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PART I.—Orders and Notifications by the Governor of West Bengal, the High Court, Government Treasury, etc.

GOVERNMENT OF WEST BENGAL

DEPARTMENT OF POWER

Bidyut Unnayan Bhavan

NOTIFICATION

No. 07-PO/O/C-III/4M-14/2016 (Part-I).—13th January, 2020.—In exercise of the powers conferred by section 15 of the Energy Conservation Act, 2001 (Central Act No. 52 of 2001), the Government of West Bengal hereby notifies the following Energy Conservation Building Code (ECBC) for efficient use of energy and its conservation in buildings or building complexes, namely-

1. (a) This Code may be called as West Bengal Energy Conservation Building Code 2020.

(b) It shall come into force on the date of its publication in *the official Gazette.*

(c) In accordance with section 14(p) of the Energy Conservation Act 2001 the purpose of this code is to provide minimum requirements for the energy-efficient design and construction of buildings.

(d) This code stands mandatory from this date of notification.

(e) Definitions of all terms, abbreviations and acronyms used in this code are detailed in §10 Appendix A.

2. Scope

(a) The Code is applicable to buildings or building complexes that will 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.

Exception: For buildings having Existing Ground level at an elevation of 1200 meters above mean sea level or higher, this code is applicable to buildings or building complexes that have a connected load of 50 kW or greater or a contract demand of 60 kVA and are intended to be used for commercial purposes.

(b) Buildings intended for residential purposes only are not covered by the Code.

2.1. Applicable 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.

Exemption: 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.

2.2. 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.

2.3. Reference Standards

Energy Conservation Building Code 2017and National Building Code 2016 are the reference documents/ standards for lighting levels, HVAC, comfort levels, natural ventilation, and any other building materials and system design criteria addressed in this code.

2.4. Building Classification

Any one or more building or part of a building with commercial purpose 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) Resorts
   (iii) Star Hotels

(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 congregator 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, 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 hypermarkets 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 area, the mixed-use building shall show compliance based on the building sub-classification having higher percentage of above grade 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 area, the compliance requirements for each sub-classification, having area more than 10% of above grade area of a mixed-use building shall be determined by the requirements for the respective building classification in §4 to §7.

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

3. Compliance & Approach

3.1. General

To comply with the Code, buildings shall

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

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

3.1.1. Energy Performance Index

The Energy Performance Index (EPI) of a building is its annual energy consumption in kilowatt-hour 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:

$$EPI = \frac{annual\ energy\ consumption\ in\ kWh}{total\ built\text{-}up area\ (excluding\ unconditioned\ basements and/or\ parking\ area)\ in\ m^2}$$

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 §4.2, §5.2, §6.2, §7.2 and minimally complies with prescriptive requirements of §4.3, §5.3 and §6.3for ECBC Buildings.

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

(a) Prescriptive Method (see §3.2.2)

(b) Whole Building Performance Method (see §3.2.3)

3.1.3. EPI Ratio for Core and Shell Buildings

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

3.1.4. EPI Ratio for Mixed-use Development

In a mixed-use building, each commercial part of a building must be classified separately and EPI Ratio shall be calculated separately for each sub-classification, as per §3.2.2.1 or §3.2.3.1. The EPI Ratio of a mixed-use Proposed Building shall be calculated based on area-weighted average method. To calculate the reference maximum design EPI Ratio, listed in Table 11.5, applicable for the mixed-use building, each commercial part of mixed-use building shall be classified separately and

(a) If a part of the mixed-use building has different classification and is less than 10% of the total above grade area (AGA), the EPI Ratio of the mixed-use Proposed Building shall be less than or equal to Maximum Allowed EPI ratio listed in Table 11.5, for the building sub-classification having highest percentage of above grade area.

(b) If a part of the mixed-use building has different classification and is more than 10% of the total above grade 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 11.5.

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

3.2. Compliance Approaches

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

3.2.1. Mandatory Requirements

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

3.2.2. Prescriptive Method

A building complies with the Code using the Prescriptive Method if it meets the prescribed minimum (or maximum) values for envelope components (§4.3), comfort systems and controls (§5.3, §5.4 and §5.5) and lighting and controls (§6.3), in addition to meeting all the mandatory requirements.

3.2.2.1 EPI Ratio through Prescriptive Method

ECBC Buildings that demonstrate compliance through Prescriptive Method (§3.2.2) shall be deemed to have an EPI equal to the Standard Building EPI, and therefore an EPI Ratio of 1.

3.2.2.2 Building Envelope Trade-off Method

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

3.2.2.3 Total System Loading Factor Method

For projects using central chilled water plants, the Total System Loading Factor approach may be used to comply with the Prescriptive Method of §5. This approach may be used in place of the prescriptive criteria of pumps (§5.3.1) and cooling towers (§5.3.2). Per this approach, a building complies if the Total System Loading Factor thresholds are met as per Table 5.12. Compliance with other prescriptive requirements (§5.3), as applicable, shall be met with.

3.2.2.4 Low Energy Comfort Systems

Low Energy Comfort Systems (§5.5) is a simplified approach that provides projects using Low Energy Comfort Systems an opportunity to achieve compliance through Prescriptive Method of §5. In addition to compliance with the applicable mandatory requirements (§5.2) and prescriptive requirements (§5.3), the projects must meet the sum of cooling and heating requirement using approved list of low energy systems as per requirements in §5.5.

3.2.3. Whole Building Performance Method

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

3.2.3.1 EPI Ratio through Whole Building Performance Method

The EPI of buildings that demonstrate compliance through Whole Building Performance Method (§3.2.3) shall be calculated using the compliance path defined in §3.1.1 and detailed in §11 Appendix B. 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 §11.5 for the applicable building type and climate zone.

3.3. Compliance Requirements

3.3.1. New Building Compliance

3.3.1.1. Full building Compliance

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

3.3.1.2. Core and Shell building Compliance

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

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

Additionally, the tenant lease agreement shall have a legal undertaking clause to ensure interior fit-outs made by tenant shall be Code compliant. The legal undertaking shall mandate the relevant energy efficiency compliance requirements in accordance with the provisions of §3.2.1 and §3.2.2for 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/ contract demand to the threshold value or above as mentioned in §2, shall comply with the provisions of §4 through §7. Compliance may be demonstrated in either of the following ways:

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

Exception: 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 §11 Appendix B or Total System Loading Factor – Alternate compliance approach of §5.4 shall show compliance through online BEP-EMIS or whole building energy simulation software endorsed by BEE.

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

3.5. Administrative Requirements

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

3.6. Compliance Documents

3.6.1. Compliance Documents

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

(a) Building Envelope: opaque construction materials and their thermal properties including thermal conductivity, specific heat, density along with thickness; fenestration U-factors, solar heat gain coefficients (SHGC), visible light transmittance (VLT) and building envelope sealing documentation; overhangs and side fins, building envelope sealing details;

(b) Heating, Ventilation and Air Conditioning: system and equipment types, sizes, efficiencies and controls; economizers; variable speed drives; piping insulation; duct sealing, insulation and location; solar water heating system; requirement for balance report;

(c) Lighting: lighting schedule showing type, number and wattage of lamps and ballasts; automatic lighting shut off, 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 generation 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, manufacturers' literature, or other data.

4. Building Envelope

4.1. General

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

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 §12 Appendix C.

4.2.1.2 Solar Heat Gain Coefficient (SHGC)

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:

(a) Shading coefficient (SC) of the center 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 (VLT)

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-rated 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 §12 Appendix C. While designing wall assembly to arrive at the desired U-factor, it shall be ensured that the structural integrity of the building as per NBC-2016 and IS 1893 is not compromised.

4.2.2.2 Solar Reflectance

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

4.2.2.3 Emittance

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

4.2.3. Daylighting

Above grade area shall meet or exceed the useful daylight illuminance (UDI) area requirements listed in Table 4.1 for 90% of the potential daylit time in a year. Mixed-use buildings shall show compliance as per the criteria prescribed in §2.4. Compliance shall be demonstrated either through daylighting simulation method in §4.2.3.1 or the manual method in §4.2.3.2. Assembly buildings and other buildings where daylighting will interfere with the functions or processes of 50% (or more) of the building floor area, are exempted from meeting the requirements listed in Table 4.1.

Table 4.1 Daylight Requirement

Building Category	*Percentage of above grade area meeting the UDI requirement*
Business, Educational	40%
No Star Hotel, Star Hotel, Healthcare	30%
Resort	45%
Shopping Complex	10%
Assembly	Exempted

4.2.3.1 Daylighting Simulation Method

Only BEE approved software shall be used to demonstrate compliance through the daylighting simulation method. Buildings shall achieve illuminance level between 100 lux and 2,000 lux for the minimum percentage of floor area prescribed in Table 4.1 for at least 90% of the potential daylit 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 continuous 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 continuous 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, following default values shall be used (Table 4.2).

(g) Documentation requirement to demonstrate compliance are:

(i) Brief description of the project with location, number of stories, space types, hours of operation and software used.

(ii) Summary describing the results of the analysis and output file from simulation tool outlining point wise compliance for the analysis grid and compliance in percentage.

(iii) Explanation of any significant modeling assumptions made.

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

(v) Building floor plans, building elevations, sections and site plan with surrounding building details (if modeled).

(vi) Material reflectance, analysis grid size, total number of grid size/resolution, total number of grid points.

Table 4.2 Default Values for Surface Reflectance

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

4.2.3.2 Manual Daylighting Compliance Method

This method can be used for demonstrating compliance with daylighting requirements without simulation. Daylight extent factors (DEF) mentioned in Table 4.3 shall be used for manually calculating percentage of above grade area meeting the UDI requirement for 90% of the potential daylit time in a year.

Table 4.3 Daylight Extent Factors (DEF) for Manually Calculating Daylight Area

Shading	*Window Type*	*VLT< 0.3*				*VLT ≥0.3*			
		North	South	East	West	North	South	East	West
No shading or PF < 0.4	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 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 4.6.									

(a) To calculate the daylit area:

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

(ii) In the direction parallel to the fenestration, daylit area extends a horizontal dimension equal to the width of the fenestration plus either 1 meter on each side of the aperture, or the distance to an opaque partition of 2m high, or one-half the distance to an adjacent fenestration, whichever is least.

(iii) For skylights, calculate the horizontal dimension in each direction equal to the top aperture dimension in that direction plus either the floor-to-ceiling height (H) for skylights or 1.5 H for monitors, H or 2H for the sawtooth configuration or the distance to the nearest 1 meter or higher opaque partition or one-half the distance to an adjacent skylight or vertical glazing, whichever is least.

(iv) Glazed façades, with non-cardinal orientation, shall be categorized under a particular cardinal direction if its orientation is within ± 45 degrees of that cardinal direction.

(v) Daylit area overlap: For overlapping daylit areas such as windows on different orientations or in case of skylights the overlapping daylit area shall be subtracted from the sum of daylit area.

(b) Documentation requirement:

(i) A separate architectural plan shall be prepared with all daylit areas marked on the floor plans.

(ii) A summary shall be provided showing compliance as per Table 4.1.

4.2.4. Building Envelope Sealing

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

(a) Joints around fenestration, skylights and door frames

(b) Openings between walls and foundations, and between walls and roof and wall panels

(c) Openings at penetrations of utility services through roofs, walls and floors

(d) Site-built fenestration and doors

(e) Building assemblies used as ducts or plenums

(f) All other openings in the building envelope

(g) Exhaust fans shall be fitted with a sealing device such as a self-closing damper

(h) Operable fenestration should be constructed to eliminate air leakages from fenestration frame and shutter frame

4.3. Prescriptive Requirements

4.3.1. Roof

Roofs shall comply with the maximum assembly U-factors in Table 4.4. The roof insulation shall be applied externally as part of roof assembly and not as a part of false ceiling.

Table 4.4 Roof Assembly U-factor ($W/m^2.K$) Requirements

	Composite	*Warm and humid*	*Cold*
All building types, except below	0.33	0.33	0.28
School <10,000 m^2 AGA	0.47	0.47	0.33
Hospitality > 10,000 m^2 AGA	0.20	0.20	0.20

4.3.1.1 Vegetated and Cool Roof

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

(a) For qualifying as a cool roof, roofs with slopes less than 20° shall have an initial solar reflectance of not less than 0.70 and an initial emittance not 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).

(b) 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 wall shall comply with the maximum assembly U-factor in Table 4.5.

Table 4.5 Opaque Assembly Maximum U-factor ($W/m^2.K$) Requirements

	Composite	*Warm and humid*	*Cold*
All building types, except below	0.40	0.40	0.34
No Star Hotel < 10,000 m^2 AGA	0.63	0.63	0.40
Business < 10,000 m^2 AGA	0.63	0.63	0.40
School <10,000 m^2 AGA	0.85	0.85	0.40

Exceptions: 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 shall comply with the following:

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

(b) Minimum allowable Visible Light Transmittance (VLT) is 0.27.

(c) Assembly U-factors shall be determined for the overall fenestration product (including the sash & frame).

Vertical fenestration shall comply with the maximum Solar Heat Gain Coefficient (SHGC) and U-factor requirements of Table 4.6. 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 4.6 Vertical Fenestration Assembly U-factor and SHGC Requirements

	Composite	*Warm and humid*	*Cold*
Maximum U-factor($W/m^2.K$)	3.00	3.00	3.00
Maximum SHGC Non-North	0.27	0.27	0.62
Maximum SHGC North	0.50	0.50	0.62

Exceptions to SHGC requirements in Table 4.6 above:

(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 4.6. 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 §10.2. The range of projection factor for using the SEF is $0.25 \leq PF \leq 1.0$. 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 §11 Appendix B.

  (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,

    a. 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

b. 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 diagram for summer solstice for the vertical fenestration.

(iv) An equivalent SHGC is calculated by dividing the SHGC of the unshaded fenestration product with a Shading Equivalent Factor (SEF). SEF shall be determined for each orientation and shading device type.

(v) The maximum allowable SHGC is calculated by multiplying the prescriptive SHGC requirement from Table 4.6 with the SEF listed in Table 4.7.

Table 4.7 Shading Equivalent Factors

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

	Direction / PF	North	East	South	West	North-East	South-East	South-West	North-East
	0.75	1.30	1.27	1.46	1.27	1.55	1.35	1.37	1.64
	0.8	1.31	1.28	1.48	1.29	1.59	1.37	1.38	1.65
	0.85	1.32	1.30	1.49	1.30	1.62	1.38	1.39	1.65
	0.90	1.34	1.31	1.51	1.31	1.65	1.40	1.40	1.64
	0.95	1.35	1.32	1.53	1.32	1.67	1.42	1.42	1.61
	≥1	1.36	1.33	1.55	1.33	1.69	1.44	1.45	1.57

(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 4.6, if the following conditions are complied with

(i) The Total Effective Aperture (WWR X VLT) for the elevation is less than 0.25, including all fenestration areas more than 1.0 meter above the floor level; and,

(ii) An interior light shelf is provided at the bottom of this fenestration area, with a projection factor on interior side not less than:

a. 1.0 for EW, SE, SW, NE, and NW orientations

b. 0.50 for S orientation.

Exception to U-factor requirements in Table 4.6:
Vertical fenestration on all unconditioned buildings or unconditioned spaces may have a maximum U-factor of 5 $W/m^2.K$ provided they comply with all conditions mentioned in Table 4.8.

Table 4.8 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	0.27	0.27	≥0.40
		North	0.27	0.27	≥0.0

4.3.4. Skylights

Skylights shall comply with the maximum U-factor and maximum SHGC requirements of Table 4.9. 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% when using the Prescriptive Method for compliance.

Table 4.9 Skylight U-factor ($W/m^2.K$) and SHGC Requirements

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

Exception: Skylights in temporary roof coverings or awnings over unconditioned spaces.

4.3.5. Building Envelope Trade-Off Method

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

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

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

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

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

Where,

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 4.10 through Table 4.12 for each class of construction

Table 4.10 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 4.11 Envelope Performance Factor Coefficients –Warm and Humid 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	24.5	-	51.2	-
Roofs	40.1	-	76.1	-
North Windows	20.7	230.7	43.6	401.5
South Windows	20.1	347.1	43.9	546.4
East Windows	19.0	301.8	41.1	490.6
West Windows	18.7	303.1	40.5	483.5

Table 4.12 Envelope Performance Factor Coefficients –Cold 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	36.3	-	30.7	-
Roofs	38.7	-	46.0	-
North Windows	21.8	137.6	28.3	163.86
South Windows	20.8	114.3	21.7	295.24
East Windows	22.7	127.5	24.1	283.20
West Windows	23.4	133.2	25.2	270.33

4.3.5.1 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 §4 for each class of construction.

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

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

5. Comfort Systems and Controls

5.1. General

All heating, ventilation and air conditioning equipment and systems and their controls shall comply with the mandatory provisions of § 5.2 and the prescriptive criteria of § 5.3. In case alternative compliance path of Total System Loading Factor or Low Energy Comfort Systems is used for compliance, requirements of §5.4 or §5.5 and relevant criteria of §5.3 shall be met with.

5.2. Mandatory Requirements

5.2.1. Ventilation

(a) All habitable spaces shall be ventilated with outdoor air in accordance with the requirements of §5.2.1 and guidelines specified in the National Building Code 2016 (Part 8: Building Services, Section 1: Lighting and Natural Ventilation, Subsection 5: Ventilation).

(b) Ventilated spaces shall be provided with outdoor air using one of the following:
   (i) Natural ventilation
   (ii) Mechanical ventilation

5.2.1.1 Natural Ventilation Design Requirements

Naturally ventilated buildings shall:

(a) Comply with guidelines provided for natural ventilation in NBC.

(b) Have minimum BEE 3-star rated ceiling fans, if provided with ceiling fans.
(c) Have exhaust fans complying with minimum efficiency requirements of fans in §5.3 if provided.

5.2.1.2 Mechanical Ventilation Air Quantity Design Requirements

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

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

5.2.1.3 Demand Control Ventilation

Mechanical ventilation systems shall have demand control ventilation if they provide outdoor air greater than 1,500 liters per second, to a space greater than 50 m^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 § 5.2.1.3:

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

5.2.2. Minimum Space Conditioning Equipment Efficiencies

5.2.2.1 Chillers

(a) Chillers shall meet or exceed the minimum efficiency requirements presented in Table 5.1 through Table 5.2 under ANSI/ AHRI 550/ 590 conditions.
(b) The application of air-cooled chiller is allowed in all buildings with cooling load less than 530 kW. For buildings with cooling load equal to or greater than 530 kW, the capacity of air-cooled chiller shall be restricted to 33% of the total installed chilled water capacity unless the authority having jurisdiction mandates the application of air-cooled chillers.
(c) Minimum efficiency requirements under BEE Standards and Labeling Program for chillers shall take precedence over the minimum requirements presented in Table 5.1 through Table 5.2.
(d) To show compliance to ECBC, minimum requirement of both COP and IPLV requirement shall be met.

Table 5.1 Minimum Energy Efficiency Requirements for water cooled Chillers

Chiller Capacity (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

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 Refrigerant Flow

Variable Refrigerant Flow (VRF) systems shall meet or exceed the efficiency requirements specified in Table 5.4 as per the ANSI/AHRI Standard 1230 while the Indian Standard on VRF is being developed. BEE Standards and Labeling requirements for VRF shall take precedence over the current minimum requirement.

*Table 5.4 Minimum Efficiency Requirements for VRF Air conditioners**

		For 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.

5.2.2.4Air 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 reheater and dehumidifier) at conditions defined in ASHRAE Standard 127-2012 Method of Testing for Rating Computer and Data Processing Room Unitary Air Conditioners).

5.2.2.5 Boilers

Gas and oil fired boilers shall meet or exceed the minimum efficiency requirements specified in Table 5.6

Table 5.6 Minimum Efficiency Requirements for Oil and Gas Fired Boilers

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 §5.2.3.1 through §5.2.3.5.

5.2.3.1Time clock

Mechanical cooling and heating systems in Universities and Training Institutions of all sizes and all Shopping Complexes with built up area greater than 20,000 m^2 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 § 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

5.2.3.2Temperature Controls

Mechanical heating and cooling 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 m^2

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

(d) Each room of size more than 30 m^2 in Educational buildings

5.2.3.4Fan Controls

Cooling towers in buildings with built up area greater than 20,000 m^2 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.

5.2.3.6 Pressurization Requirements

All spaces in buildings shall be categorized under either one of the following three zone classifications and shall meet the pressurization requirements for that zone: -

(a) Positively pressurized zones
(b) Negatively pressurized zones
(c) Neutral zones

Note:

Positively pressurized zones are the spaces in buildings that are to be maintained at a positive pressure with respect to their surrounding spaces/outdoor environment in order to exclude entry of contaminated air into the space.

Negatively pressurized zones are the spaces that are to be maintained at a negative pressure with respect to their surrounding spaces/outdoor environment in order to prevent escape of potentially contaminated air from the space. Examples of Negatively pressurized zones include Isolation rooms, sputum collection rooms, surgical operating rooms, laboratories, autopsy laboratories, morgues, infectious disease wards, clinics etc.

Neutral zones are the spaces in buildings that are to be maintained at the same pressure with respect to their surrounding spaces/outdoor environment.

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

Exceptions to§ 5.2.4.1:

(a) Reduction in insulation R value by 0.2(compared to values in Table 5.7) 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 for any pipe located in a partition outside a building with direct exposure to weather.

Table 5.7 Insulation Requirements for Pipes

Operating Temperature (°C)	*Pipe size (mm)*	
	<40	>=40
	Insulation R value (m^2.K/W)	
Heating System		
>94°C to <=121°C	0.9	1.2
>60°C to<=94°C	0.7	0.7
>40°C to <=60°C	0.4	0.7
Cooling System		
>4.5°C to <=15°C	0.4	0.7
<4.5°C	0.9	1.2

Operating Temperature (°C)	*Pipe size (mm)*	
	<40	>=40
Refrigerant Piping (Split systems)		
>4.5°C to<=15°C	0.4	0.7
<4.5°C	0.9	1.2

5.2.4.2 Ductwork and Plenum Insulation

Ductwork and plenum shall be insulated in accordance with Table 5.8.

Table 5.8 Ductwork Insulation (R-value in m^2.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 in such that heat sink is free of interference from heat discharge by devices located in adjoining spaces and also does not interfere with such other 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 area of the building is less than 20,000 m^2

(b) at least 40% of the total hot water design capacity if above grade area of the building is greater than or equal to 20,000 m^2

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

5.2.7.2 Heating Equipment Efficiency

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

(a) Solar water heater shall meet the performance/ minimum efficiency level mentioned in IS 13129 Part (1&2).

(b) Gas Instantaneous water heaters shall meet the performance/minimum efficiency level mentioned in IS 15558 with above 80% Fuel utilization efficiency.

(c) Electric water heater shall be minimum 3 star rated under BEE Standards & Labeling program.

