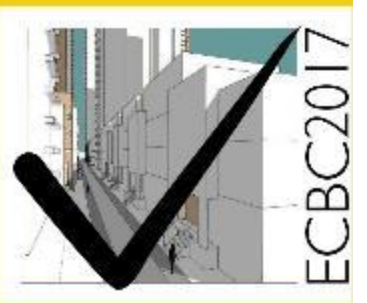
ECBC

Energy Conservation Building Code 2017

GOVERNMENT OF INDIA
MINISTRY OF POWER

Bureau of Energy Efficiency
Ministry of Power, Government of India



ENERGY CONSERVATION BUILDING CODE 2017

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Message

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

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

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

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

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

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

Piyush Goyal

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29 March, 2017

Message

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

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

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

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

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

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

(P. K. Pujari)

RIGHT TO INFORMATION

स्वच्छ भारत
एक कदम स्वच्छता की ओर

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भारत सरकार
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30 March, 2017

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

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

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

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

(B.P.Pandey)

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विद्युत मंत्रालय
MINISTRY OF POWER
श्रम शक्ति भवन, रफी मार्ग
SHRAM SHAKTI BHAWAN, RAFI MARG

नई दिल्ली - 110001
NEW DELHI - 110001

30th March, 2017

MESSAGE

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

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

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

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

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

(Raj Pal)

RIGHT TO INFORMATION

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

Abhay Bakre

Director General, Bureau of Energy Efficiency

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

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

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

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

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

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

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

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

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

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

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

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

Abhay Bakre
Director General
Bureau of Energy Efficiency

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

Saurabh Diddi

Energy Economist, Bureau of Energy Efficiency

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

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

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

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

The update process was a comprehensive exercise which was able to retain its rigor and technical consistency due to efforts of Ms. Apurva Chaturvedi, Senior Clean Energy

Specialist, USAID. Dr. Bhaskar Natarajan from PACE-D TA program provided constant support and guidance in management of the code development processes.

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

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

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

Saurabh Diddi

Director
Bureau of Energy Efficiency

USAID | INDIA
FROM THE AMERICAN PEOPLE

Mark A. White

Mission Director, USAID

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

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

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

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

Mark A. White
Mission Director

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REVISION NOTE

Following the successful launch of the updated version of Energy Conservation Building Code, in June 2017, BEE is working towards the mandatory enforcement of the code in all the states and UTs of India. To aid enforcement and implementation of the code through a standardized framework BEE developed ECBC Rules which was notified in the gazette of India in February, 2018. Parallel to this, BEE has been working on capacity building of stakeholders, training of professional, and demonstration projects and other allied activities for the propagation and adoption of the code.

The ECBC has been revised after incorporating format, typographical errors and a few amendments suggested by industry experts and stakeholders for effective implementation of the code. BEE is grateful to all the organizations to have provided us with their valuable inputs and would look forward to them to make the code robust and updated with technological advancement in the field.

I would like to acknowledge the role of ECBC steering committee and Working Groups for reviewing and finalizing the revised addition of ECBC. I would also like to thank the BEE team Mr. Abdullah Nisar, Ms. Shatakshi Suman and Ms. Meenal Anand under the guidance of Mr. Saurabh Diddi, Director, BEE for consolidating all the review comments, editing and compiling the manuscript of the revised version of the Energy Conservation Building Code, 2017.

October 30th, 2019

(Abhay Bakre)

