grade floor area of the building is less than 20,000 m<sup>2</sup>
- (b) at least 40% of the total hot water design capacity if above grade floor area of the building is greater than or equal to 20,000 m<sup>2</sup>

Exception to § 5.2.7.1: Systems that use heat recovery to provide the hot water capacity required as per the building type and size.

### 5.2.7.2 Heating Equipment Efficiency

Service water heating equipment shall meet or exceed the performance and minimum efficiency requirements presented in available Indian Standards

- (a) Solar water heater shall meet the performance/ minimum efficiency level mentioned in IS 13129 Part (1&2).
- (b) Gas Instantaneous water heaters shall meet the performance/minimum efficiency level mentioned in IS 15558 with above 80% Fuel utilization efficiency.
- (c) Electric water heater shall meet the performance/ minimum efficiency level mentioned in IS 2082.
- (d) For evacuated tube collector the storage tanks shall meet the IS 16542:2016, tubes shall meet IS 16543:2016 and IS 16544:2016 for the complete system.

### 5.2.7.3 Other Water Heating System

Supplementary heating system shall be designed to maximize the energy efficiency of the system and shall incorporate the following design features in cascade:

- (a) Maximum heat recovery from hot discharge system like condensers of air conditioning units,
- (b) Use of gas fired heaters wherever gas is available, and
- (c) Electric heater as last resort.

#### 5.2.7.4 Piping Insulation

Piping insulation shall comply with § 5.2.4.1. The entire hot water system including the storage tanks, pipelines shall be insulated conforming to the relevant IS standards on materials and applications.

#### 5.2.7.5 Heat Traps

Vertical pipe risers serving storage water heaters and storage tanks not having integral heat traps and serving a non-recirculating system shall have heat traps on both the inlet and outlet piping.

#### 5.2.7.6 Swimming Pools

All heated pools shall be provided with a vapor retardant pool cover on or at the water surface. Pools heated to more than 32°C shall have a pool cover with a minimum insulation value of R-4.1.

### 5.3 Prescriptive Requirements

Compliance shall be demonstrated with the prescriptive requirements in this section.

Supply, exhaust, and return or relief fans with motor power exceeding 0.37 kW shall meet or exceed the minimum energy efficiency requirements specified in Table 5-11 through Table 5-13 except the following need not comply with the requirement

- (a) Fans in un-ducted air conditioning unit where fan efficiency has already been taken in account to calculate the efficiency standard of the comfort system.
- (b) Fans in Health Care buildings having HEPA filters.
- (c) Fans inbuilt in energy recovery systems that pre-conditions the outdoor air.

Table 5-11 Mechanical and Motor Efficiency Requirements for Fans in ECBC Buildings

| System type       | Fan Type                   | Mechanical Efficiency | Motor Efficiency<br>(As per IS 12615) |
|-------------------|----------------------------|-----------------------|---------------------------------------|
| Air-handling unit | Supply, return and exhaust | 60%                   | IE 2                                  |

Table 5-12 Mechanical and Motor Efficiency Requirements for Fans in ECBC+ Buildings

| System type       | Fan Type                   | Mechanical Efficiency | Motor Efficiency<br>(As per IS 12615) |
|-------------------|----------------------------|-----------------------|---------------------------------------|
| Air-handling unit | Supply, return and exhaust | 65%                   | IE 3                                  |

Table 5-13 Mechanical and Motor Efficiency Requirements for Fans in SuperECBC Buildings

| System Type       | Fan Type                   | Mechanical Efficiency | Motor Efficiency<br>(As per IS 12615) |
|-------------------|----------------------------|-----------------------|---------------------------------------|
| Air-handling unit | Supply, return and exhaust | 70%                   | IE 4                                  |

### 5.3.1 Chillers

Chillers shall meet or exceed the minimum efficiency requirements for ECBC+ and SuperECBC Buildings are presented in Table 5-14 and Table 5-15 under ANSI/ AHRI 550/ 590 conditions.

Table 5-14 Minimum Energy Efficiency Requirements for water cooled Chillers

| Chiller Capacity (kW <sub>r</sub> ) | ECBC+ Building |      | SuperECBC Building |      |
|-------------------------------------|----------------|------|--------------------|------|
|                                     | COP            | IPLV | COP                | IPLV |
| <260                                | 5.2            | 6.9  | 5.8                | 7.1  |
| ≥260 & <530                         | 5.8            | 7.1  | 6.0                | 7.9  |
| ≥530 & <1,050                       | 5.8            | 7.5  | 6.3                | 8.4  |
| ≥1,050 & <1,580                     | 6.2            | 8.1  | 6.5                | 8.8  |
| ≥1,580                              | 6.5            | 8.9  | 6.7                | 9.1  |

Table 5-15 Minimum Energy Efficiency Requirements for air cooled Chillers

| Chiller Capacity (kW <sub>r</sub> ) | ECBC+ Building |      | SuperECBC Building |
|-------------------------------------|----------------|------|--------------------|
|                                     | COP            | IPLV | COP/ IPLV          |
| <260                                | 3.0            | 4.0  | NA                 |
| ≥260                                | 3.2            | 5.0  | NA                 |

### 5.3.2 Pumps

Chilled and condenser water pumps shall meet or exceed the minimum energy efficiency requirements specified in

Table 5-16 through Table 5-18. Requirements for pumps in district chiller systems and hot water pumps for space heating are limited to the installed efficiency requirement of individual pump equipment only. To show compliance, calculate the total installed pump capacity in kilo watt and achieve the prescribed limits per kilo watt of refrigeration installed in the building.

Exceptions to §5.3.2: Pumps used in processes e.g. service hot water, chilled water used for refrigeration etc.

Table 5-16 Pump Efficiency Requirements for ECBC Building

| Equipment                                  | ECBC   |
|--|--|
| Chilled Water Pump (Primary and Secondary) | 18.2 W/ kW <sub>r</sub> with VFD on secondary pump |
| Condenser Water Pump                       | 17.7 W/ kW <sub>r</sub>                            |
| Pump Efficiency (minimum)                  | 70%  |

Table 5-17 Pump Efficiency Requirements for ECBC+ Building

| Equipment                                  | ECBC+ Building                                     |
|--|--|
| Chilled Water Pump (Primary and Secondary) | 16.9 W/ kW <sub>r</sub> with VFD on secondary pump |
| Condenser Water Pump                       | 16.5 W/ kW <sub>r</sub>                            |
| Pump Efficiency (minimum)                  | 75%  |

Table 5-18 Pump Efficiency Requirements for SuperECBC Building

| Equipment                                  | SuperECBC Building                                 |
|--|--|
| Chilled Water Pump (Primary and Secondary) | 14.9 W/ kW <sub>r</sub> with VFD on secondary pump |
| Condenser Water Pump                       | 14.6 W/ kW <sub>r</sub>                            |
| Pump Efficiency (minimum)                  | 85%  |

### 5.3.3 Cooling Towers

Cooling towers shall meet or exceed the minimum efficiency requirements specified in Table 5-19. ECBC+ and SuperECBC Buildings shall have additional VFD installed in the cooling towers.

Table 5-19 Cooling Tower Efficiency Requirements for ECBC, ECBC+, and SuperECBC Buildings

| Equipment type                  | Rating Condition    | Efficiency               |
|---------------------------------|---------------------|--------------------------|
| Open circuit cooling tower Fans | 35°C entering water | 0.017 kW/kW <sub>r</sub> |
|                                 | 29°C leaving water  | 0.31 kW/ L/s             |
|                                 | 24°C WB outdoor air |                          |

### 5.3.4 Boilers

Gas and oil-fired boilers shall meet or exceed the minimum efficiency requirements specified in Table 5-20.

Table 5-20 Minimum Efficiency Requirements for Oil and Gas Fired Boilers for ECBC+ and SuperECBC building

| Equipment Type                    | Sub Category     | Size Category | Minimum FUE |
|-----------------------------------|------------------|---------------|-------------|
| Boilers, Hot Water                | Gas or oil fired | All capacity  | 85%         |
| FUE - fuel utilization efficiency |                  |               |             |

### 5.3.5 Economizers

#### 5.3.5.1 Economizer for ECBC, ECBC+, and SuperECBC Building

Each cooling fan system in buildings with built up area greater than 20,000 m<sup>2</sup>, shall include at least one of the following:

- (a) An air economizer capable of modulating outside-air and return-air dampers to supply 50% of the design supply air quantity as outside-air.
- (b) A water economizer capable of providing 50% of the expected system cooling load at outside air temperatures of 10°C dry-bulb/7.2°C wet-bulb and below.

Exception to §5.3.5.1:

- (a) Projects in warm-humid climate zones.
- (b) Projects with only daytime occupancy in the hot-dry.
- (c) Individual cooling or heating fan systems less than 3,200 liters per second.

#### 5.3.5.2 Partial Cooling

Where required by §5.3.5.1 economizers shall be capable of providing partial cooling even when additional mechanical cooling is required to meet the cooling load.

#### 5.3.5.3 Economizer Controls

Air economizer shall be equipped with controls

- (a) That allow dampers to be sequenced with the mechanical cooling equipment and not be controlled by only mixed air temperature.
- (b) capable of automatically reducing outdoor air intake to the design minimum outdoor air quantity when outdoor air intake will no longer reduce cooling energy usage.
- (c) Capable of high-limit shutoff at 24 °C dry bulb temperature.

#### 5.3.5.4 Testing

Air-side economizers shall be tested in the field following the requirements in §12 Appendix C to ensure proper operation.

Exception to §5.3.5.4: Air economizers installed by the HVAC system equipment manufacturer and certified to the building department as being factory calibrated and tested per the procedures in §12.

### 5.3.6 Variable Flow Hydronic Systems

#### 5.3.6.1 Variable Fluid Flow

HVAC pumping systems having a total pump system power exceeding 7.5 kW shall be designed for variable fluid flow and shall be capable of reducing pump flow rates to an extent which is lesser or equal to the limit, where the limit is set by the larger of:

- (a) 50% of the design flow rate, or
- (b) the minimum flow required by the equipment manufacturer for proper operation of the chillers or boilers.

#### 5.3.6.2 Isolation Valves

Water cooled air-conditioning or heat pump units with a circulation pump motor greater than or equal to 3.7 kW shall have two-way automatic isolation valves on each water-cooled air-conditioning or heat pump unit that are interlocked with the compressor to shut off condenser water flow when the compressor is not operating.

#### 5.3.6.3 Variable Speed Drives

Chilled water or condenser water systems that must comply with either §5.3.6.1 or §5.3.6.2 and that have pump motors greater than or equal to 3.7 kW shall be controlled by variable speed drives.

### 5.3.7 Unitary, Split, Packaged Air-Conditioners

Unitary air-conditioners shall meet or exceed the efficiency requirements given in Table 5-21 and Table 5-22. Window and split air conditioners shall be certified under BEE's Star Labeling Program. EER shall be as per IS 8148 for all unitary, split, packaged air conditioners greater than 10 kW.

*Table 5-21 Minimum Requirements for Unitary, Split, Packaged Air Conditioners in ECBC+ Building*

| Cooling Capacity (kW) | Water Cooled | Air Cooled |
|-----------------------|--------------|------------|
| ≤ 10.5                | NA           | BEE 4 Star |
| > 10.5                | 3.7 EER      | 3.2 EER    |

*Table 5-22 Minimum Requirements for Unitary, Split, Packaged Air Conditioners in SuperECBC Building*

| Cooling Capacity (kW) | Water Cooled | Air Cooled |
|-----------------------|--------------|------------|
| ≤ 10.5                | NA           | BEE 5 Star |
| >10.5                 | 3.9 EER      | 3.4 EER    |

### 5.3.8 Controls for ECBC+ and SuperECBC Buildings

ECBC+ building shall comply with requirements of § 5.3.8 in addition to complying with requirements of §5.2.3.

### 5.3.8.1 Centralized Demand Shed Controls

ECBC+ and SuperECBC Buildings with built up area greater than 20,000 m<sup>2</sup> shall have a building management system. All mechanical cooling and heating systems in ECBC+ and SuperECBC Buildings with any programmable logic controller (PLC) to the zone level shall have the following control capabilities to manage centralized demand shed in noncritical zones:

- (a) Automatic demand shed controls that can implement a centralized demand shed in non-critical zones during the demand response period on a demand response signal.
- (b) Controls that can remotely decrease or increase the operating temperature set points by four degrees or more in all noncritical zones on signal from a centralized control point
- (c) Controls that can provide an adjustable rate of change for the temperature setup and reset

The centralized demand shed controls shall have additional capabilities to

- (a) Be disabled by facility operators
- (b) Be manually controlled from a central point by facility operators to manage heating and cooling set points

### 5.3.8.2 Supply Air Temperature Reset

Multi zone mechanical cooling and heating systems in ECBC+ and SuperECBC Buildings shall have controls that automatically reset the supply-air temperature in response to building loads or to outdoor air temperature. Controls shall reset the supply air temperature to at least 25% of the difference between the design supply air temperature and the design room air temperature.

Exception to § 5.3.8.2 : ECBC+ and SuperECBC Buildings in warm humid climate zone.

### 5.3.8.3 Chilled Water Temperature Reset

Chilled water systems with a design capacity exceeding 350 kW<sub>r</sub> supplying chilled water to comfort conditioning systems in ECBC+ and SuperECBC Buildings shall have controls that automatically reset supply water temperatures by representative building loads (including return water temperature) or by outdoor air temperature.

Exceptions to §5.3.8.3: Controls to automatically reset chilled water temperature shall not be required where the supply temperature reset controls causes improper operation of equipment.

## 5.3.9 Controls for SuperECBC Buildings

SuperECBC Buildings shall comply with requirements of § 5.3.9 in addition to complying with requirements of § 5.2.3 and § 5.3.8.

### 5.3.9.1 Variable Air Volume Fan Control

Fans in Variable Air Volume (VAV) systems in SuperECBC Buildings shall have controls or devices that will result in fan motor demand of no more than 30% of their design wattage at 50% of design airflow based on manufacturer's certified fan data.

### 5.3.10 Energy Recovery

All Hospitality and Healthcare, with systems of capacity greater than 2,100 liters per second and minimum outdoor air supply of 70% shall have air-to-air heat recovery equipment with minimum 50% recovery effectiveness

At least 50% of heat shall be recovered from diesel and gas fired generator sets installed in Hospitality, Healthcare, and Business buildings with built up area greater than 20,000 m<sup>2</sup>.

### 5.3.11 Service Water Heating

For compliance with ECBC+ and SuperECBC,

- (a) Hospitality and Healthcare in all climatic zones shall have solar water heating equipment installed to provide at least 40% of the total hot water design capacity.
- (b) All buildings in cold climate zone with a hot water system, shall have solar water heating equipment installed to provide at least 60% of the total hot water design capacity.

Exception to §5.3.11: Systems that use heat recovery to provide the hot water capacity required as per the building type, size and efficiency level.

### 5.3.12 Total System Efficiency – Alternate Compliance Approach

Buildings may show compliance by optimizing the total system efficiency for the plant side comfort system instead of the individual equipment mentioned under the prescriptive requirement. This alternate compliance approach is applicable for central chilled water plant side system in all building types. The total installed capacity per kilo-watt refrigeration load shall be less than or equal to maximum threshold requirements as specified in Table 5-23. Equipment that can be included in central chilled water plant side system for this alternate approach are chillers, chilled water pumps, condenser water pumps, and cooling tower fan. Compliance check will be based on annual hourly simulation refer Table 9-1 for developing the proposed design.

Table 5-23 Maximum System Efficiency Threshold for ECBC, ECBC+, and SuperECBC Buildings

| <i>Water Cooled Chilled Water Plant</i> | <i>Maximum Threshold (kW/kWr)</i> |
|---|-----------------------------------|
| ECBC                                    | 0.26                              |
| ECBC+                                   | 0.23                              |
| SuperECBC                               | 0.20                              |



### 5.3.12.1 Documentation Requirement

Compliance shall be documented and compliance forms shall be submitted to the authority having jurisdiction. The information submitted shall include, at a minimum, the following:

- (a) Summary describing the results of the analysis, including the annual energy use (kWh) of chilled water plant (chillers, pumps and cooling tower) and annual chilled water use (kWh) for the Proposed Design, and software used.
- (b) Brief description of the project with location, number of stories, space types, conditioned and unconditioned areas, hours of operation.
- (c) List of the energy-related building features of the Proposed Design.
- (d) List showing compliance with the mandatory requirements of this code.
- (e) The input and output report(s) from the simulation program including an energy and chilled water usage components: space cooling and heat rejection equipment, and other HVAC equipment (such as pumps). The output reports shall also show the number of hours any loads are not met by the HVAC system the Proposed Design.
- (f) Explanation of any significant modelling assumptions made.
- (g) Explanation of any error messages noted in the simulation program output.

The total system efficiency shall be calculated as follows:

$$\text{Total System Efficiency} = \frac{\text{Chilled water plant use (kWh)}}{\text{Chilled water use (kWh)}}$$

### 5.3.13 Low-energy Comfort Systems

Alternative HVAC systems which have low energy use may be installed in place of (or in conjunction with) refrigerant-based cooling systems. Such systems shall be deemed to meet the minimum space conditioning equipment efficiency levels of §5.2.2, but shall comply with all other applicable mandatory provisions of §5.2 as applicable. Wherever applicable, requirements of §5.3 and §5.3.12 will be complied with. The approved list of low energy comfort systems<sup>1</sup> is given below:

- (a) Evaporative cooling
- (b) Desiccant cooling system
- (c) Solar air conditioning
- (d) Tri-generation (waste-to-heat)
- (e) Radiant cooling system
- (f) Ground source heat pump
- (g) Adiabatic cooling system

<sup>1</sup> This is not an all-inclusive list. The updated list of low energy comfort systems is available at BEE website (<https://www.beeindia.gov.in/>).

Buildings with an approved low-energy comfort system installed for more than 50% of the sum of cooling and heating capacity requirement of the building shall be deemed equivalent to the ECBC+ building standard prescribed in § 5.2.2.

Buildings having an approved low energy comfort system installed for more than 90% of the sum of cooling and heating capacity requirement of the building shall be deemed equivalent to the SuperECBC building standard prescribed in §5.2.2.

#### 5.3.13.1 Documentation Requirement

Compliance shall be documented and submitted to the authority having jurisdiction. The information submitted shall include, at a minimum, the following:

- (a) Summary describing the low-energy comfort system type, capacity, and efficiency.
- (b) List of showing compliance with the mandatory and prescriptive requirements other than exempted in §5.3.13.
- (c) Comparison of installed capacity of approved low-energy comfort system with other HVAC system to meet the comfort requirement of the building.

# 6 Lighting & Controls



## 6. Lighting and Controls

### 6.1 General

Lighting systems and equipment shall comply with the mandatory provisions of § 6.2 and the prescriptive criteria of § 6.3. The lighting requirements in this section shall apply to:

- (a) Interior spaces of buildings,
- (b) Exterior building features, including facades, illuminated roofs, architectural features, entrances, exits, loading docks, and illuminated canopies, and,
- (c) Exterior building grounds lighting that is provided through the building's electrical service.

Exceptions to §6.1: Emergency or security lighting that is automatically off during normal building operations.

### 6.2 Mandatory Requirements

#### 6.2.1 Lighting Control

##### 6.2.1.1 Automatic Lighting Shutoff

- (a) 90% of interior lighting fittings by wattage, in building or space of building larger than 300 m<sup>2</sup> shall be equipped with automatic control device.
- (b) Automatic control device shall function on either:
  - i. A scheduled basis at specific programmed times. An independent program schedule shall be provided for areas of no more than 2,500 m<sup>2</sup> and not more than one floor, or,
  - ii. Occupancy sensors that shall turn off the lighting fixtures within 15 minutes of an occupant leaving the space. Light fixtures controlled by occupancy sensors shall have a wall-mounted, manual switch capable of turning off lights when the space is occupied.
- (c) Additionally, occupancy sensors shall be provided in
  - i. All building types greater than 20,000 m<sup>2</sup> BUA, in
    - a. All habitable spaces less than 30 m<sup>2</sup>, enclosed by walls or ceiling height partitions.
    - b. All storage or utility spaces more than 15 m<sup>2</sup>.
    - c. Public toilets more than 25 m<sup>2</sup>, controlling at least 80 % of lighting by wattage, fitted in the toilet. The lighting fixtures, not

controlled by automatic lighting shutoff, shall be uniformly spread in the area.

- ii. Corridors of all Hospitality greater than 20,000 m<sup>2</sup> BUA, controlling minimum 70% and maximum 80% of lighting by wattage, fitted in the public corridor. The lighting fixtures, not controlled by automatic lighting shut off, shall be uniformly spread in the area.
- iii. All conference or meeting rooms.

Exception to § 6.2.1.1: Lighting systems designed for emergency and firefighting purposes.

#### 6.2.1.2 Space Control

Each space enclosed by ceiling-height partitions shall have at least one control device to independently control the general lighting within the space. Each control device shall be activated either manually by an occupant or automatically by sensing an occupant. Each control device shall

- (a) control a maximum of 250 m<sup>2</sup> for a space less than or equal to 1,000 m<sup>2</sup>, and a maximum of 1,000 m<sup>2</sup> for a space greater than 1,000 m<sup>2</sup>.
- (b) have the capability to override the shutoff control required in § 6.2.1.1 for no more than 2 hours, and
- (c) be readily accessible and located so the occupants can see the control.

Exception to § 6.2.1.2 (c): The required control device may be remotely installed if required for reasons of safety or security. A remotely located device shall have a pilot light indicator as part of or next to the control device and shall be clearly labeled to identify the controlled lighting.

#### 6.2.1.3 Control in Daylight Areas

- (a) Luminaires, installed within day lighting extent from the window as calculated in § 4.2.3, shall be equipped with either a manual control device to shut off luminaires, installed within day lit area, during potential daylit time of a day or automatic control device that:
  - i. Has a delay of minimum 5 minutes, and,
  - ii. Can dim or step down to 50% of total power.

- (b) Overrides to the daylight controls shall not be allowed.

#### 6.2.1.4 Exterior Lighting Control

- (a) Lighting for all exterior applications shall be controlled by a photo sensor or astronomical time switch that is capable of automatically turning off the exterior lighting when daylight is available or the lighting is not required.
- (b) Lighting for all exterior applications, shall have lamp efficacy not less than 80 lumens per watt for ECBC, unless the luminaire is controlled by a motion sensor or exempt under §6.1.

- (c) Façade lighting and façade non-emergency signage of Shopping Complexes shall have separate time switches.

Exemption to §6.2.1.4: Exterior Lighting systems designed for emergency and firefighting purposes.

#### 6.2.1.5 Additional Control

The following lighting applications shall be equipped with a control device to control such lighting independently of general lighting:

- (a) Display/ Accent Lighting. Display or accent lighting greater than 300 m<sup>2</sup> area shall have a separate control device.
- (b) Hotel Guest Room Lighting. Guest rooms and guest suites in a hotel shall have a master control device at the main room entry that controls all permanently installed luminaires and switched receptacles.
- (c) Task Lighting. Supplemental task lighting including permanently installed under shelf or under cabinet lighting shall have a control device integral to the luminaires or be controlled by a wall-mounted control device provided the control device complies with §6.2.1.2.
- (d) Nonvisual Lighting. Lighting for nonvisual applications, such as plant growth and food-warming, shall be equipped with a separate control device.
- (e) Demonstration Lighting. Lighting equipment that is for sale or for demonstrations in lighting education shall be equipped with a separate control device accessible only to authorized personnel.

### 6.2.2 Exit Signs

Internally-illuminated exit signs shall not exceed 5 Watts per face.

## 6.3 Prescriptive Requirements

### 6.3.1 Interior Lighting Power

The installed interior lighting power for a building or a separately metered or permitted portion of a building shall be calculated in accordance with §6.3.4 and shall not exceed the interior lighting power allowance determined in accordance with either §6.3.2 or §6.3.3.

Exception to §6.3: The following lighting equipment and applications shall not be considered when determining the interior lighting power allowance, nor shall the wattage for such lighting be included in the installed interior lighting power. However, any such lighting shall not be exempt unless it is an addition to general lighting and is controlled by an independent control device.

- (a) Display or accent lighting that is an essential element for the function performed in galleries, museums, and monuments,
- (b) Lighting that is integral to equipment or instrumentation and is installed by its manufacturer,

- (c) Lighting specifically designed for medical or dental procedures and lighting integral to medical equipment,
- (d) Lighting integral to food warming and food preparation equipment,
- (e) Lighting for plant growth or maintenance,
- (f) Lighting in spaces specifically designed for use by the visually impaired,
- (g) Lighting in retail display windows, provided the display area is enclosed by ceiling-height partitions,
- (h) Lighting in interior spaces that have been specifically designated as a registered interior historic landmark,
- (i) Lighting that is an integral part of advertising or directional signage,
- (j) Exit signs,
- (k) Lighting that is for sale or lighting educational demonstration systems,
- (l) Lighting for theatrical purposes, including performance, stage, and film or video production, and
- (m) Athletic playing areas with permanent facilities for television broadcasting.

### **6.3.2 Building Area Method**

Determination of interior lighting power allowance (watts) by the building area method shall be in accordance with the following:

- (a) Determine the allowed lighting power density for each appropriate building area type from Table 6-1 for ECBC Buildings, from Table 6-2 for ECBC+ Buildings and from Table 6-3 for SuperECBC Buildings.
- (b) Calculate the gross lighted area for each building area type.
- (c) The interior lighting power allowance is the sum of the products of the gross lighted floor area of each building area times the allowed lighting power density for that building area type.

Table 6-1 Interior Lighting Power for ECBC Buildings – Building Area Method

| <i>Building Type</i>  | <i>LPD (W/m<sup>2</sup>)</i> | <i>Building Area Type</i> | <i>LPD (W/m<sup>2</sup>)</i> |
|---|------------------------------|---------------------------|------------------------------|
| Office Building   | 9.5                          | Motion picture theater    | 9.43                         |
| Hospitals   | 9.7                          | Museum                    | 10.2                         |
| Hotels  | 9.5                          | Post office               | 10.5                         |
| Shopping Mall   | 14.1                         | Religious building        | 12.0                         |
| University and Schools  | 11.2                         | Sports arena              | 9.7                          |
| Library   | 12.2                         | Transportation            | 9.2                          |
| Dining: bar lounge/leisure  | 12.2                         | Warehouse                 | 7.08                         |
| Dining: cafeteria/fast food   | 11.5                         | Performing arts theater   | 16.3                         |
| Dining: family  | 10.9                         | Police station            | 9.9                          |
| Dormitory   | 9.1                          | Workshop                  | 14.1                         |
| Fire station  | 9.7                          | Automotive facility       | 9.0                          |
| Gymnasium   | 10.0                         | Convention center         | 12.5                         |
| Manufacturing facility  | 12.0                         | Parking garage            | 3.0                          |
| In cases where both a general building area type and a specific building area type are listed, the specific building area type shall apply. |                              |                           |                              |

Table 6-2 Interior Lighting Power for ECBC+ Buildings – Building Area Method

| <i>Building Area Type</i>   | <i>LPD (W/m<sup>2</sup>)</i> | <i>Building Area Type</i> | <i>LPD (W/m<sup>2</sup>)</i> |
|---|------------------------------|---------------------------|------------------------------|
| Office Building   | 7.6                          | Motion picture theater    | 7.5                          |
| Hospitals   | 7.8                          | Museum                    | 8.2                          |
| Hotels  | 7.6                          | Post office               | 8.4                          |
| Shopping Mall   | 11.3                         | Religious building        | 9.6                          |
| University and Schools  | 9.0                          | Sports arena              | 7.8                          |
| Library   | 9.8                          | Transportation            | 7.4                          |
| Dining: bar lounge/leisure  | 9.8                          | Warehouse                 | 5.7                          |
| Dining: cafeteria/fast food   | 9.2                          | Performing arts theater   | 13.0                         |
| Dining: family  | 8.7                          | Police station            | 7.9                          |
| Dormitory   | 7.3                          | Workshop                  | 11.3                         |
| Fire station  | 7.8                          | Automotive facility       | 7.2                          |
| Gymnasium   | 8.0                          | Convention center         | 10.0                         |
| Manufacturing facility  | 9.6                          | Parking garage            | 2.4                          |
| In cases where both a general building area type and a specific building area type are listed, the specific building area type shall apply. |                              |                           |                              |



Table 6-3 Interior Lighting Power for SuperECBC Buildings – Building Area Method

| <i>Building Area Type</i>   | <i>LPD (W/m<sup>2</sup>)</i> | <i>Building Area Type</i> | <i>LPD (W/m<sup>2</sup>)</i> |
|---|------------------------------|---------------------------|------------------------------|
| Office Building   | 5.0                          | Motion picture theater    | 4.7                          |
| Hospitals   | 4.9                          | Museum                    | 5.1                          |
| Hotels  | 4.8                          | Post office               | 5.3                          |
| Shopping Mall   | 7.0                          | Religious building        | 6.0                          |
| University and Schools  | 6.0                          | Sports arena              | 4.9                          |
| Library   | 6.1                          | Transportation            | 4.6                          |
| Dining: bar lounge/leisure  | 6.1                          | Warehouse                 | 3.5                          |
| Dining: cafeteria/fast food   | 5.8                          | Performing arts theater   | 8.2                          |
| Dining: family  | 5.5                          | Police station            | 5.0                          |
| Dormitory   | 4.6                          | Workshop                  | 7.1                          |
| Fire station  | 4.9                          | Automotive facility       | 4.5                          |
| Gymnasium   | 5.0                          | Convention center         | 6.3                          |
| Manufacturing facility  | 6.0                          | Parking garage            | 1.5                          |
| In cases where both a general building area type and a specific building area type are listed, the specific building area type shall apply. |                              |                           |                              |

### 6.3.3 Space Function Method

Determination of interior lighting power allowance (watts) by the space function method shall be in accordance with the following:

- Determine the appropriate building type and the allowed lighting power density from Table 6-4 for ECBC Buildings, Table 6-5 for ECBC+ Buildings and, Table 6-6 for SuperECBC Buildings. In cases where both a common space type and building specific space type are listed, building specific space type LPD shall apply.
- For each space, enclosed by partitions 80% or greater than ceiling height, determine the gross lighted floor area by measuring to the center of the partition wall. Include the area of balconies or other projections. Retail spaces do not have to comply with the 80% partition height requirements.
- The interior lighting power allowance is the sum of the lighting power allowances for all spaces. The lighting power allowance for a space is the product of the gross lighted floor area of the space times the allowed lighting power density for that space.

Table 6-4 Interior Lighting Power for ECBC Buildings – Space Function Method

| Category                            | LPD (W/m <sup>2</sup> ) | Lamp category                            | LPD (W/m <sup>2</sup> ) |
|-------------------------------------|-------------------------|--|-------------------------|
| Common Space Types                  |                         |  |                         |
| Restroom                            | 7.7                     | Stairway                                 | 5.5                     |
| Storage                             | 6.8                     | Corridor/Transition                      | 7.1                     |
| Conference/ Meeting                 | 11.5                    | Lobby                                    | 9.1                     |
| Parking Bays<br>(covered/ basement) | 2.2                     | Parking Driveways (covered/<br>basement) | 3.0                     |
| Electrical/Mechanical               | 7.1                     | Workshop                                 | 17.1                    |
| Business                            |                         |  |                         |
| Enclosed                            | 10.0                    | Open Plan                                | 10.0                    |
| Banking Activity Area               | 12.6                    | Service/Repair                           | 6.8                     |
| Healthcare                          |                         |  |                         |
| Emergency                           | 22.8                    | Recovery                                 | 8.6                     |
| Exam/Treatment                      | 13.7                    | Storage                                  | 5.5                     |
| Nurses' Station                     | 9.4                     | Laundry/Washing                          | 7.5                     |
| Operating Room                      | 21.8                    | Lounge/Recreation                        | 8.0                     |
| Patient Room                        | 7.7                     | Medical Supply                           | 13.7                    |
| Pharmacy                            | 10.7                    | Nursery                                  | 5.7                     |
| Physical Therapy                    | 9.7                     | Corridor/Transition                      | 9.1                     |
| Radiology/Imaging                   | 9.1                     |  |                         |
| Hospitality                         |                         |  |                         |
| Hotel Dining                        | 9.1                     | Hotel Lobby                              | 10.9                    |
| For Bar Lounge/<br>Dining           | 14.1                    | Motel Dining                             | 9.1                     |
| For food preparation                | 12.1                    | Motel Guest Rooms                        | 7.7                     |
| Hotel Guest Rooms                   | 9.1                     |  |                         |
| Shopping Complex                    |                         |  |                         |
| Mall Concourse                      | 12.8                    | For Family Dining                        | 10.9                    |
| Sales Area                          | 18.3                    | For food preparation                     | 12.1                    |
| Motion Picture<br>Theatre           | 9.6                     | Bar Lounge/ Dining                       | 14.1                    |
| Educational                         |                         |  |                         |
| Classroom/Lecture                   | 13.7                    | Card File and Cataloguing                | 9.1                     |
| For Classrooms                      | 13.8                    | Stacks (Lib)                             | 18.3                    |
| Laboratory                          | 15.1                    | Reading Area (Library)                   | 10.0                    |

| Category                          | LPD (W/m <sup>2</sup> ) | Lamp category                          | LPD (W/m <sup>2</sup> ) |
|-----------------------------------|-------------------------|--|-------------------------|
| <b>Assembly</b>                   |                         |  |                         |
| Dressing Room                     | 9.1                     | Seating Area - Performing Arts Theatre | 22.6                    |
| Exhibit Space - Convention Centre | 14.0                    | Lobby - Performing Arts Theatre        | 21.5                    |
| Seating Area - Gymnasium          | 4.6                     | Seating Area - Convention Centre       | 6.4                     |
| Fitness Area - Gymnasium          | 13.7                    | Seating Religious Building             | 16.4                    |
| Museum - General Exhibition       | 16.4                    | Playing Area - Gymnasium               | 18.8                    |
| Museum - Restoration              | 18.3                    |  |                         |

Table 6-5 Interior Lighting Power for ECBC+ Buildings – Space Function Method

| Category                        | LPD (W/m <sup>2</sup> ) | Lamp category                         | LPD (W/m <sup>2</sup> ) |
|---------------------------------|-------------------------|---------------------------------------|-------------------------|
| <b>Common Space Types</b>       |                         |                                       |                         |
| Restroom                        | 6.1                     | Stairway                              | 4.4                     |
| Storage                         | 5.4                     | Corridor/Transition                   | 3.6                     |
| Conference/ Meeting             | 9.2                     | Lobby                                 | 7.3                     |
| Parking Bay (covered/ basement) | 1.8                     | Parking Driveways (covered/ basement) | 2.5                     |
| Electrical/Mechanical           | 5.7                     | Workshop                              | 13.7                    |
| <b>Business</b>                 |                         |                                       |                         |
| Enclosed                        | 8.6                     | Open Plan                             | 8.6                     |
| Banking Activity Area           | 9.3                     | Service/Repair                        | 5.5                     |
| <b>Healthcare</b>               |                         |                                       |                         |
| Emergency                       | 18.2                    | Recovery                              | 7.0                     |
| Exam/Treatment                  | 10.9                    | Storage                               | 4.4                     |
| Nurses' Station                 | 7.5                     | Laundry/Washing                       | 6.0                     |
| Operating Room                  | 17.5                    | Lounge/Recreation                     | 6.4                     |
| Patient Room                    | 6.1                     | Medical Supply                        | 10.9                    |
| Pharmacy                        | 8.5                     | Nursery                               | 4.6                     |
| Physical Therapy                | 7.8                     | Corridor/Transition                   | 7.3                     |
| Radiology/Imaging               | 7.3                     |                                       |                         |
| <b>Hospitality</b>              |                         |                                       |                         |
| Hotel Dining                    | 7.3                     | Hotel Lobby                           | 8.8                     |
| For Bar Lounge/ Dining          | 11.3                    | Motel Dining                          | 7.3                     |

| <i>Category</i>                   | <i>LPD (W/m<sup>2</sup>)</i> | <i>Lamp category</i>                   | <i>LPD (W/m<sup>2</sup>)</i> |
|-----------------------------------|------------------------------|--|------------------------------|
| For food preparation              | 12.1                         | Motel Guest Rooms                      | 6.1                          |
| Hotel Guest Rooms                 | 7.3                          |  |                              |
| <b>Shopping Complex</b>           |                              |  |                              |
| Mall Concourse                    | 10.2                         | For Family Dining                      | 8.8                          |
| Sales Area                        | 14.6                         | For food preparation                   | 12.1                         |
| Motion Picture Theatre            | 10.3                         | Bar Lounge/ Dining                     | 11.3                         |
| <b>Educational</b>                |                              |  |                              |
| Classroom/Lecture                 | 10.9                         | Card File and Cataloguing              | 7.3                          |
| For Classrooms                    | 11.0                         | Stacks (Library)                       | 14.6                         |
| Laboratory                        | 12.1                         | Reading Area (Library)                 | 9.2                          |
| <b>Assembly</b>                   |                              |  |                              |
| Dressing Room                     | 7.3                          | Seating Area - Performing Arts Theatre | 18.1                         |
| Exhibit Space - Convention Centre | 11.2                         | Lobby - Performing Arts Theatre        | 17.2                         |
| Seating Area - Gymnasium          | 3.6                          | Seating Area – Convention Centre       | 5.1                          |
| Fitness Area - Gymnasium          | 7.9                          | Seating Religious Building             | 13.1                         |
| Museum - General Exhibition       | 11.3                         | Playing Area - Gymnasium               | 12.9                         |
| Museum - Restoration              | 11.0                         |  |                              |

Table 6-6 Interior Lighting Power for SuperECBC Buildings – Space Function Method

| <i>Category</i>                  | <i>LPD (W/m<sup>2</sup>)</i> | <i>Lamp category</i>          | <i>LPD (W/m<sup>2</sup>)</i> |
|----------------------------------|------------------------------|-------------------------------|------------------------------|
| <b>Common Space Types</b>        |                              |                               |                              |
| Restrooms                        | 3.8                          | Stairway                      | 2.7                          |
| Storage                          | 3.4                          | Corridor/Transition           | 2.3                          |
| Conference/ Meeting              | 5.7                          | Lobby                         | 4.6                          |
| Parking Bays (covered/ basement) | 1.1                          | Driveways (covered/ basement) | 1.5                          |
| Electrical/Mechanical            | 3.5                          | Workshop                      | 8.6                          |
| <b>Business</b>                  |                              |                               |                              |
| Enclosed                         | 5.4                          | Open Plan                     | 5.4                          |
| Banking Activity Area            | 5.8                          | Service/Repair                | 3.4                          |
| <b>Healthcare</b>                |                              |                               |                              |
| Emergency                        | 11.4                         | Recovery                      | 4.4                          |
| Exam/Treatment                   | 6.8                          | Storage                       | 2.7                          |
| Nurses' Station                  | 5.0                          | Laundry/Washing               | 3.8                          |

| Category                          | LPD (W/m <sup>2</sup> ) | Lamp category                          | LPD (W/m <sup>2</sup> ) |
|-----------------------------------|-------------------------|--|-------------------------|
| Operating Room                    | 10.9                    | Lounge/Recreation                      | 4.6                     |
| Patient Room                      | 3.8                     | Medical Supply                         | 6.8                     |
| Pharmacy                          | 5.3                     | Nursery                                | 2.9                     |
| Physical Therapy                  | 4.9                     | Corridor/Transition                    | 4.6                     |
| Radiology/Imaging                 | 4.6                     |  |                         |
| <b>Hospitality</b>                |                         |  |                         |
| Hotel Dining                      | 4.6                     | Hotel Lobby                            | 5.5                     |
| For Bar Lounge/ Dining            | 7.0                     | Motel Dining                           | 4.6                     |
| For food preparation              | 7.5                     | Motel Guest Rooms                      | 3.8                     |
| Hotel Guest Rooms                 | 4.6                     |  |                         |
| <b>Shopping Complex</b>           |                         |  |                         |
| Mall Concourse                    | 6.4                     | For Family Dining                      | 5.5                     |
| Sales Area                        | 9.2                     | For food preparation                   | 7.5                     |
| Motion Picture Theatre            | 6.5                     | Bar Lounge/ Dining                     | 7.0                     |
| <b>Educational</b>                |                         |  |                         |
| Classroom/Lecture                 | 6.8                     | Card File and Cataloguing              | 4.6                     |
| For Classrooms                    | 6.9                     | Stacks (Library)                       | 9.2                     |
| Laboratory                        | 7.5                     | Reading Area (Library)                 | 5.7                     |
| <b>Assembly</b>                   |                         |  |                         |
| Dressing Room                     | 4.6                     | Seating Area - Performing Arts Theatre | 11.3                    |
| Exhibit Space – Convention Centre | 7.0                     | Lobby - Performing Arts Theatre        | 10.8                    |
| Seating Area - Gymnasium          | 3.4                     | Seating Area – Convention Centre       | 3.2                     |
| Fitness Area - Gymnasium          | 3.9                     | Seating Religious Building             | 8.2                     |
| Museum – General Exhibition       | 5.7                     | Playing Area - Gymnasium               | 6.5                     |
| Museum – Restoration              | 5.5                     |  |                         |

*Note 6-1 Calculating Interior Lighting Power – Space Function Method*



A four-story building has retail on the ground floor and offices on the top three floors. Area is 3,598 m<sup>2</sup>. Space types and their respective areas are mentioned below. Steps for calculating interior lighting power allowance using the space function method for a ECBC building is described below.

For each of the space type, corresponding Lighting Power Density (LPD) values for Business and Shopping complex building type from

Table 6-4 are used. Area is multiplied with the LPD values to estimate the lighting power allowance for the whole building. It is 40,242 W.

*Table 6-1-1 Space Types, Areas and Corresponding LPDs*

| Space Function         | LPD (W/ m <sup>2</sup> ) | Area (m <sup>2</sup> ) | Lighting Power Allowance (W) |
|------------------------|--------------------------|------------------------|------------------------------|
| <b>Office</b>          |                          |                        |                              |
| Office - enclosed      | 10.0                     | 720                    | 7,200                        |
| Office – open plan     | 10.0                     | 1,485                  | 14,850                       |
| Meeting Rooms          | 11.5                     | 120                    | 1,380                        |
| Lobbies                | 9.1                      | 93                     | 846                          |
| Restrooms              | 7.7                      | 51                     | 393                          |
| Corridors              | 7.1                      | 125                    | 888                          |
| Electrical/ Mechanical | 7.1                      | 14                     | 99                           |
| Staircase              | 5.5                      | 84                     | 462                          |
| <b>Total</b>           |                          |                        | <b>26,118</b>                |
| <b>Retail</b>          |                          |                        |                              |
| General sales area     | 18.3                     | 669                    | 12,243                       |
| Offices - enclosed     | 10.0                     | 28                     | 280                          |
| Restrooms              | 7.7                      | 9                      | 69                           |
| Corridors              | 7.1                      | 79                     | 561                          |
| Storage                | 6.8                      | 93                     | 632                          |
| Food preparation       | 12.1                     | 28                     | 339                          |
| <b>Total</b>           |                          |                        | <b>14,124</b>                |
| <b>Building Total</b>  |                          |                        | <b>40,242 W</b>              |

### 6.3.4 Installed Interior Lighting Power

The installed interior lighting power calculated for compliance with §6.3 shall include all power used by the luminaires, including lamps, ballasts, current regulators, and control devices except as specifically exempted in §6.1.

Exception to §6.3.4: If two or more independently operating lighting systems in a space are controlled to prevent simultaneous user operation, the installed interior lighting power shall be based solely on the lighting system with the highest power.

#### 6.3.4.1 Luminaire Wattage

Light output ratio shall be 0.7 or above. Luminaire wattage incorporated into the installed interior lighting power shall be determined in accordance with the following:

- (a) The wattage of incandescent luminaires with medium base sockets and not containing permanently installed ballasts shall be the maximum labeled wattage of the luminaires.
- (b) The wattage of luminaires containing permanently installed ballasts shall be the operating input wattage of the specified lamp/ballast combination. Operating input wattage can be either values from manufacturers' catalogs or values from independent testing laboratory reports.
- (c) The wattage of all other miscellaneous luminaire types not described in (a) or (b) shall be the specified wattage of the luminaires.
- (d) The wattage of lighting track, plug-in busway, and flexible-lighting systems that allow the addition and/ or relocation of luminaires without altering the wiring of the system shall be the larger of the specified wattage of the luminaires included in the system or 135 Watt per meter. Systems with integral overload protection, such as fuses or circuit breakers, shall be rated at 100% of the maximum rated load of the limiting device.

### 6.3.5 Exterior Lighting Power

Connected lighting power of exterior lighting applications shall not exceed the lighting power limits specified in Table 6-7 for ECBC Buildings, Table 6-8 for ECBC+ Buildings and Table 6-9 for SuperECBC Buildings. Trade-offs between applications are not permitted.