(d) For evacuated tube collector the storage tanks shall meet the IS 16542:2016, tubes shall meet IS 16543:2016 and IS 16544:2016 for the complete system.

5.2.7.3 Other Water Heating System

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

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

5.2.7.4 Piping Insulation

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

5.2.7.5 Heat Traps

Vertical pipe risers serving storage water heaters and storage tanks not having integral heat traps and serving a non-re circulating 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 5.9 except the following need not comply with the requirement:

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

Table 5.9 Mechanical and Motor Efficiency Requirements for Fans

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

5.3.1. Pumps

Chilled and condenser water pumps shall meet or exceed the minimum energy efficiency requirements specified in Table 5.10. Requirements for pumps in district chiller systems and hot water pumps for space heating are limited to the installed efficiency requirement of individual pump equipment only. To show compliance, calculate the total installed pump capacity in kilo watt and achieve the prescribed limits per kilo watt of refrigeration installed in the building.

Exceptions to §5.3.1: Pumps used in processes e.g. service hot water, chilled water used for refrigeration etc.

Table 5.10 Pump Efficiency Requirements

Equipment	*Requirement*
Chilled Water Pump (Primary and Secondary)	18.2 W/ kW_r with VFD on secondary pump
Condenser Water Pump	17.7 W/ kW_r
Pump Efficiency (minimum)	70%

5.3.2. Cooling Towers

Cooling towers shall meet or exceed the minimum efficiency requirements specified in Table 5.11

Table 5.11 Cooling Tower Efficiency Requirements

Equipment type	*Rating Condition*	*Efficiency*
Open circuit cooling tower Fans	35°C entering water	0.017 kW/kWr
	29°C leaving water	*0.31 kW/ L/s*
	24°C WB outdoor air	

5.3.3. Economizers

5.3.3.1Economizer

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

(a) An air economizer capable of modulating outside-air and return-air dampers to supply 50% of the design supply air quantity as outside-air.

(b) A water economizer capable of providing 50% of the expected system cooling load at outside air temperatures of 10°C dry-bulb/7.2°C wet-bulb and below.

Exception to §5.3.3.1:

(a) Projects in warm-humid climate zones.

(b) Individual cooling or heating fan systems is less than 3,200 liters per second.

5.3.3.2 Partial Cooling

Where required by §5.3.3.1 economizers shall be capable of providing partial cooling even when additional mechanical cooling is required to meet the cooling load.

5.3.3.3 Economizer Controls

Air economizer shall be equipped with controls

(a) That allow dampers to be sequenced with the mechanical cooling equipment and not be controlled by only mixed air temperature.

(b) Capable of automatically reducing outdoor air intake to the design minimum outdoor air quantity when outdoor air intake will no longer reduce cooling energy usage.

(c) Capable of high-limit shutoff at 24 °C dry bulb temperature.

5.3.3.4 Testing

Air-side economizers shall be tested in the field following the requirements in §14 Appendix E to ensure proper operation.

Exception to §5.3.3.4: 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 §14Appendix E.

5.3.4. Variable Flow Hydronic Systems

5.3.4.1 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.

5.3.4.2 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.

5.3.4.3 Variable Speed Drives

Chilled water or condenser water systems that must comply with either §5.3.4.1 or §5.3.4.2 and that have pump motors greater than or equal to 3.7 kW shall be controlled by variable speed drives.

5.3.5. 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.

5.4. Total System Loading Factor

Buildings may show compliance by optimizing the total system loading factor 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 5.13. 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 fans. Compliance check will be based on annual hourly simulation (refer Table 11.1 for developing the proposed design).

Table 5.13 Maximum System Loading Factor Requirement

Water Cooled Chilled Water Plant	*Maximum Threshold (kW/kWr)*
ECBC	0.26

5.4.1. 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 (kWrh) 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 of the Proposed Design.
(f) Explanation of any significant modeling assumptions made.
(g) Explanation of any error messages noted in the simulation program output.

The total system loading factor shall be calculated as follows:

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

5.5. Low-energy Comfort Systems

Alternative HVAC systems which have low energy use may be installed in place of (or in conjunction with) refrigerant-based cooling systems. Such systems shall be deemed to meet the minimum space conditioning equipment efficiency levels of §5.2.2, but shall comply with all other applicable mandatory provisions of §5.2 as applicable. Where ever applicable requirements of §5.3 and §5.4 will be complied with. The approved list of low energy systems comfort includes (but not limited to):

(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

5.5.1 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 equipment showing compliance with the mandatory and prescriptive requirements other than exempted in §5.5.
(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 § 6.2 and the prescriptive criteria of § 6.3. The lighting requirements in this section shall apply to:

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

Exceptions to §6.1: Emergency, security and fire fightinglighting that is out of purview of normal building operations.

6.2. Mandatory Requirements

6.2.1. Lighting Control

6.2.1.1 Automatic Lighting Shutoff

(a) 90% of interior lighting fittings by wattage in building or space of building larger than 300 m^2 shall be equipped with automatic control device.

(b) Automatic control device shall function on either:
  (i) A scheduled basis at specific programmed times. An independent program schedule shall be provided for areas of no more than 2,500 m^2 and not more than one floor, or,
  (ii) Occupancy sensors, that shall turn off the lighting fixtures within 15 minutes of an occupant leaving the space. Light fixtures controlled by occupancy sensors shall have a wall-mounted, manual switch capable of turning off/on lights.

(c) Additionally, occupancy sensors shall be provided in
  (i) All building types greater than 20,000 m^2 BUA, in
    a. All habitable spaces less than 30 m^2, enclosed by walls or ceiling height partitions.
    b. All storage or utility spaces more than 15 m^2

c. Public toilets more than 25 m^2, 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) In corridors of all Hospitality greater than 20,000 m^2 BUA, controlling minimum 70% and maximum 80% of lighting fitted in the public corridor. The lighting fixtures, not controlled by automatic lighting shut off, shall be uniformly spread in the area.

(iii) All conference or meeting rooms.

6.2.1.2 Space Control

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

(a) control a maximum of 250 m^2 for a space less than or equal to 1,000 m^2 and a maximum of 1,000 m^2 for a space greater than 1,000 m^2.

(b) have the capability to override the shutoff control required in § 6.2.1.1 for no more than 2 hours, and

(c) be readily accessible and located so that the occupants can see the control.

Exception to §6.2.1.2 (c)**:** The required control device may be remotely installed if required for reasons of safety or security. A remotely located device shall have a pilot light indicator as part of or next to the control device and shall be clearly labelled 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 § 4.2.3, shall be equipped with either a manual control device to shut off luminaries, installed within day lit area, during potential daylit time of a day or automatic control device that:

(i) Has a delay of minimum 5 minutes and

(ii) Can dim or step down to 50% of total power.

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

6.2.1.4 Exterior Lighting Control

(a) Lighting for all exterior applications shall be controlled by a photo sensor or astronomical time switch that is capable of automatically turning off the exterior lighting when daylight is available or the lighting is not required.

(b) Lighting for all exterior applications, shall have lamp efficacy not less than 80 lumens per watt, unless the luminaries are controlled by a motion sensor or exempt under §6.1.

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

6.2.1.5 Additional Control

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

(a) Display/ Accent Lighting: Display or accent lighting greater than 300 m^2 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 §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 §6.3.4 and shall not exceed the interior lighting power allowance determined in accordance with either §6.3.2 or §6.3.3.

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

(a) Display or accent lighting that is an essential element for the function performed in galleries, museums, and monuments,
(b) Lighting that is integral to equipment or instrumentation and is installed by its manufacturer,
(c) Lighting specifically designed for medical or dental procedures and lighting integral to medical equipment,
(d) Lighting integral to food warming and food preparation equipment,
(e) Lighting for plant growth or maintenance,
(f) Lighting in spaces specifically designed for use by the visually impaired,
(g) Lighting in retail display windows, provided the display area is enclosed by ceilingheight 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:

Determine the allowed lighting power density for each appropriate building area type from Table 6.1.

(a) Calculate the gross lighted area for each building area type.
(b) 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 – Building Area Method

Building Type	*LPD (W/m^2)*	*Building Area Type*	*LPD (W/m^2)*
Office Building	9.5	Motion picture theater	9.4
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	7.1
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.

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 6.2. 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 areaof the space times the allowed lighting power density for that space.

Table 6.2 Interior Lighting Power– Space Function Method

Category	*LPD (W/m^2)*	*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 Cataloguing	9.1
For Classrooms	13.8	Stacks (Lib)	18.3

Category	*LPD (W/m²)*	*Category*	*LPD (W/m²)*
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 Building	16.4
Museum - General Exhibition	16.4	Playing Area - Gymnasium	18.8
Museum - Restoration	18.3		

6.3.4. Installed Interior Lighting Power

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

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

6.3.4.1 Luminaires Wattage

Light output ratio shall be 0.7 or above. Luminaires 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 labelled 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' catalogues or values from independent testing laboratory reports.

(c) The wattage of all other miscellaneous luminaires 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 6.3. Trade-offs between applications are not permitted.

Table 6.3 Exterior Building Lighting Power

Exterior lighting application	*Power limits*
Building entrance (with canopy)	10 W/m² of canopied area
Building entrance (w/o canopy)	90 W/ linear m of door width
Building exit	60 W/linear m of door width
Building façade	5.0 W/m² of vertical façade area
Emergency signs, ATM kiosks, Security areas facade	1.0 W/m²
Driveways and parking (open/ external)	1.6 W/m²
Pedestrian walkways	2.0 W/m²
Stairways	10.0 W/m²
Landscaping	0.5 W/m²
Outdoor sales area	9.0 W/m²

6.3.6. Exterior Lighting Controls

Lighting for all exterior applications, shall have lamp efficacy not less than 80 lumens per Watt, unless the luminaires is controlled by a motion sensor or exempt under §6.1.

7. Electrical and Renewable Energy Systems

7.1. General

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

7.2. Mandatory Requirements

7.2.1. Transformers

7.2.1.1 Maximum Allowable Power Transformer Losses

Power transformers of the proper ratings and design must be selected to satisfy the minimum acceptable efficiency at 50% and full load rating. The permissible loss shall not exceed to values listed in Table 7.1 for dry type transformers and Table 7.2 for oil type transformers.

Table 7.1 Permissible Losses for Dry Type Transformers

Rating (kVA)	*Max. Total Loss (W*) Up to 22 kV class*		*Max. Total Loss (W*) Up to 33 kV class*	
	50 % Load	*100% Load*	*50 % Load*	*100% Load*
100	940	2400	1120	2400
160	1290	3300	1420	3300
200	1500	3800	1750	4000
250	1700	4320	1970	4600
315	2000	5040	2400	5400
400	2380	6040	2900	6800
500	2800	7250	3300	7800
630	3340	8820	3950	9200
800	3880	10240	4650	11400
1000	4500	12000	5300	12800
1250	5190	13870	6250	14500
1600	6320	16800	7500	18000
2000	7500	20000	8880	21400
2500	9250	24750	10750	26500

* 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 upto 11 kV (W)*	
		50 % Load	*100% Load*
16	4.5	108	364
25	4.5	158	541
63	4.5	270	956
100	4.5	392	1365
160	4.5	513	1547
200	4.5	603	1911
250	4.5	864	2488
315	4.5	890	2440

Rating (kVA)	*Impedance (%)*	*Max. Total Loss upto 11 kV (W)*	
		50 % Load	*100% Load*
400	4.5	1080	3214
500	4.5	1354	3909
630	4.5	1637	4438
1000	5	2460	6364
1250	5	3142	7670
1600	6.25	3753	10821
2000	6.25	4543	13254
2500	6.25	5660	16554

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 1180i.e., average winding temperature rise plus 30^0C. An increase of 7% on total for thermal class H is allowed.
Permissible total loss values shall not exceed

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

7.2.1.2 Measurement and Reporting of Transformer Losses

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

7.2.1.3 Voltage Drop

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

7.2.2. Energy Efficient Motors

Motors shall comply with the following:

(a) Three phase induction motors shall conform to Indian Standard (IS) 12615 and shall have motors of IE 2 (high efficiency) class or a higher class:
(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 minimum 3 stars rating.

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 1000 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 1000 kVA but over 65 kVA shall have permanently installed electric metering to record demand (kW), energy (kWh) and total power factor (or kVARh) on hourly basis.
(c) Services not exceeding 65 kVA shall have permanently installed electrical metering to record energy (kWh) on hourly basis.

Sub-metering requirements for different services are outlined in Table 7.3.

Table 7.3 Sub Metering: Minimum requirements for separation of electrical load

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

In addition to requirements stated above, for building types identified in Table 7.4, respective services must be sub-metered.

Table 7.4:Additional sub-metering requirements for specific building types

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

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

7.2.5. Power Factor Correction

All 3 phases electricity supplies shall maintain their power factor above 0.97 at the point of connection.

7.2.6. Power Distribution Systems

The power cabling shall be sized so that the distribution losses do not exceed 3% of the total power usage. 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 Labelling program by BEE shall take precedence over requirements listed in this section.

Table 7.5 Energy Efficiency Requirements for UPS

UPS Size	*Energy Efficiency Requirements at 100% Load*
kVA< 20	90.20%
20<=kVA <= 100	91.90%
kVA > 100	93.80%

7.2.8. Appliances

Appliances listed in §17 Appendix H shall follow minimum BEE star labelling requirements provided against each of the appliance in §17 Appendix H.

7.2.9. Renewable Energy Systems

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

7.2.9.1 Renewable Energy Generating Zone (REGZ)

(a) 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.

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

7.2.9.2 Main Electrical Service Panel

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

7.2.9.3 Demarcation on Documents

The following shall be indicated in design and construction documents:

(a) Location for inverters and metering equipment,

(b) Pathway for routing of conduit from the REGZ to the point of interconnection with the electrical service,

(c) Routing of plumbing from the REGZ to the water-heating system and

(d) Structural design loads for roof dead and live load.

8. Energy Auditing, Reporting and Star Rating

8.1. Mandatory Requirements

8.1.1. Energy Auditing of Building

It shall be mandatory to get the building energy audit conducted by a BEE accredited/ certified energy auditor/ certified energy auditor (Buildings)/ certified ECBC Master Trainer or BEE empanelled ESCO once each three years or at such interval as notified by the SDA from time to time. The energy audit shall also be conducted after addition of utilities within the building premises which enhances or requires the contract demand to be increased by more than 50% or such value as notified by SDA from time to time. The energy audit details shall be reported to the SDA through e-mail or submitted online using the specified website in such a manner and interval as notified by the SDA/BEE from time to time.

8.1.2. Reporting

The building information and energy data of each financial year as specified in § 18 Appendix I shall be reported to the SDA within two months of closing of the financial year through post or by e-mail or submitted online using the specified website in such a manner and interval as notified by the SDA/BEE from time to time.

9. Repeal and Saving

(a) Save as otherwise provided in this Code, the West Bengal Energy Conservation Building Code 2016, is hereby repealed.

(b) Not withstanding such repeal,

(i) anything done or any action taken or purported to have been done or taken including any rule, notification, inspection, order or notice made or issued or any appointment, confirmation or declaration made or any license, permission, authorization or exemption granted or any document or instrument executed or any direction given under the repealed laws shall, in so far as it is not inconsistent with the provisions of this Code, be deemed to have been done or taken under the corresponding provisions of this Code.

(ii) The Government of West Bengal may, as and when consider necessary, by notification, amend this code.

10. Appendix A: Definitions, Abbreviations and Acronyms

10.1.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.

10.2.Definitions

A

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

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

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

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

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

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

$$AWA=\Sigma(DatapointXarea)/Totalarea$$

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

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

B

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

C

Cardinal direction: cardinal directions or cardinal points are the four main directional points of a compass: north, south, east, and west which are also known by the first letters: N,S,E, and W.

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.)

Commercial building: a building or a part of building or building complex which are used or intended to be used for commercial purposes and classified as per the time of the day the building is operational and sub classified, as per the functional requirements of its design, construction, and use as per following details:

(a) Group I – 24 hours building covering Type A Hospitality, Type B Health Care and Type C Assembly and, Type D Business and,

(b) Group II – Regular building covering Type D Business, Type E Educational and Type F Shopping Complexes.

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

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

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

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

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

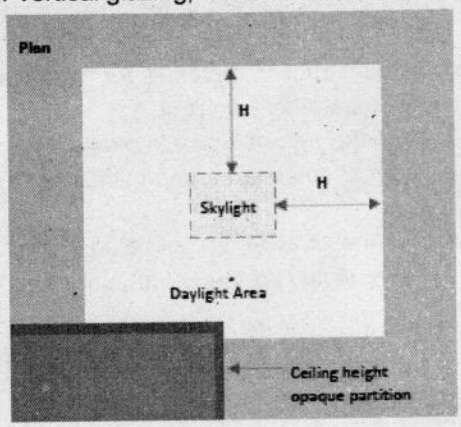
Cool roof: roof with top layer of material that has high solar reflectance and high thermal emittance properties. Cool roof surfaces are characterized by light colors so that heat can be rejected back to the environment.

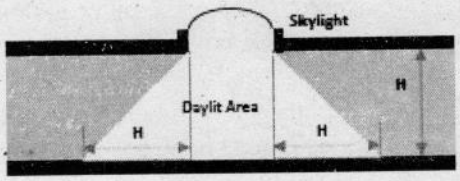
Cumulative design EPI: energy performance index for a building having two or more different functional uses and calculated based on the area weighted average (AWA) method

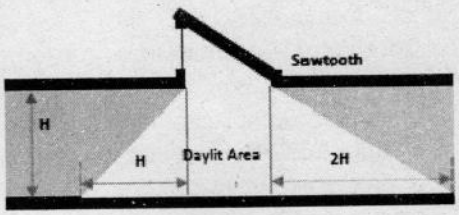
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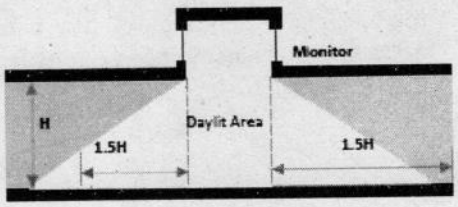
Daylight area: the daylight illuminated floor area under horizontal fenestration (skylight) or adjacent to vertical fenestration (window), described as follows:

(a) Horizontal Fenestration: the area under a skylight, monitor, or sawtooth configuration with an effective aperture greater than 0.001 (0.1%). The daylight area is calculated as the horizontal dimension in each direction equal to the top aperture dimension in that direction plus either the floor-to-ceiling height (H) for skylights, or 1.5 H for monitors, or H or 2H for the 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.

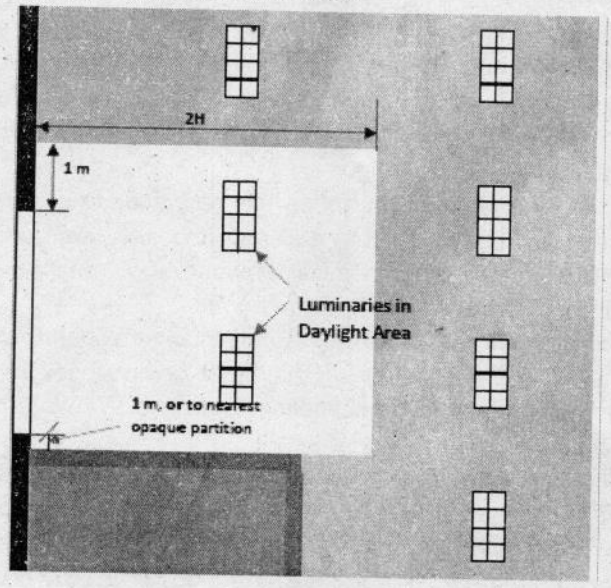








(b) Vertical Fenestration: the floor area adjacent to side apertures (vertical fenestration in walls) with an effective aperture greater than 0.06 (6%). The daylight area extends into the space perpendicular to the side aperture a distance equal to daylight extension factor (DEF) multiplied by the head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



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

Daytime Business Building: Business building operated typically only during daytime on week days upto 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 not more than one half glass, in the building envelope, including swinging and roll-up doors, fire doors, and access hatches.

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

E

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

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

ECBC Building: a building that complies with the mandatory requirements of §4 to §7 and also complies either with the prescriptive requirements stated under the ECBC Building categories of §4 to §7, or, with the whole building performance compliance method of §11 Appendix B.

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

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

Efficiency: performance at a specified rating condition

Efficiency, thermal: ratio of work output to heat input

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

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

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

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

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

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

Envelope Performance Factor (EPF): value for the building envelope performance compliance option calculated using the procedures specified in 4.3.5 and 4.3.6. For the purposes of determining building envelope requirements the classifications are defined as follows:

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

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

Energy Performance Index (EPI): of a building means its annual energy consumption in kilowatt-hours per square meter of the area of the building which shall be calculated in the existing or proposed building as per the formula below, =annual energy consumption in kWh_{total} / built-up area (excluding unconditioned basements and/or the parking in the basement)in m^2.

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

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

Equipment, existing: equipment previously installed in an existing building

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

Exemption: any exception allowed to compliance with ECBC requirements

F

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

(a) Skylight: a fenestration surface having a slope of less than 60 degrees from the horizontal plane. Other fenestration, even if mounted on the roof of a building, is considered vertical fenestration.

(b) Vertical fenestration: all fenestration other than skylights. Trombe wall assemblies, where glazing is installed within 300 mm of a mass wall, are considered walls, not fenestration.

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

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

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

Fuel: a material that may be used to produce heat or generate power by combustion

Fuel utilization efficiency (FUE): a thermal efficiency measure of combustion equipment like furnaces, boilers, and water heaters

G

Gathering hall (Type of Assembly): any building, its lobbies, rooms and other spaces connected thereto, primarily intended for assembly of people, but which has no theatrical stage or permanent theatrical and/or cinematographic accessories and has gathering space for greater or equal to 100 persons, for example, stand-alone dance halls, stand-alone night clubs, halls for incidental picture shows, dramatic, theatrical or educational presentation, lectures or other similar purposes having no theatrical stage except a raised platform and used without permanent seating arrangement; art galleries, community halls, marriage halls, places of worship, museums, stand-alone lecture halls, passenger terminals and heritage and archeological monuments, pool and billiard parlors, bowling alleys, community halls, courtrooms, gymnasiums, indoor swimming pools, indoor tennis court, any indoor stadium for sports and culture, auditoriums

Grade: finished ground level adjoining a building at all exterior walls

Guest room: any room or rooms used or intended to be used by a guest for sleeping purposes

H

Habitable spaces: space in a building or structure intended or used for working, meeting, living, sleeping, eating, or cooking. Bathrooms, water closet compartments, closets, halls, storage or utility space, and similar areas are not considered habitable spaces.

Hospitals and sanatoria (Healthcare): Any building or a group of buildings under single management, which is used for housing persons suffering from physical limitations because of health or age and those incapable of self-preservation, for example, any hospitals, infirmaries, sanatoria and nursing homes.

