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MADHYA PRADESH
ENERGY CONSERVATION BUILDING CODE
(MP-ECBC)

MADHYA PRADESH URJA VIKAS NIGAM LTD.

(MPUVNL)

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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.

While, according to section-15 of the Energy Conservation Act 2001 the State Government, can amend the Energy Conservation Building Code to suit the regional and local climatic conditions and along with Rules, can specify and notify energy conservation building codes with respect to use of energy in the buildings

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 FFICIENCY 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 Section-4 to Section-7, or by following the provisions of the Whole Building Performance (WBP) Method in Section-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 Section-4 to Section-7, or by following the provisions of the Whole Building Performance (WBP) Method in Section-9.

(c) Super Energy Conservation Building Code Building (Super-ECBC Building)
Super-ECBC Buildings shall demonstrate compliance by adopting the mandatory and prescriptive requirements listed under Super-ECBC Compliant Building requirements in Section-4 to Section-7, or by following the provisions of the Whole Building Performance (WBP) Method in Section-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 Labeling 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 CLASSIFICATIONS

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 Section-4 to Section-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 analyzing 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 analyzing 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 AND APPROACH

3.1 GENERAL

To comply with the Code, buildings shall

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

and,

(b) meet all mandatory requirements mentioned under Section-4.2, Section-5.2 , Section-6.2, and Section-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:

$$EPI = \frac{Annual\ Energy\ Consumption\ (in\ kW)}{Total\ Builtup\ Area\ (excluding\ unconditioned\ basement)}$$

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:

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

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 Section-4.2, Section-5.2 , Section-6.2, and Section-7.2, and minimally complies with prescriptive requirements of Section-4.3, Section-5.3, and Section-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 Section-3.2 –

(a) Prescriptive Method (see Section-3.2.2)

(b) Whole Building Performance Method (see Section-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 Section-3.2.2.1 or Section-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 Section-3.2.2.1 or Section-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,

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.

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 Section-2, shall comply with the Code by meeting all the mandatory requirements (see Section-3.2.1) and any of the compliance paths mentioned in Section-3.2.2, or Section-3.2.3.

3.2.1. MANDATORY REQUIREMENT

Buildings shall comply with all mandatory requirements mentioned under Section-4.2, Section-5.2 , Section-6.2, and Section-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 (Section-4.3), comfort systems and controls (Section-5.3, Section-5.3.12, Section-5.3.13), and lighting and controls (Section-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 (Section-3.2.2) shall be deemed to have an EPI equal to the Standard Building EPI, and therefore an EPI Ratio of ECBC+ Buildings and Super-ECBC Buildings that demonstrate compliance through the Prescriptive Method shall be deemed to have an EPI Ratio equal to the EPI Ratios listed in Section-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 Section-4, the Building Envelope Trade-off Method may be used in place of the prescriptive criteria of Section-4.3.1, Section-4.3.2 and Section-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 Section-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 Section-5. This approach may be used in place of the prescriptive criteria of chillers (Section-5.3.1and Section-5.3.6), chilled water pumps (Section-5.3.2), condenser water pumps (Section-5.3.2), and cooling tower fan (Section-5.3.3). As per this approach, a building complies if the Total System Efficiency thresholds are met as per Table 5-23 for Maximum System Efficiency Threshold of ECBC, ECBC+, or Super-ECBC Buildings. Compliance with other prescriptive requirements (Section-5.3), as applicable, shall be met.

3.2.2.4. Low Energy Comfort Systems

Low Energy Comfort Systems (Section-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 Super-ECBC. This approach is applicable to Prescriptive Method of Section Section-5. In addition to compliance with the applicable prescriptive requirements (Section-5.3), the projects must meet the sum of cooling and heating requirement using approved list of low energy systems as per requirements in Section-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 Section-4 trough Section-7. The mandatory requirements of Section-4 through Section-7 (Section-4.2, Section-5.2, Section-6.2, and Section-7.2) shall be met when using the WBP Method.

3.2.3.1. EPI calculation for Whole Building Performance Method

The EPI of buildings that demonstrate compliance through Whole Building Performance Method (Section-3.2.3) shall be calculated using the compliance path defined in Section-3.1.1 and detailed in Section-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 Section-9.5 for the applicable building type and climate zone.

3.3 COMPLIANCE REQUIREMENTS

3.3.1. NEW BUILDING COMPLIANCE

Full Building Compliance: New buildings with completed fit-outs shall comply with either the provisions of Section-3.2.1 and either the provision of Section-3.2.2 or Section-3.2.3.

Core and Shell building Compliance: New core and shell building shall comply with the provisions of Section-3.2.1 and either the provision of Section-3.2.2 or Section-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 Section-3.2.1 and Section-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 Section-4 through Section-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 Section-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 Section-9 or Total System Efficiency – Alternate compliance approach of Section-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 Section-4.2.3, if calculated through software tools, shall be shown through online BEP-EMIS or day-lighting 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

4.1 GENERAL

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

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 day-lit time in a year. For the purpose of day-lighting 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 Section-2.5. Compliance shall be demonstrated either through day-lighting simulation method in Section-4.2.3.1 or the manual method in Section-4.2.3.2. Assembly buildings and other buildings where day-lighting 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 Section-4.2.3:

Assembly buildings and other buildings where day-lighting 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+	Super-ECBC
Business, Educational	40%	50%	60%
No Star Hotel/ Star Hotel/ Healthcare	30%	40%	50%
Resort	45%	55%	65%
Shopping Complex	10%	15%	20%
Assembly*	Exempted		
***and other buildings where day-lighting will interfere with the functions or processes of 50% (or more) of the building floor area**			

4.2.3.1. Day-lighting Simulation Method

Only BEE approved software shall be used to demonstrate compliance through the day-lighting 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 day-lit 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 obstructers. 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 obstructers 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:

- Brief description of the project with location, number of stories, space types, hours of operation 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 modeling assumptions made.
- Explanation of any error messages noted in the simulation program output.

- Building floor plans, building elevations & sections, and site plan with surrounding building details (if modeled).
- 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 Day-lighting Compliance Method

This method can be used for demonstrating compliance with day-lighting 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 day-lit 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
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 day-lit area:

- 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.
- In the direction parallel to the fenestration, day-lit 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 will be less.
- 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 saw-tooth 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.
- Glazed façades, with non-cardinal orientation, shall be categorized under a particular cardinal direction if its orientation is within ± 45 degrees of that cardinal direction.
- Day-lit area overlap: For overlapping day-lit areas such as windows on different orientations or in case of skylights the overlapping day-lit area shall be subtracted from the sum of day-lit area.

b) Documentation requirement:

- A separate architectural plan shall be prepared with all daylight areas marked on the floor plans.
- 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

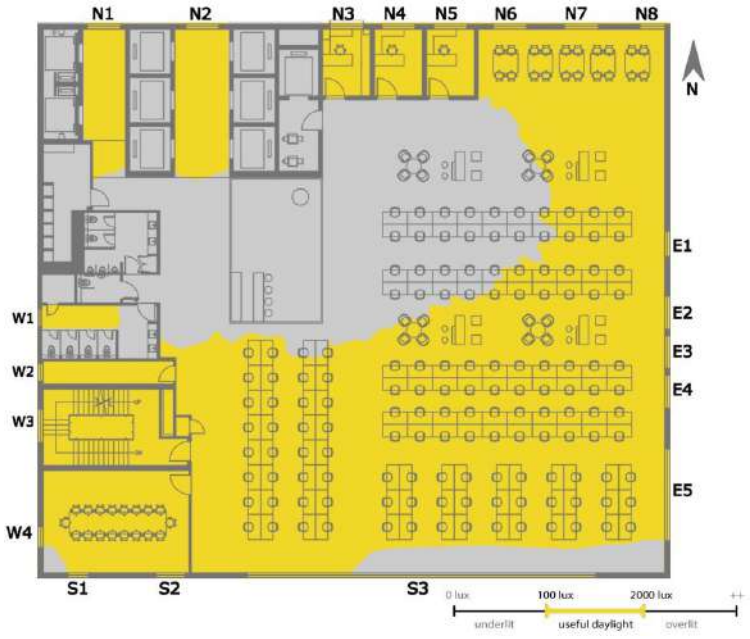
Note 4-1 Daylight Extent Factor and Useful Daylight Illuminance
Useful Daylight Illuminance (UDI) is defined as the annual occurrence of daylight between 100 lux to 2,000 lux on a work plane. This daylight is most useful to occupants, glare free and when available, eliminates the need for artificial 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^2. 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^2 (40% of 1,254 m^2) of floor area shall fulfill the UDI requirements. Day-lit area should be indicated in floor plans submitted to code enforcement authorities. Design guidelines on day-lighting stated in NBC (Part 8: Building Services, Section 1: Lighting and Natural Ventilation, Subsection 4.2: Day-lighting) 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 day-lighting requirements can be checked by analyzing the façade and floor plate design in 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

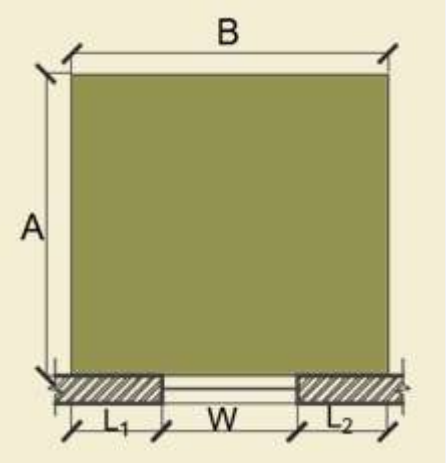


UDI Analysis with a Daylighting Analysis Software

(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 ≥ 0.39, shading PF ≥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 day-lit floor area (AxB).

A:In the direction perpendicular to the fenestration, day-lit 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 day-lit 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 day-lit areas such as corner windows. Subtract the overlapping daylit area from the sum of day-lit area.

UDI Analysis with manual calculations

As per the calculations 616.5 m2 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 m2. Thus, the building floor will comply with UDI requirement. Following Tables shows calculated Daylight Area Meeting UDI Requirement.

Orientation-**NORTH**, **DEF-3.5**, *Fenestration Head Height H - **3m***				
Window without	*Fenestration Width W (m)*	*A= H x DEF (m)*	*B= L1+W+ L2 (m) L1 =*	*Area meeting the UDI requirements*
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= L1+W+ L2 (m) L1 = L2=Distance to perpendicula*	*Area meeting the UDI requirements = AxB* (m^2)
N1	2.0	10.5	0.3+2+0.3=2.	27.3

N3	2.0.	4.0	0.4+2+0.4=2.	11.2
N4	2.0	4.0	0.4+2+0.4=2.	11.2
N5	2.0	4.0	0.4+2+0.4=2.	11.2
N8	1.5	10.5	0+1.5+1.0=2.	26.3
Daylight area meeting UDI requirement				**213.2**
Orientation-SOUTH, DEF-3, *Fenestration Head Height H - 3m*				
Window without opaque obstructions	*Fenestration Width W (m)*	*A= H x DEF (m)*	*B= L1+W+ L2 (m) L1 = L2=1m*	*Area meeting the UDI requirements = AxB (*m^2)
S1	1.2	6.2	1.0+1.2+1.0=3.	20.1
S2	1.7	6.2	1.0+1.7+0.3=3.	18.6
S3	21.0	9.0	1.0+21.0+1.0=	216.0
Daylit area meeting UDI requirement				**254.7**
Orientation-EAST, DEF-2.1, *Fenestration Head Height H - 3m*				
Window without opaque obstruction	*Fenestration Width W (m)*	*A= H x DEF (m)*	*B= L1+W+ L2 (m) L1 = L2=1m*	*Area meeting the UDI requirements = AxB (*m^2)
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	*Fenestration Width W (m)*	*A= H x DEF (m)*	*B= L1+W+ L2 (m) L1, L2=one half of distance to a*djacent fenestration	*Area meeting the UDI requirements = AxB (*m^2)
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

Daylight area meeting UDI requirement				**124.9**
Orientation-WEST, DEF-1.8, *Fenestration Head Height H - 3m*				
Window without opaque obstructions	*Fenestration W (m)*	*A= H x DEF (m)*	*B= L1+W+ L2 (m) L1 = L2=1m*	*Area meeting the UDI requirements = AxB (*m^2)
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 obstruction	*Fenestration Width W(m)*	*A= H x DEF (m)*	*B= L1+W+ L2 (m) L1 = L2=Distance to obstructions perpendicular*	*Area meeting the UDI requirements = AxB (*m^2)
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
Day-lit area meeting UDI requirement				**56.1**
Overlapping area calculations				
Width (m)	*Depth (m)*	*Area (*m^2)		
3.3	3.3	10.9		
3.3	6.5	21.5		
Overlapping daylight area (b)				**32.4**
Total Day-lit area				
ORIENTATION		*Day-lit area (*m^2)		
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/m2.K) Requirements for ECBC Compliant Building

	Composite	***Hot and dry***
All building types, except below	0.33	0.33
School <10,000 m^2 AGA	0.47	0.47
Hospitality > 10,000 m^2 AGA	0.20	0.20

Table 4-5 Roof Assembly U-factor (W/m2.K) Requirements for ECBC+ Compliant Building

	Composite	***Hot and dry***
Hospitality, Healthcare, Assembly	0.20	0.20

Business, Educational, Shopping Complex	0.26	0.26

Table 4-6 Roof Assembly U-factor (W/m2.K) Requirements for Super-ECBC Building

	Composite	***Hot and dry***
All building types	0.20	0.20

4.3.1.1. Vegetated and Cool Roofs

All roofs that are not covered by solar photo-voltaics, 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/m2.K) Requirements for an ECBC compliant Building

	Composite	***Hot and dry***

All building types, except below	0.40	0.40
No Star Hotel < 10,000 m^2 AGA	0.63	0.63
Business < 10,000 m^2 AGA	0.63	0.63
School <10,000 m^2 AGA	0.85	0.85

Table 4-8 Opaque Assembly Maximum U-factor (W/m2.K) Requirements for ECBC+ Compliant Building

	Composite	***Hot and dry***
All building types, except below	0.34	0.34
No Star Hotel < 10,000 m^2 AGA	0.44	0.44
Business < 10,000 m^2 AGA	0.44	0.44
School < 10,000 m^2 AGA	0.63	0.63

Table 4-9 Opaque Assembly Maximum U-factor (W/m2.K) Requirements for Super-ECBC Building

	Composite	***Hot and dry***
All building types	0.22	0.22

Exceptions to Section-4.3.1.1: 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 Super-ECBC, shall comply with the following:

a) Maximum allowable Window Wall Ratio (WWR) is 40% (applicable to buildings showing compliance using the Prescriptive Method, including Building Envelope Trade-off Method)

b) 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 Super-ECBC buildings. Vertical fenestration on non-cardinal direction shall be categorized under a particular cardinal direction if its orientation is within ± 45° of that cardinal direction.

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

	Composite	***Hot and dry***
Maximum U-factor ($W/m^2.K$)	3.00	3.00
Maximum SHGC Non-North	0.27	0.27
Maximum SHGC North for latitude ≥ 15°N	0.50	0.50
Maximum SHGC North for latitude < 15°N	0.27	0.27
See Appendix A for default values of unrated fenestration.		

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

	Composite	***Hot and dry***
Maximum U-factor ($W/m^2.K$)	2.20	2.20
Maximum SHGC Non-North	0.25	0.25
Maximum SHGC North for latitude ≥ 15°N	0.50	0.50
Maximum SHGC North for latitude < 15°N	0.25	0.25

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 Section-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 Section-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 ±22.5 degrees of the cardinal or primary inter-cardinal direction.

   iii. Any surrounding man-made or natural sunlight obstructers shall be considered as a permanent shading of PF equal to 0.4 if

      - the distance between the vertical fenestration of the building, for which

compliance is shown, and surrounding man-made or natural sunlight obstructers is less than or equal to twice the height of the surrounding man-made or natural sunlight obstructers; and

- the surrounding man-made or natural sunlight obstructers 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.

i. An equivalent SHGC is calculated by dividing the SHGC of the un-shaded 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.

ii. 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 ºN

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	1.7	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
	0.55	1.51	1.94	2.69	1.96	1.94	2.38	2.4	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	2.1	2.64	2.76	2.4
	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	2.9	3.12	2.64

	0.8	1.7	2.52	3.2	2.72	2.33	3.04	3.18	2.73
	0.85	1.73	2.69	3.21	2.9	2.4	3.11	3.23	2.8
	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	1.8	3.3	3.33	3.33	2.57	3.23	3.3	2.82
Overhang	0.25	1.09	1.21	1.28	1.2	1.17	1.26	1.23	1.2
	0.3	1.11	1.26	1.34	1.27	1.22	1.32	1.27	1.24
	0.35	1.13	1.3	1.39	1.33	1.26	1.39	1.32	1.28
	0.4	1.15	1.35	1.46	1.38	1.3	1.46	1.38	1.32
	0.45	1.16	1.4	1.52	1.43	1.33	1.53	1.46	1.36
	0.5	1.18	1.45	1.59	1.48	1.35	1.6	1.54	1.4
	0.55	1.2	1.51	1.66	1.52	1.38	1.67	1.62	1.44
	0.6	1.21	1.56	1.73	1.57	1.4	1.74	1.7	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	1.8	2.02	1.77	1.51	2	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	2.1	1.67
	0.95	1.29	1.99	2.21	1.98	1.67	2.15	2.13	1.7
	≥1	1.3	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	1.2	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	1.3	1.25	1.31	1.41
	0.5	1.22	1.2	1.35	1.2	1.34	1.27	1.33	1.46
	0.55	1.24	1.22	1.38	1.22	1.38	1.29	1.34	1.5
	0.6	1.25	1.23	1.4	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	1.3	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	1.3	1.49	1.3	1.62	1.38	1.39	1.65
	0.9	1.34	1.31	1.51	1.31	1.65	1.4	1.4	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 ºN

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	1.3	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	1.5	1.5	1.42	1.5	1.57	1.52	1.47	1.63
	0.4	1.56	1.59	1.5	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	1.8	1.87	1.75	1.7	1.94
	0.55	1.72	1.85	1.79	1.9	1.98	1.85	1.8	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	2.2	2.04	2	2.25
	0.7	1.86	2.11	2.08	2.24	2.31	2.15	2.1	2.36
	0.75	1.9	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	2.7	2.91
Overhang	0.25	1.15	1.19	1.09	1.2	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	1.2	1.28	1.07	1.29	1.26	1.16	1.12	1.25
	0.4	1.22	1.32	1.07	1.33	1.3	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	1.4	1.32	1.29	1.39
	0.6	1.3	1.51	1.18	1.5	1.43	1.36	1.33	1.42
	0.65	1.32	1.55	1.22	1.55	1.46	1.4	1.37	1.45
	0.7	1.33	1.6	1.26	1.59	1.48	1.43	1.4	1.48
	0.75	1.35	1.64	1.29	1.62	1.51	1.47	1.44	1.5
	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	1.7	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	1.4	1.77	1.38	1.77	1.59	1.59	1.56	1.61
	≥1	1.41	1.79	1.38	1.8	1.61	1.61	1.59	1.63
Side Fins	0.25	1.17	1.1	1.06	1.1	1.15	1.14	1.16	1.16
	0.3	1.2	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	1.2	1.25	1.22
	0.4	1.26	1.15	1.2	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	1.3	1.18	1.25	1.19	1.3	1.27	1.34	1.3
	0.55	1.32	1.19	1.27	1.2	1.33	1.29	1.36	1.33
	0.6	1.34	1.2	1.29	1.22	1.36	1.31	1.37	1.35
	0.65	1.36	1.21	1.3	1.23	1.38	1.34	1.38	1.38
	0.7	1.38	1.22	1.31	1.24	1.41	1.36	1.4	1.4
	0.75	1.4	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	1.5	1.47	1.47	1.49
	0.95	1.46	1.27	1.39	1.31	1.52	1.5	1.5	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. 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 4-2 Equivalent SHGC and Projection Factor

A 5,400 m2 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 m2. SHGC of the glazing in the East/West Fenestration is 0.3; area weighted U-Factor is 3.0 W/m2.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 Section-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: 28070' N, Longitude: 77010'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/m2.K, and VLT ≥ 0.27.