Table 6-7 Exterior Building Lighting Power for ECBC Buildings

| <i>Exterior lighting application</i>               | <i>Power limits</i>                          |
|--|--|
| Building entrance (with canopy)                    | 10 W/m <sup>2</sup> of canopied area         |
| Building entrance (w/o canopy)                     | 90 W/ linear m of door width                 |
| Building exit                                      | 60 W/lin m of door width                     |
| Building façade                                    | 5.0 W/m <sup>2</sup> of vertical façade area |
| Emergency signs, ATM kiosks, Security areas façade | 1.0 W/m <sup>2</sup>                         |
| Driveways and parking (open/ external)             | 1.6 W/m <sup>2</sup>                         |
| Pedestrian walkways                                | 2.0 W/m <sup>2</sup>                         |
| Stairways  | 10.0 W/m <sup>2</sup>                        |
| Landscaping  | 0.5 W/m <sup>2</sup>                         |
| Outdoor sales area                                 | 9.0 W/m <sup>2</sup>                         |

Table 6-8 Exterior Building Lighting Power for ECBC+ Buildings

| <i>Exterior lighting application</i>               | <i>Power limits</i>                          |
|--|--|
| Building entrance (with canopy)                    | 8.0 W/m <sup>2</sup> of canopied area        |
| Building entrance (w/o canopy)                     | 72 W/ linear m of door width                 |
| Building exit                                      | 48 W/lin m of door width                     |
| Building façade                                    | 4.0 W/m <sup>2</sup> of vertical façade area |
| Emergency signs, ATM kiosks, Security areas façade | 0.8 W/m <sup>2</sup>                         |
| Driveways and parking (open/ external)             | 1.3 W/m <sup>2</sup>                         |
| Pedestrian walkways                                | 1.6 W/m <sup>2</sup>                         |
| Stairways  | 8.0 W/m <sup>2</sup>                         |
| Landscaping  | 0.4 W/m <sup>2</sup>                         |
| Outdoor sales area                                 | 7.2 W/m <sup>2</sup>                         |

Table 6-9 Exterior Building Lighting Power for SuperECBC Buildings

| <i>Exterior lighting application</i>               | <i>Power limits</i>                          |
|--|--|
| Building entrance (with canopy)                    | 5.0 W/m <sup>2</sup> of canopied area        |
| Building entrance (w/o canopy)                     | 45 W/ linear m of door width                 |
| Building exit                                      | 30 W/lin m of door width                     |
| Building façade                                    | 2.5 W/m <sup>2</sup> of vertical façade area |
| Emergency signs, ATM kiosks, Security areas façade | 0.5 W/m <sup>2</sup>                         |
| Driveways and parking (open/ external)             | 0.8 W/m <sup>2</sup>                         |
| Pedestrian walkways                                | 1.0 W/m <sup>2</sup>                         |
| Stairways  | 5.0 W/m <sup>2</sup>                         |
| Landscaping  | 0.25 W/m <sup>2</sup>                        |
| Outdoor sales area                                 | 4.5 W/m <sup>2</sup>                         |



### **6.3.6 Controls for ECBC+ and SuperECBC Buildings**

ECBC+ and SuperECBC Buildings shall comply with requirements of § 6.3.6 in addition to complying with requirements of § 6.2.

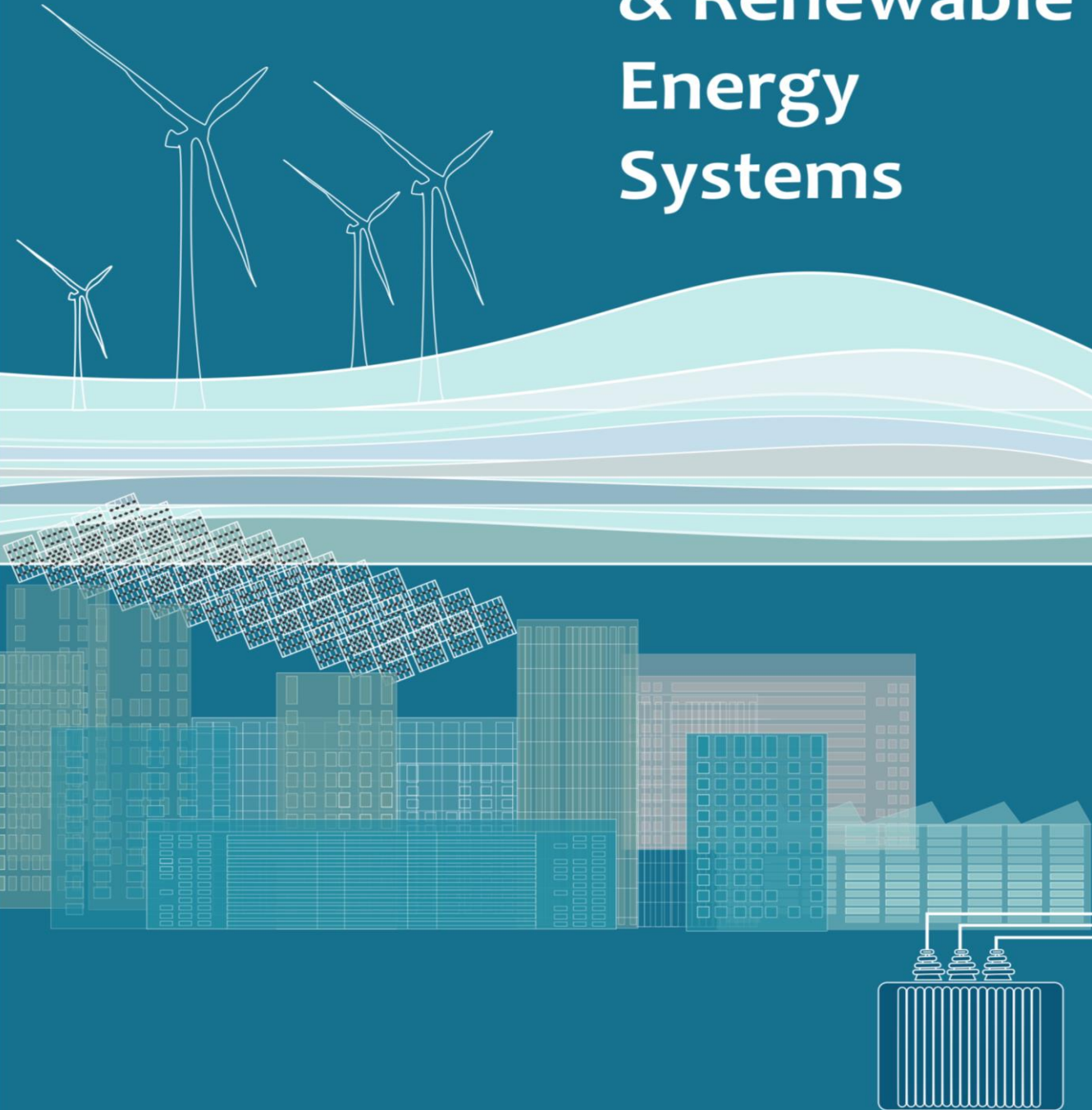
#### **6.3.6.1 Centralized Controls**

ECBC+ and SuperECBC building shall have centralized control system for schedule based automatic lighting shutoff switches.

#### **6.3.6.2 Exterior Lighting Controls**

Lighting for all exterior applications, shall have lamp efficacy not less than 80 lumens per watt, 90 lumens per watt, and 100 lumens per watt, for ECBC, ECBC+, and SuperECBC Buildings respectively, unless the luminaire is controlled by a motion sensor or exempt under §6.1.

# 7 Electrical & Renewable Energy Systems



## 7. Electrical and Renewable Energy Systems

### 7.1 General

All electric and renewable energy equipment and systems shall comply with the mandatory requirements of §7.2.

### 7.2 Mandatory Requirements

#### 7.2.1 Transformers

##### 7.2.1.1 Maximum Allowable Power Transformer Losses

Power transformers of the proper ratings and design must be selected to satisfy the minimum acceptable efficiency at 50% and full load rating. The permissible loss shall not exceed to values listed in Table 7-1 for dry type transformers and Table 7-2 for oil type transformers.

Table 7-1 Permissible Losses for Dry Type Transformers

| Rating<br>kVA | Max. Losses at<br>50% loading<br>W* | Max. Losses at<br>100% loading<br>W* | Max. Losses at<br>50% loading<br>W* | Max. Losses at<br>100% loading<br>W* |
|---------------|-------------------------------------|--------------------------------------|-------------------------------------|--------------------------------------|
|               | Up to 22 kV class                   |                                      | 33 kV class                         |                                      |
| <b>100</b>    | 940                                 | 2,400                                | 1,120                               | 2,400                                |
| <b>160</b>    | 1,290                               | 3,300                                | 1,420                               | 3,300                                |
| <b>200</b>    | 1,500                               | 3,800                                | 1,750                               | 4,000                                |
| <b>250</b>    | 1,700                               | 4,320                                | 1,970                               | 4,600                                |
| <b>315</b>    | 2,000                               | 5,040                                | 2,400                               | 5,400                                |
| <b>400</b>    | 2,380                               | 6,040                                | 2,900                               | 6,800                                |
| <b>500</b>    | 2,800                               | 7,250                                | 3,300                               | 7,800                                |
| <b>630</b>    | 3,340                               | 8,820                                | 3,950                               | 9,200                                |
| <b>800</b>    | 3,880                               | 10,240                               | 4,650                               | 11,400                               |
| <b>1,000</b>  | 4,500                               | 12,000                               | 5,300                               | 12,800                               |
| <b>1,250</b>  | 5,190                               | 13,870                               | 6,250                               | 14,500                               |
| <b>1,600</b>  | 6,320                               | 16,800                               | 7,500                               | 18,000                               |
| <b>2,000</b>  | 7,500                               | 20,000                               | 8,880                               | 21,400                               |
| <b>2,500</b>  | 9,250                               | 24,750                               | 10,750                              | 26,500                               |

\* The values as per Indian Standard/BEE Standard & Labeling notification for dry type transformer corresponding to values in this table will supersede as and when the Indian standards/ BEE Standard & Labeling notification are published.

Table 7-2 Permissible Losses for Oil Type Transformers.

| Rating (kVA) | Impedance (%) | Max. Total Loss (W) for transformers up to 11 kV class |           |                |           |                    |           |
|--------------|---------------|--|-----------|----------------|-----------|--------------------|-----------|
|              |               | ECBC Building  |           | ECBC+ Building |           | SuperECBC Building |           |
|              |               | 50 % Load  | 100% Load | 50 % Load      | 100% Load | 50 % Load          | 100% Load |
| 16           | 4.5           | 135  | 440       | 108            | 364       | 87                 | 301       |
| 25           | 4.5           | 190  | 635       | 158            | 541       | 128                | 448       |
| 63           | 4.5           | 340  | 1,140     | 270            | 956       | 219                | 791       |
| 100          | 4.5           | 475  | 1,650     | 392            | 1,365     | 317                | 1,130     |
| 160          | 4.5           | 670  | 1,950     | 513            | 1,547     | 416                | 1,281     |
| 200          | 4.5           | 780  | 2,300     | 603            | 1,911     | 488                | 1,582     |
| 250          | 4.5           | 980  | 2,930     | 864            | 2,488     | 761                | 2,113     |
| 315          | 4.5           | 1,025  | 3,100     | 890            | 2,440     | 772                | 1,920     |
| 400          | 4.5           | 1,225  | 3,450     | 1,080          | 3,214     | 951                | 2,994     |
| 500          | 4.5           | 1,510  | 4,300     | 1,354          | 3,909     | 1,215              | 3,554     |
| 630          | 4.5           | 1,860  | 5,300     | 1,637          | 4,438     | 1,441              | 3,717     |
| 1,000        | 5             | 2,790  | 7,700     | 2,460          | 6,364     | 2,170              | 5,259     |
| 1,250        | 5             | 3,300  | 9,200     | 3,142          | 7,670     | 2,991              | 6,394     |
| 1,600        | 6.25          | 4,200  | 11,800    | 3,753          | 10,821    | 3,353              | 9,924     |
| 2,000        | 6.25          | 5,050  | 15,000    | 4,543          | 13,254    | 4,088              | 11,711    |
| 2,500        | 6.25          | 6,150  | 18,500    | 5,660          | 16,554    | 5,209              | 14,813    |

Total loss values given in above table are applicable for thermal classes E, B and F and have component of load loss at reference temperature according to Clause 17 of IS 1180 i.e., average winding temperature rise as given in Column 2 of Table 8.2 plus 300C. An increase of 7% on total for thermal class H is allowed.

Permissible total loss values shall not exceed:

- 5% of the maximum total loss values mentioned in IS 1180 for oil type transformers in voltage class above 11 kV but not more than 22 kV
- 7.5% of the maximum total loss values mentioned in above IS 1180 for oil type transformers in voltage class above 22 kV and up to and including 33 kV

### 7.2.1.2 Measurement and Reporting of Transformer Losses

All measurement of losses shall be carried out by using calibrated digital meters of class 0.5 or better accuracy and certified by the manufacturer. All transformers of capacity of 500 kVA and above would be equipped with additional metering class current transformers (CTs) and potential transformers (PTs) additional to requirements of Utilities so that periodic loss monitoring study may be carried out.

### 7.2.1.3 Voltage Drop

Voltage drop for feeders shall not exceed 2% at design load. Voltage drop for branch circuit shall not exceed 3% at design load.

## 7.2.2 Energy Efficient Motors

Motors shall comply with the following:

- (a) Three phase induction motors shall conform to Indian Standard (IS) 12615 and shall fulfil the following efficiency requirements:
  - i. ECBC Buildings shall have motors of IE 2 (high efficiency) class or a higher class
  - ii. ECBC+ Buildings shall have IE 3 (premium efficiency) class motors or higher class
  - iii. SuperECBC Buildings shall have IE 4 (super premium efficiency) class motors
- (b) Motors of horsepower differing from those listed in the table shall have efficiency greater than that of the next listed kW motor.
- (c) Motor horsepower ratings shall not exceed 20% of the calculated maximum load being served.
- (d) Motor nameplates shall list the nominal full-load motor efficiencies and the full-load power factor.

## 7.2.3 Diesel Generator (DG) Sets

BEE star rated DG sets shall be used in all compliant buildings. DG sets in buildings greater than 20,000 m<sup>2</sup> BUA shall have:

- (a) minimum 3 stars rating in ECBC Buildings
- (b) minimum 4 stars rating in ECBC+ Buildings
- (c) 5 stars rating in SuperECBC Buildings

## 7.2.4 Check-Metering and Monitoring

At Building mains, installed meters must be capable of monitoring Energy use (kWh), Energy Demand (kW) and total Power Factor on an hourly basis. For sub-meters installed at building services, the following metering requirements must be complied with:

- (a) Services exceeding 1,000 kVA shall have permanently installed electrical metering to record demand (kVA), energy (kWh), and total power factor on hourly basis. The metering shall also display current (in each phase and the neutral), voltage (between phases and between each phase and neutral), and total harmonic distortion (THD) as a percentage of total current.
- (b) Services not exceeding 1,000 kVA but over 65 kVA shall have permanently installed electric metering to record demand (kW), energy (kWh), and total power factor (or kVARh) on hourly basis.

- (c) Services not exceeding 65 kVA shall have permanently installed electrical metering to record energy (kWh) on hourly basis.

Sub-metering requirements for different services are outlined in Table 7-3.

*Table 7-3 Sub Metering: Minimum requirement for separation of electrical load*

|                                | <i>Building Contract Demand</i> |                             |
|--------------------------------|---------------------------------|-----------------------------|
|                                | <i>120 kVA to 250 kVA</i>       | <i>Greater than 250 kVA</i> |
| HVAC system and components     | Required                        | Required                    |
| Interior and Exterior Lighting | Not required                    | Required                    |
| Domestic hot water             | Not required                    | Required                    |
| Plug loads                     | Not required                    | Required                    |
| Renewable power source         | Required                        | Required                    |

In addition to requirements stated above, for building types identified in Table 7-4, respective services must be sub-metered.

*Table 7-4 Additional sub-metering requirements for specific building types*

| <i>Mandatory requirement of sub- metering of services for specific building types</i> |                                    |
|---|------------------------------------|
| Shopping Complex  | Façade lighting                    |
| Shopping Complex  | Elevator, escalators, moving walks |
| Business  | Data centers                       |
| Hospitality   | Commercial kitchens                |

For tenant-based building, tenants must be provided with tap-off points to install electrical sub-meters.

### **7.2.5 Power Factor Correction**

All 3 phase shall maintain their power factor at the point of connection as follows:

- (a) 0.97 for ECBC Building
- (b) 0.98 for ECBC+ building
- (c) 0.99 for SuperECBC building

### **7.2.6 Power Distribution Systems**

The power cabling shall be sized so that the distribution losses do not exceed

- (a) 3% of the total power usage in ECBC Buildings
- (b) 2% of the total power usage in ECBC+ Buildings

## (c) 1% of total power usage in SuperECBC Buildings

Record of design calculation for the losses shall be maintained. Load calculation shall be calculated up to the panel level.

## 7.2.7 Uninterruptible Power Supply (UPS)

In all buildings, UPS shall meet or exceed the energy efficiency requirements listed in Table 7-5. Any Standards and Labeling program by BEE shall take precedence over requirements listed in this section.

Table 7-5 Energy Efficiency Requirements for UPS for ECBC, ECBC+, SuperECBC building

| UPS Size       | Energy Efficiency Requirements at 100% Load |
|----------------|---|
| kVA < 20       | 90.2%                                       |
| 20 ≤ kVA ≤ 100 | 91.9%                                       |
| kVA > 100      | 93.8%                                       |

## 7.2.8 Renewable Energy Systems

All buildings shall have provisions for installation of renewable energy systems in the future on rooftops or the site.

### 7.2.8.1 Renewable Energy Generating Zone (REGZ)

- A dedicated REGZ equivalent to at least 25 % of roof area or area required for generation of energy equivalent to 1% of total peak demand or connected load of the building, whichever is less, shall be provided in all buildings.
- The REGZ shall be free of any obstructions within its boundaries and from shadows cast by objects adjacent to the zone
- ECBC+ and SuperECBC building shall fulfil the additional requirements listed in Table 7-6 and Table 7-7 respectively.

Table 7-6 Minimum Renewable Contribution towards meeting Contract Demand in ECBC+ Building

| Building Type                          | Minimum Capacity to be Installed in REGZ |
|--|--|
| All building types except below        | Minimum 2% of total Contract Demand      |
| Star Hotel > 20,000 m <sup>2</sup> AGA | Minimum 3% of total Contract Demand      |
| Resort > 12,500 m <sup>2</sup> AGA     |  |
| University > 20,000 m <sup>2</sup> AGA |  |
| Business > 20,000 m <sup>2</sup> AGA   |  |

Table 7-7 Minimum Renewable Contribution towards meeting Contract Demand in SuperECBC Building

| <i>Building Type</i>                   | <i>Minimum Capacity to be Installed in REGZ</i> |
|--|---|
| All Building types except below        | Minimum 4% of total Contract Demand             |
| Star Hotel > 20,000 m <sup>2</sup> AGA | Minimum 6% of total Contract Demand             |
| Resort > 12,500 m <sup>2</sup> AGA     |   |
| University > 20,000 m <sup>2</sup> AGA |   |
| Business > 20,000 m <sup>2</sup> AGA   |   |

#### 7.2.8.2 Main Electrical Service Panel

Minimum rating shall be displayed on the main electrical service panel. Space shall be reserved for the installation of a double pole circuit breaker for a future renewable electric installation.

#### 7.2.8.3 Demarcation on Documents

The following shall be indicated in design and construction documents:

- Location for inverters and metering equipment,
- Pathway for routing of conduit from the REGZ to the point of interconnection with the electrical service,
- Routing of plumbing from the REGZ to the water-heating system and,
- Structural design loads for roof dead and live load.



# 8 Definitions, Abbreviations & Acronyms

## 8. Definitions, Abbreviations, and Acronyms

### 8.1 General

Certain terms, abbreviations, and acronyms are defined in this section for the purposes of this code. These definitions are applicable to all sections of this code. Terms that are not defined shall have their ordinarily accepted meanings within the context in which they are used.

### 8.2 Definitions

#### A

**Above grade area (AGA):** AGA is the cumulative floor area of all the floor levels of a building that are above the ground level. Ground level shall be as defined in building site plan. A floor level is above grade if one-third of the total external surface area of only the said floor level is above the ground level.

**Accredited independent laboratory:** testing laboratory not affiliated with producer or consumer of goods or products tested at the laboratory and accredited by national or international organizations for technical competence

**Addition:** an extension or increase in floor area or height of a building outside of the existing building envelope.

**Air conditioning and condensing units serving computer rooms:** air conditioning equipment that provides cooling by maintaining space temperature and humidity within a narrow range. Major application is in data centers where dissipating heat generated by equipment takes precedence over comfort cooling for occupants.

**Alteration:** any change, rearrangement, replacement, or addition to a building or its systems and equipment; any modification in construction or building equipment.

**Area weighted average (AWA) method:** AWA method is based on the concept of weighted arithmetic mean where instead of each data point contributing equally to the final mean; each data point contributes more “weight” than others based on the size of the area the said data point is applicable to. To calculate the area weighted average mean, a summation of each data point multiplied with its respective area is divided with the total area.

$$AWA = \sum \frac{(\text{Data point } X \text{ area})}{\text{Total area}}$$

**Astronomical time switch:** an automatic time switch that makes an adjustment for the length of the day as it varies over the year.

**Authority having jurisdiction:** the agency or agent responsible for enforcing this code.

## B

**Balancing, air system:** adjusting airflow rates through air distribution system devices, such as fans and diffusers, by manually adjusting the position of dampers, splitters vanes, extractors, etc., or by using automatic control devices, such as constant air volume or variable air volume boxes.

**Balancing, hydronic system:** adjusting water flow rates through hydronic distribution system devices, such as pumps and coils, by manually adjusting the position valves, or by using automatic control devices, such as automatic flow control valves.

**Ballast:** a device used in conjunction with an electric-discharge lamp to cause the lamp to start and operate under proper circuit conditions of voltage, current, waveform, electrode heat, etc.

**Standard Design:** a computer model of a hypothetical building, based on actual building design, that fulfils all the mandatory requirements and minimally complies with the prescriptive requirements of ECBC.

**Boiler:** a self-contained low-pressure appliance for supplying steam or hot water

**Building or building complex or complex:** a structure wholly or partially enclosed within exterior walls, or within exterior and party walls, and a roof, affording shelter to persons, animals, or property. Building complex means a building or group of buildings constructed in a contiguous area for business, commercial, institutional, healthcare, hospitality purposes or assembly buildings under the single ownership of individuals or group of individuals or under the name of a co-operative group society or on lease and sold as shops or office space or space for other commercial purposes, having a connected load of 100 kW or contract demand of 120 kVA and above.

**Building, base:** includes building structure, building envelope, common areas, circulation areas, parking, basements, services area, plant room and its supporting areas and, open project site area.

**Building, core and shell:** buildings where the developer or owner will only provide the base building and its services.

**Building, existing:** a building or portion thereof that was previously occupied or approved for occupancy by the authority having jurisdiction.

**Building envelope:** the exterior plus the semi-exterior portions of a building. For the purposes of determining building envelope requirements, the classifications are defined as follows:

- (a) **Building envelope, exterior:** the elements of a building that separate conditioned spaces from the exterior
- (b) **Building envelope, semi-exterior:** the elements of a building that separate conditioned space from unconditioned space or that enclose semi-heated spaces through which thermal energy may be transferred to or from the exterior, or to or from unconditioned spaces, or to or from conditioned spaces

**Building grounds lighting:** lighting provided through a building's electrical service for parking lot, site, roadway, pedestrian pathway, loading dock, and security applications

**Building material:** any element of the building envelope through which heat flows and that heat is included in the component U-factor calculations other than air films and insulation

**Built up area (BUA):** sum of the covered areas of all floors of a building, other than the roof, and areas covered by external walls and parapet on these floors.

**24-hour Business Building:** Business building operated and occupied for more than 12 hours on each weekday. Intensity of occupancy may vary.

## C

**Cardinal direction:** cardinal directions or cardinal points are the four main directional points of a compass: north, south, east, and west **Centralized control:** single hardware/ software for observing and controlling operations of a group of equipment and devices with similar or different functions

**Circuit breaker:** a safety device that automatically stops flow of current in electrical circuits. It protects the circuit from current surge.

**Class of construction:** classification that determines the construction materials for the building envelope, roof, wall, floor, slab-on-grade floor, opaque door, vertical fenestration, skylight

**Daylight window:** fenestration 2.2 meter above floor level, with an interior light shelf at bottom of this fenestration

**Coefficient of Performance (COP) – cooling:** the ratio of the rate of heat removal to the rate of energy input, in consistent units, for a complete refrigerating system or some specific portion of that system under designated operating conditions

**Coefficient of Performance (COP) – heating:** the ratio of the rate of heat delivered to the rate of energy input, in consistent units, for a complete heat pump system, including the compressor and, if applicable, auxiliary heat, under designated operating conditions

**Common area:** areas within a building that are available for use by all tenants in a building (i.e. lobbies, corridors, restrooms, etc.)

**Commercial building:** a building or a part of building or building complex which are used or intended to be used for commercial purposes and classified as per the time of the day the

building is operational and sub classified, as per the functional requirements of its design, construction, and use as per following details:

- a) Group I – 24 hours building covering Type A Hospitality, Type B Health Care and Type C Assembly, Type D Business and,
- b) Group II – Regular building covering Type D Business, Type E Educational and Type F Shopping Complexes.

**Compliance documents:** the forms specified in ECBC Rules and Regulations to record and check compliance with these rules. These include but are not limited to EPI Ratio Compliance Report, Building Envelope Compliance Form, Mechanical Systems Compliance Form and Permit Checklist, Lighting System Compliance Form and Permit Checklist and certificates from Certified Energy Auditor for existing or proposed buildings.

**Connected load:** the sum of the rated wattage of all equipment, appliances and devices to be installed in the building or part of building or building complexes, in terms of kilowatt (kW) that will be allocated to all applicants for electric power consumption in respect of the proposed building or building complexes on their completion.

Demand factor is the ratio of the sum of the maximum demand of a system (or part of a system) to the total connected load on the system (or part of the system) under consideration. Demand factor is always less than one.

**Contract demand:** the maximum demand in kilo Volt Ampere (kVA) (within a consumer's sanctioned load) agreed to be supplied by the electricity provider or utility in the agreement executed between the user and the utility or electricity provider.

**Construction documents:** drawings or documents, containing information pertaining to building construction processes and approvals, building materials and equipment specification, architectural details etc. required by the authority having jurisdiction.

**Controls or control device:** manually operated or automatic device or software to regulate the operation of building equipment

**Cool roof:** roof with top layer of material that has high solar reflectance and high thermal emittance properties. Cool roof surfaces are characterized by light colors so that heat can be rejected back to the environment.

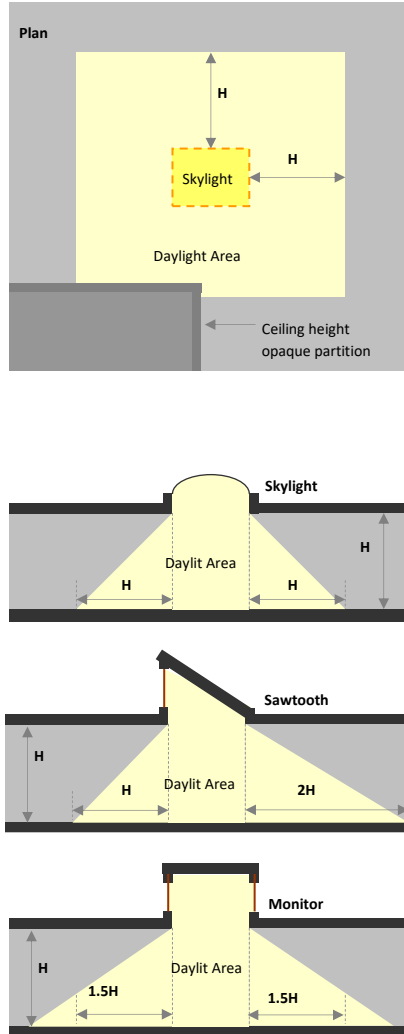
**Cumulative design EPI:** energy performance index for a building having two or more different functional uses and calculated based on the area weighted average (AWA) method

## D

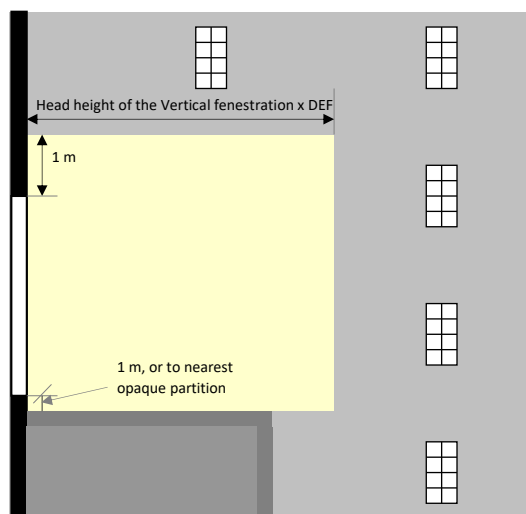
**Daylight area:** the daylight illuminated floor area under horizontal fenestration (skylight) or adjacent to vertical fenestration (window), described as follows:

- (a) Horizontal Fenestration: the area under a skylight, monitor, or sawtooth configuration with an effective aperture greater than 0.001 (0.1%). The daylight area is calculated as the horizontal dimension in each direction equal to the top

aperture dimension in that direction plus either the floor-to-ceiling height ( $H$ ) for skylights, or  $1.5 H$  for monitors, or  $H$  or  $2H$  for the sawtooth configuration, or the distance to the nearest 1 meter or higher opaque partition, or one-half the distance to an adjacent skylight or vertical glazing, whichever is least, as shown in the plan and section figures below.



- (b) Vertical Fenestration: the floor area adjacent to side apertures (vertical fenestration in walls) with an effective aperture greater than 0.06 (6%). The daylight area extends into the space perpendicular to the side aperture a distance equal to daylight extension factor (DEF) multiplied by the head height of the side aperture or till higher opaque partition, whichever is less. In the direction parallel to the window, the daylight area extends a horizontal dimension equal to the width of the window plus either 1 meter on each side of the aperture, or the distance to an opaque partition, or one-half the distance to an adjacent skylight or window, whichever is least.



**Daylight Extension Factor (DEF):** factor to manually calculate the daylight area on floor plates. It is to be multiplied by the head height of windows. It is dependent on orientation and glazing VLT, shading devices adjacent to it and building location.

**Daytime Business Building:** Business building operated typically only during daytime on weekdays upto 12 hours each day.

**Deadband:** the range of values within which a sensed variable can vary without initiating a change in the controlled process.

**Demand:** maximum rate of electricity (kW) consumption recorded for a building or facility during a selected time frame.

**Demand control ventilation (DCV):** a ventilation system capability that provides automatic reduction of outdoor air intake below design rates when the actual occupancy of spaces served by the system is less than design occupancy

**Design capacity:** output capacity of a mechanical or electrical system or equipment at design conditions

**Design conditions:** specified indoor environmental conditions, such as temperature, humidity and light intensity, required to be produced and maintained by a system and under which the system must operate

**Distribution system:** network or system comprising controlling devices or equipment and distribution channels (cables, coils, ducts, pipes etc.) for delivery of electrical power or, cooled or heated water or air in buildings

**Door:** all operable opening areas, that are not more than one half glass, in the building envelope, including swinging and roll-up doors, fire doors, and access hatches.

**Door area:** total area of the door measured using the rough opening and including the door slab and the frame.

## E

**Economizer, air:** a duct and damper arrangement with automatic controls that allow a cooling system to supply outdoor air to reduce or eliminate the need for mechanical cooling during mild or cold weather

**Economizer, water:** a system by which the supply air of a cooling system is cooled indirectly with water that is itself cooled by heat or mass transfer to the environment without the use of mechanical cooling

**ECBC Building:** a building that complies with the mandatory requirements of §4 to §7 and also complies either with the prescriptive requirements stated under the ECBC Building categories of §4 to §7, or, with the whole building performance compliance method of §9.

**ECBC+ Building:** a building that complies with the mandatory requirements of §4 to §7 and also complies either with the prescriptive requirements stated under the ECBC+ Building categories of §4 to §7, or, with the whole building performance compliance method of §9. This is a voluntary level of compliance with ECBC.

**Effective aperture:** Visible light transmittance x window-to-wall Ratio. ( $EA = VLT \times WWR$ )

**Efficacy:** the lumens produced by a lamp plus ballast system divided by the total watts of input power (including the ballast), expressed in lumens per watt

**Efficiency:** performance at a specified rating condition

**Efficiency, thermal:** ratio of work output to heat input

**Efficiency, combustion:** efficiency with which fuel is burned during the combustion process in equipment

**Emittance:** the ratio of the radiant heat flux emitted by a specimen to that emitted by a blackbody at the same temperature and under the same conditions

**Energy:** power derived from renewable or non-renewable resources to provide heating, cooling and light to a building or operate any building equipment and appliances. It has various forms such as thermal (heat), mechanical (work), electrical, and chemical that may be transformed from one into another. Customary unit of measurement is watts (W)

**Energy Conservation Building Code (ECBC):** the Energy Conservation Building Code as updated from time to time by the Bureau and displayed on its website ([www.beeindia.gov.in](http://www.beeindia.gov.in)).

**Energy Efficiency Ratio (EER):** the ratio of net cooling capacity in watt to total rate of electric input in watts under design operating conditions

**Energy recovery system:** equipment to recover energy from building or space exhaust air and use it to treat (pre-heat or pre-cool) outdoor air taken inside the building or space by ventilation systems



**Envelope Performance Factor (EPF):** value for the building envelope performance compliance option calculated using the procedures specified in 4.3.5 and 4.3.5.1.1. For the purposes of determining building envelope requirements the classifications are defined as follows:

- (a) Standard Building EPF: envelope performance factor calculated for the Standard Building using prescriptive requirements for walls, vertical fenestrations and roofs
- (b) Proposed Building EPF: the building envelope performance factor for the Proposed Building using proposed values for walls, vertical fenestrations and roofs

**Energy Performance Index (EPI):** of a building means its annual energy consumption in kilowatt-hours per square meter of the area of the building which shall be calculated in the existing or proposed building as per the formula below,

$$= \frac{\text{annual energy consumption in kWh}}{\text{total built – up area (excluding storage area and the parking in the basement) in m}^2}$$

**EPI Ratio:** of a building means the ratio of the EPI of the Proposed Building to the EPI of the Standard Building.

**Equipment:** mechanical, electrical or static devices for operating a building, including but not limited to those required for providing cooling, heating, ventilation, lighting, service hot water, vertical circulation

**Equipment, existing:** equipment previously installed in an existing building

**Equivalent SHGC:** SHGC for a fenestration with a permanent external shading projection. It is calculated using the Projection Factor (PF) of the permanent external shading projection and Shading Equivalent Factor (SEF) listed in §4.3.1.

**Exemption:** any exception allowed to compliance with ECBC requirements

## F

**Fan system power:** sum of the nominal power demand (nameplate W or HP) of motors of all fans that are required to operate at design conditions to supply air from the heating or cooling source to the conditioned space(s) and return it to the point where it can be exhausted to outside the building.

**Fenestration:** all areas (including the frames) in the building envelope that let in light, including windows, plastic panels, clerestories, skylights, glass doors that are more than one-half glass, and glass block walls.

- (a) Skylight: a fenestration surface having a slope of less than 60 degrees from the horizontal plane. Other fenestration, even if mounted on the roof of a building, is considered vertical fenestration.
- (b) Vertical fenestration: all fenestration other than skylights. Trombe wall assemblies, where glazing is installed within 300 mm of a mass wall, are considered walls, not fenestration.

**Fenestration area:** total area of the fenestration measured using the rough opening and including the glazing, sash, and frame. For doors where the glazed vision area is less than 50% of the door area, the fenestration area is the glazed vision area. For all other doors, the fenestration area is the door area.

**Finished floor level:** level of floor achieved after finishing materials have been added to the subfloor or rough floor or concrete floor slab.

**Fossil fuel:** fuel derived from a hydrocarbon deposit such as petroleum, coal, or natural gas derived from living matter of a previous geologic time

**Fuel:** a material that may be used to produce heat or generate power by combustion

**Fuel utilization efficiency (FUE):** a thermal efficiency measure of combustion equipment like furnaces, boilers, and water heaters

## G

**Gathering hall (Type of Assembly):** any building, its lobbies, rooms and other spaces connected thereto, primarily intended for assembly of people, but which has no theatrical stage or permanent theatrical and/or cinematographic accessories and has gathering space for greater or equal to 100 persons, for example, stand-alone dance halls, stand-alone night clubs, halls for incidental picture shows, dramatic, theatrical or educational presentation, lectures or other similar purposes having no theatrical stage except a raised platform and used without permanent seating arrangement; art galleries, community halls, marriage halls, places of worship, museums, stand-alone lecture halls, passenger terminals and heritage and archeological monuments, pool and billiard parlors, bowling alleys, community halls, courtrooms, gymnasiums, indoor swimming pools, indoor tennis court, any indoor stadium for sports and culture, auditoriums

**Grade:** finished ground level adjoining a building at all exterior walls

**Guest room:** any room or rooms used or intended to be used by a guest for sleeping purposes

## H

**Habitable spaces:** space in a building or structure intended or used for working, meeting, living, sleeping, eating, or cooking. Bathrooms, water closet compartments, closets, halls, storage or utility space, and similar areas are not considered habitable spaces.

**Hospitals and sanatoria (Healthcare):** Any building or a group of buildings under single management, which is used for housing persons suffering from physical limitations because of health or age and those incapable of self-preservation, for example, any hospitals, infirmaries, sanatoria and nursing homes.

**HVAC system:** equipment, distribution systems, and terminal devices that provide, either collectively or individually, the processes of heating, ventilating, or air conditioning to a building or parts of a building.

**Hyper Markets (Type F of Shopping Complex):** large retail establishments that are a combination of supermarket and department stores. They are considered as a one-stop shop for all needs of the customer.

## I

**Infiltration:** uncontrolled inward air leakage through cracks and crevices in external surfaces of buildings, around windows and doors due to pressure differences across these caused by factors such as wind or indoor and outside temperature differences (stack effect), and imbalance between supply and exhaust air systems

**Installed interior lighting power:** power in watts of all permanently installed general, task, and furniture lighting systems and luminaires

**Integrated part-load value (IPLV):** weighted average efficiency of chillers measured when they are operating at part load conditions (less than design or 100% conditions). It is more realistic measurement of chiller efficiency during its operational life.

## K

**Kilovolt-ampere (kVA):** where the term “kilovolt-ampere” (kVA) is used in this Code, it is the product of the line current (amperes) times the nominal system voltage (kilovolts) times 1.732 for three-phase currents. For single-phase applications, kVA is the product of the line current (amperes) times the nominal system voltage (kilovolts).

**Kilowatt (kW):** the basic unit of electric power, equal to 1000 W.

## L

**Labeled:** equipment or materials to which a symbol or other identifying mark has been attached by the manufacturer indicating compliance with specified standard or performance in a specified manner.

**Lamp:** a device for giving light consisting of electric bulb with its holder and shade or cover.

**Lighted floor area, gross:** gross area of lighted floor spaces

**Lighting, emergency:** battery backed lighting that provides illumination only when there is a power outage and general lighting luminaires are unable to function.

**Lighting, general:** lighting that provides a substantially uniform level of illumination throughout an area. General lighting shall not include decorative lighting or lighting that provides a dissimilar level of illumination to serve a specialized application or feature within such area.

**Lighting system:** a group of luminaires circuited or controlled to perform a specific function.

**Lighting power allowance:**

- (a) Interior lighting power allowance: the maximum lighting power in watts allowed for

the interior of a building

- (b) **Exterior lighting power allowance:** the maximum lighting power in watts allowed for the exterior of a building

**Lighting Power Density (LPD):** maximum lighting power per unit area of a space as per its function or building as per its classification.

**Low energy comfort systems:** space conditioning or ventilation systems that are less energy intensive than vapor compression based space condition systems. These primarily employ alternate heat transfer methods or materials (adiabatic cooling, radiation, desiccant, etc.), or renewable sources of energy (solar energy, geo-thermal) so that minimal electrical energy input is required to deliver heating or cooling to spaces.

**Luminaires:** a complete lighting unit consisting of a lamp or lamps together with the housing designed to distribute the light, position and protect the lamps, and connect the lamps to the power supply.

## M

**Man-made daylight obstruction:** any permanent man-made object (equipment, adjacent building) that obstructs sunlight or solar radiation from falling on a portion or whole of a building's external surface at any point of time during a year is called as a man-made sunlight obstructer.

**Manual (non-automatic):** requiring personal intervention for control. Non-automatic does not necessarily imply a manual controller, only that personal intervention is necessary.

**Manufacturing processes:** processes through which raw material is converted into finished goods for commercial sale using machines, labor, chemical or biological processes, etc.

**Manufacturer:** company or person or group of persons who produce and assemble goods or purchases goods manufactured by a third party in accordance with their specifications.

**Mean temperature:** average of the minimum daily temperature and maximum daily temperature.

**Mechanical cooling:** reducing the temperature of a gas or liquid by using vapor compression, absorption, and desiccant dehumidification combined with evaporative cooling, or another energy-driven thermodynamic cycle. Indirect or direct evaporative cooling alone is not considered mechanical cooling.

**Metering:** practice of installing meters in buildings to acquire data for energy consumption and other operational characteristics of individual equipment or several equipment grouped on basis of their function (lighting, appliances, chillers, etc.). Metering is done in buildings to monitor their energy performance.

**Mixed mode air-conditioned building:** building in which natural ventilation is employed as the primary mode of ventilating the building, and air conditioning is deployed as and when required.

**Mixed use development:** a single building or a group of buildings used for a combination of residential, commercial, business, educational, hospitality and assembly purposes

## N

**National Building Code 2016 (NBC):** model building code that provides guidelines for design and construction of buildings. In this code, National Building Code 2016 refers to the latest version by the Bureau of Indian Standards.

**Natural daylight obstruction:** any natural object, like tree, hill, etc., that obstructs sunlight from falling on part or whole of a building's external surface at any point of time during a year and casts a shadow on the building surface.

**Naturally ventilated building:** a building that does not use mechanical equipment to supply air to and exhaust air from indoor spaces. It is primarily ventilated by drawing and expelling air through operable openings in the building envelope.

**Non-cardinal directions:** any direction which is not a cardinal direction, i.e. perfect north, south, east, or west, is termed as non-cardinal direction.

**No Star hotel (Type of Hospitality):** any building or group of buildings under the same management, in which separate sleeping accommodation on commercial basis, with or without dining facilities or cooking facilities, is provided for individuals. This includes lodging rooms, inns, clubs, motels, no star hotel and guest houses and excludes residential apartments rented on a lease agreement of 4 months or more. These shall also include any building in which group sleeping accommodation is provided, with or without dining facilities for persons who are not members of the same family, in one room or a series of adjoining rooms under joint occupancy and single management, for example, school and college dormitories, students, and other hostels and military barracks.

## O

**Occupant sensor:** a device that detects the presence or absence of people within an area and causes lighting, equipment, or appliances to be dimmed, or switched on or off accordingly.

**Opaque assembly or opaque construction:** surface of the building roof or walls other than fenestration and building service openings such as vents and grills.

**Opaque external wall:** external wall composed of materials which are not transparent or translucent, usually contains the structural part of the building, and supports the glazed façade. This type may be composed of one or more materials.

**Open Gallery Mall (Type of Shopping Complex):** a large retail complex containing a variety of stores and often restaurants and other business establishments housed in a series of connected or adjacent buildings or in a single large building. The circulation area and atrium of the open gallery mall is an unconditioned space and is open to sky.

**Orientation:** the direction a building facade faces, i.e., the direction of a vector perpendicular to and pointing away from the surface of the facade. For vertical fenestration, the two categories are north-oriented and all other.

**Outdoor (outside) air:** air taken from the outside the building and has not been previously circulated through the building.

**Out-patient Healthcare (Type of Healthcare):** any building or a group of buildings under single management, which is used only for treating persons requiring treatment or diagnosis of disease but not requiring overnight or longer accommodation in the building during treatment or diagnosis.

**Overcurrent:** any current in excess of the rated current of the equipment of the ampacity of the conductor. It may result from overload, short circuit, or ground fault.

**Owner:** a person, group of persons, company, trust, institute, Registered Body, state or central Government and its attached or sub-ordinate departments, undertakings and like agencies or organization in whose name the property stands registered in the revenue records for the construction of a building or building complex

## P

**Party wall:** a firewall on an interior lot line used or adapted for joint service between two buildings.

**Permanently installed:** equipment that is fixed in place and is not portable or movable.

**Plenum:** a compartment or chamber to which one or more ducts are connected, that forms a part of the air distribution system, and that is not used for occupancy or storage.

**Plug loads:** energy used by products that are powered by means of an AC plug. This term excludes building energy that is attributed to major end uses specified in § 5, § 6, § 7 (like HVAC, lighting, water heating, etc.).

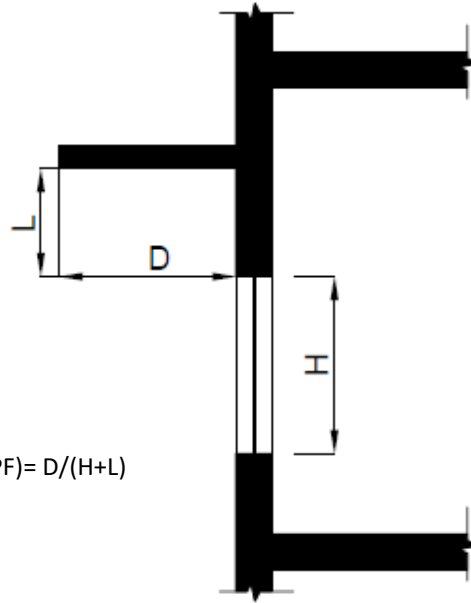
**Pool:** any structure, basin, or tank containing an artificial body of water for swimming, diving, or recreational bathing. The terms include, but no limited to, swimming pool, whirlpool, spa, hot tub.