Director General
Bureau of Energy Efficiency

ECBC

Energy
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Building
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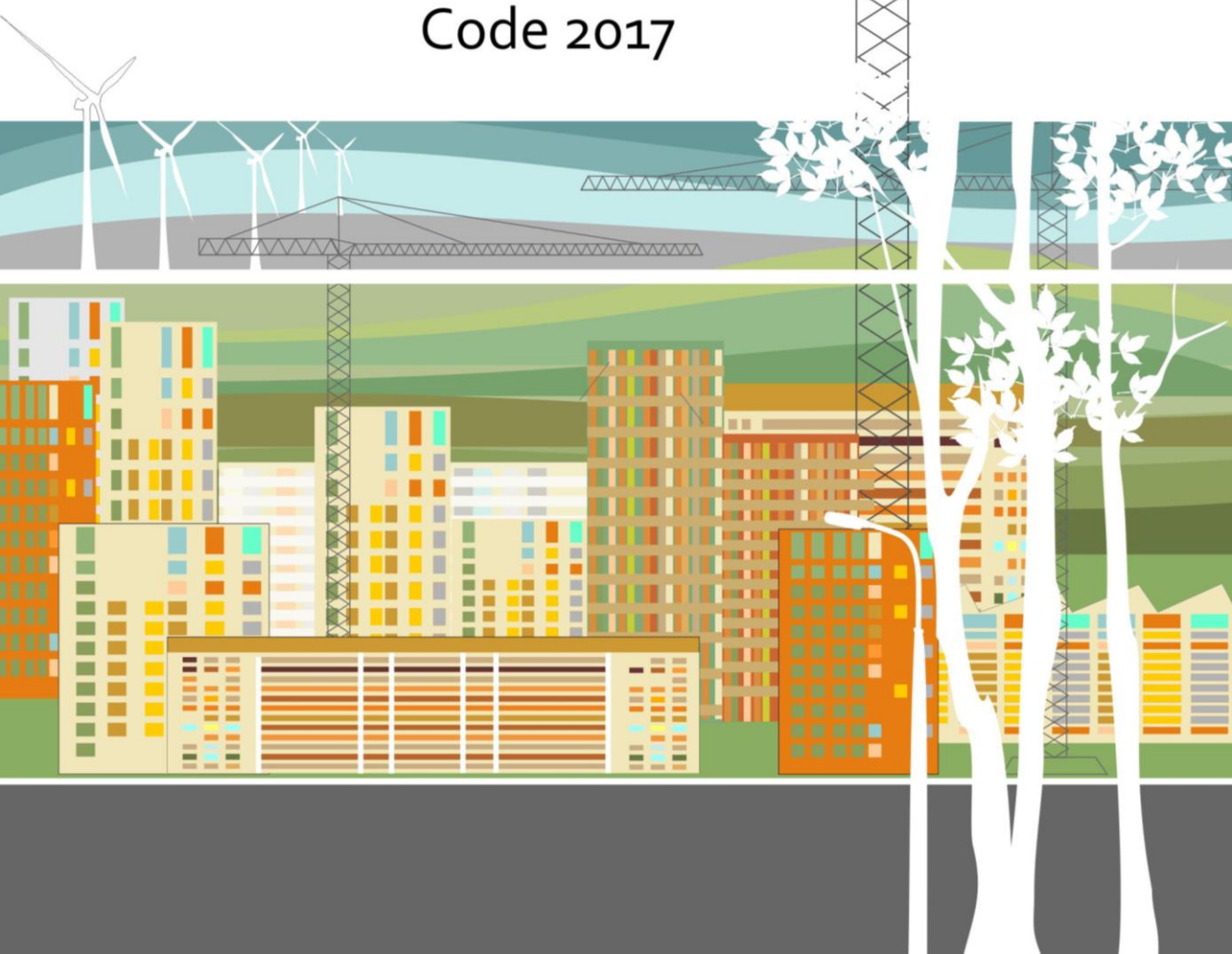

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1 Purpose

1. Purpose

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

2 Scope

2. Scope

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

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

2.1 Energy Efficiency Performance Levels

The code prescribes the following three levels of energy efficiency:

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

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

Energy Conservation Building Code Plus Building (ECBC+ Building)

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

Super Energy Conservation Building Code Building (SuperECBC Building)

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

2.2 Building Systems

The provisions of this code apply to:

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

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

2.3 Precedence

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

(a) Any policy notified as taking precedence over this Code, or any other rules on safety, security, health, or environment by Central, State, or Local Government.

Bureau of Energy Efficiency's Standards and Labelling for appliances and Star Rating Program for buildings provided both or either are more stringent than the requirements of this Code.

2.4 Reference Standards

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

Standards and labelling (S&L) Program of BEE will be applicable for minimum equipment efficiency standards, wherever specified. In case the schedule of S&L is revised for any equipment, the design approval year of building will be considered as base year for ECBC compliance.

2.5 Building Classification

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

(a) **Hospitality**: Any building in which sleeping accommodation is provided for commercial purposes, except any building classified under Health Care. Buildings and structures under Hospitality shall include the following:

i. No-star Hotels – like Lodging-houses, dormitories, no-star hotels/motels
ii. Resort
iii. Star Hotel

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.

Assembly: Any building or part of a building, where number of persons congregate or gather for amusement, recreation, social, religious, patriotic, civil, travel and similar purposes. Buildings like theatres or motion picture halls, gathering halls, and transport buildings like

airports, railway stations, bus stations, and underground and elevated mass rapid transit system are included in this group.

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.

Educational: Any building used for schools, colleges, universities, and other training institutions for day-care purposes involving assembly for instruction, education, or recreation for students. If residential accommodation is provided in the schools, colleges, or universities or coaching/ training institution, that portion of occupancy shall be classified as a No-star Hotel. Buildings and structures under Educational shall include following types-

iv. Schools
v. All other types of institutes, e.g. college, university, training institutes etc.

Shopping Complex: Any building or part thereof, which is used as shops, stores, market, for display and sale of merchandise, either wholesale or retail. Buildings like shopping malls, stand-alone retails, open gallery malls, super markets, or hyper markets are included in this type.

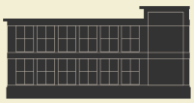
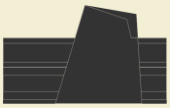
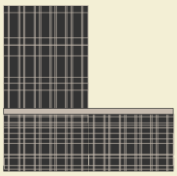
Mixed-use Building: In a mixed-use building, each commercial part of a building must be classified separately, and –

vi. If a part of the mixed-use building has different classification and is less than 10% of the total above grade floor area, the mixed-use building shall show compliance based on the building sub-classification having higher percentage of above grade floor area.
vii. If a part of the mixed-use building has different classification and one or more sub-classification is more than 10% of the total above grade floor area, the compliance requirements for each sub-classification, having area more than 10% of above grade floor area of a mixed-use building shall be determined by the requirements for the respective building classification in §4 to §7.