HVAC system: equipment, distribution systems, and terminal devices that provide, either collectively or individually, the processes of heating, ventilating, or air conditioning to a building or parts of a building.

Hyper Markets (Type F of Shopping Complex): large retail establishments that are a combination of supermarket and department stores. They are considered as a one-stop shop for all needs of the customer.

I

Infiltration: uncontrolled inward air leakage through cracks and crevices in external surfaces of buildings, around windows and doors due to pressure differences across these caused by factors such as wind or indoor and outside temperature differences (stack effect), and imbalance between supply and exhaust air systems

Installed interior lighting power: power in watts of all permanently installed general, task, and furniture lighting systems and luminaires

Integrated part-load value (IPLV): weighted average efficiency of chillers measured when they are operating at part load conditions (less than design or 100% conditions). It is more realistic measurement of chiller efficiency during its operational life.

K

Kilovolt-ampere (kVA): where the term "kilovolt-ampere" (kVA) is used in this Code, it is the product of the line current (amperes) times the nominal system voltage (kilovolts) times 1.732 for three-phase currents. For single-phase applications, kVA is the product of the line current (amperes) times the nominal system voltage (kilovolts).

Kilowatt (kW): the basic unit of electric power, equal to 1000 W.

L

Labeled: equipment or materials to which a symbol or other identifying mark has been attached by the manufacturer indicating compliance with specified standard or performance in a specified manner.

Lamp: a device for giving light consisting of electric bulb with its holder and shade or cover

Lighted floor area, gross: gross area of lighted floor spaces

Lighting, emergency: battery backed lighting that provides illumination only when there is a power outage and general lighting luminaries are unable to function.

Lighting, general: lighting that provides a substantially uniform level of illumination throughout an area. General lighting shall not include decorative lighting or lighting that provides a dissimilar level of illumination to serve a specialized application or feature within such area.

Lighting system: a group of luminaires circuited or controlled to perform a specific function.

Lighting power allowance:

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

(b) Exterior lighting power allowance: the maximum lighting power in watts allowed for the exterior of a building

Lighting Power Density (LPD): maximum lighting power per unit area of a space as per its function or building as per its classification.

Low energy comfort systems: space conditioning or ventilation systems that are less energy intensive then vapor compression based space condition systems. These primarily employ alternate heat transfer methods or materials (adiabatic cooling, radiation, desiccant, etc.), or renewable sources of energy (solar energy, geo-thermal) so that minimal electrical energy input is required to deliver heating or cooling to spaces.

Luminaires: a complete lighting unit consisting of a lamp or lamps together with the housing designed to distribute the light, position and protect the lamps, and connect the lamps to the power supply.

M

Man-made daylight obstruction: any permanent man-made object (equipment, adjacent building) that obstructs sunlight or solar radiation from falling on a portion or whole of a building's external surface at any point of time during a year is called as a man-made sunlight obstructer.

Manual (non-automatic): requiring personal intervention for control. Non-automatic does not necessarily imply a manual controller, only that personal intervention is necessary.

Manufacturing processes: processes through which raw material is converted into finished goods for commercial sale using machines, labor, chemical or biological processes, etc.

Manufacturer: company or person or group of persons who produce and assemble goods or purchases goods manufactured by a third party in accordance with their specifications.

Mean temperature: average of the minimum daily temperature and maximum daily temperature.

Mechanical cooling: reducing the temperature of a gas or liquid by using vapor compression, absorption, and desiccant dehumidification combined with evaporative cooling, or another energy-driven thermodynamic cycle. Indirect or direct evaporative cooling alone is not considered mechanical cooling.

Metering: practice of installing meters in buildings to acquire data for energy consumption and other operational characteristics of individual equipment or several equipment grouped on basis of their function (lighting, appliances, chillers, etc.). Metering is done in buildings to monitor their energy performance.

Mixed mode air-conditioned building: building in which natural ventilation is employed as the primary mode of ventilating the building and air conditioning is deployed as and when required.

Mixed use development: a single building or a group of buildings used for a combination of residential, commercial, business, educational, hospitality and assembly purposes

N

National Building Code 2016 (NBC): model-building code that provides guidelines for design and construction of buildings. In this code, National Building Code 2016 refers to the latest version by the Bureau of Indian Standards.

Natural daylight obstruction: any natural object, like tree, hill, etc., that obstructs sunlight from falling on part or whole of a building's external surface at any point of time during a year and casts a shadow on the building surface.

Naturally ventilated building: a building that does not use mechanical equipment to supply air to and exhaust air from indoor spaces. It is primarily ventilated by drawing and expelling air through operable openings in the building envelope.

Non-cardinal directions: any direction which is not a cardinal direction, i.e. perfect north, south, east, or west, is termed as non-cardinal direction.

No Star hotel (Type of Hospitality): any building or group of buildings under the same management, in which separate sleeping accommodation on commercial basis, with or without dining facilities or cooking facilities, is provided for individuals. This includes lodging rooms, inns, clubs, motels, no star hotel and guest houses and excludes residential apartments rented on a lease agreement of 4 months or more. These shall also include any building in which group sleeping accommodation is provided, with or without dining facilities for persons who are not members of the same family, in one room or a series of adjoining rooms under joint occupancy and single management, for example, school and college dormitories, students, and other hostels and military barracks.

O

Occupant sensor: a device that detects the presence or absence of people within an area and causes lighting, equipment, or appliances to be dimmed, or switched on or off accordingly.

Opaque assembly or opaque construction: surface of the building roof or walls other than fenestration and building service openings such as vents and grills.

Opaque external wall: external wall composed of materials which are not transparent or translucent, usually contains the structural part of the building, and supports the glazed façade. This type may be composed of one or more materials.

Open Gallery Mall (Type of Shopping Complex): a large retail complex containing a variety of stores and often restaurants and other business establishments housed in a series of connected or adjacent buildings or in a single large building. The circulation area and atrium of the open gallery mall is an unconditioned space and is open to sky.

Orientation: the direction a building facade faces, i.e., the direction of a vector perpendicular to and pointing away from the surface of the facade. For vertical fenestration, the two categories are north-oriented and all other.

Outdoor (outside) air: air taken from the outside the building and has not been previously circulated through the building.

Out-patient Healthcare (Type of Healthcare): any building or a group of buildings under single management, which is used only for treating persons requiring treatment or diagnosis of disease but not requiring overnight or longer accommodation in the building during treatment or diagnosis.

Over current: any current in excess of the rated current of the equipment of the capacity of the conductor. It may result from overload, short circuit, or ground fault.

Owner: a person, group of persons, company, trust, institute, Registered Body, state or central Government and its attached or sub-ordinate departments, undertakings and like agencies or organization in whose name the property stands registered in the revenue records for the construction of a building or building complex

P

Party wall: a firewall on an interior lot line used or adapted for joint service between two buildings.

Permanently installed: equipment that is fixed in place and is not portable or movable.

Plenum: a compartment or chamber to which one or more ducts are connected, that forms a part of the air distribution system, and that is not used for occupancy or storage.

Plug loads: energy used by products that are powered by means of an AC plug. This term excludes building energy that is attributed to major end uses specified in §5, §6, §7 (like HVAC, lighting, water heating, etc.).

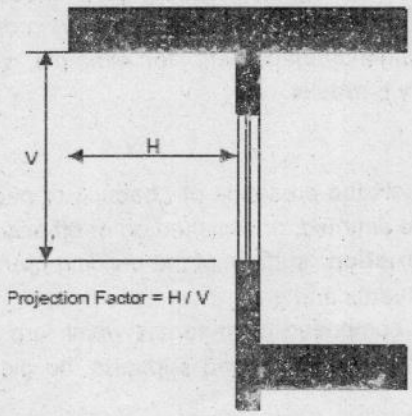
Pool: any structure, basin, or tank containing an artificial body of water for swimming, diving, or recreational bathing. The terms include, but no limited to, swimming pool, whirlpool, spa, hot tub.

Potential daylit time: amount of time in a day when there is daylight to light a space adequately without using artificial lighting. Potential daylit time is fixed for 8 hours per day i.e. from 09:00 AM to 5:00 PM local time, resulting 2920 hours in total for all building types except for Type E-1 - Educational, which shall be analyzed for 7 hours per day i.e. from 08:00 AM to 3:00 PM local time.

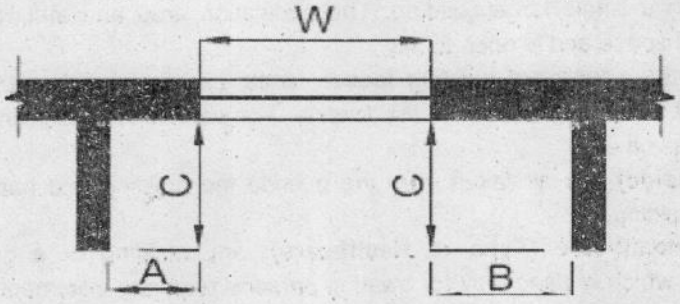
Primary inter-cardinal direction: any of the four points of the compass, midway between the cardinal points; northeast, southeast, southwest, or northwest are called primary inter-cardinal direction.

Process load: building loads resulting from the consumption or release of energy due to industrial processes or processes other than those for providing space conditioning, lighting, ventilation, or service hot water heating.

Projection factor, overhang: 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 Left Fin(PF_L)= C/(A+W) Projection factor Right Fin(PF_R)= C/(B+W)

Projection Factor, overhang and side fin: average of ratio projection factor for overhang only and projection factor of side fin only.

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

Proposed Design: a computer model of the proposed building, consistent with its actual design, which complies with all the mandatory requirements of ECBC.

R

R-value (thermal resistance): the reciprocal of the time rate of heat flow through a unit area induced by a unit temperature difference between two defined surfaces of material or construction under steady-state conditions. Units of R value are $m^2.K/W$.

Readily accessible: capable of being reached quickly for operation, renewal, or inspections without requiring those to whom ready access is requisite to climb over or remove obstacles or to resort to portable ladders, chairs, etc. In public facilities, accessibility may be limited to certified personnel through locking covers or by placing equipment in locked rooms.

Recirculating system: a domestic or service hot water distribution system that includes a close circulation circuit designed to maintain usage temperatures in hot water pipes near terminal devices (e.g., lavatory faucets, shower heads) in order to reduce the time required to obtain hot water when the terminal device valve is opened. The motive force for circulation is either natural (due to water density variations with temperature) or mechanical (recirculation pump).

Renewable Energy Generating Zone: a contiguous or semi-contiguous area, either on rooftop or elsewhere within site boundary, dedicated for installation of renewable energy systems.

Resort (Type of Hospitality): commercial establishments that provide relaxation and recreation over and above the accommodation, meals and other basic amnesties. The characteristics of resort are as below –

(a) Includes 1 or more recreation(s) facility like spa, swimming pool, or any sport;
(b) Is located in the midst of natural and picturesque surroundings outside the city;
(c) Comprises of 2 or more blocks of buildings within the same site less than or equal to 3 floors (including the ground floor).

Reset: automatic adjustment of the controller set point to a higher or lower value.

Roof: the upper portion of the building envelope, including opaque areas and fenestration, that is horizontal or tilted at an angle of less than 60° from horizontal. This includes podium roof as well which are exposed to direct sun rays.

Roof area, gross: the area of the roof measured from the exterior faces of walls or from the centerline of party walls

S

Service: the equipment for delivering energy from the supply or distribution system to the premises served.

Service water heating equipment: equipment for heating water for domestic or commercial purposes other than space heating and process requirements.

Set point: the desired temperature (°C) of the heated or cooled space that must be maintained by mechanical heating or cooling equipment.

Shading Coefficient (SC): Measure of thermal performance of glazing. It is the ratio of solar heat gain through glazing due to solar radiation at normal incidence to that occurring through 3 mm thick clear, double-strength glass. Shading coefficient, as used herein, does not include interior, exterior, or integral shading devices.

Shading Equivalent Factor: coefficient for calculating effective SHGC of fenestrations shaded by overhangs or side fins.

Shopping Mall (Shopping Complex): a large retail complex containing a variety of stores and often restaurants and other business establishments housed in a series of connected or adjacent buildings or in a single large building. The circulation area and atrium of the mall is an enclosed space covered completely by a permanent or temporary structure.

Simulation program: software in which virtual building models can be developed to simulate the energy performance of building systems and daylight analysis.

Single-zone system: an HVAC system serving a single HVAC zone.

Site-recovered energy: waste energy recovered at the building site that is used to offset consumption of purchased fuel or electrical energy supplies.

Slab-on-grade floor: floor slab of the building that is in contact with ground and that is either above grade or is less than or equal to 300 mm below the final elevation of the nearest exterior grade.

Solar Heat Gain Coefficient (SHGC): the ratio of the solar heat gain entering the space through the fenestration area to the incident solar radiation. Solar heat gain includes directly transmitted solar heat and absorbed solar radiation, which is then reradiated, conducted, or convicted into the space.

Solar Reflectance: ratio of the solar radiation reflected by a surface to the solar radiation incident upon it

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

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

(b) Semi-heated space: an enclosed space within a building that is heated by a heating system whose output capacity is greater or equal to 10.7 W/m^2 but is not a conditioned space.

(c) Non-conditioned space: an enclosed space within a building that is not conditioned space or a semi-heated space. 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.

Story: portion of a building that is between one finished floor level and the next higher finished floor level or building roof. Basement and cellar shall not be considered a story.

Summer Solar Insolation: measure of solar radiation energy received on a given surface area from the month of March to October within the same calendar year. Units of measurement are watts per square meter (W/m^2) or kilowatt-hours per square meter per day (kW/h/ (m^2/day)) (or hours/day).

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 reduces its efficiency.

Transport Buildings (Assembly): any building or structure used for the purpose of transportation and transit like airports, railway stations, bus stations, and underground and elevated mass rapid transit system example, underground or elevated railways.

U

Unconditioned buildings: building in which more than 90% of spaces are unconditioned spaces.

Unconditioned space: mechanically or naturally ventilated space that is not cooled or heated by mechanical equipment.

Universities and all others coaching/training institutions (Educational): a building or a group of buildings, under single management, used for imparting education to students numbering more than 100 or public or private training institution built to provide training/coaching etc.

Useful Daylight Illuminance: percentage of annual daytime hours that a given point on a work plane height of 0.8 m above finished floor level receives daylight between 100 lux to 2,000 lux.

U-factor (Thermal Transmittance): heat transmission in unit time through unit area of a material or construction and the boundary air films, induced by unit temperature difference between the environments on each side. Unit of U value is $W/m^2.K$.

V

Variable Air Volume (VAV) system: HVAC system that controls the dry-bulb temperature within a space by varying the volumetric flow of heated or cooled air supplied to the space.

Vegetative roofs: also known as green roofs, they are thin layers of living vegetation installed on top of conventional flat or sloping roofs.

Ventilation: the process of supplying or removing air by natural or mechanical means to or from any space. Such air is not required to have been conditioned.

Vision Windows: windows or area of large windows that are primarily for both daylight and exterior views. Typically, their placement in the wall is between 1 meter and 2.2 meter above the floor level.

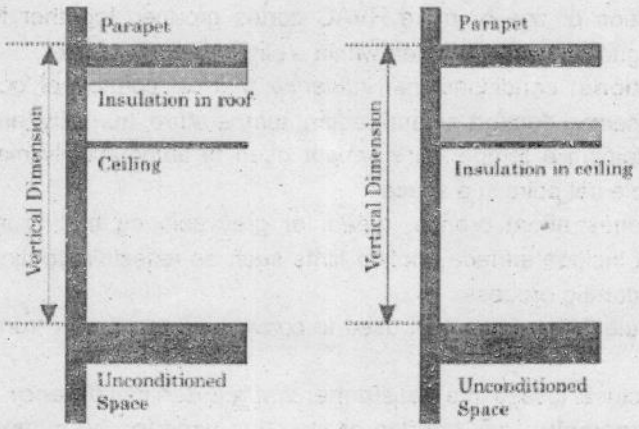
W

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

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

(b) Wall, below grade: that portion of a wall in the building envelope that is entirely below the finish grade and in contact with the ground

Wall area, gross: the overall area off a wall including openings such as windows and doors measured horizontally from outside surface to outside 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-story buildings.



Water heater: vessel in which water is heated and withdrawn for use external to the system.

Z

Zone, HVAC: a space or group of spaces within a building with heating and cooling requirements that are sufficiently similar so that desired conditions (e.g., temperature) can be maintained throughout using a single sensor (e.g., thermostat or temperature sensor).

Zone, Critical: a zone serving a process where reset of the zone temperature set point 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

10.3.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/m4.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-°F/ Btu
1 °C	((°C x 9/5) + 32) °F
1 kWr	0.284 TR
1 kW	1.34 hp
1 kW	3412.142 Btu/hr

10.4.Abbreviations and Acronyms

AFUE	Annual fuel utilization efficiency
AHRI	Air-conditioning, Heating and Refrigeration Institute
ANSI	American National Standards Institute
ARI	Air-Conditioning and Refrigeration Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASTM	American Society for Testing and Materials
BIS	Bureau of Indian Standards
Btu	British thermal unit
Btu/h	British thermal units per hour
Btu/h-ft^2-°F	British thermal units per hour per square foot per degree Fahrenheit
BUA	Built up area
C	Celsius
Cm/h	cubic meter per hour
cm	centimeter
COP	coefficient of performance
DEF	daylight extent factor
EER	energy efficiency ratio
EPI	energy performance index
F	Fahrenheit
ft	foot
h	hour
h-ft^2-°F/Btu	hour per square foot per degree Fahrenheit per British thermal unit
h-m^2-°C/W	hour per square meter per degree Celsius per Watt
hp	horsepower
HVAC	heating, ventilation, and air conditioning
I-P	inch-pound

in.	inch
IPLV	integrated part-load value
IS	Indian Standard
ISO	International Organization for Standardization
kVA	kilovolt-ampere
kW	Kilowatt of electricity
kWr	kilowatt of refrigeration
kWh	kilowatt-hour
l/s	liter per second
LE	luminous efficacy
lin	linear
linft	linear foot
lin m	linear meter
lm	lumens
Lm/W	lumens per watt
LPD	lighting power density
m	meter
mm	millimeter
m2	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-s^{-1}	watt per liter 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	Watt hour

11. Appendix B: Whole Building Performance Method

11.1.General

11.1.1. Scope

The Whole Building Performance Method is an alternative to the Prescriptive Method compliance path contained in §4 through §7 of this Code. It applies to all building types covered by the Code as mentioned in §2.4.

11.1.2. Compliance

A building complies with the Code using the Whole Building Performance (WBP) Method, when the estimated EPI Ratio is equal to or less than 1, even though it may not comply with the specific provisions of the prescriptive requirements in §4 trough §7. The mandatory requirements of §4 through §7 (§4.2, §5.2, §6.2, and §7.2) shall be met when using the WBP Method.

11.1.3. 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.

11.1.4. 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.

11.1.5. 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 modeling assumptions made.

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

(h) Building floor plans, building elevations and site plan.

11.2.Mandatory Requirements

All requirements of §4.2, §5.2, §6.2 and §7.2 shall be met. These sections contain the mandatory provisions of the Code and are prerequisites for demonstrating compliance using the WBP Method.

11.3.Simulation Requirements

11.3.1. Energy Simulation Program

The simulation software shall be a computer-based program for the analysis of energy consumption in buildings and be approved by the authority having jurisdiction. The simulation program shall, at a minimum, have the ability to model the following:

(a) Energy flows on an hourly basis for all 8,760 hours of the year,

(b) Hourly variations in occupancy, lighting power, miscellaneous equipment power, thermostat set points, and HVAC system operation, defined separately for each day of the week and holidays,

(c) Thermal mass effects,

(d) Ten or more thermal zones,
(e) Part-load and temperature dependent performance of heating and cooling equipment,
(f) Air-side and water-side economizers with integrated control.

In addition to the above, the simulation tool shall be able to produce hourly reports of energy use by energy source and shall have the capability to performing design load calculations to determine required HVAC equipment capacities, air, and water flow rates in accordance with §5 for both the proposed and Standard building designs.

The simulation program shall be tested according to ASHRAE Standard 140 Method of Test for the Evaluation of Building Energy Analysis Computer Programs (ANSI approved) and the results shall be furnished by the software provider.

11.3.2. 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.

11.3.3. 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.

11.4.Calculating Energy Consumption of Proposed Design and Standard Design

11.4.1. 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 11.1. The Standard Design is based on the mandatory and prescriptive requirements of the ECBC compliant building.

Table 11.1 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 §4.2, §5.2, §6.2, and §7.2 and §4.3, §5.3, and §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.

Case	*Proposed Design*	*Standard Design*
2. Space Use Classification	The building type or space type classifications shall be chosen in accordance with §2.4. 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 §11.6. In case a schedule for an occupancy type is missing in §11.6, 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.BuildingEnvelope	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 §4.3.1.1.	The Standard Design shall have identical conditioned floor area and identical exterior dimensions and orientations as the Proposed Design, except as noted in (a), (b), (c), (d) and (e) below. 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

Case	*Proposed Design*	*Standard Design*
	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 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 0.75.	capacity as the Proposed Design but with the maximum U-factor allowed in §4.3.1 and §4.3.2. c) 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) Skylight areas shall equal that in the Proposed Design or 5% of gross roof area, whichever is smaller. e) Roof Solar Reflectance and Thermal Emittance: The exterior roof surfaces shall be modeled using a solar reflectance of 0.70 and a thermal emittance of 0.75.
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 §6.3.4.	Interior Lighting power in the Standard Design shall be determined using the same categorization procedure (building area or space function) and categories as the Proposed Design with lighting power set equal to the

Case	*Proposed Design*	*Standard Design*
	Where no lighting exists, or is specified, lighting power shall be determined in accordance with the §6.3.2 or §6.3.3for 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, exterior spaces and building facades shall be modeled Minimum Lighting controls, as per the ECBC requirements of §6.2.1, shall be modeled in the Proposed case. Automatic daylighting controls shall be modeled directly in the software or through schedule adjustments determined by a separate daylight analysis approved by the authority having jurisdiction. Other automatic lighting controls shall be modeled directly in the software by adjusting the lighting power as per Table 11.3.	maximum allowed for the corresponding method and category in either §6.3.2 or §6.3.3. Power for fixtures not included in the lighting power density calculation shall be modeled identically in the Proposed Design and Standard Design. Lighting controls shall be as per the ECBC requirements of §6.2.1. Exterior lighting power in the standard design shall be set equal to the maximum allowed in §6.3.5.
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	Same as Proposed Design

Case	*Proposed Design*	*Standard Design*
	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.	
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 §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 11.2 and related performance parameters for the Standard Design shall be determined from requirements of §11.4.2. Equipment performance shall meet the requirements of §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 §5.2.7.2.