**Potential daylit time:** amount of time in a day when there is daylight to light a space adequately without using artificial lighting. Potential daylit time is fixed for 8 hours per day i.e. from 09:00 AM to 5:00 PM local time, resulting 2920 hours in total for all building types except for Type E-1 - Educational, which shall be analyzed for 7 hours per day i.e. from 08:00 AM to 3:00 PM local time.

**Primary inter-cardinal direction:** any of the four points of the compass, midway between the cardinal points; northeast, southeast, southwest, or northwest are called primary inter-cardinal direction.

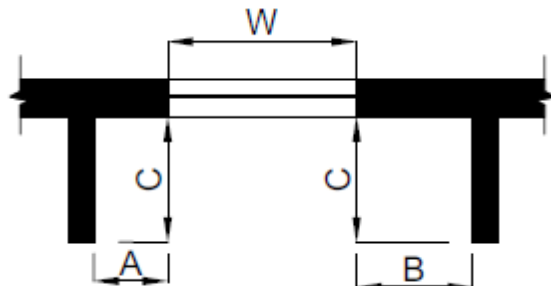
**Process load:** building loads resulting from the consumption or release of energy due to industrial processes or processes other than those for providing space conditioning, lighting, ventilation, or service hot water heating.

**Projection factor, overhang:** It is the ratio of the horizontal depth of the external shading projection to the sum of the height of the fenestration and the distance from the top of the fenestration to the bottom of the farthest point of the external shading projection, in consistent units.



Projection factor (PF) =  $D / (H + L)$

**Projection factor, side fin:** It is the ratio of the horizontal depth of the external shading projection to the distance from the window jamb to the farthest point of the external shading projection, in consistent units.



Projection factor Left Fin (PF<sub>L</sub>) =  $C / (A + W)$

Projection factor Right Fin (PF<sub>R</sub>) =  $C / (B + W)$

**Projection Factor, overhang and side fin:** average of ratio projection factor for overhang only and projection factor of side fin only.

**Proposed Building:** is consistent with the actual design of the building and complies with all the mandatory requirements of ECBC.

**Proposed Design:** a computer model of the proposed building, consistent with its actual design, which complies with all the mandatory requirements of ECBC.

R

**R-value (thermal resistance):** the reciprocal of the time rate of heat flow through a unit area induced by a unit temperature difference between two defined surfaces of material or construction under steady-state conditions. Units of R value are  $m^2.K / W$ .

**Readily accessible:** capable of being reached quickly for operation, renewal, or inspections without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, chairs, etc. In public facilities, accessibility may be limited to certified personnel through locking covers or by placing equipment in locked rooms.

**Recirculating system:** a domestic or service hot water distribution system that includes a close circulation circuit designed to maintain usage temperatures in hot water pipes near terminal devices (e.g., lavatory faucets, shower heads) in order to reduce the time required to obtain hot water when the terminal device valve is opened. The motive force for circulation is either natural (due to water density variations with temperature) or mechanical (recirculation pump).

**Renewable Energy Generating Zone:** a contiguous or semi-contiguous area, either on rooftop or elsewhere within site boundary, dedicated for installation of renewable energy systems.

**Resort (Type of Hospitality):** commercial establishments that provide relaxation and recreation over and above the accommodation, meals and other basic amenities. The characteristics of resort are as below –

- i. Includes 1 or more recreation(s) facility like spa, swimming pool, or any sport;
- ii. Is located in the midst of natural and picturesque surroundings outside the city;
- iii. Comprises of 2 or more blocks of buildings within the same site less than or equal to 3 floors (including the ground floor).

**Reset:** automatic adjustment of the controller set point to a higher or lower value.

**Roof:** the upper portion of the building envelope, including opaque areas and fenestration, that is horizontal or tilted at an angle of less than 60° from horizontal. This includes podium roof as well which are exposed to direct sun rays.

**Roof area, gross:** the area of the roof measured from the exterior faces of walls or from the centerline of party walls



## S

**Service:** the equipment for delivering energy from the supply or distribution system to the premises served.

**Service water heating equipment:** equipment for heating water for domestic or commercial purposes other than space heating and process requirements.

**Set point:** the desired temperature ( $^{\circ}\text{C}$ ) of the heated or cooled space that must be maintained by mechanical heating or cooling equipment.

**Shading Coefficient (SC):** measure of thermal performance of glazing. It is the ratio of solar heat gain through glazing due to solar radiation at normal incidence to that occurring through 3 mm thick clear, double-strength glass. Shading coefficient, as used herein, does not include interior, exterior, or integral shading devices.

**Shading Equivalent Factor:** coefficient for calculating effective SHGC of fenestrations shaded by overhangs or side fins.

**Shopping Mall (Shopping Complex):** a large retail complex containing a variety of stores and often restaurants and other business establishments housed in a series of connected or adjacent buildings or in a single large building. The circulation area and atrium of the mall is an enclosed space covered completely by a permanent or temporary structure.

**Simulation program:** software in which virtual building models can be developed to simulate the energy performance of building systems and daylighting analysis

**Single-zone system:** an HVAC system serving a single HVAC zone.

**Site-recovered energy:** waste energy recovered at the building site that is used to offset consumption of purchased fuel or electrical energy supplies.

**Slab-on-grade floor:** floor slab of the building that is in contact with ground and that is either above grade or is less than or equal to 300 mm below the final elevation of the nearest exterior grade. **Solar energy source:** source of thermal, chemical, or electrical energy derived from direction conversion of incident solar radiation at the building site.

**Solar Heat Gain Coefficient (SHGC):** the ratio of the solar heat gain entering the space through the fenestration area to the incident solar radiation. Solar heat gain includes directly transmitted solar heat and absorbed solar radiation, which is then reradiated, conducted, or convected into the space.

**Solar Reflectance:** ratio of the solar radiation reflected by a surface to the solar radiation incident upon it.

**Space:** an enclosed area within a building. The classifications of spaces are as follows for purpose of determining building envelope requirements:

- (a) Conditioned space: a cooled space, heated space, or directly conditioned space.
- (b) Semi-heated space: an enclosed space within a building that is heated by a heating

system whose output capacity is greater or equal to  $10.7 \text{ W/m}^2$  but is not a conditioned space.

- (c) Non-conditioned space: an enclosed space within a building that is not conditioned space or a semi-heated space. Crawlspace, attics, and parking garages with natural or mechanical ventilation are not considered enclosed spaces.

**Star Hotels/motels (Star Hotel):** any building or group of buildings under single management and accredited as a starred hotel by the Hotel and Restaurant Approval and Classification Committee, Ministry of Tourism, in which sleeping accommodation, with or without dining facilities is provided.

**Stand-alone Retail (Shopping Complex):** a large retail store owned or sublet to a single management which may offer customers a variety of products under self-branding or products of different brands. The single management shall have a complete ownership of all the spaces of the building and no space within the building is further sold or sublet to a different management.

**Standard Building:** a building that minimally complies with all the mandatory and prescriptive requirements of Energy Conservation Building Code and has same floor area, gross wall area, and gross roof area of the Proposed Building.

**Standard Design:** a computer model of a hypothetical building, based on actual building design, that fulfils all the mandatory requirements and minimally complies with the prescriptive requirements of ECBC, as described in the Whole Building Performance method.

**Story:** portion of a building that is between one finished floor level and the next higher finished floor level or building roof. Basement and cellar shall not be considered a story.

**Summer Solar Insolation:** measure of solar radiation energy received on a given surface area from the month of March to October within the same calendar year. Units of measurement are watts per square meter ( $\text{W/m}^2$ ) or kilowatt-hours per square meter per day ( $\text{kW}\cdot\text{h}/(\text{m}^2\cdot\text{day})$ ) (or hours/day).

**SuperECBC Building:** a building that complies with the mandatory requirements of §4 to §7 and also complies either with the prescriptive requirements stated under the SuperECBC Building categories of §4 to §7, or, with the whole building performance compliance method of §9. This is a voluntary level of compliance with ECBC.

**Super Market (Shopping Complex):** supermarkets are large self-service grocery stores that offer customers a variety of foods and household supplies. The merchandise is organized into an organized aisle format, where each aisle has only similar goods placed together.

**System:** a combination of equipment and auxiliary devices (e.g., controls, accessories, interconnecting means, and terminal elements) by which energy is transformed so it performs a specific function such as HVAC, service water heating, or lighting.

**System Efficiency:** the system efficiency is the ratio of annual kWh electricity consumption of equipment of water cooled chilled water plant (i.e. chillers, chilled and condenser water pumps, cooling tower) to chiller thermal kWh used in a building.

**System, existing:** a system or systems previously installed in an existing building.

## T

**Tenant lease agreement:** The formal legal document entered into between a Landlord and a Tenant to reflect the terms of the negotiations between them; that is, the lease terms have been negotiated and agreed upon, and the agreement has been reduced to writing. It constitutes the entire agreement between the parties and sets forth their basic legal rights.

**Tenant leased area:** area of a building that is leased to tenant(s) as per the tenant lease agreement.

**Terminal device:** a device through which heated or cooled air is supplied to a space to maintain its temperature. It usually contains dampers and heating and cooling coils. Or a device by which energy from a system is finally delivered, e.g., registers, diffusers, lighting fixtures, faucets, etc.

**Theater or motion picture hall (Type of Assembly):** any building primarily meant for theatrical or operatic performances and which has a stage, proscenium curtain, fixed or portable scenery or scenery loft, lights, mechanical appliances or other theatrical accessories and equipment for example, theaters, motion picture houses, auditoria, concert halls, television and radio studios admitting an audience and which are provided with fixed seats.

**Thermal block:** a collection of one or more HVAC zones grouped together for simulation purposes. Spaces need not be contiguous to be combined within a single thermal block.

**Thermal comfort conditions:** conditions that influence thermal comfort of occupants. Environmental conditions that influence thermal comfort air and radiant temperature, humidity, and air speed.

**Thermostat:** device containing a temperature sensor used to automatically maintain temperature at a desirable fixed or adjustable set point in a space.

**Tinted:** (as applied to fenestration) bronze, green, or grey coloring that is integral with the glazing material. Tinting does not include surface applied films such as reflective coatings, applied either in the field or during the manufacturing process.

**Transformer:** a piece of electrical equipment used to convert electric power from one voltage to another voltage.

**Transformer losses:** electrical losses in a transformer that reduces its efficiency.

**Transport Buildings (Assembly):** any building or structure used for the purpose of transportation and transit like airports, railway stations, bus stations, and underground and elevated mass rapid transit system example, underground or elevated railways.

## U

**Unconditioned buildings:** building in which more than 90% of spaces are unconditioned spaces.

**Unconditioned space:** mechanically or naturally ventilated space that is not cooled or heated by mechanical equipment.

**Universities and all others coaching/training institutions (Educational):** a building or a group of buildings, under single management, used for imparting education to students numbering more than 100 or public or private training institution built to provide training/coaching etc.

**Useful Daylight Illuminance:** percentage of annual daytime hours that a given point on a work plane height of 0.8 m above finished floor level receives daylight between 100 lux to 2,000 lux.

**U-factor (Thermal Transmittance):** heat transmission in unit time through unit area of a material or construction and the boundary air films, induced by unit temperature difference between the environments on each side. Unit of U value is  $W/m^2.K$ .

## V

**Variable Air Volume (VAV) system:** HVAC system that controls the dry-bulb temperature within a space by varying the volumetric flow of heated or cooled air supplied to the space

**Vegetative roofs:** also known as green roofs, they are thin layers of living vegetation installed on top of conventional flat or sloping roofs.

**Ventilation:** the process of supplying or removing air by natural or mechanical means to or from any space. Such air is not required to have been conditioned.

**Vision Windows:** windows or area of large windows that are primarily for both daylight and exterior views. Typically, their placement in the wall is between 1 meter and 2.2 meter above the floor level.

## W

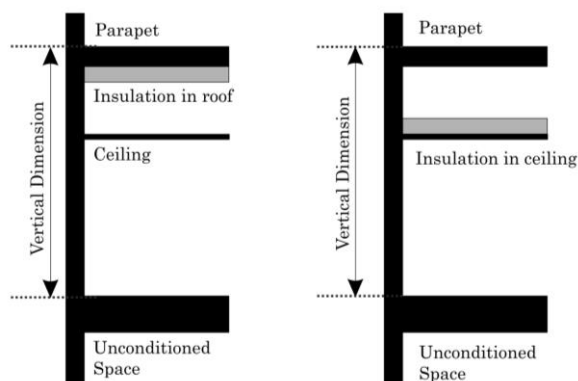
**Wall:** that portion of the building envelope, including opaque area and fenestration, that is vertical or tilted at an angle of  $60^\circ$  from horizontal or greater. This includes above- and below-grade walls, between floor spandrels, peripheral edges of floors, and foundation walls.

(a) Wall, above grade: a wall that is not below grade

(b) Wall, below grade: that portion of a wall in the building envelope that is entirely below the finish grade and in contact with the ground

**Wall area, gross:** the overall area off a wall including openings such as windows and doors measured horizontally from outside surface to outside surface and measured vertically from the top of the floor to the top of the roof. If roof insulation is installed at the ceiling level

rather than the roof, then the vertical measurement is made to the top of the ceiling. The gross wall area includes the area between the ceiling and the floor for multi-story buildings.



**Water heater:** vessel in which water is heated and withdrawn for use external to the system.

## Z

**Zone, HVAC:** a space or group of spaces within a building with heating and cooling requirements that are sufficiently similar so that desired conditions (e.g., temperature) can be maintained throughout using a single sensor (e.g., thermostat or temperature sensor).

**Zone, Critical:** a zone serving a process where reset of the zone temperature setpoint during a demand shed event might disrupt the process, including but not limited to data centers, telecom and private branch exchange (PBX) rooms, and laboratories.

**Zone, Non-Critical:** a zone that is not a critical zone.

### 8.3 SI to IP Conversion Factors

| SI Unit                | IP Unit                           |
|------------------------|-----------------------------------|
| 1 cmh                  | 1.7 cfm                           |
| 1 Pa                   | 0.0040 inch of water gauge        |
| 1m                     | 3.28 ft                           |
| 1m                     | 39.37 in                          |
| 1mm                    | 0.039 in                          |
| 1 l/s                  | 2.12 cfm                          |
| 1 m <sup>2</sup>       | 10.76 ft <sup>2</sup>             |
| 1 W/m <sup>2</sup>     | 10.76 W/ ft <sup>2</sup>          |
| 1 W/ lin m             | 3.28 W/ ft                        |
| 1 W/m <sup>2</sup> .K  | 5.678 Btu/ h-ft <sup>2</sup> -°F  |
| 1 W/ l-s <sup>-1</sup> | 0.063 W/ gpm                      |
| 1 m <sup>2</sup> .K/W  | 0.1761 ft <sup>2</sup> -h-°F/ Btu |
| 1 °C                   | ((°C X 9/5) + 32) °F              |
| 1 kW <sub>r</sub>      | 0.284 TR                          |
| 1 kW                   | 1.34 hp                           |
| 1 kW                   | 3412.142 Btu/hr                   |

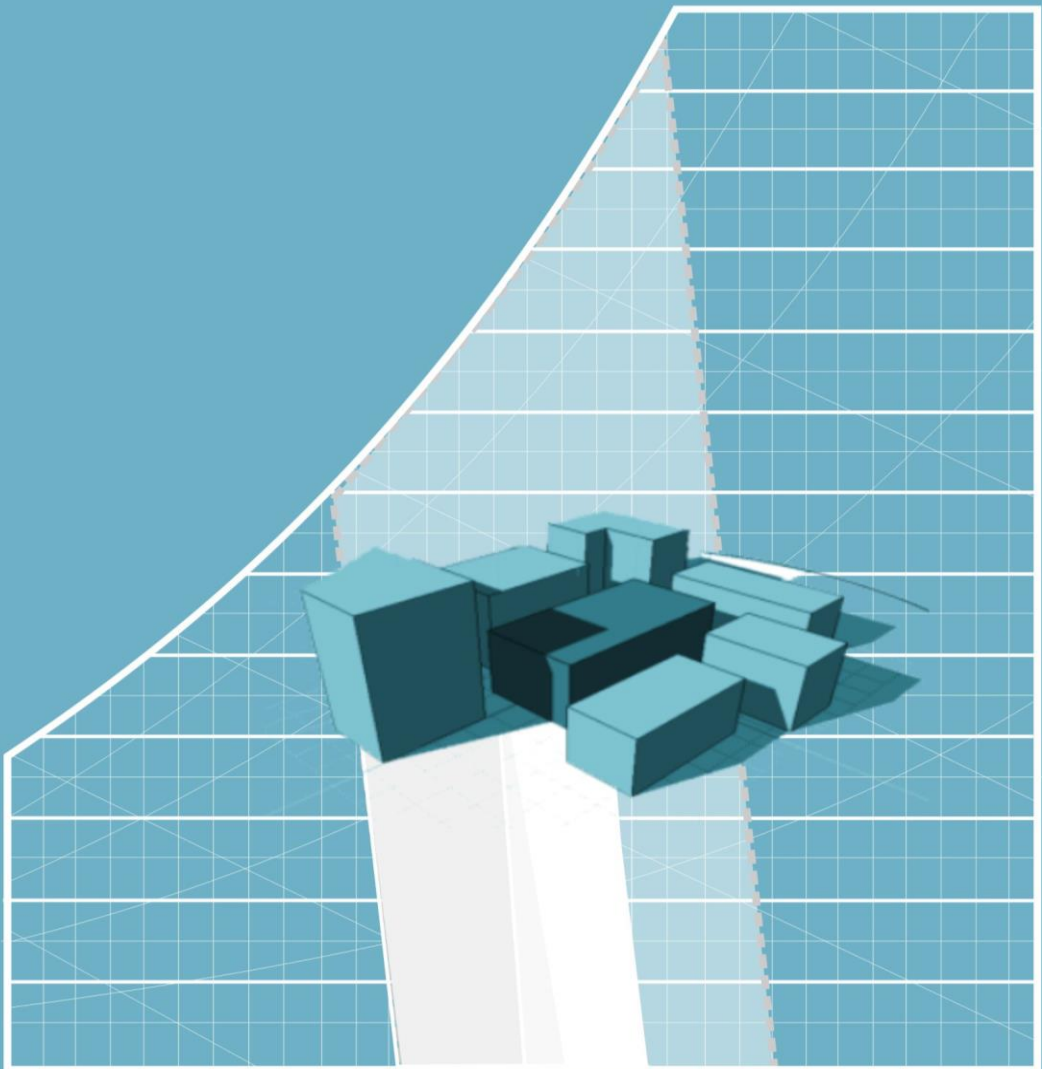
## 8.4 Abbreviations and Acronyms

|                           |   |
|---------------------------|---|
| AFUE                      | Annual fuel utilization efficiency  |
| AHRI                      | Air-conditioning, Heating and Refrigeration Institute                     |
| ANSI                      | American National Standards Institute                                     |
| ARI                       | Air-Conditioning and Refrigeration Institute                              |
| ASHRAE                    | American Society of Heating, Refrigerating and Air-Conditioning Engineers |
| ASTM                      | American Society for Testing and Materials                                |
| BIS                       | Bureau of Indian Standards  |
| Btu                       | British thermal unit  |
| Btu/h                     | British thermal units per hour  |
| Btu/h-ft <sup>2</sup> -°F | British thermal units per hour per square foot per degree Fahrenheit      |
| BUA                       | Built up area   |
| C                         | Celsius   |
| cmh                       | cubic meter per hour  |
| cm                        | centimeter  |
| COP                       | coefficient of performance  |
| DEF                       | daylight extent factor  |
| EER                       | energy efficiency ratio   |
| EPI                       | energy performance index  |
| F                         | Fahrenheit  |
| ft                        | foot  |
| h                         | hour  |
| h-ft <sup>2</sup> -°F/Btu | hour per square foot per degree Fahrenheit per British thermal unit       |
| h-m <sup>2</sup> -°C/W    | hour per square meter per degree Celsius per Watt                         |
| hp                        | horsepower  |
| HVAC                      | heating, ventilation, and air conditioning                                |
| I-P                       | inch-pound  |
| in.                       | inch  |
| IPLV                      | integrated part-load value  |
| IS                        | Indian Standard   |
| ISO                       | International Organization for Standardization                            |
| kVA                       | kilovolt-ampere   |
| kW                        | Kilowatt of electricity   |
| kW <sub>r</sub>           | kilowatt of refrigeration   |
| kWh                       | kilowatt-hour   |
| l/s                       | liter per second  |

|                      |                                   |
|----------------------|-----------------------------------|
| LE                   | luminous efficacy                 |
| lin                  | linear                            |
| lin ft               | linear foot                       |
| lin m                | linear meter                      |
| lm                   | lumens                            |
| Lm/W                 | lumens per watt                   |
| LPD                  | lighting power density            |
| m                    | meter                             |
| mm                   | millimeter                        |
| m <sup>2</sup>       | square meter                      |
| m <sup>2</sup> .K/W  | square meter Kelvin per watt      |
| NBC                  | National Building Code 2016       |
| Pa                   | pascal                            |
| PF                   | projection factor                 |
| R                    | R-value (thermal resistance)      |
| SC                   | shading coefficient               |
| SEF                  | Shading equivalent factor         |
| SHGC                 | solar heat gain coefficient       |
| TR                   | tons of refrigeration             |
| UPS                  | uninterruptible power supply      |
| VAV                  | variable air volume               |
| VLT                  | visible light transmission        |
| W                    | watt                              |
| W/ l-s <sup>-1</sup> | watt per litre per second         |
| W/m <sup>2</sup>     | watts per square meter            |
| W/m <sup>2</sup> .K  | watts per square meter per Kelvin |
| W/m <sup>2</sup>     | watts per hour per square meter   |
| W/m.K                | watts per lineal meter per Kelvin |
| Wh                   | watthour                          |



# 9 Whole Building Performance Method



## 9. Whole Building Performance Method

### 9.1 General

#### 9.1.1 Scope

The Whole Building Performance Method is an alternative to the Prescriptive Method compliance path contained in §4 through §7 of this Code. It applies to all building types covered by the Code as mentioned in §2.5.

#### 9.1.2 Compliance

A building complies with the Code using the Whole Building Performance (WBP) Method, when the estimated EPI Ratio is equal to or less than 1, even though it may not comply with the specific provisions of the prescriptive requirements in §4 through §7. The mandatory requirements of §4 through §7 (§4.2, §5.2, §6.2, and §7.2) shall be met when using the WBP Method.

#### 9.1.3 Annual Energy Use

Annual energy use for the purposes of the WBP Method shall be calculated in kilowatt-hours (kWh) of electricity use per year per unit area. Energy sources other than electricity that are used in the building shall be converted to kWh of electric energy at the rate of 0.75 kWh per megajoule.

**Note:** *The annual energy use calculation as per the Whole Building Performance Method is not a prediction of the actual energy use of the building once it gets operational. Actual energy performance of a building depends on a number of factors like weather, occupant behaviour, equipment performance and maintenance, among others, which are not covered by this Code.*

#### 9.1.4 Trade-offs Limited to Building Permit

The WBP Method may be used for building permit applications that include less than the whole building; however, any design parameters that are not part of the building permit application shall be identical for both the Proposed Design and the Standard Design. Future improvements to the building shall comply with both the mandatory and prescriptive requirements of concurrent code.

#### 9.1.5 Documentation Requirements

Compliance shall be documented and compliance forms shall be submitted to the authority having jurisdiction. The information submitted shall include, at a minimum, the following:

- (a) Summary describing the results of the analysis, including the annual energy use for the Proposed Design and the Standard Design, and software used.
- (b) Brief description of the project with location, number of stories, space types, conditioned and unconditioned areas, hours of operation.
- (c) List of the energy-related building features of the Proposed Design. This list shall also document features different from the Standard Design.
- (d) List showing compliance with the mandatory requirements of this code.
- (e) The input and output report(s) from the simulation program including a breakdown of energy usage by at least the following components: lights, internal equipment loads, service water heating equipment, space heating equipment, space cooling and heat rejection equipment, fans, and other HVAC equipment (such as pumps). The output reports shall also show the number of hours any loads are not met by the HVAC system for both the Proposed Design and Standard Design.
- (f) Explanation of any significant modelling assumptions made.
- (g) Explanation of any error messages noted in the simulation program output.
- (h) Building floor plans, building elevations, and site plan.

## 9.2 Mandatory Requirements

All requirements of §4.2, §5.2, §6.2, and §7.2 shall be met. These sections contain the mandatory provisions of the Code and are prerequisites for demonstrating compliance using the WBP Method.

## 9.3 Simulation Requirements

### 9.3.1 Energy Simulation Program

The simulation software shall be a computer-based program for the analysis of energy consumption in buildings and be approved by the authority having jurisdiction. The simulation program shall, at a minimum, have the ability to model the following:

- (a) Energy flows on an hourly basis for all 8,760 hours of the year,
- (b) Hourly variations in occupancy, lighting power, miscellaneous equipment power, thermostat set points, and HVAC system operation, defined separately for each day of the week and holidays,
- (c) Thermal mass effects,
- (d) Ten or more thermal zones,
- (e) Part-load and temperature dependent performance of heating and cooling equipment,
- (f) Air-side and water-side economizers with integrated control.

In addition to the above, the simulation tool shall be able to produce hourly reports of energy use by energy source and shall have the capability to performing design load calculations to determine required HVAC equipment capacities, air, and water flow rates in accordance with §5 for both the proposed and Standard building designs.

The simulation program shall be tested according to ASHRAE Standard 140 Method of Test

for the Evaluation of Building Energy Analysis Computer Programs (ANSI approved) and the results shall be furnished by the software provider.

9.3.2 Climate Data

The simulation program shall use hourly values of climatic data, such as temperature and humidity, from representative climatic data for the city in which the Proposed Design is to be located. For cities or urban regions with several climate data entries, and for locations where weather data are not available, the designer shall select available weather data that best represent the climate at the construction site.

9.3.3 Compliance Calculations

The Proposed Design and Standard Design shall be calculated using the following:

- (a) Same simulation program,
- (b) Same weather data, and
- (c) Identical building operation assumptions (thermostat set points, schedules, equipment and occupant loads, etc.) unless an exception is allowed by this Code or the authority having jurisdiction for a given category.

9.4 Calculating Energy Consumption of Proposed Design and Standard Design

9.4.1 Energy Simulation Model

The simulation model for calculating the Proposed Design and the Standard Design shall be developed in accordance with the requirements in Table 9-1. The Standard Design is based on the mandatory and prescriptive requirements of the ECBC compliant building. The Standard Design will be the same for all compliance levels (ECBC, ECBC+, Super ECBC).

Table 9-1 Modelling Requirements for Calculating Proposed and Standard Design

| Case               | Proposed Design  | Standard Design  |
|--------------------|--|--|
| 1.<br>Design Model | <p>(a) The simulation model of the Proposed Design shall be consistent with the design documents, including proper accounting of fenestration and opaque envelope types and area; interior lighting power and controls; HVAC system types, sizes, and controls; and service water heating systems and controls.</p> <p>(b) When the whole building performance method is applied to buildings in which energy-related features have not been designed yet (e.g., a lighting system), those yet-to-be-designed features shall be described in the Proposed Design so that</p> | <p>The Standard Design shall be developed by modifying the Proposed Design as described in this table. Unless specified in this table, all building systems and equipment shall be modeled identically in the Standard Design and Proposed Design.</p> |

they minimally comply with applicable mandatory and prescriptive requirements of §4.2, §5.2, §6.2, and §7.2 and §4.3, §5.3, and §6.3 respectively.

|   |  |   |
|---|--|---|
| <p><b>2.</b><br/>Space Use<br/>Classification</p> | <p>The building type or space type classifications shall be chosen in accordance with §2.5. More than one building type category may be used in a building if it is a mixed-use facility.</p>  | <p>Same as Proposed Design.</p>   |
| <p><b>3.</b><br/>Schedules</p>                    | <p>Operational schedules (hourly variations in occupancy, lighting power, equipment power, HVAC equipment operation, etc.) suitable for the building and/or space type shall be modeled for showing compliance. Schedules must be modeled as per §9.6. In case a schedule for an occupancy type is missing in §9.6, appropriate schedule may be used. Temperature and humidity schedules and set points shall be identical in the Standard and Proposed Designs. Temperature control/thermostat throttling ranges shall also be modeled identically in both the Designs.</p>   | <p>Same as Proposed Design.<br/>Exception: Schedules may be allowed to differ between the Standard and Proposed models wherever it is necessary to model nonstandard efficiency measures and/or measures which can be best approximated by a change in schedule. Measures that may warrant a change in operating schedules include but are not limited to automatic controls for lighting, natural ventilation, demand controlled ventilation systems, controls for service water heating load reduction. Schedule change is not allowed for manual controls under any category. This is subject to approval by the authority having jurisdiction.</p>  |
| <p><b>4.</b><br/>Building<br/>Envelope</p>        | <p>All components of the building envelope in the Proposed Design shall be modeled as shown on architectural drawings or as installed for existing building envelopes. Exceptions: The following building elements are permitted to differ from architectural drawings.</p> <p>(a) Any envelope assembly that covers less than 5% of the total area of that assembly type (e.g., exterior walls) need not be separately described. If not separately described, the area of an envelope assembly must be added to the area of the adjacent assembly of that same type.</p> <p>(b) Exterior surfaces whose azimuth orientation and tilt differ by no more than 45 degrees and are otherwise the same may be described as either a single surface or by using multipliers.</p> <p>(c) For exterior roofs, other than roofs with ventilated attics, the reflectance and emittance of the roof surface shall be modeled in accordance with §4.3.1.1.</p> <p>(d) Manually operated fenestration shading devices such as blinds or shades shall not be</p> | <p>The Standard Design shall have identical conditioned floor area and identical exterior dimensions and orientations as the Proposed Design, except as noted in (a), (b), (c),(d) and (e) below.</p> <p>(a) Orientation. The Standard Design performance shall be generated by simulating the building with its actual orientation and again after rotating the entire building 90, 180, 270 degrees, then averaging the results. The building shall be modeled so that it does not shade itself</p> <p>(b) Opaque assemblies such as roof, floors, doors, and walls shall be modeled with the maximum U-factor allowed in §4.3.1 and §4.3.2.</p> <p>(c) Fenestration. Fenestration areas shall equal that in the Proposed Design or 40% of gross above grade wall area, whichever is smaller, and shall be distributed on each face in the same proportions as in the Proposed Design No shading projections are to be modeled; fenestration shall be assumed to be flush</p> |

|                        |   |  |
|------------------------|---|--|
|                        | <p>modeled. Permanent shading devices such as fins, overhangs, and light shelves shall be modeled.</p> <p>(e) The exterior roof surface shall be modeled using the solar reflectance in accordance with ASTM E903-96 and thermal emittance determined in accordance with ASTM E408-71. Where cool roof is proposed, emittance and reflectance shall be modeled as per ASTM E408-71 and ASTM E903-96 respectively. Where cool roof is not proposed, the exterior roof surfaces shall be modeled as per §4.3.1.1 i.e. the exterior roof surface shall be modeled with a solar reflectance of 0.70 and a thermal emittance of 0.75.</p>  | <p>with the exterior wall or roof. Manually operated fenestration shading devices such as blinds or shades shall not be modeled. Fenestration U-factor shall be the maximum allowed for the climate, and the solar heat gain coefficient shall be the maximum allowed for the climate and orientation.</p> <p>(d) Skylight areas shall equal that in the Proposed Design or 5% of gross roof area, whichever is smaller.</p> <p>(e) Roof Solar Reflectance and Thermal Emittance: The exterior roof surfaces shall be modeled using a solar reflectance of 0.70 and a thermal emittance of 0.75.as per §4.3.1.1</p>                                  |
| <p>5.<br/>Lighting</p> | <p>Lighting power in the Proposed Design shall be determined as follows:</p> <p>Where a complete lighting system exists, the actual lighting power shall be used in the model.</p> <p>Where a lighting system has been designed, lighting power shall be determined in accordance with either §6.3.4.</p> <p>Where no lighting exists, or is specified, lighting power shall be determined in accordance with the §6.3.2 or §6.3.3 for the appropriate building type.</p> <p>Lighting system power shall include all lighting system components shown or provided for on plans (including lamps, ballasts, task fixtures, and furniture-mounted fixtures).</p> <p>Lighting power for parking garages, exterior spaces and building facades shall be modeled</p> <p>Minimum Lighting controls, as per the ECBC requirements of §6.2.1, shall be modeled in the Proposed case.</p> <p>Automatic daylighting controls shall be modeled directly in the software or through schedule adjustments determined by a separate daylight analysis approved by the authority having jurisdiction.</p> <p>Other automatic lighting controls shall be modeled directly in the software by adjusting the lighting power as per Table 9-3.</p> | <p>Interior lighting power in the Standard Design shall be determined using the same categorization procedure (building area or space function) and categories as the Proposed Design with lighting power set equal to the maximum allowed for the corresponding method and category in either §6.3.2 or §6.3.3. Power for fixtures not included in the lighting power density calculation shall be modeled identically in the Proposed Design and Standard Design. Lighting controls shall be as per the ECBC requirements of §6.2.1.</p> <p>Exterior lighting power in the standard design shall be set equal to the maximum allowed in §6.3.5</p> |

|   |   |
|---|---|
| <p><b>6.</b><br/>HVAC Thermal Zones</p> | <p>HVAC Zones Designed: Where HVAC zones are defined on design drawings, each HVAC zone shall be modeled as a separate thermal block.<br/>Exception: Identical zones (similar occupancy and usage, similar internal loads, similar set points and type of HVAC system, glazed exterior walls face the same orientation or vary by less than 45°) may be combined for simplicity.<br/>HVAC Zones Not Designed: Where HVAC zones are not defined on design drawings, HVAC zones shall be defined based on similar occupancy and usage, similar internal loads, similar set points and type of HVAC system, glazed exterior walls that face the same orientation or vary by less than 45° in combination with the following rules:<br/>Perimeter Core Zoning: Separate thermal block shall be modeled for perimeter and core spaces. Perimeter spaces are defined as spaces located within 5 meters of an exterior or semi exterior wall. Core spaces are defined as spaces located greater than 5 meters of an exterior or semi exterior wall. Separate thermal blocks shall be modeled for floors in contact with ground and for floors which have a ceiling/roof exposure to the ambient.</p> |
| <p><b>7.</b><br/>HVAC Systems</p>       | <p>The HVAC system type and all related performance parameters, such as equipment capacities and efficiencies, in the Proposed Design shall be determined as follows:<br/>(a) Where a complete HVAC system exists, the model shall reflect the actual system type using actual component capacities and efficiencies.<br/>(b) Where an HVAC system has been designed, the HVAC model shall be consistent with design documents. Mechanical equipment efficiencies shall be adjusted from actual design conditions to the rating conditions specified in §5, if required by the simulation model.<br/>(c) Where no heating system has been specified, the heating system shall be assumed to be electric. The system characteristics shall be identical to the system modeled in the Standard Design.<br/>(d) Where no cooling system has been specified, the cooling system and its</p> <p>Same as Proposed Design</p> <p>The HVAC system type shall be as per Table 9-2 and related performance parameters for the Standard Design shall be determined from requirements of §9.4.2. Equipment performance shall meet the requirements of §5 for code compliant building.</p>                 |

|   |   |  |
|---|---|--|
|   | characteristics shall be identical to the system modeled in the Standard Design.  |  |
| <b>8.</b><br>Service Hot Water                                | <p>The service hot water system type and all related performance parameters, such as equipment capacities and efficiencies, in the Proposed Design shall be determined as follows:</p> <p>(a) Where a complete service hot water system exists, the model shall reflect the actual system type using actual component capacities and efficiencies.</p> <p>(b) Where a service hot water system has been designed, the service hot water model shall be consistent with design documents.</p> <p>(c) Where no service hot water system exists, or is specified, no service hot water heating shall be modeled.</p>   | <p>The service water heating system shall be of the same type as the Proposed Design. For residential facilities, hotels and hospitals the Standard Design shall have a solar hot water system capable of meeting 20% of the hot water demand. Systems shall meet the efficiency requirements of §5.2.7.2.</p> |
| <b>9.</b><br>Miscellaneous Loads                              | <p>Receptacle, motor, and process loads shall be modeled and estimated based on the building type or space type category. These loads shall be included in simulations of the building and shall be included when calculating the Standard Design and Proposed Design. All end-use load components within and associated with the building shall be modeled, unless specifically excluded by this Table, but not limited to, exhaust fans, parking garage ventilation fans, exterior building lighting, swimming pool heaters and pumps, elevators and escalators, refrigeration equipment, and cooking equipment.</p>  | <p>Receptacle, motor and process loads shall be modeled the same as the Proposed Design.</p>   |
| <b>10.</b><br>Modelling Limitations to the Simulation Program | <p>If the simulation program cannot model a component or system included in the Proposed Design, one of the following methods shall be used with the approval of the authority having jurisdiction:</p> <p>(a) Ignore the component if the energy impact on the trade-offs being considered is not significant.</p> <p>(b) Model the component substituting a thermodynamically similar component model.</p> <p>(c) Model the HVAC system components or systems using the HVAC system of the Standard Design in accordance with Section 6 of this table.</p> <p>Whichever method is selected, the component shall be modeled identically for both the Proposed Design and Standard Design models.</p> | <p>Same as Proposed Design.</p>  |



Table 9-2 HVAC Systems Map for Standard Design

|                          |   |  |  |  |
|--------------------------|---|--|--|--|
|                          | Hotel/Motel, Hospital Patient Rooms, Hotel Guest Rooms, Resorts, Villas, Sleeping Quarters in Mixed-use Buildings, Schools, Classrooms/Lecture Rooms <sup>1</sup>   | Buildings with Less than or Equal to 12,500 m <sup>2</sup> of Conditioned Area   | Buildings with More than 12,500 m <sup>2</sup> of Conditioned Area   | Data Centre/ Server/Computer Rooms         |
| Name                     | <b>System A</b>   | <b>System B</b>  | <b>System C</b>  | <b>System D</b>                            |
| System Type <sup>2</sup> | Split AC  | VRF: Variable Refrigerant Flow   | VAV: Central cooling plant with variable volume AHU <sup>3</sup>   | Computer Room air conditioners             |
| Fan Control              | Constant Volume   | Constant volume  | Variable volume  | Constant volume                            |
| Cooling Type             | Direct expansion with air cooled condenser  | Direct expansion with air cooled condenser   | Chilled Water with water cooled condenser  | Direct expansion with air cooled condenser |
| Heating Type             | 1. Heat Pump: Where no heating system has been specified or where an electric heating system has been specified in the Proposed Design<br>2. Fossil Fuel Boiler, Fossil/Electric Hybrid: Where a heating system exists and a fossil fuel hot water boiler has been specified in the Proposed Design | 1. Heat Pump: Where no heating system has been specified or where an electric heating system has been specified in the Proposed Design<br>2. Fossil Fuel Boiler Fossil/Electric Hybrid: Where a heating system exists and a fossil fuel hot water boiler has been specified in the Proposed Design | 1. Electric resistance: Where no heating system has been specified or where an electric heating system has been specified in the Proposed Design<br>2. Fossil Fuel Boiler Fossil/Electric Hybrid: Where a heating system exists and a fossil fuel hot water boiler has been specified in the Proposed Design | NA   |

## Notes:

1. Buildings of the listed occupancy types or spaces in Mixed-use Buildings with the listed occupancy types.

2. Where attributes make a building eligible for more than one system type; use the predominant condition to determine the Standard Design system type provided the non-predominant conditions apply to less than 1,000 m<sup>2</sup> of conditioned floor area. Use additional system type for non-predominant conditions if those conditions apply to more than 1,000 m<sup>2</sup> of conditioned floor area.

Use additional system type for any space which has a substantial difference in peak loads and/or operational hours compared to the predominant space type. Such spaces may include but are not limited to computer/server rooms, retail areas in residential, or office buildings.

3. One AHU per floor at a minimum.

Table 9-3 Power Adjustment Factors for Automatic Lighting Controls

| <i>Automatic Control Device</i>                  | <i>Daytime occupancy and area &lt;300 m<sup>2</sup></i> | <i>All Others</i> |
|--|---|-------------------|
| Programmable Timing Control                      | 10%   | 0%                |
| Occupancy Sensor                                 | 10%   | 10%               |
| Occupancy Sensor and Programmable Timing Control | 15%   | 10%               |

## 9.4.2 HVAC Systems

The HVAC system type and related performance parameters for the Standard Design shall be determined from Table 9-2 and the following rules:

- (a) Other components: Components and parameters not listed in Table 9-2 or otherwise specifically addressed in this subsection shall be identical to those in the Proposed Design.

Exception to § 9.4.2(a): Where there are specific requirements in §5.2.2, the component efficiency in the Standard Design shall be adjusted to the lowest efficiency level allowed by the requirement for that component type.

- (b) All HVAC and service water heating equipment in the Standard Design shall be modeled at the minimum efficiency levels, both part load and full load, in accordance with §5.2.2.
- (c) Where efficiency ratings, such as EER and COP, include fan energy, the descriptor shall be broken down into its components so that supply fan energy can be modeled separately.
- (d) Minimum outdoor air ventilation rates shall be the same for both the Standard Design and the Proposed Design except for conditions specified in §9.4.2.1.
- (e) The equipment capacity for the standard design shall be based on sizing runs for each orientation and shall be oversized by 15% for cooling and 25% for heating, i.e., the ratio between the capacities determined by the sizing runs shall be 1.15 for cooling and 1.25 for heating.
- (f) Unmet load hours for the Proposed Design shall not differ from unmet load hours for the Standard Design by more than 50 hours. Maximum number of unmet hours shall not exceed 300 for either case.

### 9.4.2.1 Minimum Outdoor air rates:

Minimum outdoor air rates shall be identical for both the Standard Design and Proposed Design, except

- (a) when modeling demand controlled ventilation (DCV) in the Proposed Design (DCV is not required in the Standard Design as per §5.2.1.3.
- (b) when the Proposed Design has a ventilation flow higher than the minimum required by the applicable code, the Standard Design shall be modeled as per the minimum

ventilation rate required by the applicable code and the Proposed Design shall be modeled as per actual design (higher than Standard Design)

#### 9.4.2.2 Fan Schedules

Supply and return fans shall operate continuously whenever the spaces are occupied and shall be cycled to meet heating and cooling loads during unoccupied hours.

#### 9.4.2.3 Fan Power

(a) For Systems Types A, B and D,

$$P_{fan} = cmh \times .51$$

Where  $P_{fan}$  = Standard Design fan power in watts

cmh = Standard Design supply airflow rate auto-sized by the simulation software

(b) For System Type C

Fan power shall be modeled as per efficiency limits specified in Table 5-11 using a static pressure of 622 Pa or the design static pressure, whichever is higher. The simulation software shall automatically calculate the Standard Design fan power based on the above inputs.

#### 9.4.2.4 Design Airflow Rates

Design airflow rates for the Standard Design shall be sized based on a supply air to room air temperature difference of 11 °C for cooling and 18°C for heating. The Proposed Design airflow rates shall be as per design.

#### 9.4.2.5 Economizers (airside and waterside)

Airside economizers shall be modeled in the Standard Design as per the requirements of §5.3.5.

Exception to §9.4.2.5: Airside economizer shall not be modeled for Standard Design HVAC System Type A.

#### 9.4.2.6 Energy Recovery

Energy recovery shall be modeled in the Standard Design as per the requirements of §5.3.

#### 9.4.2.7 Chilled Water Design Supply Temperatures

Chilled water design supply temperature shall be modeled at 6.7°C and return temperature at 13.3°C.

#### 9.4.2.8 Chillers

Only electric chillers shall be modeled in the Standard Design for System C. Chillers shall meet the minimum efficiency requirements indicated in Table 5-1 and Table 5-2. Chillers in the Standard Design shall be selected as per Table 9-4 below:

Table 9-4 Types and Number of Chillers for Standard Design

| Peak Building Cooling Load (kW <sub>r</sub> ) | Chiller Type  |
|---|---|
| < 1,055                                       | 1 Water Cooled Screw Chiller  |
| 1,055 to 2,110                                | 2 Water Cooled Screw Chillers equally sized   |
| > 2,110                                       | 2 or more Water Cooled Centrifugal Chillers, equally sized such that no Chiller is greater than 2,813 kW <sub>r</sub> |

Exception to 9.4.2.8: Air cooled chillers are allowed to be modeled in the Standard Design if the Proposed Design has air cooled chillers. If the proposed building has a mix of air and water cooled chillers, then the Standard Design shall be modeled with a mix of air and water cooled chillers in the same proportion as in the Proposed Design.

#### 9.4.2.9 Chilled Water Pumps

*Chilled and condenser water pumps for the Standard Design shall be modeled as per power and efficiency limits specified in*

Table 5-16. Standard Design chilled water pumps shall be modeled as primary-secondary with variable secondary flow.

#### 9.4.2.10 Cooling Tower

Standard Design cooling tower shall be modeled as an open circuit axial flow tower with power and efficiency as per §5.3.3. The fans shall be modeled as two speed.

Condenser water design supply temperature shall be 29.4°C or 5.6°C approach to wet bulb temperature, whichever is lower, with a design temperature rise of 5.6°C.

#### 9.4.2.11 Boiler

Standard Design boilers shall be modeled as natural draft boilers and shall use the same fuel as the Proposed Design. Boiler efficiency shall be modeled as per Table 5-6.