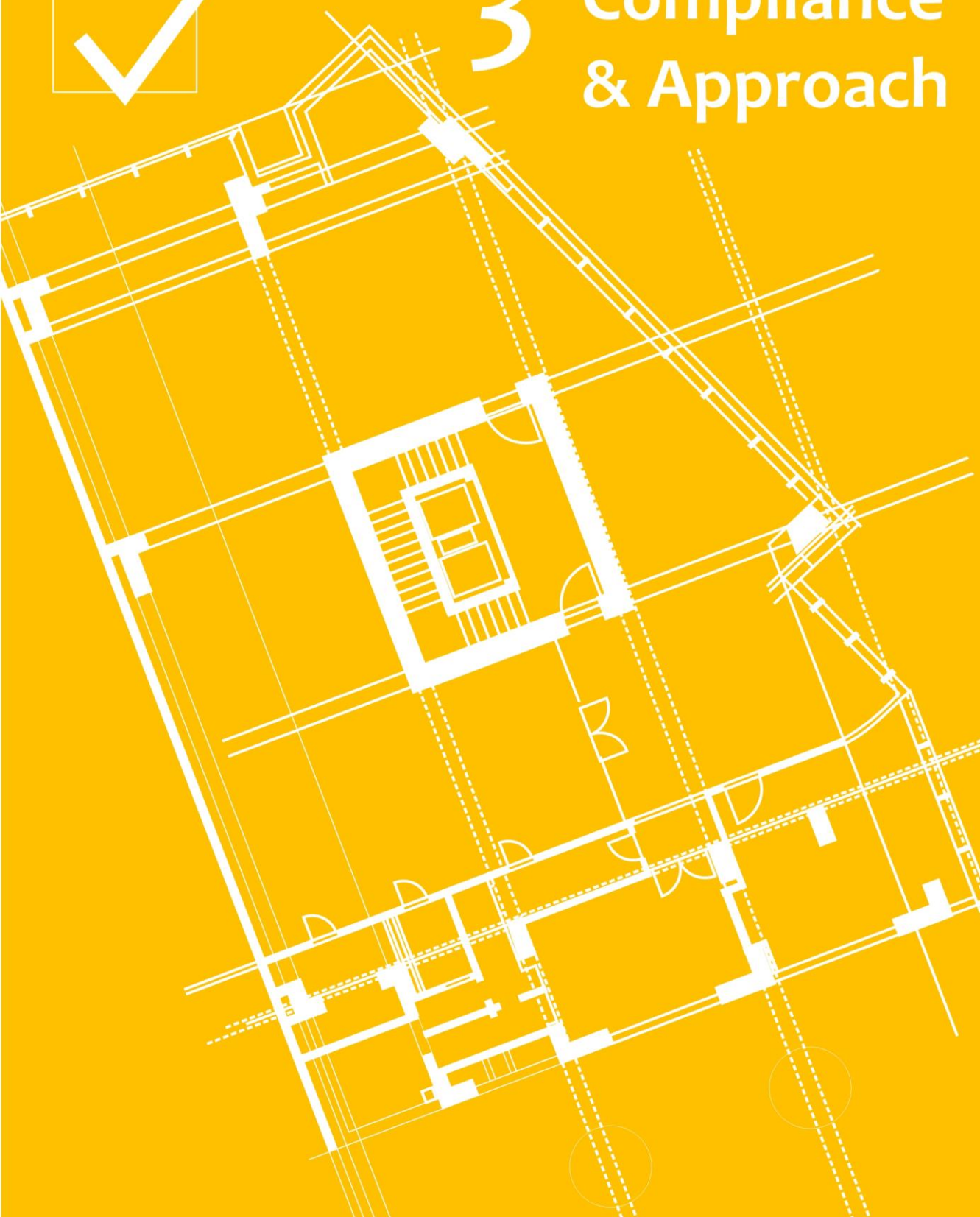
Any building which does not fall under any of the categories defined above shall be classified in a category mentioned above that best describes the function of the building.

Note 2-1 Building Typologies for ECBC 2017

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

 **Hospitality**	1. Star Hotel 2. No Star Hotel 3. Resort
 **Educational**	1. College 2. University 3. Institution 4. School
 **Health Care**	1. Hospital 2. Out-patient Healthcare
 **Shopping Complex**	1. Shopping Mall 2. Stand-alone Retails 3. Open Gallery Malls 4. Super Markets
 **Business**	1. Daytime use 2. 24-hours use
 **Assembly**	1. Multiplex 2. Theatre 3. Building used for Transport Services

3 Compliance & Approach



3. Compliance and Approach

3.1 General

To comply with the Code, buildings shall

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

and,

meet all mandatory requirements mentioned under §4.2, §5.2 , §6.2, and §7.2.