Total Floor area = 5400 m2

Total wall area = 2 x (2x ((90m x 4m) + (30m x 4m))) = 1,920 m2

Total Fenestration area = 374.7 m2

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/m2.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).

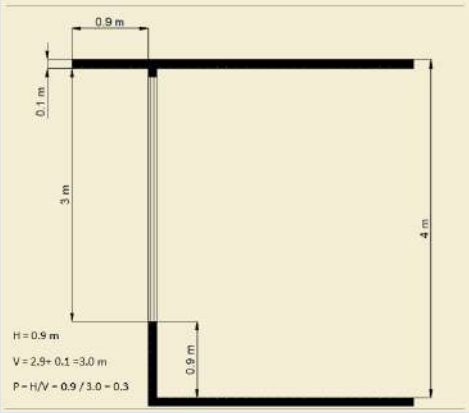
For projection factor (PF) 0.3, the SEF for east, and west are taken from

Table 4-12, as the latitude is greater than 15˚N. SEF for east for PF = 0.3 = 1.26

Therefore, equivalent $SHGC_{East}$ = 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 $SHGC_{West}$ = 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/m2.K provided they comply with all conditions mentioned in Table 4-14.

Table 4-14 U-factor (W/m2.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 North for latitude < 15°N	0.27	0.27	≥ 0.40
		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 and SHGC Requirements (U-factor in W/m2.K)

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

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

4.3.5. BUILDING ENVELOPE TRADE-OFF METHOD

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 4.2: EPF Total = EPF Roof + EPF Wall + EPF Fenest

$$EPF_{Roof} = c_{Roof} \sum_{S=1}^{n} U_S A_S$$

$$EPF_{Wall} = c_{Wall,mass} \sum_{S=1}^{n} U_S A_S + c_{Wall,Other} \sum_{S=1}^{n} U_S A_S$$

$$\begin{aligned} EPF_{Fenest} = {} & c_{1Fenest,North} \sum_{W=1}^{n} U_W A_W \\ & + c_{2\ Fenest,North} \sum_{W=1}^{n} \frac{SHGC_W}{SEF_W} A_W + c_{1Fenest,South} \sum_{W=1}^{n} U_W A_W \\ & + c_{2\ Fenest,South} \sum_{W=1}^{n} \frac{SHGC_W}{SEF_W} A_W + c_{1Fenest,East} \sum_{W=1}^{n} U_W A_W \\ & + c_{2\ Fenest,East} \sum_{W=1}^{n} \frac{SHGC_W}{SEF_W} A_W + c_{1Fenest,West} \sum_{W=1}^{n} U_W A_W \\ & + c_{2\ Fenest,West} \sum_{W=1}^{n} \frac{SHGC_W}{SEF_W} A_W \end{aligned}$$

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_{1Fenes} = A coefficient for the "Fenestration U-factor"

C_{2Fenes} = 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, Shopping Complex		24-hour -Business, Hospitality, Health Care, 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, Shopping Complex		24-hour Business, Hospitality, 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	22.8.1	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

4.3.5.1. Standard Building EPF Calculation

EPF of the Standard Building shall be calculated as follows:

a) 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

b) The U-factor of each envelope component shall be equal to the criteria from Section-4 for each class of construction

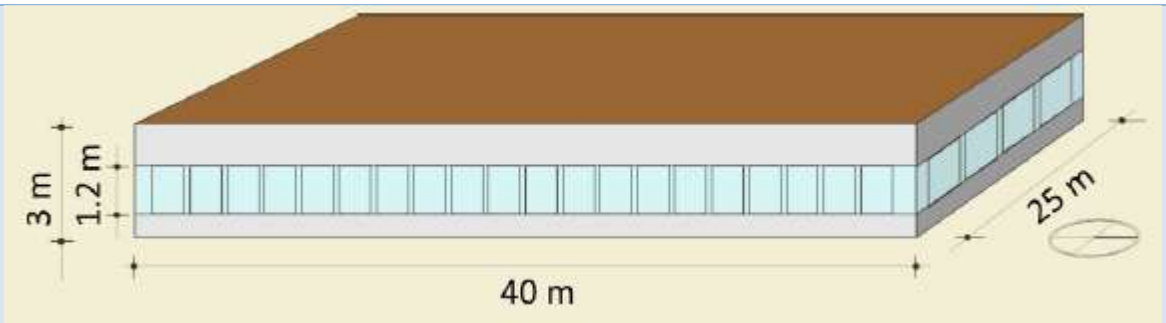
c) The SHGC of each window shall be equal to the criteria from Section-4.3.3.

d) Shading devices shall not be considered for calculating EPF for Standard Building (i.e. SEF=1).

Note 4-3 Building Envelope Trade-off Method

Application of Building Envelope Trade-off method

A 1,000 m^2 single storey 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= 0.4 $W/m^2.K$, external wall assembly U-value = 0.25 $W/m^2.K$, glazing SHGC = 0.25, VLT = 0.27, area weighted U-value for glazing = 1.8 $W/m^2.K$. External walls are mass wall construction type. 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 values, and SHGC must comply with requirements listed in Table 4-4, Table 4-7, Table 4-10 and VLT and WWR with requirements in Section- 4.3.3 for a 24-hour 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 ($W/m^2.K$)			Proposed U-factor ($W/m^2.K$)			Area (m^2)
Wall1-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

U-value of the roof of the proposed building, at 0.4 $W/m^2.K$ does not fulfill prescriptive

requirements. Similarly, Section-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.

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

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

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

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

Total Fenestration Area = 156 m^2, Total Wall Area = 390 m^2

WWR = 156/390= 0.4.

Hence, this building will not be compliant if the prescriptive approach is followed.

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:

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

Where,

$$\boldsymbol{EPF_{Roof} = c_{Roof} \sum_{S=1}^{n} U_S A_S}$$

$$\boldsymbol{EPF_{Wall} = c_{Wall,mass} \sum_{S=1}^{n} U_S A_S + c_{Wall,Other} \sum_{S=1}^{n} U_S A_S}$$

$$EPF_{Fenest} = c_{1Fenest,North} \sum_{W=1}^{n} U_W A_W + c_{2\ Fenest,North} \sum_{W=1}^{n} \frac{SHGC_W}{SEF_W} A_W + c_{1Fenest,South} \sum_{W=1}^{n} U_W A_W + c_{2\ Fenest,South} \sum_{W=1}^{n} \frac{SHGC_W}{SEF_W} A_W + c_{1Fenest,East} \sum_{W=1}^{n} U_W A_W + c_{2\ Fenest,East} \sum_{W=1}^{n} \frac{SHGC_W}{SEF_W} A_W + c_{1Fenest,West} \sum_{W=1}^{n} U_W A_W + c_{2\ Fenest,West} \sum_{W=1}^{n} \frac{SHGC_W}{SEF_W} A_W$$

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 Section- 4.3.3 for a 24-hour use building in the hot and dry climate zone. Values of 'C' are from 24-hour Office building in hot and dry climatic zone for each class of construction from Table 4-16. Since There is no shading for the windows, Mw will not be considered.

Step 1: Calculation of EPF $_{\text{Proposed Building}}$ from actual envelope properties

$$EPF_{Roof,Actual} = c_{Roof} \sum_{S=1}^{n} U_S A_S$$

= 14.82 x 0.40 x 1,000 = 5,928

$$EPF_{Wall,Actual} = c_{Wall,mass} \sum_{S=1}^{n} U_S A_S + c_{Wall,Other} \sum_{S=1}^{n} U_S A_S$$

= (6.4 x 0.25 x 90) + (6.4 x 0.25 x 144) = 374.4

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

$$EPF_{Fenest} = C_{1\ Fenest} \sum_{W=1}^{n} U_W A_W + C_{2\ Fenest} \sum_{W=1}^{n} \frac{SHGC_W}{SEF_W} A_W$$

$EPF_{\ Fenest,\ North}$= -0.37 x 1.8 x 30 + 101.66 x 0.25 x 30 = -19.98 + 762.45= 742.47

$EPF_{Fenest, South}$ = -1.35 x 1.8 x 30 + 252.90 x 0.25 x 30 = -72.9 + 1,896.75 = 1,823.85

$EPF_{Fenest, East}$ = -0.85 x 1.8 x 48 + 219.91 x 0.25 x 48 = - 73.44 + 2,638.9 = 2, 565.46

$EPF_{Fenest, West}$ = -0.80 x 1.8 x 48 + 226.57 x 0.25 x 48 = -69.12 + 2,718.8 = 2,649.7

Therefore,

EPF_{Fenest} =7,781.5

$EPF_{Proposed}$ = 5,928 + 374.4 + 7,781.5 = 14,083.9

Step 2: Calculating $EPF_{Standard\ Building}$ *from prescriptive envelope requirements*

$$\boldsymbol{EPF_{Wall,Actual} = c_{Roof} \sum_{S=1}^{n} U_S A_S}$$

= 14.82 x 0.33 x 1000 = 4,890.6

$$\boldsymbol{EPF_{Wall,Actual} = c_{Wall,mass} \sum_{S=1}^{n} U_S A_S + c_{Wall,Other} \sum_{S=1}^{n} U_S A_S}$$

= (6.4 x 0.63 x 90) + (6.4 x 0.63 x 144) = 362.88 + 580.6 = 943.5

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

Now,

$EPF_{Fenest, North}$ = -0.37 x 3.3 x 30 + 101.66 x 0.5 x 30 = - 36.63 + 1,524.9 = 1,488.3

$EPF_{Fenest, South}$ = -1.35 x 3.3 x 30 + 252.9 x 0.27 x 30 = -133.7 + 2.048.5 = 1,914.8

$EPF_{Fenest, East}$ = -0.85 x 3.3 x 48 + 219.91 x 0.27 x 48 = -134.64 + 2,850 = 2,715.4

$EPF_{Fenest, West}$ = -0.8 x 3.3 x 48 + 226.57 x 0.27 x 48 = -126.7 + 2,936 = 2,809.6

Therefore,

EPF_{Fenest} =8,928

$EPF_{Baseline}$ = 4,890.6 + 943.5 + 8,928= 14,762.2

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

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 Section-5.2 and the prescriptive criteria of Section-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 Section-5.3.12 or Section-5.3.13 and relevant criteria of Section-5.3 shall be met.

5.2 MANDATORY REQUIREMENTS

5.2.1. VENTILATION

All habitable spaces shall be ventilated with outdoor air in accordance with the requirements of Section-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). Also Ventilated spaces shall be provided with outdoor air using one of the following:

5.2.1.1. NATURAL VENTILATION

Naturally ventilated buildings shall:

Comply with guidelines provided for natural ventilation in NBC.

Have minimum BEE 3-star rated ceiling fans, if provided with ceiling fans.

Have exhaust fans complying with minimum efficiency requirements of fans in Section-5.3, if provided.

5.2.1.2. MECHANICAL VENTILATION

5.2.1.2.1. 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:

Install mechanical systems that provide outdoor air change rate as per NBC.

Have a ventilation system controlled by CO sensors for basement car-park spaces with total car park space greater than or equal to 600 m^2.

5.2.1.2.2. 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^2, with occupant density exceeding 40 people per 100 m^2 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 Section- 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

Chillers shall meet or exceed the minimum efficiency requirements presented in Table 5-1 through Table 5-2 under ANSI/ AHRI 550/ 590 conditions.

a) 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.

b) 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.

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 (kWr)	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 (kWr)	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 kWr

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

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

5.2.2.3. VARIABLE REFREGERANT 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 Requirements for Variable Refrigerant Flow

For Heating or cooling or both			
Type	Size category (kWr)	EER (W/W)	IEER
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[a]	Minimum SCOP-127[b]	
		Down flow	Up flow
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 re-heater and dehumidifier) at conditions defined in ASHRAE Standard 127-2012 Method of Testing for Rating Computer and Data Processing Room Unitary Air

5.2.2.5. BOILER

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

Equipment Type	*Sub Category*	*Size Category*	*Minimum FUE*
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 Section-5.2.3.1 through Section-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 m2 shall be controlled by time clocks that:

a) Can start and stop the system under different schedules for at least three different day- types per week,

b) Are capable of retaining programming and time setting during loss of power for a period of at least 10 hours, and

c) Include an accessible manual override that allows temporary operation of the system for up to 2 hours.

Exceptions to Section-5.2.3.1:

a) Cooling systems less than 17.5 kWr

b) Heating systems less than 5.0 kWr

c) 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:

a) 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^2 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 m2

c) Each conference and meeting room in a Star Hotel or Business

d) Each room of size more than 30 m2 in Educational buildings

5.2.3.4. FAN CONTROLS

Cooling towers in buildings with built up area greater than 20,000 m2, 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) Back-draft 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 back-draft 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 Section- 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 (ºC)	Pipe size (mm)	
	<40	>=40
	Insulation R value (m^2.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 (ºC)	Pipe size (mm)	
	< 40	>=40
	Insulation R value (m^2.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 Super-ECBC Buildings

Operating Temperature (ºC)	Pipe size (mm)	
	< 40	>=40
	Insulation R value (m^2.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 m2. 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^2

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 m2

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 m2

Exception to Section- 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 Section- 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-recirculation 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 built in energy recovery systems must pre-condition the outdoor air.

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

System Type	Fan Type	Mechanical Efficiency	*Motor Efficiency (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 (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 Super-ECBC Buildings

System Type	Fan Type	Mechanical Efficiency	*Motor Efficiency (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 Super-ECBC Buildings are presented in Table 5-14 and Table 5-15 under ANSI/ AHRI 550/ 590 conditions.

Table 5-14 Minimum efficiency requirements for water cooled chillers

Equipment	*ECBC+ Building*		*Super-ECBC Building*	
Chiller Capacity (kWr)	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
Chiller Capacity (kWr)	COP	IPLV	COP	IPLV
<260	5.2	6.9	5.8	7.1
≥260 & <530	5.8	7.1	6.0	7.9

Table 5-15 Minimum efficiency requirements for air-cooled chillers chillers

Equipment	*ECBC+ Building*		*Super-ECBC Building*	
Chiller Capacity (kWr)	COP	IPLV	COP/ IPLV	Chiller
<260	3.0	4.0	NA	<260
≥260	3.2	5.0	NA	≥260

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 Section-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/ kWr with VFD on secondary pump
Condenser Water Pump	17.7 W/ kWr
Pump Efficiency (minimum)	70%

Table 3-17 Pump Efficiency Requirements for ECBC+ Building

Equipment	*ECBC*
Chilled Water Pump (Primary and	16.9 W/ kWr with VFD on
Condenser Water Pump	16.5 W/ kWr
Pump Efficiency (minimum)	75%

Table 3-18 Pump Efficiency Requirements for Super-ECBC Building

Equipment	*ECBC*
Chilled Water Pump (Primary and	14.9 W/ kWr with VFD on
Condenser Water Pump	14.6 W/ kWr
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 Super-ECBC Buildings shall have additional VFD installed in the cooling towers.

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

Equipment type	*Rating*	*Efficiency*

Open circuit cooling tower Fans	35°C entering water 29°C leaving water 24°C WB	0.017 kW/kWr *0.31 kW/ L/s*

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 Super-ECBC building

Equipment	*Sub*	*Size*	*Minimum*
Boilers,	Gas or oil	All	85%
FUE - fuel utilization efficiency			

5.3.5. ECONOMIZERS

5.3.5.1. Economizer for ECBC, ECBC+, and Super-ECBC Building

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

An air-economizer capable of modulating outside-air, and return-air dampers to supply 50% of the design supply air quantity as outside-air

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 Section-5.3.5.1:

Projects in warm-humid climate zones.

Projects with only daytime occupancy in the hot-dry.

Individual cooling or heating fan systems less than 3,200 liters per second.

5.3.5.2. Partial Cooling

Where required by Section-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

That allows dampers to be sequenced with the mechanical cooling equipment and not be controlled by only mixed air temperature.

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.

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 Section-12 Appendix C to ensure proper operation.

Exception to Section-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 Section-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 Section-5.3.6.1 or Section-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 kWr

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

Cooling Capacity	Water Cooled	Air Cooled
≤ 10	NA	BEE 4 Star
> 10	3.7 EER	3.2 EER

Table 5-22 Minimum Requirements for Unitary, Split, Packaged Air Conditioners in Super-ECBC Building

Cooling Capacity (kWr)	Water Cooled	Air Cooled
≤ 10	NA	BEE 5 Star
>10	3.9 EER	EER

5.3.8. CONTROLS FOR ECBC+ AND SUPER-ECBC BUILDINGS

ECBC+ building shall comply with requirements of Section-5.3.8 in addition to complying

with requirements of Section-5.2.3.

5.3.8.1. Centralized Demand Shed Controls

ECBC+ and Super-ECBC Buildings with built up area greater than 20,000 m^2 shall have a building management system. All mechanical cooling and heating systems in ECBC+ and Super-ECBC 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 Super-ECBC 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 Section- 5.3.8.2 : ECBC+ and Super-ECBC Buildings in warm humid climate zone.

5.3.8.3. Chilled Water Temperature Reset

Chilled water systems with a design capacity exceeding 350 kWr supplying chilled water to comfort conditioning systems in ECBC+ and Super-ECBC 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 Section-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 SUPER-ECBC BUILDINGS

Super-ECBC Buildings shall comply with requirements of Section-5.3.9 in addition to complying with requirements of Section-5.2.3 and Section-5.3.8.

5.3.9.1. Variable Air Volume Fan Control

Fans in Variable Air Volume (VAV) systems in Super-ECBC 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^2.

5.3.11. SERVICE WATER HEATING

For compliance with ECBC+ and Super-ECBC,

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.

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 Section-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.

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

Water Cooled Chilled	*Maximum Threshold (kW/kWr)*
ECBC	0.26
ECBC+	0.23
Super-ECBC	0.20

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

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 (kWhr)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) 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 of the Proposed Design.

g) Explanation of any significant modeling assumptions made.

h) Explanation of any error messages noted in the simulation program output.

i) The total system efficiency shall be calculated as, Total System Efficiency = Chilled water plant use (kWh) / Chilled water use (kWhr)

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 Section-5.2.2, but shall comply with all other applicable mandatory provisions of Section-5.2 as applicable. Wherever applicable, requirements of Section-5.3 and Section-5.3.12 will be complied with. The approved list of low energy comfort systems[1] 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

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 Section- 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 Super-ECBC building standard prescribed in Section-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 Section-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 AND CONTROLS

6.1 GENERAL

Lighting systems and equipment shall comply with the mandatory provisions of Section-6.2 and the prescriptive criteria of Section- 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 Section-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 m2 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 m2 and not more than one floor, or

ii. Occupancy sensors that shall turn-off the lighting fixtures, within 15-minutes as occupant will leave from 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 m2 BUA, in

a) All habitable spaces less than 30 m2, enclosed by walls or ceiling height partitions.

b) All storage or utility spaces more than 15 m2.

c) Public toilets more than 25 m2, 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 m2 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 rooms and meeting rooms

Exception to Section- 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 m2 for a space less than or equal to 1,000 m2, and a maximum of 1,000 m2 for a space greater than 1,000 m2

b) have the capability to override the shutoff control required in Section- 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 Section-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) Luminaries, installed within day lighting extent from the window as calculated in Section-4.2.3, shall be equipped with either a manual control device to shut off luminaries, installed within day lit area, during potential daylight 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 luminaries is controlled by a motion sensor or exempt under Section-6.1.

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

Exemption to Section-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 m2 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 luminaries 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 luminaries or be controlled by a wall-mounted control device provided the control device complies with Section-6.2.1.2.

d) Non-visual Lighting. Lighting for non-visual 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 Section-6.3.4 and shall not exceed the interior lighting power allowance determined in accordance with either Section-6.3.2 or Section-6.3.3.