#### 9.4.2.12 Hot Water Design Supply Temperatures

Hot water design supply temperature shall be modeled at 82°C and return temperature at 54°C.

#### 9.4.2.13 Hot Water Pumps

The Standard Design hot water pumps shall be modeled with a minimum efficiency of 70% and a pump power of 300 W/l-s<sup>-1</sup>.

Standard Design hot water pumps shall be modeled as primary-secondary with variable secondary flow.

#### 9.4.2.14 Campus/District Cooling Systems

All district cooling plants shall be assumed to be on grid electricity, unless otherwise specified and supported through pertinent documents. New district plants shall comply with

the mandatory requirements of ECBC irrespective of who owns and/or operates the district plant.

Projects may choose either option A or option B given below for modelling campus/district cooling systems.

#### **Option A**

The cooling source shall be modeled as purchased chilled water in both the Standard Design and Proposed Design. For the Standard Design, Table 9-2, shall be modified as follows:

- (a) For System Type C; purchased chilled water shall be modeled as the cooling source.
- (b) System Types A and B shall be replaced with a two-pipe fan coil system with purchased chilled water as the cooling source.

The chilled water/thermal energy consumption simulated by the software shall be converted to units of kWh and added to the overall building energy consumption. The following conversion factors shall be used to convert chilled water/thermal energy consumption to units of kWh.

$$1 \text{ ton hour} = 0.85 \text{ kWh}$$

$$1 \text{ MBtu} = 1,000,000 \text{ Btu} = 293 \text{ kWh}$$

#### **Option B**

The Standard Design shall be modeled as per Table 9-2 HVAC Systems Map.

For the Proposed Design, model a virtual onsite chilled water plant with Chiller, Pumps and cooling towers modeled at minimum efficiency levels as per §9.4.2.7 to §9.4.2.10.

Airside/low side capacities shall be modeled as per design and the plant capacities shall be auto-sized by the software.

### **9.4.3 Compliance Thresholds for ECBC compliant, ECBC+ and SuperECBC Buildings**

For buildings to qualify as ECBC+ and SuperECBC Buildings, the WBP Method shall be followed for the Standard Design as detailed above. The Proposed Design for ECBC+ and SuperECBC Buildings shall meet the mandatory provisions of §4.2, §5.2, §6.2, and §7.2.

The EPI Ratio for ECBC+ and SuperECBC Buildings shall be equal to or less than the EPI Ratios listed under the applicable climate zone in Table 9-5 through Table 9-9 of §9.5.

## 9.5 Maximum Allowed EPI Ratios

Table 9-5 Maximum Allowed EPI Ratios for Building in Composite Climate

| Building Type            | Composite |       |           |
|--------------------------|-----------|-------|-----------|
|                          | ECBC      | ECBC+ | SuperECBC |
| Hotel (No Star and Star) | 1         | 0.91  | 0.81      |
| Resort                   | 1         | 0.88  | 0.76      |
| Hospital                 | 1         | 0.85  | 0.77      |
| Outpatient               | 1         | 0.85  | 0.75      |
| Assembly                 | 1         | 0.86  | 0.77      |
| Office (Regular Use)     | 1         | 0.86  | 0.78      |
| Office (24Hours)         | 1         | 0.88  | 0.76      |
| Schools and University   | 1         | 0.77  | 0.66      |
| Open Gallery Mall        | 1         | 0.85  | 0.76      |
| Shopping Mall            | 1         | 0.86  | 0.74      |
| Supermarket              | 1         | 0.81  | 0.70      |
| Strip retail             | 1         | 0.82  | 0.68      |

Table 9-6 Maximum Allowed EPI Ratios for Buildings in Hot and Dry Climate

| Building Type            | Hot and Dry |       |           |
|--------------------------|-------------|-------|-----------|
|                          | ECBC        | ECBC+ | SuperECBC |
| Hotel (No Star and Star) | 1           | 0.90  | 0.81      |
| Resort                   | 1           | 0.88  | 0.76      |
| Hospital                 | 1           | 0.84  | 0.76      |
| Outpatient               | 1           | 0.85  | 0.75      |
| Assembly                 | 1           | 0.86  | 0.78      |
| Office (Regular Use)     | 1           | 0.86  | 0.78      |
| Office (24Hours)         | 1           | 0.88  | 0.76      |
| Schools and University   | 1           | 0.77  | 0.66      |
| Open Gallery Mall        | 1           | 0.85  | 0.77      |
| Shopping Mall            | 1           | 0.84  | 0.72      |
| Supermarket              | 1           | 0.73  | 0.69      |
| Strip retail             | 1           | 0.82  | 0.68      |

Table 9-7 Maximum Allowed EPI Ratios for Buildings in Temperate Climate

| Building Type            | Temperate |       |           |
|--------------------------|-----------|-------|-----------|
|                          | ECBC      | ECBC+ | SuperECBC |
| Hotel (No Star and Star) | 1         | 0.90  | 0.80      |
| Resort                   | 1         | 0.88  | 0.75      |
| Hospital                 | 1         | 0.82  | 0.73      |
| Outpatient               | 1         | 0.85  | 0.75      |
| Assembly                 | 1         | 0.85  | 0.76      |
| Office (Regular Use)     | 1         | 0.85  | 0.75      |
| Office (24Hours)         | 1         | 0.87  | 0.74      |
| Schools and University   | 1         | 0.77  | 0.66      |
| Open Gallery Mall        | 1         | 0.83  | 0.74      |
| Shopping Mall            | 1         | 0.84  | 0.71      |
| Supermarket              | 1         | 0.81  | 0.69      |
| Strip retail             | 1         | 0.81  | 0.67      |

Table 9-8 Maximum Allowed EPI Ratios for Buildings in Warm and Humid Climate

| Building Type            | Warm and Humid |       |           |
|--------------------------|----------------|-------|-----------|
|                          | ECBC           | ECBC+ | SuperECBC |
| Hotel (No Star and Star) | 1              | 0.91  | 0.81      |
| Resort                   | 1              | 0.88  | 0.75      |
| Hospital                 | 1              | 0.86  | 0.77      |
| Outpatient               | 1              | 0.86  | 0.76      |
| Assembly                 | 1              | 0.88  | 0.80      |
| Office (Regular Use)     | 1              | 0.86  | 0.76      |
| Office (24Hours)         | 1              | 0.88  | 0.76      |
| Schools and University   | 1              | 0.77  | 0.66      |
| Open Gallery Mall        | 1              | 0.86  | 0.77      |
| Shopping Mall            | 1              | 0.85  | 0.72      |
| Supermarket              | 1              | 0.82  | 0.70      |
| Strip retail             | 1              | 0.83  | 0.68      |

Table 9-9 Maximum Allowed EPI Ratios for Buildings in Cold Climate

| Building Type            | Cold |       |           |
|--------------------------|------|-------|-----------|
|                          | ECBC | ECBC+ | SuperECBC |
| Hotel (No Star and Star) | 1    | 0.91  | 0.82      |
| Resort                   | 1    | 0.88  | 0.75      |
| Hospital                 | 1    | 0.88  | 0.80      |
| Outpatient               | 1    | 0.85  | 0.75      |
| Assembly                 | 1    | 0.87  | 0.81      |
| Office (Regular Use)     | 1    | 0.88  | 0.80      |
| Office (24Hours)         | 1    | 0.87  | 0.75      |
| Schools and University   | 1    | 0.85  | 0.73      |
| Open Gallery Mall        | 1    | 0.82  | 0.73      |
| Shopping Mall            | 1    | 0.96  | 0.93      |
| Supermarket              | 1    | 0.80  | 0.68      |
| Strip retail             | 1    | 0.80  | 0.66      |



## 9.6 Schedules

Table 9-10 Schedules for Business - Office Buildings

| Business - Office |                    |                   |                            |                      |                   |                   |                   |
|-------------------|--------------------|-------------------|----------------------------|----------------------|-------------------|-------------------|-------------------|
| Time Period       | Elevator Schedules |                   | External Lighting Schedule | Basement Ventilation |                   | Basement Lighting |                   |
|                   | Daytime Business   | 24 Hours Business | 7 Days / week              | Daytime Business     | 24 Hours Business | Daytime Business  | 24 Hours Business |
| 00:00-01:00       | 0.05               | 0.55              | 0.80                       | 0.00                 | 1.00              | 0.05              | 1.00              |
| 01:00-02:00       | 0.05               | 0.25              | 0.80                       | 0.00                 | 1.00              | 0.05              | 1.00              |
| 02:00-03:00       | 0.05               | 0.25              | 0.80                       | 0.00                 | 1.00              | 0.05              | 1.00              |
| 03:00-04:00       | 0.05               | 0.15              | 0.80                       | 0.00                 | 1.00              | 0.05              | 1.00              |
| 04:00-05:00       | 0.05               | 0.35              | 0.80                       | 0.00                 | 1.00              | 0.05              | 1.00              |
| 05:00-06:00       | 0.05               | 0.50              | 0.80                       | 0.00                 | 1.00              | 0.05              | 1.00              |
| 06:00-07:00       | 0.20               | 0.20              | 0.00                       | 0.00                 | 1.00              | 0.05              | 1.00              |
| 07:00-08:00       | 0.40               | 0.40              | 0.00                       | 0.00                 | 1.00              | 0.05              | 1.00              |
| 08:00-09:00       | 0.80               | 0.80              | 0.00                       | 1.00                 | 1.00              | 1.00              | 1.00              |
| 09:00-10:00       | 0.80               | 0.80              | 0.00                       | 1.00                 | 1.00              | 1.00              | 1.00              |
| 10:00-11:00       | 0.55               | 0.55              | 0.00                       | 1.00                 | 1.00              | 1.00              | 1.00              |
| 11:00-12:00       | 0.35               | 0.35              | 0.00                       | 1.00                 | 1.00              | 1.00              | 1.00              |
| 12:00-13:00       | 0.25               | 0.25              | 0.00                       | 1.00                 | 1.00              | 1.00              | 1.00              |
| 13:00-14:00       | 0.95               | 0.95              | 0.00                       | 1.00                 | 1.00              | 1.00              | 1.00              |
| 14:00-15:00       | 0.95               | 0.95              | 0.00                       | 1.00                 | 1.00              | 1.00              | 1.00              |
| 15:00-16:00       | 0.35               | 0.35              | 0.00                       | 1.00                 | 1.00              | 1.00              | 1.00              |
| 16:00-17:00       | 0.15               | 0.35              | 0.00                       | 1.00                 | 1.00              | 1.00              | 1.00              |
| 17:00-18:00       | 0.75               | 0.70              | 0.00                       | 1.00                 | 1.00              | 1.00              | 1.00              |
| 18:00-19:00       | 0.95               | 0.95              | 0.80                       | 1.00                 | 1.00              | 1.00              | 1.00              |
| 19:00-20:00       | 0.50               | 0.50              | 0.80                       | 1.00                 | 1.00              | 1.00              | 1.00              |
| 20:00-21:00       | 0.30               | 0.35              | 0.80                       | 1.00                 | 1.00              | 1.00              | 1.00              |
| 21:00-22:00       | 0.20               | 0.25              | 0.80                       | 0.00                 | 1.00              | 0.05              | 1.00              |
| 22:00-23:00       | 0.05               | 0.25              | 0.80                       | 0.00                 | 1.00              | 0.05              | 1.00              |
| 23:00-24:00       | 0.05               | 0.55              | 0.80                       | 0.00                 | 1.00              | 0.05              | 1.00              |

Table 9-11: Schedules for Business - Office Building Daytime Business

| Business – Office Daytime Business |                    |                    |                         |                   |                    |                         |                    |                         |                                    |         |
|------------------------------------|--------------------|--------------------|-------------------------|-------------------|--------------------|-------------------------|--------------------|-------------------------|------------------------------------|---------|
| Time Period                        | Occupancy Schedule |                    |                         | Lighting Schedule |                    |                         | Equipment Schedule |                         | HVAC Fan Schedule (On/Off)         |         |
|                                    | Office             | Corridor/<br>Lobby | Conference<br>/ Meeting | Office            | Corridor/<br>Lobby | Conference<br>/ Meeting | Office             | Conference<br>/ Meeting | Office/<br>Corridor/<br>Conference | Meeting |
| 00:00-01:00                        | 0.00               | 0.00               | 0.00                    | 0.10              | 0.10               | 0.00                    | 0.00               | 0.00                    | 0                                  | 0       |
| 01:00-02:00                        | 0.00               | 0.00               | 0.00                    | 0.10              | 0.10               | 0.00                    | 0.00               | 0.00                    | 0                                  | 0       |
| 02:00-03:00                        | 0.00               | 0.00               | 0.00                    | 0.10              | 0.10               | 0.00                    | 0.00               | 0.00                    | 0                                  | 0       |
| 03:00-04:00                        | 0.00               | 0.00               | 0.00                    | 0.10              | 0.10               | 0.00                    | 0.00               | 0.00                    | 0                                  | 0       |
| 04:00-05:00                        | 0.00               | 0.00               | 0.00                    | 0.10              | 0.10               | 0.00                    | 0.00               | 0.00                    | 0                                  | 0       |
| 05:00-06:00                        | 0.00               | 0.00               | 0.00                    | 0.10              | 0.10               | 0.00                    | 0.00               | 0.00                    | 0                                  | 0       |
| 06:00-07:00                        | 0.00               | 0.00               | 0.00                    | 0.10              | 0.10               | 0.00                    | 0.00               | 0.00                    | 0                                  | 0       |
| 07:00-08:00                        | 0.00               | 0.00               | 0.00                    | 0.10              | 0.10               | 0.00                    | 0.00               | 0.00                    | 1                                  | 0       |
| 08:00-09:00                        | 0.20               | 0.70               | 0.00                    | 0.90              | 0.90               | 0.00                    | 0.10               | 0.00                    | 1                                  | 1       |
| 09:00-10:00                        | 0.95               | 0.80               | 0.00                    | 0.90              | 0.90               | 0.00                    | 0.90               | 0.00                    | 1                                  | 1       |
| 10:00-11:00                        | 0.95               | 0.70               | 0.75                    | 0.90              | 0.90               | 0.90                    | 0.90               | 0.90                    | 1                                  | 1       |
| 11:00-12:00                        | 0.95               | 0.30               | 0.75                    | 0.90              | 0.90               | 0.90                    | 0.90               | 0.90                    | 1                                  | 1       |
| 12:00-13:00                        | 0.95               | 0.30               | 0.75                    | 0.90              | 0.90               | 0.90                    | 0.90               | 0.90                    | 1                                  | 1       |
| 13:00-14:00                        | 0.50               | 0.80               | 0.5                     | 0.50              | 0.90               | 0.50                    | 0.80               | 0.50                    | 1                                  | 1       |
| 14:00-15:00                        | 0.95               | 0.50               | 0.75                    | 0.90              | 0.90               | 0.90                    | 0.90               | 0.90                    | 1                                  | 1       |
| 15:00-16:00                        | 0.95               | 0.30               | 0.75                    | 0.90              | 0.90               | 0.90                    | 0.90               | 0.90                    | 1                                  | 1       |
| 16:00-17:00                        | 0.95               | 0.30               | 0.75                    | 0.90              | 0.90               | 0.90                    | 0.90               | 0.90                    | 1                                  | 1       |
| 17:00-18:00                        | 0.95               | 0.80               | 0.75                    | 0.95              | 0.90               | 0.90                    | 0.90               | 0.90                    | 1                                  | 1       |
| 18:00-19:00                        | 0.30               | 0.70               | 0.50                    | 0.50              | 0.90               | 0.90                    | 0.50               | 0.90                    | 1                                  | 1       |
| 19:00-20:00                        | 0.00               | 0.30               | 0.00                    | 0.30              | 0.90               | 0.00                    | 0.10               | 0.00                    | 1                                  | 0       |
| 20:00-21:00                        | 0.00               | 0.00               | 0.00                    | 0.10              | 0.10               | 0.00                    | 0.10               | 0.00                    | 1                                  | 0       |
| 21:00-22:00                        | 0.00               | 0.00               | 0.00                    | 0.10              | 0.10               | 0.00                    | 0.00               | 0.00                    | 0                                  | 0       |
| 22:00-23:00                        | 0.00               | 0.00               | 0.00                    | 0.10              | 0.10               | 0.00                    | 0.00               | 0.00                    | 0                                  | 0       |
| 23:00-24:00                        | 0.00               | 0.00               | 0.00                    | 0.10              | 0.10               | 0.00                    | 0.00               | 0.00                    | 0                                  | 0       |

Table 9-12: Schedules for Business - Office Building 24-hours Business

| Business – Office 24-hour Business |                    |                 |                     |                   |                 |                     |                    |                     |  |
|------------------------------------|--------------------|-----------------|---------------------|-------------------|-----------------|---------------------|--------------------|---------------------|--|
| Time Period                        | Occupancy Schedule |                 |                     | Lighting Schedule |                 |                     | Equipment Schedule |                     | HVAC Fan Schedule (On/Off)                   |
|                                    | Office             | Corridor/ Lobby | Conference/ Meeting | Office            | Corridor/ Lobby | Conference/ Meeting | Office             | Conference/ Meeting | Office/ Corridor/ Lobby/ Conference/ Meeting |
| 00:00-01:00                        | 0.90               | 0.20            | 0.00                | 0.90              | 0.90            | 0.00                | 0.95               | 0.00                | 1  |
| 01:00-02:00                        | 0.90               | 0.50            | 0.00                | 0.90              | 0.90            | 0.00                | 0.95               | 0.00                | 1  |
| 02:00-03:00                        | 0.90               | 0.20            | 0.00                | 0.90              | 0.90            | 0.00                | 0.95               | 0.00                | 1  |
| 03:00-04:00                        | 0.90               | 0.20            | 0.00                | 0.90              | 0.90            | 0.00                | 0.95               | 0.00                | 1  |
| 04:00-05:00                        | 0.50               | 0.20            | 0.50                | 0.50              | 0.90            | 0.50                | 0.00               | 0.90                | 1  |
| 05:00-06:00                        | 0.20               | 0.50            | 0.50                | 0.05              | 0.90            | 0.50                | 0.00               | 0.90                | 1  |
| 06:00-07:00                        | 0.10               | 0.50            | 0.50                | 0.05              | 0.50            | 0.50                | 0.00               | 0.90                | 1  |
| 07:00-08:00                        | 0.10               | 0.50            | 0.00                | 0.90              | 0.50            | 0.00                | 0.95               | 0.00                | 1  |
| 08:00-09:00                        | 0.90               | 0.70            | 0.00                | 0.90              | 0.90            | 0.00                | 0.95               | 0.00                | 1  |
| 09:00-10:00                        | 0.90               | 0.80            | 0.50                | 0.90              | 0.90            | 0.50                | 0.95               | 0.90                | 1  |
| 10:00-11:00                        | 0.90               | 0.70            | 0.75                | 0.90              | 0.90            | 0.90                | 0.95               | 0.90                | 1  |
| 11:00-12:00                        | 0.90               | 0.30            | 0.75                | 0.90              | 0.90            | 0.90                | 0.95               | 0.90                | 1  |
| 12:00-13:00                        | 0.90               | 0.30            | 0.75                | 0.90              | 0.90            | 0.90                | 0.95               | 0.90                | 1  |
| 13:00-14:00                        | 0.20               | 0.80            | 0.25                | 0.50              | 0.50            | 0.50                | 0.20               | 0.50                | 1  |
| 14:00-15:00                        | 0.90               | 0.50            | 0.75                | 0.90              | 0.90            | 0.90                | 0.95               | 0.90                | 1  |
| 15:00-16:00                        | 0.90               | 0.30            | 0.75                | 0.90              | 0.90            | 0.90                | 0.95               | 0.90                | 1  |
| 16:00-17:00                        | 0.90               | 0.30            | 0.75                | 0.90              | 0.90            | 0.90                | 0.95               | 0.90                | 1  |
| 17:00-18:00                        | 0.90               | 0.80            | 0.75                | 0.90              | 0.90            | 0.90                | 0.95               | 0.90                | 1  |
| 18:00-19:00                        | 0.90               | 0.70            | 0.50                | 0.90              | 0.90            | 0.90                | 0.20               | 0.90                | 1  |
| 19:00-20:00                        | 0.20               | 0.30            | 0.00                | 0.90              | 0.90            | 0.00                | 0.95               | 0.00                | 1  |
| 20:00-21:00                        | 0.90               | 0.20            | 0.00                | 0.90              | 0.90            | 0.00                | 0.95               | 0.00                | 1  |
| 21:00-22:00                        | 0.90               | 0.20            | 0.50                | 0.90              | 0.90            | 0.50                | 0.95               | 0.90                | 1  |
| 22:00-23:00                        | 0.90               | 0.20            | 0.50                | 0.90              | 0.90            | 0.50                | 0.95               | 0.90                | 1  |
| 23:00-24:00                        | 0.90               | 0.20            | 0.50                | 0.90              | 0.90            | 0.50                | 0.20               | 0.90                | 1  |

Table 9-13: Schedules for Business - Server Room

| Business Building - Server Room |                    |                  |                   |                  |                    |                            |
|---------------------------------|--------------------|------------------|-------------------|------------------|--------------------|----------------------------|
| Time Period                     | Occupancy Schedule |                  | Lighting Schedule |                  | Equipment Schedule | HVAC Fan Schedule (ON/OFF) |
|                                 | Daytime Business   | 24-hour business | Daytime Business  | 24-hour business | All time running   |                            |
| 00:00-01:00                     | 0.00               | 0.00             | 0.10              | 0.10             | 1.00               | 1                          |
| 01:00-02:00                     | 0.00               | 0.00             | 0.10              | 0.10             | 1.00               | 1                          |
| 02:00-03:00                     | 0.00               | 0.00             | 0.10              | 0.10             | 1.00               | 1                          |
| 03:00-04:00                     | 0.00               | 0.00             | 0.10              | 0.10             | 1.00               | 1                          |
| 04:00-05:00                     | 0.00               | 0.00             | 0.10              | 0.10             | 1.00               | 1                          |
| 05:00-06:00                     | 0.00               | 1.00             | 0.10              | 0.10             | 1.00               | 1                          |
| 06:00-07:00                     | 0.00               | 1.00             | 0.10              | 0.10             | 1.00               | 1                          |
| 07:00-08:00                     | 0.00               | 1.00             | 0.10              | 0.10             | 1.00               | 1                          |
| 08:00-09:00                     | 1.00               | 1.00             | 0.10              | 0.10             | 1.00               | 1                          |
| 09:00-10:00                     | 1.00               | 1.00             | 0.50              | 0.50             | 1.00               | 1                          |
| 10:00-11:00                     | 1.00               | 1.00             | 0.50              | 0.50             | 1.00               | 1                          |
| 11:00-12:00                     | 1.00               | 1.00             | 0.50              | 0.50             | 1.00               | 1                          |
| 12:00-13:00                     | 1.00               | 1.00             | 0.50              | 0.50             | 1.00               | 1                          |
| 13:00-14:00                     | 1.00               | 1.00             | 0.50              | 0.50             | 1.00               | 1                          |
| 14:00-15:00                     | 1.00               | 1.00             | 0.50              | 0.50             | 1.00               | 1                          |
| 15:00-16:00                     | 1.00               | 1.00             | 0.50              | 0.50             | 1.00               | 1                          |
| 16:00-17:00                     | 1.00               | 1.00             | 0.50              | 0.50             | 1.00               | 1                          |
| 17:00-18:00                     | 1.00               | 1.00             | 0.50              | 0.50             | 1.00               | 1                          |
| 18:00-19:00                     | 0.00               | 1.00             | 0.10              | 0.50             | 1.00               | 1                          |
| 19:00-20:00                     | 0.00               | 1.00             | 0.10              | 0.50             | 1.00               | 1                          |
| 20:00-21:00                     | 0.00               | 1.00             | 0.10              | 0.50             | 1.00               | 1                          |
| 21:00-22:00                     | 0.00               | 1.00             | 0.10              | 0.50             | 1.00               | 1                          |
| 22:00-23:00                     | 0.00               | 0.00             | 0.10              | 0.10             | 1.00               | 1                          |
| 23:00-24:00                     | 0.00               | 0.00             | 0.10              | 0.10             | 1.00               | 1                          |

Table 9-14: Schedules for Assembly Buildings (A)

| Assembly Buildings – Common Areas |                   |                            |               |                          |                            |                      |                   |
|-----------------------------------|-------------------|----------------------------|---------------|--------------------------|----------------------------|----------------------|-------------------|
| Time Period                       | Elevator Schedule | HVAC Fan Schedule (On/Off) |               |                          | External Lighting Schedule | Basement Ventilation | Basement Lighting |
|                                   |                   | Seating / Public Space     | Exhibit Space | Meeting/ Conference Room |                            |                      |                   |
| 00:00-01:00                       | 0.00              | 0                          | 0             | 0                        | 0.80                       | 0.00                 | 0.05              |
| 01:00-02:00                       | 0.00              | 0                          | 0             | 0                        | 0.80                       | 0.00                 | 0.05              |
| 02:00-03:00                       | 0.00              | 0                          | 0             | 0                        | 0.80                       | 0.00                 | 0.05              |
| 03:00-04:00                       | 0.00              | 0                          | 0             | 0                        | 0.80                       | 0.00                 | 0.05              |
| 04:00-05:00                       | 0.00              | 0                          | 0             | 0                        | 0.80                       | 0.00                 | 0.05              |
| 05:00-06:00                       | 0.00              | 0                          | 0             | 0                        | 0.80                       | 0.00                 | 0.05              |
| 06:00-07:00                       | 0.00              | 0                          | 0             | 1                        | 0.00                       | 0.00                 | 0.05              |
| 07:00-08:00                       | 0.00              | 1                          | 1             | 1                        | 0.00                       | 0.00                 | 0.05              |
| 08:00-09:00                       | 0.20              | 1                          | 1             | 1                        | 0.00                       | 1.00                 | 1.00              |
| 09:00-10:00                       | 0.50              | 1                          | 1             | 1                        | 0.00                       | 1.00                 | 1.00              |
| 10:00-11:00                       | 0.50              | 1                          | 1             | 1                        | 0.00                       | 1.00                 | 1.00              |
| 11:00-12:00                       | 0.50              | 1                          | 1             | 1                        | 0.00                       | 1.00                 | 1.00              |
| 12:00-13:00                       | 0.50              | 1                          | 1             | 1                        | 0.00                       | 1.00                 | 1.00              |
| 13:00-14:00                       | 0.50              | 1                          | 1             | 1                        | 0.00                       | 1.00                 | 1.00              |
| 14:00-15:00                       | 0.50              | 0                          | 1             | 1                        | 0.00                       | 1.00                 | 1.00              |
| 15:00-16:00                       | 0.50              | 0                          | 1             | 0                        | 0.00                       | 1.00                 | 1.00              |
| 16:00-17:00                       | 0.50              | 0                          | 1             | 0                        | 0.00                       | 1.00                 | 1.00              |
| 17:00-18:00                       | 0.50              | 0                          | 0             | 0                        | 0.00                       | 1.00                 | 0.50              |
| 18:00-19:00                       | 0.50              | 0                          | 0             | 0                        | 0.80                       | 0.00                 | 0.05              |
| 19:00-20:00                       | 0.40              | 0                          | 0             | 0                        | 0.80                       | 0.00                 | 0.05              |
| 20:00-21:00                       | 0.20              | 0                          | 0             | 0                        | 0.80                       | 0.00                 | 0.05              |
| 21:00-22:00                       | 0.20              | 0                          | 0             | 0                        | 0.80                       | 0.00                 | 0.05              |
| 22:00-23:00                       | 0.00              | 0                          | 0             | 0                        | 0.80                       | 0.00                 | 0.05              |
| 23:00-24:00                       | 0.00              | 0                          | 0             | 0                        | 0.80                       | 0.00                 | 0.05              |

Table 9-15: Schedules for Assembly Buildings (B)

| Assembly Buildings |                       |               |                     |                       |               |                     |                    |                     |
|--------------------|-----------------------|---------------|---------------------|-----------------------|---------------|---------------------|--------------------|---------------------|
| Time Period        | Occupancy Schedule    |               |                     | Lighting Schedule     |               |                     | Equipment Schedule |                     |
|                    | Seating/ Public Space | Exhibit Space | Meeting/ Conference | Seating/ Public Space | Exhibit Space | Meeting/ Conference | Exhibit Space      | Meeting/ Conference |
| 00:00-01:00        | 0.00                  | 0.00          | 0.00                | 0.10                  | 0.10          | 0.10                | 0.00               | 0.00                |
| 01:00-02:00        | 0.00                  | 0.00          | 0.00                | 0.10                  | 0.10          | 0.10                | 0.00               | 0.00                |
| 02:00-03:00        | 0.00                  | 0.00          | 0.00                | 0.10                  | 0.10          | 0.10                | 0.00               | 0.00                |
| 03:00-04:00        | 0.00                  | 0.00          | 0.00                | 0.10                  | 0.10          | 0.10                | 0.00               | 0.00                |
| 04:00-05:00        | 0.00                  | 0.00          | 0.00                | 0.10                  | 0.10          | 0.10                | 0.00               | 0.00                |
| 05:00-06:00        | 0.00                  | 0.00          | 0.00                | 0.10                  | 0.10          | 0.10                | 0.00               | 0.00                |
| 06:00-07:00        | 0.00                  | 0.00          | 0.00                | 0.10                  | 0.10          | 0.10                | 0.00               | 0.00                |
| 07:00-08:00        | 0.00                  | 0.00          | 0.00                | 0.10                  | 0.10          | 0.10                | 0.00               | 0.00                |
| 08:00-09:00        | 0.50                  | 0.50          | 0.00                | 0.90                  | 0.90          | 0.10                | 0.00               | 0.00                |
| 09:00-10:00        | 0.60                  | 0.50          | 0.50                | 0.90                  | 0.90          | 0.90                | 0.90               | 0.80                |
| 10:00-11:00        | 0.70                  | 0.80          | 0.75                | 0.90                  | 0.90          | 0.90                | 0.90               | 0.80                |
| 11:00-12:00        | 0.70                  | 0.80          | 0.75                | 0.90                  | 0.90          | 0.90                | 0.90               | 0.80                |
| 12:00-13:00        | 0.70                  | 0.80          | 0.75                | 0.90                  | 0.90          | 0.90                | 0.90               | 0.80                |
| 13:00-14:00        | 0.90                  | 0.25          | 0.50                | 0.90                  | 0.50          | 0.50                | 0.50               | 0.50                |
| 14:00-15:00        | 0.90                  | 0.25          | 0.75                | 0.90                  | 0.50          | 0.90                | 0.90               | 0.80                |
| 15:00-16:00        | 0.70                  | 0.80          | 0.75                | 0.90                  | 0.90          | 0.90                | 0.90               | 0.80                |
| 16:00-17:00        | 0.70                  | 0.80          | 0.75                | 0.90                  | 0.90          | 0.90                | 0.90               | 0.80                |
| 17:00-18:00        | 0.70                  | 0.80          | 0.75                | 0.90                  | 0.90          | 0.90                | 0.90               | 0.80                |
| 18:00-19:00        | 0.80                  | 0.50          | 0.50                | 0.90                  | 0.90          | 0.50                | 0.00               | 0.00                |
| 19:00-20:00        | 0.80                  | 0.00          | 0.00                | 0.90                  | 0.10          | 0.10                | 0.00               | 0.00                |
| 20:00-21:00        | 0.80                  | 0.00          | 0.00                | 0.90                  | 0.10          | 0.10                | 0.00               | 0.00                |
| 21:00-22:00        | 0.70                  | 0.00          | 0.00                | 0.90                  | 0.10          | 0.10                | 0.00               | 0.00                |
| 22:00-23:00        | 0.60                  | 0.00          | 0.00                | 0.90                  | 0.10          | 0.10                | 0.00               | 0.00                |
| 23:00-24:00        | 0.50                  | 0.00          | 0.00                | 0.90                  | 0.10          | 0.10                | 0.00               | 0.00                |

Table 9-16: Schedules for Assembly Buildings (C)

| Assembly Buildings - Museum |                    |                    |                   |                    |                    |                    |                            |                    |
|-----------------------------|--------------------|--------------------|-------------------|--------------------|--------------------|--------------------|----------------------------|--------------------|
| Time Period                 | Occupancy Schedule |                    | Lighting Schedule |                    | Equipment Schedule |                    | HVAC Fan Schedule (ON/OFF) |                    |
|                             | Museum Exhibition  | Museum Restoration | Museum Exhibition | Museum Restoration | Museum Exhibition  | Museum Restoration | Museum Exhibition          | Museum Restoration |
| 00:00-01:00                 | 0.00               | 0.00               | 0.10              | 0.10               | 0.00               | 0.00               | 0                          | 0                  |
| 01:00-02:00                 | 0.00               | 0.00               | 0.10              | 0.10               | 0.00               | 0.00               | 0                          | 0                  |
| 02:00-03:00                 | 0.00               | 0.00               | 0.10              | 0.10               | 0.00               | 0.00               | 0                          | 0                  |
| 03:00-04:00                 | 0.00               | 0.00               | 0.10              | 0.10               | 0.00               | 0.00               | 0                          | 0                  |
| 04:00-05:00                 | 0.00               | 0.00               | 0.10              | 0.10               | 0.00               | 0.00               | 0                          | 0                  |
| 05:00-06:00                 | 0.00               | 0.00               | 0.10              | 0.10               | 0.00               | 0.00               | 0                          | 0                  |
| 06:00-07:00                 | 0.00               | 0.00               | 0.10              | 0.10               | 0.00               | 0.00               | 0                          | 0                  |
| 07:00-08:00                 | 0.00               | 0.00               | 0.10              | 0.10               | 0.00               | 0.00               | 1                          | 1                  |
| 08:00-09:00                 | 0.50               | 0.80               | 0.90              | 0.90               | 0.00               | 0.90               | 1                          | 1                  |
| 09:00-10:00                 | 0.50               | 0.25               | 0.90              | 0.50               | 0.90               | 0.25               | 1                          | 1                  |
| 10:00-11:00                 | 0.80               | 0.25               | 0.90              | 0.50               | 0.90               | 0.25               | 1                          | 1                  |
| 11:00-12:00                 | 0.80               | 0.25               | 0.90              | 0.50               | 0.90               | 0.25               | 1                          | 1                  |
| 12:00-13:00                 | 0.80               | 0.25               | 0.90              | 0.50               | 0.90               | 0.25               | 1                          | 1                  |
| 13:00-14:00                 | 0.25               | 0.80               | 0.50              | 0.90               | 0.50               | 0.90               | 1                          | 1                  |
| 14:00-15:00                 | 0.25               | 0.80               | 0.50              | 0.90               | 0.90               | 0.90               | 1                          | 1                  |
| 15:00-16:00                 | 0.80               | 0.25               | 0.90              | 0.50               | 0.90               | 0.25               | 1                          | 1                  |
| 16:00-17:00                 | 0.80               | 0.25               | 0.90              | 0.50               | 0.90               | 0.25               | 1                          | 1                  |
| 17:00-18:00                 | 0.80               | 0.25               | 0.90              | 0.50               | 0.90               | 0.25               | 1                          | 1                  |
| 18:00-19:00                 | 0.25               | 0.80               | 0.90              | 0.90               | 0.00               | 0.90               | 1                          | 1                  |
| 19:00-20:00                 | 0.00               | 0.00               | 0.10              | 0.10               | 0.00               | 0.00               | 1                          | 1                  |
| 20:00-21:00                 | 0.00               | 0.00               | 0.10              | 0.10               | 0.00               | 0.00               | 0                          | 0                  |
| 21:00-22:00                 | 0.00               | 0.00               | 0.10              | 0.10               | 0.00               | 0.00               | 0                          | 0                  |
| 22:00-23:00                 | 0.00               | 0.00               | 0.10              | 0.10               | 0.00               | 0.00               | 0                          | 0                  |
| 23:00-24:00                 | 0.00               | 0.00               | 0.10              | 0.10               | 0.00               | 0.00               | 0                          | 0                  |

**Table 9-17: Schedules for Assembly Buildings (D)**

[illegible]



Table 9-18: Schedules for Healthcare - Hospital Buildings (A)

| Healthcare - Hospital |                    |               |               |                            |                   |                  |                            |               |                    |                            |               |
|-----------------------|--------------------|---------------|---------------|----------------------------|-------------------|------------------|----------------------------|---------------|--------------------|----------------------------|---------------|
| Time Period           | Occupancy Schedule |               |               |                            | Lighting Schedule |                  |                            |               | Equipment Schedule |                            |               |
|                       | In Patient & ICU   | Public Spaces | OPD & Offices | Diagnostic, emergency & OT | Public Spaces     | In Patient & ICU | Diagnostic, emergency & OT | OPD & Offices | In Patient & ICU   | Diagnostic, emergency & OT | OPD & Offices |
|                       | 7 Days/ week       | 7 Days/ week  | 7 Days/ week  | 7 Days/ week               | 7 Days/ week      | 7 Days/ week     | 7 Days/ week               | 7 Days/ week  | 7 Days/ week       | 7 Days/ week               | 7 Days/ week  |
| 00:00-01:00           | 0.90               | 0.00          | 0.00          | 0.50                       | 0.10              | 0.10             | 0.50                       | 0.05          | 0.40               | 0.00                       | 0.00          |
| 01:00-02:00           | 0.90               | 0.00          | 0.00          | 0.40                       | 0.10              | 0.10             | 0.50                       | 0.05          | 0.40               | 0.00                       | 0.00          |
| 02:00-03:00           | 0.90               | 0.00          | 0.00          | 0.40                       | 0.10              | 0.10             | 0.50                       | 0.05          | 0.40               | 0.00                       | 0.00          |
| 03:00-04:00           | 0.90               | 0.00          | 0.00          | 0.40                       | 0.10              | 0.10             | 0.50                       | 0.05          | 0.40               | 0.00                       | 0.00          |
| 04:00-05:00           | 0.90               | 0.00          | 0.00          | 0.40                       | 0.10              | 0.10             | 0.50                       | 0.05          | 0.40               | 0.00                       | 0.00          |
| 05:00-06:00           | 0.90               | 0.00          | 0.00          | 0.40                       | 0.10              | 0.10             | 0.50                       | 0.05          | 0.40               | 0.00                       | 0.00          |
| 06:00-07:00           | 0.90               | 0.00          | 0.00          | 0.50                       | 0.10              | 0.10             | 0.50                       | 0.10          | 0.40               | 0.00                       | 0.00          |
| 07:00-08:00           | 0.90               | 0.10          | 0.10          | 0.70                       | 0.50              | 0.20             | 0.50                       | 0.30          | 0.70               | 0.70                       | 0.70          |
| 08:00-09:00           | 0.90               | 0.50          | 0.30          | 0.70                       | 0.90              | 0.20             | 0.90                       | 0.90          | 0.90               | 0.90                       | 0.90          |
| 09:00-10:00           | 0.90               | 0.95          | 0.90          | 0.95                       | 0.90              | 0.20             | 0.90                       | 0.90          | 0.90               | 0.90                       | 0.90          |
| 10:00-11:00           | 0.90               | 0.95          | 0.90          | 0.95                       | 0.90              | 0.20             | 0.90                       | 0.90          | 0.90               | 0.90                       | 0.90          |
| 11:00-12:00           | 0.90               | 0.95          | 0.50          | 0.95                       | 0.90              | 0.20             | 0.90                       | 0.90          | 0.90               | 0.90                       | 0.90          |
| 12:00-13:00           | 0.90               | 0.95          | 0.20          | 0.95                       | 0.90              | 0.20             | 0.90                       | 0.90          | 0.90               | 0.90                       | 0.90          |
| 13:00-14:00           | 0.90               | 0.95          | 0.50          | 0.95                       | 0.90              | 0.20             | 0.90                       | 0.50          | 0.90               | 0.90                       | 0.90          |
| 14:00-15:00           | 0.90               | 0.95          | 0.90          | 0.95                       | 0.90              | 0.20             | 0.90                       | 0.90          | 0.90               | 0.90                       | 0.90          |
| 15:00-16:00           | 0.90               | 0.95          | 0.90          | 0.95                       | 0.90              | 0.20             | 0.90                       | 0.90          | 0.90               | 0.90                       | 0.90          |
| 16:00-17:00           | 0.90               | 0.95          | 0.90          | 0.95                       | 0.30              | 0.20             | 0.90                       | 0.90          | 0.60               | 0.60                       | 0.90          |
| 17:00-18:00           | 0.90               | 0.70          | 0.90          | 0.95                       | 0.30              | 0.70             | 0.90                       | 0.90          | 0.60               | 0.60                       | 0.90          |
| 18:00-19:00           | 0.90               | 0.50          | 0.50          | 0.95                       | 0.30              | 0.90             | 0.90                       | 0.50          | 0.60               | 0.60                       | 0.60          |
| 19:00-20:00           | 0.90               | 0.30          | 0.50          | 0.95                       | 0.30              | 0.90             | 0.90                       | 0.50          | 0.60               | 0.60                       | 0.60          |
| 20:00-21:00           | 0.90               | 0.10          | 0.50          | 0.70                       | 0.30              | 0.90             | 0.50                       | 0.30          | 0.60               | 0.60                       | 0.60          |
| 21:00-22:00           | 0.90               | 0.00          | 0.10          | 0.70                       | 0.30              | 0.90             | 0.50                       | 0.20          | 0.60               | 0.00                       | 0.00          |
| 22:00-23:00           | 0.90               | 0.00          | 0.00          | 0.50                       | 0.30              | 0.70             | 0.50                       | 0.10          | 0.60               | 0.00                       | 0.00          |
| 23:00-24:00           | 0.90               | 0.00          | 0.00          | 0.50                       | 0.10              | 0.10             | 0.50                       | 0.05          | 0.40               | 0.00                       | 0.00          |

Table 9-19: Schedules for Healthcare - Hospital Buildings (B)

| Healthcare - Hospital |                            |              |                    |               |                            |           |                   |                  |                      |                   |
|-----------------------|----------------------------|--------------|--------------------|---------------|----------------------------|-----------|-------------------|------------------|----------------------|-------------------|
| Time Period           | HVAC Fan Schedule (On/Off) |              |                    |               | External Lighting Schedule | Elevators | Service Hot Water |                  | Basement Ventilation | Basement Lighting |
|                       | Public Spaces              | Beds & ICU   | Diagn, emerg, & OT | OPD & Offices |                            |           | Building Summer   | Building Winters |                      |                   |
|                       | 7 Days/ week               | 7 Days/ week | 7 Days/ week       | 7 Days/ week  |                            |           | 7 Days/ week      | 7 Days/ week     |                      |                   |
| 00:00-01:00           | 0                          | 1            | 1                  | 0             | 1.00                       | 0.20      | 0.00              | 0.30             | 0.50                 | 0.50              |
| 01:00-02:00           | 0                          | 1            | 1                  | 0             | 1.00                       | 0.20      | 0.00              | 0.30             | 0.50                 | 0.50              |
| 02:00-03:00           | 0                          | 1            | 1                  | 0             | 1.00                       | 0.20      | 0.00              | 0.30             | 0.50                 | 0.50              |
| 03:00-04:00           | 0                          | 1            | 1                  | 0             | 1.00                       | 0.20      | 0.00              | 0.30             | 0.50                 | 0.50              |
| 04:00-05:00           | 0                          | 1            | 1                  | 0             | 1.00                       | 0.20      | 0.00              | 0.30             | 0.50                 | 0.50              |
| 05:00-06:00           | 0                          | 1            | 1                  | 0             | 1.00                       | 0.20      | 0.00              | 0.30             | 0.50                 | 0.50              |
| 06:00-07:00           | 0                          | 1            | 1                  | 0             | 0.00                       | 0.20      | 0.00              | 0.30             | 0.50                 | 0.50              |
| 07:00-08:00           | 1                          | 1            | 1                  | 0             | 0.00                       | 0.50      | 0.00              | 0.20             | 0.50                 | 0.50              |
| 08:00-09:00           | 1                          | 1            | 1                  | 1             | 0.00                       | 0.75      | 0.20              | 0.60             | 1.00                 | 1.00              |
| 09:00-10:00           | 1                          | 1            | 1                  | 1             | 0.00                       | 1.00      | 0.30              | 0.60             | 1.00                 | 1.00              |
| 10:00-11:00           | 1                          | 1            | 1                  | 1             | 0.00                       | 1.00      | 0.30              | 0.80             | 1.00                 | 1.00              |
| 11:00-12:00           | 1                          | 1            | 1                  | 1             | 0.00                       | 1.00      | 0.30              | 0.80             | 1.00                 | 1.00              |
| 12:00-13:00           | 1                          | 1            | 1                  | 1             | 0.00                       | 0.75      | 0.25              | 0.70             | 1.00                 | 1.00              |
| 13:00-14:00           | 1                          | 1            | 1                  | 1             | 0.00                       | 1.00      | 0.25              | 0.80             | 1.00                 | 1.00              |
| 14:00-15:00           | 1                          | 1            | 1                  | 1             | 0.00                       | 1.00      | 0.25              | 0.80             | 1.00                 | 1.00              |
| 15:00-16:00           | 1                          | 1            | 1                  | 1             | 0.00                       | 1.00      | 0.25              | 0.70             | 1.00                 | 1.00              |
| 16:00-17:00           | 1                          | 1            | 1                  | 1             | 0.00                       | 1.00      | 0.25              | 0.70             | 1.00                 | 1.00              |
| 17:00-18:00           | 1                          | 1            | 1                  | 1             | 0.00                       | 1.00      | 0.10              | 0.50             | 1.00                 | 1.00              |
| 18:00-19:00           | 1                          | 1            | 1                  | 1             | 1.00                       | 0.50      | 0.00              | 0.35             | 1.00                 | 1.00              |
| 19:00-20:00           | 1                          | 1            | 1                  | 1             | 1.00                       | 0.50      | 0.00              | 0.35             | 1.00                 | 1.00              |
| 20:00-21:00           | 1                          | 1            | 1                  | 1             | 1.00                       | 0.50      | 0.00              | 0.35             | 1.00                 | 1.00              |
| 21:00-22:00           | 1                          | 1            | 1                  | 0             | 1.00                       | 0.30      | 0.00              | 0.30             | 0.50                 | 0.50              |
| 22:00-23:00           | 0                          | 1            | 1                  | 0             | 1.00                       | 0.20      | 0.00              | 0.30             | 0.50                 | 0.50              |
| 23:00-24:00           | 0                          | 1            | 1                  | 0             | 1.00                       | 0.20      | 0.00              | 0.30             | 0.50                 | 0.50              |