Case	*Proposed Design*	*Standard Design*
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 11.2 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

	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 Cohditioned 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*
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, Fossil/Electric Hybrid: Where a heating system exists and a fossil fuel hot water boiler has been specified in the Proposed Design	1. Heat Pump: Where no heating system has been specified or where an electric heating system has been specified in the Proposed Design 2. Fossil Fuel Boiler, Fossil/Electric Hybrid: Where a heating system exists and a fossil fuel hot water boiler has been specified in the Proposed Design	1. Electric resistance: Where no heating system has been specified or where an electric heating system has been specified in the Proposed Design 2. Fossil Fuel Boiler, Fossil/Electric Hybrid: Where a heating system exists and a fossil fuel hot water boiler has been specified in the Proposed Design	NA

Notes:

1. Buildings of the listed occupancy types or spaces in Mixed-use Buildings with the listed occupancy types.
2. Where attributes make a building eligible for more than one system type; use the predominant condition to determine the Standard Design system type provided the non-predominant conditions apply to less than 1,000 m^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 11.3 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 Timing Control	*15%*	*10%*

11.4.2. HVAC Systems

The HVAC system type and related performance parameters for the Standard Design shall be determined from Table 11.2 and the following rules:

(a) Other components: Components and parameters not listed in Table 11.2 or otherwise specifically addressed in this subsection shall be identical to those in the Proposed Design.

Exception to §11.4.2 (a): Where there are specific requirements in §5.2.2, the component efficiency in the Standard Design shall be adjusted to the lowest efficiency level allowed by the requirement for that component type.

(b) All HVAC and service water heating equipment in the Standard Design shall be modeled at the minimum efficiency levels, both part load and full load, in accordance with §5.2.2.

(c) Where efficiency ratings, such as EER and COP, include fan energy, the descriptor shall be broken down into its components so that supply fan energy can be modeled separately.

(d) Minimum outdoor air ventilation rates shall be the same for both the Standard Design and the Proposed Design except for conditions specified in §11.4.2.1.

(e) The equipment capacity for the standard design shall be based on sizing runs for each orientation and shall be oversized by 15% for cooling and 25% for heating, i.e., the ratio between the capacities determined by the sizing runs shall be 1.15 for cooling and 1.25 for heating.

(f) Annual 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 annual unmet hours shall not exceed 300 for either case.

11.4.2.1 Minimum Outdoor air rates:

Minimum outdoor air rates shall be identical for both the Standard Design and Proposed Design, except

(a) when modeling Demand Controlled Ventilation (DCV) in the Proposed Design (DCV is not required in the Standard Design as per §5.2.1.3).

(b) when the Proposed Design has a ventilation flow higher than the minimum required by the applicable code, the Standard Design shall be modeled as per the minimum ventilation rate required by the applicable code and the Proposed Design shall be modeled as per actual design (higher than Standard Design).

11.4.2.2 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.

11.4.2.3 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

Fan power shall be modeled as per power and efficiency limits specified in Table 5.8 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.

11.4.2.4 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.

11.4.2.5 Economizers (airside and waterside)

Airside economizers shall be modeled in the Standard Design as per the requirements of §5.3.3.

Exception to §11.4.2.5: Airside economizer shall not be modeled for Standard Design HVAC System Type A.

11.4.2.6 Energy Recovery

Energy recovery shall be modeled in the Standard Design as per the requirements of §5.3.5

11.4.2.7 Chilled Water Design Supply Temperatures

Chilled water design supply temperature shall be modeled at 6.7° C and return temperature at 13.3° C.

11.4.2.8 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 11.4 below:

Table 11.4: 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 Chiller, equally sized such that no Chiller is greater than 2,813 kWr

Exception to 11.4.2.8: 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.

11.4.2.9 Chilled Water Pumps

Chilled and condenser water pumps for the Standard Design shall be modeled as per power and efficiency limits specified in Table 5.10. Standard Design chilled water pumps shall be modeled as primary-secondary with variable secondary flow.

11.4.2.10 Cooling Tower

Standard Design cooling tower shall be modeled as an open circuit axial flow tower with power and efficiency as per Table 5.11. 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.

11.4.2.11 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.

11.4.2.12 Hot Water Design Supply Temperatures

Hot water design supply temperature shall be modeled at 82°C and return temperature at 54°C.

11.4.2.13Hot 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). Standard Design hot water pumps shall be modeled as primary-secondary with variable secondary flow.

11.4.2.14 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 modeling 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 11.2, shall be modified as follows:

(a) For System Type C, purchased chilled water shall be modeled as the cooling source.

(b) System Types A and B shall be replaced with a two-pipe fan coil system with purchased chilled water as the cooling source.

The chilled water/thermal energy consumption simulated by the software shall be converted to units of kWh and added to the overall building energy consumption. The following conversion factors shall be used to convert chilled water/thermal energy consumption to units of kWh.

1 ton hour = 0.85 kWh

1 MBtu = 10,00,000 Btu = 293 kWh

Option B

The Standard Design shall be modeled as per Table 11.2.

For the Proposed Design, model a virtual onsite chilled water plant with Chiller, Pumps and cooling towers modeled at minimum efficiency levels as per §11.4.2.7 to §11.4.2.10. Airside/low side capacities shall be modeled as per design and the plant capacities shall be auto-sized by the software.

11.5.Maximum Allowed EPI Ratio

Table 11.5 Maximum Allowed EPI Ratios for buildings in Composite, Warm & Humid, and Cold Climate

Building Type	*Allowed EPI Ratio*
Hotel (No Star and Star)	1
Resort	1
Hospital	1
Outpatient	1
Assembly	1
Office (Regular Use)	1
Office (24Hours)	1
Schools and University	1
Open Gallery Mall	1
Shopping Mall	1
Supermarket	1
Strip retail	1

11.6.Schedules

Table 11.6 Schedules for Business - Office Buildings

Business - Office							
Time Period	*Elevator Schedules*		*External Lighting Schedule*	*Basement Ventilation*		*Basement Lighting*	
	Daytime Business	*24 Hours Business*	*7 Days / week*	*Daytime Business*	*24 Hours Business*	*Daytime Business*	*24 Hours Business*
00:00-01 00	0.05	0.55	0.80	0.00	1.00	0.05	1.00
01:00-02:00	0.05	0.25	0.80	0.00	1.00	0.05	1.00
02:00-03:00	0.05	0.25	0.80	0.00	1.00	0.05	1.00
03:00-04:00	0.05	0.15	0.80	0.00	1.00	0.05	1.00
04:00-05:00	0.05	0.35	0.80	0.00	1.00	0.05	1.00
05:00-06:00	0.05	0.50	0.80	0.00	1.00	0.05	1.00
06:00-07:00	0.20	0.20	0.00	0.00	1.00	0.05	1.00
07:00-08:00	0.40	0.40	0.00	0.00	1.00	0.05	1.00
08:00-09:00	0.80	0.80	0.00	1.00	1.00	1.00	1.00
09:00-10:00	0.80	0.80	0.00	1.00	1.00	1.00	1.00
10:00-11:00	0.55	0.55	0.00	1.00	1.00	1.00	1.00
11:00-12:00	0.35	0.35	0.00	1.00	1.00	1.00	1.00

Business - Office							
Time Period	Elevator Schedules		External Lighting Schedule	Basement Ventilation		Basement Lighting	
	Daytime Business	24 Hours Business	7 Days / week	Daytime Business	24 Hours Business	Daytime Business	24 Hours Business
12:00-13:00	0.25	0.25	0.00	1.00	1.00	1.00	1.00
13:00-14:00	0.95	0.95	0.00	1.00	1.00	1.00	1.00
14:00-15:00	0.95	0.95	0.00	1.00	1.00	1.00	1.00
15:00-16:00	0.35	0.35	0.00	1.00	1.00	1.00	1.00
16:00-17:00	0.15	0.35	0.00	1.00	1.00	1.00	1.00
17:00-18:00	0.75	0.70	0.00	1.00	1.00	1.00	1.00
18:00-19:00	0.95	0.95	0.80	1.00	1.00	1.00	1.00
19:00-20:00	0.50	0.50	0.80	1.00	1.00	1.00	1.00
20:00-21:00	0.30	0.35	0.80	1.00	1.00	1.00	1.00
21:00-22:00	0.20	0.25	0.80	0.00	1.00	0.05	1.00
22:00-23:00	0.05	0.25	0.80	0.00	1.00	0.05	1.00
23:00-24:00	0.05	0.55	0.80	0.00	1.00	0.05	1.00

Table 11.7: Schedules for Business - Office Building Daytime Business

Business – Office Daytime Business										
Time Period	Occupancy Schedule			Lighting Schedule			Equipment Schedule		HVAC Fan Schedule (On/Off)	
	Office	Corridor/ Lobby	Conference / Meeting Room	Office	Corridor/ Lobby	Conference / Meeting Room	Office	Conference / Meeting Room	Office/ Corridor/	Conference / Meeting Room
00:00-01:00	0.00	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0	0
01:00-02:00	0.00	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0	0
02:00-03:00	0.00	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0	0
03:00-04:00	0.00	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0	0
04:00-05:00	0.00	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0	0
05:00-06:00	0.00	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0	0
06:00-07:00	0.00	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0	0
07:00-08:00	0.00	0.00	0.00	0.10	0.10	0.00	0.00	0.00	1	0
08:00-09:00	0.20	0.70	0.00	0.90	0.90	0.00	0.10	0.00	1	1
09:00-10:00	0.95	0.80	0.00	0.90	0.90	0.00	0.90	0.00	1	1
10:00-11:00	0.95	0.70	0.75	0.90	0.90	0.90	0.90	0.90	1	1
11:00-12:00	0.95	0.30	0.75	0.90	0.90	0.90	0.90	0.90	1	1
12:00-13:00	0.95	0.30	0.75	0.90	0.90	0.90	0.90	0.90	1	1
13:00-14:00	0.50	0.80	0.5	0.50	0.90	0.50	0.80	0.50	1	1
14:00-15:00	0.95	0.50	0.75	0.90	0.90	0.90	0.90	0.90	1	1
15:00-16:00	0.95	0.30	0.75	0.90	0.90	0.90	0.90	0.90	1	1
16:00-17:00	0.95	0.30	0.75	0.90	0.90	0.90	0.90	0.90	1	1

Business – Office Daytime Business										
Time Period	Occupancy Schedule			Lighting Schedule			Equipment Schedule		HVAC Fan Schedule (On/Off)	
	Office	Corridor/ Lobby	Conference / Meeting Room	Office	Corridor/ Lobby	Conference / Meeting Room	Office	Conference / Meeting Room	Office/ Corridor/	Conference / Meeting Room
17:00-18:00	0.95	0.80	0.75	0.95	0.90	0.90	0.90	0.90	1	1
18:00-19:00	0.30	0.70	0.50	0.50	0.90	0.90	0.50	0.90	1	1
19:00-20:00	0.00	0.30	0.00	0.30	0.90	0.00	0.10	0.00	1	0
20:00-21:00	0.00	0.00	0.00	0.10	0.10	0.00	0.10	0.00	1	0
21:00-22:00	0.00	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0	0
22:00-23:00	0.00	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0	0
23:00-24:00	0.00	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0	0

Table 11.8: Schedules for Business - Office Building 24-hours Business

Business – Office 24-hour Business									
Time Period	Occupancy Schedule			Lighting Schedule			Equipment Schedule		HVAC Fan Schedule (On/Off)
	Office	Corridor/ Lobby	Conference/ Meeting Room	Office	Corridor/ Lobby	Conference/ Meeting Room	Office	Conference/ Meeting Room	Office/ Corridor/ Lobby/ Conference/ Meeting Room
00:00-01:00	0.90	0.20	0.00	0.90	0.90	0.00	0.95	0.00	1
01:00-02:00	0.90	0.50	0.00	0.90	0.90	0.00	0.95	0.00	1
02:00-03:00	0.90	0.20	0.00	0.90	0.90	0.00	0.95	0.00	1
03:00-04:00	0.90	0.20	0.00	0.90	0.90	0.00	0.95	0.00	1
04:00-05:00	0.50	0.20	0.50	0.50	0.90	0.50	0.00	0.90	1
05:00-06:00	0.20	0.50	0.50	0.05	0.90	0.50	0.00	0.90	1
06:00-07:00	0.10	0.50	0.50	0.05	0.50	0.50	0.00	0.90	1
07:00-08:00	0.10	0.50	0.00	0.90	0.50	0.00	0.95	0.00	1
08:00-09:00	0.90	0.70	0.00	0.90	0.90	0.00	0.95	0.00	1
09:00-10:00	0.90	0.80	0.50	0.90	0.90	0.50	0.95	0.90	1
10:00-11:00	0.90	0.70	0.75	0.90	0.90	0.90	0.95	0.90	1
11:00-12:00	0.90	0.30	0.75	0.90	0.90	0.90	0.95	0.90	1
12:00-13:00	0.90	0.30	0.75	0.90	0.90	0.90	0.95	0.90	1
13:00-14:00	0.20	0.80	0.25	0.50	0.50	0.50	0.20	0.50	1
14:00-15:00	0.90	0.50	0.75	0.90	0.90	0.90	0.95	0.90	1
15:00-16:00	0.90	0.30	0.75	0.90	0.90	0.90	0.95	0.90	1
16:00-17:00	0.90	0.30	0.75	0.90	0.90	0.90	0.95	0.90	1
17:00-18:00	0.90	0.80	0.75	0.90	0.90	0.90	0.95	0.90	1
18:00-19:00	0.90	0.70	0.50	0.90	0.90	0.90	0.20	0.90	1
19:00-20:00	0.20	0.30	0.00	0.90	0.90	0.00	0.95	0.00	1
20:00-21:00	0.90	0.20	0.00	0.90	0.90	0.00	0.95	0.00	1
21:00-22:00	0.90	0.20	0.50	0.90	0.90	0.50	0.95	0.90	1

Business – Office 24-hour Business									
Time Period	Occupancy Schedule			Lighting Schedule			Equipment Schedule		HVAC Fan Schedule (On/Off)
	Office	Corridor/ Lobby	Conference/ Meeting Room	Office	Corridor/ Lobby	Conference/ Meeting Room	Office	Conference/ Meeting Room	Office/ Corridor/ Lobby/ Conference/ Meeting Room
22:00-23:00	0.90	0.20	0.50	0.90	0.90	0.50	0.95	0.90	1
23:00-24:00	0.90	0.20	0.50	0.90	0.90	0.50	0.20	0.90	1

Table 11.9: Schedules for Business - Server Room

Business Building - Server Room						
Time Period	Occupancy Schedule		Lighting Schedule		Equipment Schedule	HVAC Fan Schedule (ON/OFF)
	Daytime Business	24-hour business	Daytime Business	24-hour business	All time running	
00:00-01:00	0.00	0.00	0.10	0.10	1.00	1
01:00-02:00	0.00	0.00	0.10	0.10	1.00	1
02:00-03:00	0.00	0.00	0.10	0.10	1.00	1
03:00-04:00	0.00	0.00	0.10	0.10	1.00	1
04:00-05:00	0.00	0.00	0.10	0.10	1.00	1
05:00-06:00	0.00	1.00	0.10	0.10	1.00	1
06:00-07:00	0.00	1.00	0.10	0.10	1.00	1
07:00-08:00	0.00	1.00	0.10	0.10	1.00	1
08:00-09:00	1.00	1.00	0.10	0.10	1.00	1
09:00-10:00	1.00	1.00	0.50	0.50	1.00	1
10:00-11:00	1.00	1.00	0.50	0.50	1.00	1
11:00-12:00	1.00	1.00	0.50	0.50	1.00	1
12:00-13:00	1.00	1.00	0.50	0.50	1.00	1
13:00-14:00	1.00	1.00	0.50	0.50	1.00	1
14:00-15:00	1.00	1.00	0.50	0.50	1.00	1
15:00-16:00	1.00	1.00	0.50	0.50	1.00	1
16:00-17:00	1.00	1.00	0.50	0.50	1.00	1
17:00-18:00	1.00	1.00	0.50	0.50	1.00	1
18:00-19:00	0.00	1.00	0.10	0.50	1.00	1
19:00-20:00	0.00	1.00	0.10	0.50	1.00	1
20:00-21:00	0.00	1.00	0.10	0.50	1.00	1
21:00-22:00	0.00	1.00	0.10	0.50	1.00	1
22:00-23:00	0.00	0.00	0.10	0.10	1.00	1
23:00-24:00	0.00	0.00	0.10	0.10	1.00	1

Table 11.10: Schedules for Assembly Buildings (A)

Assembly Buildings – Common Areas							
Time Period	Elevator Schedule	HVAC Fan Schedule (On/Off)			External Lighting Schedule	Basement Ventilation	Basement Lighting
		Seating / Public Space	Exhibit Space	Meeting/ Conference Room			
00:00-01:00	0.00	0	0	0	0.80	0.00	0.05
01:00-02:00	0.00	0	0	0	0.80	0.00	0.05
02:00-03:00	0.00	0	0	0	0.80	0.00	0.05
03:00-04:00	0.00	0	0	0	0.80	0.00	0.05
04:00-05:00	0.00	0	0	0	0.80	0.00	0.05
05:00-06:00	0.00	0	0	0	0.80	0.00	0.05
06:00-07:00	0.00	0	0	1	0.00	0.00	0.05
07:00-08:00	0.00	1	1	1	0.00	0.00	0.05
08:00-09:00	0.20	1	1	1	0.00	1.00	1.00
09:00-10:00	0.50	1	1	1	0.00	1.00	1.00
10:00-11:00	0.50	1	1	1	0.00	1.00	1.00
11:00-12:00	0.50	1	1	1	0.00	1.00	1.00
12:00-13:00	0.50	1	1	1	0.00	1.00	1.00
13:00-14:00	0.50	1	1	1	0.00	1.00	1.00
14:00-15:00	0.50	0	1	1	0.00	1.00	1.00
15:00-16:00	0.50	0	1	0	0.00	1.00	1.00
16:00-17:00	0.50	0	1	0	0.00	1.00	1.00
17:00-18:00	0.50	0	0	0	0.00	1.00	0.50
18:00-19:00	0.50	0	0	0	0.80	0.00	0.05
19:00-20:00	0.40	0	0	0	0.80	0.00	0.05
20:00-21:00	0.20	0	0	0	0.80	0.00	0.05
21:00-22:00	0.20	0	0	0	0.80	0.00	0.05
22:00-23:00	0.00	0	0	0	0.80	0.00	0.05
23:00-24:00	0.00	0	0	0	0.80	0.00	0.05

Table 11.11: Schedules for Assembly Buildings (B)

Assembly Buildings								
Time Period	Occupancy Schedule			Lighting Schedule			Equipment Schedule	
	Seating/ Public Space	Exhibit Space	Meeting/ Conference Room	Seating/ Public Space	Exhibit Space	Meeting/ Conference Room	Exhibit Space	Meeting/ Conference Room
00:00-01:00	0.00	0.00	0.00	0.10	0.10	0.10	0.00	0.00
01:00-02:00	0.00	0.00	0.00	0.10	0.10	0.10	0.00	0.00
02:00-03:00	0.00	0.00	0.00	0.10	0.10	0.10	0.00	0.00
03:00-04:00	0.00	0.00	0.00	0.10	0.10	0.10	0.00	0.00
04:00-05:00	0.00	0.00	0.00	0.10	0.10	0.10	0.00	0.00
05:00-06:00	0.00	0.00	0.00	0.10	0.10	0.10	0.00	0.00
06:00-07:00	0.00	0.00	0.00	0.10	0.10	0.10	0.00	0.00

Assembly Buildings								
Time Period	Occupancy Schedule			Lighting Schedule			Equipment Schedule	
	Seating/ Public Space	Exhibit Space	Meeting/ Conference Room	Seating/ Public Space	Exhibit Space	Meeting/ Conference Room	Exhibit Space	Meeting/ Conference Room
07:00-08:00	0.00	0.00	0.00	0.10	0.10	0.10	0.00	0.00
08:00-09:00	0.50	0.50	0.00	0.90	0.90	0.10	0.00	0.00
09:00-10:00	0.60	0.50	0.50	0.90	0.90	0.90	0.90	0.80
10:00-11:00	0.70	0.80	0.75	0.90	0.90	0.90	0.90	0.80
11:00-12:00	0.70	0.80	0.75	0.90	0.90	0.90	0.90	0.80
12:00-13:00	0.70	0.80	0.75	0.90	0.90	0.90	0.90	0.80
13:00-14:00	0.90	0.25	0.50	0.90	0.50	0.50	0.50	0.50
14:00-15:00	0.90	0.25	0.75	0.90	0.50	0.90	0.90	0.80
15:00-16:00	0.70	0.80	0.75	0.90	0.90	0.90	0.90	0.80
16:00-17:00	0.70	0.80	0.75	0.90	0.90	0.90	0.90	0.80
17:00-18:00	0.70	0.80	0.75	0.90	0.90	0.90	0.90	0.80
18:00-19:00	0.80	0.50	0.50	0.90	0.90	0.50	0.00	0.00
19:00-20:00	0.80	0.00	0.00	0.90	0.10	0.10	0.00	0.00
20:00-21:00	0.80	0.00	0.00	0.90	0.10	0.10	0.00	0.00
21:00-22:00	0.70	0.00	0.00	0.90	0.10	0.10	0.00	0.00
22:00-23:00	0.60	0.00	0.00	0.90	0.10	0.10	0.00	0.00
23:00-24:00	0.50	0.00	0.00	0.90	0.10	0.10	0.00	0.00

Table 11.12: Schedules for Assembly Buildings (C)

Assembly Buildings - Museum								
Time Period	Occupancy Schedule		Lighting Schedule		Equipment Schedule		HVAC Fan Schedule (ON/OFF)	
	Museum Exhibition	Museum Restoration	Museum Exhibition	Museum Restoration	Museum Exhibition	Museum Restoration	Museum Exhibition	Museum Restoration
00:00-01:00	0.00	0.00	0.10	0.10	0.00	0.00	0	0
01:00-02:00	0.00	0.00	0.10	0.10	0.00	0.00	0	0
02:00-03:00	0.00	0.00	0.10	0.10	0.00	0.00	0	0
03:00-04:00	0.00	0.00	0.10	0.10	0.00	0.00	0	0
04:00-05:00	0.00	0.00	0.10	0.10	0.00	0.00	0	0
05:00-06:00	0.00	0.00	0.10	0.10	0.00	0.00	0	0
06:00-07:00	0.00	0.00	0.10	0.10	0.00	0.00	0	0
07:00-08:00	0.00	0.00	0.10	0.10	0.00	0.00	1	1
08:00-09:00	0.50	0.80	0.90	0.90	0.00	0.90	1	1
09:00-10:00	0.50	0.25	0.90	0.50	0.90	0.25	1	1
10:00-11:00	0.80	0.25	0.90	0.50	0.90	0.25	1	1
11:00-12:00	0.80	0.25	0.90	0.50	0.90	0.25	1	1