Exception to Section-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 Super-ECBC 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^2)	***Building Area Type***	***LPD*** (W/m^2)
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 Type	***LPD*** (W/m^2)	***Building Area Type***	***LPD*** (W/m^2)
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 Super-ECBC Buildings – Building Area Method

Building Type	***LPD*** (W/m^2)	***Building Area Type***	***LPD*** (W/m^2)
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:

a) 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 Super-ECBC Buildings. In cases where both a common space type and building specific space

type are listed, building specific space type LPD shall apply.

b) 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.

c) 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^2)*	*Lamp category*	*LPD (W/m^2)*
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 (covered/ basement)	2.2	Parking Driveways (covered/ 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/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 Theatre	9.6	Bar Lounge/ Dining	14.1
Educational			
Classroom/Lecture	13.7	Card File and	9.1
For Classrooms	13.8	Stacks (Lib)	18.3
Laboratory	15.1	Reading Area (Library)	10.0
Assembly			
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	16.4
Museum -General	16.4	Playing Area -	18.8
Museum - Restoration	18.3		

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

Category	*LPD (W/m^2)*	*Lamp category*	*LPD (W/m^2)*
Common Space Types			
Restroom	6.1	Stairway	4.4
Storage	5.4	Corridor/Transition	3.6
Conference/ Meeting	9.2	Lobby	7.3
Parking Bays (covered/ basement)	1.8	Parking Driveways (covered/ basement)	2.5
Electrical/Mechanical	5.7	Workshop	13.7
Business			
Enclosed	8.6	Open Plan	8.6
Banking Activity Area	9.3	Service/Repair	5.5
Healthcare			
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		
Hospitality			
Hotel Dining	7.3	Hotel Lobby	8.8
For Bar Lounge/	11.3	Motel Dining	7.3
For food preparation	12.1	Motel Guest Rooms	6.1
Hotel Guest Rooms	7.3		
Shopping Complex			
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
Educational			
Classroom/Lecture	10.9	Card File and	7.3
For Classrooms	11.0	Stacks (Library)	14.6
Laboratory	12.1	Reading Area (Library)	9.2
Assembly			
Dressing Room	7.3	Seating Area -	18.1
Exhibit Space - Convention	11.2	Lobby - Performing Arts	17.2
Seating Area - Gymnasium	3.6	Seating Area – Convention	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 Super-ECBC Buildings – Space Function Method

Category	*LPD (W/m^2)*	*Lamp category*	*LPD (W/m^2)*
Common Space			

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
Business			
Enclosed	5.4	Open Plan	5.4
Banking Activity Area	5.8	Service/Repair	3.4
Healthcare			
Emergency	11.4	Recovery	4.4
Exam/Treatment	6.8	Storage	2.7
Nurses' Station	5.0	Laundry/Washing	3.8
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		
Hospitality			
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		
Shopping Complex			
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
Educational			
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
Assembly			
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	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^2. 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.

Space Function	LPD (W/ m^2)	Area	Lighting Power Allowance (W)
Office			
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/	7.1	14	99
Staircase	5.5	84	462
Total			26,118
Retail			
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 Section-6.3 shall include all power used by the luminaires, including lamps, ballasts, current regulators, and control devices except as specifically exempted in Section-6.1.

Exception to Section-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 bus-way, 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 Super-ECBC Buildings. Trade-offs between applications are not permitted.

Table 6-7 Exterior Building Lighting Power for ECBC Buildings

Exterior lighting application	**Power limits**
Building entrance (with canopy)	10 W/m^2 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^2 of vertical façade area
Emergency signs, ATM kiosks, Security areas façade	1.0 W/m^2
Driveways and parking (open/ external)	1.6 W/m^2
Pedestrian walkways	2.0 W/m^2
Stairways	10.0 W/m^2
Landscaping	0.5 W/m^2
Outdoor sales area	9.0 W/m^2

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

Exterior lighting application	**Power limits**
Building entrance (with canopy)	8.0 W/m^2 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^2 of vertical façade area
Emergency signs, ATM kiosks, Security areas façade	0.8 W/m^2
Driveways and parking (open/ external)	1.3 W/m^2
Pedestrian walkways	1.6 W/m^2
Stairways	8.0 W/m^2
Landscaping	0.4 W/m^2
Outdoor sales area	7.2 W/m^2

Table 6-9 Exterior Building Lighting Power for Super-ECBC Buildings

Exterior lighting application	**Power limits**
Building entrance (with canopy)	5.0 W/m^2 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^2 of vertical façade area
Emergency signs, ATM kiosks, Security areas façade	0.5 W/m^2
Driveways and parking (open/ external)	0.8 W/m^2
Pedestrian walkways	1.0 W/m^2
Stairways	5.0 W/m^2
Landscaping	0.25 W/m^2
Outdoor sales area	4.5 W/m^2

6.3.6. CONTROLS FOR ECBC+ AND SUPER-ECBC BUILDINGS

ECBC+ and Super-ECBC Buildings shall comply with requirements of Section- 6.3.6 in addition to complying with requirements of Section- 6.2.

6.3.6.1. Centralized Controls

ECBC+ and Super-ECBC 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 Super-ECBC Buildings respectively, unless the luminaries is controlled by a motion sensor or exempt under Section-6.1.

7. ELECTRICAL AND RENEWABLE ENERGY SYSTEMS

7.1 GENERAL

All electric and renewable energy equipment and systems shall comply with the mandatory requirements of Section-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 kVA	Max. Losses at 50% loading W*	Max. Losses at 100% loading W*	Max. Losses at 50% loading W*	Max. Losses at 100% loading 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		Super-ECBC 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	1,08	3,214	951	2,994
500	4.5	1,510	4,300	1,35	3,909	1,215	3,554
630	4.5	1,860	5,300	1,63	4,438	1,441	3,717
1,000	5	2,790	7,700	2,46	6,364	2,170	5,259
1,250	5	3,300	9,200	3,14	7,670	2,991	6,394
1,600	6.25	4,200	11,800	3,75	10,821	3,353	9,924
2,000	6.25	5,050	15,000	4,54	13,254	4,088	11,711
2,500	6.25	6,150	18,500	5,66	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.

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. Super-ECBC 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^2 BUA shall have:

a) minimum 3 stars rating in ECBC Buildings

b) minimum 4 stars rating in ECBC+ Buildings

c) stars rating in Super-ECBC 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.

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

Table 7-3 Sub-metering 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	Façade lighting
Shopping	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 Super-ECBC building

7.2.6. POWER DISTRIBUTION SYSTEM

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 Super-ECBC 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.

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) A dedicated REGZ area of 20% of total connected load of the building (*If not possible then building owner have to submit necessary justification; and needs to provide RE system on at least 25% of non-shaded roof area)

b) The REGZ shall be free of any obstructions within its boundaries and from shadows cast by objects adjacent to the zone

c) ECBC+ and Super-ECBC building shall fulfill the additional requirements listed in Table 7-5 and Table 7-6 respectively

Table 7-5 Minimum Solar Zone Area/Renewable Energy Generating Zone Requirement for ECBC+ Building

Building Type	*Minimum Electricity to be Generated in REGZ
All building types except below	Minimum 25% of total electrical connected load
Star Hotel > 20,000 m^2 Resort > 12,500 m^2 University > 20,000 m^2 Business >20,000 m^2	Minimum 30% of total electrical connected load

* If not possible then building owner have to submit necessary justification; and needs to provide RE system on at least 40% of non-shaded roof area

Table 7-6 Minimum Solar Zone Area/Renewable Energy Generating Zone Requirement for Super-ECBC Building

Building Type	Minimum Electricity to be Generated in REGZ
All Building types except below	Minimum 35% of total electrical connected load
Star Hotel > 20,000 m^2 Resort > 12,500 m^2 University > 20,000 m^2 Business >20,000 m^2	Minimum 40% of total electrical connected load

* If not possible then building owner have to submit necessary justification; and needs to provide RE system on at least 60% of non-shaded roof area

7.2.9. 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.

7.2.10. Demarcation 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, 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 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;

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.

$$AWA = \Sigma(DatapointXarea) \,/\, Total\ area$$

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

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.

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

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:

Building envelope, exterior: the elements of a building that separate conditioned spaces from the exterior

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

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 which are also known by the first letters: N,S,E, and W.

Carpet area: net area measured between external walls, from the inner faces of walls. Thickness of internal or partition walls is excluded.

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

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.)

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

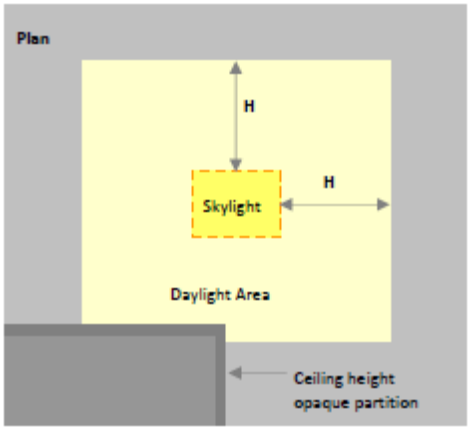
Cool roof: roof with top layer of material that has high solar reflectance and high thermal emittance properties. Cool roof surfaces are characterized by light colors so that heat can be rejected back to the environment.

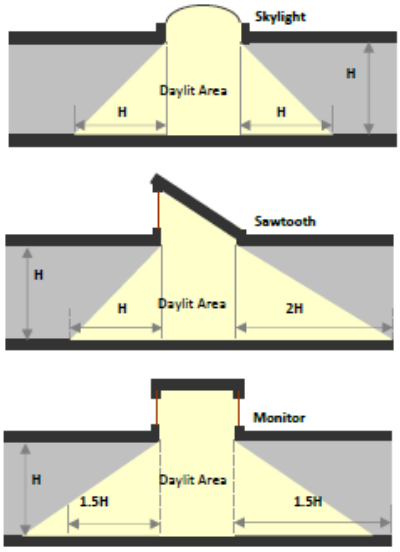
Cumulative design EPI: energy performance index for a building having two or more different functional uses and calculated based on the area weighted average (AWA) method

D

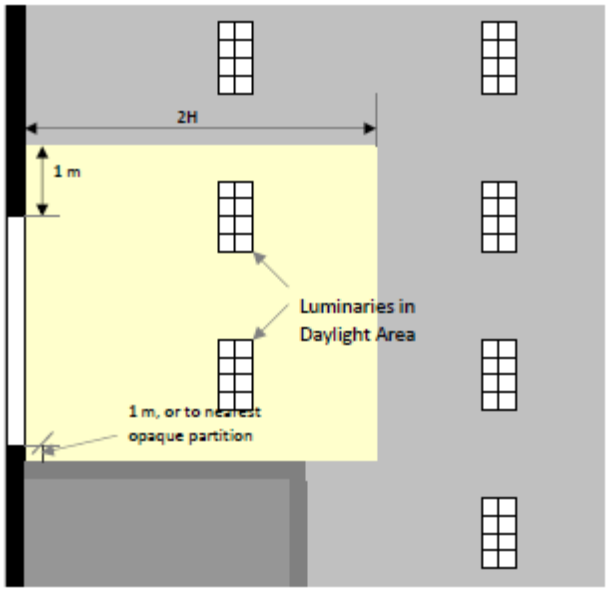
Daylight area: the daylight illuminated floor area under horizontal fenestration (skylight) or adjacent to vertical fenestration (window), described as follows:

Horizontal Fenestration: the area under a skylight, monitor, or saw-tooth 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 saw-tooth 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.





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.

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

Daytime Business Building: Business building operated typically only during daytime on weekday's up-to 12 hours each day.

Dead-band: 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 used for transition of human or utilities, in the building envelope, including swinging and roll-up doors, fire doors, and access hatches. For the purposes of determining building envelope requirements, the door types are defined as follows:

Door, non-swinging: roll-up sliding, and all other doors that are not swinging doors.

Door, swinging: all operable opaque panels with hinges on one side and opaque revolving

doors.

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 Section-4 to Section-7 and also complies either with the prescriptive requirements stated under the ECBC Building categories of Section-4 to Section-7, or, with the whole building performance compliance method of Section-9.

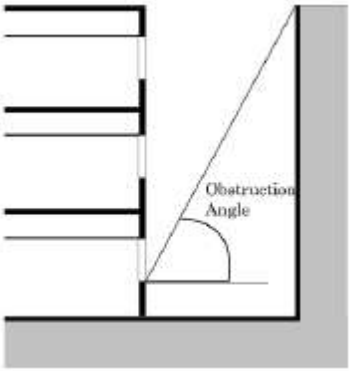
ECBC+ Building: a building that complies with the mandatory requirements of Section-4 to Section-7 and also complies either with the prescriptive requirements stated under the ECBC+ Building categories of Section-4 to Section-7, or, with the whole building performance compliance method of Section-9.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

Effective aperture: Visible Light Transmittance x window-to-wall Ratio. (EA = VLT x WWR)

Effective aperture, horizontal fenestration: a measure of the amount of daylight that enters a space through horizontal fenestration (skylights). It is the ratio of the skylight area times the visible light transmission divided by the gross roof area above the daylight area. See also daylight area.

Effective aperture, vertical fenestration: a measure of the amount of daylight that enters a space through vertical fenestration. It is the ratio of the daylight window area times its visible light transmission plus half the vision glass area times its visible light

transmission and the sum is divided by the gross wall area. Daylight window area is located 2.2 m or more above the floor and vision window area is located above 1 m but below 2.2 m. The window area, for the purposes of determining effective aperture shall not include windows located in light wells when the angle of obstruction (α) of objects obscuring the sky dome is greater than 70^{o}, measured from the horizontal, nor shall it include window area located below a height of 1 m. See also daylight area.



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

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 Conservation Building Code (ECBC): the Energy Conservation Building Code as updated from time to time by the Bureau

Energy Efficiency Ratio (EER): the ratio of net cooling capacity in kW to total rate of electric input in kiloWatts 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 4.3.6. For the

purposes of determining building envelope requirements the classifications are defined as follows:

Standard Building EPF: envelope performance factor calculated for the Standard Building using prescriptive requirements for walls, vertical fenestrations and roofs

Proposed Building EPF: the building envelope performance factor for the Proposed Building using proposed values for walls, vertical fenestrations and roofs

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 Section-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 is 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.

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.

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

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.

Heat capacity: amount of heat necessary to raise the temperature of a given mass by 1°C. Numerically, the heat capacity per unit area of surface ($W/m^2.K$) is the sum of the products of the mass per unit area of each individual material in the roof, wall, or floor surface multiplied by its individual specific heat.

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), the nominal system voltage (kilovolts), and 1.732 for three-phase configuration. For single-phase configuration, 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.

KiloWattHour (kWh): the basic unit of electrical energy, equal to energy consumed by one-kiloWatt system in one hour

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 generic term for man-made light source often called bulb or tube

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.

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 luminaries circuited or controlled to perform a specific function.

Lighting power allowance:

Interior lighting power allowance: the maximum lighting power in watts allowed for the interior of a building

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.

Luminous Efficacy (LE): total luminous flux (visible light) emitted from a lamp or lamp/ballast combination divided by input power, expressed in lumens per Watt.

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.

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, and can accommodate various physical processes at a time, as the insulation and thermal inertia.

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.

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.

Over-current: 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 Section- 5, Section- 6, Section- 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.

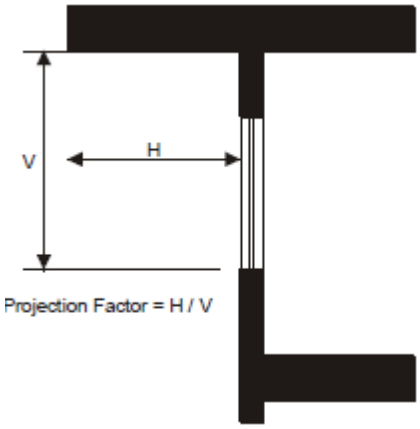
Potential daylit time: amount of time in a day when there is daylight to light a space adequately without using artificial lighting. Potential daylit time is fixed for 8 hours per day i.e. from 09:00 AM to 5:00 PM local time, resulting 2920 hours in total for all building types except for Type E-1 - 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: 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, side fin: 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, 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 forcirculation is either natural (due to water density variations with temperature) or mechanical (recirculation pump).

Reflectance: ratio of the light or radiation reflected by a surface to the light or radiation incident upon it.

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 –

Includes 1 or more recreation(s) facility like spa, swimming pool, or any sport;

Is located in the midst of natural and picturesque surroundings outside the city;

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

Selectivity ratio of a glass: ratio between light transmission and solar factor of glass.

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.

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.

Soft water: water that is free from dissolved salts of metals such as calcium, iron, or magnesium, which form insoluble deposits on surfaces. These deposits appear as scale in boilers or soap curds in bathtubs and laundry equipment.

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 retransferred through radiation, conduction, or convection into the space.

Space: an enclosed area within a building. The classifications of spaces are as follows for purpose of determining building envelope requirements:

Conditioned space: a cooled space, heated space, or directly conditioned space.

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 W/m^2 but is not a conditioned space.

Non-conditioned space: an enclosed space within a building that is not conditioned space or a semi-heated space. Crawlspaces, 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.

Storey: 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 storey.

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 (W/m^2) or kilowatt-hours per square meter per day ($kW*h/ (m^2*day)$) (or hours/day).

Super-ECBC B**uilding:** a building that complies with the mandatory requirements of Section-4 to Section-7 and also complies either with the prescriptive requirements stated under the Super-ECBC Building categories of Section-4 to Section-7, or, with the whole building performance compliance method of Section-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 form 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 reduce 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.

Universities and all others coaching/training institutions (Educational): a building or a group of buildings, under single management, used for imparting education to students.

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.

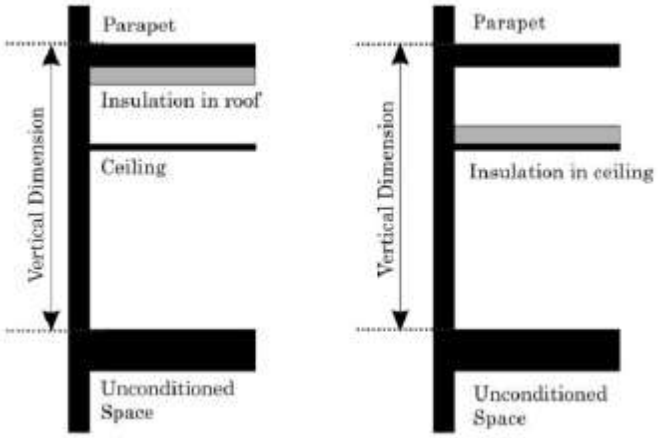
W

Wall: that portion of the building envelope, including opaque area and fenestration, that is vertical or tilted at an angle of 60° from horizontal or greater. This includes above- and below-grade walls, between floor spandrels, peripheral edges of floors, and foundation walls.

Wall, above grade: a wall that is not below grade

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 service 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-storey 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^2	10.76 ft^2
1 W/m^2	10.76 W/ ft^2
1 W/ lin m	3.28 W/ ft
1 $W/m^2.K$	5.678 Btu/ h-ft^2-°F
1 W/ l-s^{-1}	0.063 W/ gpm
1 m^2.K/W	0.1761 ft^2-h-ºF/ Btu
1 ºC	((ºC X 9/5) + 32) ºF
1 kW_r	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-
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-	British thermal units per hour per square foot per degree
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
$h\text{-}ft^2\text{-}$	hour per square foot per degree Fahrenheit per British
$h\text{-}m^2\text{-}$	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
kWr	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^2	square meter
$m^2.K/W$	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
$W/l\text{-}s^{-1}$	watt per litre per second
W/m^2	watts per square meter
$W/m^2.K$	watts per square meter per Kelvin
W/m^2	watts per hour per square meter
W/m.K	watts per lineal meter per Kelvin
Wh	watthour

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 Section-4 through Section-7 of this Code. It applies to all building types covered by the Code as mentioned in Section-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 Section-4 trough Section-7. The mandatory requirements of Section-4 through Section-7 (Section-4.2, Section-5.2, Section-6.2, and Section-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 mega joule.