3.1.1 Energy Performance Index

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

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

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

3.1.2 Determining EPI Ratio

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

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

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

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

(a) Prescriptive Method (see §3.2.2)

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

3.1.3 EPI Ratio for Core and Shell Buildings

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

3.1.4 EPI Ratio for Mixed-use Development

In a mixed-use building, each commercial part of a building must be classified separately, and EPI Ratio shall be calculated separately for each sub-classification, as per §3.2.2.1 or §3.2.3.1. The EPI Ratio of a mixed-use Proposed Building shall be calculated based on area-weighted average method. To calculate the reference maximum design EPI Ratio, listed in Table 9-7 through Table 9-11, applicable for the mixed-use building, each commercial part of mixed-use building shall be classified separately, and,

(a) If a part of the mixed-use building has different classification and is less than 10% of the total above grade area (AGA), the EPI Ratio of the mixed-use Proposed Building shall be less than or equal to Maximum Allowed EPI ratio listed in Table 9-7 through Table 9-11 , for the building sub-classification having highest percentage of above grade floor area.

If a part of the mixed-use building has different classification and is more than 10% of the total above grade floor area, the EPI ratio of the mixed-use Proposed Building shall be less than or equal to Maximum Allowed EPI ratio for compliance calculated based on area weighted average method for all building sub-classifications listed in Table 9-7 through Table 9-11.

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

3.2 Compliance Approaches

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

3.2.1 Mandatory Requirements

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

3.2.2 Prescriptive Method

A building complies with the Code using the Prescriptive Method if it meets the prescribed minimum (or maximum) values for envelope components (§4.3), comfort systems and controls (§5.3, §5.3.13, §5.3.14), and lighting and controls (§6.3), in addition to meeting all the mandatory requirements.

3.2.2.1 EPI Ratio through Prescriptive Method

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

3.2.2.2 Building Envelope Trade-off Method

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

3.2.2.3 Total System Efficiency Method

For projects using central chilled water plants, the Total System Efficiency approach may be used to comply with the Prescriptive Method of §5. This approach may be used in place of the prescriptive criteria of chillers (§5.3.1and §5.3.7), chilled water pumps (§5.3.2), condenser water pumps (§5.3.2), and cooling tower fan (§5.3.3). Per this approach, a building complies if the Total System Efficiency thresholds are met as per Table 5-19 Maximum System Efficiency Threshold for ECBC, ECBC+, and SuperECBC Buildings. Compliance with other prescriptive requirements (§5.3), as applicable, shall be met.

3.2.2.4 Low Energy Comfort Systems

Low Energy Comfort Systems (§5.3.14) is a simplified approach that provides projects using Low Energy Comfort Systems an opportunity to achieve improved compliance levels of ECBC+ and SuperECBC. This approach is applicable to Prescriptive Method of Section §5. In addition to compliance with the applicable prescriptive requirements (§5.3), the projects must meet the sum of cooling and heating requirement using approved list of low energy systems as per requirements in §5.3.14.

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 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.

3.2.3.1 EPI Ratio through Whole Building Performance Method

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

3.3 Compliance Requirements

3.3.1 New Building Compliance

3.3.1.1 Full building Compliance

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

3.3.1.2 Core and Shell building Compliance

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

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

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

3.3.2 Additions and Alterations to Existing Buildings

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

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

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

3.4 Approved Compliance Tools

A building following the whole building performance method of §9 or Total System Efficiency – Alternate compliance approach of §5.3.13 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;

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;

Lighting: lighting schedule showing type, number, and wattage of lamps and ballasts; automatic lighting shutoff, occupancy sensors, and other lighting controls; lamp efficacy for exterior lamps;