Assembly Buildings - Museum								
Time Period	Occupancy Schedule		Lighting Schedule		Equipment Schedule		HVAC Fan Schedule (ON/OFF)	
	Museum Exhibition	Museum Restoration	Museum Exhibition	Museum Restoration	Museum Exhibition	Museum Restoration	Museum Exhibition	Museum Restoration
12:00-13:00	0.80	0.25	0.90	0.50	0.90	0.25	1	1
13:00-14:00	0.25	0.80	0.50	0.90	0.50	0.90	1	1
14:00-15:00	0.25	0.80	0.50	0.90	0.90	0.90	1	1
15:00-16:00	0.80	0.25	0.90	0.50	0.90	0.25	1	1
16:00-17:00	0.80	0.25	0.90	0.50	0.90	0.25	1	1
17:00-18:00	0.80	0.25	0.90	0.50	0.90	0.25	1	1
18:00-19:00	0.25	0.80	0.90	0.90	0.00	0.90	1	1
19:00-20:00	0.00	0.00	0.10	0.10	0.00	0.00	1	1
20:00-21:00	0.00	0.00	0.10	0.10	0.00	0.00	0	0
21:00-22:00	0.00	0.00	0.10	0.10	0.00	0.00	0	0
22:00-23:00	0.00	0.00	0.10	0.10	0.00	0.00	0	0
23:00-24:00	0.00	0.00	0.10	0.10	0.00	0.00	0	0

Table 11.13: Schedules for Assembly Buildings (D)

Assembly Buildings – Gym and Transport								
Time Period	Occupancy Schedule		Lighting Schedule		Equipment Schedule		HVAC Fan Schedule (ON/OFF)	
	Gym	Transport Buildings	Gym	Transport Buildings	Gym	Transport Buildings	Gym	Transport Buildings
00:00-01:00	0.00	0.00	0.00	0.00	0.00	0.80	0	1
01:00-02:00	0.00	0.00	0.00	0.00	0.00	0.80	0	1
02:00-03:00	0.00	0.00	0.00	0.00	0.00	0.80	0	1
03:00-04:00	0.00	0.00	0.00	0.00	0.00	0.80	0	1
04:00-05:00	0.00	0.50	0.50	0.50	0.50	0.80	1	1
05:00-06:00	0.60	0.90	0.90	0.75	0.75	0.90	1	1
06:00-07:00	0.90	0.90	0.90	0.75	0.75	0.90	1	1
07:00-08:00	0.90	0.90	0.90	0.75	0.75	0.90	1	1
08:00-09:00	0.90	0.90	0.90	0.75	0.75	0.90	1	1
09:00-10:00	0.60	0.90	0.90	0.50	0.50	0.90	1	1
10:00-11:00	0.20	0.50	0.50	0.20	0.20	0.90	1	1
11:00-12:00	0.00	0.00	0.00	0.00	0.00	0.90	1	1
12:00-13:00	0.00	0.00	0.00	0.00	0.00	0.90	1	1
13:00-14:00	0.00	0.00	0.00	0.00	0.00	0.50	1	1
14:00-15:00	0.00	0.00	0.00	0.00	0.00	0.90	1	1
15:00-16:00	0.00	0.00	0.00	0.00	0.00	0.90	1	1
16:00-17:00	0.00	0.00	0.00	0.00	0.00	0.90	1	1

Assembly Buildings – Gym and Transport								
Time Period	Occupancy Schedule		Lighting Schedule		Equipment Schedule		HVAC Fan Schedule (ON/OFF)	
	Gym	Transport Buildings	Gym	Transport Buildings	Gym	Transport Buildings	Gym	Transport Buildings
17:00-18:00	0.60	0.75	0.75	0.50	0.50	0.90	1	1
18:00-19:00	0.90	0.90	0.90	0.75	0.75	0.90	1	1
19:00-20:00	0.90	0.90	0.90	0.75	0.75	0.90	1	1
20:00-21:00	0.60	0.90	0.90	0.75	0.75	0.90	1	1
21:00-22:00	0.20	0.75	0.75	0.50	0.50	0.50	1	1
22:00-23:00	0.00	0.00	0.00	0.00	0.00	0.90	0	1
23:00-24:00	0.00	0.00	0.00	0.00	0.00	0.90	0	1

Table 11.14: Schedules for Healthcare - Hospital Buildings (A)

Healthcare - Hospital											
Time Period	Occupancy Schedule				Lighting Schedule				Equipment Schedule		
	In Patient & ICU	Public Spaces	OPD& Offices	Diagnostic, emergency & OT	Public Spaces	In Patient & ICU	Diagnostic, emergency, & OT	OPD& Offices	In Patient & ICU	Diagnostic, emergency, & OT	OPD& Offices
	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week
00:00-01:00	0.90	0.00	0.00	0.50	0.10	0.10	0.50	0.05	0.40	0.00	0.00
01:00-02:00	0.90	0.00	0.00	0.40	0.10	0.10	0.50	0.05	0.40	0.00	0.00
02:00-03:00	0.90	0.00	0.00	0.40	0.10	0.10	0.50	0.05	0.40	0.00	0.00
03:00-04:00	0.90	0.00	0.00	0.40	0.10	0.10	0.50	0.05	0.40	0.00	0.00
04:00-05:00	0.90	0.00	0.00	0.40	0.10	0.10	0.50	0.05	0.40	0.00	0.00
05:00-06:00	0.90	0.00	0.00	0.40	0.10	0.10	0.50	0.05	0.40	0.00	0.00
06:00-07:00	0.90	0.00	0.00	0.50	0.10	0.10	0.50	0.10	0.40	0.00	0.00
07:00-08:00	0.90	0.10	0.10	0.70	0.50	0.20	0.50	0.30	0.70	0.70	0.70
08:00-09:00	0.90	0.50	0.30	0.70	0.90	0.20	0.90	0.90	0.90	0.90	0.90
09:00-10:00	0.90	0.95	0.90	0.95	0.90	0.20	0.90	0.90	0.90	0.90	0.90
10:00-11:00	0.90	0.95	0.90	0.95	0.90	0.20	0.90	0.90	0.90	0.90	0.90
11:00-12:00	0.90	0.95	0.50	0.95	0.90	0.20	0.90	0.90	0.90	0.90	0.90
12:00-13:00	0.90	0.95	0.20	0.95	0.90	0.20	0.90	0.90	0.90	0.90	0.90
13:00-14:00	0.90	0.95	0.50	0.95	0.90	0.20	0.90	0.50	0.90	0.90	0.90
14:00-15:00	0.90	0.95	0.90	0.95	0.90	0.20	0.90	0.90	0.90	0.90	0.90
15:00-16:00	0.90	0.95	0.90	0.95	0.90	0.20	0.90	0.90	0.90	0.90	0.90
16:00-17:00	0.90	0.95	0.90	0.95	0.30	0.20	0.90	0.90	0.60	0.60	0.90
17:00-18:00	0.90	0.70	0.90	0.95	0.30	0.70	0.90	0.90	0.60	0.60	0.90
18:00-19:00	0.90	0.50	0.50	0.95	0.30	0.90	0.90	0.50	0.60	0.60	0.60
19:00-20:00	0.90	0.30	0.50	0.95	0.30	0.90	0.90	0.50	0.60	0.60	0.60

Healthcare - Hospital											
Time Period	Occupancy Schedule				Lighting Schedule				Equipment Schedule		
	In Patient & ICU	Public Spaces	OPD& Offices	Diagnostic, emergency & OT	Public Spaces	In Patient & ICU	Diagnostic, emergency, & OT	OPD& Offices	In Patient & ICU	Diagnostic, emergency, & OT	OPD& Offices
	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week
20:00-21:00	0.90	0.10	0.50	0.70	0.30	0.90	0.50	0.30	0.60	0.60	0.60
21:00-22:00	0.90	0.00	0.10	0.70	0.30	0.90	0.50	0.20	0.60	0.00	0.00
22:00-23:00	0.90	0.00	0.00	0.50	0.30	0.70	0.50	0.10	0.60	0.00	0.00
23:00-24:00	0.90	0.00	0.00	0.50	0.10	0.10	0.50	0.05	0.40	0.00	0.00

Table 11.15: Schedules for Healthcare - Hospital Buildings (B)

Healthcare - Hospital										
Time Period	HVAC Fan Schedule (On/Off)				External Lighting Schedule	Elevators	Service Hot Water		Basement Ventilation	Basement Lighting
	Public Spaces	Beds & ICU	Diagn, emerg, & OT	OPD& Offices			Building Summer	Building Winters		
	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week
00:00-01:00	0	1	1	0	1.00	0.20	0.00	0.30	0.50	0.50
01:00-02:00	0	1	1	0	1.00	0.20	0.00	0.30	0.50	0.50
02:00-03:00	0	1	1	0	1.00	0.20	0.00	0.30	0.50	0.50
03:00-04:00	0	1	1	0	1.00	0.20	0.00	0.30	0.50	0.50
04:00-05:00	0	1	1	0	1.00	0.20	0.00	0.30	0.50	0.50
05:00-06:00	0	1	1	0	1.00	0.20	0.00	0.30	0.50	0.50
06:00-07:00	0	1	1	0	0.00	0.20	0.00	0.30	0.50	0.50
07:00-08:00	1	1	1	0	0.00	0.50	0.00	0.20	0.50	0.50
08:00-09:00	1	1	1	1	0.00	0.75	0.20	0.60	1.00	1.00
09:00-10:00	1	1	1	1	0.00	1.00	0.30	0.60	1.00	1.00
10:00-11:00	1	1	1	1	0.00	1.00	0.30	0.80	1.00	1.00
11:00-12:00	1	1	1	1	0.00	1.00	0.30	0.80	1.00	1.00
12:00-13:00	1	1	1	1	0.00	0.75	0.25	0.70	1.00	1.00
13:00-14:00	1	1	1	1	0.00	1.00	0.25	0.80	1.00	1.00
14:00-15:00	1	1	1	1	0.00	1.00	0.25	0.80	1.00	1.00
15:00-16:00	1	1	1	1	0.00	1.00	0.25	0.70	1.00	1.00
16:00-17:00	1	1	1	1	0.00	1.00	0.25	0.70	1.00	1.00
17:00-18:00	1	1	1	1	0.00	1.00	0.10	0.50	1.00	1.00
18:00-19:00	1	1	1	1	1.00	0.50	0.00	0.35	1.00	1.00

Healthcare - Hospital										
Time Period	HVAC Fan Schedule (On/Off)				External Lighting Schedule	Elevators	Service Hot Water		Basement Ventilation	Basement Lighting
	Public Spaces	Beds & ICU	Diagn, emerg, & OT	OPD& Offices			Building Summer	Building Winters		
	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week
19:00-20:00	1	1	1	1	1.00	0.50	0.00	0.35	1.00	1.00
20:00-21:00	1	1	1	1	1.00	0.50	0.00	0.35	1.00	1.00
21:00-22:00	1	1	1	0	1.00	0.30	0.00	0.30	0.50	0.50
22:00-23:00	0	1	1	0	1.00	0.20	0.00	0.30	0.50	0.50
23:00-24:00	0	1	1	0	1.00	0.20	0.00	0.30	0.50	0.50

Table 11.16: 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

	Healthcare – Out-patient Healthcare						
	Occupancy Schedule			Lighting Schedule		Equipment Schedule	
Time Period	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
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 11.17: 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

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
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 11.18: Schedules for Educational School Building (A)

Educational – School Building							
Time Period	Elevator Schedule	HVAC Fan Schedule (On/Off)			External Lighting Schedule	Basement Ventilation	Basement Lighting
		Student Area	Back Office	Corridor/ Lobby			
	7 Days/ week	5 Days/ week	5 Days/ week	5 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week
00:00-01:00	0.00	0	0	0	0.80	0.00	0.05
01:00-02:00	0.00	0	0	0	0.80	0.00	0.05
02:00-03:00	0.00	0	0	0	0.80	0.00	0.05
03:00-04:00	0.00	0	0	0	0.80	0.00	0.05
04:00-05:00	0.00	0	0	0	0.80	0.00	0.05
05:00-06:00	0.00	0	0	0	0.80	0.00	0.05
06:00-07:00	0.05	0	0	1	0.00	0.00	0.05
07:00-08:00	0.80	1	1	1	0.00	0.00	0.05
08:00-09:00	0.80	1	1	1	0.00	1.00	1.00
09:00-10:00	0.25	1	1	1	0.00	1.00	1.00
10:00-11:00	0.25	1	1	1	0.00	1.00	1.00
11:00-12:00	0.25	1	1	1	0.00	1.00	1.00
12:00-13:00	0.25	1	1	1	0.00	1.00	1.00
13:00-14:00	0.90	1	1	1	0.00	1.00	1.00
14:00-15:00	0.60	0	1	1	0.00	1.00	1.00
15:00-16:00	0.20	0	1	0	0.00	1.00	1.00
16:00-17:00	0.30	0	1	0	0.00	1.00	1.00
17:00-18:00	0.40	0	0	0	0.00	1.00	0.50
18:00-19:00	0.00	0	0	0	0.80	0.00	0.05
19:00-20:00	0.00	0	0	0	0.80	0.00	0.05
20:00-21:00	0.00	0	0	0	0.80	0.00	0.05
21:00-22:00	0.00	0	0	0	0.80	0.00	0.05
22:00-23:00	0.00	0	0	0	0.80	0.00	0.05
23:00-24:00	0.00	0	0	0	0.80	0.00	0.05

Table 11.19: Schedules for Educational - School Buildings (B)

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

Table 11.20: Schedules for Educational - University Building (A)

Educational – University Buildings									
Time Period	Elevator Schedule		HVAC Fan Schedule (On/Off)				External Lighting Schedule	Basement Ventilation	Basement Lighting
	Library & Comp. Centre	Student and Back office	Student Area	Back Office	Library & Comp. Centre	Corridor/ Lobby			
	7 days/ week	7 days/ week	5 days/ week	5 days/ week	7 days/ week	5 days/ week	7 days/ week	7 days/ week	7 days/ week
00:00-01:00	0.00	0.00	0	0	0	0	0.80	0.00	0.05
01:00-02:00	0.00	0.00	0	0	0	0	0.80	0.00	0.05

Educational – University Buildings									
Time Period	Elevator Schedule		HVAC Fan Schedule (On/Off)				External Lighting Schedule	Basement Ventilation	Basement Lighting
	Library & Comp. Centre	Student and Back office	Student Area	Back Office	Library & Comp. Centre	Corridor/ Lobby			
	7 days/ week	7 days/ week	5 days/ week	5 days/ week	7 days/ week	5 days/ week	7 days/ week	7 days/ week	7 days/ week
02:00-03:00	0.00	0.00	0	0	0	0	0.80	0.00	0.05
03:00-04:00	0.00	0.00	0	0	0	0	0.80	0.00	0.05
04:00-05:00	0.00	0.00	0	0	0	0	0.80	0.00	0.05
05:00-06:00	0.00	0.00	0	0	0	0	0.80	0.00	0.05
06:00-07:00	0.00	0.05	0	0	0	0	0.00	0.00	0.05
07:00-08:00	0.00	0.25	1	1	1	1	0.00	0.00	0.05
08:00-09:00	0.50	0.85	1	1	1	1	0.00	1.00	1.00
09:00-10:00	0.50	0.25	1	1	1	1	0.00	1.00	1.00
10:00-11:00	0.30	0.25	1	1	1	1	0.00	1.00	1.00
11:00-12:00	0.20	0.25	1	1	1	1	0.00	1.00	1.00
12:00-13:00	0.20	0.25	1	1	1	1	0.00	1.00	1.00
13:00-14:00	0.40	0.90	1	1	1	1	0.00	1.00	1.00
14:00-15:00	0.30	0.60	1	1	1	1	0.00	1.00	1.00
15:00-16:00	0.30	0.25	1	1	1	1	0.00	1.00	1.00
16:00-17:00	0.30	0.25	1	1	1	1	0.00	1.00	1.00
17:00-18:00	0.50	0.90	1	0	1	1	0.00	1.00	1.00
18:00-19:00	0.50	0.15	0	0	1	1	0.80	1.00	1.00
19:00-20:00	0.50	0.05	0	0	1	0	0.80	1.00	1.00
20:00-21:00	0.50	0.00	0	0	1	0	0.80	0.00	0.50
21:00-22:00	0.50	0.00	0	0	1	0	0.80	0.00	0.05
22:00-23:00	0.50	0.00	0	0	1	0	0.80	0.00	0.05
23:00-24:00	0.00	0.00	0	0	0	0	0.80	0.00	0.05

Table 11.21: Schedules for Educational - University Buildings (B)

Educational – University Buildings											
Time Period	Occupancy Schedule				Lighting Schedule				Equipment Schedule		
	Student Zone	Back Office	Library & Computer	Corridor/ Lobby	Student Zone	Back Office	Library & Computer	Corridor/ Lobby	Student Zone	Back Office	Library & Computer
	5 Days/ week	5 Days/ week	7Days/ week	5 Days/ week	5 Days/ week	5 Days/ week	7 Days/ week	5 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	0.00	0.00	0.10	0.10
01:00-02:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10
02:00-03:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10
03:00-04:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10

Educational – University Buildings											
Time Period	Occupancy Schedule				Lighting Schedule				Equipment Schedule		
	Student Zone	Back Office	Library & Computer	Corridor/ Lobby	Student Zone	Back Office	Library & Computer	Corridor/ Lobby	Student Zone	Back Office	Library & Computer
	5 Days/ week	5 Days/ week	7Days/ week	5 Days/ week	5 Days/ week	5 Days/ week	7 Days/ week	5 Days/ week	5 Days/ week	5 Days/ week	7 Days/ week
04:00-05:00	0.00	0.00	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	0.00	0.00	0.10	0.10
06:00-07:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.10
07:00-08:00	0.40	0.00	0.00	0.00	0.90	0.00	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	0.90	0.90	0.95	0.95	0.70
09:00-10:00	0.90	0.90	0.40	0.30	0.90	0.90	0.90	0.50	0.95	0.95	0.70
10:00-11:00	0.90	0.90	0.50	0.30	0.90	0.90	0.90	0.50	0.95	0.95	0.70
11:00-12:00	0.90	0.90	0.50	0.30	0.90	0.90	0.90	0.50	0.95	0.95	0.70
12:00-13:00	0.90	0.90	0.50	0.90	0.90	0.90	0.90	0.90	0.95	0.95	0.70
13:00-14:00	0.10	0.20	0.20	0.50	0.60	0.30	0.20	0.90	0.20	0.40	0.70
14:00-15:00	0.90	0.90	0.50	0.30	0.90	0.90	0.90	0.50	0.95	0.95	0.70
15:00-16:00	0.90	0.90	0.50	0.30	0.90	0.90	0.90	0.50	0.95	0.95	0.70
16:00-17:00	0.90	0.90	0.50	0.70	0.90	0.90	0.90	0.50	0.95	0.95	0.70
17:00-18:00	0.40	0.00	0.50	0.90	0.90	0.50	0.90	0.90	0.95	0.10	0.80
18:00-19:00	0.00	0.00	0.60	0.00	0.00	0.00	0.90	0.00	0.00	0.10	0.80
19:00-20:00	0.00	0.00	0.60	0.00	0.00	0.00	0.90	0.00	0.00	0.10	0.80
20:00-21:00	0.00	0.00	0.60	0.00	0.00	0.00	0.90	0.00	0.00	0.10	0.80
21:00-22:00	0.00	0.00	0.60	0.00	0.00	0.00	0.90	0.00	0.00	0.10	0.80
22:00-23:00	0.00	0.00	0.60	0.00	0.00	0.00	0.90	0.00	0.00	0.10	0.80
23:00-24:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00

Table 11.22: Schedules for Hospitality Buildings (A)

Hospitality									
Time Period	Elevator Schedule		External Lighting Schedule	Service Hot Water (SHW)				Basement Ventilation	Basement Lighting
				Guest rooms		Kitchen	Laundry		
	Week Days	Weekends	7 Days/ week	Week Days	Weekends	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week
00:00-01:00	0.10	0.10	1.00	0.01	0.01	0.00	0.00	0.50	0.50
01:00-02:00	0.10	0.10	1.00	0.01	0.01	0.00	0.00	0.50	0.50
02:00-03:00	0.10	0.10	1.00	0.01	0.01	0.00	0.00	0.50	0.50
03:00-04:00	0.10	0.10	1.00	0.01	0.01	0.00	0.00	0.50	0.50
04:00-05:00	0.10	0.10	1.00	0.01	0.01	0.00	0.00	0.50	0.50
05:00-06:00	0.20	0.20	1.00	0.01	0.01	0.00	0.00	0.50	0.50

Hospitality									
Time Period	Elevator Schedule		External Lighting Schedule	Service Hot Water (SHW)				Basement Ventilation	Basement Lighting
				Guest rooms		Kitchen	Laundry		
	Week Days	Weekends	7 Days/ week	Week Days	Weekends	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week
06:00-07:00	0.40	0.50	0.00	0.50	0.70	0.60	0.00	0.50	0.50
07:00-08:00	0.50	0.60	0.00	0.50	0.70	0.80	0.00	0.50	0.50
08:00-09:00	0.50	0.60	0.00	0.30	0.50	0.80	1.00	1.00	1.00
09:00-10:00	0.35	0.40	0.00	0.15	0.30	0.60	1.00	1.00	1.00
10:00-11:00	0.15	0.20	0.00	0.15	0.20	0.60	1.00	1.00	1.00
11:00-12:00	0.15	0.20	0.00	0.15	0.20	0.80	1.00	1.00	1.00
12:00-13:00	0.15	0.20	0.00	0.15	0.20	0.80	1.00	1.00	1.00
13:00-14:00	0.15	0.20	0.00	0.15	0.20	0.80	1.00	1.00	1.00
14:00-15:00	0.15	0.20	0.00	0.15	0.20	0.60	1.00	1.00	1.00
15:00-16:00	0.15	0.20	0.00	0.15	0.20	0.60	1.00	1.00	1.00
16:00-17:00	0.35	0.40	0.00	0.15	0.20	0.60	0.00	1.00	1.00
17:00-18:00	0.50	0.60	0.00	0.30	0.30	0.80	0.00	1.00	1.00
18:00-19:00	0.50	0.60	1.00	0.50	0.50	0.80	0.00	1.00	1.00
19:00-20:00	0.50	0.60	1.00	0.50	0.70	0.80	0.00	1.00	1.00
20:00-21:00	0.50	0.60	1.00	0.65	0.70	0.80	0.00	1.00	1.00
21:00-22:00	0.30	0.40	1.00	0.65	0.90	0.80	0.00	0.50	0.50
22:00-23:00	0.20	0.30	1.00	0.01	0.01	0.60	0.00	0.50	0.50
23:00-24:00	0.10	0.10	1.00	0.01	0.01	0.60	0.00	0.50	0.50