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 behavior, 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 Section-4.2, Section-5.2, Section-6.2, and Section-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 REQUIREMENT

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 Section-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 Modeling Requirements for Calculating Proposed and Standard Design

Case	*Proposed Design*	*Standard Design*
1. Design Model	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. 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 they minimally comply with applicable mandatory and prescriptive requirements of Section-4.2, Section-5.2 , Section-6.2, and Section-7.2 and Section-4.3, Section-5.3, and Section-6.3 respectively.	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.
2. Space Use Classification	The building type or space type classifications shall be chosen in accordance with Section-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. 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 Section-9.6. In case a schedule for an occupancy type is missing in Section-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. 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. Building 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. 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. 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. c) For exterior roofs, other than roofs with ventilated attics, the reflectance and emittance of the roof surface shall be modeled in accordance with Section-4.3.1.1. d) Manually operated fenestration shading devices such as blinds or shades shall not be modeled. Permanent shading devices such as fins, overhangs, and light shelves shall be modeled. 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	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), and (d) below. 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. b) Opaque assemblies such as roof, floors, doors, and walls shall be modeled as having the same heat capacity as the Proposed Design but with the maximum U-factor allowed in Section-4.3.1 and Section-4.3.1.1. 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 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. d) Roof Solar Reflectance and Thermal Emittance: The exterior roof surfaces shall be modeled using a solar reflectance of 0.6 and a thermal emittance of 0.9.

	respectively. Where cool roof is not proposed, the exterior roof surface shall be modeled with a reflectance of 0.3 and a thermal emittance of 0.9.	
5. Lighting	Lighting power in the Proposed Design shall be determined as follows: Where a complete lighting system exists, the actual lighting power shall be used in the model. Where a lighting system has been designed, lighting power shall be determined in accordance with either Section-6.3.4. Where no lighting exists, or is specified, lighting power shall be determined in accordance with the Section-6.3.2 or Section-6.3.3 for the appropriate building type. Lighting system power shall include all lighting system components shown or provided for on plans (including lamps, ballasts, task fixtures, and furniture-mounted fixtures). Lighting power for parking garages and building facades shall be modeled. Minimum Lighting controls, as per the ECBC requirements of Section-6.2.1, shall be modeled in the Proposed case. Automatic day-lighting controls shall be modeled directly in the software or through schedule adjustments determined by a separate daylight analysis approved by the authority having jurisdiction. Other automatic lighting controls shall be modeled directly in the software by adjusting the lighting power as per Table 9-4.	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 Section-6.3.2 or Section-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 Section-6.2.1.

6. HVAC Thermal Zones	HVAC Zones Designed: Where HVAC zones are defined on design drawings, each HVAC zone shall be modeled as a separate thermal block. 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. 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: 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.	Same as Proposed Design

7. HVAC Systems	The HVAC system type and all related performance parameters, such as equipment capacities and efficiencies, in the Proposed Design shall be determined as follows: a) Where a complete HVAC system exists, the model shall reflect the actual system type using actual component capacities and efficiencies. 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 Section-5, if required by the simulation model. 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. d) Where no cooling system has been specified, the cooling system and its characteristics shall be identical to the system modeled in the Standard Design.	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 Section-9.4.2. Equipment performance shall meet the requirements of Section-5 for code compliant building.

8. Service Hot Water	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: a) Where a complete service hot water system exists, the model shall reflect the actual system type using actual component capacities and efficiencies. b) Where a service hot water system has been designed, the service hot water model shall be consistent with design documents. c) Where no service hot water system exists, or is specified, no service hot water heating shall be modeled.	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 Section-5.2.9.2, the pipe insulation requirements of Section-5.2.9.4 and incorporate heat traps in accordance with Section-5.2.9.5.
9. Miscellaneous Loads	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.	Receptacle, motor and process loads shall be modeled the same as the Proposed Design.

10. Modeling Limitations to the Simulation Program	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: a) Ignore the component if the energy impact on the trade-offs being considered is not significant. b) Model the component substituting a thermodynamically similar component model. c) Model the HVAC system components or systems using the HVAC system of the Standard Design in accordance with Section 6 of this table. d) Whichever method is selected, the component shall be modeled identically for both the Proposed Design and Standard Design models.	Same as Proposed Design.

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[#1]	Buildings with Less than or Equal to 12,500 m² of Conditioned Area	Buildings with More than 12,500 m² of Conditioned Area	Data Centre/ Server/ Computer Rooms
Name	System A	System B	System C	System D

System Type[#2]	Split AC	VRF : Variable Refrigerant Flow	VAV: Central cooling plant with variable volume AHU[#3]	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 2. Fossil Fuel Boiler: 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 2. Fossil Fuel Boiler: 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 2. Fossil Fuel Boiler: 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^2 of conditioned floor area. Use additional system type for non-predominant conditions if those conditions apply to more than 1,000 m^2 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

Automatic Control Device	*Daytime occupancy and area <300 m^2*	*All Others*
Programmable Timing Control	10%	0%
Occupancy Sensor	10%	10%
Occupancy Sensor and Programmable	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.

b) Exception to Section- 9.4.2(a): Where there are specific requirements in Section-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.

c) 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 Section-5.2.2.

d) 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.

e) Minimum outdoor air ventilation rates shall be the same for both the Standard Design and the Proposed Design except for conditions specified in Section-9.4.2.1.

f) 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.

g) 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 Section-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 x .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

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 Section-5.3.5.

Exception to Section-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 Section-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 (kWr)	*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_r

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 Section-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-1.

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:

- For System Type C; purchased chilled water shall be modeled as the cooling source.
- 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. (Where, 1 ton hour = 0.85 kWh; 1 MBtu = 1,000,000 Btu = 293 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 Section-9.4.2.7 to Section-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 SUPER-ECBC BUILDINGS

For buildings to qualify as ECBC+ and Super-ECBC Buildings, the WBP Method shall be followed for the Standard Design as detailed above. The Proposed Design for ECBC+ and Super-ECBC Buildings shall meet the mandatory provisions of Section-4.2, Section-5.2, Section-6.2, and Section-7.2.

The EPI Ratio for ECBC+ and Super-ECBC 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 Section-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+	Super-ECBC
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+**	**Super-ECBC**
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

9.6 SCHEDULES

Table 9-7 Schedules for Business Buildings

Business								
Time Period	Occupancy Schedule		Lighting Schedule		Equipment Schedule		Elevator Schedule	
	Daytime Business	24 Hour Business	Daytime Business	24 Hour Business	Daytime Business	24 Hour Business	Daytime Business	24 Hour Business
00:00-01:00	0.00	0.90	0.05	0.90	0.00	0.95	0.05	0.55
01:00-02:00	0.00	0.90	0.05	0.90	0.00	0.95	0.05	0.25
02:00-03:00	0.00	0.90	0.05	0.90	0.00	0.95	0.05	0.25
03:00-04:00	0.00	0.90	0.05	0.90	0.00	0.95	0.05	0.15
04:00-05:00	0.00	0.50	0.05	0.50	0.00	0.00	0.05	0.35
05:00-06:00	0.00	0.20	0.05	0.05	0.00	0.00	0.05	0.50
06:00-07:00	0.00	0.10	0.10	0.05	0.00	0.00	0.20	0.20
07:00-08:00	0.10	0.10	0.30	0.90	0.00	0.95	0.40	0.40
08:00-09:00	0.20	0.90	0.90	0.90	0.10	0.95	0.80	0.80
09:00-10:00	0.95	0.90	0.90	0.90	0.90	0.95	0.80	0.80
10:00-11:00	0.95	0.90	0.90	0.90	0.90	0.95	0.55	0.55
11:00-12:00	0.95	0.90	0.90	0.90	0.90	0.95	0.35	0.35
12:00-13:00	0.95	0.90	0.90	0.90	0.90	0.95	0.25	0.25
13:00-14:00	0.50	0.20	0.50	0.50	0.80	0.20	0.95	0.95
14:00-15:00	0.95	0.90	0.90	0.90	0.90	0.95	0.95	0.95
15:00-16:00	0.95	0.90	0.90	0.90	0.90	0.95	0.35	0.35
16:00-17:00	0.95	0.90	0.90	0.90	0.90	0.95	0.15	0.35
17:00-18:00	0.95	0.90	0.95	0.90	0.90	0.95	0.75	0.70
18:00-19:00	0.30	0.90	0.50	0.90	0.50	0.20	0.95	0.95
19:00-20:00	0.10	0.20	0.30	0.90	0.10	0.95	0.50	0.50
20:00-21:00	0.10	0.90	0.30	0.90	0.10	0.95	0.30	0.35
21:00-22:00	0.10	0.90	0.20	0.90	0.00	0.95	0.20	0.25
22:00-23:00	0.00	0.90	0.10	0.90	0.00	0.95	0.05	0.25
23:00-24:00	0.00	0.90	0.05	0.90	0.00	0.20	0.05	0.55

Table 9-8 Schedules for Assembly Buildings

Assembly								
Time Period	Occupancy Schedule	Lighting Schedule	Equipment Schedule	Elevator Schedule	HVAC Fan Schedule (On/Off)	External Lighting Schedule	Basement Ventilation	Basement Lighting
00:00-01:00	0.00	0.00	0.00	0.00	0	0.80	0.00	0.80
01:00-02:00	0.00	0.00	0.00	0.00	0	0.80	0.00	0.10
02:00-03:00	0.00	0.00	0.00	0.00	0	0.80	0.00	0.10
03:00-04:00	0.00	0.00	0.00	0.00	0	0.80	0.00	0.10
04:00-05:00	0.00	0.00	0.00	0.00	0	0.80	0.00	0.10
05:00-06:00	0.00	0.00	0.00	0.00	0	0.80	0.00	0.10
06:00-07:00	0.00	0.00	0.00	0.00	0	0.00	0.00	0.10
07:00-08:00	0.00	0.00	0.00	0.00	0	0.00	0.00	0.10
08:00-09:00	0.20	0.40	0.30	0.20	0	0.00	1.00	0.80
09:00-10:00	0.20	0.75	0.50	0.50	1	0.00	1.00	0.80
10:00-11:00	0.20	0.95	0.95	0.50	1	0.00	1.00	0.80
11:00-12:00	0.80	0.95	0.95	0.50	1	0.00	1.00	0.80
12:00-13:00	0.80	0.95	0.95	0.50	1	0.00	1.00	0.80
13:00-14:00	0.80	0.95	0.95	0.50	1	0.00	1.00	0.80
14:00-15:00	0.80	0.95	0.95	0.50	1	0.00	1.00	0.80
15:00-16:00	0.80	0.95	0.95	0.50	1	0.00	1.00	0.80
16:00-17:00	0.80	0.95	0.95	0.50	1	0.00	1.00	0.80
17:00-18:00	0.80	0.95	0.95	0.50	1	0.00	1.00	0.80
18:00-19:00	0.50	0.95	0.50	0.50	1	0.80	1.00	0.80
19:00-20:00	0.20	0.40	0.30	0.40	1	0.80	1.00	0.80
20:00-21:00	0.20	0.40	0.30	0.20	0	0.80	1.00	0.80
21:00-22:00	0.20	0.40	0.30	0.20	0	0.80	1.00	0.80
22:00-23:00	0.10	0.10	0.00	0.00	0	0.80	1.00	0.80
23:00-24:00	0.10	0.10	0.00	0.00	0	0.80	0.00	0.80

Table 9-9 Schedules for Business - Office Buildings

Time Period	HVAC Fan Schedule (On/Off)		External Lighting Schedule	Basement Ventilation		Basement Lighting	
Business - Office	Daytime Business	24 Hours Business	7 Days/ week	Daytime Business	24 Hours Business	Daytime Business	24 Hours Business
00:00-01 00	0	1	0.80	0.00	1.00	0.05	1.00
01:00-02:00	0	1	0.80	0.00	1.00	0.05	1.00
02:00-03:00	0	1	0.80	0.00	1.00	0.05	1.00
03:00-04:00	0	1	0.80	0.00	1.00	0.05	1.00
04:00-05:00	0	1	0.80	0.00	1.00	0.05	1.00
05:00-06:00	0	1	0.80	0.00	1.00	0.05	1.00
06:00-07:00	0	1	0.00	0.00	1.00	0.05	1.00
07:00-08:00	1	1	0.00	0.00	1.00	0.05	1.00
08:00-09:00	1	1	0.00	1.00	1.00	1.00	1.00
09:00-10:00	1	1	0.00	1.00	1.00	1.00	1.00
10:00-11:00	1	1	0.00	1.00	1.00	1.00	1.00
11:00-12:00	1	1	0.00	1.00	1.00	1.00	1.00
12:00-13:00	1	1	0.00	1.00	1.00	1.00	1.00
13:00-14:00	1	1	0.00	1.00	1.00	1.00	1.00
14:00-15:00	1	1	0.00	1.00	1.00	1.00	1.00
15:00-16:00	1	1	0.00	1.00	1.00	1.00	1.00
16:00-17:00	1	1	0.00	1.00	1.00	1.00	1.00
17:00-18:00	1	1	0.00	1.00	1.00	1.00	1.00
18:00-19:00	1	1	0.80	1.00	1.00	1.00	1.00
19:00-20:00	1	1	0.80	1.00	1.00	1.00	1.00
20:00-21:00	1	1	0.80	1.00	1.00	1.00	1.00
21:00-22:00	1	1	0.80	0.00	1.00	0.05	1.00
22:00-23:00	0	1	0.80	0.00	1.00	0.05	1.00
23:00-24:00	0	1	0.80	0.00	1.00	0.05	1.0

Table 9-10 Schedules for Educational - School Buildings (A)

Educational - School						
	Occupancy Schedule		Lighting Schedule		Equipment Schedule	
Time Period	Student Zone	Back Office	Student Zone	Back Office	Student Zone	Back Office
	5 Days/ week	5 Days/ week	5 Days/ week	5 Days/ week	5 Days/ week	5 Days/ week
00:00-01:00	0.00	0.00	0.00	0.00	0.00	0.00
01:00-02:00	0.00	0.00	0.00	0.00	0.00	0.00
02:00-03:00	0.00	0.00	0.00	0.00	0.00	0.00
03:00-04:00	0.00	0.00	0.00	0.00	0.00	0.00
04:00-05:00	0.00	0.00	0.00	0.00	0.00	0.00
05:00-06:00	0.00	0.00	0.00	0.00	0.00	0.00
06:00-07:00	0.00	0.00	0.00	0.20	0.00	0.00
07:00-08:00	0.70	0.00	0.90	0.70	0.35	0.35
08:00-09:00	0.90	0.90	0.90	0.90	0.95	0.95
09:00-10:00	0.90	0.90	0.90	0.90	0.95	0.95
10:00-11:00	0.90	0.90	0.90	0.90	0.95	0.95
11:00-12:00	0.20	0.90	0.20	0.90	0.20	0.95
12:00-13:00	0.90	0.90	0.90	0.90	0.95	0.95
13:00-14:00	0.90	0.20	0.90	0.30	0.95	0.40
14:00-15:00	0.00	0.90	0.00	0.90	0.00	0.95
15:00-16:00	0.00	0.90	0.00	0.90	0.00	0.95
16:00-17:00	0.00	0.90	0.00	0.90	0.00	0.95
17:00-18:00	0.00	0.50	0.00	0.30	0.00	0.25
18:00-19:00	0.00	0.00	0.00	0.10	0.00	0.00
19:00-20:00	0.00	0.00	0.00	0.00	0.00	0.00
20:00-21:00	0.00	0.00	0.00	0.00	0.00	0.00
21:00-22:00	0.00	0.00	0.00	0.00	0.00	0.00
22:00-23:00	0.00	0.00	0.00	0.00	0.00	0.00
23:00-24:00	0.00	0.00	0.00	0.00	0.00	0.0

Table 9-11 Schedules for Educational - School Buildings (B)

Educational - School						
Time Period	Elevator Schedule	HVAC Fan Schedule (On/Off)		External Lighting Schedule	Basement Ventilation	Basement Lighting
		Student Area	Back Office			
	7 Days/ week	5 Days/ week	5 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week
00:00-01:00	0.00	0.00	0.00	0.00	0.00	0.00
01:00-02:00	0.00	0.00	0.00	0.00	0.00	0.00
02:00-03:00	0.00	0.00	0.00	0.00	0.00	0.00
03:00-04:00	0.00	0.00	0.00	0.00	0.00	0.00
04:00-05:00	0.00	0.00	0.00	0.00	0.00	0.00
05:00-06:00	0.00	0.00	0.00	0.00	0.00	0.00
06:00-07:00	0.00	0.00	0.00	0.20	0.00	0.00
07:00-08:00	0.70	0.00	0.90	0.70	0.35	0.35
08:00-09:00	0.90	0.90	0.90	0.90	0.95	0.95
09:00-10:00	0.90	0.90	0.90	0.90	0.95	0.95
10:00-11:00	0.90	0.90	0.90	0.90	0.95	0.95
11:00-12:00	0.20	0.90	0.20	0.90	0.20	0.95
12:00-13:00	0.90	0.90	0.90	0.90	0.95	0.95
13:00-14:00	0.90	0.20	0.90	0.30	0.95	0.40
14:00-15:00	0.00	0.90	0.00	0.90	0.00	0.95
15:00-16:00	0.00	0.90	0.00	0.90	0.00	0.95
16:00-17:00	0.00	0.90	0.00	0.90	0.00	0.95
17:00-18:00	0.00	0.50	0.00	0.30	0.00	0.25
18:00-19:00	0.00	0.00	0.00	0.10	0.00	0.00
19:00-20:00	0.00	0.00	0.00	0.00	0.00	0.00
20:00-21:00	0.00	0.00	0.00	0.00	0.00	0.00
21:00-22:00	0.00	0.00	0.00	0.00	0.00	0.00
22:00-23:00	0.00	0.00	0.00	0.00	0.00	0.00
23:00-24:00	0.00	0.00	0.00	0.00	0.00	0.0

Table 9-12: Schedules for Educational - University Buildings (A)

Educational - University									
Time Period	Occupancy Schedule			Lighting Schedule			Equipment Schedule		
	Student Zone	Back Office	Library & Computer Centre	Student Zone	Back Office	Library & Computer Centre	Student Zone	Back Office	Library & Computer Center
	5 Days/ week	5 Days/ week	7 Days/ week	5 Days/ week	5 Days/ week	7 Days/ week	5 Days/ week	5 Days/ week	7 Days/ week
00:00-01:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10
01:00-02:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10
02:00-03:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10
03:00-04:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10
04:00-05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10
05:00-06:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10
06:00-07:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10
07:00-08:00	0.40	0.00	0.00	0.90	0.00	0.00	0.35	0.35	0.10
08:00-09:00	0.90	0.90	0.30	0.90	0.90	0.90	0.95	0.95	0.70
09:00-10:00	0.90	0.90	0.40	0.90	0.90	0.90	0.95	0.95	0.70
10:00-11:00	0.90	0.90	0.50	0.90	0.90	0.90	0.95	0.95	0.70
11:00-12:00	0.90	0.90	0.50	0.90	0.90	0.90	0.95	0.95	0.70
12:00-13:00	0.90	0.90	0.50	0.90	0.90	0.90	0.95	0.95	0.70
13:00-14:00	0.10	0.20	0.20	0.60	0.30	0.20	0.20	0.40	0.70
14:00-15:00	0.90	0.90	0.50	0.90	0.90	0.90	0.95	0.95	0.70
15:00-16:00	0.90	0.90	0.50	0.90	0.90	0.90	0.95	0.95	0.70
16:00-17:00	0.90	0.90	0.50	0.90	0.90	0.90	0.95	0.95	0.70
17:00-18:00	0.40	0.00	0.50	0.90	0.50	0.90	0.95	0.10	0.80
18:00-19:00	0.00	0.00	0.60	0.00	0.00	0.90	0.00	0.10	0.80
19:00-20:00	0.00	0.00	0.60	0.00	0.00	0.90	0.00	0.10	0.80
20:00-21:00	0.00	0.00	0.60	0.00	0.00	0.90	0.00	0.10	0.80
21:00-22:00	0.00	0.00	0.60	0.00	0.00	0.90	0.00	0.10	0.80
22:00-23:00	0.00	0.00	0.60	0.00	0.00	0.90	0.00	0.10	0.80