Table 9-20: Schedules for Healthcare – Out-patient Healthcare Buildings (A)

| Healthcare – Out-patient Healthcare |                    |                        |                   |                        |                   |                        |                   |
|-------------------------------------|--------------------|------------------------|-------------------|------------------------|-------------------|------------------------|-------------------|
| Time Period                         | Occupancy Schedule |                        |                   | Lighting Schedule      |                   | Equipment Schedule     |                   |
|                                     | Lobby              | Diagnostic & Emergency | OPD & Back Office | Diagnostic & Emergency | OPD & Back Office | Diagnostic & Emergency | OPD & Back Office |
|                                     | 6 days/ week       | 6 days/ week           | 6 days/ week      | 6 days/ week           | 6 days/ week      | 6 days/ week           | 6 days/ week      |
| 00:00-01:00                         | 0.00               | 0.00                   | 0.00              | 0.10                   | 0.00              | 0.00                   | 0.00              |
| 01:00-02:00                         | 0.00               | 0.00                   | 0.00              | 0.10                   | 0.00              | 0.00                   | 0.00              |
| 02:00-03:00                         | 0.00               | 0.00                   | 0.00              | 0.10                   | 0.00              | 0.00                   | 0.00              |
| 03:00-04:00                         | 0.00               | 0.00                   | 0.00              | 0.10                   | 0.00              | 0.00                   | 0.00              |
| 04:00-05:00                         | 0.00               | 0.00                   | 0.00              | 0.10                   | 0.00              | 0.00                   | 0.00              |
| 05:00-06:00                         | 0.00               | 0.00                   | 0.00              | 0.10                   | 0.00              | 0.00                   | 0.00              |
| 06:00-07:00                         | 0.00               | 0.20                   | 0.20              | 0.10                   | 0.10              | 0.00                   | 0.00              |
| 07:00-08:00                         | 0.10               | 0.20                   | 0.20              | 0.50                   | 0.30              | 0.50                   | 0.00              |
| 08:00-09:00                         | 0.50               | 0.30                   | 0.20              | 0.90                   | 0.90              | 0.95                   | 0.95              |
| 09:00-10:00                         | 0.80               | 0.90                   | 0.90              | 0.90                   | 0.90              | 0.95                   | 0.95              |
| 10:00-11:00                         | 0.80               | 0.90                   | 0.90              | 0.90                   | 0.90              | 0.95                   | 0.95              |
| 11:00-12:00                         | 0.80               | 0.90                   | 0.90              | 0.90                   | 0.90              | 0.95                   | 0.95              |
| 12:00-13:00                         | 0.80               | 0.90                   | 0.50              | 0.90                   | 0.90              | 0.95                   | 0.95              |
| 13:00-14:00                         | 0.80               | 0.90                   | 0.20              | 0.90                   | 0.50              | 0.95                   | 0.95              |
| 14:00-15:00                         | 0.80               | 0.90                   | 0.50              | 0.90                   | 0.90              | 0.95                   | 0.95              |
| 15:00-16:00                         | 0.80               | 0.90                   | 0.90              | 0.90                   | 0.90              | 0.95                   | 0.95              |
| 16:00-17:00                         | 0.80               | 0.90                   | 0.90              | 0.90                   | 0.90              | 0.95                   | 0.95              |
| 17:00-18:00                         | 0.80               | 0.90                   | 0.90              | 0.90                   | 0.95              | 0.95                   | 0.95              |
| 18:00-19:00                         | 0.80               | 0.90                   | 0.50              | 0.90                   | 0.95              | 0.95                   | 0.95              |
| 19:00-20:00                         | 0.80               | 0.90                   | 0.50              | 0.90                   | 0.30              | 0.95                   | 0.95              |
| 20:00-21:00                         | 0.20               | 0.65                   | 0.20              | 0.90                   | 0.30              | 0.80                   | 0.80              |
| 21:00-22:00                         | 0.20               | 0.20                   | 0.20              | 0.50                   | 0.20              | 0.00                   | 0.00              |
| 22:00-23:00                         | 0.00               | 0.00                   | 0.00              | 0.30                   | 0.00              | 0.00                   | 0.00              |
| 23:00-24:00                         | 0.00               | 0.00                   | 0.00              | 0.10                   | 0.00              | 0.00                   | 0.00              |

Table 9-21: Schedules for Healthcare – Out-patient Healthcare Buildings (B)

| Healthcare - Out-patient Healthcare |                   |                            |                            |                         |                  |                      |                   |
|-------------------------------------|-------------------|----------------------------|----------------------------|-------------------------|------------------|----------------------|-------------------|
| Time Period                         | Elevator Schedule | HVAC Fan Schedule (On/Off) | External Lighting Schedule | Service Hot Water (SHW) |                  | Basement Ventilation | Basement Lighting |
|                                     |                   | All Spaces                 |                            | Building Summer         | Building Winters |                      |                   |
|                                     | 6 days/ week      | 6 days/ week               | 7 Days/ week               | 6 days/ week            | 6 days/ week     | 6 days/ week         | 6 days/ week      |
| 00:00-01:00                         | 0.05              | 0                          | 0.20                       | 0.00                    | 0.00             | 0.00                 | 0.00              |
| 01:00-02:00                         | 0.05              | 0                          | 0.20                       | 0.00                    | 0.00             | 0.00                 | 0.00              |
| 02:00-03:00                         | 0.05              | 0                          | 0.20                       | 0.00                    | 0.00             | 0.00                 | 0.00              |
| 03:00-04:00                         | 0.05              | 0                          | 0.20                       | 0.00                    | 0.00             | 0.00                 | 0.00              |
| 04:00-05:00                         | 0.05              | 0                          | 0.20                       | 0.00                    | 0.00             | 0.00                 | 0.00              |
| 05:00-06:00                         | 0.05              | 0                          | 0.20                       | 0.00                    | 0.00             | 0.00                 | 0.00              |
| 06:00-07:00                         | 0.05              | 0                          | 0.00                       | 0.00                    | 0.00             | 0.00                 | 0.00              |
| 07:00-08:00                         | 0.50              | 0                          | 0.00                       | 0.00                    | 0.20             | 0.00                 | 0.00              |
| 08:00-09:00                         | 0.75              | 1                          | 0.00                       | 0.20                    | 0.60             | 1.00                 | 1.00              |
| 09:00-10:00                         | 1.00              | 1                          | 0.00                       | 0.30                    | 0.60             | 1.00                 | 1.00              |
| 10:00-11:00                         | 1.00              | 1                          | 0.00                       | 0.30                    | 0.80             | 1.00                 | 1.00              |
| 11:00-12:00                         | 1.00              | 1                          | 0.00                       | 0.30                    | 0.80             | 1.00                 | 1.00              |
| 12:00-13:00                         | 0.75              | 1                          | 0.00                       | 0.25                    | 0.70             | 1.00                 | 1.00              |
| 13:00-14:00                         | 1.00              | 1                          | 0.00                       | 0.25                    | 0.80             | 1.00                 | 1.00              |
| 14:00-15:00                         | 1.00              | 1                          | 0.00                       | 0.25                    | 0.80             | 1.00                 | 1.00              |
| 15:00-16:00                         | 1.00              | 1                          | 0.00                       | 0.25                    | 0.70             | 1.00                 | 1.00              |
| 16:00-17:00                         | 1.00              | 1                          | 0.00                       | 0.25                    | 0.70             | 1.00                 | 1.00              |
| 17:00-18:00                         | 1.00              | 1                          | 0.00                       | 0.10                    | 0.50             | 1.00                 | 1.00              |
| 18:00-19:00                         | 0.50              | 1                          | 0.50                       | 0.01                    | 0.20             | 1.00                 | 1.00              |
| 19:00-20:00                         | 0.50              | 1                          | 0.50                       | 0.01                    | 0.20             | 1.00                 | 1.00              |
| 20:00-21:00                         | 0.50              | 1                          | 0.50                       | 0.01                    | 0.20             | 1.00                 | 1.00              |
| 21:00-22:00                         | 0.30              | 0                          | 0.50                       | 0.01                    | 0.10             | 1.00                 | 1.00              |
| 22:00-23:00                         | 0.05              | 0                          | 0.20                       | 0.01                    | 0.01             | 0.00                 | 0.00              |
| 23:00-24:00                         | 0.05              | 0                          | 0.20                       | 0.01                    | 0.01             | 0.00                 | 0.00              |

Table 9-22: Schedules for Educational School Building (A)

| Educational – School Building |                   |                            |                 |                  |                            |                      |                   |
|-------------------------------|-------------------|----------------------------|-----------------|------------------|----------------------------|----------------------|-------------------|
| Time Period                   | Elevator Schedule | HVAC Fan Schedule (On/Off) |                 |                  | External Lighting Schedule | Basement Ventilation | Basement Lighting |
|                               |                   | Student Area               | Back Office     | Corridor / Lobby |                            |                      |                   |
|                               | 7 Days/<br>week   | 5 Days/<br>week            | 5 Days/<br>week | 5 Days/<br>week  | 7 Days/<br>week            | 7 Days/<br>week      | 7 Days/<br>week   |
| 00:00-01:00                   | 0.00              | 0                          | 0               | 0                | 0.80                       | 0.00                 | 0.05              |
| 01:00-02:00                   | 0.00              | 0                          | 0               | 0                | 0.80                       | 0.00                 | 0.05              |
| 02:00-03:00                   | 0.00              | 0                          | 0               | 0                | 0.80                       | 0.00                 | 0.05              |
| 03:00-04:00                   | 0.00              | 0                          | 0               | 0                | 0.80                       | 0.00                 | 0.05              |
| 04:00-05:00                   | 0.00              | 0                          | 0               | 0                | 0.80                       | 0.00                 | 0.05              |
| 05:00-06:00                   | 0.00              | 0                          | 0               | 0                | 0.80                       | 0.00                 | 0.05              |
| 06:00-07:00                   | 0.05              | 0                          | 0               | 1                | 0.00                       | 0.00                 | 0.05              |
| 07:00-08:00                   | 0.80              | 1                          | 1               | 1                | 0.00                       | 0.00                 | 0.05              |
| 08:00-09:00                   | 0.80              | 1                          | 1               | 1                | 0.00                       | 1.00                 | 1.00              |
| 09:00-10:00                   | 0.25              | 1                          | 1               | 1                | 0.00                       | 1.00                 | 1.00              |
| 10:00-11:00                   | 0.25              | 1                          | 1               | 1                | 0.00                       | 1.00                 | 1.00              |
| 11:00-12:00                   | 0.25              | 1                          | 1               | 1                | 0.00                       | 1.00                 | 1.00              |
| 12:00-13:00                   | 0.25              | 1                          | 1               | 1                | 0.00                       | 1.00                 | 1.00              |
| 13:00-14:00                   | 0.90              | 1                          | 1               | 1                | 0.00                       | 1.00                 | 1.00              |
| 14:00-15:00                   | 0.60              | 0                          | 1               | 1                | 0.00                       | 1.00                 | 1.00              |
| 15:00-16:00                   | 0.20              | 0                          | 1               | 0                | 0.00                       | 1.00                 | 1.00              |
| 16:00-17:00                   | 0.30              | 0                          | 1               | 0                | 0.00                       | 1.00                 | 1.00              |
| 17:00-18:00                   | 0.40              | 0                          | 0               | 0                | 0.00                       | 1.00                 | 0.50              |
| 18:00-19:00                   | 0.00              | 0                          | 0               | 0                | 0.80                       | 0.00                 | 0.05              |
| 19:00-20:00                   | 0.00              | 0                          | 0               | 0                | 0.80                       | 0.00                 | 0.05              |
| 20:00-21:00                   | 0.00              | 0                          | 0               | 0                | 0.80                       | 0.00                 | 0.05              |
| 21:00-22:00                   | 0.00              | 0                          | 0               | 0                | 0.80                       | 0.00                 | 0.05              |
| 22:00-23:00                   | 0.00              | 0                          | 0               | 0                | 0.80                       | 0.00                 | 0.05              |
| 23:00-24:00                   | 0.00              | 0                          | 0               | 0                | 0.80                       | 0.00                 | 0.05              |

*Table 9-23: Schedules for Educational - School Buildings (B)*

[illegible]

Table 9-24: Schedules for Educational - University Building (A)

| Educational – University Buildings |                        |                         |                            |              |                        |                 |                            |                      |                   |
|------------------------------------|------------------------|-------------------------|----------------------------|--------------|------------------------|-----------------|----------------------------|----------------------|-------------------|
| Time Period                        | Elevator Schedule      |                         | HVAC Fan Schedule (On/Off) |              |                        |                 | External Lighting Schedule | Basement Ventilation | Basement Lighting |
|                                    | Library & Comp. Centre | Student and Back office | Student Area               | Back Office  | Library & Comp. Centre | Corridor/ Lobby |                            |                      |                   |
|                                    | 7 days/ week           | 7 days/ week            | 5 days/ week               | 5 days/ week | 7 days/ week           | 5 days/ week    |                            |                      |                   |
| 00:00-01:00                        | 0.00                   | 0.00                    | 0                          | 0            | 0                      | 0               | 0.80                       | 0.00                 | 0.05              |
| 01:00-02:00                        | 0.00                   | 0.00                    | 0                          | 0            | 0                      | 0               | 0.80                       | 0.00                 | 0.05              |
| 02:00-03:00                        | 0.00                   | 0.00                    | 0                          | 0            | 0                      | 0               | 0.80                       | 0.00                 | 0.05              |
| 03:00-04:00                        | 0.00                   | 0.00                    | 0                          | 0            | 0                      | 0               | 0.80                       | 0.00                 | 0.05              |
| 04:00-05:00                        | 0.00                   | 0.00                    | 0                          | 0            | 0                      | 0               | 0.80                       | 0.00                 | 0.05              |
| 05:00-06:00                        | 0.00                   | 0.00                    | 0                          | 0            | 0                      | 0               | 0.80                       | 0.00                 | 0.05              |
| 06:00-07:00                        | 0.00                   | 0.05                    | 0                          | 0            | 0                      | 0               | 0.00                       | 0.00                 | 0.05              |
| 07:00-08:00                        | 0.00                   | 0.25                    | 1                          | 1            | 1                      | 1               | 0.00                       | 0.00                 | 0.05              |
| 08:00-09:00                        | 0.50                   | 0.85                    | 1                          | 1            | 1                      | 1               | 0.00                       | 1.00                 | 1.00              |
| 09:00-10:00                        | 0.50                   | 0.25                    | 1                          | 1            | 1                      | 1               | 0.00                       | 1.00                 | 1.00              |
| 10:00-11:00                        | 0.30                   | 0.25                    | 1                          | 1            | 1                      | 1               | 0.00                       | 1.00                 | 1.00              |
| 11:00-12:00                        | 0.20                   | 0.25                    | 1                          | 1            | 1                      | 1               | 0.00                       | 1.00                 | 1.00              |
| 12:00-13:00                        | 0.20                   | 0.25                    | 1                          | 1            | 1                      | 1               | 0.00                       | 1.00                 | 1.00              |
| 13:00-14:00                        | 0.40                   | 0.90                    | 1                          | 1            | 1                      | 1               | 0.00                       | 1.00                 | 1.00              |
| 14:00-15:00                        | 0.30                   | 0.60                    | 1                          | 1            | 1                      | 1               | 0.00                       | 1.00                 | 1.00              |
| 15:00-16:00                        | 0.30                   | 0.25                    | 1                          | 1            | 1                      | 1               | 0.00                       | 1.00                 | 1.00              |
| 16:00-17:00                        | 0.30                   | 0.25                    | 1                          | 1            | 1                      | 1               | 0.00                       | 1.00                 | 1.00              |
| 17:00-18:00                        | 0.50                   | 0.90                    | 1                          | 0            | 1                      | 1               | 0.00                       | 1.00                 | 1.00              |
| 18:00-19:00                        | 0.50                   | 0.15                    | 0                          | 0            | 1                      | 1               | 0.80                       | 1.00                 | 1.00              |
| 19:00-20:00                        | 0.50                   | 0.05                    | 0                          | 0            | 1                      | 0               | 0.80                       | 1.00                 | 1.00              |
| 20:00-21:00                        | 0.50                   | 0.00                    | 0                          | 0            | 1                      | 0               | 0.80                       | 0.00                 | 0.50              |
| 21:00-22:00                        | 0.50                   | 0.00                    | 0                          | 0            | 1                      | 0               | 0.80                       | 0.00                 | 0.05              |
| 22:00-23:00                        | 0.50                   | 0.00                    | 0                          | 0            | 1                      | 0               | 0.80                       | 0.00                 | 0.05              |
| 23:00-24:00                        | 0.00                   | 0.00                    | 0                          | 0            | 0                      | 0               | 0.80                       | 0.00                 | 0.05              |

[illegible]



Table 9-26: Schedules for Hospitality Buildings (A)

| Hospitality |                   |          |                            |                         |          |              |              |                      |                   |
|-------------|-------------------|----------|----------------------------|-------------------------|----------|--------------|--------------|----------------------|-------------------|
| Time Period | Elevator Schedule |          | External Lighting Schedule | Service Hot Water (SHW) |          |              |              | Basement Ventilation | Basement Lighting |
|             |                   |          |                            | Guest rooms             |          | Kitchen      | Laundry      |                      |                   |
|             | Week Days         | Weekends | 7 Days/ week               | Week Days               | Weekends | 7 Days/ week | 7 Days/ week | 7 Days/ week         | 7 Days/ week      |
| 00:00-01:00 | 0.10              | 0.10     | 1.00                       | 0.01                    | 0.01     | 0.00         | 0.00         | 0.50                 | 0.50              |
| 01:00-02:00 | 0.10              | 0.10     | 1.00                       | 0.01                    | 0.01     | 0.00         | 0.00         | 0.50                 | 0.50              |
| 02:00-03:00 | 0.10              | 0.10     | 1.00                       | 0.01                    | 0.01     | 0.00         | 0.00         | 0.50                 | 0.50              |
| 03:00-04:00 | 0.10              | 0.10     | 1.00                       | 0.01                    | 0.01     | 0.00         | 0.00         | 0.50                 | 0.50              |
| 04:00-05:00 | 0.10              | 0.10     | 1.00                       | 0.01                    | 0.01     | 0.00         | 0.00         | 0.50                 | 0.50              |
| 05:00-06:00 | 0.20              | 0.20     | 1.00                       | 0.01                    | 0.01     | 0.00         | 0.00         | 0.50                 | 0.50              |
| 06:00-07:00 | 0.40              | 0.50     | 0.00                       | 0.50                    | 0.70     | 0.60         | 0.00         | 0.50                 | 0.50              |
| 07:00-08:00 | 0.50              | 0.60     | 0.00                       | 0.50                    | 0.70     | 0.80         | 0.00         | 0.50                 | 0.50              |
| 08:00-09:00 | 0.50              | 0.60     | 0.00                       | 0.30                    | 0.50     | 0.80         | 1.00         | 1.00                 | 1.00              |
| 09:00-10:00 | 0.35              | 0.40     | 0.00                       | 0.15                    | 0.30     | 0.60         | 1.00         | 1.00                 | 1.00              |
| 10:00-11:00 | 0.15              | 0.20     | 0.00                       | 0.15                    | 0.20     | 0.60         | 1.00         | 1.00                 | 1.00              |
| 11:00-12:00 | 0.15              | 0.20     | 0.00                       | 0.15                    | 0.20     | 0.80         | 1.00         | 1.00                 | 1.00              |
| 12:00-13:00 | 0.15              | 0.20     | 0.00                       | 0.15                    | 0.20     | 0.80         | 1.00         | 1.00                 | 1.00              |
| 13:00-14:00 | 0.15              | 0.20     | 0.00                       | 0.15                    | 0.20     | 0.80         | 1.00         | 1.00                 | 1.00              |
| 14:00-15:00 | 0.15              | 0.20     | 0.00                       | 0.15                    | 0.20     | 0.60         | 1.00         | 1.00                 | 1.00              |
| 15:00-16:00 | 0.15              | 0.20     | 0.00                       | 0.15                    | 0.20     | 0.60         | 1.00         | 1.00                 | 1.00              |
| 16:00-17:00 | 0.35              | 0.40     | 0.00                       | 0.15                    | 0.20     | 0.60         | 0.00         | 1.00                 | 1.00              |
| 17:00-18:00 | 0.50              | 0.60     | 0.00                       | 0.30                    | 0.30     | 0.80         | 0.00         | 1.00                 | 1.00              |
| 18:00-19:00 | 0.50              | 0.60     | 1.00                       | 0.50                    | 0.50     | 0.80         | 0.00         | 1.00                 | 1.00              |
| 19:00-20:00 | 0.50              | 0.60     | 1.00                       | 0.50                    | 0.70     | 0.80         | 0.00         | 1.00                 | 1.00              |
| 20:00-21:00 | 0.50              | 0.60     | 1.00                       | 0.65                    | 0.70     | 0.80         | 0.00         | 1.00                 | 1.00              |
| 21:00-22:00 | 0.30              | 0.40     | 1.00                       | 0.65                    | 0.90     | 0.80         | 0.00         | 0.50                 | 0.50              |
| 22:00-23:00 | 0.20              | 0.30     | 1.00                       | 0.01                    | 0.01     | 0.60         | 0.00         | 0.50                 | 0.50              |
| 23:00-24:00 | 0.10              | 0.10     | 1.00                       | 0.01                    | 0.01     | 0.60         | 0.00         | 0.50                 | 0.50              |

Table 9-27: Schedules for Hospitality Buildings (B)

| Hospitality - Occupancy |                    |              |              |              |               |              |              |              |              |              |                             |                 |
|-------------------------|--------------------|--------------|--------------|--------------|---------------|--------------|--------------|--------------|--------------|--------------|-----------------------------|-----------------|
| Time Period             | Occupancy Schedule |              |              |              |               |              |              |              |              |              |                             |                 |
|                         | Guest Room         |              | Lobby        |              | Public Spaces |              | Restaurant   |              | Back Office  |              | Conference/<br>Banquet Room | Kitchen         |
|                         | Week<br>Days       | Week<br>ends | Week<br>Days | Week<br>ends | Week<br>Days  | Week<br>ends | Week<br>Days | Week<br>ends | Week<br>Days | Week<br>ends | 7 Days/<br>week             | 7 Days/<br>week |
| 00:00-01:00             | 0.65               | 0.90         | 0.10         | 0.10         | 0.00          | 0.00         | 0.00         | 0.00         | 0.20         | 0.20         | 0.00                        | 0.00            |
| 01:00-02:00             | 0.65               | 0.90         | 0.10         | 0.10         | 0.00          | 0.00         | 0.00         | 0.00         | 0.20         | 0.20         | 0.00                        | 0.00            |
| 02:00-03:00             | 0.65               | 0.90         | 0.10         | 0.10         | 0.00          | 0.00         | 0.00         | 0.00         | 0.20         | 0.20         | 0.00                        | 0.00            |
| 03:00-04:00             | 0.65               | 0.90         | 0.10         | 0.10         | 0.00          | 0.00         | 0.00         | 0.00         | 0.20         | 0.20         | 0.00                        | 0.00            |
| 04:00-05:00             | 0.65               | 0.90         | 0.10         | 0.10         | 0.00          | 0.00         | 0.00         | 0.00         | 0.20         | 0.20         | 0.00                        | 0.00            |
| 05:00-06:00             | 0.65               | 0.90         | 0.10         | 0.10         | 0.20          | 0.50         | 0.00         | 0.00         | 0.20         | 0.20         | 0.00                        | 0.00            |
| 06:00-07:00             | 0.50               | 0.70         | 0.20         | 0.20         | 0.40          | 0.70         | 0.00         | 0.00         | 0.20         | 0.20         | 0.00                        | 0.50            |
| 07:00-08:00             | 0.50               | 0.70         | 0.30         | 0.40         | 0.40          | 0.70         | 0.30         | 0.30         | 0.20         | 0.20         | 0.00                        | 0.80            |
| 08:00-09:00             | 0.30               | 0.50         | 0.40         | 0.70         | 0.40          | 0.70         | 0.30         | 0.30         | 0.20         | 0.20         | 0.20                        | 0.80            |
| 09:00-10:00             | 0.15               | 0.30         | 0.40         | 0.70         | 0.40          | 0.70         | 0.30         | 0.30         | 0.95         | 0.50         | 0.50                        | 0.50            |
| 10:00-11:00             | 0.15               | 0.20         | 0.40         | 0.70         | 0.40          | 0.70         | 0.30         | 0.30         | 0.95         | 0.50         | 0.90                        | 0.50            |
| 11:00-12:00             | 0.15               | 0.20         | 0.40         | 0.70         | 0.20          | 0.30         | 0.30         | 0.30         | 0.95         | 0.50         | 0.90                        | 0.80            |
| 12:00-13:00             | 0.15               | 0.20         | 0.40         | 0.70         | 0.20          | 0.30         | 0.80         | 0.80         | 0.95         | 0.50         | 0.90                        | 0.80            |
| 13:00-14:00             | 0.15               | 0.20         | 0.20         | 0.20         | 0.20          | 0.30         | 0.80         | 0.80         | 0.50         | 0.30         | 0.90                        | 0.80            |
| 14:00-15:00             | 0.15               | 0.20         | 0.20         | 0.20         | 0.20          | 0.30         | 0.80         | 0.80         | 0.95         | 0.50         | 0.90                        | 0.50            |
| 15:00-16:00             | 0.15               | 0.20         | 0.20         | 0.20         | 0.40          | 0.70         | 0.30         | 0.30         | 0.95         | 0.50         | 0.90                        | 0.50            |
| 16:00-17:00             | 0.15               | 0.20         | 0.20         | 0.20         | 0.40          | 0.70         | 0.30         | 0.30         | 0.95         | 0.50         | 0.90                        | 0.50            |
| 17:00-18:00             | 0.30               | 0.30         | 0.40         | 0.40         | 0.40          | 0.70         | 0.30         | 0.30         | 0.95         | 0.50         | 0.50                        | 0.80            |
| 18:00-19:00             | 0.50               | 0.50         | 0.40         | 0.40         | 0.50          | 0.70         | 0.50         | 0.50         | 0.30         | 0.30         | 0.20                        | 0.80            |
| 19:00-20:00             | 0.50               | 0.70         | 0.40         | 0.40         | 0.80          | 0.70         | 0.80         | 0.90         | 0.20         | 0.20         | 0.20                        | 0.80            |
| 20:00-21:00             | 0.65               | 0.70         | 0.30         | 0.30         | 0.90          | 0.70         | 0.80         | 0.90         | 0.20         | 0.20         | 0.00                        | 0.80            |
| 21:00-22:00             | 0.65               | 0.90         | 0.20         | 0.20         | 0.80          | 0.70         | 0.80         | 0.90         | 0.20         | 0.20         | 0.00                        | 0.80            |
| 22:00-23:00             | 0.65               | 0.90         | 0.10         | 0.10         | 0.60          | 0.60         | 0.80         | 0.90         | 0.20         | 0.20         | 0.00                        | 0.50            |
| 23:00-24:00             | 0.65               | 0.90         | 0.10         | 0.10         | 0.30          | 0.30         | 0.50         | 0.90         | 0.20         | 0.20         | 0.00                        | 0.50            |

Table 9-28: Schedules for Hospitality Buildings (C)

| Hospitality – Lighting |                   |              |              |              |               |              |              |              |              |              |                             |                 |
|------------------------|-------------------|--------------|--------------|--------------|---------------|--------------|--------------|--------------|--------------|--------------|-----------------------------|-----------------|
| Time Period            | Lighting Schedule |              |              |              |               |              |              |              |              |              |                             |                 |
|                        | Guest Room        |              | Lobby        |              | Public Spaces |              | Restaurant   |              | Back Office  |              | Conference/<br>Banquet Room | Kitchen         |
|                        | Week<br>Days      | Week<br>ends | Week<br>Days | Week<br>ends | Week<br>Days  | Week<br>ends | Week<br>Days | Week<br>ends | Week<br>Days | Week<br>ends | 7 Days/<br>week             | 7 Days/<br>week |
| 00:00-01:00            | 0.20              | 0.30         | 0.30         | 0.30         | 0.20          | 0.20         | 0.50         | 0.50         | 0.05         | 0.05         | 0.00                        | 0.50            |
| 01:00-02:00            | 0.20              | 0.25         | 0.30         | 0.30         | 0.15          | 0.20         | 0.10         | 0.10         | 0.05         | 0.05         | 0.00                        | 0.05            |
| 02:00-03:00            | 0.10              | 0.10         | 0.30         | 0.30         | 0.10          | 0.10         | 0.10         | 0.10         | 0.05         | 0.05         | 0.00                        | 0.05            |
| 03:00-04:00            | 0.10              | 0.10         | 0.30         | 0.30         | 0.10          | 0.10         | 0.10         | 0.10         | 0.05         | 0.05         | 0.00                        | 0.05            |
| 04:00-05:00            | 0.10              | 0.10         | 0.30         | 0.30         | 0.10          | 0.10         | 0.10         | 0.10         | 0.05         | 0.05         | 0.00                        | 0.05            |
| 05:00-06:00            | 0.20              | 0.10         | 0.30         | 0.30         | 0.20          | 0.10         | 0.10         | 0.10         | 0.05         | 0.05         | 0.00                        | 0.05            |
| 06:00-07:00            | 0.45              | 0.40         | 0.40         | 0.40         | 0.40          | 0.30         | 0.10         | 0.10         | 0.10         | 0.10         | 0.00                        | 0.10            |
| 07:00-08:00            | 0.55              | 0.40         | 0.30         | 0.40         | 0.50          | 0.30         | 0.50         | 0.50         | 0.30         | 0.30         | 0.00                        | 0.30            |
| 08:00-09:00            | 0.45              | 0.55         | 0.40         | 0.70         | 0.40          | 0.40         | 0.50         | 0.50         | 0.90         | 0.60         | 0.50                        | 0.90            |
| 09:00-10:00            | 0.20              | 0.20         | 0.40         | 0.70         | 0.20          | 0.40         | 0.50         | 0.50         | 0.90         | 0.60         | 0.80                        | 0.90            |
| 10:00-11:00            | 0.20              | 0.20         | 0.40         | 0.70         | 0.20          | 0.40         | 0.50         | 0.50         | 0.90         | 0.60         | 0.90                        | 0.90            |
| 11:00-12:00            | 0.20              | 0.20         | 0.40         | 0.70         | 0.20          | 0.40         | 0.50         | 0.50         | 0.90         | 0.60         | 0.90                        | 0.90            |
| 12:00-13:00            | 0.20              | 0.20         | 0.40         | 0.70         | 0.20          | 0.40         | 0.90         | 0.90         | 0.90         | 0.60         | 0.90                        | 0.90            |
| 13:00-14:00            | 0.20              | 0.20         | 0.40         | 0.40         | 0.20          | 0.40         | 0.90         | 0.90         | 0.50         | 0.50         | 0.90                        | 0.50            |
| 14:00-15:00            | 0.20              | 0.20         | 0.40         | 0.40         | 0.20          | 0.40         | 0.90         | 0.90         | 0.90         | 0.60         | 0.90                        | 0.90            |
| 15:00-16:00            | 0.20              | 0.20         | 0.40         | 0.40         | 0.20          | 0.40         | 0.50         | 0.50         | 0.90         | 0.60         | 0.90                        | 0.90            |
| 16:00-17:00            | 0.20              | 0.20         | 0.40         | 0.40         | 0.20          | 0.40         | 0.50         | 0.50         | 0.90         | 0.60         | 0.90                        | 0.90            |
| 17:00-18:00            | 0.30              | 0.30         | 0.40         | 0.40         | 0.25          | 0.40         | 0.50         | 0.50         | 0.95         | 0.60         | 0.50                        | 0.95            |
| 18:00-19:00            | 0.70              | 0.85         | 0.40         | 0.40         | 0.60          | 0.60         | 0.90         | 0.90         | 0.50         | 0.50         | 0.50                        | 0.95            |
| 19:00-20:00            | 0.90              | 1.00         | 0.40         | 0.40         | 0.80          | 0.70         | 0.90         | 0.90         | 0.30         | 0.30         | 0.50                        | 0.95            |
| 20:00-21:00            | 1.00              | 1.00         | 0.30         | 0.30         | 0.90          | 0.70         | 0.90         | 0.90         | 0.30         | 0.30         | 0.00                        | 0.95            |
| 21:00-22:00            | 0.90              | 1.00         | 0.40         | 0.40         | 0.80          | 0.70         | 0.90         | 0.90         | 0.20         | 0.20         | 0.00                        | 0.95            |
| 22:00-23:00            | 0.70              | 0.85         | 0.30         | 0.30         | 0.60          | 0.60         | 0.90         | 0.90         | 0.10         | 0.10         | 0.00                        | 0.95            |
| 23:00-24:00            | 0.30              | 0.40         | 0.30         | 0.30         | 0.30          | 0.30         | 0.90         | 0.90         | 0.05         | 0.05         | 0.00                        | 0.95            |

Table 9-29: Schedules for Hospitality Buildings (D)

| Hospitality – Equipment |                    |          |               |            |          |             |          |                             |              |
|-------------------------|--------------------|----------|---------------|------------|----------|-------------|----------|-----------------------------|--------------|
| Time Period             | Equipment Schedule |          |               |            |          |             |          |                             |              |
|                         | Guest Room         |          | Public Spaces | Restaurant |          | Back Office |          | Conference/<br>Banquet Room | Kitchen      |
|                         | Week Days          | Weekends | 7 Days/ week  | Week Days  | Weekends | Week Days   | Weekends | 7 Days/ week                | 7 Days/ week |
| 00:00-01:00             | 0.20               | 0.20     | 0.30          | 0.50       | 0.50     | 0.05        | 0.05     | 0.00                        | 0.30         |
| 01:00-02:00             | 0.20               | 0.20     | 0.20          | 0.00       | 0.00     | 0.05        | 0.05     | 0.00                        | 0.10         |
| 02:00-03:00             | 0.20               | 0.20     | 0.20          | 0.00       | 0.00     | 0.05        | 0.05     | 0.00                        | 0.10         |
| 03:00-04:00             | 0.20               | 0.20     | 0.20          | 0.00       | 0.00     | 0.05        | 0.05     | 0.00                        | 0.10         |
| 04:00-05:00             | 0.20               | 0.20     | 0.20          | 0.00       | 0.00     | 0.05        | 0.05     | 0.00                        | 0.10         |
| 05:00-06:00             | 0.20               | 0.20     | 0.30          | 0.00       | 0.00     | 0.05        | 0.05     | 0.00                        | 0.10         |
| 06:00-07:00             | 0.30               | 0.30     | 0.50          | 0.00       | 0.00     | 0.05        | 0.05     | 0.00                        | 0.30         |
| 07:00-08:00             | 0.40               | 0.60     | 0.50          | 0.60       | 0.60     | 0.10        | 0.10     | 0.00                        | 0.30         |
| 08:00-09:00             | 0.70               | 0.90     | 0.50          | 0.60       | 0.60     | 0.30        | 0.30     | 0.50                        | 0.30         |
| 09:00-10:00             | 0.20               | 0.20     | 0.50          | 0.60       | 0.60     | 0.95        | 0.70     | 0.50                        | 0.30         |
| 10:00-11:00             | 0.20               | 0.20     | 0.35          | 0.60       | 0.60     | 0.95        | 0.70     | 0.90                        | 0.30         |
| 11:00-12:00             | 0.20               | 0.20     | 0.35          | 0.60       | 0.60     | 0.95        | 0.70     | 0.90                        | 0.30         |
| 12:00-13:00             | 0.20               | 0.20     | 0.35          | 0.80       | 0.80     | 0.95        | 0.70     | 0.90                        | 0.30         |
| 13:00-14:00             | 0.20               | 0.20     | 0.35          | 0.80       | 0.80     | 0.50        | 0.70     | 0.90                        | 0.30         |
| 14:00-15:00             | 0.20               | 0.20     | 0.35          | 0.80       | 0.80     | 0.95        | 0.70     | 0.90                        | 0.30         |
| 15:00-16:00             | 0.20               | 0.20     | 0.35          | 0.60       | 0.60     | 0.95        | 0.70     | 0.90                        | 0.30         |
| 16:00-17:00             | 0.20               | 0.20     | 0.35          | 0.60       | 0.60     | 0.95        | 0.70     | 0.90                        | 0.30         |
| 17:00-18:00             | 0.30               | 0.30     | 0.35          | 0.60       | 0.60     | 0.95        | 0.70     | 0.50                        | 0.30         |
| 18:00-19:00             | 0.50               | 0.50     | 0.70          | 0.80       | 0.80     | 0.30        | 0.30     | 0.50                        | 0.30         |
| 19:00-20:00             | 0.50               | 0.50     | 0.90          | 0.80       | 0.90     | 0.10        | 0.10     | 0.50                        | 0.30         |
| 20:00-21:00             | 0.50               | 0.70     | 0.90          | 0.80       | 0.90     | 0.10        | 0.10     | 0.00                        | 0.30         |
| 21:00-22:00             | 0.70               | 0.70     | 0.90          | 0.80       | 0.90     | 0.10        | 0.10     | 0.00                        | 0.30         |
| 22:00-23:00             | 0.40               | 0.40     | 0.70          | 0.80       | 0.90     | 0.05        | 0.05     | 0.00                        | 0.30         |
| 23:00-24:00             | 0.20               | 0.20     | 0.40          | 0.80       | 0.90     | 0.05        | 0.05     | 0.00                        | 0.30         |

Table 9-30: Schedules for Hospitality Buildings (E)

| Hospitality – HVAC Fan Schedules |                   |              |               |              |              |                           |              |
|----------------------------------|-------------------|--------------|---------------|--------------|--------------|---------------------------|--------------|
| Time Period                      | HVAC Fan Schedule |              |               |              |              |                           |              |
|                                  | Guest Room        | Lobby        | Public Spaces | Restaurants  | Back Office  | Conference / Banquet Room | Kitchen      |
|                                  | 7 Days/ week      | 7 Days/ week | 7 Days/ week  | 7 Days/ week | 7 Days/ week | 7 Days/ week              | 7 Days/ week |
| 00:00-01:00                      | 1                 | 0            | 0             | 0            | 0            | 0                         | 0            |
| 01:00-02:00                      | 1                 | 0            | 0             | 0            | 0            | 0                         | 0            |
| 02:00-03:00                      | 1                 | 0            | 0             | 0            | 0            | 0                         | 0            |
| 03:00-04:00                      | 1                 | 0            | 0             | 0            | 0            | 0                         | 0            |
| 04:00-05:00                      | 1                 | 0            | 0             | 0            | 0            | 0                         | 0            |
| 05:00-06:00                      | 1                 | 1            | 1             | 0            | 0            | 0                         | 1            |
| 06:00-07:00                      | 1                 | 1            | 1             | 1            | 0            | 0                         | 1            |
| 07:00-08:00                      | 1                 | 1            | 1             | 1            | 0            | 0                         | 1            |
| 08:00-09:00                      | 1                 | 1            | 1             | 1            | 1            | 1                         | 1            |
| 09:00-10:00                      | 1                 | 1            | 1             | 1            | 1            | 1                         | 1            |
| 10:00-11:00                      | 1                 | 1            | 1             | 1            | 1            | 1                         | 1            |
| 11:00-12:00                      | 1                 | 1            | 1             | 1            | 1            | 1                         | 1            |
| 12:00-13:00                      | 1                 | 1            | 1             | 1            | 1            | 1                         | 1            |
| 13:00-14:00                      | 1                 | 1            | 1             | 1            | 1            | 1                         | 1            |
| 14:00-15:00                      | 1                 | 1            | 1             | 1            | 1            | 1                         | 1            |
| 15:00-16:00                      | 1                 | 1            | 1             | 1            | 1            | 1                         | 1            |
| 16:00-17:00                      | 1                 | 1            | 1             | 1            | 1            | 1                         | 1            |
| 17:00-18:00                      | 1                 | 1            | 1             | 1            | 1            | 1                         | 1            |
| 18:00-19:00                      | 1                 | 1            | 1             | 1            | 1            | 1                         | 1            |
| 19:00-20:00                      | 1                 | 1            | 1             | 1            | 0            | 1                         | 1            |
| 20:00-21:00                      | 1                 | 1            | 1             | 1            | 0            | 1                         | 1            |
| 21:00-22:00                      | 1                 | 1            | 1             | 1            | 0            | 0                         | 1            |
| 22:00-23:00                      | 1                 | 0            | 1             | 1            | 0            | 0                         | 1            |
| 23:00-24:00                      | 1                 | 0            | 1             | 1            | 0            | 0                         | 1            |

Table 9-31: Schedules for Shopping Complexes Buildings (A)

| Shopping Complex |                            |                   |               |                            |                      |                   |                   |          |
|------------------|----------------------------|-------------------|---------------|----------------------------|----------------------|-------------------|-------------------|----------|
| Time Period      | HVAC Fan Schedule (ON/OFF) |                   |               | External Lighting Schedule | Basement Ventilation | Basement Lighting | Elevator Schedule |          |
|                  | Retail                     | Corridor & Atrium | Special Zones |                            |                      |                   |                   |          |
|                  | 7 Days/ week               | 7 Days/ week      | 7 Days/ week  |                            |                      |                   | Weekdays          | Weekends |
| 00:00-01:00      | 0                          | 0                 | 0             | 1.00                       | 1.00                 | 1.00              | 0.20              | 0.20     |
| 01:00-02:00      | 0                          | 0                 | 0             | 0.50                       | 0.00                 | 0.05              | 0.05              | 0.20     |
| 02:00-03:00      | 0                          | 0                 | 0             | 0.50                       | 0.00                 | 0.05              | 0.05              | 0.05     |
| 03:00-04:00      | 0                          | 0                 | 0             | 0.50                       | 0.00                 | 0.05              | 0.05              | 0.05     |
| 04:00-05:00      | 0                          | 0                 | 0             | 0.50                       | 0.00                 | 0.05              | 0.05              | 0.05     |
| 05:00-06:00      | 0                          | 0                 | 0             | 0.50                       | 0.00                 | 0.05              | 0.05              | 0.05     |
| 06:00-07:00      | 0                          | 0                 | 0             | 0.00                       | 0.00                 | 0.05              | 0.05              | 0.05     |
| 07:00-08:00      | 0                          | 0                 | 0             | 0.00                       | 0.00                 | 0.05              | 0.10              | 0.10     |
| 08:00-09:00      | 0                          | 0                 | 0             | 0.00                       | 0.00                 | 0.05              | 0.10              | 0.10     |
| 09:00-10:00      | 0                          | 1                 | 1             | 0.00                       | 1.00                 | 1.00              | 0.20              | 0.20     |
| 10:00-11:00      | 1                          | 1                 | 1             | 0.00                       | 1.00                 | 1.00              | 0.40              | 0.40     |
| 11:00-12:00      | 1                          | 1                 | 1             | 0.00                       | 1.00                 | 1.00              | 0.70              | 0.70     |
| 12:00-13:00      | 1                          | 1                 | 1             | 0.00                       | 1.00                 | 1.00              | 0.70              | 0.80     |
| 13:00-14:00      | 1                          | 1                 | 1             | 0.00                       | 1.00                 | 1.00              | 0.70              | 0.95     |
| 14:00-15:00      | 1                          | 1                 | 1             | 0.00                       | 1.00                 | 1.00              | 0.70              | 0.95     |
| 15:00-16:00      | 1                          | 1                 | 1             | 0.00                       | 1.00                 | 1.00              | 0.70              | 0.95     |
| 16:00-17:00      | 1                          | 1                 | 1             | 0.00                       | 1.00                 | 1.00              | 0.70              | 0.95     |
| 17:00-18:00      | 1                          | 1                 | 1             | 0.00                       | 1.00                 | 1.00              | 0.80              | 0.95     |
| 18:00-19:00      | 1                          | 1                 | 1             | 1.00                       | 1.00                 | 1.00              | 0.80              | 0.95     |
| 19:00-20:00      | 1                          | 1                 | 1             | 1.00                       | 1.00                 | 1.00              | 0.80              | 0.95     |
| 20:00-21:00      | 1                          | 1                 | 1             | 1.00                       | 1.00                 | 1.00              | 0.80              | 0.95     |
| 21:00-22:00      | 0                          | 1                 | 1             | 1.00                       | 1.00                 | 1.00              | 0.80              | 0.80     |
| 22:00-23:00      | 0                          | 1                 | 1             | 1.00                       | 1.00                 | 1.00              | 0.50              | 0.60     |
| 23:00-24:00      | 0                          | 1                 | 1             | 1.00                       | 1.00                 | 1.00              | 0.30              | 0.40     |