Table 11.23: Schedules for Hospitality Buildings (B)

Hospitality- Occupancy												
Time Period	Occupancy Schedule											
	Guest Room		Lobby		Public Spaces		Restaurant		Back Office		Conference/ Banquet Room	Kitchen
	Week Days	Weekends	Week Days	Weekends	Week Days	Weekends	Week Days	Weekends	Week Days	Weekends	7 Days/ week	7 Days/ week
00:00-01:00	0.65	0.90	0.10	0.10	0.00	0.00	0.00	0.00	0.20	0.20	0.00	0.00
01:00-02:00	0.65	0.90	0.10	0.10	0.00	0.00	0.00	0.00	0.20	0.20	0.00	0.00
02:00-03:00	0.65	0.90	0.10	0.10	0.00	0.00	0.00	0.00	0.20	0.20	0.00	0.00
03:00-04:00	0.65	0.90	0.10	0.10	0.00	0.00	0.00	0.00	0.20	0.20	0.00	0.00
04:00-05:00	0.65	0.90	0.10	0.10	0.00	0.00	0.00	0.00	0.20	0.20	0.00	0.00
05:00-06:00	0.65	0.90	0.10	0.10	0.20	0.50	0.00	0.00	0.20	0.20	0.00	0.00
06:00-07:00	0.50	0.70	0.20	0.20	0.40	0.70	0.00	0.00	0.20	0.20	0.00	0.50

Hospitality- Occupancy												
Time Period	Occupancy Schedule											
	Guest Room		Lobby		Public Spaces		Restaurant		Back Office		Conference/ Banquet Room	Kitchen
	Week Days	Weekends	Week Days	Weekends	Week Days	Weekends	Week Days	Weekends	Week Days	Weekends	7 Days/ week	7 Days/ week
07:00-08:00	0.50	0.70	0.30	0.40	0.40	0.70	0.30	0.30	0.20	0.20	0.00	0.80
08:00-09:00	0.30	0.50	0.40	0.70	0.40	0.70	0.30	0.30	0.20	0.20	0.20	0.80
09:00-10:00	0.15	0.30	0.40	0.70	0.40	0.70	0.30	0.30	0.95	0.50	0.50	0.50
10:00-11:00	0.15	0.20	0.40	0.70	0.40	0.70	0.30	0.30	0.95	0.50	0.90	0.50
11:00-12:00	0.15	0.20	0.40	0.70	0.20	0.30	0.30	0.30	0.95	0.50	0.90	0.80
12:00-13:00	0.15	0.20	0.40	0.70	0.20	0.30	0.80	0.80	0.95	0.50	0.90	0.80
13:00-14:00	0.15	0.20	0.20	0.20	0.20	0.30	0.80	0.80	0.50	0.30	0.90	0.80
14:00-15:00	0.15	0.20	0.20	0.20	0.20	0.30	0.80	0.80	0.95	0.50	0.90	0.50
15:00-16:00	0.15	0.20	0.20	0.20	0.40	0.70	0.30	0.30	0.95	0.50	0.90	0.50
16:00-17:00	0.15	0.20	0.20	0.20	0.40	0.70	0.30	0.30	0.95	0.50	0.90	0.50
17:00-18:00	0.30	0.30	0.40	0.40	0.40	0.70	0.30	0.30	0.95	0.50	0.50	0.80
18:00-19:00	0.50	0.50	0.40	0.40	0.50	0.70	0.50	0.50	0.30	0.30	0.20	0.80
19:00-20:00	0.50	0.70	0.40	0.40	0.80	0.70	0.80	0.90	0.20	0.20	0.20	0.80
20:00-21:00	0.65	0.70	0.30	0.30	0.90	0.70	0.80	0.90	0.20	0.20	0.00	0.80
21:00-22:00	0.65	0.90	0.20	0.20	0.80	0.70	0.80	0.90	0.20	0.20	0.00	0.80
22:00-23:00	0.65	0.90	0.10	0.10	0.60	0.60	0.80	0.90	0.20	0.20	0.00	0.50
23:00-24:00	0.65	0.90	0.10	0.10	0.30	0.30	0.50	0.90	0.20	0.20	0.00	0.50

Table 11.24: Schedules for Hospitality Buildings (C)

Hospitality – Lighting												
Time Period	Lighting Schedule											
	Guest Room		Lobby		Public Spaces		Restaurant		Back Office		Conference/ Banquet Room	Kitchen
	Week Days	Weekends	Week Days	Weekends	Week Days	Weekends	Week Days	Weekends	Week Days	Weekends	7 Days/ week	7 Days/ week
00:00-01:00	0.20	0.30	0.30	0.30	0.20	0.20	0.50	0.50	0.05	0.05	0.00	0.50
01:00-02:00	0.20	0.25	0.30	0.30	0.15	0.20	0.10	0.10	0.05	0.05	0.00	0.05
02:00-03:00	0.10	0.10	0.30	0.30	0.10	0.10	0.10	0.10	0.05	0.05	0.00	0.05
03:00-04:00	0.10	0.10	0.30	0.30	0.10	0.10	0.10	0.10	0.05	0.05	0.00	0.05
04:00-05:00	0.10	0.10	0.30	0.30	0.10	0.10	0.10	0.10	0.05	0.05	0.00	0.05
05:00-06:00	0.20	0.10	0.30	0.30	0.20	0.10	0.10	0.10	0.05	0.05	0.00	0.05
06:00-07:00	0.45	0.40	0.40	0.40	0.40	0.30	0.10	0.10	0.10	0.10	0.00	0.10

Hospitality – Lighting												
Time Period	Lighting Schedule											
	Guest Room		Lobby		Public Spaces		Restaurant		Back Office		Conference/ Banquet Room	Kitchen
	Week Days	Weekends	Week Days	Weekends	Week Days	Weekends	Week Days	Weekends	Week Days	Weekends	7 Days/ week	7 Days/ week
07:00-08:00	0.55	0.40	0.30	0.40	0.50	0.30	0.50	0.50	0.30	0.30	0.00	0.30
08:00-09:00	0.45	0.55	0.40	0.70	0.40	0.40	0.50	0.50	0.90	0.60	0.50	0.90
09:00-10:00	0.20	0.20	0.40	0.70	0.20	0.40	0.50	0.50	0.90	0.60	0.80	0.90
10:00-11:00	0.20	0.20	0.40	0.70	0.20	0.40	0.50	0.50	0.90	0.60	0.90	0.90
11:00-12:00	0.20	0.20	0.40	0.70	0.20	0.40	0.50	0.50	0.90	0.60	0.90	0.90
12:00-13:00	0.20	0.20	0.40	0.70	0.20	0.40	0.90	0.90	0.90	0.60	0.90	0.90
13:00-14:00	0.20	0.20	0.40	0.40	0.20	0.40	0.90	0.90	0.50	0.50	0.90	0.50
14:00-15:00	0.20	0.20	0.40	0.40	0.20	0.40	0.90	0.90	0.90	0.60	0.90	0.90
15:00-16:00	0.20	0.20	0.40	0.40	0.20	0.40	0.50	0.50	0.90	0.60	0.90	0.90
16:00-17:00	0.20	0.20	0.40	0.40	0.20	0.40	0.50	0.50	0.90	0.60	0.90	0.90
17:00-18:00	0.30	0.30	0.40	0.40	0.25	0.40	0.50	0.50	0.95	0.60	0.50	0.95
18:00-19:00	0.70	0.85	0.40	0.40	0.60	0.60	0.90	0.90	0.50	0.50	0.50	0.95
19:00-20:00	0.90	1.00	0.40	0.40	0.80	0.70	0.90	0.90	0.30	0.30	0.50	0.95
20:00-21:00	1.00	1.00	0.30	0.30	0.90	0.70	0.90	0.90	0.30	0.30	0.00	0.95
21:00-22:00	0.90	1.00	0.40	0.40	0.80	0.70	0.90	0.90	0.20	0.20	0.00	0.95
22:00-23:00	0.70	0.85	0.30	0.30	0.60	0.60	0.90	0.90	0.10	0.10	0.00	0.95
23:00-24:00	0.30	0.40	0.30	0.30	0.30	0.30	0.90	0.90	0.05	0.05	0.00	0.95

Table 11.25: Schedules for Hospitality Buildings (D)

Hospitality – Equipment									
Time Period	Equipment Schedule								
	Guest Room		Public Spaces	Restaurant		Back Office		Conference/ Banquet Room	Kitchen
	Week Days	Weekends	7 Days/ week	Week Days	Weekends	Week Days	Weekends	7 Days/ week	7 Days/ week
00:00-01:00	0.20	0.20	0.30	0.50	0.50	0.05	0.05	0.00	0.30
01:00-02:00	0.20	0.20	0.20	0.00	0.00	0.05	0.05	0.00	0.10
02:00-03:00	0.20	0.20	0.20	0.00	0.00	0.05	0.05	0.00	0.10
03:00-04:00	0.20	0.20	0.20	0.00	0.00	0.05	0.05	0.00	0.10
04:00-05:00	0.20	0.20	0.20	0.00	0.00	0.05	0.05	0.00	0.10
05:00-06:00	0.20	0.20	0.30	0.00	0.00	0.05	0.05	0.00	0.10
06:00-07:00	0.30	0.30	0.50	0.00	0.00	0.05	0.05	0.00	0.30
07:00-08:00	0.40	0.60	0.50	0.60	0.60	0.10	0.10	0.00	0.30
08:00-09:00	0.70	0.90	0.50	0.60	0.60	0.30	0.30	0.50	0.30

Hospitality – Equipment									
Time Period	Equipment Schedule								
	Guest Room		Public Spaces	Restaurant		Back Office		Conference/ Banquet Room	Kitchen
	Week Days	Weekends	7 Days/ week	Week Days	Weekends	Week Days	Weekends	7 Days/ week	7 Days/ week
09:00-10:00	0.20	0.20	0.50	0.60	0.60	0.95	0.70	0.50	0.30
10:00-11:00	0.20	0.20	0.35	0.60	0.60	0.95	0.70	0.90	0.30
11:00-12:00	0.20	0.20	0.35	0.60	0.60	0.95	0.70	0.90	0.30
12:00-13:00	0.20	0.20	0.35	0.80	0.80	0.95	0.70	0.90	0.30
13:00-14:00	0.20	0.20	0.35	0.80	0.80	0.50	0.70	0.90	0.30
14:00-15:00	0.20	0.20	0.35	0.80	0.80	0.95	0.70	0.90	0.30
15:00-16:00	0.20	0.20	0.35	0.60	0.60	0.95	0.70	0.90	0.30
16:00-17:00	0.20	0.20	0.35	0.60	0.60	0.95	0.70	0.90	0.30
17:00-18:00	0.30	0.30	0.35	0.60	0.60	0.95	0.70	0.50	0.30
18:00-19:00	0.50	0.50	0.70	0.80	0.80	0.30	0.30	0.50	0.30
19:00-20:00	0.50	0.50	0.90	0.80	0.90	0.10	0.10	0.50	0.30
20:00-21:00	0.50	0.70	0.90	0.80	0.90	0.10	0.10	0.00	0.30
21:00-22:00	0.70	0.70	0.90	0.80	0.90	0.10	0.10	0.00	0.30
22:00-23:00	0.40	0.40	0.70	0.80	0.90	0.05	0.05	0.00	0.30
23:00-24:00	0.20	0.20	0.40	0.80	0.90	0.05	0.05	0.00	0.30

Table 11.26: Schedules for Hospitality Buildings (E)

Hospitality – HVAC Fan Schedules							
Time Period	HVAC Fan Schedule						
	Guest Room	Lobby	Public Spaces	Restaurants	Back Office	Conference / Banquet Room	Kitchen
	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week
00:00-01:00	1	0	0	0	0	0	0
01:00-02:00	1	0	0	0	0	0	0
02:00-03:00	1	0	0	0	0	0	0
03:00-04:00	1	0	0	0	0	0	0
04:00-05:00	1	0	0	0	0	0	0
05:00-06:00	1	1	1	0	0	0	1
06:00-07:00	1	1	1	1	0	0	1
07:00-08:00	1	1	1	1	0	0	1
08:00-09:00	1	1	1	1	1	1	1

Hospitality – HVAC Fan Schedules							
Time Period	HVAC Fan Schedule						
	Guest Room	Lobby	Public Spaces	Restaurants	Back Office	Conference / Banquet Room	Kitchen
	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week
09:00-10:00	1	1	1	1	1	1	1
10:00-11:00	1	1	1	1	1	1	1
11:00-12:00	1	1	1	1	1	1	1
12:00-13:00	1	1	1	1	1	1	1
13:00-14:00	1	1	1	1	1	1	1
14:00-15:00	1	1	1	1	1	1	1
15:00-16:00	1	1	1	1	1	1	1
16:00-17:00	1	1	1	1	1	1	1
17:00-18:00	1	1	1	1	1	1	1
18:00-19:00	1	1	1	1	1	1	1
19:00-20:00	1	1	1	1	0	1	1
20:00-21:00	1	1	1	1	0	1	1
21:00-22:00	1	1	1	1	0	0	1
22:00-23:00	1	0	1	1	0	0	1
23:00-24:00	1	0	1	1	0	0	1

Table 11.27: Schedules for Shopping Complexes Buildings (A)

Shopping Complex								
Time Period	HVAC Fan Schedule (ON/OFF)			External Lighting Schedule	Basement Ventilation	Basement Lighting	Elevator Schedule	
	Retail	Corridors & Atrium	Special Zones					
	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	Weekdays	Weekends
00:00-01:00	0	0	0	1.00	1.00	1.00	0.20	0.20
01:00-02:00	0	0	0	0.50	0.00	0.05	0.05	0.20
02:00-03:00	0	0	0	0.50	0.00	0.05	0.05	0.05
03:00-04:00	0	0	0	0.50	0.00	0.05	0.05	0.05
04:00-05:00	0	0	0	0.50	0.00	0.05	0.05	0.05
05:00-06:00	0	0	0	0.50	0.00	0.05	0.05	0.05
06:00-07:00	0	0	0	0.00	0.00	0.05	0.05	0.05
07:00-08:00	0	0	0	0.00	0.00	0.05	0.10	0.10
08:00-09:00	0	0	0	0.00	0.00	0.05	0.10	0.10
09:00-10:00	0	1	1	0.00	1.00	1.00	0.20	0.20
10:00-11:00	1	1	1	0.00	1.00	1.00	0.40	0.40
11:00-12:00	1	1	1	0.00	1.00	1.00	0.70	0.70

Shopping Complex								
Time Period	HVAC Fan Schedule (ON/OFF)			External Lighting Schedule	Basement Ventilation	Basement Lighting	Elevator Schedule	
	Retail	Corridors & Atrium	Special Zones					
	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	Weekdays	Weekends
12:00-13:00	1	1	1	0.00	1.00	1.00	0.70	0.80
13:00-14:00	1	1	1	0.00	1.00	1.00	0.70	0.95
14:00-15:00	1	1	1	0.00	1.00	1.00	0.70	0.95
15:00-16:00	1	1	1	0.00	1.00	1.00	0.70	0.95
16:00-17:00	1	1	1	0.00	1.00	1.00	0.70	0.95
17:00-18:00	1	1	1	0.00	1.00	1.00	0.80	0.95
18:00-19:00	1	1	1	1.00	1.00	1.00	0.80	0.95
19:00-20:00	1	1	1	1.00	1.00	1.00	0.80	0.95
20:00-21:00	1	1	1	1.00	1.00	1.00	0.80	0.95
21:00-22:00	0	1	1	1.00	1.00	1.00	0.80	0.80
22:00-23:00	0	1	1	1.00	1.00	1.00	0.50	0.60
23:00-24:00	0	1	1	1.00	1.00	1.00	0.30	0.40

Table 11.28: Schedules for Shopping Complexes Buildings (B)

Shopping Complex											
Time Period	Occupancy Schedule						Lighting Schedule			Equipment Schedule	
	Retail		Corridors & Atrium		Special Zone		Retail	Corridors & Atrium	Special Zone	Retail	Special Zone
	Weekday	Weekend	Weekday	Weekend	Weekday	Weekend	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week
00:00-01:00	0.00	0.00	0.00	0.10	0.00	0.00	0.05	0.05	0.05	0.05	0.05
01:00-02:00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.05	0.05
02:00-03:00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.05	0.05
03:00-04:00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.05	0.05
04:00-05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.05	0.05
05:00-06:00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.05	0.05
06:00-07:00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.05	0.05
07:00-08:00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.05	0.05
08:00-09:00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.05	0.50
09:00-10:00	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.05	0.50
10:00-11:00	0.40	0.40	0.40	0.40	0.20	0.20	0.50	0.50	0.40	0.90	0.90
11:00-12:00	0.60	0.60	0.60	0.60	0.30	0.50	0.95	0.50	0.60	0.90	0.90
12:00-13:00	0.60	0.70	0.60	0.70	0.50	0.70	0.95	0.50	0.60	0.90	0.90

Shopping Complex											
Time Period	Occupancy Schedule						Lighting Schedule			Equipment Schedule	
	Retail		Corridors & Atrium		Special Zone		Retail	Corridors & Atrium	Special Zone	Retail	Special Zone
	Weekday	Weekend	Weekday	Weekend	Weekday	Weekend	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week
13:00-14:00	0.60	0.90	0.60	0.90	0.50	0.70	0.95	0.50	0.60	0.90	0.90
14:00-15:00	0.70	0.90	0.70	0.90	0.50	0.70	0.95	0.50	0.60	0.90	0.90
15:00-16:00	0.70	0.90	0.70	0.90	0.50	0.80	0.95	0.50	0.40	0.90	0.90
16:00-17:00	0.70	0.90	0.70	0.90	0.50	0.80	0.95	0.70	0.40	0.90	0.90
17:00-18:00	0.70	0.90	0.70	0.90	0.50	0.80	0.95	0.95	0.40	0.90	0.90
18:00-19:00	0.90	0.95	0.90	0.95	0.60	0.95	0.95	0.95	0.80	0.90	0.90
19:00-20:00	0.90	0.95	0.90	0.95	0.60	0.95	0.95	0.95	0.80	0.90	0.90
20:00-21:00	0.90	0.95	0.90	0.95	0.60	0.95	0.95	0.95	0.80	0.50	0.90
21:00-22:00	0.00	0.00	0.40	0.40	0.60	0.95	0.05	0.50	0.80	0.05	0.90
22:00-23:00	0.00	0.00	0.30	0.30	0.60	0.95	0.05	0.30	0.80	0.05	0.90
23:00-24:00	0.00	0.00	0.10	0.10	0.30	0.95	0.05	0.30	0.80	0.05	0.90

Table 11.29: Schedules for Shopping Complexes Buildings – Food Court

Shopping Complex - Food Court												
Time Period	Occupancy Schedule			Lighting Schedule			Equipment Schedule			HVAC Fan Schedule		
	Family Dining	Food Preparation	Bar Lounge	Family Dining	Food Preparation	Bar Lounge	Family Dining	Food Preparation	Bar Lounge	Family Dining	Food Preparation	Bar Lounge
00:00-01:00	0.00	0.50	0.70	0.50	0.70	0.70	0.50	0.60	0.70	1	0	1
01:00-02:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0
02:00-03:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0
03:00-04:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0
04:00-05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0
05:00-06:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0
06:00-07:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0
07:00-08:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0
08:00-09:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0
09:00-10:00	0.00	0.20	0.00	0.00	0.50	0.00	0.00	0.60	0.00	0	0	0
10:00-11:00	0.20	0.50	0.00	0.50	0.70	0.00	0.60	0.70	0.00	0	1	0
11:00-12:00	0.20	0.80	0.00	0.50	0.90	0.00	0.60	0.70	0.00	1	1	0
12:00-13:00	0.70	0.80	0.00	0.90	0.90	0.00	0.80	0.70	0.00	1	1	0
13:00-14:00	0.70	0.80	0.00	0.90	0.90	0.00	0.80	0.70	0.00	1	1	0
14:00-15:00	0.70	0.80	0.00	0.90	0.90	0.00	0.80	0.70	0.00	1	1	0
15:00-16:00	0.20	0.50	0.00	0.50	0.70	0.00	0.60	0.40	0.00	1	1	0

Shopping Complex - Food Court												
Time Period	Occupancy Schedule			Lighting Schedule			Equipment Schedule			HVAC Fan Schedule		
	Family Dining	Food Preparation	Bar Lounge	Family Dining	Food Preparation	Bar Lounge	Family Dining	Food Preparation	Bar Lounge	Family Dining	Food Preparation	Bar Lounge
16:00-17:00	0.20	0.30	0.00	0.50	0.50	0.00	0.60	0.40	0.00	1	1	1
17:00-18:00	0.20	0.30	0.50	0.50	0.50	0.70	0.60	0.40	0.70	1	1	1
18:00-19:00	0.50	0.50	0.70	0.90	0.70	0.80	0.80	0.40	0.70	1	1	1
19:00-20:00	0.80	0.90	0.80	0.90	0.90	0.80	0.80	0.70	0.70	1	1	1
20:00-21:00	0.80	0.90	0.80	0.90	0.90	0.80	0.80	0.70	0.70	1	1	1
21:00-22:00	0.80	0.90	0.80	0.90	0.90	0.80	0.80	0.70	0.70	1	1	1
22:00-23:00	0.80	0.90	0.80	0.90	0.90	0.80	0.80	0.70	0.70	1	1	1
23:00-24:00	0.50	0.50	0.80	0.90	0.90	0.80	0.80	0.40	0.70	1	1	1

Table 11.30: Schedules for Shopping Complex- Strip Retail & Supermall Buildings

Strip Retail & Supermall										
Time Period	Occupancy Schedule		Lighting Schedule	Equipment Schedule	HVAC Fan Schedule (On/ Off)	Elevator Schedule		External Lighting Schedule	Basement Ventilation	Basement Lighting
	Retail & Circulation		All Spaces	All Spaces						
	Weekdays	Weekends	7 Days/ week	7 Days/ week	7 Days/ week	Weekdays	Weekends	7 Days/ week	7 Days/ week	7 Days/ week
00:00-01:00	0.00	0.00	0.05	0.05	0	0.00	0.00	0.20	0.00	0.05
01:00-02:00	0.00	0.00	0.05	0.05	0	0.00	0.00	0.20	0.00	0.05
02:00-03:00	0.00	0.00	0.05	0.05	0	0.00	0.00	0.20	0.00	0.05
03:00-04:00	0.00	0.00	0.05	0.05	0	0.00	0.00	0.20	0.00	0.05
04:00-05:00	0.00	0.00	0.05	0.05	0	0.00	0.00	0.20	0.00	0.05
05:00-06:00	0.00	0.00	0.05	0.05	0	0.00	0.00	0.20	0.00	0.05
06:00-07:00	0.00	0.00	0.05	0.05	0	0.00	0.00	0.00	0.00	0.05
07:00-08:00	0.00	0.00	0.05	0.05	0	0.10	0.10	0.00	0.00	0.05
08:00-09:00	0.00	0.00	0.05	0.05	0	0.10	0.10	0.00	0.00	0.05
09:00-10:00	0.20	0.20	0.20	0.05	1	0.20	0.20	0.00	1.00	1.00
10:00-11:00	0.40	0.40	0.50	0.90	1	0.40	0.40	0.00	1.00	1.00
11:00-12:00	0.60	0.60	0.95	0.90	1	0.70	0.70	0.00	1.00	1.00
12:00-13:00	0.60	0.70	0.95	0.90	1	0.70	0.80	0.00	1.00	1.00
13:00-14:00	0.60	0.90	0.95	0.90	1	0.70	0.95	0.00	1.00	1.00
14:00-15:00	0.70	0.90	0.95	0.90	1	0.70	0.95	0.00	1.00	1.00
15:00-16:00	0.70	0.90	0.95	0.90	1	0.70	0.95	0.00	1.00	1.00

Strip Retail & Supermall										
Time Period	Occupancy Schedule		Lighting Schedule	Equipment Schedule	HVAC Fan Schedule (On/ Off)	Elevator Schedule		External Lighting Schedule	Basement Ventilation	Basement Lighting
	Retail & Circulation		All Spaces	All Spaces						
	Weekdays	Weekends	7 Days/ week	7 Days/ week	7 Days/ week	Weekdays	Weekends	7 Days/ week	7 Days/ week	7 Days/ week
16:00-17:00	0.70	0.90	0.95	0.90	1	0.70	0.95	0.00	1.00	1.00
17:00-18:00	0.70	0.90	0.95	0.90	1	0.80	0.95	0.00	1.00	1.00
18:00-19:00	0.90	0.95	0.95	0.90	1	0.80	0.95	1.00	1.00	1.00
19:00-20:00	0.90	0.95	0.95	0.90	1	0.80	0.95	1.00	1.00	1.00
20:00-21:00	0.90	0.95	0.95	0.50	1	0.80	0.95	1.00	1.00	1.00
21:00-22:00	0.00	0.00	0.05	0.05	0	0.00	0.00	1.00	0.20	0.50
22:00-23:00	0.00	0.00	0.05	0.05	0	0.00	0.00	0.20	0.00	0.05
23:00-24:00	0.00	0.00	0.05	0.05	0	0.00	0.00	0.20	0.00	0.05

12. Appendix C: Default Values for Typical Constructions

12.1. Procedure for Determining Fenestration Product U-factor and Solar Heat Gain Coefficient

§ 4.2.1.1 and § 4.2.1.2 require that U-factors and solar heat gain coefficients (SHGC) be determined for the overall fenestration product (including the sash and frame) in accordance with ISO 15099.