Table 9-13 Schedules for Educational - University Buildings (B)

University								
Time Period	Elevator Schedule		HVAC Fan Schedule (On/Off)			External Lighting Schedule	Basement Ventilation	Basement Lighting
	Library & Comp. Centre	Student and Back	Student Area	Back Office	Library & Comp. Centre			
	7 days/ week	7 days/ week	5 days/ week	5 days/ week	7 days/ week	7 days/ week	7 days/ week	7 days/ week
00:00-01:00	0.00	0.00	0	0	0	0.80	0.00	0.05
01:00-02:00	0.00	0.00	0	0	0	0.80	0.00	0.05
02:00-03:00	0.00	0.00	0	0	0	0.80	0.00	0.05
03:00-04:00	0.00	0.00	0	0	0	0.80	0.00	0.05
04:00-05:00	0.00	0.00	0	0	0	0.80	0.00	0.05
05:00-06:00	0.00	0.00	0	0	0	0.80	0.00	0.05
06:00-07:00	0.00	0.05	0	0	0	0.00	0.00	0.05
07:00-08:00	0.00	0.25	1	1	1	0.00	0.00	0.05
08:00-09:00	0.50	0.85	1	1	1	0.00	1.00	1.00
09:00-10:00	0.50	0.25	1	1	1	0.00	1.00	1.00
10:00-11:00	0.30	0.25	1	1	1	0.00	1.00	1.00
11:00-12:00	0.20	0.25	1	1	1	0.00	1.00	1.00
12:00-13:00	0.20	0.25	1	1	1	0.00	1.00	1.00
13:00-14:00	0.40	0.90	1	1	1	0.00	1.00	1.00

14:00-15:00	0.30	0.60	1	1	1	0.00	1.00	1.00
15:00-16:00	0.30	0.25	1	1	1	0.00	1.00	1.00
16:00-17:00	0.30	0.25	1	1	1	0.00	1.00	1.00
17:00-18:00	0.50	0.90	1	0	1	0.00	1.00	1.00
18:00-19:00	0.50	0.15	0	0	1	0.80	1.00	1.00
19:00-20:00	0.50	0.05	0	0	1	0.80	1.00	1.00
20:00-21:00	0.50	0.00	0	0	1	0.80	0.00	0.50
21:00-22:00	0.50	0.00	0	0	1	0.80	0.00	0.05
22:00-23:00	0.50	0.00	0	0	1	0.80	0.00	0.05
23:00-24:00	0.00	0.00	0	0	0	0.80	0.00	0.05

Table 9-14 Schedules for Healthcare - Hospital Buildings (A)

Healthcare – Hospital								
Time Period	Occupancy Schedule				Lighting Schedule			
	In Patient & ICU	Public Spaces	OPD & Offices	Diagnostic, emergen	Public Spaces	In Patient & ICU	Diagnostic, emergen	OPD & Offices
	7 days/ week	7 days/ week	6 days/ week	7 days/ week	7 days/ week	7 days/ week	7 days/ week	6 days/ week
00:00-01:00	0.90	0.00	0.00	0.50	0.10	0.10	0.50	0.05
01:00-02:00	0.90	0.00	0.00	0.40	0.10	0.10	0.50	0.05
02:00-03:00	0.90	0.00	0.00	0.40	0.10	0.10	0.50	0.05
03:00-04:00	0.90	0.00	0.00	0.40	0.10	0.10	0.50	0.05
04:00-05:00	0.90	0.00	0.00	0.40	0.10	0.10	0.50	0.05
05:00-06:00	0.90	0.00	0.00	0.40	0.10	0.10	0.50	0.05
06:00-07:00	0.90	0.00	0.00	0.50	0.10	0.10	0.50	0.10
07:00-08:00	0.90	0.10	0.10	0.70	0.50	0.20	0.50	0.30
08:00-09:00	0.90	0.50	0.30	0.70	0.90	0.20	0.90	0.90
09:00-10:00	0.90	0.95	0.90	0.95	0.90	0.20	0.90	0.90
10:00-11:00	0.90	0.95	0.90	0.95	0.90	0.20	0.90	0.90
11:00-12:00	0.90	0.95	0.50	0.95	0.90	0.20	0.90	0.90
12:00-13:00	0.90	0.95	0.20	0.95	0.90	0.20	0.90	0.90
13:00-14:00	0.90	0.95	0.50	0.95	0.90	0.20	0.90	0.50
14:00-15:00	0.90	0.95	0.90	0.95	0.90	0.20	0.90	0.90
15:00-16:00	0.90	0.95	0.90	0.95	0.90	0.20	0.90	0.90
16:00-17:00	0.90	0.95	0.90	0.95	0.30	0.20	0.90	0.90
17:00-18:00	0.90	0.70	0.90	0.95	0.30	0.70	0.90	0.90
18:00-19:00	0.90	0.50	0.50	0.95	0.30	0.90	0.90	0.50
19:00-20:00	0.90	0.30	0.50	0.95	0.30	0.90	0.90	0.50
20:00-21:00	0.90	0.10	0.50	0.70	0.30	0.90	0.50	0.30
21:00-22:00	0.90	0.00	0.10	0.70	0.30	0.90	0.50	0.20
22:00-23:00	0.90	0.00	0.00	0.50	0.30	0.70	0.50	0.10
23:00-24:00	0.90	0.00	0.00	0.50	0.10	0.10	0.50	0.05

Table 9-15 Schedules for Healthcare - Hospital Buildings (B)

Healthcare - Hospital							
Time Period	Equipment Schedule					Elevator Schedule	
	In Patient & ICU	Diagnostic, emergency, & OT	OPD & Offices			Elevator	
	7 days/ week	7 days/ week	7 days/ week			7 days/ week	
00-01 Hrs	0.40	0.00	0.00			0.20	
01-02 Hrs	0.40	0.00	0.00			0.20	
02-03 Hrs	0.40	0.00	0.00			0.20	
03-04 Hrs	0.40	0.00	0.00			0.20	
04-05 Hrs	0.40	0.00	0.00			0.20	
05-06 Hrs	0.40	0.00	0.00			0.20	
06-07 Hrs	0.40	0.00	0.00			0.20	
07-08 Hrs	0.70	0.70	0.70			0.50	
08-09 Hrs	0.90	0.90	0.90			0.75	
09-10 Hrs	0.90	0.90	0.90			1.00	
10-11 Hrs	0.90	0.90	0.90			1.00	
11-12 Hrs	0.90	0.90	0.90			1.00	
12-13 Hrs	0.90	0.90	0.90			0.75	
13-14 Hrs	0.90	0.90	0.90			1.00	
14-15 Hrs	0.90	0.90	0.90			1.00	
15-16 Hrs	0.90	0.90	0.90			1.00	
16-17 Hrs	0.60	0.60	0.90			1.00	
17-18 Hrs	0.60	0.60	0.90			1.00	
18-19 Hrs	0.60	0.60	0.60			0.50	
19-20 Hrs	0.60	0.60	0.60			0.50	
20-21 Hrs	0.60	0.60	0.60			0.50	
21-22 Hrs	0.60	0.00	0.00			0.30	
22-23 Hrs	0.60	0.00	0.00			0.20	
23-00 Hrs	0.40	0.00	0.00			0.20	

Table 9-16 Schedules for Healthcare - Hospital Buildings (C)

Healthcare - Hospital									
Time Period	HVAC Fan Schedule (On/Off)				External Lighting Schedule	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	7 days/ week	7 days/ week	7 days/ week
00:00-01:00	0	1	1	0	1.00	0.00	0.30	0.50	0.50
01:00-02:00	0	1	1	0	1.00	0.00	0.30	0.50	0.50
02:00-03:00	0	1	1	0	1.00	0.00	0.30	0.50	0.50
03:00-04:00	0	1	1	0	1.00	0.00	0.30	0.50	0.50
04:00-05:00	0	1	1	0	1.00	0.00	0.30	0.50	0.50
05:00-06:00	0	1	1	0	1.00	0.00	0.30	0.50	0.50
06:00-07:00	0	1	1	0	0.00	0.00	0.30	0.50	0.50
07:00-08:00	1	1	1	0	0.00	0.00	0.20	0.50	0.50
08:00-09:00	1	1	1	1	0.00	0.20	0.60	1.00	1.00
09:00-10:00	1	1	1	1	0.00	0.30	0.60	1.00	1.00
10:00-11:00	1	1	1	1	0.00	0.30	0.80	1.00	1.00
11:00-12:00	1	1	1	1	0.00	0.30	0.80	1.00	1.00
12:00-13:00	1	1	1	1	0.00	0.25	0.70	1.00	1.00
13:00-14:00	1	1	1	1	0.00	0.25	0.80	1.00	1.00
14:00-15:00	1	1	1	1	0.00	0.25	0.80	1.00	1.00
15:00-16:00	1	1	1	1	0.00	0.25	0.70	1.00	1.00
16:00-17:00	1	1	1	1	0.00	0.25	0.70	1.00	1.00
17:00-18:00	1	1	1	1	0.00	0.10	0.50	1.00	1.00
18:00-19:00	1	1	1	1	1.00	0.00	0.35	1.00	1.00
19:00-20:00	1	1	1	1	1.00	0.00	0.35	1.00	1.00
20:00-21:00	1	1	1	1	1.00	0.00	0.35	1.00	1.00
21:00-22:00	1	1	1	0	1.00	0.00	0.30	0.50	0.50
22:00-23:00	0	1	1	0	1.00	0.00	0.30	0.50	0.50
23:00-24:00	0	1	1	0	1.00	0.00	0.30	0.50	0.50

Table 9-17 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 9-18 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 9-19 Schedules for Hospitality Buildings (A)

Hospitality								
Time Period	Occupancy Schedule							
	Guest Room		Lobby		Special Zones		Restaurant	
	Week Days	Weekends	Week Days	Weekends	Week Days	Weekends	Week Days	Weekends
00:00-01:00	0.65	0.90	0.10	0.10	0.00	0.00	0.00	0.00
01:00-02:00	0.65	0.90	0.10	0.10	0.00	0.00	0.00	0.00
02:00-03:00	0.65	0.90	0.10	0.10	0.00	0.00	0.00	0.00
03:00-04:00	0.65	0.90	0.10	0.10	0.00	0.00	0.00	0.00
04:00-05:00	0.65	0.90	0.10	0.10	0.00	0.00	0.00	0.00
05:00-06:00	0.65	0.90	0.10	0.10	0.20	0.50	0.00	0.00
06:00-07:00	0.50	0.70	0.20	0.20	0.40	0.70	0.30	0.50
07:00-08:00	0.50	0.70	0.30	0.40	0.40	0.70	0.50	0.80
08:00-09:00	0.30	0.50	0.40	0.70	0.40	0.70	0.50	0.80
09:00-10:00	0.15	0.30	0.40	0.70	0.40	0.70	0.50	0.80
10:00-11:00	0.15	0.20	0.40	0.70	0.40	0.70	0.50	0.80
11:00-12:00	0.15	0.20	0.40	0.70	0.20	0.30	0.00	0.00
12:00-13:00	0.15	0.20	0.40	0.70	0.20	0.30	0.00	0.00
13:00-14:00	0.15	0.20	0.20	0.20	0.20	0.30	0.50	0.50
14:00-15:00	0.15	0.20	0.20	0.20	0.20	0.30	0.50	0.80
15:00-16:00	0.15	0.20	0.20	0.20	0.40	0.70	0.00	0.80
16:00-17:00	0.15	0.20	0.20	0.20	0.40	0.70	0.30	0.30
17:00-18:00	0.30	0.30	0.40	0.40	0.40	0.70	0.30	0.30
18:00-19:00	0.50	0.50	0.40	0.40	0.40	0.70	0.00	0.00
19:00-20:00	0.50	0.70	0.40	0.40	0.40	0.70	0.30	0.50
20:00-21:00	0.65	0.70	0.30	0.30	0.00	0.00	0.50	0.90
21:00-22:00	0.65	0.90	0.20	0.20	0.00	0.00	0.50	0.90
22:00-23:00	0.65	0.90	0.10	0.10	0.00	0.00	0.50	0.90
23:00-24:00	0.65	0.90	0.10	0.10	0.00	0.00	0.50	0.90

Table 9-20 Schedules for Hospitality Buildings (B)

Hospitality								
Time Period	Occupancy Schedule				Lighting Schedule			
	Back office		Conference/ Banquet Rooms	Kitchen	Public Spaces		Guest Rooms	
	Week Days	Weekends	7 Days/ week	7 Days/ week	Week Days	Weekends	Week Days	Weekends
00:00-01:00	0.20	0.20	0.00	0.00	0.20	0.20	0.20	0.30
01:00-02:00	0.20	0.20	0.00	0.00	0.15	0.20	0.20	0.25
02:00-03:00	0.20	0.20	0.00	0.00	0.10	0.10	0.10	0.10
03:00-04:00	0.20	0.20	0.00	0.00	0.10	0.10	0.10	0.10
04:00-05:00	0.20	0.20	0.00	0.00	0.10	0.10	0.10	0.10
05:00-06:00	0.20	0.20	0.00	0.00	0.20	0.10	0.20	0.10
06:00-07:00	0.20	0.20	0.00	0.50	0.40	0.30	0.45	0.40
07:00-08:00	0.20	0.20	0.00	0.80	0.50	0.30	0.55	0.40
08:00-09:00	0.20	0.20	0.20	0.80	0.40	0.40	0.45	0.55
09:00-10:00	0.95	0.50	0.50	0.50	0.20	0.40	0.20	0.20
10:00-11:00	0.95	0.50	0.90	0.50	0.20	0.40	0.20	0.20
11:00-12:00	0.95	0.50	0.90	0.80	0.20	0.40	0.20	0.20
12:00-13:00	0.95	0.50	0.90	0.80	0.20	0.40	0.20	0.20
13:00-14:00	0.50	0.30	0.90	0.80	0.20	0.40	0.20	0.20
14:00-15:00	0.95	0.50	0.90	0.50	0.20	0.40	0.20	0.20
15:00-16:00	0.95	0.50	0.90	0.50	0.20	0.40	0.20	0.20
16:00-17:00	0.95	0.50	0.90	0.50	0.20	0.40	0.20	0.20
17:00-18:00	0.95	0.50	0.50	0.80	0.25	0.40	0.30	0.30
18:00-19:00	0.30	0.30	0.20	0.80	0.60	0.60	0.70	0.85
19:00-20:00	0.20	0.20	0.20	0.80	0.80	0.70	0.90	1.00
20:00-21:00	0.20	0.20	0.00	0.80	0.90	0.70	1.00	1.00
21:00-22:00	0.20	0.20	0.00	0.80	0.80	0.70	0.90	1.00
22:00-23:00	0.20	0.20	0.00	0.50	0.60	0.60	0.70	0.85
23:00-24:00	0.20	0.20	0.00	0.50	0.30	0.30	0.30	0.40

Table 9-21 Schedules for Hospitality Buildings (C)

Hospitality									
Time Period	Lighting Schedule			Equipment Schedule					
	Back Office		Kitchen	Public Spaces	Guest Rooms		Back Office		Kitchen
	Week Days	Weekends	7 Days/ week	7 Days/ week	Week Days	Weekends	Week Days	Weekends	7 Days/ week
00:00-01:00	0.05	0.05	0.50	0.30	0.20	0.20	0.05	0.05	0.30
01:00-02:00	0.05	0.05	0.05	0.20	0.20	0.20	0.05	0.05	0.10
02:00-03:00	0.05	0.05	0.05	0.20	0.20	0.20	0.05	0.05	0.10
03:00-04:00	0.05	0.05	0.05	0.20	0.20	0.20	0.05	0.05	0.10
04:00-05:00	0.05	0.05	0.05	0.20	0.20	0.20	0.05	0.05	0.10
05:00-06:00	0.05	0.05	0.05	0.30	0.20	0.20	0.05	0.05	0.10
06:00-07:00	0.10	0.10	0.10	0.50	0.30	0.30	0.05	0.05	0.30
07:00-08:00	0.30	0.30	0.30	0.50	0.40	0.60	0.10	0.10	0.30
08:00-09:00	0.90	0.60	0.90	0.50	0.70	0.90	0.30	0.30	0.30
09:00-10:00	0.90	0.60	0.90	0.50	0.20	0.20	0.95	0.70	0.30
10:00-11:00	0.90	0.60	0.90	0.35	0.20	0.20	0.95	0.70	0.30
11:00-12:00	0.90	0.60	0.90	0.35	0.20	0.20	0.95	0.70	0.30
12:00-13:00	0.90	0.60	0.90	0.35	0.20	0.20	0.95	0.70	0.30
13:00-14:00	0.50	0.50	0.50	0.35	0.20	0.20	0.50	0.70	0.30
14:00-15:00	0.90	0.60	0.90	0.35	0.20	0.20	0.95	0.70	0.30
15:00-16:00	0.90	0.60	0.90	0.35	0.20	0.20	0.95	0.70	0.30
16:00-17:00	0.90	0.60	0.90	0.35	0.20	0.20	0.95	0.70	0.30
17:00-18:00	0.95	0.60	0.95	0.35	0.30	0.30	0.95	0.70	0.30
18:00-19:00	0.50	0.50	0.95	0.70	0.50	0.50	0.30	0.30	0.30
19:00-20:00	0.30	0.30	0.95	0.90	0.50	0.50	0.10	0.10	0.30
20:00-21:00	0.30	0.30	0.95	0.90	0.50	0.70	0.10	0.10	0.30
21:00-22:00	0.20	0.20	0.95	0.90	0.70	0.70	0.10	0.10	0.30
22:00-23:00	0.10	0.10	0.95	0.70	0.40	0.40	0.05	0.05	0.30
23:00-24:00	0.05	0.05	0.95	0.40	0.20	0.20	0.05	0.05	0.30

Table 9-22 Schedules for Hospitality Buildings (D)

Hospitality						
Time Period	Elevator Schedule		HVAC Fan Schedule (On/Off)			
			Public Spaces	Guest Room		Back office
	Week Days	Weekends	7 Days/ week	Week Days	Weekends	7 Days/ week
00:00-01:00	0.10	0.10	0	1	1	0
01:00-02:00	0.10	0.10	0	1	1	0
02:00-03:00	0.10	0.10	0	1	1	0
03:00-04:00	0.10	0.10	0	1	1	0
04:00-05:00	0.10	0.10	0	1	1	0
05:00-06:00	0.20	0.20	0	1	1	0
06:00-07:00	0.40	0.50	0	1	1	0
07:00-08:00	0.50	0.60	1	1	1	0
08:00-09:00	0.50	0.60	1	1	1	1
09:00-10:00	0.35	0.40	1	1	1	1
10:00-11:00	0.15	0.20	1	1	1	1
11:00-12:00	0.15	0.20	1	1	1	1
12:00-13:00	0.15	0.20	1	1	1	1
13:00-14:00	0.15	0.20	1	1	1	1
14:00-15:00	0.15	0.20	1	1	1	1
15:00-16:00	0.15	0.20	1	1	1	1
16:00-17:00	0.35	0.40	1	1	1	1
17:00-18:00	0.50	0.60	1	1	1	1
18:00-19:00	0.50	0.60	1	1	1	1
19:00-20:00	0.50	0.60	1	1	1	0
20:00-21:00	0.50	0.60	1	1	1	0
21:00-22:00	0.30	0.40	1	1	1	0
22:00-23:00	0.20	0.30	1	1	1	0
23:00-24:00	0.10	0.10	1	1	1	0