Table 9-32: Schedules for Shopping Complexes Buildings (B)

| Shopping Complex |                    |         |                    |         |              |         |                   |                    |              |                    |              |
|------------------|--------------------|---------|--------------------|---------|--------------|---------|-------------------|--------------------|--------------|--------------------|--------------|
| Time Period      | Occupancy Schedule |         |                    |         |              |         | Lighting Schedule |                    |              | Equipment Schedule |              |
|                  | Retail             |         | Corridors & Atrium |         | Special Zone |         | Retail            | Corridors & Atrium | Special Zone | Retail             | Special Zone |
|                  | Weekday            | Weekend | Weekday            | Weekend | Weekday      | Weekend | 7 Days/ week      | 7 Days/ week       | 7 Days/ week | 7 Days/ week       | 7 Days/ week |
| 00:00-01:00      | 0.00               | 0.00    | 0.00               | 0.10    | 0.00         | 0.00    | 0.05              | 0.05               | 0.05         | 0.05               | 0.05         |
| 01:00-02:00      | 0.00               | 0.00    | 0.00               | 0.00    | 0.00         | 0.00    | 0.05              | 0.05               | 0.05         | 0.05               | 0.05         |
| 02:00-03:00      | 0.00               | 0.00    | 0.00               | 0.00    | 0.00         | 0.00    | 0.05              | 0.05               | 0.05         | 0.05               | 0.05         |
| 03:00-04:00      | 0.00               | 0.00    | 0.00               | 0.00    | 0.00         | 0.00    | 0.05              | 0.05               | 0.05         | 0.05               | 0.05         |
| 04:00-05:00      | 0.00               | 0.00    | 0.00               | 0.00    | 0.00         | 0.00    | 0.05              | 0.05               | 0.05         | 0.05               | 0.05         |
| 05:00-06:00      | 0.00               | 0.00    | 0.00               | 0.00    | 0.00         | 0.00    | 0.05              | 0.05               | 0.05         | 0.05               | 0.05         |
| 06:00-07:00      | 0.00               | 0.00    | 0.00               | 0.00    | 0.00         | 0.00    | 0.05              | 0.05               | 0.05         | 0.05               | 0.05         |
| 07:00-08:00      | 0.00               | 0.00    | 0.00               | 0.00    | 0.00         | 0.00    | 0.05              | 0.05               | 0.05         | 0.05               | 0.05         |
| 08:00-09:00      | 0.00               | 0.00    | 0.00               | 0.00    | 0.00         | 0.00    | 0.05              | 0.05               | 0.05         | 0.05               | 0.50         |
| 09:00-10:00      | 0.20               | 0.20    | 0.20               | 0.20    | 0.20         | 0.20    | 0.20              | 0.20               | 0.20         | 0.05               | 0.50         |
| 10:00-11:00      | 0.40               | 0.40    | 0.40               | 0.40    | 0.20         | 0.20    | 0.50              | 0.50               | 0.40         | 0.90               | 0.90         |
| 11:00-12:00      | 0.60               | 0.60    | 0.60               | 0.60    | 0.30         | 0.50    | 0.95              | 0.50               | 0.60         | 0.90               | 0.90         |
| 12:00-13:00      | 0.60               | 0.70    | 0.60               | 0.70    | 0.50         | 0.70    | 0.95              | 0.50               | 0.60         | 0.90               | 0.90         |
| 13:00-14:00      | 0.60               | 0.90    | 0.60               | 0.90    | 0.50         | 0.70    | 0.95              | 0.50               | 0.60         | 0.90               | 0.90         |
| 14:00-15:00      | 0.70               | 0.90    | 0.70               | 0.90    | 0.50         | 0.70    | 0.95              | 0.50               | 0.60         | 0.90               | 0.90         |
| 15:00-16:00      | 0.70               | 0.90    | 0.70               | 0.90    | 0.50         | 0.80    | 0.95              | 0.50               | 0.40         | 0.90               | 0.90         |
| 16:00-17:00      | 0.70               | 0.90    | 0.70               | 0.90    | 0.50         | 0.80    | 0.95              | 0.70               | 0.40         | 0.90               | 0.90         |
| 17:00-18:00      | 0.70               | 0.90    | 0.70               | 0.90    | 0.50         | 0.80    | 0.95              | 0.95               | 0.40         | 0.90               | 0.90         |
| 18:00-19:00      | 0.90               | 0.95    | 0.90               | 0.95    | 0.60         | 0.95    | 0.95              | 0.95               | 0.80         | 0.90               | 0.90         |
| 19:00-20:00      | 0.90               | 0.95    | 0.90               | 0.95    | 0.60         | 0.95    | 0.95              | 0.95               | 0.80         | 0.90               | 0.90         |
| 20:00-21:00      | 0.90               | 0.95    | 0.90               | 0.95    | 0.60         | 0.95    | 0.95              | 0.95               | 0.80         | 0.50               | 0.90         |
| 21:00-22:00      | 0.00               | 0.00    | 0.40               | 0.40    | 0.60         | 0.95    | 0.05              | 0.50               | 0.80         | 0.05               | 0.90         |
| 22:00-23:00      | 0.00               | 0.00    | 0.30               | 0.30    | 0.60         | 0.95    | 0.05              | 0.30               | 0.80         | 0.05               | 0.90         |
| 23:00-24:00      | 0.00               | 0.00    | 0.10               | 0.10    | 0.30         | 0.95    | 0.05              | 0.30               | 0.80         | 0.05               | 0.90         |

Table 9-33: Schedules for Shopping Complexes Buildings – Food Court

| Shopping Complex - Food Court |                    |                  |            |                   |                  |            |                    |                  |            |                   |                  |            |
|-------------------------------|--------------------|------------------|------------|-------------------|------------------|------------|--------------------|------------------|------------|-------------------|------------------|------------|
| Time Period                   | Occupancy Schedule |                  |            | Lighting Schedule |                  |            | Equipment Schedule |                  |            | HVAC Fan Schedule |                  |            |
|                               | Family Dining      | Food Preparation | Bar Lounge | Family Dining     | Food Preparation | Bar Lounge | Family Dining      | Food Preparation | Bar Lounge | Family Dining     | Food Preparation | Bar Lounge |
| 00:00-01:00                   | 0.00               | 0.50             | 0.70       | 0.50              | 0.70             | 0.70       | 0.50               | 0.60             | 0.70       | 1                 | 0                | 1          |
| 01:00-02:00                   | 0.00               | 0.00             | 0.00       | 0.00              | 0.00             | 0.00       | 0.00               | 0.00             | 0.00       | 0                 | 0                | 0          |
| 02:00-03:00                   | 0.00               | 0.00             | 0.00       | 0.00              | 0.00             | 0.00       | 0.00               | 0.00             | 0.00       | 0                 | 0                | 0          |
| 03:00-04:00                   | 0.00               | 0.00             | 0.00       | 0.00              | 0.00             | 0.00       | 0.00               | 0.00             | 0.00       | 0                 | 0                | 0          |
| 04:00-05:00                   | 0.00               | 0.00             | 0.00       | 0.00              | 0.00             | 0.00       | 0.00               | 0.00             | 0.00       | 0                 | 0                | 0          |
| 05:00-06:00                   | 0.00               | 0.00             | 0.00       | 0.00              | 0.00             | 0.00       | 0.00               | 0.00             | 0.00       | 0                 | 0                | 0          |
| 06:00-07:00                   | 0.00               | 0.00             | 0.00       | 0.00              | 0.00             | 0.00       | 0.00               | 0.00             | 0.00       | 0                 | 0                | 0          |
| 07:00-08:00                   | 0.00               | 0.00             | 0.00       | 0.00              | 0.00             | 0.00       | 0.00               | 0.00             | 0.00       | 0                 | 0                | 0          |
| 08:00-09:00                   | 0.00               | 0.00             | 0.00       | 0.00              | 0.00             | 0.00       | 0.00               | 0.00             | 0.00       | 0                 | 0                | 0          |
| 09:00-10:00                   | 0.00               | 0.20             | 0.00       | 0.00              | 0.50             | 0.00       | 0.00               | 0.60             | 0.00       | 0                 | 0                | 0          |
| 10:00-11:00                   | 0.20               | 0.50             | 0.00       | 0.50              | 0.70             | 0.00       | 0.60               | 0.70             | 0.00       | 0                 | 1                | 0          |
| 11:00-12:00                   | 0.20               | 0.80             | 0.00       | 0.50              | 0.90             | 0.00       | 0.60               | 0.70             | 0.00       | 1                 | 1                | 0          |
| 12:00-13:00                   | 0.70               | 0.80             | 0.00       | 0.90              | 0.90             | 0.00       | 0.80               | 0.70             | 0.00       | 1                 | 1                | 0          |
| 13:00-14:00                   | 0.70               | 0.80             | 0.00       | 0.90              | 0.90             | 0.00       | 0.80               | 0.70             | 0.00       | 1                 | 1                | 0          |
| 14:00-15:00                   | 0.70               | 0.80             | 0.00       | 0.90              | 0.90             | 0.00       | 0.80               | 0.70             | 0.00       | 1                 | 1                | 0          |
| 15:00-16:00                   | 0.20               | 0.50             | 0.00       | 0.50              | 0.70             | 0.00       | 0.60               | 0.40             | 0.00       | 1                 | 1                | 0          |
| 16:00-17:00                   | 0.20               | 0.30             | 0.00       | 0.50              | 0.50             | 0.00       | 0.60               | 0.40             | 0.00       | 1                 | 1                | 1          |
| 17:00-18:00                   | 0.20               | 0.30             | 0.50       | 0.50              | 0.50             | 0.70       | 0.60               | 0.40             | 0.70       | 1                 | 1                | 1          |
| 18:00-19:00                   | 0.50               | 0.50             | 0.70       | 0.90              | 0.70             | 0.80       | 0.80               | 0.40             | 0.70       | 1                 | 1                | 1          |
| 19:00-20:00                   | 0.80               | 0.90             | 0.80       | 0.90              | 0.90             | 0.80       | 0.80               | 0.70             | 0.70       | 1                 | 1                | 1          |
| 20:00-21:00                   | 0.80               | 0.90             | 0.80       | 0.90              | 0.90             | 0.80       | 0.80               | 0.70             | 0.70       | 1                 | 1                | 1          |
| 21:00-22:00                   | 0.80               | 0.90             | 0.80       | 0.90              | 0.90             | 0.80       | 0.80               | 0.70             | 0.70       | 1                 | 1                | 1          |
| 22:00-23:00                   | 0.80               | 0.90             | 0.80       | 0.90              | 0.90             | 0.80       | 0.80               | 0.70             | 0.70       | 1                 | 1                | 1          |
| 23:00-24:00                   | 0.50               | 0.50             | 0.80       | 0.90              | 0.90             | 0.80       | 0.80               | 0.40             | 0.70       | 1                 | 1                | 1          |



Table 9-34: Schedules for Shopping Complex- Strip Retail &amp; Supermall Buildings

| Strip Retail & Supermall |                      |          |                   |                    |                            |                   |          |                            |                      |                   |
|--------------------------|----------------------|----------|-------------------|--------------------|----------------------------|-------------------|----------|----------------------------|----------------------|-------------------|
| Time Period              | Occupancy Schedule   |          | Lighting Schedule | Equipment Schedule | HVAC Fan Schedule (On/Off) | Elevator Schedule |          | External Lighting Schedule | Basement Ventilation | Basement Lighting |
|                          | Retail & Circulation |          | All Spac          | All Spac           |                            |                   |          |                            |                      |                   |
|                          | Weekdays             | Weekends | 7 Days/ week      | 7 Days/ week       | 7 Days/ week               | Weekdays          | Weekends | 7 Days/ week               | 7 Days/ week         | 7 Days/ week      |
| 00:00-01:00              | 0.00                 | 0.00     | 0.05              | 0.05               | 0                          | 0.00              | 0.00     | 0.20                       | 0.00                 | 0.05              |
| 01:00-02:00              | 0.00                 | 0.00     | 0.05              | 0.05               | 0                          | 0.00              | 0.00     | 0.20                       | 0.00                 | 0.05              |
| 02:00-03:00              | 0.00                 | 0.00     | 0.05              | 0.05               | 0                          | 0.00              | 0.00     | 0.20                       | 0.00                 | 0.05              |
| 03:00-04:00              | 0.00                 | 0.00     | 0.05              | 0.05               | 0                          | 0.00              | 0.00     | 0.20                       | 0.00                 | 0.05              |
| 04:00-05:00              | 0.00                 | 0.00     | 0.05              | 0.05               | 0                          | 0.00              | 0.00     | 0.20                       | 0.00                 | 0.05              |
| 05:00-06:00              | 0.00                 | 0.00     | 0.05              | 0.05               | 0                          | 0.00              | 0.00     | 0.20                       | 0.00                 | 0.05              |
| 06:00-07:00              | 0.00                 | 0.00     | 0.05              | 0.05               | 0                          | 0.00              | 0.00     | 0.00                       | 0.00                 | 0.05              |
| 07:00-08:00              | 0.00                 | 0.00     | 0.05              | 0.05               | 0                          | 0.10              | 0.10     | 0.00                       | 0.00                 | 0.05              |
| 08:00-09:00              | 0.00                 | 0.00     | 0.05              | 0.05               | 0                          | 0.10              | 0.10     | 0.00                       | 0.00                 | 0.05              |
| 09:00-10:00              | 0.20                 | 0.20     | 0.20              | 0.05               | 1                          | 0.20              | 0.20     | 0.00                       | 1.00                 | 1.00              |
| 10:00-11:00              | 0.40                 | 0.40     | 0.50              | 0.90               | 1                          | 0.40              | 0.40     | 0.00                       | 1.00                 | 1.00              |
| 11:00-12:00              | 0.60                 | 0.60     | 0.95              | 0.90               | 1                          | 0.70              | 0.70     | 0.00                       | 1.00                 | 1.00              |
| 12:00-13:00              | 0.60                 | 0.70     | 0.95              | 0.90               | 1                          | 0.70              | 0.80     | 0.00                       | 1.00                 | 1.00              |
| 13:00-14:00              | 0.60                 | 0.90     | 0.95              | 0.90               | 1                          | 0.70              | 0.95     | 0.00                       | 1.00                 | 1.00              |
| 14:00-15:00              | 0.70                 | 0.90     | 0.95              | 0.90               | 1                          | 0.70              | 0.95     | 0.00                       | 1.00                 | 1.00              |
| 15:00-16:00              | 0.70                 | 0.90     | 0.95              | 0.90               | 1                          | 0.70              | 0.95     | 0.00                       | 1.00                 | 1.00              |
| 16:00-17:00              | 0.70                 | 0.90     | 0.95              | 0.90               | 1                          | 0.70              | 0.95     | 0.00                       | 1.00                 | 1.00              |
| 17:00-18:00              | 0.70                 | 0.90     | 0.95              | 0.90               | 1                          | 0.80              | 0.95     | 0.00                       | 1.00                 | 1.00              |
| 18:00-19:00              | 0.90                 | 0.95     | 0.95              | 0.90               | 1                          | 0.80              | 0.95     | 1.00                       | 1.00                 | 1.00              |
| 19:00-20:00              | 0.90                 | 0.95     | 0.95              | 0.90               | 1                          | 0.80              | 0.95     | 1.00                       | 1.00                 | 1.00              |
| 20:00-21:00              | 0.90                 | 0.95     | 0.95              | 0.50               | 1                          | 0.80              | 0.95     | 1.00                       | 1.00                 | 1.00              |
| 21:00-22:00              | 0.00                 | 0.00     | 0.05              | 0.05               | 0                          | 0.00              | 0.00     | 1.00                       | 0.20                 | 0.50              |
| 22:00-23:00              | 0.00                 | 0.00     | 0.05              | 0.05               | 0                          | 0.00              | 0.00     | 0.20                       | 0.00                 | 0.05              |
| 23:00-24:00              | 0.00                 | 0.00     | 0.05              | 0.05               | 0                          | 0.00              | 0.00     | 0.20                       | 0.00                 | 0.05              |

# Appendices

## 10. Appendix A: Default Values for Typical Constructions

### 10.1 Procedure for Determining Fenestration Product U-factor and Solar Heat Gain Coefficient

§ 4.2.1.1 and § 4.2.1.2 require that U-factors and solar heat gain coefficients (SHGC) be determined for the overall fenestration product (including the sash and frame) in accordance with ISO 15099.

In several cases, ISO 15099 suggests that individual national standards will need to be more specific and in other cases the ISO document gives users the choice of two options. This section clarifies these specific issues as they are to be implemented for this code:

- (a) § 4.1 of ISO 15099: For calculating the overall U-factor, ISO 15099 offers a choice between the linear thermal transmittance (4.1.2) and the area weighted method (4.1.3). The area weighted method (4.1.3) shall be used.
- (b) § 4.2.2 of ISO 15099: Frame and divider SHGC's shall be calculated in accordance with § 4.2.2. The alternate approach in § 8.6 shall not be used.
- (c) § 6.4 of ISO 15099 refers the issue of material properties to national standards. Material conductivities and emissivity shall be determined in accordance with Indian standards.
- (d) § 7 of ISO 15099 on shading systems is currently excluded.
- (e) § 8.2 of ISO 15099 addresses environmental conditions. The following are defined for India:

For U-factor calculations:

$$T_{in} = 24 \text{ }^{\circ}\text{C}$$

$$T_{out} = 32 \text{ }^{\circ}\text{C}$$

$$V = 3.35 \text{ m/s}$$

$$T_{rm,out}=T_{out}$$

$$T_{rm,in}=T_{in}$$

$$I_s=0 \text{ W/m}^2$$

For SHGC calculations:

$$T_{in} = 24 \text{ }^{\circ}\text{C}$$

$$T_{out} = 32 \text{ }^{\circ}\text{C}$$

$$V = 2.75 \text{ m/s}$$

$$T_{rm,out}=T_{out}$$

$$T_{rm,in}=T_{in}$$

$$I_s=783 \text{ W/m}^2$$

- (f) § 8.3 of ISO 15099 addresses convective film coefficients on the interior and exterior of the window product. In § 8.3.1 of ISO 15099, simulations shall use the

heat transfer coefficient based on the center of glass temperature and the entire window height; this film coefficient shall be used on all indoor surfaces, including frame sections. In § 8.3.2 of ISO 15099, the formula from this section shall be applied to all outdoor exposed surfaces.

- (g) § 8.4.2 of ISO 15099 presents two possible approaches for incorporating the impacts of self-viewing surfaces on interior radiative heat transfer calculations. Products shall use the method in § 8.4.2.1 of ISO 15099 (Two-Dimensional Element to Element View Factor Based Radiation Heat Transfer Calculation). The alternate approach in § 8.4.3 of ISO 15099 shall not be used.

**10.2 Default U-factors, Visible Light Transmittance and Solar Heat Gain Coefficients for Unrated Fenestration Products**

All fenestration with U-factors, SHGC, or visible light transmittance determined, certified, and labeled in accordance ISO 15099 shall be assigned those values.

**10.2.1 Unrated Vertical Fenestration.**

For unrated vertical fenestration, both operable and fixed, the glass VLT reported by manufacturer must meet or exceed 0.37 (as it accounts for framing). The SHGC values reported by glass manufacturer must meet or exceed the prescriptive requirements in Table 4-10 and Table 4-11 for compliance.

U-factors for unrated vertical fenestration, both operable and fixed, shall be assigned as per Table 10-1.

*Table 10-1 Defaults for Unrated Fenestration (Overall Assembly including the Sash and Frame)*

| Frame Type   | Glazing Type  | U-Factor<br>(W/m <sup>2</sup> .K) |
|--|---|-----------------------------------|
| All frame types  | Single Glazing  | 7.1                               |
| Wood, vinyl, or fiberglass frame or metal frame with thermal break | Double Glazing (COG U value >1.6 W/m <sup>2</sup> .K) | 3.4                               |
| Wood, vinyl, or fiberglass frame or metal frame with thermal break | Double Glazing (COG U value <1.6 W/m <sup>2</sup> .K) | 3.0                               |
| Metal and other frame type   | Double Glazing  | 5.1                               |

**10.3 Typical Roof Constructions**

For calculating the overall U-factor of a typical roof construction, the U-factors from the typical wall construction type and effective U-factor for insulation shall be combined according to the following equation:

$$U_{TotalRoof} = \frac{1}{\frac{1}{U_{TypicalRoof}} + \frac{1}{U_{TyipcalInsulation}}}$$

where

|                                 |  |
|---------------------------------|--|
| U <sub>TotalRoof</sub>          | Total U-factor of the roof with insulation |
| U <sub>Typical Roof</sub>       | U-factor of the roof                       |
| U <sub>Typical Insulation</sub> | U-factor of the effective insulation       |

10.4 Typical Wall Constructions

For calculating the overall U-factor of a typical wall construction, the U-factors from the typical wall construction type and effective U-factor for insulation shall be combined according to the following equation:

$$U_{TotalWall} = \frac{1}{\frac{1}{U_{TypicalWall}} + \frac{1}{U_{TyipcalInsulation}}}$$

where

|                                 |  |
|---------------------------------|--|
| U <sub>TotalWall</sub>          | Total U-factor of the wall with insulation |
| U <sub>Typical Wall</sub>       | U-factor of the wall                       |
| U <sub>Typical Insulation</sub> | U-factor of the effective insulation       |

Table 10-2 Typical Thermal Properties of Common Building and Insulating Materials<sup>2,a</sup>

| Description                                     | Density<br>kg/m <sup>3</sup> | Conductivity <sup>b</sup> k,<br>W/(m·K) | Resistance R,<br>(m <sup>2</sup> ·K)/W | Specific<br>Heat,<br>kJ/(kg·K) |
|---|------------------------------|---|--|--------------------------------|
| <b>Building Board and Siding</b>                |                              |   |  |                                |
| <b>Board</b>                                    |                              |   |  |                                |
| Asbestos/cement board                           | 1900                         | 0.57                                    | -                                      | 1                              |
| Cement board                                    | 1150                         | 0.25                                    | -                                      | 0.84                           |
| Fiber/cement board                              | 1400                         | 0.25                                    | -                                      | 0.84                           |
|   | 1000                         | 0.19                                    | -                                      | 0.84                           |
|   | 400                          | 0.07                                    | -                                      | 1.88                           |
|   | 300                          | 0.06                                    | -                                      | 1.88                           |
| Gypsum or plaster board                         | 640                          | 0.16                                    | -                                      | 1.15                           |
| Oriented strand board (OSB) 9 to 11 mm          | 650                          | -                                       | 0.11                                   | 1.88                           |
| Oriented strand board (OSB) 12.7 mm             | 650                          | -                                       | 0.12                                   | 1.88                           |
| Plywood (douglas fir) 12.7 mm                   | 460                          | -                                       | 0.14                                   | 1.88                           |
| Plywood (douglas fir) 15.9 mm                   | 540                          | -                                       | 0.15                                   | 1.88                           |
| Plywood/wood panels 19.0 mm                     | 550                          | -                                       | 0.19                                   | 1.88                           |
| <i>Vegetable fiber board</i>                    |                              |   |  | -                              |
| Sheathing, regular density <sup>e</sup> 12.7 mm | 290                          | -                                       | 0.23                                   | 1.3                            |
| Intermediate density <sup>e</sup> .. 12.7 mm    | 350                          | -                                       | 0.19                                   | 1.3                            |
| Nail-base sheathing <sup>e</sup> 12.7 mm        | 400                          | -                                       | 0.19                                   | 1.3                            |
| Shingle backer 9.5 mm                           | 290                          | -                                       | 0.17                                   | 1.3                            |
| Sound deadening board. 12.7 mm                  | 240                          | -                                       | 0.24                                   | 1.26                           |
| Tile and lay-in panels, plain or acoustic       | 290                          | 0.058                                   | -                                      | 0.59                           |
| Laminated paperboard                            | 480                          | 0.072                                   | -                                      | 1.38                           |
| Homogeneous board from repulped paper           | 480                          | 0.072                                   | -                                      | 1.17                           |
| <b>Hardboard<sup>e</sup></b>                    |                              |   |  |                                |
| Medium density                                  | 800                          | 0.105                                   | -                                      | 1.3                            |
| High density, service-tempered                  | 880                          | 0.12                                    | -                                      | 1.34                           |
| <b>Grade and service grade</b>                  |                              |   |  |                                |
| High density, standard-tempered grade           | 1010                         | 0.144                                   | -                                      | 1.34                           |
| <b>Particleboard<sup>e</sup></b>                |                              |   |  |                                |

<sup>2</sup> ASHRAE- Handbook of Fundamentals

|  |      |       |            |      |
|--|------|-------|------------|------|
| Low density  | 590  | 0.102 | -          | 1.3  |
| Medium density   | 800  | 0.135 | -          | 1.3  |
| High density   | 1000 | 0.18  | -          | -    |
| Underlayment 15.9 mm   | 640  | -     | 1.22       | 1.21 |
| Waferboard   | 700  | 0.072 | -          | 1.88 |
| <i>Shingles</i>  |      |       |            |      |
| Asbestos/cement  | 1900 | -     | 0.37       | -    |
| Wood, 400 mm, 190 mm exposure  | -    | -     | 0.015      | 1.3  |
| Wood, double, 400 mm, 300 mm exposure  | -    | -     | 0.21       | 1.17 |
| Wood, plus ins. backer board 8 mm  | -    | -     | 0.25       | 1.3  |
| Siding   | -    | -     | -          | -    |
| Asbestos/cement, lapped 6.4 mm   | -    | -     | 0.037      | 1.01 |
| Asphalt roll siding  | -    | -     | 0.026      | 1.47 |
| <i>Siding</i>  |      |       |            |      |
| Asphalt insulating siding (12.7 mm bed)  | -    | -     | 0.26       | 1.47 |
| Hardboard siding 11 mm   | -    | -     | 0.12       | 1.17 |
| Wood, drop, 200 mm 25 mm   | -    | -     | 0.14       | 1.17 |
| Wood, bevel 200 mm, lapped 13 mm   | -    | -     | 0.14       | 1.17 |
| Wood, bevel 250 mm, lapped 19 mm   | -    | -     | 0.18       | 1.17 |
| Wood, plywood, lapped 9.5 mm   | -    | -     | 0.1        | 1.22 |
| Aluminum, steel, or vinyl, <sup>j,k</sup> over sheathing<br>Hollow-backed                  | -    | -     | 0.11       | 1.22 |
| Aluminum, steel, or vinyl, <sup>j,k</sup> over sheathing<br>Insulating-board-backed 9.5 mm | -    | -     | 0.32       | 1.34 |
| Aluminum, steel, or vinyl, <sup>j,k</sup> over sheathing<br>Foil-backed 9.5 mm             | -    | -     | 0.52       | -    |
| Architectural (soda-lime float) glass  | 2500 | 1     | -          | 0.84 |
| Building Membrane  |      |       |            |      |
| Vapor-permeable felt   | -    | -     | 0.011      | -    |
| Vapor: seal, 2 layers of mopped 0.73 kg/m <sup>2</sup><br>felt                             | -    | -     | 0.21       | -    |
| Vapor: seal, plastic film  | -    | -     | Negligible | -    |
| Finish Flooring Materials  |      |       |            |      |
| Carpet and rebounded urethane pad 19 mm  | 110  | -     | 0.42       | -    |
| Carpet and rubber pad (one-piece) 9.5 mm   | 320  | -     | 0.12       | -    |
| Pile carpet with rubber pad 9.5 to 12.7 mm   | 290  | -     | 0.28       | -    |
| Linoleum/cork tile 6.4 mm  | 465  | -     | 0.09       | -    |
| PVC/Rubber floor covering  | -    | 0.4   | -          | -    |
| Rubber tile 25 mm  | 1900 | -     | 0.06       | -    |

|   |            |                |       |      |
|---|------------|----------------|-------|------|
| Terrazzo 25 mm  | -          | -              | 0.014 | 0.8  |
| Insulating Materials  |            |                |       |      |
| <i>Blanket and batts<sup>c,d</sup></i>                            |            |                |       |      |
| Glass-fiber batts 85 to 90 mm                                     | 10 to 14   | 0.043          | -     | 0.84 |
| Glass-fiber batts 50 mm   | 8 to 13    | 0.045 to 0.048 | -     | 0.84 |
| Mineral fiber 140 mm  | 30         | 0.036          | -     | 0.84 |
| Mineral wool, felted  | 16 to 48   | 0.04           | -     | -    |
|   | 65 to 130  | 0.035          | -     | -    |
| Slag wool .   | 50 to 190  | 0.038          | -     | -    |
|   | 255        | 0.04           | -     | -    |
|   | 305        | 0.043          | -     | -    |
|   | 350        | 0.048          | -     | -    |
|   | 400        | 0.05           | -     | -    |
| <i>Board and slabs</i>  |            |                |       |      |
| Cellular glass.   | 130        | 0.048          | -     | 0.75 |
| Cement fiber slabs, shredded wood with Portland cement binder     | 400 to 430 | 0.072 to 0.076 | -     | -    |
|   |            |                | -     |      |
| Cement fiber slabs, shredded wood with magnesia oxysulfide binder | 350        | 0.082          | -     | 1.3  |
| Glass fiber board   | 160        | 0.032 to 0.040 | -     | 0.84 |
| Expanded rubber (rigid)   | 70         | 0.032          | -     | 1.67 |
| Expanded polystyrene extruded (smooth skin)                       | 25 to 40   | 0.022 to 0.030 | -     | 1.47 |
| Expanded polystyrene, molded beads                                | 15 to 25   | 0.032 to 0.039 | -     | 1.47 |
| Mineral fiberboard, wet felted                                    | 160        | 0.038          | -     | 0.84 |
| Mineral fiberboard, core or roof insulation                       | 255 to 270 | 0.049          | -     | -    |
| Mineral fiberboard, acoustical tile <sup>g</sup>                  | 290        | 0.05           | -     | 0.8  |
|   | 335        | 0.053          | -     | -    |
| Mineral fiberboard, wet-molded, acoustical tile.                  | 370        | 0.061          | -     | 0.59 |
| Perlite board   | 160        | 0.052          | -     | -    |
| Polyisocyanurate, aged unfaced                                    | 25 to 35   | 0.020 to 0.027 | -     | -    |
| Polyisocyanurate, aged with facers                                | 65         | 0.019          | -     | 1.47 |
| Phenolic foam board with facers, aged                             | 65         | 0.019          | -     | -    |
| <i>Loose fill</i>   |            |                |       |      |



|   |            |                |            |      |
|---|------------|----------------|------------|------|
| Cellulosic (milled paper or wood pulp)  | 35 to 50   | 0.039 to 0.045 | -          | 1.38 |
| Perlite, expanded   | 30 to 65   | 0.039 to 0.046 | -          | 1.09 |
|   | 65 to 120  | 0.045 to 0.052 | -          | -    |
|   | 120 to 180 | 0.052 to 0.061 | -          | -    |
| Mineral fiber (rock, slag, or glass) <sup>d</sup> approx. 95 to 130 mm                | 10 to 30   | -              | 1.92       | 0.71 |
| Mineral fiber (rock, slag, or glass) <sup>d</sup> approx. 170 to 220 mm               | 11 to 30   | -              | 3.33       | -    |
| Mineral fiber (rock, slag, or glass) <sup>d</sup> approx. 190 to 250 mm               | 12 to 30   | -              | 3.85       | -    |
| Mineral fiber (rock, slag, or glass) <sup>d</sup> approx. 260 to 350 mm               | 13 to 30   | -              | 5.26       | -    |
| Mineral fiber (rock, slag, or glass) <sup>d</sup> 90 mm (closed sidewall application) | 30 to 55   | -              | 2.1 to 2.5 | -    |
| Vermiculite, exfoliated   | 110 to 130 | 0.068          | -          | 1.34 |
|   | 64 to 96   | 0.063          | -          | -    |
| <i>Spray-applied</i>  |            |                |            |      |
| Cellulosic fiber  | 55 to 95   | 0.042 to 0.049 | -          | -    |
| Glass fiber   | 55 to 70   | 0.038 to 0.039 | -          | -    |
| Polyurethane foam (low density)   | 6 to 8     | 0.042          | -          | 1.47 |
|   | 40         | 0.026          | -          | 1.47 |
| Polyurethane foam (low density) aged and dry 40 mm                                    | 30         | -              | 1.6        | 1.47 |
| Polyurethane foam (low density) 50 mm   | 55         | -              | 1.92       | 1.47 |
| Polyurethane foam (low density) 120 mm  | 30         | -              | 3.69       | -    |
| Ureaformaldehyde foam, dry  | 8 to 20    | 0.030 to 0.032 | -          | -    |
| Roofing   |            |                |            |      |
| Asbestos/cement shingles  | 1120       | -              | 0.037      | 1    |
| Asphalt (bitumen with inert fill)   | 1600       | 0.43           | -          | -    |
|   | 1900       | 0.58           | -          | -    |
|   | 2300       | 1.15           | -          | -    |
| Asphalt roll roofing  | 920        | -              | 0.027      | 1.51 |
| Asphalt shingles  | 920        | -              | 0.078      | 1.26 |
| Built-up roofing  | 920        | -              | 0.059      | 1.47 |
| Mastic asphalt (heavy, 20% grit)  | 950        | 0.19           | -          | -    |
| Reed thatch   | 270        | 0.09           | -          | -    |
| Roofing felt  | 2250       | 1.2            | -          | -    |

|   |      |              |       |      |
|---|------|--------------|-------|------|
| Slate 13 mm                                 | -    | -            | 0.009 | 1.26 |
| Straw thatch                                | 240  | 0.07         | -     | -    |
| Wood shingles, plain and plastic-film-faced | -    | -            | 0.166 | 1.3  |
| Plastering Materials                        |      |              |       |      |
| Cement plaster, sand aggregate              | 1860 | 0.72         | -     | 0.84 |
| Sand aggregate 10 mm                        | -    | -            | 0.013 | 0.84 |
| Sand aggregate 20 mm                        | -    | -            | 0.026 | 0.84 |
| Gypsum plaster                              | 1120 | 0.38         | -     | -    |
|   | 1280 | 0.46         | -     | -    |
| Lightweight aggregate                       | 720  | -            | 0.056 | -    |
| Lightweight aggregate                       | 720  | -            | 0.066 | -    |
| Lightweight aggregate                       | -    | -            | 0.083 | -    |
| Perlite aggregate                           | 720  | 0.22         | -     | 1.34 |
| Sand aggregate                              | 1680 | 0.81         | -     | 0.84 |
| Sand aggregate on metal lath 19 mm          | -    | -            | 0.023 | -    |
| Vermiculite aggregate                       | 480  | 0.14         | -     | -    |
|   | 600  | 0.2          | -     | -    |
|   | 720  | 0.25         | -     | -    |
|   | 840  | 0.26         | -     | -    |
|   | 960  | 0.3          | -     | -    |
| Perlite plaster                             | 400  | 0.08         | -     | -    |
|   | 600  | 0.19         | -     | -    |
| Pulpboard or paper plaster                  | 600  | 0.07         | -     | -    |
| Sand/cement plaster, conditioned            | 1560 | 0.63         | -     | -    |
| Sand/cement/lime plaster, conditioned       | 1440 | 0.48         | -     | -    |
| Sand/gypsum (3:1) plaster, conditioned      | 1550 | 0.65         | -     | -    |
| Masonry Materials                           |      |              |       |      |
| <i>Masonry units</i>                        |      |              |       |      |
| Brick, fired clay                           | 2400 | 1.21 to 1.47 | -     | -    |
|   | 2240 | 1.07 to 1.30 | -     | -    |
|   | 2080 | 0.92 to 1.12 | -     | -    |
|   | 1920 | 0.81 to 0.98 | -     | 0.8  |
|   | 1760 | 0.71 to 0.85 | -     | -    |
|   | 1600 | 0.61 to 0.74 | -     | -    |
|   | 1440 | 0.52 to 0.62 | -     | -    |
|   | 1280 | 0.43 to 0.53 | -     | -    |
|   | 1120 | 0.36 to 0.45 | -     | -    |
| Clay tile, hollow 1 cell deep 75 mm         | -    | -            | 0.14  | 0.88 |

|   |     |      |              |      |
|---|-----|------|--------------|------|
| Clay tile, hollow 1 cell deep 100 mm  | -   | -    | 0.2          | -    |
| Clay tile, hollow 2 cells deep 150 mm   | -   | -    | 0.27         | -    |
| Clay tile, hollow 2 cells deep 200 mm   | -   | -    | 0.33         | -    |
| Clay tile, hollow 2 cells deep 250 mm   | -   | -    | 0.39         | -    |
| Clay tile, hollow 3 cells deep 300 mm   | -   | -    | 0.44         | -    |
| Lightweight brick   | 800 | 0.2  | -            | -    |
|   | 770 | 0.22 | -            | -    |
| Concrete blocks <sup>h,i</sup> Limestone aggregate<br>~200 mm, 16.3 kg, 2200 kg/m <sup>3</sup> concrete, 2<br>cores ..  | -   | -    | -            | -    |
| Concrete blocks <sup>h,i</sup> Limestone aggregate<br>~200 mm, 16.3 kg, 2200 kg/m <sup>3</sup> concrete<br>with perlite-filled cores                                    | -   | -    | 0.37         | -    |
| Concrete blocks <sup>h,i</sup> Limestone aggregate<br>~300 mm, 25 kg, 2200 kg/m <sup>3</sup> concrete, 2<br>cores   | -   | -    | -            | -    |
| Normal-weight aggregate (sand and<br>gravel)~200 mm, 16 kg, 2100 kg/m <sup>3</sup><br>concrete, 2 or 3 cores ..   | -   | -    | 0.20 to 0.17 | 0.92 |
| Normal-weight aggregate (sand and<br>gravel)~200 mm, 16 kg, 2100 kg/m <sup>3</sup> with<br>perlite-filled cores   | -   | -    | 0.35         | -    |
| Normal-weight aggregate (sand and<br>gravel)~200 mm, 16 kg, 2100 kg/m <sup>3</sup> with<br>vermiculite-filled cores   | -   | -    | 0.34 to 0.24 | -    |
| Normal-weight aggregate (sand and<br>gravel)~200 mm, 16 kg, 2100 kg/m <sup>3</sup> ~300<br>mm, 22.7 kg, 2000 kg/m <sup>3</sup> concrete, 2 cores<br>..                  | -   | -    | 0.217        | 0.92 |
| Medium-weight aggregate (combinations<br>of normal and lightweight aggregate) ~200<br>mm, 13 kg, 1550 to 1800 kg/m <sup>3</sup> concrete, 2<br>or 3 cores               | -   | -    | 0.30 to 0.22 | -    |
| Medium-weight aggregate (combinations<br>of normal and lightweight aggregate) ~200<br>mm, 13 kg, 1550 to 1800 kg/m <sup>3</sup> with<br>perlite-filled cores            | -   | -    | 0.65 to 0.41 | -    |
| Medium-weight aggregate (combinations<br>of normal and lightweight aggregate) ~200<br>mm, 13 kg, 1550 to 1800 kg/m <sup>3</sup> with<br>vermiculite-filled cores        | -   | -    | 0.58         | -    |
| Medium-weight aggregate (combinations<br>of normal and lightweight aggregate) ~200<br>mm, 13 kg, 1550 to 1800 kg/m <sup>3</sup> with<br>molded-EPS-filled (beads) cores | -   | -    | 0.56         | -    |
| Medium-weight aggregate (combinations<br>of normal and lightweight aggregate) ~200<br>mm, 13 kg, 1550 to 1800 kg/m <sup>3</sup> with<br>molded EPS inserts in cores     | -   | -    | 0.47         | -    |

|   |      |      |              |      |
|---|------|------|--------------|------|
| Low-mass aggregate (expanded shale, clay, slate or slag, pumice) ~150 mm, 7 1/2 kg, 1400 kg/m <sup>2</sup> concrete, 2 or 3 cores                                 | -    | -    | 0.34 to 0.29 | -    |
| Low-mass aggregate (expanded shale, clay, slate or slag, pumice) ~150 mm, 7 1/2 kg, 1400 kg/m <sup>2</sup> with perlite-filled cores                              | -    | -    | 0.74         | -    |
| Low-mass aggregate (expanded shale, clay, slate or slag, pumice) ~150 mm, 7 1/2 kg, 1400 kg/m <sup>2</sup> with vermiculite-filled cores                          | -    | -    | 0.53         | -    |
| Low-mass aggregate (expanded shale, clay, slate or slag, pumice) 200 mm, 8 to 10 kg, 1150 to 1380 kg/m <sup>2</sup> concrete                                      | -    | -    | 0.56 to 0.33 | 0.88 |
| Low-mass aggregate (expanded shale, clay, slate or slag, pumice) 200 mm, 8 to 10 kg, 1150 to 1380 kg/m <sup>2</sup> concrete with perlite-filled cores            | -    | -    | 1.20 to 0.77 | -    |
| Low-mass aggregate (expanded shale, clay, slate or slag, pumice) 200 mm, 8 to 10 kg, 1150 to 1380 kg/m <sup>2</sup> concrete with vermiculite-filled cores        | -    | -    | 0.93 to 0.69 | -    |
| Low-mass aggregate (expanded shale, clay, slate or slag, pumice) 200 mm, 8 to 10 kg, 1150 to 1380 kg/m <sup>2</sup> concrete with molded-EPS-filled (beads) cores | -    | -    | 0.85         | -    |
| Low-mass aggregate (expanded shale, clay, slate or slag, pumice) 200 mm, 8 to 10 kg, 1150 to 1380 kg/m <sup>2</sup> concrete with UF foam-filled cores            | -    | -    | 0.79         | -    |
| Low-mass aggregate (expanded shale, clay, slate or slag, pumice) 200 mm, 8 to 10 kg, 1150 to 1380 kg/m <sup>2</sup> concrete with molded EPS inserts in cores     | -    | -    | 0.62         | -    |
| Low-mass aggregate (expanded shale, clay, slate or slag, pumice) 300 mm, 16 kg, 1400 kg/m <sup>3</sup> ,concrete, 2 or 3 cores                                    | -    | -    | 0.46 to 0.40 | -    |
| Low-mass aggregate (expanded shale, clay, slate or slag, pumice) 300 mm, 16 kg, 1400 kg/m <sup>3</sup> ,with perlite-filled cores                                 | -    | -    | 1.6 to 1.1   | -    |
| Low-mass aggregate (expanded shale, clay, slate or slag, pumice) 300 mm, 16 kg, 1400 kg/m <sup>3</sup> ,with vermiculite-filled cores                             | -    | -    | 1            | -    |
| Stone, lime, or sand  | 2800 | 10.4 | -            | -    |
| Quartzitic and sandstone  | 2560 | 6.2  | -            | -    |
|   | 2240 | 3.46 | -            | -    |
|   | 1920 | 1.88 | -            | 0.88 |
| Calcitic, dolomitic, limestone, marble, and granite   | 2880 | 4.33 | -            | -    |
|   | 2560 | 3.17 | -            | -    |
|   | 2240 | 2.31 | -            | -    |
|   | 1920 | 1.59 | -            | 0.88 |

|  |            |              |       |              |
|--|------------|--------------|-------|--------------|
|  | 1600       | 1.15         | -     | -            |
| Gypsum partition tile .75 by 300 by 760 mm, solid  | -          | -            | 0.222 | 0.79         |
| Gypsum partition tile .4 cells   | -          | -            | 0.238 | -            |
| Gypsum partition tile .100 by 300 by 760 mm, 3 cells   | -          | -            | 0.294 | -            |
| Limestone  | 2400       | 0.57         | -     | 0.84         |
|  | 2600       | 0.93         | -     | 0.84         |
| <b>Concretes</b>   |            |              |       |              |
| Sand and gravel or stone aggregate concretes (concretes with >50% quartz or quartzite sand have conductivities in higher end of range)   | 2400       | 1.4 to 2.9   | -     | -            |
|  | 2240       | 1.3 to 2.6   | -     | 0.80 to 1.00 |
|  | 2080       | 1.0 to 1.9   | -     | -            |
| Low-mass aggregate or limestone concretes  | 1920       | 0.9 to 1.3   | -     | -            |
| Low-mass aggregate or limestone concretes Expanded shale, clay, or slate; expanded slags ;cinders; pumice (with density up to 1600 kg/m <sup>3</sup> ); scoria (sanded concretes have conductivities in higher end of range) | 1600       | 0.68 to 0.89 | -     | 0.84         |
|  | 1280       | 0.48 to 0.59 | -     | 0.84         |
|  | 960        | 0.30 to 0.36 | -     | -            |
|  | 640        | 0.18         | -     | -            |
| Gypsum/fiber concrete (87.5% gypsum, 12.5% wood chips)   | 800        | 0.24         | -     | 0.84         |
| Cement/lime, mortar, and stucco  | 1920       | 1.4          | -     | -            |
|  | 1600       | 0.97         | -     | -            |
|  | 1280       | 0.65         | -     | -            |
| Perlite, vermiculite, and polystyrene beads  | 800        | 0.26 to 0.27 | -     | -            |
|  | 640        | 0.20 to 0.22 | -     | 0.63 to 0.96 |
|  | 480        | 0.16         | -     | -            |
|  | 320        | 0.12         | -     | -            |
| Foam concretes   | 1920       | 0.75         | -     | -            |
|  | 1600       | 0.6          | -     | -            |
|  | 1280       | 0.44         | -     | -            |
|  | 1120       | 0.36         | -     | -            |
| Foam concretes and cellular concretes  | 960        | 0.3          | -     | -            |
|  | 640        | 0.2          | -     | -            |
|  | 320        | 0.12         | -     | -            |
| Aerated concrete (oven-dried)  | 430 to 800 | 0.2          | -     | 0.84         |
| Polystyrene concrete (oven-dried)  | 255 to 800 | 0.37         | -     | 0.84         |
| Polymer concrete   | 1950       | 1.64         | -     | -            |
|  | 2200       | 1.03         | -     | -            |

|                                     |            |              |   |      |
|-------------------------------------|------------|--------------|---|------|
| Polymer cement                      | 1870       | 0.78         | - | -    |
| Slag concrete                       | 960        | 0.22         | - | -    |
|                                     | 1280       | 0.32         | - | -    |
|                                     | 1600       | 0.43         | - | -    |
|                                     | 2000       | 1.23         | - | -    |
| <b>Woods (12% moisture content)</b> |            |              |   |      |
| <i>Hardwoods</i>                    | -          | -            | - | 1.63 |
| Oak                                 | 660 to 750 | 0.16 to 0.18 | - | -    |
| Birch                               | 680 to 725 | 0.17 to 0.18 | - | -    |
| Maple                               | 635 to 700 | 0.16 to 0.17 | - | -    |
| Ash                                 | 615 to 670 | 0.15 to 0.16 | - | -    |
| <i>Softwoods</i>                    | -          | -            | - | 1.63 |
| Southern pine                       | 570 to 660 | 0.14 to 0.16 | - | -    |
| Southern yellow pine                | 500        | 0.13         | - | -    |
| Eastern white pine                  | 400        | 0.1          | - | -    |
| Douglas fir/larch                   | 535 to 580 | 0.14 to 0.15 | - | -    |
| Southern cypress                    | 500 to 515 | 0.13         | - | -    |
| Hem/fir, spruce/pine/fir            | 390 to 500 | 0.11 to 0.13 | - | -    |
| Spruce                              | 400        | 0.09         | - | -    |
| Western red cedar                   | 350        | 0.09         | - | -    |
| West coast woods, cedars            | 350 to 500 | 0.10 to 0.13 | - | -    |
| Eastern white cedar                 | 360        | 0.1          | - | -    |
| California redwood                  | 390 to 450 | 0.11 to 0.12 | - | -    |
| Pine (oven-dried)                   | 370        | 0.092        | - | 1.88 |
| Spruce (oven-dried)                 | 395        | 0.1          | - | 1.88 |

<sup>a</sup>Values are for mean temperature of 24°C. Representative values for dry materials are intended as design (not specification) values for materials in normal use. Thermal values of insulating materials may differ from design values depending on in-situ properties (e.g., density and moisture content, orientation, etc.) and manufacturing variability. For properties of specific product, use values supplied by manufacturer or unbiased tests.