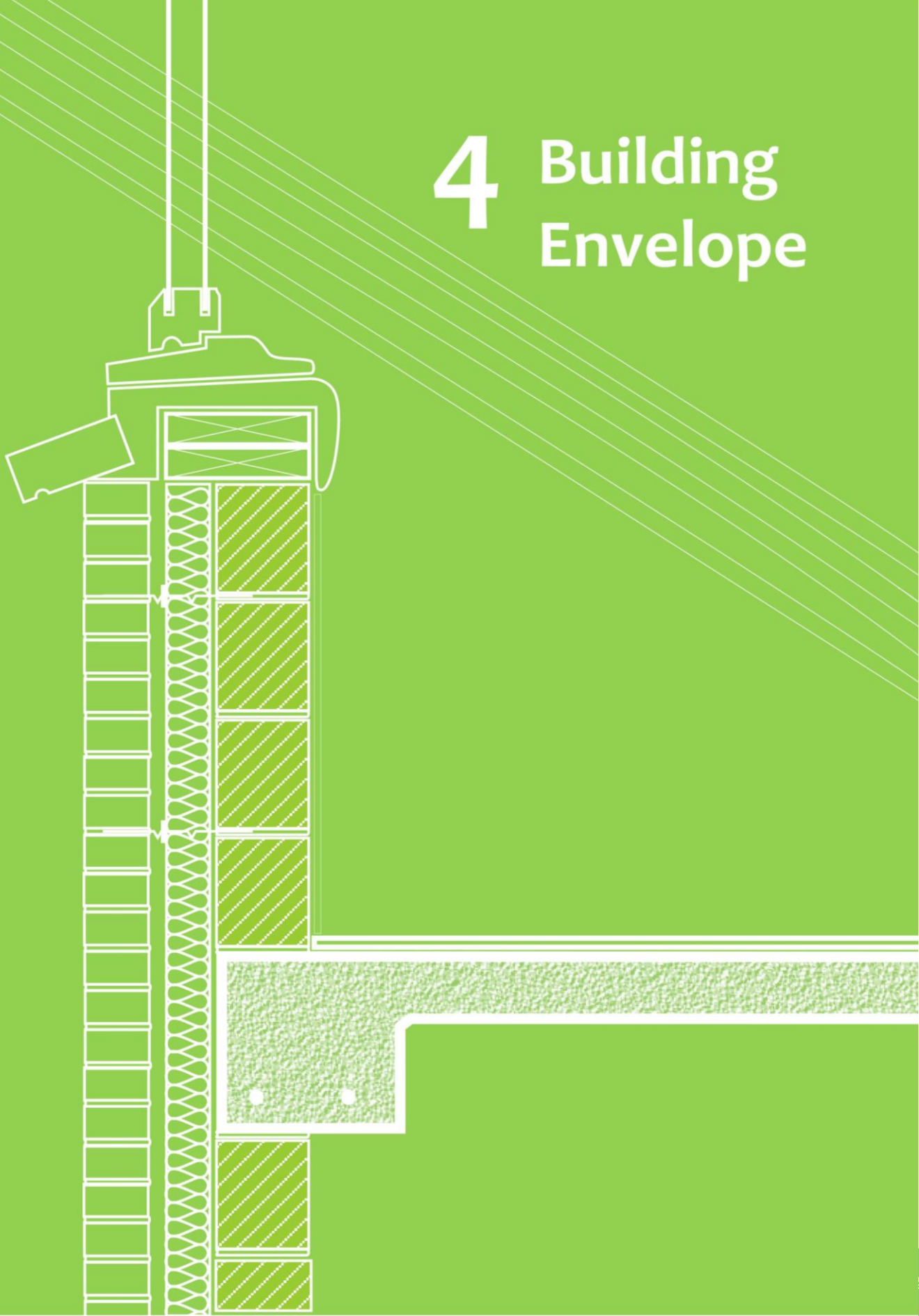
Electrical Power: electric schedule showing transformer losses, motor efficiencies, and power factor correction devices; electric check metering and monitoring system.

Renewable energy systems: system peak installed capacity, technical specifications, solar zone area

3.6.2 Supplemental Information

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

4 Building Envelope



4. Building Envelope

4.1 General

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

4.2 Mandatory Requirements

4.2.1 Fenestration

4.2.1.1 U-Factor

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

4.2.1.2 Solar Heat Gain Coefficient

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

Exceptions to §4.2.1.2:

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

Solar heat gain coefficient (SHGC) of the glass alone is an acceptable alternate for compliance with the SHGC requirements for the overall fenestration product.

4.2.1.3 Visible light transmittance

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

4.2.2 Opaque Construction

4.2.2.1 U-Factor

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

4.2.2.2 Solar Reflectance

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

4.2.2.3 Emittance

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

4.2.3 Daylighting

Above grade floor areas shall meet or exceed the useful daylight illuminance (UDI) area requirements listed in Table 4-1 for 90% of the potential daylit time in a year. Mixed-use buildings shall show compliance as per the criteria prescribed in §2.5. Compliance shall be demonstrated either through daylighting simulation method in §0 or the manual method in §4.2.3.2. Assembly buildings and other buildings where daylighting will interfere with the functions or processes of 50% (or more) of the building floor area, are exempted from meeting the requirements listed in Table 4-1.

Exceptions to §4.2.3:

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

Table 4-1 Daylight Requirement

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

4.2.3.1 Daylighting Simulation Method

Only BEE approved software shall be used to demonstrate compliance through the daylighting simulation method. Buildings shall achieve illuminance level between 100 lux and 2,000 lux for the minimum percentage of floor area prescribed in Table 4-1 for at least 90% of the potential 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.
The period of analysis shall be fixed for continuously 8 hours per day, anytime between 7:00 AM IST to 5:00 PM IST, resulting in 2,920 hours in total for all building types except for Schools. Schools shall be analyzed for continuously 7 hours per day, anytime between 7:00 AM IST to 3:00 PM IST.
Available useful daylight across a space shall be measured based on point-by-point grid values. UDI shall be calculated for at least one point for each square meter of floor area.
Fenestration shall be modeled with actual visible light transmission (VLT) as per the details provided in the material specification sheet.
All surrounding natural or man-made daylight obstructions shall be modeled if the distance between the façade of the building (for which compliance is shown) and surrounding natural or man-made daylight obstructions is less than or equal to twice the height of the man-made or natural sunlight 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.
Interior surface reflectance shall be modeled based on the actual material specification. If material specification is not available, the default values in Table 4-2 shall be used:
Documentation requirement to demonstrate compliance are:

i. Brief description of the project with location, number of stories, space types, hours of operation and and software used.
ii. Summary describing the results of the analysis and output file from simulation tool outlining point wise compliance for the analysis grid and compliance in percentage.