Table 9-23 Schedules for Hospitality Buildings (E)

Hospitality						
Time Period	External Lighting Schedule	Service Hot Water (SHW)			Basement Ventilation	Basement Lighting
		Guest rooms		Laundry		
	7 Days/ week	Week Days	Weekends	7 Days/ week	7 Days/ week	7 Days/ week
00:00-01:00	1.00	0.01	0.01	0.00	0.50	0.50
01:00-02:00	1.00	0.01	0.01	0.00	0.50	0.50
02:00-03:00	1.00	0.01	0.01	0.00	0.50	0.50
03:00-04:00	1.00	0.01	0.01	0.00	0.50	0.50
04:00-05:00	1.00	0.01	0.01	0.00	0.50	0.50
05:00-06:00	1.00	0.01	0.01	0.00	0.50	0.50
06:00-07:00	0.00	0.50	0.70	0.00	0.50	0.50
07:00-08:00	0.00	0.50	0.70	0.00	0.50	0.50
08:00-09:00	0.00	0.30	0.50	1.00	1.00	1.00
09:00-10:00	0.00	0.15	0.30	1.00	1.00	1.00
10:00-11:00	0.00	0.15	0.20	1.00	1.00	1.00
11:00-12:00	0.00	0.15	0.20	1.00	1.00	1.00
12:00-13:00	0.00	0.15	0.20	1.00	1.00	1.00
13:00-14:00	0.00	0.15	0.20	1.00	1.00	1.00
14:00-15:00	0.00	0.15	0.20	1.00	1.00	1.00
15:00-16:00	0.00	0.15	0.20	1.00	1.00	1.00
16:00-17:00	0.00	0.15	0.20	0.00	1.00	1.00
17:00-18:00	0.00	0.30	0.30	0.00	1.00	1.00
18:00-19:00	1.00	0.50	0.50	0.00	1.00	1.00
19:00-20:00	1.00	0.50	0.70	0.00	1.00	1.00
20:00-21:00	1.00	0.65	0.70	0.00	1.00	1.00
21:00-22:00	1.00	0.65	0.90	0.00	0.50	0.50
22:00-23:00	1.00	0.01	0.01	0.00	0.50	0.50
23:00-24:00	1.00	0.01	0.01	0.00	0.50	0.50

Table 9-24 Schedules for Shopping Complexes Buildings (A)

Shopping Complex									
Time Period	Occupancy Schedule						Lighting Schedule		
	Retail		Corridors & Atrium		Special Zone		Retail	Corridors & Atrium	Special Zone
	Weekday	Weekend	Weekday	Weekend	Weekday	Weekend	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
01:00-02:00	0.00	0.00	0.00	0.00	0.00	0.00	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
03:00-04:00	0.00	0.00	0.00	0.00	0.00	0.00	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
05:00-06:00	0.00	0.00	0.00	0.00	0.00	0.00	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
07:00-08:00	0.00	0.00	0.00	0.00	0.00	0.00	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
09:00-10:00	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
10:00-11:00	0.40	0.40	0.40	0.40	0.20	0.20	0.50	0.50	0.40
11:00-12:00	0.60	0.60	0.60	0.60	0.30	0.50	0.95	0.50	0.60
12:00-13:00	0.60	0.70	0.60	0.70	0.50	0.70	0.95	0.50	0.60
13:00-14:00	0.60	0.90	0.60	0.90	0.50	0.70	0.95	0.50	0.60
14:00-15:00	0.70	0.90	0.70	0.90	0.50	0.70	0.95	0.50	0.60
15:00-16:00	0.70	0.90	0.70	0.90	0.50	0.80	0.95	0.50	0.40
16:00-17:00	0.70	0.90	0.70	0.90	0.50	0.80	0.95	0.70	0.40
17:00-18:00	0.70	0.90	0.70	0.90	0.50	0.80	0.95	0.95	0.40
18:00-19:00	0.90	0.95	0.90	0.95	0.60	0.95	0.95	0.95	0.80
19:00-20:00	0.90	0.95	0.90	0.95	0.60	0.95	0.95	0.95	0.80
20:00-21:00	0.90	0.95	0.90	0.95	0.60	0.95	0.95	0.95	0.80
21:00-22:00	0.00	0.00	0.40	0.40	0.60	0.95	0.05	0.50	0.80
22:00-23:00	0.00	0.00	0.30	0.30	0.60	0.95	0.05	0.30	0.80
23:00-24:00	0.00	0.00	0.10	0.10	0.30	0.95	0.05	0.30	0.80

Table 9-25 Schedules for Shopping Complexes Buildings (B)

Shopping Complex				
Time Period	Equipment Schedule		Elevator Schedule	
	Retail	Special Zone		
	7 Days/ week	7 Days/ week	Weekdays	Weekends
00:00-01:00	0.05	0.05	0.20	0.20
01:00-02:00	0.05	0.05	0.05	0.20
02:00-03:00	0.05	0.05	0.05	0.05
03:00-04:00	0.05	0.05	0.05	0.05
04:00-05:00	0.05	0.05	0.05	0.05
05:00-06:00	0.05	0.05	0.05	0.05
06:00-07:00	0.05	0.05	0.05	0.05
07:00-08:00	0.05	0.05	0.10	0.10
08:00-09:00	0.05	0.50	0.10	0.10
09:00-10:00	0.05	0.50	0.20	0.20
10:00-11:00	0.90	0.90	0.40	0.40
11:00-12:00	0.90	0.90	0.70	0.70
12:00-13:00	0.90	0.90	0.70	0.80
13:00-14:00	0.90	0.90	0.70	0.95
14:00-15:00	0.90	0.90	0.70	0.95
15:00-16:00	0.90	0.90	0.70	0.95
16:00-17:00	0.90	0.90	0.70	0.95
17:00-18:00	0.90	0.90	0.80	0.95
18:00-19:00	0.90	0.90	0.80	0.95
19:00-20:00	0.90	0.90	0.80	0.95
20:00-21:00	0.50	0.90	0.80	0.95
21:00-22:00	0.05	0.90	0.80	0.80
22:00-23:00	0.05	0.90	0.50	0.60
23:00-24:00	0.05	0.90	0.30	0.40

Table 9-26 Schedules for Shopping Complexes Buildings (C)

Shopping Complex						
Time Period	HVAC Fan Schedule (On/Off)			External Lighting Schedule	Basement Ventilation	Basement Lighting
	Retail	Corridors & Atrium	Special Zones			
	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week
00:00-01:00	0	0	0	1.00	1.00	1.00
01:00-02:00	0	0	0	0.50	0.00	0.05
02:00-03:00	0	0	0	0.50	0.00	0.05
03:00-04:00	0	0	0	0.50	0.00	0.05
04:00-05:00	0	0	0	0.50	0.00	0.05
05:00-06:00	0	0	0	0.50	0.00	0.05
06:00-07:00	0	0	0	0.00	0.00	0.05
07:00-08:00	0	0	0	0.00	0.00	0.05
08:00-09:00	0	0	0	0.00	0.00	0.05
09:00-10:00	0	1	1	0.00	1.00	1.00
10:00-11:00	1	1	1	0.00	1.00	1.00
11:00-12:00	1	1	1	0.00	1.00	1.00
12:00-13:00	1	1	1	0.00	1.00	1.00
13:00-14:00	1	1	1	0.00	1.00	1.00
14:00-15:00	1	1	1	0.00	1.00	1.00
15:00-16:00	1	1	1	0.00	1.00	1.00
16:00-17:00	1	1	1	0.00	1.00	1.00
17:00-18:00	1	1	1	0.00	1.00	1.00
18:00-19:00	1	1	1	1.00	1.00	1.00
19:00-20:00	1	1	1	1.00	1.00	1.00
20:00-21:00	1	1	1	1.00	1.00	1.00
21:00-22:00	0	1	1	1.00	1.00	1.00
22:00-23:00	0	1	1	1.00	1.00	1.00
23:00-24:00	0	1	1	1.00	1.00	1.00

Table 9-27 Schedules for Shopping Complex- Strip Retail & Supermall Buildings (A)

Strip Retail & Supermall						
Time Period	Occupancy Schedule		Lighting Schedule	Equipment Schedule	Elevator Schedule	
	Retail & Circulation		All Spaces	All Spaces		
	Weekdays	Weekends	7 Days/ week	7 Days/ week	Weekdays	Weekends
00:00-01:00	0.00	0.00	0.05	0.05	0.00	0.00
01:00-02:00	0.00	0.00	0.05	0.05	0.00	0.00
02:00-03:00	0.00	0.00	0.05	0.05	0.00	0.00
03:00-04:00	0.00	0.00	0.05	0.05	0.00	0.00
04:00-05:00	0.00	0.00	0.05	0.05	0.00	0.00
05:00-06:00	0.00	0.00	0.05	0.05	0.00	0.00
06:00-07:00	0.00	0.00	0.05	0.05	0.00	0.00
07:00-08:00	0.00	0.00	0.05	0.05	0.10	0.10
08:00-09:00	0.00	0.00	0.05	0.05	0.10	0.10
09:00-10:00	0.20	0.20	0.20	0.05	0.20	0.20
10:00-11:00	0.40	0.40	0.50	0.90	0.40	0.40
11:00-12:00	0.60	0.60	0.95	0.90	0.70	0.70
12:00-13:00	0.60	0.70	0.95	0.90	0.70	0.80
13:00-14:00	0.60	0.90	0.95	0.90	0.70	0.95
14:00-15:00	0.70	0.90	0.95	0.90	0.70	0.95
15:00-16:00	0.70	0.90	0.95	0.90	0.70	0.95
16:00-17:00	0.70	0.90	0.95	0.90	0.70	0.95
17:00-18:00	0.70	0.90	0.95	0.90	0.80	0.95
18:00-19:00	0.90	0.95	0.95	0.90	0.80	0.95
19:00-20:00	0.90	0.95	0.95	0.90	0.80	0.95
20:00-21:00	0.90	0.95	0.95	0.50	0.80	0.95
21:00-22:00	0.00	0.00	0.05	0.05	0.00	0.00
22:00-23:00	0.00	0.00	0.05	0.05	0.00	0.00
23:00-24:00	0.00	0.00	0.05	0.05	0.00	0.00

Table 9-28 Schedules for Shopping Complex- Strip Retail & Supermall Buildings (A)

Strip Retail & Supermall				
Time Period	HVAC Fan Schedule (On/Off)	External Lighting Schedule	Basement Ventilation	Basement Lighting
	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week
00:00-01:00	0	0.20	0.00	0.05
01:00-02:00	0	0.20	0.00	0.05
02:00-03:00	0	0.20	0.00	0.05
03:00-04:00	0	0.20	0.00	0.05
04:00-05:00	0	0.20	0.00	0.05
05:00-06:00	0	0.20	0.00	0.05
06:00-07:00	0	0.00	0.00	0.05
07:00-08:00	0	0.00	0.00	0.05
08:00-09:00	0	0.00	0.00	0.05
09:00-10:00	1	0.00	1.00	1.00
10:00-11:00	1	0.00	1.00	1.00
11:00-12:00	1	0.00	1.00	1.00
12:00-13:00	1	0.00	1.00	1.00
13:00-14:00	1	0.00	1.00	1.00
14:00-15:00	1	0.00	1.00	1.00
15:00-16:00	1	0.00	1.00	1.00
16:00-17:00	1	0.00	1.00	1.00
17:00-18:00	1	0.00	1.00	1.00
18:00-19:00	1	1.00	1.00	1.00
19:00-20:00	1	1.00	1.00	1.00
20:00-21:00	1	1.00	1.00	1.00
21:00-22:00	0	1.00	0.20	0.50
22:00-23:00	0	0.20	0.00	0.05
23:00-24:00	0	0.20	0.00	0.05

Table 9-29 Schedules for Assembly Buildings

Assembly								
Time Period	Occupancy Schedule	Lighting Schedule	Equipment Schedule	Elevator Schedule	HVAC Fan Schedule (On/Off)	External Lighting Schedule	Basement Ventilation	Basement Lighting
00:00-01:00	0.00	0.00	0.00	0.00	0	0.80	0.00	0.80
01:00-02:00	0.00	0.00	0.00	0.00	0	0.80	0.00	0.10
02:00-03:00	0.00	0.00	0.00	0.00	0	0.80	0.00	0.10
03:00-04:00	0.00	0.00	0.00	0.00	0	0.80	0.00	0.10
04:00-05:00	0.00	0.00	0.00	0.00	0	0.80	0.00	0.10
05:00-06:00	0.00	0.00	0.00	0.00	0	0.80	0.00	0.10
06:00-07:00	0.00	0.00	0.00	0.00	0	0.00	0.00	0.10
07:00-08:00	0.00	0.00	0.00	0.00	0	0.00	0.00	0.10
08:00-09:00	0.20	0.40	0.30	0.20	0	0.00	1.00	0.80
09:00-10:00	0.20	0.75	0.50	0.50	1	0.00	1.00	0.80
10:00-11:00	0.20	0.95	0.95	0.50	1	0.00	1.00	0.80
11:00-12:00	0.80	0.95	0.95	0.50	1	0.00	1.00	0.80
12:00-13:00	0.80	0.95	0.95	0.50	1	0.00	1.00	0.80
13:00-14:00	0.80	0.95	0.95	0.50	1	0.00	1.00	0.80
14:00-15:00	0.80	0.95	0.95	0.50	1	0.00	1.00	0.80
15:00-16:00	0.80	0.95	0.95	0.50	1	0.00	1.00	0.80
16:00-17:00	0.80	0.95	0.95	0.50	1	0.00	1.00	0.80
17:00-18:00	0.80	0.95	0.95	0.50	1	0.00	1.00	0.80
18:00-19:00	0.50	0.95	0.50	0.50	1	0.80	1.00	0.80
19:00-20:00	0.20	0.40	0.30	0.40	1	0.80	1.00	0.80
20:00-21:00	0.20	0.40	0.30	0.20	0	0.80	1.00	0.80
21:00-22:00	0.20	0.40	0.30	0.20	0	0.80	1.00	0.80
22:00-23:00	0.10	0.10	0.00	0.00	0	0.80	1.00	0.80
23:00-24:00	0.10	0.10	0.00	0.00	0	0.80	0.00	0.80

Table 9-30 Schedules for Business - Office Buildings

Business - Office							
Time Period	HVAC Fan Schedule (On/Off)		External Lighting Schedule	Basement Ventilation		Basement Lighting	
	Daytime Business	24 Hour Business	7 Days/ week	Daytime Business	24 Hour Business	Daytime Business	24 Hour Business
00:00-01:00	0	1	0.80	0.00	1.00	0.05	1.00
01:00-02:00	0	1	0.80	0.00	1.00	0.05	1.00
02:00-03:00	0	1	0.80	0.00	1.00	0.05	1.00
03:00-04:00	0	1	0.80	0.00	1.00	0.05	1.00
04:00-05:00	0	1	0.80	0.00	1.00	0.05	1.00
05:00-06:00	0	1	0.80	0.00	1.00	0.05	1.00
06:00-07:00	0	1	0.00	0.00	1.00	0.05	1.00
07:00-08:00	1	1	0.00	0.00	1.00	0.05	1.00
08:00-09:00	1	1	0.00	1.00	1.00	1.00	1.00
09:00-10:00	1	1	0.00	1.00	1.00	1.00	1.00
10:00-11:00	1	1	0.00	1.00	1.00	1.00	1.00
11:00-12:00	1	1	0.00	1.00	1.00	1.00	1.00
12:00-13:00	1	1	0.00	1.00	1.00	1.00	1.00
13:00-14:00	1	1	0.00	1.00	1.00	1.00	1.00
14:00-15:00	1	1	0.00	1.00	1.00	1.00	1.00
15:00-16:00	1	1	0.00	1.00	1.00	1.00	1.00
16:00-17:00	1	1	0.00	1.00	1.00	1.00	1.00
17:00-18:00	1	1	0.00	1.00	1.00	1.00	1.00
18:00-19:00	1	1	0.80	1.00	1.00	1.00	1.00
19:00-20:00	1	1	0.80	1.00	1.00	1.00	1.00
20:00-21:00	1	1	0.80	1.00	1.00	1.00	1.00
21:00-22:00	1	1	0.80	0.00	1.00	0.05	1.00
22:00-23:00	0	1	0.80	0.00	1.00	0.05	1.00
23:00-24:00	0	1	0.80	0.00	1.00	0.05	1.00

10. APPENDIX A: DEFAULT VALUES FOR TYPICAL CONSTRUCTIONS

10.1 PROCEDURE FOR DETERMINING FENESTRATION PRODUCT U-FACTOR AND SOLAR HEAT GAIN COEFFICIENT

Section-4.2.1.1 and Section-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) Section- 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) Section- 4.2.2 of ISO 15099: Frame and divider SHGC's shall be calculated in accordance with Section- 4.2.2. The alternate approach in Section- 8.6 shall not be used.

c) Section- 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) Section- 7 of ISO 15099 on shading systems is currently excluded.

e) Section- 8.2 of ISO 15099 addresses environmental conditions. The following are defined for India:

For U-factor calculations:

T_{in} = 24 ^{o}C T_{out} = 32 ^{o}C V = 3.35 m/s $T_{rm,out}$=Tout $T_{rm,in}$=T_{in}

I_s=0 W/m^2

For SHGC calculations:

T_{in} = 24 ^{o}C T_{out} = 32 ^{o}C V = 2.75 m/s $T_{rm,out}$=T_{out} $T_{rm,in}$=T_{in} I_s=783 W/m2

f) Section- 8.3 of ISO 15099 addresses convective film coefficients on the interior and

exterior of the window product. In Section- 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 Section- 8.3.2 of ISO 15099, the formula from this section shall be applied to all outdoor exposed surfaces.

g) Section- 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 Section- 8.4.2.1 of ISO 15099 (Two-Dimensional Element to Element View Factor Based Radiation Heat Transfer Calculation). The alternate approach in Section- 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 ($W/m^2.K$)*
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	3.4

Wood, vinyl, or fiberglass frame or metal frame with thermal break	Double Glazing (COG U value <1.6	3.0
Metal and other frame type	Double Glazing	5.1

10.2.2. 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:

$$U_{Total\ Roof} = 1/(U_{Typical\ Roof} + U_{Typical\ Insulation})$$

Where,

$U_{Total\ Roof}$ Total U-factor of the roof with insulation

$U_{Typical\ Roof}$ U-factor of the roof

$U_{Typical\ Insulation}$ U-factor of the effective insulation

10.2.3. 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:

$$U_{Total\ Wall} = 1/(U_{Typical\ Wall} + U_{Typical\ Insulation})$$

Where,

$U_{Total\ Wall}$ Total U-factor of the Wall with insulation

$U_{Typical\ Wall}$ U-factor of the Wall

$U_{Typical\ Insulation}$ U-factor of the effective insulation

Table 10-2 Typical Thermal Properties of Common Building and Insulating Materials2,a

Description	Density	Conductivit	Resista	Specific
Building Board and Siding	kg/m3	W/(m·K)	(m^2·K)/W)	kJ/(kg·K)
Board				
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	650	-	0.11	1.88
Oriented strand board (OSB) 12.7	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
Vegetable fiber board				-
Sheathing, regular density[e] 12.7	290	-	0.23	1.3
Intermediate density[e] 12.7 mm	350	-	0.19	1.3
Nail-base sheathing[e] 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	290	0.058	-	0.59
Laminated paperboard	480	0.072	-	1.38
Homogeneous board from re-pulped	480	0.072	-	1.17
Hardboard[e]				
Medium density	800	0.105	-	1.3
High density, service-tempered	880	0.12	-	1.34
Grade and service grade				
High density, standard-tempered	1010	0.144	-	1.34
Particleboard[e]				
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
Wafer-board	700	0.072	-	1.88
Shingles				