<sup>b</sup>Symbol  $\lambda$  also used to represent thermal conductivity.

<sup>c</sup>Does not include paper backing and facing, if any. Where insulation forms boundary (reflective or otherwise) of airspace

<sup>d</sup>Conductivity varies with fiber diameter. Batt, blanket, and loose-fill mineral fiber insulations are manufactured to achieve specified R-values, the most common of which are listed in the table. Because of differences in manufacturing processes and materials, the product thicknesses, densities, and thermal conductivities vary over considerable ranges for a specified R-value.

<sup>e</sup>Values are for aged products with gas-impermeable facers on the two major surfaces. An aluminum foil facer of 25  $\mu$ m thickness or greater is generally considered impermeable to gases. For change in conductivity with age of expanded polyisocyanurate.

<sup>f</sup>Cellular phenolic insulation may no longer be manufactured. Thermal conductivity and resistance values do not represent aged insulation, which may have higher thermal conductivity and lower thermal resistance.

<sup>g</sup>Insulating values of acoustical tile vary, depending on density of board and on type, size, and depth of perforations.

---

<sup>b</sup>Values for fully grouted block may be approximated using values for concrete with similar unit density.

<sup>c</sup>Values for concrete block and concrete are at moisture contents representative of normal use.

<sup>d</sup>Values for metal or vinyl siding applied over flat surfaces vary widely, depending on ventilation of the airspace beneath the siding; whether airspace is reflective or nonreflective; and on thickness, type, and application of insulating backing-board used. Values are averages for use as design guides, and were obtained from several guarded hot box tests (ASTM *Standard C236*) or calibrated hot box (ASTM *Standard C976*) on hollow-backed types and types made using backing of wood fiber, foamed plastic, and glass fiber. Departures of  $\pm 50\%$  or more from these values may occur.

<sup>e</sup>Vinyl specific heat =  $1.0 \text{ kJ}/(\text{kg}\cdot\text{K})$

<sup>f</sup>See Adams (1971), MacLean (1941), and Wilkes (1979). Conductivity values listed are for heat transfer across the grain. Thermal conductivity of wood varies linearly with density, and density ranges listed are those normally found for wood species given. If density of wood species is not known, use mean conductivity value. For extrapolation to other moisture contents, the following empirical equation developed by Wilkes (1979) may be used:

$$k = 0.1791 + \frac{(1.874 \times 10^{-2} + 5.733 \times 10^{-4} M)\rho}{1 + 0.01 M}$$

where  $\rho$  is density of moist wood in  $\text{kg}/\text{m}^3$ , and  $M$  is moisture content in percent.

<sup>g</sup>From Wilkes (1979), an empirical equation for specific heat of moist wood at  $24^\circ\text{C}$  is as follows:

$$C_p = \frac{(0.299 + 0.01 M)}{(1 + 0.01 M)} + \Delta C_p$$

where  $\Delta C_p$  accounts for heat of sorption and is denoted by

$$\Delta C_p = M(1.921 \times 10^{-3} - 3.168 \times 10^{-5} M)$$

where  $M$  is moisture content in percent by mass.

<sup>h</sup>Blank space in reference column indicates historical values from previous volumes of *ASHRAE Handbook*. Source of information could not be determined.

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## 11. Appendix B: Climate Zone Map of India

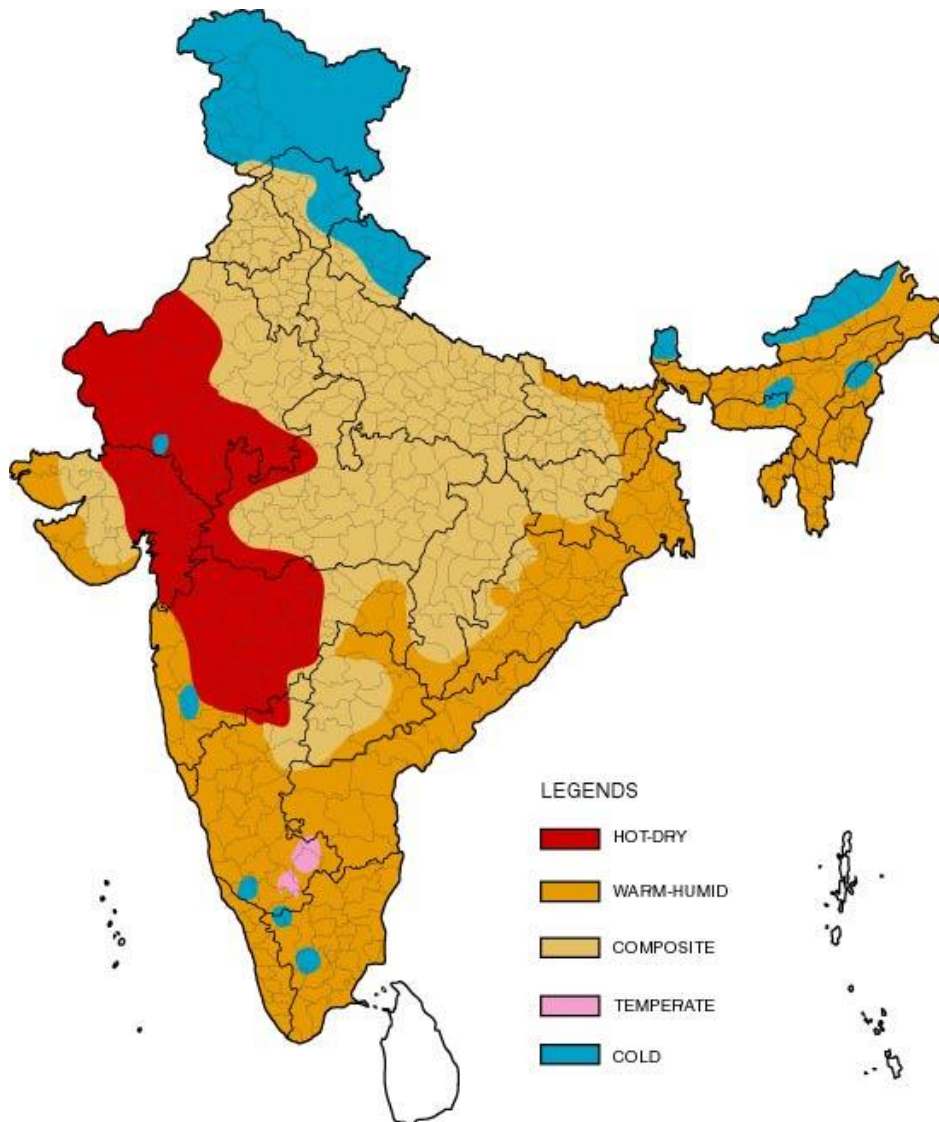




Table 11-1 Climate Zone for Major Indian Cities

| City        | Climate Type | City            | Climate Type |
|-------------|--------------|-----------------|--------------|
| Ahmedabad   | Hot & Dry    | Kurnool         | Warm & Humid |
| Allahabad   | Composite    | Leh             | Cold         |
| Amritsar    | Composite    | Lucknow         | Composite    |
| Aurangabad  | Hot & Dry    | Ludhiana        | Composite    |
| Bangalore   | Temperate    | Chennai         | Warm & Humid |
| Barmer      | Hot & Dry    | Manali          | Cold         |
| Belgaum     | Warm & Humid | Mangalore       | Warm & Humid |
| Bhagalpur   | Warm & Humid | Mumbai          | Warm & Humid |
| Bhopal      | Composite    | Nagpur          | Composite    |
| Bhubaneswar | Warm & Humid | Nellore         | Warm & Humid |
| Bikaner     | Hot & Dry    | New Delhi       | Composite    |
| Chandigarh  | Composite    | Panjim          | Warm & Humid |
| Chitradurga | Warm & Humid | Patna           | Composite    |
| Dehradun    | Composite    | Pune            | Warm & Humid |
| Dibrugarh   | Warm & Humid | Raipur          | Composite    |
| Guwahati    | Warm & Humid | Rajkot          | Composite    |
| Gorakhpur   | Composite    | Ramgundam       | Warm & Humid |
| Gwalior     | Composite    | Ranchi          | Composite    |
| Hissar      | Composite    | Ratnagiri       | Warm & Humid |
| Hyderabad   | Composite    | Raxaul          | Warm & Humid |
| Imphal      | Warm & Humid | Saharanpur      | Composite    |
| Indore      | Composite    | Shillong        | Cold         |
| Jabalpur    | Composite    | Sholapur        | Hot & Dry    |
| Jagdelpur   | Warm & Humid | Srinagar        | Cold         |
| Jaipur      | Composite    | Sundernagar     | Cold         |
| Jaisalmer   | Hot & Dry    | Surat           | Hot & Dry    |
| Jalandhar   | Composite    | Tezpur          | Warm & Humid |
| Jamnagar    | Warm & Humid | Tiruchirappalli | Warm & Humid |
| Jodhpur     | Hot & Dry    | Trivandrum      | Warm & Humid |
| Jorhat      | Warm & Humid | Tuticorin       | Warm & Humid |
| Kochi       | Warm & Humid | Udhagamandalam  | Cold         |
| Kolkata     | Warm & Humid | Vadodara        | Hot & Dry    |
| Kota        | Hot & Dry    | Veraval         | Warm & Humid |
| Kullu       | Cold         | Vishakhapatnam  | Warm & Humid |

## 12. Appendix C: Air-Side Economizer Acceptance Procedures

### 12.1 Construction Inspection

Prior to Performance Testing, verify and document the following:

- (a) System controls are wired correctly to ensure economizer is fully integrated (i.e. economizer will operate when mechanical cooling is enabled).
- (b) Economizer lockout control sensor location is adequate (open to air but not exposed to direct sunlight nor in an enclosure; away from sources of building exhaust; at least 8 meters away from cooling towers).
- (c) System is provided with barometric relief, relief fan or return fan to control building pressure.

### 12.2 Equipment Testing

Step 1: Simulate a cooling load and enable the economizer by adjusting the lockout control set point. Verify and document the following:

- (a) Economizer damper modulates opens to 100% outside air.
- (b) Return air damper modulates closed and is completely closed when economizer damper is 100% open.
- (c) Economizer damper is 100% open before mechanical cooling is enabled.
- (d) Relief fan or return fan (if applicable) is operating or barometric relief dampers freely swing open.

Step 2: Continue from Step 1 and disable the economizer by adjusting the lockout control set point. Verify and document the following:

- (a) Economizer damper closes to minimum ventilation position.
- (b) Return air damper opens to at or near 100%.
- (c) Relief fan (if applicable) shuts off or barometric relief dampers close. Return fan (if applicable) may still operate even when economizer is disabled.

## 13. Appendix D: Compliance Forms

## Envelope Summary

Energy Conservation Building Code 2017 Compliance Forms

|                       |  |                             |
|-----------------------|--|-----------------------------|
| Project Info          | Project Address                            | Date                        |
|                       |  | For Building Department Use |
|                       | Project Built-up Area [m <sup>2</sup> ]    |                             |
|                       | Project Above-grade Area [m <sup>2</sup> ] |                             |
|                       | Project Conditioned Area [m <sup>2</sup> ] |                             |
|                       | Applicant Name and Address                 |                             |
|                       |  |                             |
| Project Climatic Zone |  |                             |

|                         |                                      |   |
|-------------------------|--------------------------------------|---|
| Building Classification | <input type="checkbox"/> Hospitality | <input type="checkbox"/> Business         |
|                         | <input type="checkbox"/> Health Care | <input type="checkbox"/> Educational      |
|                         | <input type="checkbox"/> Assembly    | <input type="checkbox"/> Shopping Complex |

|  |  |   |   |
|--|--|---|---|
| Project Description                              | <input type="checkbox"/> New Building  | <input type="checkbox"/> Addition       | <input type="checkbox"/> Alteration       |
|  | <input type="checkbox"/> Self-occupied | <input type="checkbox"/> Core and Shell | <input type="checkbox"/> Mixed-Use        |
| Compliance is sought for Energy efficiency level | <input type="radio"/> ECBC Compliant   | <input type="radio"/> ECBC+ Compliant   | <input type="radio"/> SuperECBC Compliant |
| EPI Ratio  |  |   |   |

|                     |                     |                                   |   |
|---------------------|---------------------|-----------------------------------|---|
| Compliance Approach | Prescriptive Method | Whole Building Performance Method | Building Trade-off Method-Envelope Compliance |
|---------------------|---------------------|-----------------------------------|---|

|  |  |         |                                      |
|--|--|---------|--------------------------------------|
| Building Envelope                      |  |         |                                      |
| Vertical Fenestration Area Calculation | Total Vertical Fenestration Area (rough opening) | /       | Gross Exterior Wall Area             |
|  |  |         | X 100 = % Window to Wall Ratio (WWR) |
|  |  | X 100 = |                                      |

|                                    |  |                   |   |                                |
|------------------------------------|--|-------------------|---|--------------------------------|
| Skylight Area Calculation          | Total Skylight Area (rough opening) / Gross Exterior Roof Area |                   | times 100 equals  | % Skylight to roof ratio (SRR) |
|                                    | ÷  |                   | X 100 =   |                                |
| Opaque Assembly                    |  |                   | Daylighting Summary   |                                |
| Wall (Minimum Insulation U-factor) |  |                   | % above-grade floor area meeting the UDI requirement for 90% of the potential daylit time in a year |                                |
| Roof (Minimum Insulation U-factor) |  |                   |   |                                |
|                                    |  |                   |   |                                |
| Cool Roof                          |  |                   | Fenestration  |                                |
| Solar Reflectance                  |  |                   | Vertical  |                                |
| Emittance                          |  |                   | Maximum U-factor  |                                |
|                                    |  |                   | Maximum SHGC (or SC)  |                                |
| Wall Assembly                      |  |                   | Minimum VLT   |                                |
| Material                           | R-value  | Assembly U-Factor | Overhang / Sidesfins / Box Frame Projection (yes or no)   |                                |
|                                    |  |                   | If yes, enter Projection Factor for each orientation and effective SHGC                             |                                |
|                                    |  |                   | Skylight  |                                |
|                                    |  |                   | Maximum U-factor  |                                |
|                                    |  |                   | Maximum SHGC (or SC)  |                                |

## Envelope Checklist

Energy Conservation Building Code 2017 Compliance Forms

|                 |  |      |  |
|-----------------|--|------|--|
| Project Address |  | Date |  |
|-----------------|--|------|--|

| Applicability                      |    |     | Code Section | Component                   | Information Required   | Location on Plans | Building Department Notes |
|------------------------------------|----|-----|--------------|-----------------------------|--|-------------------|---------------------------|
| Yes                                | No | N/A |              |                             |  |                   |                           |
| Mandatory Provisions (Section 4.2) |    |     |              |                             |  |                   |                           |
|                                    |    |     | 4.2.1        | Fenestration                |  |                   |                           |
|                                    |    |     | 4.2.1.1      | U-factor                    | Specify reference standard                                   |                   |                           |
|                                    |    |     | 4.2.1.2      | SHGC                        | Specify reference standard                                   |                   |                           |
|                                    |    |     | 4.2.1.3      | Visible light transmittance | Specify reference standard                                   |                   |                           |
|                                    |    |     | 4.2.2        | Opaque Construction         |  |                   |                           |
|                                    |    |     | 4.2.2.1      | U-factors                   | Specify reference standard                                   |                   |                           |
|                                    |    |     | 4.2.2.2      | Solar Reflectance           | Specify reference standard                                   |                   |                           |
|                                    |    |     | 4.2.2.3      | Emittance                   | Specify reference standard                                   |                   |                           |
|                                    |    |     | 4.2.3        | Daylighting                 | Specify simulation approach or prescriptive                  |                   |                           |
|                                    |    |     | 4.2.4        | Building envelope sealing   | Indicate sealing, caulking, gasketing, and weather stripping |                   |                           |

| Prescriptive Compliance Option (Section 4.3) |  |  |         |                       |  |  |  |
|--|--|--|---------|-----------------------|--|--|--|
|  |  |  | 4.3.1   | Roofs                 | Specify implemented U factor   |  |  |
|  |  |  | 4.3.1.1 | Vegetative cool roof  | Specify the solar reflectance, emittance, and reference standards  |  |  |
|  |  |  | 4.3.2   | Opaque External Wall  | Specify implemented U factor   |  |  |
|  |  |  | 4.3.3   | Vertical fenestration | (1) Indicate U-factors on fenestration schedule. Indicate if values are rated or default. If values are default, then specify frame type, glazing layers, gapwidth, low-e.<br>(2) Indicate SHGC or SC on fenestration schedule. Indicate if values are rated or default.<br>(3) Indicate VLT of fenestration schedule. Indicate if values are rated or default.<br>(4) Indicate if overhangs or side fins or box-frame projection are used for compliance purposes. If so, provide projection factor calculation and equivalent SHGC calculation |  |  |

|  |  |  |              |                                       |   |  |  |
|--|--|--|--------------|---------------------------------------|---|--|--|
|  |  |  | 4.3.3<br>(a) | fenestration U<br>factor<br>exemption | Specify if applicable, specify<br>unconditioned space percentage,<br>and specify incorporated<br>specifications   |  |  |
|  |  |  | 4.3.4        | Skylights                             | (1) Indicate U-factors on<br>fenestration schedule. Indicate if<br>values are rated or default. If values<br>are default, then specify frame type,<br>glazing layers, gap width, low-e. (2)<br>Indicate SHGC or SC on fenestration<br>schedule. Indicate if values are<br>rated or default. |  |  |
|  |  |  |              |                                       |   |  |  |

| Building Envelope Trade-Off Option (Section 4.3.4) |  |  |  |  |                      |  |  |
|--|--|--|--|--|----------------------|--|--|
|  |  |  |  |  | Provide calculations |  |  |

## Comfort System and Control Summary

Energy Conservation Building Code 2017 Compliance Forms

|              |                                  |                             |
|--------------|----------------------------------|-----------------------------|
| Project Info | Project Address:                 | Date                        |
|              |                                  | For Building Department Use |
|              | Project Built-up Area (sq.m):    |                             |
|              | Project Above-grade area (sq.m): |                             |
|              | Project Conditioned Area (sq.m): |                             |
|              | Applicant Name and Address:      |                             |
|              |                                  |                             |
|              | Project Climatic Zone:           |                             |

### Project Description

|  |  |
|--|--|
| Briefly describe comfort system type and features. | Natural ventilation, mechanical Ventilation, Low energy comfort system, heating and cooling mechanical equipment. percentage area distribution for the installed system, and related information |
|  |  |
|  |  |

### Compliance Option

|                   |                     |                                   |
|-------------------|---------------------|-----------------------------------|
| System efficiency | Prescriptive Method | Whole Building Performance Method |
|-------------------|---------------------|-----------------------------------|

### Equipment Schedules

|  |
|--|
| The following information is required to be incorporated with the mechanical equipment schedules on the plans. For projects without plans, fill in the required information below. |
|--|

### Cooling Equipment Schedule

| Equip. ID | Brand Name | Model No. | Capacity kW | Testing Standards | OSA CFM or Economizer? | COP | IPLV | Location |
|-----------|------------|-----------|-------------|-------------------|------------------------|-----|------|----------|
|           |            |           |             |                   |                        |     |      |          |
|           |            |           |             |                   |                        |     |      |          |
|           |            |           |             |                   |                        |     |      |          |
|           |            |           |             |                   |                        |     |      |          |
|           |            |           |             |                   |                        |     |      |          |
|           |            |           |             |                   |                        |     |      |          |

### Heating Equipment Schedule

| Equip. ID | Brand Name | Model No. | Capacity kW | Testing Standards | OSA CFM | Input kW | Output kW | Efficiency |
|-----------|------------|-----------|-------------|-------------------|---------|----------|-----------|------------|
|-----------|------------|-----------|-------------|-------------------|---------|----------|-----------|------------|



[illegible][illegible]

# Comfort System & Controls Checklist

Energy Conservation Building Code 2017 Compliance Forms

| Project Address   |    |     |              |   | Date   |                   |                           |
|---|----|-----|--------------|---|--|-------------------|---------------------------|
| The following information is necessary to check a building permit application for compliance with the mechanical requirements in the Energy Conservation Building Code. |    |     |              |   |  |                   |                           |
| Applicability   |    |     | Code Section | Component   | Information Required   | Location on Plans | Building Department Notes |
| Yes   | No | N/A |              |   |  |                   |                           |
| Comfort Systems and Control   |    |     |              |   |  |                   |                           |
| Mandatory Provisions (Section 5.2)  |    |     |              |   |  |                   |                           |
|   |    |     | 5.2.1        | Ventilation                                       | Indicate all habitable spaces are ventilated with outdoor air in accordance with § 5.2.1 and guidelines specified in NBC   |                   |                           |
|   |    |     | 5.2.2        | Minimum Space Conditioning Equipment Efficiencies | Provide equipment schedule with type, capacity, efficiency   |                   |                           |
|   |    |     | 5.2.3        | Controls  |  |                   |                           |
|   |    |     | 5.2.3.1      | Timeclock   | Indicate thermostat with night setback, 3 different day types per week, and 2-hour manual override, capable of retaining programming and time setting during loss of power for a period of at least 10 hours |                   |                           |
|   |    |     | 5.2.3.2      | Temperature Controls                              | Indicate temperature control with 3°C deadband minimum if the system provides both heating and cooling.  |                   |                           |
|   |    |     |              |   | Indicate thermostats are interlocked to prevent simultaneous heating and cooling, where separate heating and cooling systems are there   |                   |                           |
|   |    |     |              |   | Indicate separate thermostat control for space types mentioned in § 5.2.3.2.(c)  |                   |                           |
|   |    |     | 5.2.3.3      | Occupancy Controls                                | Indicate occupancy controls for space types mentioned in § 5.2.3.3   |                   |                           |
|   |    |     | 5.2.3.4      | Fan Controls                                      | Indicate two-speed motor, pony motor, or variable speed drive to control the fans and controls shall be capable to reduce the fan speed to at least two third of installed fan power                         |                   |                           |
|   |    |     | 5.2.3.5      | Dampers   | Indicate all air supply and exhaust equipment's having VFD shall have dampers that automatically close upon the situations mentioned in § 5.2.3.5  |                   |                           |
|   |    |     | 5.2.4        | Piping & ductwork                                 | Indicate sealing, caulking, gasketing, and weatherstripping  |                   |                           |
|   |    |     | 5.2.4.1      | Piping insulation                                 | Indicate R-value of insulation   |                   |                           |
|   |    |     | 5.2.4.2      | Ductwork and Plenum insulation                    | Indicate R-value of insulation   |                   |                           |
|   |    |     | 5.2.5        | System Balancing                                  | Show written balance report for HVAC systems serving zones with a total conditioned area exceeding 500 m2  |                   |                           |
|   |    |     | 5.2.6        | Condensers  | Indicate location of condenser and source of water used for condenser  |                   |                           |
|   |    |     | 5.2.7        | Service Hot Water Heating                         |  |                   |                           |
|   |    |     | 5.2.7.1      | Solar Water Heating                               | Indicate all Hotels and hospitals have solar water heating equipment installed for hot water design capacity as per § 5.2.9.1  |                   |                           |

|  |  |  |         |                              |   |
|--|--|--|---------|------------------------------|---|
|  |  |  | 5.2.7.2 | Heating Equipment Efficiency | Indicate service water heating equipment shall meet the performance and efficiency as per § 5.2.9.2   |
|  |  |  | 5.2.7.3 | Other Water Heating System   | Indicate supplementary heating system is designed in consideration with § 5.2.9.3   |
|  |  |  | 5.2.7.4 | Piping Insulation            | Indicate the Piping insulation is compliant with § 5.2.6.1.   |
|  |  |  | 5.2.7.5 | Heat Traps                   | Indicate vertical pipe risers serving water heaters and storage tanks are as per § 5.2.9.5  |
|  |  |  | 5.2.7.6 | Swimming Pools               | Indicate the heated pools are provided with a vapor retardent pool cover on the water surface and temperature control and minimum insulation value as per § 5.2.9.6 |

### Prescriptive Compliance Option (Section 5.3)

|  |  |  |         |   |  |
|--|--|--|---------|---|--|
|  |  |  | 5.3.1   | Chillers                                  | Indicate chiller type, capacity, COP & IPLV  |
|  |  |  | 5.3.2   | Pumps                                     | Indicate pump type (Primary, secondary, and condenser), its total installed capacity and efficiency  |
|  |  |  | 5.3.3   | Cooling Towers                            | Indicate cooling tower type and installed capacity   |
|  |  |  | 5.3.4   | Boilers                                   | Indicate boiler type, capacity and efficiency  |
|  |  |  | 5.3.5.1 | Air-Economizer (ECBC/ECBC+/SuperECBC)     | Indicate air economizer is capable of modulating outside-air and return-air dampers to supply 50% of design supply air quantity as outside-air for respective building type.   |
|  |  |  | 5.3.5.1 | Water-economizer (ECBC/ECBC+/SuperECBC)   | Indicate water economizer is capable of providing 50% of the expected system cooling load at outside air temperatures of 10°C dry-bulb/7.2°C wet-bulb and below, if the designed building is a respective building type. |
|  |  |  | 5.3.5.2 | Partial Cooling                           | Indicate where required by § 5.3.4 economizers shall be capable of providing partial cooling even when additional mechanical cooling is required to meet the cooling load.   |
|  |  |  | 5.3.5.3 | Economizer Controls                       | Indicate air economizers are equipped with controls as specified in § 5.3.4.4  |
|  |  |  | 5.3.5.4 | Testing                                   | Indicate air-side economizers have been tested as per the requirement specified  |
|  |  |  | 5.3.6   | Variable Flow Hydronic Systems            |  |
|  |  |  | 5.3.6.1 | Variable Fluid Flow                       | Indicate design flow rate of HVAC pumping system   |
|  |  |  | 5.3.6.2 | Isolation Valves                          | Indicate water cooled air-conditioning have two-way automatic isolation valves and pump motors greater than or equal to 3.7 kW is controlled by variable speed drives  |
|  |  |  | 5.3.6.3 | Variable Speed Drives                     | Indicate Chilled water or condenser water systems comply with either § 5.3.5.1 or § 5.3.5.2  |
|  |  |  | 5.3.7   | Unitary, Split, Packaged Air-Conditioners | Indicate the type of system, cooling capacity.   |
|  |  |  | 5.3.8   | Controls for ECBC+ & SuperECBC Building   |  |
|  |  |  | 5.3.8.1 | Centralized Demand Shed Controls          | Indicate the building has a Building Management System, with all Mechanical cooling and heating systems having PLC to the zone level shall have the control capabilities mentioned in § 5.2.4.1                          |
|  |  |  | 5.3.8.2 | Supply Air temperature reset              | Indicate multi zone mechanical cooling and heating systems shall have controls to automatically reset supply air temperature in response to building loads or outdoor air  |

|  |  |  |         |   |   |
|--|--|--|---------|---|---|
|  |  |  |         |   | temperature by at least 25% of the difference between design supply air temperature and the design room air temperature.  |
|  |  |  | 5.3.8.3 | Chilled Water Temperature                             | Indicate chilled water systems exceeding 350 kW shall have controls to automatically reset supply water temperatures by representative building loads or by outdoor air temperature |
|  |  |  | 5.3.9   | Controls for SuperECBC Building                       | Indicate that the mechanical systems comply with § 5.2.4 and § 5.2.5  |
|  |  |  | 5.3.9.1 | Variable Air Volume Fan Control                       | Indicate Fans in VAV systems shall have controls or devices to limit fan motor demand as per § 5.2.5.1  |
|  |  |  | 5.3.10  | Heat Recovery   | Indicate for all Hospitality and Healthcare, heat recovery effectiveness, and efficiency of oil and gas fired boilers   |
|  |  |  | 5.3.11  | Service Water Heating                                 | Indicate all Buildings, Hotels and hospitals have solar water heating equipment installed for hot water design capacity as per § 5.3.11   |
|  |  |  | 5.3.12  | Total System Efficiency-Alternate Compliance approach | Attach simulation report  |
|  |  |  | 5.3.13  | Low Energy Comfort Systems                            | Indicate system type and list the exemption claimed   |

## Lighting and Controls Summary

Energy Conservation Building Code 2017 Compliance Forms

|              |   |                                |
|--------------|---|--------------------------------|
| Project Info | Project Address:                            | Date                           |
|              |   | For Building<br>Department Use |
|              | Project Built-up Area (m <sup>2</sup> ):    |                                |
|              | Project Above-grade area (m <sup>2</sup> ): |                                |
|              | Project Conditioned Area (m <sup>2</sup> ): |                                |
|              | Applicant Name and Address:                 |                                |
|              | Project Climatic Zone:                      |                                |

|                   |  |  |
|-------------------|--|--|
| Compliance Option | <input type="checkbox"/> Space by Space method | <input type="checkbox"/> Whole Building Method |
|-------------------|--|--|

Maximum Allowed Lighting Power (Interior, Section 6.3.2 or 6.3.3)

| Location<br>(floor/room no.) | Occupancy Description | Allowed<br>Watts per<br>m <sup>2</sup> ** | Area in m <sup>2</sup> | Allowed<br>x Area |
|------------------------------|-----------------------|---|------------------------|-------------------|
|                              |                       |   |                        |                   |
|                              |                       |   |                        |                   |
|                              |                       |   |                        |                   |
| ** Document all exceptions   |                       |   | Total Allowed Watts    |                   |

Proposed Lighting Power (Interior)

| Location<br>(floor/room no.)  | Fixture Description | Number of<br>Fixtures | Watts/<br>Fixture    | Watts<br>Proposed |
|---|---------------------|-----------------------|----------------------|-------------------|
|   |                     |                       |                      |                   |
|   |                     |                       |                      |                   |
|   |                     |                       |                      |                   |
| Total Proposed Watts may not exceed Total Allowed Watts<br>for Interior |                     |                       | Total Proposed Watts |                   |

Maximum Allowed Lighting Wattage (Exterior, Section 6.3.5)

| Location            | Description | Allowed<br>Watts<br>per m <sup>2</sup> or<br>per lm | Area in m <sup>2</sup><br>(or lm for<br>perimeter) | Allowed<br>Watts<br>x m <sup>2</sup> (or x<br>lm) |
|---------------------|-------------|---|--|---|
|                     |             |   |  |   |
|                     |             |   |  |   |
|                     |             |   |  |   |
|                     |             |   |  |   |
|                     |             |   |  |   |
| Total Allowed Watts |             |   |  |   |

Proposed Lighting Wattage (Exterior)

| Location | Fixture Description | Number of<br>Fixtures | Watts/<br>Fixture | Watts<br>Proposed |
|----------|---------------------|-----------------------|-------------------|-------------------|
|          |                     |                       |                   |                   |
|          |                     |                       |                   |                   |

|  |    |     |              |  |  |                   |                           |      |  |
|--|----|-----|--------------|--|--|-------------------|---------------------------|------|--|
|  |    |     |              |  |  |                   |                           |      |  |
| Total Proposed Watts may not exceed Total Allowed Watts for Exterior   |    |     |              | Total Proposed Watts                   |  |                   |                           |      |  |
| <b>Lighting &amp; Controls Checklist</b>   |    |     |              |  |  |                   |                           |      |  |
| Energy Conservation Building Code 2017 Compliance Forms  |    |     |              |  |  |                   |                           |      |  |
| Project Address  |    |     |              |  |  |                   |                           | Date |  |
| The following information is necessary to check a building permit application for compliance with the lighting requirements in the Energy Conservation Building Code 2017. |    |     |              |  |  |                   |                           |      |  |
| Applicability  |    |     | Code Section | Component                              | Information Required   |                   |                           |      |  |
| Yes  | No | N/A |              |  |  | Location on Plans | Building Department Notes |      |  |
|  |    |     |              |  |  |                   |                           |      |  |
| <b>Lighting and Controls</b>   |    |     |              |  |  |                   |                           |      |  |
| Mandatory Provisions (Section 6.2)   |    |     |              |  |  |                   |                           |      |  |
|  |    |     | 6.2.1        | Lighting Controls                      |  |                   |                           |      |  |
|  |    |     | 6.2.1.1      | Automatic shutoff                      | Indicate automatic shutoff locations or occupancy sensors  |                   |                           |      |  |
|  |    |     | 6.2.1.2      | Space control                          | Provide schedule with type, indicate locations   |                   |                           |      |  |
|  |    |     | 6.2.1.3      | Control in Daylight Areas              | Provide manual or automatic control device schedule with type and features, indicate locations   |                   |                           |      |  |
|  |    |     | 6.2.1.4      | Ext. lighting control                  | Indicate photosensor or astronomical time switch   |                   |                           |      |  |
|  |    |     | 6.2.1.5      | Additional control                     | Provide schedule with type, indicate locations   |                   |                           |      |  |
|  |    |     | 6.2.2        | Exit signs                             | Indicate wattage per face of Exit signs  |                   |                           |      |  |
| Prescriptive Interior Lighting Power Compliance Option (Section 6.3)   |    |     |              |  |  |                   |                           |      |  |
|  |    |     | 6.3.1        | LPD compliance                         | Indicate whether project is complying with the Building Area Method (6.3.2) or the Space Function Method (6.3.3)   |                   |                           |      |  |
|  |    |     | 6.3.2        | Building area method                   | Provide lighting schedule with wattage of lamp and ballast and number of fixtures. Document all exceptions.  |                   |                           |      |  |
|  |    |     | 6.3.3        | Space function method                  | Provide lighting schedule with wattage of lamp and ballast and number of fixtures. Document all exceptions.  |                   |                           |      |  |
|  |    |     | 6.3.4.1      | Luminaire wattage                      | Indicate the wattage of installed luminaires on the floor plan. In case of luminaires containing permanently installed ballasts, the operating input wattage has to be provided, either from manufacturers catalogs or values from independent testing laboratory reports. |                   |                           |      |  |
|  |    |     | 6.3.6        | Controls_ECBC+ and SuperECBC Buildings | Provide centralized control system schedule with type and features, indicate locations   |                   |                           |      |  |
| Prescriptive Exterior Lighting Power Compliance Option (Section 6.3.5)   |    |     |              |  |  |                   |                           |      |  |
|  |    |     | 6.3.5        | External light power                   | Provide lighting schedule with wattage of lamp and ballast and number of fixtures. Document all exceptions.  |                   |                           |      |  |

## Electrical and Renewable Energy Systems Summary

Energy Conservation Building Code 2017 Compliance Forms

|              |  |                             |
|--------------|--|-----------------------------|
| Project Info | Project Address                            | Date                        |
|              |  | For Building Department Use |
|              | Project Built-up Area [m <sup>2</sup> ]    |                             |
|              | Project Above-grade Area [m <sup>2</sup> ] |                             |
|              | Project Conditioned Area [m <sup>2</sup> ] |                             |
|              | Applicant Name and Address                 |                             |
|              |  |                             |
|              | Project Climatic Zone                      |                             |

|  |   |
|--|---|
| <b>Project Description</b><br>Briefly describe electrical systems and renewable energy installed in the facility | Transformers, Diesel Generator sets, Uninterruptible Power Supply, Renewable Energy Systems and related information |
|  |   |
|  |   |

|                     |                     |                                   |
|---------------------|---------------------|-----------------------------------|
| Compliance Approach | Prescriptive Method | Whole Building Performance Method |
|---------------------|---------------------|-----------------------------------|

|   |  |                               |                                |
|---|--|-------------------------------|--------------------------------|
| Transformers                                    |  |                               |                                |
| Type of Transformer                             | Dry Type Transformer/ Oil Type Transformer |                               |                                |
|   | X 100 =                                    |                               |                                |
| Transformer Losses                              | kVA Rating of Transformer                  | / Losses at 50% Loading in kW | / Losses at 100% Loading in kW |
| Diesel Generator Sets                           |  |                               |                                |
| Star Rating of DG set                           | 3 Star / 4 Star / 5 Star                   |                               |                                |
| Uninterruptible Power Supply                    |  |                               |                                |
| Efficiency at 100% Load                         |  |                               |                                |
| Renewable Energy Systems                        |  |                               |                                |
| Capacity and Type of Renewable Energy Installed |  |                               |                                |

# Electrical and Renewable Energy Systems Checklist

Energy Conservation Building Code 2017 Compliance Forms

|  |    |     |              |   |   |                   |                           |
|--|----|-----|--------------|---|---|-------------------|---------------------------|
| Project Address  |    |     |              |   | Date  |                   |                           |
| The following information is necessary to check a building permit application for compliance with the Electrical and Renewable Energy requirements in the Energy Conservation Building Code. |    |     |              |   |   |                   |                           |
| Applicability  |    |     | Code Section | Component                                       | Information Required  | Location on Plans | Building Department Notes |
| Yes  | No | N/A |              |   |   |                   |                           |
| Electrical and Renewable Energy Systems  |    |     |              |   |   |                   |                           |
| Mandatory Provisions (Section 5.2)   |    |     |              |   |   |                   |                           |
|  |    |     | 7.2.1        | Transformers                                    |   |                   |                           |
|  |    |     | 7.2.1.1      | Maximum Allowable Power Transformer Losses      | Provide losses at 50% load and 100% load, capacity and efficiency   |                   |                           |
|  |    |     | 7.2.1.2      | Measurement and Reporting of Transformer Losses | For less than 500 kVA transformer meters are calibrated of 0.5 class accuracy and digital meters  |                   |                           |
|  |    |     |              |   | For above 500 kVA additional Ct's and PT's are installed  |                   |                           |
|  |    |     | 7.2.1.3      | Voltage Drop                                    | Indicate the Voltage drop for feeders shall not exceed 2% at design load. Voltage drop for branch circuit shall not exceed 3% at design load.   |                   |                           |
|  |    |     | 7.2.2        | Energy Efficient Motors                         | Indicate the motor class IE2/IE3/IE4.   |                   |                           |
|  |    |     |              |   | Indicate the motors capacity more than 0.375 kW have efficiency according to the latest version of IS 12615.  |                   |                           |
|  |    |     |              |   | Motor nameplate indicates nominal full-load motor efficiencies and full-load power factor.  |                   |                           |
|  |    |     |              |   | Indicate the motor horsepower ratings does not exceed 20% of the calculated maximum load being served.  |                   |                           |
|  |    |     | 7.2.3        | Diesel Generator Sets                           | Indicate the star rating of the Diesel Generator Set  |                   |                           |
|  |    |     | 7.2.4        | Check-Metering and Monitoring                   | Indicate the services exceeding 1000 kVA have permanently installed electrical metring to record kVA, kWh and total power factor. And provision for display of current in each phase, voltage between each phase and between each phase and neutral and total harmonic distortion as a percentage of total current. |                   |                           |



|  |  |  |         |                                  |   |
|--|--|--|---------|----------------------------------|---|
|  |  |  |         |                                  | Indicate the services not exceeding 1000 kVA but over 65 kVA shall have permanently installed electric metering to record kW, kWh and power factor or kVARh on hourly basis.  |
|  |  |  |         |                                  | Indicate the services not exceeding 65 kVA shall have permanently installed electric metering to record kWh on hourly basis.  |
|  |  |  |         |                                  | Indicate in case of tenant based building, for recording metering should be provided at a location from where each tenant could attach the services.  |
|  |  |  | 7.2.5   | Power Factor Correction          | Indicate that the power factor correction has been maintained at the point of connection.   |
|  |  |  | 7.2.6   | Power Distribution System        | Indicate the power cable has been sized so that the distribution losses do not exceed the values mentioned in the code.   |
|  |  |  | 7.2.7   | Uninterruptible Power Supply     | Indicate the UPS meets or exceed the energy efficiency requirements listed in the table 7-4.  |
|  |  |  | 7.2.8   | Renewable Energy Systems         | Indicate the buildings have provision for installation of renewable energy systems in the future on rooftop or the site.  |
|  |  |  | 7.2.8.1 | Renewable Energy Generating Zone | Indicate a dedicated REGZ equivalent to at least 25 % of roof area or area required for generation of energy equivalent to 1% of total peak demand or connected load of the building, whichever is less, shall be provided in all buildings.  |
|  |  |  |         |                                  | Indicate the REGZ shall is free of any obstructions within its boundaries and from shadows cast by objects adjacent to the zone   |
|  |  |  | 7.2.8.2 | Main Electrical Service Panel    | Indicate the minimum rating is displayed on the main electrical service panel. And space is reserved for the installation of double pole circuit breaker for future solar electric installation.  |
|  |  |  | 7.2.8.3 | Demarcation on Documents         | Location for inverters and metering equipment,<br>Pathway for routing of conduit from the REGZ to the point of interconnection with the electrical service,<br>Routing of plumbing from the REGZ to the water-heating system and,<br>Structural design loads for roof dead and live load. |

## 14. Appendix E: BEE approved list of software to show compliance<sup>3</sup>

Table 14-1 Bureau of Energy Efficiency Approved Software for Demonstrating Compliance with ECBC

| Analysis                          | Software   |
|-----------------------------------|--|
| Whole Building Performance Method | AECOSim  |
|                                   | Design Builder                                     |
|                                   | DOE2   |
|                                   | EnergyPlus   |
|                                   | eQUEST   |
|                                   | HAP  |
|                                   | IDA-ICE  |
|                                   | IES-VE   |
|                                   | OpenStudio   |
|                                   | Simergy  |
|                                   | Trace700   |
|                                   | TRNSYS   |
|                                   | Visual DOE   |
|                                   | BEP-EMIS   |
| Daylighting                       | AGI32 (Licaso)                                     |
|                                   | Daysim   |
|                                   | Design Builder                                     |
|                                   | DIVA   |
|                                   | Groundhog  |
|                                   | IES-VE   |
|                                   | OpenStudio   |
|                                   | RadianceRhino-Grasshopper with Daylighting Plugins |
|                                   | Sefaira  |
|                                   | Sensor Placement + Optimization Tool (SPOT)        |

<sup>3</sup> This is not an all-inclusive list. The current list of approved software is available at BEE website (<https://www.beeindia.gov.in/>).