In several cases, ISO 15099 suggests that individual national standards will need to be more specific and in other cases the ISO document gives users the choice of two options. This section clarifies these specific issues as they are to be implemented for this code:

(a) § 4.1 of ISO 15099: For calculating the overall U-factor, ISO 15099 offers a choice between the linear thermal transmittance (4.1.2) and the area weighted method (4.1.3). The area weighted method (4.1.3) shall be used.

(b) § 4.2.2 of ISO 15099: Frame and divider SHGC shall be calculated in accordance with § 4.2.2. The alternate approach in § 8.6 shall not be used.

(c) § 6.4 of ISO 15099 refers the issue of material properties to national standards. Material conductivities and emissivity shall be determined in accordance with Indian standards.

(d) § 7 of ISO 15099 on shading systems is currently excluded.

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

For U-factor calculations:

T_{in} = 24 °C

T_{out} = 32 °C

V = 3.35 m/s

$T_{rm,out}=T_{out}$

$T_{rm,in}=T_{in}$

I_s=0 W/m^2

For SHGC calculations:

T_{in} = 24 °C

T_{out} = 32 °C

V = 2.75 m/s

$T_{rm,out}=T_{out}$

$T_{rm,in}=T_{in}$

I_s=783 W/m^2

(f) § 8.3 of ISO 15099 addresses convective film coefficients on the interior and exterior of the window product. In § 8.3.1 of ISO 15099, simulations shall use the heat transfer coefficient based on the center of glass temperature and the entire window height; this film coefficient shall be used on all indoor surfaces, including frame sections. In § 8.3.2 of ISO 15099, the formula from this section shall be applied to all outdoor exposed surfaces.

(g) § 8.4.2 of ISO 15099 presents two possible approaches for incorporating the impacts of self-viewing surfaces on interior radiative heat transfer calculations. Products shall use the method in § 8.4.2.1 of ISO 15099 (Two-Dimensional Element to Element View Factor Based Radiation Heat Transfer Calculation). The alternate approach in § 8.4.3 of ISO 15099 shall not be used.

12.2. 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 with ISO 15099 shall be assigned those values.

12.2.1. 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 4.6 for compliance.

U-factors for unrated vertical fenestration, both operable and fixed, shall be assigned as per Table 12.1.

Table 12.1: 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 W/m2.K)	3.4
Wood, vinyl, or fiberglass frame or metal frame with thermal break	Double Glazing (COG U value <1.6 W/m2.K)	3.0
Metal and other frame type	Double Glazing	5.1

12.3. Typical Roof Constructions

For calculating the overall U-factor of a typical roof construction, the U-factors from the typical wall construction type and effective U-factor for insulation shall be combined according to the following equation:

$$U_{TotalRoof} = \frac{1}{\frac{1}{U_{TypicalRoof}} + \frac{1}{U_{TypicalInsulation}}}$$

where

$U_{TotalRoof}$	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

12.4. Typical Wall Constructions

For calculating the overall U-factor of a typical wall construction, the U-factors from the typical wall construction type and effective U-factor for insulation shall be combined according to the following equation:

$$U_{TotalWall} = \frac{1}{\frac{1}{U_{TypicalWall}} + \frac{1}{U_{TypicalInsulation}}}$$

where

$U_{TotalWall}$	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 12.2: Typical Thermal Properties of Common Building and Insulating Materials[a]

Description	*Density kg/m³*	*Conductivity*[b] *k, W/(m·K)*	*Resistance R, (m²·K)/W*	*Specific Heat kJ/(kg·K)*
Building Board and Siding				
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 mm	650	-	0.11	1.88
Oriented strand board (OSB) 12.7 mm	650	-	0.12	1.88
Plywood (douglas fir) 12.7 mm	460	-	0.14	1.88
Plywood (douglas fir) 15.9 mm	540	-	0.15	1.88
Plywood/wood panels 19.0 mm	550	-	0.19	1.88
Vegetable fiber board				
Sheathing, regular density[e] 12.7 mm	290	-	0.23	1.3
Intermediate density[e] .. 12.7 mm	350	-	0.19	1.3
Nail-basesheathing[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 acoustic	290	0.058	-	0.59
Laminated paperboard	480	0.072	-	1.38
Homogeneous board from repulped paper	480	0.072	-	1.17
Hard board[e]				
Medium density	800	0.105	-	1.3
High density, service-tempered grade and service grade	880	0.12	-	1.34
High density, standard-tempered grade	1010	0.144	-	1.34
Particle board[e]				
Low density	590	0.102	-	1.3
Medium density	800	0.135	-	1.3
High density	1000	0.18	-	-

Description	*Density kg/m³*	*Conductivity[a] k, W/(m·K)*	*Resistance R, (m²·K)/W*	*Specific Heat kJ/(kg·K)*
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 exposure	-	-	0.21	1.17
Wood, plus ins. backer board 8 mm	-	-	0.25	1.3
Siding				
Asbestos/cement, lapped 6.4 mm	-	-	0.037	1.01
Asphalt roll siding	-	-	0.026	1.47
Siding				
Asphalt insulating siding (12.7 mm bed)	-	-	0.26	1.47
Hardboard siding 11 mm	-	-	0.12	1.17
Wood, drop, 200 mm 25 mm	-	-	0.14	1.17
Wood, bevel 200 mm, 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 9.5 mm	-	-	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/m² felt	-	-	0.21	-
Vapor: seal, plastic film	-	-	Negligible	-
Finish Flooring Materials				
Carpet and rebounded urethane pad 19 mm	110	-	0.42	-
Carpet and rubber pad (one-piece) 9.5 mm	320	-	0.12	-
Pile carpet with rubber pad 9.5 to 12.7 mm	290	-	0.28	-
Linoleum/cork tile 6.4 mm	465	-	0.09	-
PVC/Rubber floor covering	-	0.4	-	-
Rubber tile 25 mm	1900	-	0.06	-
Terrazzo 25 mm	-	-	0.014	0.8
Insulating Materials				
Blanket and batt[e]				
Glass-fiber batts 85 to 90 mm	10 to 14	0.043	-	0.84
Glass-fiber batts 50 mm	8 to 13	0.045 to 0.048	-	0.84
Mineral fiber 140 mm	30	0.036	-	0.84
Mineral wool, felted	16 to 48	0.04	-	-
	65 to 130	0.035	-	-
Slag wool	50 to 190	0.038	-	-

Description	Density kg/m³	Conductivity[b] k, W/(m·K)	Resistance R, (m²·K)/W	Specific Heat kJ/(kg·K)
	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 binder	400 to 430	0.072 to 0.076	-	-
Cement fiber slabs, shredded wood with magnesia oxysulfide binder	350	0.082	-	1.3
Glass fiber board	160	0.032 to 0.040	-	0.84
Expanded rubber (rigid)	70	0.032	-	1.67
Expanded polystyrene extruded (smooth skin)	25 to 40	0.022 to 0.030	-	1.47
Expanded polystyrene, molded beads	15 to 25	0.032 to 0.039	-	1.47
Mineral fiberboard, wet felted	160	0.038	-	0.84
Mineral fiberboard, core or roof insulation	255 to 270	0.049	-	-
Mineral fiberboard, acoustical tile[e]	290	0.05	-	0.8
	335	0.053	-	-
Mineral fiberboard, wet-molded, acoustical tile	370	0.061	-	0.59
Perlite board	160	0.052	-	-
Polyisocyanurate, aged unfaced	25 to 35	0.020 to 0.027	-	-
Polyisocyanurate, aged with facers	65	0.019	-	1.47
Phenolic foam board with facers, aged	65	0.019	-	-
Loose fill				
Cellulosic (milled paper or wood pulp)	35 to 50	0.039 to 0.045	-	1.38
Perlite, expanded	30 to 65	0.039 to 0.046	-	1.09
	65 to 120	0.045 to 0.052	-	-
	120 to 180	0.052 to 0.061	-	-
Mineral fiber (rock, slag, or glass)[e]approx. 95 to 130 mm	10 to 30	-	1.92	0.71
Mineral fiber (rock, slag, or glass)[e]approx. 170 to 220 mm	11 to 30	-	3.33	-
Mineral fiber (rock, slag, or glass)[e]approx. 190 to 250 mm	12 to 30	-	3.85	-
Mineral fiber (rock, slag, or glass)[e]approx. 260 to 350 mm	13 to 30	-	5.26	-
Mineral fiber (rock, slag, or glass)[e]90 mm (closed sidewall application)	30 to 55	-	2.1 to 2.5	-
Vermiculite, exfoliated	110 to 130	0.068	-	1.34
	64 to 96	0.063	-	-
Spray-applied				
Cellulosic fiber	55 to 95	0.042 to 0.049	-	-
Glass fiber	55 to 70	0.038 to 0.039	-	-
Polyurethane foam (low density)	6 to 8	0.042	-	1.47

Description	*Density kg/m³*	*Conductivity[b] k, W/(m·K)*	*Resistance R, (m²·K)/W*	*Specific Heat kJ/(kg·K)*
	40	0.026	-	1.47
Polyurethane foam (low density) aged and dry 40 mm	30	-	1.6	1.47
Polyurethane foam (low density) 50 mm	55	-	1.92	1.47
Polyurethane foam (low density) 120 mm	30	-	3.69	-
Urea formaldehyde foam, dry	8 to 20	0.030 to 0.032	-	-
Roofing				
Asbestos/cement shingles	1120	-	0.037	1
Asphalt (bitumen with inert fill)	1600	0.43	-	-
	1900	0.58	-	-
	2300	1.15	-	-
Asphalt roll roofing	920	-	0.027	1.51
Asphalt shingles	920	-	0.078	1.26
Built-up roofing	920	-	0.059	1.47
Mastic asphalt (heavy, 20% grit)	950	0.19	-	-
Reed thatch	270	0.09	-	-
Roofing felt	2250	1.2	-	-
Slate 13 mm	-	-	0.009	1.26
Straw thatch	240	0.07	-	-
Wood shingles, plain and plastic-film-faced	-	-	0.166	1.3
Plastering Materials				
Cement plaster, sand aggregate	1860	0.72	-	0.84
Sand aggregate 10 mm	-	-	0.013	0.84
Sand aggregate 20 mm	-	-	0.026	0.84
Gypsum plaster	1120	0.38	-	-
	1280	0.46	-	-
Lightweight aggregate	720	-	0.056	-
Lightweight aggregate	720	-	0.066	-
Lightweight aggregate	-	-	0.083	-
Perlite aggregate	720	0.22	-	1.34
Sand aggregate	1680	0.81	-	0.84
Sand aggregate on metal lath 19 mm	-	-	0.023	-
Vermiculite aggregate	480	0.14	-	-
	600	0.2	-	-
	720	0.25	-	-
	840	0.26	-	-
	960	0.3	-	-
Perlite plaster	400	0.08	-	-
	600	0.19	-	-
Pulp board or paper plaster	600	0.07	-	-
Sand/cement plaster, conditioned	1560	0.63	-	-
Sand/cement/lime plaster, conditioned	1440	0.48	-	-
Sand/gypsum (3:1) plaster, conditioned	1550	0.65	-	-

Description	*Density kg/m³*	*Conductivity[b] k, W/(m·K)*	*Resistance R, (m²·K)/W*	*Specific Heat kJ/(kg·K)*
Masonry Materials				
Masonry unit				
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] Limestone aggregate ~200 mm, 16.3 kg, 2200 kg/m³concrete, 2 cores	-	-	-	-
Concrete blocks[h] Limestone aggregate ~200 mm, 16.3 kg, 2200 kg/m³concrete with perlite-filled cores	-	-	0.37	-
Concrete blocks[h] Limestone aggregate ~300 mm, 25 kg, 2200 kg/m³concrete, 2 cores	-	-	-	-
Normal-weight aggregate (sand and gravel)~200 mm, 16 kg, 2100 kg/m³	-	-	0.20 to 0.17	0.92
Normal-weight aggregate (sand and gravel)~200 mm, 16 kg, 2100 kg/m³with perlite-filled cores	-	-	0.35	-
Normal-weight aggregate (sand and vermiculite-filled cores	-	-	0.34 to 0.24	-
Normal-weight aggregate (sand and gravel)~200 mm, 16 kg, 2100 kg/m³~300 mm, 22.7 kg, 2000 kg/m³concrete, 2 cores	-	-	0.217	0.92
Medium-weight aggregate (combinations of normal and lightweight aggregate) ~200 mm, 13 kg, 1550 to 1800 kg/m³concrete, 2 or 3 cores	-	-	0.30 to 0.22	-
Medium-weight aggregate (combinations of normal and lightweight aggregate) ~200 mm, 13 kg, 1550 to 1800 kg/m³with 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/m³with vermiculite-filled cores	-	-	0.58	-

Description	Density kg/m^3	Conductivity[b] k, W/(m·K)	Resistance R, (m^2·K)/W	Specific Heat kJ/(kg·K)
Medium-weight aggregate (combinations of normal and lightweight aggregate) ~200 mm, 13 kg, 1550 to 1800 kg/m³with molded-EPS-filled (Beads) Cores	-	-	0.56	-
Medium-weight aggregate (combinations of normal and lightweight aggregate) ~200 mm, 13 kg, 1550 to 1800 kg/m³with 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/m³concrete, 2 or 3 cores	-	-	0.34 to 0.29	-
Low-mass aggregate (expanded shale, clay, slate or slag, pumice) ~150 mm, 7 1/2 kg, 1400 kg/m³with perlite-filled cores	-	-	0.74	-
Low-mass aggregate (expanded shale, clay, slate or slag, pumice) ~150 mm, 7 1/2 kg, 1400 kg/m³with 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/m³concrete	-	-	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/m³concrete 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/m³concrete 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/m³concrete 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/m³concrete 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/m³concrete with molded EPS inserts in cores	-	-	0.62	-
Low-mass aggregate (expanded shale, clay, slate or slag, pumice) 300 mm, 16 kg, 1400 kg/m³,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/m³,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/m³,with vermiculite-filled cores	-	-	1.0	-
Stone, lime, or sand	2800	10.4	-	-
Quartzitic and sandstone	2560	6.2	-	-
	2240	3.46	-	-
	1920	1.88	-	0.88

Description	*Density kg/m³*	*Conductivity[b] k, W/(m·K)*	*Resistance R, (m²·K)/W*	*Specific Heat kJ/(kg·K)*
Calcitic, dolomitic, limestone, marble, and granite	2880	4.33	-	-
	2560	3.17	-	-
	2240	2.31	-	-
	1920	1.59	-	0.88
	1600	1.15	-	-
Gypsum partition tile .75 by 300 by 760 mm, solid	-	-	0.222	0.79
Gypsum partition tile .4 cells	-	-	0.238	-
Gypsum partition tile .100 by 300 by 760 mm, 3 cells	-	-	0.294	-
Limestone	2400	0.57	-	0.84
	2600	0.93	-	0.84
Concretes[i]				
Sand and gravel or stone aggregate concretes (concretes with >50% quartz or quartzite sand have conductivities in higher end of range)	2400	1.4 to 2.9	-	-
	2240	1.3 to 2.6	-	0.80 to 1.00
	2080	1.0 to 1.9	-	-
Low-mass aggregate or limestone concretes	1920	0.9 to 1.3	-	-
Low-mass aggregate or limestone mm, solid concretes Expanded shale, clay, or slate; expanded slags; cinders; pumice (with density up to 1600 kg/m³); scoria (sanded concretes have conductivities in higher end of range)	1600	0.68 to 0.89	-	0.84
	1280	0.48 to 0.59	-	0.84
	960	0.30 to 0.36	-	-
	640	0.18	-	-
Gypsum/fiber concrete (87.5% gypsum, 12.5% wood chips)	800	0.24	-	0.84
Cement/lime, mortar, and stucco	1920	1.4	-	-
	1600	0.97	-	-
	1280	0.65	-	-
Perlite, vermiculite, and polystyrene beads	800	0.26 to 0.27	-	-
	640	0.20 to 0.22	-	0.63 to 0.96
	480	0.16	-	-
	320	0.12	-	-
Foam concretes	1920	0.75	-	-
	1600	0.60	-	-
	1280	0.44	-	-
	1120	0.36	-	-
Foam concretes and cellular concretes	960	0.30	-	-
	640	0.20	-	-
	320	0.12	-	-
Aerated concrete (oven-dried)	430 to 800	0.20	-	0.84
Polystyrene concrete (oven-dried)	255 to 800	0.37	-	0.84
Polymer concrete	1950	1.64	-	-
	2200	1.03	-	-
Polymer cement	1870	0.78	-	-
Slag concrete	960	0.22	-	-
	1280	0.32	-	-
	1600	0.43	-	-

Description	*Density kg/m³*	*Conductivity[b] k, W/(m·K)*	*Resistance R, (m²·K)/W*	*Specific Heat kJ/(kg·K)*
	2000	1.23	-	-
Woods (12% moisture content)				
Hardwoods	-	-	-	1.63
Oak	660 to 750	0.16 to 0.18	-	-
Birch	680 to 725	0.17 to 0.18	-	-
Maple	635 to 700	0.16 to 0.17	-	-
Ash	615 to 670	0.15 to 0.16	-	-
Softwoods	-	-	-	1.63
Southern pine	570 to 660	0.14 to 0.16	-	-
Southern yellow pine	500	0.13	-	-
Eastern white pine	400	0.10	-	-
Douglas fir/larch	535 to 580	0.14 to 0.15	-	-
Southern cypress	500 to 515	0.13	-	-
Hem/fir, spruce/pine/fir	390 to 500	0.11 to 0.13	-	-
Spruce	400	0.09	-	-
Western red cedar	350	0.09	-	-
West coast woods, cedars	350 to 500	0.10 to 0.13	-	-
Eastern white cedar	360	0.1	-	-
California redwood	390 to 450	0.11 to 0.12	-	-
Pine (oven-dried)	370	0.092	-	1.88
Spruce (oven-dried)	395	0.1	-	1.88

[a]Reference document is ASHRAE-Handbook of Fundamentals. 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 m 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 non-reflective; 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 hotbox tests (ASTM Standard C236) or calibrated hotbox (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:

$$k = 0.1791 + \frac{(1.874 \times 10^{-2} + 5.733 \times 10^{-4} M)\rho}{1 + 0.01 M}$$

where ρ is density of moist wood in kg/m^3, and M is moisture content in percent

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

$$C_p = \frac{(0.299 + 0.01 M)}{(1 + 0.01 M)} + \Delta C_p$$

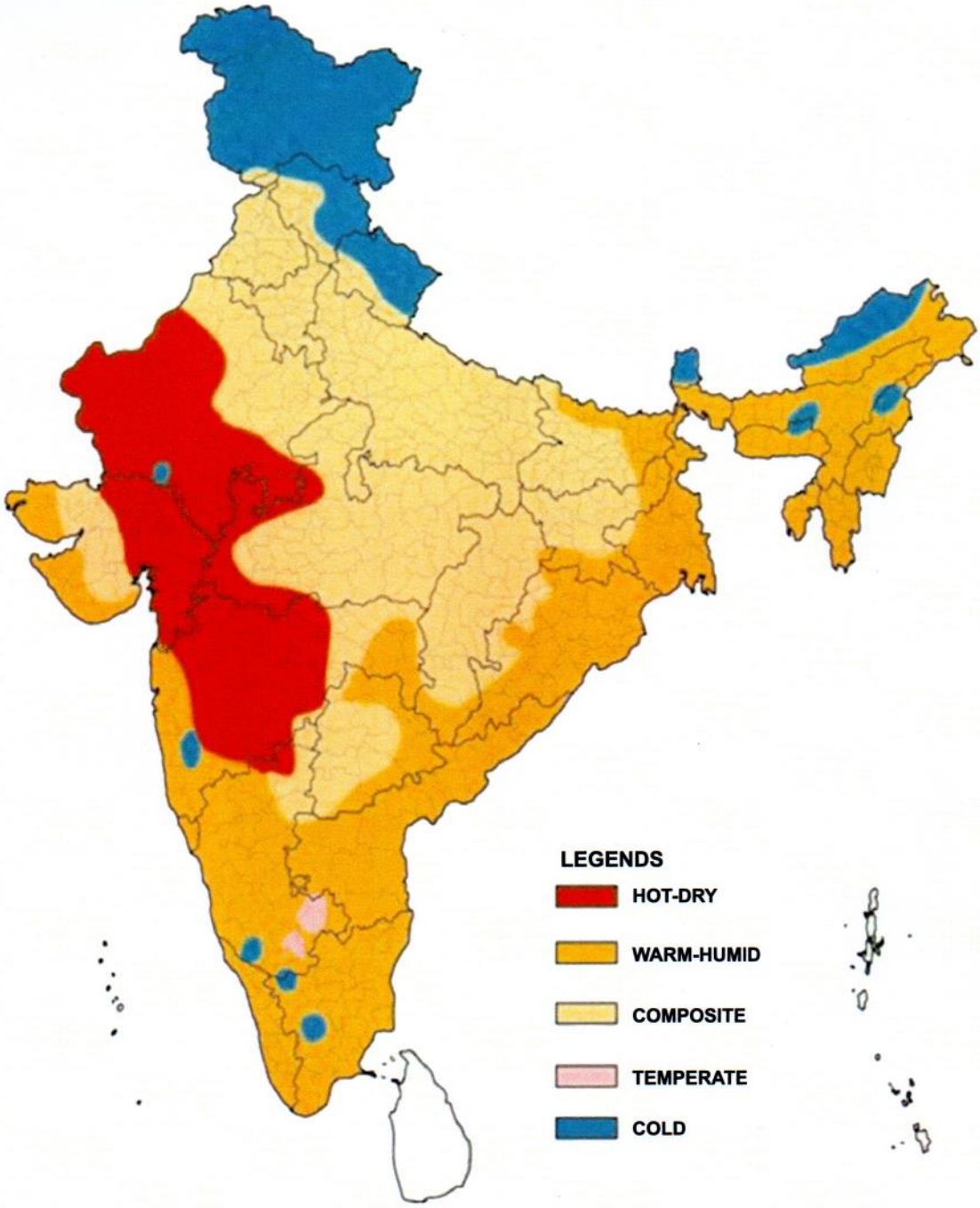
where ΔC_p *accounts for heat of sorption and is denoted by*

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

where, M is moisture content in percent by mass.