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

Table 4-2 Default Values for Surface Reflectance

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

4.2.3.2 Manual Daylighting Compliance Method

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

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

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

* To qualify as light shelf the internal projection shall meet the requirements specified under Exceptions to SHGC requirements in Table 4-10 and Table 4-11 0

(a) To calculate the daylit area:

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

ii. In the direction parallel to the fenestration, daylit area extends a horizontal dimension equal to the width of the fenestration plus either 1 meter on each side of the aperture, or the distance to an opaque partition of 2 m high, or one-half the distance to an adjacent fenestration, whichever is least.
iii. For skylights, calculate the horizontal dimension in each direction equal to the top aperture dimension in that direction plus either the floor-to-ceiling height (H) for skylights, or 1.5 H for monitors, or H or 2H for the sawtooth configuration, or the distance to the nearest 1 meter or higher opaque partition, or one-half the distance to an adjacent skylight or vertical glazing, whichever is least.
iv. Glazed façades, with non-cardinal orientation, shall be categorized under a particular cardinal direction if its orientation is within ± 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.

Documentation requirement:

vi. A separate architectural plan shall be prepared with all daylit areas marked on the floor plans.
vii. 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
Openings between walls and foundations, and between walls and roof, and wall panels
Openings at penetrations of utility services through roofs, walls, and floors
Site-built fenestration and doors
Building assemblies used as ducts or plenums
All other openings in the building envelope
Exhaust fans shall be fitted with a sealing device such as a self-closing damper
Operable fenestration should be constructed to eliminate air leakages from fenestration frame and shutter frame

Note 4.1 Daylight Extent Factor and Useful Daylight Illuminance

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

Calculating Useful Daylight Illuminance (UDI)

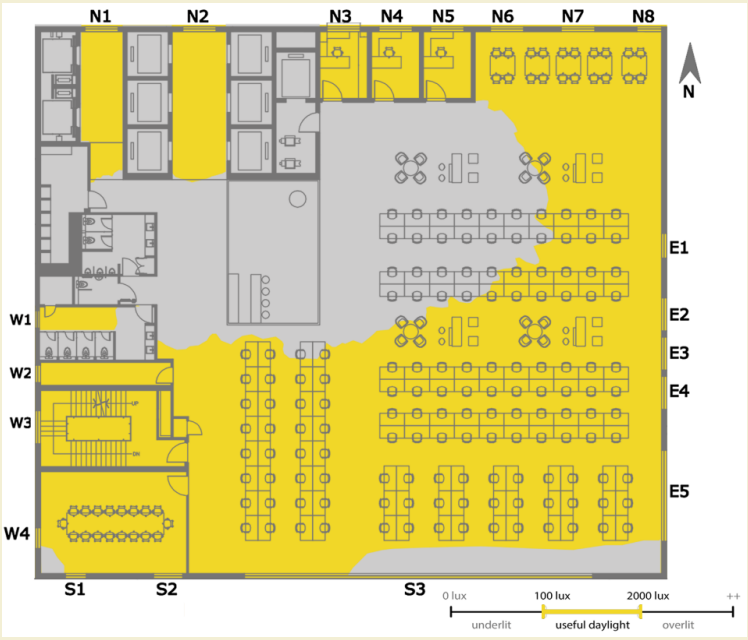
An office building located in New Delhi, India is pursuing ECBC compliance. Table 4-1 lists the minimum daylight area requirements for compliance. The table specifies that for office buildings, minimum 40% of its floor area shall receive daylight in range of 100 – 2,000 lux for at least 90% of the year.

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

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

(a) Analysis through software

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



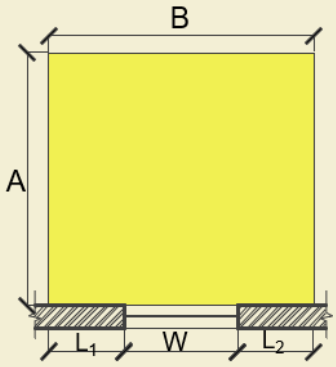
UDI Analysis with a Daylighting Analysis Software

(b) Manual calculation method

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

1. From Table 4.3 determine the daylight extent factor (**DEF**) for each orientation. For a building located in Delhi (latitude > 15 degrees), with glazing of VLT ≥ 0.39, shading PF ≥0.4 and light shelves in windows, DEFs for windows in North = 3.5, in South = 3.0, in East = 2.1, and in West = 1.8. Head height is 3.0 m.