# **APPENDIX B-1**

## **Climate Classification of Maharashtra**

## 1. Climate Map of Maharashtra



**2. District wise classification of climatic data for Maharashtra State :**

| <b>A) NASHIK DIVISION</b>  |                 |                |  |                     |                                       |
|----------------------------|-----------------|----------------|--|---------------------|---------------------------------------|
| <b>1. Nashik District</b>  |                 |                |  |                     |                                       |
| <b>Sr. No.</b>             | <b>District</b> | <b>Talukas</b> | <b>Name of Municipal Council / Corporation</b> | <b>Climate Zone</b> | <b>Closest available weather file</b> |
| 1.                         | Nashik          | Baglan         | Satana   | Hot and Dry         | Pune/Mumbai                           |
| 2.                         | Nashik          | Chandvad       | -  | Hot and Dry         | Pune/Mumbai                           |
| 3.                         | Nashik          | Deola          | -  | Hot and Dry         | Pune/Mumbai                           |
| 4.                         | Nashik          | Dindori        | -  | Composite           | Pune/Mumbai                           |
| 5.                         | Nashik          | Igatpuri       | Igatpuri                                       | Composite           | Pune/Mumbai                           |
| 6.                         | Nashik          | Kalwan         | Saptashrungigad                                | Hot and Dry         | Pune/Mumbai                           |
| 7.                         | Nashik          | Malegaon       | Malegaon                                       | Hot and Dry         | Pune/Mumbai                           |
| 8.                         | Nashik          | Nandgaon       | Manmad   | Hot and Dry         | Pune/Mumbai                           |
|                            | Nashik          |                | Nandgaon                                       |                     | Pune/Mumbai                           |
| 9.                         | Nashik          | Nashik         | Nashik   | Composite           | Pune/Mumbai                           |
|                            | Nashik          |                | Bhagur   |                     | Pune/Mumbai                           |
| 10.                        | Nashik          | Niphad         | -  | Composite           | Pune/Mumbai                           |
| 11.                        | Nashik          | Peint          | -  | Composite           | Pune/Mumbai                           |
| 12.                        | Nashik          | Sinnar         | Sinnar   | Composite           | Pune/Mumbai                           |
| 13.                        | Nashik          | Surgana        | -  | Composite           | Pune/Mumbai                           |
| 14.                        | Nashik          | Trimbakeshwar  | Tryambakeshwar                                 | Composite           | Pune/Mumbai                           |
| 15.                        | Nashik          | Yeola          | Yeola  | Hot and Dry         | Pune/Mumbai                           |
| <b>2. Jalgaon District</b> |                 |                |  |                     |                                       |
| <b>Sr. No.</b>             | <b>District</b> | <b>Talukas</b> | <b>Name of Municipal Council / Corporation</b> | <b>Climate Zone</b> | <b>Closest available weather file</b> |
| 1.                         | Jalgaon         | Amalner        | Amalner  | Hot and Dry         | Nagpur                                |
| 2.                         | Jalgaon         | Bhadgaon       | -  | Hot and Dry         | Nagpur                                |
| 3.                         | Jalgaon         | Bhusaval       | Bhusaval                                       | Hot and Dry         | Nagpur                                |
| 4.                         | Jalgaon         | Bodvad         | -  | Hot and Dry         | Nagpur                                |
| 5.                         | Jalgaon         | Chalisgaon     | Chalisgaon                                     | Hot and Dry         | Nagpur                                |
| 6.                         | Jalgaon         | Chopda         | Chopda   | Hot and Dry         | Nagpur                                |
| 7.                         | Jalgaon         | Dharangaon     | Dharangaon                                     | Hot and Dry         | Nagpur                                |
| 8.                         | Jalgaon         | Erandol        | Erandol  | Hot and Dry         | Nagpur                                |
| 9.                         | Jalgaon         | Jalgaon        | Jalgaon  | Hot and Dry         | Nagpur                                |
| 10.                        | Jalgaon         | Jamner         | -  | Hot and Dry         | Nagpur                                |
| 11.                        | Jalgaon         | Muktainagar    | -  | Hot and Dry         | Nagpur                                |

| 12.                           | Jalgaon    | Pachora    | Pachora                                 | Hot and Dry  | Nagpur                         |
|-------------------------------|------------|------------|---|--------------|--------------------------------|
| 13.                           | Jalgaon    | Parola     | Parola                                  | Hot and Dry  | Nagpur                         |
| 14.                           | Jalgaon    | Raver      | Raver                                   | Hot and Dry  | Nagpur                         |
|                               | Jalgaon    |            | Savda                                   |              | Nagpur                         |
| 15.                           | Jalgaon    | Yawal      | Yawal                                   | Hot and Dry  | Nagpur                         |
|                               | Jalgaon    |            | Faizpur                                 |              | Nagpur                         |
| <b>3. Nandurbar District</b>  |            |            |   |              |                                |
| Sr. No.                       | District   | Talukas    | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
| 1.                            | Nandurbar  | Akkalkuwa  | -                                       | Hot and Dry  | Nagpur                         |
| 2.                            | Nandurbar  | Akrani     | -                                       | Hot and Dry  | Nagpur                         |
| 3.                            | Nandurbar  | Nandurbar  | Nandurbar                               | Hot and Dry  | Nagpur                         |
| 4.                            | Nandurbar  | Navapur    | Navapur                                 | Hot and Dry  | Nagpur                         |
| 5.                            | Nandurbar  | Shahada    | Shahada                                 | Hot and Dry  | Nagpur                         |
| 6.                            | Nandurbar  | Taloda     | Taloda                                  | Hot and Dry  | Nagpur                         |
| <b>4. Dhule District</b>      |            |            |   |              |                                |
| Sr. No.                       | District   | Talukas    | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
| 1.                            | Dhule      | Dhule      | -                                       | Hot and Dry  | Nagpur                         |
| 2.                            | Dhule      | Sakri      | -                                       | Hot and Dry  | Nagpur                         |
| 3.                            | Dhule      | Shirpur    | Shirpur-Warwade                         | Hot and Dry  | Nagpur                         |
| 4.                            | Dhule      | Sindkheda  | Dondaicha-Warwade                       | Hot and Dry  | Nagpur                         |
| <b>5. Ahmednagar District</b> |            |            |   |              |                                |
| Sr. No.                       | District   | Talukas    | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
| 1.                            | Ahmednagar | Ahmednagar | Ahmednagar                              | Composite    | Pune                           |
| 2.                            | Ahmednagar | Akola      | -                                       | Composite    | Pune                           |
| 3.                            | Ahmednagar | Jamkhed    | -                                       | Composite    | Pune                           |
| 4.                            | Ahmednagar | Karjat     | -                                       | Composite    | Pune                           |
| 5.                            | Ahmednagar | Kopargaon  | Kopargaon                               | Hot and Dry  | Pune                           |
| 6.                            | Ahmednagar | Nevasa     | Nevasa-Khurd                            | Hot and Dry  | Pune                           |
| 7.                            | Ahmednagar | Parner     | -                                       | Hot and Dry  | Pune                           |
| 8.                            | Ahmednagar | Pathardi   | Pathardi                                | Hot and Dry  | Pune                           |
| 9.                            | Ahmednagar | Rahta      | Rahta                                   | Composite    | Pune                           |
|                               | Ahmednagar |            | Shirdi                                  |              | Pune                           |
| 10.                           | Ahmednagar | Rahuri     | Rahuri                                  | Composite    | Pune                           |
|                               | Ahmednagar |            | Deolali-Pravara                         |              | Pune                           |
| 11.                           | Ahmednagar | Sangamner  | Sangamner                               | Composite    | Pune                           |
| 12.                           | Ahmednagar | Shevgaon   | Shevgaon                                | Hot and Dry  | Pune                           |

|     |            |           |           |             |      |
|-----|------------|-----------|-----------|-------------|------|
| 13. | Ahmednagar | Shrigonda | Shrigonda | Hot and Dry | Pune |
| 14. | Ahmednagar | Srirampur | Srirampur | Hot and Dry | Pune |
|     | Ahmednagar |           | Belapur   |             | Pune |

## B) AURANGABAD DIVISION

### 1. Aurangabad District

| Sr. No. | District   | Talukas    | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
|---------|------------|------------|---|--------------|--------------------------------|
| 1.      | Aurangabad | Aurangabad | Aurangabad                              | Hot and dry  | Aurangabad                     |
| 2.      | Aurangabad | Gangapur   | Gangapur                                | Hot and Dry  | Aurangabad                     |
| 3.      | Aurangabad | Kannad     | Kannad                                  | Hot and Dry  | Aurangabad                     |
| 4.      | Aurangabad | Khuldabad  | -                                       | Hot and Dry  | Aurangabad                     |
| 5.      | Aurangabad | Paithan    | Paithan                                 | Hot and Dry  | Aurangabad                     |
| 6.      | Aurangabad | Phulambri  | -                                       | Hot and Dry  | Aurangabad                     |
| 7.      | Aurangabad | Sillod     | Sillod                                  | Hot and Dry  | Aurangabad                     |
| 8.      | Aurangabad | Soegaon    | -                                       | Hot and Dry  | Aurangabad                     |
| 9.      | Aurangabad | Vaijapur   | Vaijapur                                | Hot and Dry  | Aurangabad                     |

### 2. Hingoli District

| Sr. No. | District | Talukas          | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
|---------|----------|------------------|---|--------------|--------------------------------|
| 1.      | Hingoli  | Aundha (Nagnath) | -                                       | Hot and Dry  | Aurangabad                     |
| 2.      | Hingoli  | Basmatnagar      | Basmatnagar                             | Hot and Dry  | Aurangabad                     |
| 3.      | Hingoli  | Hingoli          | Hingoli                                 | Hot and Dry  | Aurangabad                     |
| 4.      | Hingoli  | Kalamnuri        | Kalamnuri                               | Hot and Dry  | Aurangabad                     |
| 5.      | Hingoli  | Sengaon          | -                                       | Hot and Dry  | Aurangabad                     |

### 3. Parbhani District

| Sr. No. | District | Talukas   | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
|---------|----------|-----------|---|--------------|--------------------------------|
| 1.      | Parbhani | Gangakhed | Gangakhed                               | Hot and Dry  | Aurangabad                     |
| 2.      | Parbhani | Jintur    | Jintur                                  | Hot and Dry  | Aurangabad                     |
| 3.      | Parbhani | Manvat    | Manvat                                  | Hot and Dry  | Aurangabad                     |
| 4.      | Parbhani | Palam     | -                                       | Hot and Dry  | Aurangabad                     |
| 5.      | Parbhani | Parbhani  | Parbhani                                | Hot and Dry  | Aurangabad                     |
| 6.      | Parbhani | Pathri    | Pathri                                  | Hot and Dry  | Aurangabad                     |
| 7.      | Parbhani | Purna     | Purna                                   | Hot and Dry  | Aurangabad                     |
| 8.      | Parbhani | Sailu     | Sailu                                   | Hot and Dry  | Aurangabad                     |
| 9.      | Parbhani | Sonpath   | Sonpeth                                 | Hot and Dry  | Aurangabad                     |

**4. Latur District**

| <b>Sr. No.</b> | <b>District</b> | <b>Talukas</b>    | <b>Name of Municipal Council / Corporation</b> | <b>Climate Zone</b> | <b>Closest available weather file</b> |
|----------------|-----------------|-------------------|--|---------------------|---------------------------------------|
| 1.             | Latur           | Ahemadpur         | Ahemadpur                                      | Hot and Dry         | Aurangabad                            |
| 2.             | Latur           | Ausa              | Ausa (R)                                       | Composite           | Aurangabad                            |
| 3.             | Latur           | Chakur            | -  | Composite           | Aurangabad                            |
| 4.             | Latur           | Deoni             | -  | Hot and Dry         | Aurangabad                            |
| 5.             | Latur           | Jalkot            | -  | Hot and Dry         | Aurangabad                            |
| 6.             | Latur           | Latur             | Latur  | Hot and Dry         | Aurangabad                            |
| 7.             | Latur           | Nilanga           | Nilanga  | Hot and Dry         | Aurangabad                            |
| 8.             | Latur           | Renapur           | -  | Hot and Dry         | Aurangabad                            |
| 9.             | Latur           | Shirur – Anantpal | -  | Composite           | Aurangabad                            |
| 10.            | Latur           | Udgir             | Udgir  | Hot and Dry         | Aurangabad                            |

**5. Jalna District**

| <b>Sr. No.</b> | <b>District</b> | <b>Talukas</b> | <b>Name of Municipal Council / Corporation</b> | <b>Climate Zone</b> | <b>Closest available weather file</b> |
|----------------|-----------------|----------------|--|---------------------|---------------------------------------|
| 1.             | Jalna           | Ambad          | Ambad  | Composite           | Aurangabad                            |
| 2.             | Jalna           | Badnapur       | -  | Hot and Dry         | Aurangabad                            |
| 3.             | Jalna           | Bhokardan      | Bhokardan                                      | Hot and Dry         | Aurangabad                            |
| 4.             | Jalna           | Ghansawangi    | -  | Composite           | Aurangabad                            |
| 5.             | Jalna           | Jafferabad     | -  | Composite           | Aurangabad                            |
| 6.             | Jalna           | Jalna          | Jalna  | Hot and dry         | Aurangabad                            |
| 7.             | Jalna           | Mantha         | -  | Hot and Dry         | Aurangabad                            |
| 8.             | Jalna           | Partur         | Partur   | Composite           | Aurangabad                            |

**6. Osmanabad District**

| <b>Sr. No.</b> | <b>District</b> | <b>Talukas</b> | <b>Name of Municipal Council / Corporation</b> | <b>Climate Zone</b> | <b>Closest available weather file</b> |
|----------------|-----------------|----------------|--|---------------------|---------------------------------------|
| 1.             | Osmanabad       | Bhum           | Bhum   | Composite           | Aurangabad                            |
| 2.             | Osmanabad       | Kalamb         | Kalamb   | Hot and Dry         | Aurangabad                            |
| 3.             | Osmanabad       | Lohara         | -  | Composite           | Aurangabad                            |
| 4.             | Osmanabad       | Osmanabad      | Osmanabad                                      | Composite           | Aurangabad                            |
| 5.             | Osmanabad       | Paranda        | Paranda  | Hot and Dry         | Aurangabad                            |
| 6.             | Osmanabad       | Tuljapur       | Tuljapur                                       | Composite           | Aurangabad                            |
|                | Osmanabad       |                | Naldurg  |                     | Aurangabad                            |
| 7.             | Osmanabad       | Umerga         | Umerga   | Hot and Dry         | Aurangabad                            |
|                | Osmanabad       |                | Murum  |                     | Aurangabad                            |
| 8.             | Osmanabad       | Washi          | -  | Composite           | Aurangabad                            |



| 7. Nanded District |          |                     |   |              |                                |
|--------------------|----------|---------------------|---|--------------|--------------------------------|
| Sr. No.            | District | Talukas             | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
| 1.                 | Nanded   | Ardhapur            | -                                       | Hot and Dry  | Aurangabad                     |
| 2.                 | Nanded   | Bhokar              | Bhokar                                  | Composite    | Aurangabad                     |
| 3.                 | Nanded   | Biloli              | Biloli                                  | Composite    | Aurangabad                     |
|                    | Nanded   |                     | Kundalwadi                              |              | Aurangabad                     |
| 4.                 | Nanded   | Deglur              | Deglur                                  | Composite    | Aurangabad                     |
| 5.                 | Nanded   | Dharmabad           | Dharmabad                               | Composite    | Aurangabad                     |
| 6.                 | Nanded   | Hadgaon             | Hadgaon                                 | Hot and Dry  | Aurangabad                     |
| 7.                 | Nanded   | Himayatnagar        | -                                       | Composite    | Aurangabad                     |
| 8.                 | Nanded   | Kandhar             | Kandhar                                 | Composite    | Aurangabad                     |
| 9.                 | Nanded   | Kinwat              | Kinwat                                  | Composite    | Aurangabad                     |
| 10.                | Nanded   | Loha                | Loha                                    | Composite    | Aurangabad                     |
| 11.                | Nanded   | Mahur               | Mahur                                   | Composite    | Aurangabad                     |
| 12.                | Nanded   | Mudkhed             | Mudkhed                                 | Composite    | Aurangabad                     |
| 13.                | Nanded   | Mukhed              | Mukhed                                  | Composite    | Aurangabad                     |
| 14.                | Nanded   | Naigaon (Khairgaon) | Naigaon                                 | Composite    | Aurangabad                     |
| 15.                | Nanded   | Nanded              | -                                       | Composite    | Aurangabad                     |
| 16.                | Nanded   | Umri                | Umri                                    | Composite    | Aurangabad                     |

| 8. Beed District |          |                |   |              |                                |
|------------------|----------|----------------|---|--------------|--------------------------------|
| Sr. No.          | District | Talukas        | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
| 1.               | Beed     | Ambejogai      | Ambejogai                               | Composite    | Aurangabad                     |
| 2.               | Beed     | Ashti          | Ashti                                   | Composite    | Aurangabad                     |
| 3.               | Beed     | Beed           | Beed                                    | Hot and Dry  | Aurangabad                     |
| 4.               | Beed     | Dharur         | KilleDharur                             | Composite    | Aurangabad                     |
| 5.               | Beed     | Georai         | Georai                                  | Hot and Dry  | Aurangabad                     |
| 6.               | Beed     | Kaij           | Kaij                                    | Composite    | Aurangabad                     |
| 7.               | Beed     | Majalgaon      | Majalgaon                               | Hot and Dry  | Aurangabad                     |
| 8.               | Beed     | Parli          | Parali-Waijanath                        | Composite    | Aurangabad                     |
| 9.               | Beed     | Patoda         | Patoda                                  | Composite    | Aurangabad                     |
| 10.              | Beed     | Shirur (Kasar) | -                                       | Composite    | Aurangabad                     |
| 11.              | Beed     | Wadwani        | -                                       | Composite    | Aurangabad                     |

### C) AMRAVATI DIVISION

| 1. Amravati District |          |          |   |              |                                |
|----------------------|----------|----------|---|--------------|--------------------------------|
| Sr. No.              | District | Talukas  | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
| 1.                   | Amravati | Achalpur | Achalpur                                | Hot and Dry  | Nagpur                         |
| 2.                   | Amravati | Amravati | Amravati                                | Hot and Dry  | Nagpur                         |

|     |          |                      |                    |             |        |
|-----|----------|----------------------|--------------------|-------------|--------|
| 3.  | Amravati | AnjangaonSurji       | AnjangaonSurji     | Hot and Dry | Nagpur |
| 4.  | Amravati | Bhatkuli             | -                  | Hot and Dry | Nagpur |
| 5.  | Amravati | Chandur Railway      | Chandur Rly        | Composite   | Nagpur |
| 6.  | Amravati | Chandurbazar         | Chandur Bazar      | Composite   | Nagpur |
| 7.  | Amravati | Chilkhaldara         | -                  | Hot and Dry | Nagpur |
| 8.  | Amravati | Daryapur             | Daryapur           | Hot and Dry | Nagpur |
| 9.  | Amravati | Dhamangaon Railway   | Dhamangaon Railway | Composite   | Nagpur |
| 10. | Amravati | Dharni               | -                  | Hot and Dry | Nagpur |
| 11. | Amravati | Morshi               | Morshi             | Composite   | Nagpur |
| 12. | Amravati | Nandgaon-Khandeshwar | -                  | Composite   | Nagpur |
| 13. | Amravati | Teosa                | -                  | Composite   | Nagpur |
| 14. | Amravati | Warud                | Warud              | Composite   | Nagpur |

**2. Akola District**

| Sr. No. | District | Talukas     | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
|---------|----------|-------------|---|--------------|--------------------------------|
| 1.      | Akola    | Akola       | Akola                                   | Hot and Dry  | Nagpur                         |
| 2.      | Akola    | Akot        | Akot                                    | Hot and Dry  | Nagpur                         |
| 3.      | Akola    | Balapur     | Balapur (partly)                        | Hot and Dry  | Nagpur                         |
| 4.      | Akola    | BarshiTakli | BarshiTakali                            | Hot and Dry  | Nagpur                         |
| 5.      | Akola    | Murtizapur  | Murtizapur                              | Hot and Dry  | Nagpur                         |
| 6.      | Akola    | Patur       | Patur                                   | Hot and Dry  | Nagpur                         |
| 7.      | Akola    | Telhara     | Telhara                                 | Hot and Dry  | Nagpur                         |

**3. Washim District**

| Sr. No. | District | Talukas    | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
|---------|----------|------------|---|--------------|--------------------------------|
| 1.      | Washim   | Karanja    | Karanja                                 | Hot and Dry  | Nagpur                         |
| 2.      | Washim   | Malegaon   | Malegaon                                | Hot and Dry  | Nagpur                         |
| 3.      | Washim   | Mangrulpir | Mangrulpir                              | Hot and Dry  | Nagpur                         |
| 4.      | Washim   | Manora     | -                                       | Hot and Dry  | Nagpur                         |
| 5.      | Washim   | Risod      | Risod                                   | Hot and Dry  | Nagpur                         |
| 6.      | Washim   | Washim     | Washim                                  | Hot and Dry  | Nagpur                         |

**4. Buldhana District**

| Sr. No. | District | Talukas         | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
|---------|----------|-----------------|---|--------------|--------------------------------|
| 1.      | Buldhana | Buldhana        | Buldhana                                | Hot and Dry  | Nagpur                         |
| 2.      | Buldhana | Chikhali        | Chikhali                                | Hot and Dry  | Nagpur                         |
| 3.      | Buldhana | Deolgaon Raja   | Deulgaon Raja                           | Hot and Dry  | Nagpur                         |
| 4.      | Buldhana | Jalgaon (Jamod) | JalgaonJamod                            | Hot and Dry  | Nagpur                         |
| 5.      | Buldhana | Khamgaon        | Khamgaon                                | Hot and Dry  | Nagpur                         |

|     |          |               |               |             |        |
|-----|----------|---------------|---------------|-------------|--------|
| 6.  | Buldhana | Lonar         | Lonar         | Hot and Dry | Nagpur |
| 7.  | Buldhana | Malkapur      | Malkapur      | Hot and Dry | Nagpur |
| 8.  | Buldhana | Mehekar       | Mehekar       | Hot and Dry | Nagpur |
| 9.  | Buldhana | Motala        | -             | Hot and Dry | Nagpur |
| 10. | Buldhana | Nandura       | Nandura       | Hot and Dry | Nagpur |
| 11. | Buldhana | Sangrampur    | -             | Hot and Dry | Nagpur |
| 12. | Buldhana | Shegaon       | Shegaon       | Hot and Dry | Nagpur |
| 13. | Buldhana | Sindkhed Raja | Sindkhed Raja | Hot and Dry | Nagpur |

**5. Yavatmal District**

| Sr. No. | District | Talukas     | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
|---------|----------|-------------|---|--------------|--------------------------------|
| 1.      | Yavatmal | Arni        | -                                       | Composite    | Nagpur                         |
| 2.      | Yavatmal | Babulgaon   | -                                       | Composite    | Nagpur                         |
| 3.      | Yavatmal | Darwha      | Darwha                                  | Hot and Dry  | Nagpur                         |
| 4.      | Yavatmal | Digras      | Digras                                  | Hot and Dry  | Nagpur                         |
| 5.      | Yavatmal | Ghatanji    | Ghatanji                                | Composite    | Nagpur                         |
| 6.      | Yavatmal | Kalamb      | -                                       | Hot and Dry  | Nagpur                         |
| 7.      | Yavatmal | Kelapur     | Pandharkavda                            | Composite    | Nagpur                         |
| 8.      | Yavatmal | Mahagaon    | -                                       | Composite    | Nagpur                         |
| 9.      | Yavatmal | Maregaon    | -                                       | Composite    | Nagpur                         |
| 10.     | Yavatmal | Ner         | NerNawabpur                             | Hot and Dry  | Nagpur                         |
| 11.     | Yavatmal | Pusad       | Pusad                                   | Hot and Dry  | Nagpur                         |
| 12.     | Yavatmal | Ralegaon    | -                                       | Composite    | Nagpur                         |
| 13.     | Yavatmal | Umarkhed    | Umarkhed                                | Hot and Dry  | Nagpur                         |
| 14.     | Yavatmal | Wani        | Wani                                    | Composite    | Nagpur                         |
| 15.     | Yavatmal | Yavatmal    | Yavatmal                                | Hot and Dry  | Nagpur                         |
| 16.     | Yavatmal | Zari-Jamani | -                                       | Composite    | Nagpur                         |

**D) PUNE DIVISION**

**1. Pune District**

| Sr. No. | District | Talukas          | Name of Municipal Council / Corporation | Climate Zone   | Closest available weather file |
|---------|----------|------------------|---|----------------|--------------------------------|
| 1.      | Pune     | Ambegaon         | -                                       | Composite      | Pune                           |
| 2.      | Pune     | Baramati         | Baramati                                | Hot and Dry    | Pune                           |
| 3.      | Pune     | Bhor             | Bhor                                    | Composite      | Pune                           |
| 4.      | Pune     | Daund            | Daund                                   | Hot and Dry    | Pune                           |
| 5.      | Pune     | Indapur          | Indapur                                 | Hot and Dry    | Pune                           |
| 6.      | Pune     | Junnar           | Junnar                                  | Composite      | Pune                           |
| 7.      | Pune     | Khed             | Alandi                                  | Composite      | Pune                           |
| 8.      | Pune     | Mawal            | Talegaon-Dhabhade                       | Warm and Humid | Pune                           |
| 9.      | Pune     | Mulshi           | -                                       | Warm and Humid | Pune                           |
| 10.     | Pune     | Pune City Haveli | Pune                                    | Composite      | Pune                           |

|     |      |          |                 |                |      |
|-----|------|----------|-----------------|----------------|------|
|     | Pune |          | PimpriChinchwad |                | Pune |
|     | Pune |          | Loni-Kalbhor    |                | Pune |
| 11. | Pune | Purandar | Jejuri          | Composite      | Pune |
|     | Pune |          | Saswad          |                | Pune |
| 12. | Pune | Shirur   | Shirur          | Hot and Dry    | Pune |
| 13. | Pune | Velhe    | -               | Warm and Humid | Pune |

**2.Kolhapur District**

| Sr. No. | District | Talukas     | Name of Municipal Council / Corporation | Climate Zone   | Closest available weather file |
|---------|----------|-------------|---|----------------|--------------------------------|
| 1.      | Kolhapur | Ajra        | -                                       | Composite      | Pune                           |
| 2.      | Kolhapur | Bavda       | -                                       | Warm and Humid | Pune                           |
| 3.      | Kolhapur | Bhudargad   | -                                       | Composite      | Pune                           |
| 4.      | Kolhapur | Chandgad    | -                                       | Warm and Humid | Pune                           |
| 5.      | Kolhapur | Gandhinglaj | Gandhinglaj                             | Composite      | Pune                           |
| 6.      | Kolhapur | Hatkanangle | Ichalkarnji                             | Composite      | Pune                           |
|         | Kolhapur |             | Vadgaon                                 |                | Pune                           |
| 7.      | Kolhapur | Kagal       | Kagal                                   | Composite      | Pune                           |
|         | Kolhapur |             | Murgud                                  |                | Pune                           |
| 8.      | Kolhapur | Karvir      | -                                       | Composite      | Pune                           |
| 9.      | Kolhapur | Kolhapur    | -                                       | Composite      | Pune                           |
| 10.     | Kolhapur | Panhala     | -                                       | Composite      | Pune                           |
| 11.     | Kolhapur | Radhanagari | -                                       | Warm and Humid | Pune                           |
| 12.     | Kolhapur | Shahuwadi   | Malkapur                                | Composite      | Pune                           |
| 13.     | Kolhapur | Shirol      | Jaysingpur                              | Composite      | Pune                           |
|         |          |             | Kurundwad                               |                | Pune                           |

**3.Satara District**

| Sr. No. | District | Talukas       | Name of Municipal Council / Corporation | Climate Zone   | Closest available weather file |
|---------|----------|---------------|---|----------------|--------------------------------|
| 1.      | Satara   | Jaoli         | -                                       | Hot and Dry    | Pune                           |
| 2.      | Satara   | Karad         | Karad                                   | Composite      | Pune                           |
| 3.      | Satara   | Khandala      | Lonand                                  | Composite      | Pune                           |
| 4.      | Satara   | Khatav        | -                                       | Warm and Humid | Pune                           |
| 5.      | Satara   | Koregaon      | Koregaon                                | Warm and Humid | Pune                           |
|         | Satara   |               | Rahimatpur                              |                | Pune                           |
| 6.      | Satara   | Man           | Mhaswad                                 | Composite      | Pune                           |
| 7.      | Satara   | Mahabaleshwar | -                                       | Warm and Humid | Pune                           |
| 8.      | Satara   | Patan         | -                                       | Hot and Dry    | Pune                           |
| 9.      | Satara   | Phaltan       | Phaltan                                 | Composite      | Pune                           |
| 10.     | Satara   | Satara        | Satara                                  | Composite      | Pune                           |
| 11.     | Satara   | Wai           | Wai                                     | Composite      | Pune                           |

**4. Solapur District**

| Sr. No. | District | Talukas  | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
|---------|----------|----------|---|--------------|--------------------------------|
| 1.      | Solapur  | Akkalkot | Akkalkot                                | Hot and Dry  | Pune                           |

|                           | Solapur  |                | Dudhani                                 |              | Pune                           |
|---------------------------|----------|----------------|---|--------------|--------------------------------|
|                           | Solapur  |                | Maindargi                               |              | Pune                           |
| 2.                        | Solapur  | Barshi         | Barshi                                  | Hot and Dry  | Pune                           |
| 3.                        | Solapur  | Karmala        | Karmala                                 | Hot and Dry  | Pune                           |
| 4.                        | Solapur  | Madha          | Kurduwadi                               | Hot and Dry  | Pune                           |
| 5.                        | Solapur  | Malshiras      | Akluj                                   | Hot and Dry  | Pune                           |
| 6.                        | Solapur  | Mangalwedha    | Mangalwedha                             | Hot and Dry  | Pune                           |
| 7.                        | Solapur  | Mohol          | -                                       | Hot and Dry  | Pune                           |
| 8.                        | Solapur  | Pandharpur     | Pandharpur                              | Hot and Dry  | Pune                           |
| 9.                        | Solapur  | Sangola        | Sangola                                 | Hot and Dry  | Pune                           |
| 10.                       | Solapur  | Solapur North  | Solapur                                 | Hot and Dry  | Pune                           |
| 11.                       | Solapur  | Solapur South  |   | Hot and Dry  | Pune                           |
| <b>5. Sangli District</b> |          |                |   |              |                                |
| Sr. No.                   | District | Talukas        | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
| 1.                        | Sangli   | Atpadi         | -                                       | Hot and Dry  | Pune                           |
| 2.                        | Sangli   | Jat            | -                                       | Composite    | Pune                           |
| 3.                        | Sangli   | Kadegaon       | -                                       | Composite    | Pune                           |
| 4.                        | Sangli   | KavatheMahakal | -                                       | Composite    | Pune                           |
| 5.                        | Sangli   | Khanapur       | Vita                                    | Composite    | Pune                           |
| 6.                        | Sangli   | Miraj          | -                                       | Composite    | Pune                           |
| 7.                        | Sangli   | Palus          | -                                       | Composite    | Pune                           |
| 8.                        | Sangli   | Sangli         | -                                       | Composite    | Pune                           |
| 9.                        | Sangli   | Shirala        | -                                       | Composite    | Pune                           |
| 10.                       | Sangli   | Tasgaon        | Tasgaon                                 | Composite    | Pune                           |
| 11.                       | Sangli   | Walwa          | Ashta                                   | Composite    | Pune                           |
|                           |          |                | Islampur                                |              | Pune                           |

## E) NAGPUR DIVISION

### 1. Nagpur District

| Sr. No. | District | Talukas        | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
|---------|----------|----------------|---|--------------|--------------------------------|
| 1.      | Nagpur   | Bhiwapur       | Bhiwapur                                | Composite    | Nagpur                         |
| 2.      | Nagpur   | Hingna         | -                                       | Composite    | Nagpur                         |
| 3.      | Nagpur   | Kalameshwar    | Kalameshwar                             | Composite    | Nagpur                         |
|         | Nagpur   |                | Mohpa                                   |              | Nagpur                         |
| 4.      | Nagpur   | Kamthi         | Kamthi                                  | Composite    | Nagpur                         |
| 5.      | Nagpur   | Katol          | Katol                                   | Composite    | Nagpur                         |
| 6.      | Nagpur   | Kuhi           | -                                       | Composite    | Nagpur                         |
| 7.      | Nagpur   | Mauda          | -                                       | Composite    | Nagpur                         |
| 8.      | Nagpur   | Nagpur (Rural) |   | Composite    | Nagpur                         |
| 9.      | Nagpur   | Nagpur (Urban) | Nagpur                                  | Composite    | Nagpur                         |

|     |        |          |           |           |        |
|-----|--------|----------|-----------|-----------|--------|
| 10. | Nagpur | Narkhed  | Narkhed   | Composite | Nagpur |
|     | Nagpur |          | Mowad (R) |           | Nagpur |
| 11. | Nagpur | Parseoni | -         | Composite | Nagpur |
| 12. | Nagpur | Ramtek   | Ramtek    | Composite | Nagpur |
| 13. | Nagpur | Saoner   | Saoner    | Composite | Nagpur |
|     | Nagpur |          | Khapa     |           | Nagpur |
| 14. | Nagpur | Umred    | Umred     | Composite | Nagpur |

**2. Wardha District**

| Sr. No. | District | Talukas    | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
|---------|----------|------------|---|--------------|--------------------------------|
| 1.      | Wardha   | Arvi       | Arvi                                    | Composite    | Nagpur                         |
| 2.      | Wardha   | Ashti      | -                                       | Composite    | Nagpur                         |
| 3.      | Wardha   | Deoli      | Deoli                                   | Composite    | Nagpur                         |
|         | Wardha   |            | Pulgaon                                 |              | Nagpur                         |
| 4.      | Wardha   | Hinganghat | Hinganghat                              | Composite    | Nagpur                         |
| 5.      | Wardha   | Karanja    | -                                       | Composite    | Nagpur                         |
| 6.      | Wardha   | Samudrapur | -                                       | Composite    | Nagpur                         |
| 7.      | Wardha   | Seloo      | Sindi (Rly)                             | Composite    | Nagpur                         |
| 8.      | Wardha   | Wardha     | Wardha                                  | Composite    | Nagpur                         |
|         |          |            | Sevagram                                |              | Nagpur                         |

**3. Gadchiroli District**

| Sr. No. | District   | Talukas            | Name of Municipal Council / Corporation | Climate Zone   | Closest available weather file |
|---------|------------|--------------------|---|----------------|--------------------------------|
| 1.      | Gadchiroli | Aheri              | -                                       | Warm and Humid | Nagpur                         |
| 2.      | Gadchiroli | Armori             | Armori                                  | Warm and Humid | Nagpur                         |
| 3.      | Gadchiroli | Bhamragad          | -                                       | Warm and Humid | Nagpur                         |
| 4.      | Gadchiroli | Chamorshi          | -                                       | Warm and Humid | Nagpur                         |
| 5.      | Gadchiroli | Desaiganj (Vadasa) | Desaiganj                               | Warm and Humid | Nagpur                         |
| 6.      | Gadchiroli | Dhanora            | -                                       | Warm and Humid | Nagpur                         |
| 7.      | Gadchiroli | Etapalli           | -                                       | Warm and Humid | Nagpur                         |
| 8.      | Gadchiroli | Gadchiroli         | Gadchiroli                              | Warm and Humid | Nagpur                         |
| 9.      | Gadchiroli | Korchi             | -                                       | Warm and Humid | Nagpur                         |
| 10.     | Gadchiroli | Kurkheda           | -                                       | Warm and Humid | Nagpur                         |
| 11.     | Gadchiroli | Mulchera           | -                                       | Warm and Humid | Nagpur                         |
| 12.     | Gadchiroli | Sironcha           | -                                       | Warm and Humid | Nagpur                         |

**4. Bhandara District**

| Sr. No. | District | Talukas   | Name of Municipal Council / Corporation | Climate Zone   | Closest available weather file |
|---------|----------|-----------|---|----------------|--------------------------------|
| 1.      | Bhandara | Bhandara  | Bhandara                                | Composite      | Nagpur                         |
| 2.      | Bhandara | Lakhandur | -                                       | Warm and Humid | Nagpur                         |
| 3.      | Bhandara | Lakhani   | Lakhani                                 | Warm and Humid | Nagpur                         |
| 4.      | Bhandara | Mohadi    | -                                       | Composite      | Nagpur                         |

|    |          |        |        |                |        |
|----|----------|--------|--------|----------------|--------|
| 5. | Bhandara | Paoni  | Paoni  | Warm and Humid | Nagpur |
| 6. | Bhandara | Sakoli | Sakoli | Warm and Humid | Nagpur |
| 7. | Bhandara | Tumsar | Tumsar | Composite      | Nagpur |

**5. Chandrapur District**

| Sr. No. | District   | Talukas    | Name of Municipal Council / Corporation | Climate Zone   | Closest available weather file |
|---------|------------|------------|---|----------------|--------------------------------|
| 1.      | Chandrapur | Ballarpur  | Ballarpur                               | Warm and Humid | Nagpur                         |
| 2.      | Chandrapur | Bhadravati | -                                       | Warm and Humid | Nagpur                         |
| 3.      | Chandrapur | Brahmapuri | Brahmapuri                              | Warm and Humid | Nagpur                         |
| 4.      | Chandrapur | Chandrapur | Chandrapur                              | Warm and Humid | Nagpur                         |
| 5.      | Chandrapur | Chimur     | -                                       | Warm and Humid | Nagpur                         |
| 6.      | Chandrapur | Gondpipri  | -                                       | Warm and Humid | Nagpur                         |
| 7.      | Chandrapur | Jiwati     | -                                       | Warm and Humid | Nagpur                         |
| 8.      | Chandrapur | Korpana    | -                                       | Warm and Humid | Nagpur                         |
| 9.      | Chandrapur | Mul        | Mul                                     | Warm and Humid | Nagpur                         |
| 10.     | Chandrapur | Nagbhir    | -                                       | Warm and Humid | Nagpur                         |
| 11.     | Chandrapur | Pombhurna  | -                                       | Warm and Humid | Nagpur                         |
| 12.     | Chandrapur | Rajura     | Rajura                                  | Warm and Humid | Nagpur                         |
| 13.     | Chandrapur | Sawali     | -                                       | Warm and Humid | Nagpur                         |
| 14.     | Chandrapur | Sindewahi  | -                                       | Warm and Humid | Nagpur                         |
| 15.     | Chandrapur | Warora     | Warora                                  | Warm and Humid | Nagpur                         |

**6. Gondia District**

| Sr. No. | District | Talukas         | Name of Municipal Council / Corporation | Climate Zone | Closest available weather file |
|---------|----------|-----------------|---|--------------|--------------------------------|
| 1.      | Gondia   | Amgaon          | -                                       | Composite    | Nagpur                         |
| 2.      | Gondia   | Arjuni- Morgaon | -                                       | Composite    | Nagpur                         |
| 3.      | Gondia   | Deori           | Deori                                   | Composite    | Nagpur                         |
| 4.      | Gondia   | Gondia          | Gondia                                  | Composite    | Nagpur                         |
| 5.      | Gondia   | Goregaon        | -                                       | Composite    | Nagpur                         |
| 6.      | Gondia   | Sadak-Arjuni    | -                                       | Composite    | Nagpur                         |
| 7.      | Gondia   | Salekasa        | -                                       | Composite    | Nagpur                         |
| 8.      | Gondia   | Tirora          | Tirora (EP)                             | Composite    | Nagpur<br>Nagpur               |

**F) KONKAN DIVISION****1. Raigad District**

| Sr. No. | District | Talukas  | Name of Municipal Council / Corporation | Climate Zone   | Closest available weather file |
|---------|----------|----------|---|----------------|--------------------------------|
| 1.      | Raigad   | Alibaug  | Alibaug                                 | Warm and Humid | Mumbai                         |
| 2.      | Raigad   | Karjat   | Karjat                                  | Warm and Humid | Mumbai                         |
| 3.      | Raigad   | Khalapur | Khopoli                                 | Warm and Humid | Mumbai                         |

|     |        |            |               |                |        |
|-----|--------|------------|---------------|----------------|--------|
| 4.  | Raigad | Mahad      | Mahad         | Warm and Humid | Mumbai |
| 5.  | Raigad | Mangaon    | -             | Warm and Humid | Mumbai |
| 6.  | Raigad | Mhasla     | -             | Warm and Humid | Mumbai |
| 7.  | Raigad | Murud      | Murud-Janjira | Warm and Humid | Mumbai |
| 8.  | Raigad | Panvel     | Panvel        | Warm and Humid | Mumbai |
| 9.  | Raigad | Pen        | Pen           | Warm and Humid | Mumbai |
| 10. | Raigad | Poladpur   | -             | Warm and Humid | Mumbai |
| 11. | Raigad | Raigad     | -             | Warm and Humid | Mumbai |
| 12. | Raigad | Roha       | Roha          | Warm and Humid | Mumbai |
| 13. | Raigad | Srivardhan | Srivardhan    | Warm and Humid | Mumbai |
| 14. | Raigad | Sudhagad   | -             | Warm and Humid | Mumbai |
| 15. | Raigad | Tala       | -             | Warm and Humid | Mumbai |
| 16. | Raigad | Uran       | Uran          | Warm and Humid | Mumbai |

### 2. Thane District

| Sr. No. | District | Talukas    | Name of Municipal Council / Corporation | Climate Zone   | Closest available weather file |
|---------|----------|------------|---|----------------|--------------------------------|
| 1.      | Thane    | Ambarnath  | Ambarnath                               | Warm and Humid | Mumbai                         |
| 2.      | Thane    | Bhiwandi   | Bhiwandi-Nizampur                       | Warm and Humid | Mumbai                         |
| 3.      | Thane    | Dahanu     | -                                       | Warm and Humid | Mumbai                         |
| 4.      | Thane    | Jawhar     | Jawhar                                  | Warm and Humid | Mumbai                         |
| 5.      | Thane    | Kalyan     | Kalyan-Dombivali                        | Warm and Humid | Mumbai                         |
|         | Thane    |            | Kulgoan-Badalapur                       |                | Mumbai                         |
| 6.      | Thane    | Mokhada    | -                                       | Warm and Humid | Mumbai                         |
| 7.      | Thane    | Murbad     | -                                       | Warm and Humid | Mumbai                         |
| 8.      | Thane    | Palghar    | Umarpada-Safala                         | Warm and Humid | Mumbai                         |
| 9.      | Thane    | Shahapur   | -                                       | Warm and Humid | Mumbai                         |
| 10.     | Thane    | Talasari   | -                                       | Warm and Humid | Mumbai                         |
| 11.     | Thane    | Thane      | Thane                                   | Warm and Humid | Mumbai                         |
|         |          |            | Navi Mumbai                             |                | Mumbai                         |
| 12.     | Thane    | Ulhasnagar | Ulhasnagar                              | Warm and Humid | Mumbai                         |
| 13.     | Thane    | Vada       | -                                       | Warm and Humid | Mumbai                         |
| 14.     | Thane    | Vasai      | Vasai-Virar                             | Warm and Humid | Mumbai                         |
| 15.     | Thane    | Vikramgad  | -                                       | Warm and Humid | Mumbai                         |

### 3. Ratnagiri District

| Sr. No. | District  | Talukas | Name of Municipal Council / Corporation | Climate Zone   | Closest available weather file |
|---------|-----------|---------|---|----------------|--------------------------------|
| 1.      | Ratnagiri | Chiplun | Chiplun                                 | Warm and Humid | Mumbai                         |
| 2.      | Ratnagiri | Dapoli  | -                                       | Warm and Humid | Mumbai                         |
| 3.      | Ratnagiri | Guhagar | -                                       | Warm and Humid | Mumbai                         |
| 4.      | Ratnagiri | Khed    | Khed                                    | Warm and Humid | Mumbai                         |



|    |           |              |           |                |        |
|----|-----------|--------------|-----------|----------------|--------|
| 5. | Ratnagiri | Lanja        | -         | Warm and Humid | Mumbai |
| 6. | Ratnagiri | Mandangad    | -         | Warm and Humid | Mumbai |
| 7. | Ratnagiri | Rajapur      | Rajapur   | Warm and Humid | Mumbai |
| 8. | Ratnagiri | Ratnagiri    | Ratnagiri | Warm and Humid | Mumbai |
| 9. | Ratnagiri | Sangameshwar | -         | Warm and Humid | Mumbai |

**4. Sindhudurg District**

| Sr. No. | District   | Talukas     | Name of Municipal Council / Corporation | Climate Zone   | Closest available weather file |
|---------|------------|-------------|---|----------------|--------------------------------|
| 1.      | Sindhudurg | Devgad      | -                                       | Warm and Humid | Mumbai                         |
| 2.      | Sindhudurg | Dodamarg    | -                                       | Warm and Humid | Mumbai                         |
| 3.      | Sindhudurg | Kankawali   | Kankawali                               | Warm and Humid | Mumbai                         |
| 4.      | Sindhudurg | Kudal       | -                                       | Warm and Humid | Mumbai                         |
| 5.      | Sindhudurg | Malvan      | Malvan                                  | Warm and Humid | Mumbai                         |
| 6.      | Sindhudurg | Sawantwadi  | Sawantwadi                              | Warm and Humid | Mumbai                         |
| 7.      | Sindhudurg | Sindhudurg  | -                                       | Warm and Humid | Mumbai                         |
| 8.      | Sindhudurg | Vaibhavwadi | -                                       | Warm and Humid | Mumbai                         |
| 9.      | Sindhudurg | Vengurla    | Vengurla                                | Warm and Humid | Mumbai                         |

**5. Mumbai District**

| Sr. No. | District | Talukas         | Name of Municipal Council / Corporation | Climate Zone   | Closest available weather file |
|---------|----------|-----------------|---|----------------|--------------------------------|
| 1.      | Mumbai   | Mumbai          | Municipal Corporation of Greater Mumbai | Warm and Humid | Mumbai                         |
| 2.      | Mumbai   | Mumbai Suburban |   | Warm and Humid | Mumbai                         |

By order and in the name of the Governor of Maharashtra,

PRASHANT P. BADGERI,  
Deputy Secretary to Government.