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

13. Appendix D: Climate Zone Map of India



Source : National Building Code 2005, Part 8, Fig. 2

14. Appendix E: Air-Side Economizer Acceptance Procedures

14.1. 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.

14.2. 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.

15. Appendix F: Compliance Forms

Envelope Summary

West Bengal Energy Conservation Building Code Compliance Forms

Project Info	Project Address	Date
		For Authority Having Jurisdiction Use
	Project Built-up Area [m^2]	
	Project Above-grade Area [m^2]	
	Project Conditioned Area [m^2]	
	Applicant Name and Address	
	Project Climatic Zone	

Building Classification		
	☐ Hospitality	☐ Business
	☐ HealthCare	☐ Educational
	☐ Assembly	☐ Shopping Complex

Project Description			
	☐ New Building	☐ Addition	☐ Alteration
	☐ Self-occupied	☐ Core and Shell	☐ Mixed-Use
Compliance is sought for Energy efficiency level	○ 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	X 100 = % Window to Wall Ratio (WWR)
			X 100 =
Skylight Area Calculation	Total Skylight Area (rough opening)	+ Gross Exterior Roof Area	X 100 =% Skylight to roof ratio (SRR)
			X 100 =

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

Cool Roof	
Solar Reflectance	
Emittance	

Wall Assembly		
Material	R-value	Assembly U-Factor

Daylighting Summary	
% above-grade area meeting the UDI requirementfor90% of the potential daylit time in a year	

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

West Bengal Energy Conservation Building Code Compliance Forms

Project Address						Date	
Applicability			Code Section	Component	Information Required	Location on Plans	Authority Having Jurisdiction Notes
Yes	No	N/A					
Mandatory Provisions (Section 4.2)							
			4.2.1	Fenestration rating			
			4.2.1.1	U-factor	Specify reference standard		
			4.2.1.2	SHGC	Specify reference standard		
			4.2.1.3	VLT	Specify reference standard		
			4.2.2	Opaque Construction			
			4.2.2.1	U-factors	Specify reference standard		
			4.2.2.2	Solar Reflectance	Specify reference standard		
			4.2.2.3	Emittance	Specify reference standard		
			4.2.3	Daylighting	Specify simulation approach or prescriptive		
			4.2.4	Building envelope sealing	Indicate sealing, caulking, gasketing, and Weather stripping		
Prescriptive Compliance Option (Section 4.3)							
			4.3.1	Roofs	Specify implemented U factor		
			4.3.1.1	Vegetative cool roof	Specify the solar reflectance, emittance, and reference standards		
			4.3.2	Opaque External Wall	Specify implemented U factor		
			4.3.3	Vertical fenestration	(1) Indicate U-factors on fenestration schedule. Indicate if values are rated or default. If values are default, then specify frame type, glazing layers, 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-frame projection are used for compliance purposes. If so, provide projection factor calculation and equivalent SHGC calculation		
			4.3.3(a)	Fenestration U factor exemption	Specify if applicable, specify unconditioned space percentage, and specify incorporated		
			4.3.4	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 default.		

Comfort System and Control Summary

Building Envelope Trade-Off Option (Section 4.3.5)							
					Provide calculations		

West Bengal Energy Conservation Building Code Compliance Forms

Project Info	Project Address:	Date
		For Authority Having Jurisdiction Use
	Project Built-up Area [sq.m]:	
	Project Above-grade Area [sq.m]:	
	Project Conditioned Area [sq.m]:	
	Applicant Name and Address:	
	Project Climatic Zone:	

Project Description	
Briefly described comfort system type and features.	Natural ventilation, mechanical Ventilation, Low energy comfort system, heating and cooling mechanical equipment. percentage area distribution for the installed system, and related information

Compliance Option	System efficiency	Prescriptive Method	Whole Building Performance Method

Equipment Schedules	The following information is required to be incorporated with the mechanical equipment schedules on the plans. For projects without plans, fill in the required information below.

Cooling Equipment Schedule								
Equip. ID	Brand Name	Model No.	Capacity kW	Testing Standards	OSACFM or Economizer?	COP	IPLV	Location

Heating Equipment Schedule

Equip. ID	Brand Name	Model No.	Capacity kW	Testing Standards	OSACFM or Economizer?	Input kW	Output kW	Efficiency

Fan Equipment Schedule

Equipment ID	Brand Name	Model No.	Testing Standards	SP	Efficiency	Flow Control	Location of Service	

Comfort System & Controls Checklist

West Bengal Energy Conservation Building Code Compliance Forms

Project Address	Date

Applicability			Code Section	Component	Information Required	Location on Plans	Authority Having Jurisdiction Notes
Yes	No	N/A					
Comfort Systems and Control							
Mandatory Provisions(Section5.2)							
			5.2.1	Ventilation	Indicate all habitable spaces are ventilated with outdoor air in accordancewith§5.2.1 and guide lines 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-hourmanual override, capable of retaining programming and time setting using gloss of power for a periodof at least10 hours		
			5.2.3.2	Temperature Controls	Indicate temperature controlwith3°Cdeadbandminimumif the system provides both heating and cooling.		
					Indicate thermostats are interlocked to prevent simultaneous heating and cooling, where separate heating and cooling systems are there		
					Indicate separate thermostat control for space types mentioned in§5.2.3.2.(c)		
			5.2.3.3	Occupancy Controls	Indicate occupancy controls for space types mentioned in§5.2.3.3		
			5.2.3.4	Fan Controls	Indicate two-speed motor, pony motor, or variable speed drive to control the fans and controls shall be capable to reduce the fan speed to at least two third of installed fan power		
			5.2.3.5	Dampers	Indicate all air supply and exhaust equipment's having VFD shall have dampers that automatically close upon the situations mentioned in§5.2.3.5		
			5.2.3.6	Pressurization Requirements	Indicate categorization requirements based on pressure of the zones		
			5.2.4	Piping& ductwork	Indicate sealing, caulking, gasketing, and weatherstripping		
			5.2.4.1	Piping insulation	Indicate R-value of insulation		
			5.2.4.2	Ductwork and Plenum insulation	Indicate R-value of Insulation		
			5.2.5	System Balancing	Show written balance report for HVAC systems serving zones with a total conditioned area exceeding500m²		
			5.2.6	Condensers	Indicate location of condenser and source of water used for condenser		
			5.2.7	Service Hot Water Heating			
			5.2.7.1	Solar Water Heating	Indicate all Hotels and hospitals have solar water heating equipment installed for hot water design capacity as per§ 5.2.7.1		
			5.2.7.2	Heating Equipment Efficiency	Indicate service water heating equipment shall meet the performance and efficiency asper§5.2.7.2		

			5.2.7.3	Other Water Heating System	Indicate supplementary heating system is designed in Consideration with §5.2.7.3		
			5.2.7.4	Piping Insulation	Indicate the Piping Insulation is compliant with§5.2.7.4.		
			5.2.7.5	Heat Traps	Indicate vertical pipe rise reserving water heater sand storage tanks are asper§5.2.7.5		
			5.2.7.6	Swimming Pools	Indicate the heated pools are provided with a vapor retardant pool cover on the water surface and temperature control and minimum insulation value asper§5.2.7.6		

Prescriptive Compliance Option(Section5.3)							
			5.3.1	Pumps	Indicate pump type(Primary, secondary, and condenser), its total installed capacity and efficiency		
			5.3.2	Cooling Towers	Indicate cooling tower type and installed capacity		
			5.3.3.1	Air-Economizer	Indicate air economizer is capable of modulating outside-air and return-air dampers tosupply50% of design supply air quantity as outside-airfor respective buildingtype.		
			5.3.3.1	Water-economizer	Indicate water economizer is capable of providing50% of the Expected system cooling load at outside air temperatures of 10°Cdry-bulb/7.2°Cwet-bulbandbelow,if the designed buildingisa respective buildingtype.		
			5.3.3.2	Partial Cooling	Indicatewhererequiredby§5.3.3.1economizersshallbe capable Of providing partial cooling even when additional mechanical Cooling is required to meet the cooling load.		
			5.3.3.3	Economizer Controls	Indicate air economizers are equipped with controlsasspecifiedin§5.3.3.3		
			5.3.3.4	Testing	Indicate air-side economizers have been tested as per the requirement specified		
			5.3.4	Variable Flow Hydronic Systems			
			5.3.4.1	Variable Fluid Flow	Indicate design flow rate of HVAC pumping system		
			5.3.4.2	Isolation Valves	Indicate water cooled air-conditioning have two-way automatic Isolation valves and pump motors greater than or equalto3.7 kW is controlled by variable speed drives		
			5.3.4.3	Variable Speed Drives	Indicate Chilled water or condenser water systems comply with either§5.3.4.1 or§5.3.4.2		
			5.3.5	Energy Recovery	Indicate for all Hospitality and Health care, heat recovery effectiveness, and efficiency of oil and gas fired boilers		
			5.4	Total System Loading Factor-Alternate compliance approach	Attach simulation report		
			5.5	Low Energy Comfort Systems	Indicate system type and list the exemption claimed		

Lighting and Controls Summary

West Bengal Energy Conservation Building Code Compliance Forms

Project Info	Project Address:	Date
		For Authority Having Jurisdiction Use
	Project Built-up Area (m^2):	
	Project Above-grade area (m^2):	
	Project Conditioned Area (m^2):	
	Applicant Name and Address:	
	Project Climatic Zone:	

Compliance Option	☐ Space by Space method	☐ Whole Building Method

Maximum Allowed Lighting Power (Interior, Section 6.3.2 or 6.3.3)

Location (Floor/room no.)	Occupancy Description	Allowed Watts per m^{2**}	Area in m^2	Allow edx Area
** Document all exceptions		Total Allowed Watts		

Proposed Lighting Power(Interior)

Location (floor/room no.)	Fixture Description	Number of Fixtures	Watts/ Fixture	Watts Proposed
Total Proposed Watts may not exceed Total Allowed Watts for Interior			Total Proposed Watts	

Maximum Allowed Lighting Wattage (Exterior,Section6.3.5)

Location	Description	Allowed Watts perm^{2}or per	Area in m^2 (or lm for perimeter)	Allowed Watts x m^2(or x lm)
			Total Allowed Watts	

Proposed Lighting Wattage(Exterior)

Location	Fixture Description	Number of Fixtures	Watts/ Fixture	Watts Proposed
Total Proposed Watts may not exceed Total Allowed Watts for Exterior			Total Proposed Watts	

Lighting and Controls Checklist

West Bengal Energy Conservation Building Code Compliance Forms

Project Address						Date	
Applicability			Code Section	Component	Information Required	Location on Plans	Authority Having Jurisdiction Notes
Yes	No	N/A					
Lighting and Controls							
Mandatory Provisions (Section 6.2)							
			6.2.1	Lighting Controls			
			6.2.1.1	Automatic lighting shutoff	Indicate automatic shutoff locations or occupancy sensors		
			6.2.1.2	Space control	Provide schedule with type, indicate locations		
			6.2.1.3	Control in Daylight Areas	Provide manual or automatic control device schedule with type and features, indicate locations		
			6.2.1.4	Ext. lighting control	Indicate photo sensor or astronomical time switch		
			6.2.1.5	Additional control	Provide schedule with type, indicate locations		
			6.2.2	Exit Signs	Indicate wattage per face of Exit signs		
Prescriptive Interior Lighting Power Compliance Option(Section6.3)							
			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 exceptions.		
			6.3.3	Space function method	Provide lighting schedule with wattage of lamp and ballast and number of fixtures. Document all exceptions.		
			6.3.4	Installed Interior Lighting Power	Indicate the wattage of installed luminaires on the floor plan. In case of luminaires containing permanently installed ballasts, the operating input wattage has to be provided, either from manufacturer's catalogs or values from independent testing laboratory reports.		
Prescriptive Exterior Lighting Power Compliance Option (Section6.3.5)							
			6.3.5	Exterior lighting Power	Provide lighting schedule with wattage of lamp and ballast and number of fixtures. Document all exceptions.		

Electrical & Renewable Energy Systems Summary

West Bengal Energy Conservation Building Code Compliance Forms

Project Info	Project Address	Date
		For Authority Having Jurisdiction 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 and renewable energy installed in the facility	Transformers, Diesel Generator sets, Uninterruptible Power Supply, Renewable Energy Systems and related information	
Compliance Approach	Prescriptive Method	Whole Building Performance Method
Transformers		
Type of Transformer	Dry Type Transformer / Oil Type Transformer	
		X 100 =
Transformer Losses	kVA Rating of / at 100% Loading in kW Transformer	Losses at 50% Loading in kW / Losses
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 & Renewable Energy Systems Checklist

West Bengal Energy Conservation Building Code Compliance Forms

Project Address						Date	
Applicability			Code Section	Component	Information Required	Location on Plans	Authority Having Jurisdiction Notes
Yes	No	N/A					
Electrical and Renewable Energy System							
Mandatory Provisions (Section 7.2)							
			7.2.1	Transformers			
			7.2.1.1	Maximum Allowable Power Transformer Losses	Provide losses at 50% load and 100% load, capacity and efficiency		
			7.2.1.2	Measurement and Reporting of Transformer Losses	For less than 500 kVA transformer meters are calibrated of 0.5 class accuracy and digital meters		
					For above 500 kVA additional Ct's and PT's are installed		
			7.2.1.3	Voltage Drop	Indicate the Voltage drop for feeders shall not exceed 2% at design load. Voltage drop for branch circuit shall not exceed 3% at design load.		
			7.2.2	Energy Efficient Motors	Indicate the motor class IE2/IE3/IE4.		
					Indicate the motors capacity more than 0.375 kW have efficiency according to the latest version of IS 12615.		
					Indicate the motor horsepower ratings does not exceed 20% of the calculated maximum load being served.		
			7.2.3	Diesel Generator (DG) 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 Systems	Indicate the power cable has been sized so that the distribution losses do not exceed the values mentioned in the code.
			7.2.7	Uninterruptible Power Supply (UPS)	Indicate the UPS meets or exceed the energy efficiency requirements listed in the table 7.5.
			7.2.8.1	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 (REGZ)	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, Structural design loads for roof dead and live load.

16. APPENDIX G: BEE approved list of software to show compliance

Table 16.1 Bureau of Energy Efficiency Approved Software for Demonstrating Compliance with ECBC

Analysis	Software
Whole Building Performance Method	AECOsim Design Builder DOE2 EnergyPlus eQUEST HAP IDA-ICE IES-VE OpenStudio Simergy Trace700 TRNSYS Visual DOE BEP-EMIS
Daylighting	AGI32 (Licaso) Daysim Design Builder DIVA Groundhog IES-VE OpenStudio RadianceRhino-Grasshopper with Daylighting Plugins Sefaira Sensor Placement + Optimization Tool (SPOT)

17. APPENDIX H: Star Labeling for Appliances*

Appliance	*Details*	*Minimum Star Labeling*
Air Conditioner	Room air conditioner of the vapour compression type which are of unitary air conditioner or split air conditioner or window air conditioner or 1:1 high wall split air conditioner or ceiling mounted split air conditioner or floor standing split air conditioner up to a rated cooling capacity of 10.5kW or as amended from time to time	Minimum 3 star
Frost-free Refrigerator	Refrigerators with frost free system in which cooling is provided by forced air circulation and the evaporators are defrosted by an automatic defrosting system or as amended from time to time	Minimum 3 star
Direct Cool Refrigerator	Direct Cool Refrigerator with or without a crisper, ice making or frozen food storage compartments and are not cooled by internal forced air circulation in which cooling is obtained primarily by natural convection only and however some products may have fan to avoid internal condensation but not to claim as frost free or as amended from time to time	Minimum 3 star
Tubular Fluorescent Lamps	Tubular Fluorescent Lamps of 1200 millimeter in size consuming energy upto 40 watts covering colour temperature of 6500 kelvin for halo-phosphate category, and 2700 kelvin,4000 kelvin and 6500 kelvin for tri-phosphate categories or as amended from time to time	Minimum 3 star
Colour Television	Colour Television with native resolution upto 1920 x 1080 pixels, of cathode ray tube (CRT), liquid crystal display (LCD) with cold cathode fluorescent lamp backlight, and plasma technologies type, and liquid crystal display with light emitting diode backlight, excluding computer monitors or as amended from time to time	Minimum 3 star
LED lamps	Self-ballasted LED lamp for general lighting services that works on single phase alternating current supply up to and including 250V, 50Hz or as amended from time to time	Minimum 3 star
Ceiling Fans	All ceiling fans of sweep 1200mm or as amended from time to time	Minimum 3 star

(*) The list of appliances shall be governed by appropriate notifications under the star labeling or appropriate clause of EC Act 2001 by BEE and as amended from time to time.

18. APPENDIX I: BEE Star Rating for Buildings

18.1.Annexure – I: Building Information and Energy Data.

Table 18.1: Building Information and Energy Data

Name of the Building: City:

Primary Data			Year
No.	Item		Value
1	Connected Load (kW) or contract Demand (kVA)		
2	Installed capacity : DG/GG Sets (kVA or kW)		
3	a) Annual Electricity Consumption, through Diesel from Utilities (kWh)		
	b) Annual Electricity Consumption, through Diesel Generating (DG)/Gas Generating (GG) Set(s) (kWh)		
	c) Total Annual Electricity Consumption, Utilities + DG/GG Sets (kWh)		
4	a) Annual Cost of Electricity, purchased from Utilities (Rs.)		
	b) Annual Cost of Electricity generated through DG/GG Sets (Rs.)		
	c) Total Annual Electricity Cost, Utilities + DG/GG Sets (Rs.)		
5	Area of the building (exclude parking, lawn, roads, etc.)	a) Built up area (sqm) (Excluding Basement Area)	
		o Conditioned Area (in sqm)	
		o Conditioned Area (as % of built up area)	
6	Working hours (e.g. day working/24 hour working)		
7	Working days/week (e.g. 5/6/7 days per week)		
8	a) Office	Total No. of Employees	
		Average no. of persons at any time in office during office hours	
9	Installed capacity of Air Conditioning System (TR)		
10	Installed lighting load (kW) (if available)		
11	HSD (or any other fuel oil used, specify)/Gas consumption in DG/GG Sets (Liters/cu. meters) in the year		
12	Fuel (e.g. FO, LDO,LPG, NG) used for generating steam/water heating in the year (in appropriate units)		
13	EPI (Energy Performance Index) in kWh/sqm/year Energy includes electricity purchased and generated (excluding electricity generated from on-site renewable resources)		
14	Star Label applicable		

I hereby declare that the building is fully occupied for the last one year and all the above furnished information is true in all respect

Signature of the building owner or authorized

18.2.Annexure – II: Contact Details.

Table 18.2: Contact Details of the Organization and the Contact Person

No.		Details
	Organization	
a)	Name of the Organization	
b)	Postal Address	
c)	Phone No.	
	Contact Person	
a)	Name & Designation	
b)	E-mail Address	
c)	Phone Nos.	
a)	Name of the Architect	
b)	Postal Address	
c)	Phone No.	
a)	Name of the Contractor	
b)	Postal Address	
c)	Phone No.	

18.3.Annexure – III: EPI and Star Label for buildings *

Based on the data collected from different categories of commercial buildings, the following tables show the indicative EPI benchmarks.

EPI Benchmark for Office Buildings

Climate Zone	Less than 50% AC	More than 50% AC
	EPI(kWh/m^2/yr)	
Warm and Humid	101	182
Composite	86	179
Hot and Dry	90	173
Moderate	94	179

EPI Benchmark for Shopping Malls

Climate Zone	EPI(kWh/m^2/yr)
Warm and Humid	428
Composite	327
Hot and Dry	273
Moderate	257

EPI Benchmark for Hotels

Climate Zone	Upto 3 Star	Above 3 Star
	EPI(kWh/m^2/yr)	
Warm and Humid	215	333
Composite	201	290
Hot and Dry	167	250
Moderate	107	313

EPI Benchmark for Institutes

Climate Zone	EPI(kWh/m^2/yr)
Warm and Humid	150
Composite	117
Hot and Dry	106
Moderate	129

EPI Benchmark for BPO

Climate Zone	EPI(kWh/m^2/yr)
Warm and Humid	452
Composite	437
Hot and Dry	-
Moderate	433

EPI Benchmark for Hospitals

Climate Zone	EPI(kWh/m^2/yr)
Warm and Humid	275
Composite	264
Hot and Dry	261
Moderate	247

(*) EPI values and star labels as prescribed for the energy labeling program of buildings or as amended from time to time by the BEE.

By order of the Governor,

S. Suresh Kumar
Additional Chief Secretary to the Govt. of West Bengal

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