2. For fenestration clear of any opaque obstructions calculate daylit floor area (**AxB**).



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

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

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

UDI Analysis with manual calculations

As per the calculations **616.5 m²** of floor area will meet the UDI requirements during 90% of the year. This is **49.2 %** of the total above grade floor area of 1,254 m². Thus, the building floor will comply with UDI requirement. Following Tables shows calculated Daylight Area Meeting UDI Requirement.

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

Orientation-**NORTH**, **DEF-3.5**, *Fenestration Head Height H - **3m***

Window without opaque obstructions	*Fenestration Width W (m)*	*A= H x DEF (m)*	*B= L_1+W+ L_2 (m)* *L_1 = L_2=1m*	*Area meeting the UDI requirements = AxB* (m²)
N7	2.0	10.5	4.0	42.0
N6	2.0	10.5	4.0	42.0
N2	2.0	10.5	4.0	42.0
Window with opaque obstructions	*Fenestration Width W (m)*	*A= Distance till parallel Obstruction (m)*	*B= L_1+W+ L_2 (m)* *L_1 = L_2=Distance to perpendicular Obstructions*	*Area meeting the UDI requirements = AxB* (m²)
N1	2.0	10.5	0.3+2+0.3=2.6	27.3
N3	2.0.	4.0	0.4+2+0.4=2.8	11.2
N4	2.0	4.0	0.4+2+0.4=2.8	11.2
N5	2.0	4.0	0.4+2+0.4=2.8	11.2
N8	1.5	10.5	0+1.5+1.0=2.5	26.3
Daylit area meeting UDI requirement				**213.2**

Orientation-**SOUTH, DEF-3**, *Fenestration Head Height H - **3m***

Window without opaque obstructions	*Fenestration Width W (m)*	*A= H x DEF (m)*	*B= L_1+W+ L_2 (m)* *L_1 = L_2=1m*	*Area meeting the UDI requirements = AxB* (m²)
S1	1.2	6.2	1.0+1.2+1.0=3.3	20.1
S2	1.7	6.2	1.0+1.7+0.3=3.0	18.6
S3	21.0	9.0	1.0+21.0+1.0=24	216.0
Daylit area meeting UDI requirement				**254.7**

Orientation-**EAST**, **DEF-2.1**, *Fenestration Head Height H - **3m***

Window without opaque obstructions	*Fenestration Width W (m)*	*A= H x DEF (m)*	*B= L_1+W+ L_2 (m)* *L_1 = L_2=1m*	*Area meeting the UDI requirements = AxB* (m^2)
E1	1.5	6.3	1.0+1.5+1.0=3.5	22.1
E5	5.5	6.3	1.0+5.5+1.0=7.5	47.3
Adjacent fenestration less than two meter apart	*Fenestration Width W (m)*	*A= H x DEF (m)*	*B= L_1+W+ L_2 (m)* *L_1, L_2=one half of distance to a*djacent fenestration	*Area meeting the UDI requirements = AxB* (m^2)
E2	2	6.3	1.0+2.0+0.2=3.2	20.2
E3	2	6.3	0.2+2+0.2=2.4	15.1
E4	2	6.3	0.2+2+1=3.2	20.2
Daylit area meeting UDI requirement				**124.9**

Orientation-**WEST**, **DEF-1.8**, *Fenestration Head Height H - **3m***

Window without opaque obstructions	*Fenestration Width W (m)*	*A= H x DEF (m)*	*B= L_1+W+ L_2 (m)* *L_1 = L_2=1m*	*Area meeting the UDI requirements = AxB* (m^2)
W3	2.0	5.4	1.0+2.0+1.0=4.0	21.6
W4	1.4	5.4	1.0+1.2+1.0=3.2	17.3
Window with opaque obstructions in daylit area	*Fenestration Width W (m)*	*A= H x DEF (m)*	*B= L_1+W+ L_2 (m)* *L_1 = L_2=Distance to perpendicular Obstructions*	*Area meeting the UDI requirements = AxB* (m^2)
W1	1.0	5.4	0.3+1+0.3=1.6	8.6
W2	1.0	5.4	0.3+1+0.3=1.6	8.6
Daylit area meeting UDI requirement				**56.1**

Overlapping area calculations

Window with overlap areas	*Width (m)*	*Depth (m)*	*Area (*m^2)
N4 and S1	3.3	3.3	10.9
S3 and E5	3.3	6.5	21.5
Overlapping daylight area (b)			**32.4**

Total Daylit area

ORIENTATION	*Daylit area* (*m^2*)
NORTH	213.2
SOUTH	254.7
EAST	124.9
WEST	56.1
Total daylight area (a)	648.9
Total Overlapping daylit area (b)	32.4
Total daylit area meeting UDI requirement during 90% of the year (a-b)	**616.5**

4.3 Prescriptive Requirements

4.3.1 Roof

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

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

	Composite	*Hot and dry*	*Warm and humid*	*Temperate*	*Cold*
All building types, except below	0.33	0.33	0.33	0.33	0.28
School <10,000 m² AGA	0.47	0.47	0.47	0.47	0.33
Hospitality > 10,000 m² AGA	0.20	0.20	0.20	0.20	0.20

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

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

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

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

4.3.1.1 Vegetated and Cool Roof

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

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

For qualifying as a vegetated roof, roof areas shall be covered by living vegetation of >50 mm high.