Asbestos/cement	1900	-	0.37	-
Wood, 400 mm, 190 mm exposure	-	-	0.015	1.3
Wood, double, 400 mm, 300 mm	-	-	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
Siding				
Asphalt insulating siding (12.7 mm	-	-	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, lapped13 mm	-	-	0.14	1.17
Wood, bevel 250 mm, lapped19 mm	-	-	0.18	1.17
Wood, plywood, lapped 9.5 mm	-	-	0.1	1.22
Aluminum, steel, or vinyl,[j,k] over sheathing Hollow-backed	-	-	0.11	1.22
Aluminum, steel, or vinyl,[j,k] over sheathing Insulating-board-backed	-	-	0.32	1.34
Aluminum, steel, or vinyl,[j,k] over sheathing 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^2 felt	-	-	0.21	-
Vapor: seal, plastic film	-	-	Negligib	-
Finish Flooring Materials				
Carpet and rebounded urethane pad	110	-	0.42	-
Carpet and rubber pad (one-piece)	320	-	0.12	-
Pile carpet with rubber pad 9.5 to	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				
Blanket and batt[c,d]				
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	-	0.84
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	-	-
Board and slabs				
Cellular glass.	130	0.048	-	0.75
Cement fiber slabs, shredded wood with Portland cement	400 to 430	0.072 to 0.076	-	-
	-			
Cement fiber slabs, shredded wood with magnesia oxy-sulfide binder	350	0.082	-	1.3
Glass fiber board	160	0.032 to	-	0.84
Expanded rubber (rigid)	70	0.032	-	1.67
Expanded polystyrene extruded	25 to 40	0.022 to	-	1.47
Expanded polystyrene, molded beads	15 to 25	0.032 to	-	1.47
Mineral fiberboard, wet felted	160	0.038	-	0.84
Mineral fiberboard, core or roof	255 to 270	0.049	-	-
Mineral fiberboard, acoustical tile[g]	290	0.05	-	0.8
	335	0.053	-	-
Mineral fiberboard, wet-molded,	370	0.061	-	0.59
Perlite board	160	0.052	-	-
Polyisocyanurate, aged unfaced	25 to 35	0.020 to	-	-
Polyisocyanurate, aged with facers	65	0.019	-	1.47
Phenolic foam board with facers,	65	0.019	-	-
Loose fill				
Cellulosic (milled paper or wood	35 to 50	0.039 to	-	1.38
Perlite, expanded	30 to 65	0.039 to	-	1.09
	65 to 120	0.045 to	-	-
	120 to 180	0.052 to	-	-
Mineral fiber (rock, slag, or glass)[d]	10 to 30	-	1.92	0.71
Mineral fiber (rock, slag, or glass)[d]	11 to 30	-	3.33	-

Mineral fiber (rock, slag, or glass)[d]	12 to 30	-	3.85	-
Mineral fiber (rock, slag, or glass)[d]	13 to 30	-	5.26	-
Mineral fiber (rock, slag, or glass)[d]	30 to 55	-	2.1 to 2.5	-
Vermiculite, exfoliated	110 to 130	0.068	-	1.34
	64 to 96	0.063	-	-
Spray-applied				
Cellulosic fiber	55 to 95	0.042 to	-	-
Glass fiber	55 to 70	0.038 to	-	-
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	55	-	1.92	1.47
Polyurethane foam (low density)	30	-	3.69	-
Urea formaldehyde foam, dry	8 to 20	0.030 to	-	-
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	-	-
Pulp-board or paper plaster	600	0.07	-	-
Sand/cement plaster, conditioned	1560	0.63	-	-
Sand/cement/lime plaster,	1440	0.48	-	-
Sand/gypsum (3:1) plaster,	1550	0.65	-	-
Masonry Materials				
Masonry units				
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[h,i] Limestone aggregate ~200 mm, 16.3 kg, 2200 kg/m^3 concrete, 2cores	-	-	-	-
Concrete blocks[h,i] Limestone aggregate ~200 mm, 16.3 kg, 2200 kg/m^3 concrete with perlite-filled cores	-	-	0.37	-
Concrete blocks[h,i] Limestone	-		-	-
Normal-weight aggregate (sand and gravel)~200 mm, 16 kg, 2100 kg/m^3	-	-	0.20 to 0.17	0.92
Normal-weight aggregate (sand and gravel)~200 mm, 16 kg, 2100 kg/m^3	-	-	0.35	-
Normal-weight aggregate (sand and gravel)~200 mm, 16 kg, 2100 kg/m^3	-	-	0.34 to 0.24	-
Normal-weight aggregate (sand and gravel)~200 mm, 16 kg, 2100 kg/m^3	-	-	0.217	0.92
Medium-weight aggregate (combinations of normal and	-	-	0.30 to 0.22	-
Medium-weight aggregate (combinations of normal and lightweight aggregate) ~200 mm, 13 kg, 1550 to 1800 kg/m^3 with perlite-filled cores	-	-	0.65 to 0.41	-
Medium-weight aggregate (combinations of normal and lightweight aggregate) ~200 mm, 13 kg, 1550 to 1800 kg/m^3 with vermiculite-filled cores	-	-	0.58	-
Medium-weight aggregate (combinations of normal and lightweight aggregate) ~200 mm, 13 kg, 1550 to 1800 kg/m^3 with molded-EPS-filled (beads) cores	-	-	0.56	-

Medium-weight aggregate (combinations of normal and lightweight aggregate) ~200 mm, 13 kg, 1550 to 1800 kg/m^3 with 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^2 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, 1400kg/m^2 with perlite-filled cores	-	-	0.74	-
Low-mass aggregate (expanded shale, clay, slate or slag, pumice) ~150 mm, 7 1/2 kg, 1400kg/m^2 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^2 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^2 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^2 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^2 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^2 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^2 concrete with molded EPS inserts in cores	-	-	0.62	-
Low-mass aggregate (expanded shale, clay, slate or slag, pumice) 300 mm, 16 kg, 1400kg/m^3, 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^3, 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^3,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,	2880	4.33	-	-
	2560	3.17	-	-
	2240	2.31	-	-
	1920	1.59	-	0.88
	1600	1.15	-	-
Gypsum partition tile .75 by 300 by	-	-	0.222	0.79
Gypsum partition tile .4 cells	-	-	0.238	-
Gypsum partition tile .100 by 300 by	-	-	0.294	-
Limestone	2400	0.57	-	0.84
	2600	0.93	-	0.84
Concretes				

Sand and gravel or stone aggregate concretes (concretes with >50% quartz or quartzite sand have conductivities in higher end of	2400	1.4 to 2.9	-	-
	2240	1.3 to 2.6	-	0.80 to
	2080	1.0 to 1.9	-	-
Low-mass aggregate or limestone	1920	0.9 to 1.3	-	-
Low-mass aggregate or limestone concretes Expanded shale, clay, or slate; expanded slags ;cinders;	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	800	0.26 to 0.27	-	-
	640	0.20 to 0.22	-	0.63 to
	480	0.16	-	-
	320	0.12	-	-
Foam concretes	1920	0.75	-	-
	1600	0.6	-	-
	1280	0.44	-	-
	1120	0.36	-	-
Foam concretes and cellular	960	0.3	-	-
	640	0.2	-	-
	320	0.12	-	-
Aerated concrete (oven-dried)	430 to	0.2	-	0.84
Polystyrene concrete (oven-dried)	255 to	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	-	-
Woods (12% moisture				
Hardwoods	-	-	-	1.63
Oak	660 to	0.16 to 0.18	-	-
Birch	680 to	0.17 to 0.18	-	-
Maple	635 to	0.16 to 0.17	-	-
Ash	615 to	0.15 to 0.16	-	-
Softwoods	-	-	-	1.63
Southern pine	570 to	0.14 to 0.16	-	-
Southern yellow pine	500	0.13	-	-
Eastern white pine	400	0.1	-	-
Douglas fir/larch	535 to	0.14 to 0.15	-	-
Southern cypress	500 to	0.13	-	-
Hem/fir, spruce/pine/fir	390 to	0.11 to 0.13	-	-
Spruce	400	0.09	-	-
Western red cedar	350	0.09	-	-
West coast woods, cedars	350 to	0.10 to 0.13	-	-
Eastern white cedar	360	0.1	-	-
California redwood	390 to	0.11 to 0.12	-	-
Pine (oven-dried)	370	0.092	-	1.88
Spruce (oven-dried)	395	0.1	-	1.88

[a]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.

[b]Symbol λ also used to represent thermal conductivity.

[c]Does not include paper backing and facing, if any. Where insulation forms boundary (reflective or otherwise) of airspace

[d]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.

[e]Values are for aged products with gas-impermeable facers on the two major surfaces. An aluminum foil facer of 25 μm thickness or greater is generally considered impermeable to gases. For change in conductivity with age of expanded polyisocyanurate.

[f]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.

[g]Insulating values of acoustical tile vary, depending on density of board and on type, size, and depth of perforations.

[h]Values for fully grouted block may be approximated using values for concrete with similar unit density.

[i]Values for concrete block and concrete are at moisture contents representative of normal use.

[j]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 ±50% or more from these values may occur.

[k]Vinyl specific heat = 1.0 kJ/(kg·K)

[l]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:

[m]From Wilkes (1979), an empirical equation for specific heat of moist wood at 24°C is as follows:

$$Cp = ((0.299 + 0.01\,M) / (1 + 0.01\,M)) + \Delta Cp$$

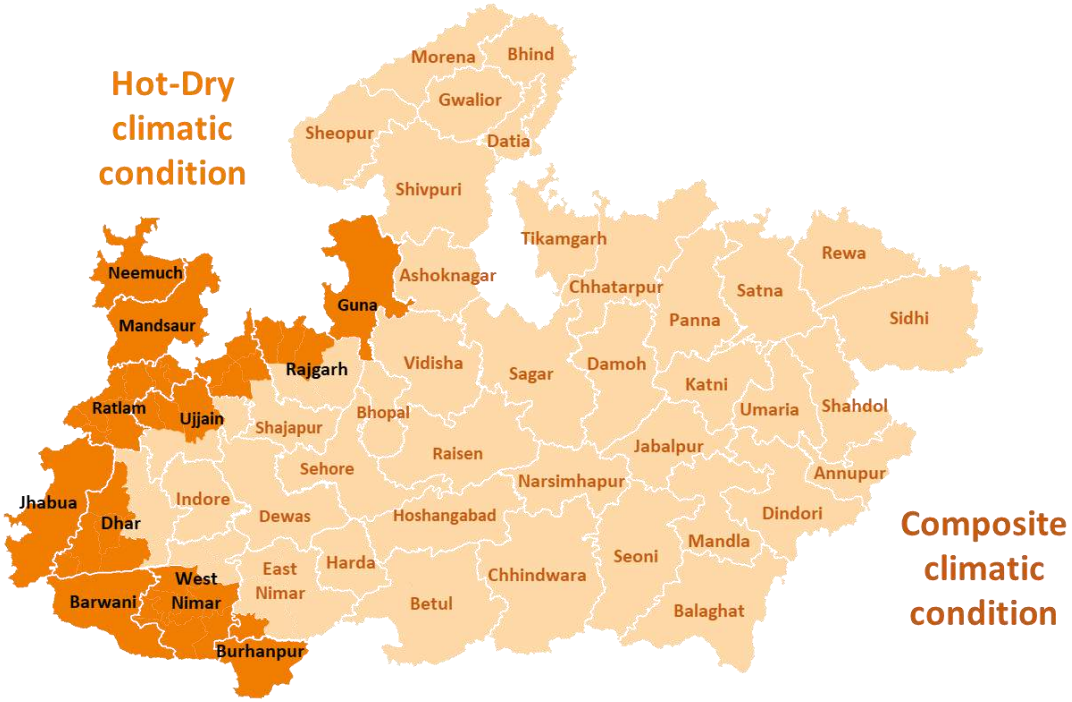
where Δcp accounts for heat of sorption and is denoted by

$$\Delta Cp = M(1.921 \times 10^{-3} - 3.168 \times 10^{-5} M)$$

Where, M is moisture content in percent by mass.

[n]Blank space in reference column indicates historical values from previous volumes of *ASHRAE Handbook*. Source of information could not be determined.

11. APPENDIX:B CLIMATE ZONE MAP OF MADHYA PRADESH



Sr. No.	Division	District	City	Climatic Condition	Nearest Climatic available epw file
1	Bhopal	Bhopal	Bhopal	Composite	Bhopal
2			Berasia	Composite	Bhopal
3			Kolar	Composite	Bhopal
4		Sehore	Sehore	Composite	Bhopal
5			Ashtha	Composite	Bhopal
6			Budhni	Composite	Bhopal
7			Ichchawar	Composite	Bhopal
8			Jawar	Composite	Bhopal
9			Nasrullaganj	Composite	Bhopal
10			Rehti	Composite	Bhopal
11		Raisen	Raisen	Composite	Bhopal
12			Goharganj	Composite	Bhopal
13			Mandideep	Composite	Bhopal
14			Begamganj	Composite	Bhopal

15			Gairaganj	Composite	Bhopal
16			Silwani	Composite	Bhopal
17			Bareli	Composite	Bhopal
18			Udaipura	Composite	Bhopal
19			Badi	Composite	Bhopal
20		**Rajgarh**	Jeerapur	Hot-dry	Bhopal
21			Khilchipur	Hot-dry	Bhopal
22			Rajgarh	Hot-dry	Bhopal
23			Narsinghgarh	Hot-dry	Bhopal
24			Biaora	Hot-dry	Bhopal
25			Pachore	Hot-dry	Bhopal
26			Sarangpur	Hot-dry	Bhopal
27		**Vidisha**	Vidisha	Composite	Bhopal
28			GanjBasoda	Composite	Bhopal
29			Kurwari	Composite	Bhopal
30			Lateri	Composite	Bhopal
31			Sironj	Composite	Bhopal
32	**Narmadapuram**	**Hoshangabad**	Hoshangabad	Composite	Bhopal
33			Itarsi	Composite	Bhopal
34			Seoni-Malwa	Composite	Bhopal
35			Pipariya	Composite	Bhopal
36			Sohagpur	Composite	Bhopal
37			Babai	Composite	Bhopal
38			Bankhedi	Composite	Bhopal
39			Dolariya	Composite	Bhopal
40		**Betul**	Betul	Composite	Bhopal
41			Sarni	Composite	Bhopal
42			Multai	Composite	Bhopal
43			Amla	Composite	Bhopal
44			Chicholi	Composite	Bhopal
45			GhoraDongri	Composite	Bhopal
46			Athner	Composite	Bhopal
47			Bhainsdehi	Composite	Bhopal
48			Betul Bazaar	Composite	Bhopal
49		**Harda**	Harda	Composite	Bhopal
50			Rehatgaon	Composite	Bhopal
51			Khirkiya	Composite	Bhopal
52			Sirali	Composite	Bhopal
53			Timarni	Composite	Bhopal
54			Handiya	Composite	Bhopal
55	**Gwalior**	**Gwalior**	Gwalior	Composite	Gwalior

56			Dabra	Composite	Gwalior
57			Bhitarwar	Composite	Gwalior
58			Chinour	Composite	Gwalior
59		**Shivpuri**	Shivpuri	Composite	Gwalior
60			Pichchore	Composite	Gwalior
61			Pohri	Composite	Gwalior
62			Narwar	Composite	Gwalior
63			Karera	Composite	Gwalior
64			Khaniyadhana	Composite	Gwalior
65			Badarwas	Composite	Gwalior
66			Kolaras	Composite	Gwalior
67		**Guna**	Guna	Hot-dry	Gwalior
68			Bamori	Hot-dry	Gwalior
69			Raghogarh	Hot-dry	Gwalior
70			Aron	Hot-dry	Gwalior
71			Chachaura	Hot-dry	Gwalior
72			Kumbhraj	Hot-dry	Gwalior
73			Maksoodangarh	Hot-dry	Gwalior
74		**Ashoknagar**	Ashoknagar	Composite	Gwalior
75			Mungaoli	Composite	Gwalior
76			Isagarh	Composite	Gwalior
77			Chanderi	Composite	Gwalior
78			Shadhora	Composite	Gwalior
79		**Datia**	Datia	Composite	Gwalior
80			Bhander	Composite	Gwalior
81			Indergarh	Composite	Gwalior
82			Seondha	Composite	Gwalior
83	**Chambal**	**Sheopur**	Sheopur	Composite	Gwalior
84			Vijaypur	Composite	Gwalior
85			Karahal	Composite	Gwalior
86			Badoda	Composite	Gwalior
87			Beerpur	Composite	Gwalior
88		**Morena**	Morena	Composite	Gwalior
89			Joura	Composite	Gwalior
90			Ambah	Composite	Gwalior
91			Porsa	Composite	Gwalior
92			Sabalgarh	Composite	Gwalior
93			Kailaras	Composite	Gwalior
94		**Bhind**	Bhind	Composite	Gwalior
95			Gormi	Composite	Gwalior
96			Ater	Composite	Gwalior

97			Ron	Composite	Gwalior
98			Mihona	Composite	Gwalior
99			Mehgaon	Composite	Gwalior
100			Gohad	Composite	Gwalior
101			Lahar	Composite	Gwalior
102	**Jabalpur**	**Jabalpur**	Jabalpur	Composite	Jabalpur
103			Panagar	Composite	Jabalpur
104			Shahpura	Composite	Jabalpur
105			Sihora	Composite	Jabalpur
106			Majholi	Composite	Jabalpur
107			Patan	Composite	Jabalpur
108			Kundam	Composite	Jabalpur
109		**Katni**	Katni	Composite	Jabalpur
110			Murwara	Composite	Jabalpur
111			Vijayraghavgarh	Composite	Jabalpur
112			Bahoriband	Composite	Jabalpur
113			Dhimarkheda	Composite	Jabalpur
114			Rithi	Composite	Jabalpur
115			Badwara	Composite	Jabalpur
116			Barhi	Composite	Jabalpur
117		**Narsimhapur**	Narsimhapur	Composite	Jabalpur
118			Gotegaon	Composite	Jabalpur
119			Kareli	Composite	Jabalpur
120			Tendukheda	Composite	Jabalpur
121			Gadarwada	Composite	Jabalpur
122		**Chhindwara**	Chhindwara	Composite	Jabalpur
123			Harrai	Composite	Jabalpur
124			Padhurna	Composite	Jabalpur
125			Tamia	Composite	Jabalpur
126			Dongar Parasia	Composite	Jabalpur
127			Amarwara	Composite	Jabalpur
128			Jamai	Composite	Jabalpur
129			Umreth	Composite	Jabalpur
130			Damua	Composite	Jabalpur
131			Chaurai	Composite	Jabalpur
132			Junnardeo	Composite	Jabalpur
133			Mohkhed	Composite	Jabalpur
134			Sausar	Composite	Jabalpur
135			Bichchua	Composite	Jabalpur
136		**Seoni**	Seoni	Composite	Jabalpur
137			Lakhnadon	Composite	Jabalpur

138			Barghat	Composite	Jabalpur
139			Keolari	Composite	Jabalpur
140			Ghansaur	Composite	Jabalpur
141			Chhapara	Composite	Jabalpur
142			Kural	Composite	Jabalpur
143			Dhanora	Composite	Jabalpur
144		Mandla	Mandla	Composite	Jabalpur
145			Bichchiya	Composite	Jabalpur
146			Ghugari	Composite	Jabalpur
147			Nainpur	Composite	Jabalpur
148			Niwas	Composite	Jabalpur
149			Narayanganj	Composite	Jabalpur
150		Balaghat	Balaghat	Composite	Jabalpur
151			Baiher	Composite	Jabalpur
152			Malanjkhand	Composite	Jabalpur
153			Lanji	Composite	Jabalpur
154			Waraseoni	Composite	Jabalpur
155			Kirnapur	Composite	Jabalpur
156			Laibarra	Composite	Jabalpur
157			Khairlanji	Composite	Jabalpur
158			Paraswada	Composite	Jabalpur
159			Katangi	Composite	Jabalpur
160			Tirodi	Composite	Jabalpur
161	Sagar	Sagar	Sagar	Composite	Jabalpur
162			Banda	Composite	Jabalpur
163			Bina	Composite	Jabalpur
164			Khurai	Composite	Jabalpur
165			Deori	Composite	Jabalpur
166			Malthon	Composite	Jabalpur
167			Rehli	Composite	Jabalpur
168			Shahgarh	Composite	Jabalpur
169			Rahatgarh	Composite	Jabalpur
170			Garhakota	Composite	Jabalpur
171			Kesli	Composite	Jabalpur
172		Damoh	Damoh	Composite	Jabalpur
173			Patharia	Composite	Jabalpur
174			Jabera	Composite	Jabalpur
175			Tendukheda	Composite	Jabalpur
176			Hatta	Composite	Jabalpur
177			Batiyagarh	Composite	Jabalpur
178			Patera	Composite	Jabalpur
179		Panna	Panna	Composite	Jabalpur

180			Ajaigarh	Composite	Jabalpur
181			Pawai	Composite	Jabalpur
182			Gunnor	Composite	Jabalpur
183			Amanganj	Composite	Jabalpur
184			Shahnagar	Composite	Jabalpur
185			Devendranagar	Composite	Jabalpur
186			Rajpura	Composite	Jabalpur
187		**Chhatarpur**	Chhatarpur	Composite	Jabalpur
188			Bada malhera	Composite	Jabalpur
189			Bijawar	Composite	Jabalpur
190			Buxwaha	Composite	Jabalpur
191			Chandla	Composite	Jabalpur
192			Gaurihar	Composite	Jabalpur
193			Laundi	Composite	Jabalpur
194			Maharajpur	Composite	Jabalpur
195			Nogaon	Composite	Jabalpur
196			Rajnagar	Composite	Jabalpur
197		**Tikamgarh**	Tikamgarh	Composite	Jabalpur
198			Palera	Composite	Jabalpur
199			Jatara	Composite	Jabalpur
200			Prithvipur	Composite	Jabalpur
201			Niwari	Composite	Jabalpur
202			Baldeogarh	Composite	Jabalpur
203			Khargapur	Composite	Jabalpur
204			Mohangarh	Composite	Jabalpur
205			Orchha	Composite	Jabalpur
206	**Rewa**	**Rewa**	Rewa	Composite	Jabalpur
207			Huzur	Composite	Jabalpur
208			Hanumana	Composite	Jabalpur
209			Teonthar	Composite	Jabalpur
210			Mangawan	Composite	Jabalpur
211			Jawa	Composite	Jabalpur
212			Sirmour	Composite	Jabalpur
213			Mauganj	Composite	Jabalpur
214			Naigarh	Composite	Jabalpur
215			Semaria	Composite	Jabalpur
216			Gurh	Composite	Jabalpur
217			Rajpur - Karchuliyan	Composite	Jabalpur
218		**Singhrauli**	Singhrauli	Composite	Jabalpur
219			Chitrangi	Composite	Jabalpur
220			Deosar	Composite	Jabalpur

221		Sidhi	Sidhi	Composite	Jabalpur
222			Gopadbanas	Composite	Jabalpur
223			Sihawal	Composite	Jabalpur
224			Rampur Naikin	Composite	Jabalpur
225			Majhauli	Composite	Jabalpur
226			Churhat	Composite	Jabalpur
227			Kusmi	Composite	Jabalpur
228		Satna	Satna	Composite	Jabalpur
229			Raghurannagar	Composite	Jabalpur
230			Maihar	Composite	Jabalpur
231			Nagod	Composite	Jabalpur
232			Amarpatan	Composite	Jabalpur
233			Uchahara	Composite	Jabalpur
234			Rampur Baghelan	Composite	Jabalpur
235			Ramnagar	Composite	Jabalpur
236			Majhgawan	Composite	Jabalpur
237			Birsinghpur	Composite	Jabalpur
238			Kotar	Composite	Jabalpur
239	Shahdol	Shahdol	Shahdol	Composite	Jabalpur
240			Sohagpur	Composite	Jabalpur
241			Beohari	Composite	Jabalpur
242			Jaisinghnagar	Composite	Jabalpur
243			Dhanpuri	Composite	Jabalpur
244			Jaitpur	Composite	Jabalpur
245		Umaria	Umaria	Composite	Jabalpur
246			Manpur	Composite	Jabalpur
247			Bandhogarh	Composite	Jabalpur
248			Pali	Composite	Jabalpur
249			Chandia	Composite	Jabalpur
250			Nowrozabad	Composite	Jabalpur
251		Dindori	Dindori	Composite	Jabalpur
252			Shahpura	Composite	Jabalpur
253		Anuppur	Anuppur	Composite	Jabalpur
254			Pushparajgarh	Composite	Jabalpur
255			Pasan	Composite	Jabalpur
256			Kotma	Composite	Jabalpur
257			Jaithari	Composite	Jabalpur
258	Indore	Indore	Indore	Hot-dry	Indore
259			Mhow	Composite	Indore
260			Depalpur	Composite	Indore
261			Sawer	Composite	Indore

262			Hatod	Composite	Indore
263		Dhar	Dhar	Hot-dry	Indore
264			Kukshi	Hot-dry	Indore
265			Manawar	Hot-dry	Indore
266			Sardarpur	Hot-dry	Indore
267			Barwani	Hot-dry	Indore
268			Badnawar	Composite	Indore
269			Dharampuri	Composite	Indore
270			Gandhwani	Composite	Indore
271			Dahi	Composite	Indore
272		Alirajpur	Alirajpur	Hot-dry	Indore
273			Jobat	Hot-dry	Indore
274			Bhavra	Hot-dry	Indore
275		Jhabua	Jhabua	Hot-dry	Indore
276			Petlawad	Hot-dry	Indore
277			Thandla	Hot-dry	Indore
278			Meghnagar	Hot-dry	Indore
279			Ranapur	Hot-dry	Indore
280		Khargone	Khargone	Hot-dry	Indore
281			Barwaha	Composite	Indore
282			Bhagwanpura	Hot-dry	Indore
283			Bhikangaon	Hot-dry	Indore
284			Sanavad	Hot-dry	Indore
285			Gogaon	Hot-dry	Indore
286			Jhiranya	Hot-dry	Indore
287			Kasrawad	Hot-dry	Indore
288			Maheshwar	Composite	Indore
289			Segaon	Hot-dry	Indore
290		Barwani	Barwani	Hot-dry	Indore
291			Sendhwa	Hot-dry	Indore
292			Rajpur	Hot-dry	Indore
293			Pati	Hot-dry	Indore
294			Pansemal	Hot-dry	Indore
295			Varla	Hot-dry	Indore
296			Niwali	Hot-dry	Indore
297			Anjad	Hot-dry	Indore
298			Thikri	Hot-dry	Indore
299		Khandwa	Khandwa	Hot-dry	Indore
300			Harsud	Composite	Indore
301			Khalwa	Hot-dry	Indore
302			Pandhana	Hot-dry	Indore

303			Punasa	Composite	Indore
304		Burhanpur	Burhanpur	Hot-dry	Indore
305			Nepanagar	Hot-dry	Indore
306			Khaknar	Hot-dry	Indore
307	Ujjain	Ujjain	Ujjain	Composite	Indore
308			Badnagar	Composite	Indore
309			Mahidpur	Hot-dry	Indore
310			Tarana	Composite	Indore
311			Nagda	Hot-dry	Indore
312			Khachrod	Hot-dry	Indore
313			Ghatiya	Composite	Indore
314		Dewas	Dewas	Composite	Indore
315			Bagli	Composite	Indore
316			Khategaon	Composite	Indore
317			Sonkatch	Composite	Indore
318			Tonkkhurd	Composite	Indore
319			Kannod	Composite	Indore
320			Hatpiplya	Composite	Indore
321		Ratlam	Ratlam	Composite	Indore
322			Jaora	Hot-dry	Indore
323			Piploda	Hot-dry	Indore
324			Sailana	Hot-dry	Indore
325			Alot	Hot-dry	Indore
326			Tal	Hot-dry	Indore
327			Rawti	Hot-dry	Indore
328			Bajna	Hot-dry	Indore
329		Shajapur	Shajapur	Composite	Indore
330			Shujalpur	Composite	Indore
331			Kalapipal	Composite	Indore
332			Gulana	Composite	Indore
333			Moman Badodiya	Composite	Indore
334			Agar	Composite	Indore
335			Susner	Hot-dry	Indore
336			Badod	Hot-dry	Indore
337			Nalkheda	Composite	Indore
338		Mandsaur	Mandsaur	Hot-dry	Indore
339			Malharganj	Hot-dry	Indore
340			Sitamau	Hot-dry	Indore
341			Bhanpura	Hot-dry	Indore
342			Garoth	Hot-dry	Indore
343			Shamgarh	Hot-dry	Indore

344			Daloda	Hot-dry	Indore
345			Suwasara	Hot-dry	Indore
346		Neemuch	Neemuch	Hot-dry	Indore
347			Manasa	Hot-dry	Indore
348			Jawad	Hot-dry	Indore
349			Singoli	Hot-dry	Indore
350			Jiran	Hot-dry	Indore

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

Project Info	Project Address	Date
	Project Built-up Area (m^2)	For Departmental Use
	Project Above-grade Area (m^2)	
	Project Conditioned Area (m^2)	
	Applicant Name and Address	
	Project Climatic Zones	

Building Classification	Hospital		Assembly		Business	
	Health Care		Shopping Complex		Educational	

Project Description	New building		Addition		Alteration	
	Self-occupied		Core and Shell		Mixed-use	
Compliance is sought for Energy Efficiency level	ECBC Compliant		ECBC+ Compliant		Super ECBC 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	*100	=	% window to wall ratio (WWR)
Skylight Area Calculation	Total Skylight Area (rough opening) / Gross Exterior Wall Area	*100	=	% skylight to roof ratio (SRR)

	=	

Opaque Assembly	
Wall (Minimum Insulation U-factor)	
Roof (Minimum Insulation U-factor)	

	Daylight Summary	
%above-grade floor area meeting the UDI requirement for 90% of the potential daylit time in a year		

Cool Roof	
Solar Reflectance	
Emittance	

Wall Assembly	
Material	R-value

Fenestration	
Vertical	
Maximum U-factor	
Maximum SHGC (or SC)	
Minimum VLT	
Overhang / Side-fins / 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

Project Address		Date

Applicability			Code Section	Component	Information Required	Location on Plans	Building Department Notes
Y	N	N/A					
Mandatory Provisions (Section 4.2)							
			4.2.1	Fenestration Rating	Specify reference standard		
			4.2.1.1	U-Factor	Specify reference standard		
			4.2.1.2	SHGC	Specify reference standard		
			4.2.2	Opaque U-factors	Specify reference standard		
			4.2.3	Daylighting	Indicate sealing, clauking, gasketing, and weather stripping		
			4.2.4	Building Envelope Sealing			

Prescriptive Compliance Option (Section 4.3)							
			4.2.5	Roofs	Specify implemented U-factor		
			4.2.6	Opaque External Wall	Specify implemented U-factor		

			4.3.1	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, gap-width, low-e. (2) indicate SHGC or SC on fenestration schedule. Indicate if values are rated or default. (3) Indicate VLT of fenestration schedule. Indicate if values are rated or default. (4) Indicate if overhangs or side-fins or box-frames projections are used for compliance purpose. If so provide projection factor calculation and equivalent SHGC calculation		
			4.3.2	Fenestration U-factor exemption	Specify if applicable, specify unconditioned percentage, and specify incorporated specifications		
			4.3.2	Skylights	(1) Indicate U-factors on fenestration schedule. Indicate if values are rated or default. If values are default, then specify frame type, glazing layers, gap-width, low-e. (2) indicate SHGC or SC on fenestration schedule. Indicate if values are rated or reference standards		

			4.3.3.1	Vegetative cool roof	Specify the solar reflectance, emittance and reference standards		

Building Envelope Trade-off Option (Section 4.3.4)							
					Provide calculations		

COMFORT SYSTEM AND CONTROL SUMMARY

Project Info	Project Address	Date
	Project Built-up Area (m^2)	For Departmental Use
	Project Above-grade Area (m^2)	
	Project Conditioned Area (m^2)	
	Applicant Name and Address	
	Project Climatic Zones	

Project Description						
Briefly describe comfort system type and features	Natural ventilation, mechanical ventilation, low energy comfort system, heating 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 and Model No.	Capacity (kW)	Testing Standards	OSA CFM or Economizer	Efficiency (COP and IPLV)	Location

Heating Equipment Schedule						
Equip. ID	Brand Name and Model No.	Capacity (kW)	Testing Standards	OSA CFM or Economizer	Input (kW)/Output (kW)	Efficiency

Fan Equipment Schedule						
Equip. ID	Brand Name and Model No.	Testing Standards	SP	Efficiency	Flow Control	Location Service

COMFORT SYSTEM AND CONTROL SUMMARY

COMFORT SYSTEM AND CONTROL CHECKLIST

Project Address		Date

Applicability			Code Section	Component	Information Required	Location on Plans	Building Department Notes
Y	N	N/A					
Comfort System and Controls							
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	Time-clock	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 10hours		
			5.2.3.2	Temperature Controls	Indicate thermostats are interlocked to prevent simultaneous heating and cooling, where separate heating and cooling systems are there		
			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	Additional Controls for ECBC+ Building			
			5.2.4.1	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		
			5.2.4.2	Supply Air Temperature reset	Indicate multi zone mechanical cooling and heating systems shall have the control 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		
			5.2.4.3	Chilled Water Temperature	Indicate chilled water systems exceeding 350kW shall have controls to automatically reset supply water temperature by representative building loads or by outdoor air temperature		
			5.2.5	Additional Controls for Super-ECBC Building	Indicate that the mechanical systems comply with #5.2.4 and #5.2.5		
			5.2.5.1	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		
			5.2.6	Piping and Duct work	Indicate sealing, caulking, gasketing, and weather stripping		

			5.2.6.1	Piping Insulation	Indicate R-value of insulation
			5.2.6.2	Ductwork and Plenum insulation	Indicate R-value of insulation
			5.2.7	System balancing	Indicate R-value of insulation
			5.2.8	Condensers	Indicate location of condenser and source of water used for condenser
			5.2.9	Service Hot water heating	
			5.2.9.1	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
			5.2.9.2	Heating Equipment Efficiency	
			5.2.9.3	Supplementary Water Heating System	Indicate supplementary heating system is designed in consideration with #5.2.9.3
			5.2.9.4	Piping Insulation	Indicate the piping insulation is compliant with #5.2.6.1
			5.2.9.5	Heat Traps	Indicate vertical pipe risers serving water heaters and storage tanks are as per #5.2.9.5
			5.2.9.6	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	Fans	Indicate fan type, motor efficiency and mechanical efficiency
			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 installed capacity
			5.3.4	Air-economizer (ECBC/ECBC+/ Super ECBC)	Indicate air-economizer is capable of modulation outside-air and return-air dampers to supply minimum 50% of design supply air quantity as outside-air for respective building type
			5.3.4	Water-economizer (ECBC/ECBC+/ Super ECBC)	Indicate water-economizer is capable of providing 50% of expected system cooling load at outside air temperature of 10^{o}C dry-bulb/7.2^{o}C wet-bulb and below, if the designed building is a respective building type
			5.3.4.3	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
			5.3.4.4	Controls	Indicate air economizers are equipped with controls as specified in #5.3.4.4
			5.3.9	Testing	Indicate air-side economizer have been tested as per the requirement specified
			5.3.5	Variable Flow Hydronic Systems	
			5.3.5.1	Variable Fluid Flow	Indicate design flow rate of HVAC pumping system
			5.3.5.2	Isolation Valves	Indicate water cooled air-conditioning have two-way automatic isolation valves and pump motors greater than or equal to 3.7kW is controlled by variable speed drives

			5.3.5.3	Variable Speed Drives	Indicate chilled water or condenser water system comply with either #5.3.5.1. or #5.3.5.2
			5.3.5.4	Heat Recovery	Indicate for all hospitality and healthcare, heat recovery effectiveness, and efficiency of oil and gas fired boilers
			5.4	System Efficiency-Alternate compliance approach	Attach simulation report
			5.5	Low energy comfort systems	Indicate system type and list the exemption claimed

LIGHTING AND CONTROLS SUMMARY

Project Info	Project Address	Date
	Project Built-up Area (m^2)	For Building Department Use
	Project Above-grade Area (m^2)	
	Project Conditioned Area (m^2)	
	Applicant Name and Address	
	Project Climatic Zones	

Compliance option	Space by space method			Whole building performance method	

Maximum allowed lighting power (Interior, section 6.3.2 or 6.3.3)						
Location (Floor/room no.)	Occupancy Description		Allowed Lighting Power Density (Watts/m^2)		Area (in m^2)	Allowed LPD*area
Total Allowed watts						

Proposed Lighting Power (Interior)				
Location (Floor/room no.)	Fixture Description	No. of Fixtures	Watts per fixture	Watts Proposed
Total proposed watts shall not exceed total allowed watts for interior			Total Proposed watts	

Maximum Allowed Lighting Wattage (Exterior, Section 6.3.5)				
Location (Floor/room no.)	Description	Allowed Lighting Power Density (Watts/m^2)	Area (in m^2)	Allowed LPD*area

			Total Allowed watts	

Proposed Lighting Wattage (Exterior)

Location (Floor/room no.)	Occupancy Description	Allowed Lighting Power Density (Watts/m^2)	Area (in m^2)	Allowed LPD*area
	Total proposed watts may not exceed total allowed watts for exterior		Total proposed watts	

LIGHTING AND CONTROLS CHECKLIST

Project Address		Date

Applicability			Code Section	Component	Information Required	Location on Plans	Building Department Notes
Y	N	N/A					

Lighting and Controls

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	Daylit Zones	Provide manual or automatic control device schedule with type and features, indicate locations
			6.2.1.4	Centralized Controls ECBC+ and SuperECBC Buildings	Provide centralized control system schedule with type and features, indicate locations
			6.2.1.5	Ext. Lighting control	Indicate photo-sensor or astronomical time
			6.2.1.6	Additional control	Provide schedule with type, indicate locations
			6.2.3	Exit Signs	Indicate wattage per face of Exit signs

Prescriptive Interior Lighting Power Compliance Option (Section 6.3)					
			6.3	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 exemptions
			6.3.2	Space function method	Provide lighting schedule with wattage of lamp and ballast and number of fixtures. Document all exemptions
			6.3.3	Luminaire wattage	Indicate the wattage of installed luminaries on the floor plan, In case of luminaries containing permanently installed ballast, the operating input wattage has to be provided, wither from manufacturers catalogue or values from independent testing laboratory reports

Prescriptive Exterior Lighting Power Compliance Option (section 6.3.5)					
			6.4	Exterior Lighting	Provide lighting schedule with wattage of lamp and ballast and number of fixtures. Document all exceptions

ELECTRICAL AND RENEWABLE SYSTEM

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	

Project Description Briefly describe electrical systems	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 SYSTEM CHECKLISTS

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	Component	Information Required	Building Department

Y	N	N/A	Section			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	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 metering 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	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, 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

14. APPENDIX E: BEE APPROVED LIST OF SOFTWARE TO SHOW COMPLIANCE

Table 18 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 Open Studio Simergy Trace700 TRNSYS Visual DOE BEP-EMIS
Daylighting	AGI32 (Licaso) Daysim Design Builder DIVA Groundhog IES-VE OpenStudio Radiance Rhino-Grasshopper with Daylighting Plugins Sefaira Sensor Placement + Optimization Tool (SPOT)