4.3.2 Opaque External Wall

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

Table 4-7 Opaque Assembly Maximum U-factor (W/m².K) Requirements for a ECBC compliant Building

	Composite	*Hot and dry*	*Warm and humid*	*Temperate*	*Cold*
All building types, except below	0.40	0.40	0.40	0.55	0.34
No Star Hotel < 10,000 m² AGA	0.63	0.63	0.63	0.63	0.40
Business < 10,000 m² AGA	0.63	0.63	0.63	0.63	0.40
School <10,000 m² AGA	0.85	0.85	0.85	1.00	0.40

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

	Composite	*Hot and dry*	*Warm and humid*	*Temperate*	*Cold*
All building types, except below	0.34	0.34	0.34	0.55	0.22
No Star Hotel < 10,000 m² AGA	0.44	0.44	0.44	0.44	0.34
Business < 10,000 m² AGA	0.44	0.44	0.44	0.55	0.34
School <10,000 m² AGA	0.63	0.63	0.63	0.75	0.44

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

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

Exceptions to §4.3.2: Opaque external walls of an unconditioned building of No Star Hotel, Healthcare, and School categories in all climatic zones, except for cold climatic zone, shall have a maximum assembly U-factor of 0.8 W/m².K.

4.3.3 Vertical Fenestration

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

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

Minimum allowable Visible light transmittance (VLT) is 0.27

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

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

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

	Composite	*Hot and dry*	*Warm and humid*	*Temperate*	*Cold*
Maximum U-factor ($W/m^2.K$)	3.00	3.00	3.00	3.00	3.00
Maximum SHGC Non-North	0.27	0.27	0.27	0.27	0.62
Maximum SHGC North for latitude ≥ 15°N	0.50	0.50	0.50	0.50	0.62
Maximum SHGC North for latitude < 15°N	0.27	0.27	0.27	0.27	0.62
See Appendix A for default values of unrated fenestration.					

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

	Composite	*Hot and dry*	*Warm and humid*	*Temperate*	*Cold*
Maximum U-factor ($W/m^2.K$)	2.20	2.20	2.20	3.00	1.80
Maximum SHGC Non-North	0.25	0.25	0.25	0.25	0.62
Maximum SHGC North for latitude ≥ 15°N	0.50	0.50	0.50	0.50	0.62
Maximum SHGC North for latitude < 15°N	0.25	0.25	0.25	0.25	0.62

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

(a) For fenestration with a permanent external projection, including but not limited to overhangs, side fins, box frame, verandah, balcony, and fixed canopies that provide permanent shading to the fenestration, the equivalent SHGC for the proposed shaded fenestration may be determined as less than or equal to the SHGC requirements of Table 4-10 and Table 4-11. Equivalent SHGC shall be calculated by following the steps listed below:

i. Projection factor (PF) for the external permanent projection, shall be calculated as per the applicable shading type listed in §8.2. The range of projection factor for using the SEF is $0.25 \leq PF \leq 1.0$. The SEF is applicable for both side fins shading only other than overhangs. The projection factor shall be calculated for both side fins and the lower projection factor of each fin shall be considered. Other shading devices shall be modeled through the Whole Building Performance Method in §9.

ii. A shaded vertical fenestration on a non-cardinal direction, shall be categorized either under a particular cardinal direction or a primary inter-cardinal direction if its orientation is within the range of ±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 analysis for summer solstice for the vertical fenestration.

iv. An equivalent SHGC is calculated by dividing the SHGC of the unshaded fenestration product with a Shading Equivalent Factor (SEF). SEF shall be determined for each orientation and shading device type from Table 4-10 and Table 4-11.

v. The maximum allowable SHGC is calculated by multiplying the prescriptive SHGC requirement for respective compliance level from Table 4-10 and Table 4-11 with the SEF.

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

Shading Equivalent Factors (SEF) for latitudes greater than or equal to 15°N									
SEF	PF	North	East	South	West	North-East	South-East	South-West	North-West
Overhang + Fins	0.25	1.25	1.37	1.58	1.36	1.47	1.47	1.42	1.53
	0.3	1.29	1.48	1.72	1.43	1.54	1.65	1.57	1.58
	0.35	1.34	1.58	1.88	1.51	1.62	1.81	1.73	1.65
	0.4	1.39	1.67	2.06	1.61	1.70	1.97	1.89	1.75
	0.45	1.43	1.76	2.26	1.71	1.78	2.11	2.06	1.87
	0.5	1.47	1.85	2.47	1.83	1.86	2.25	2.23	2.00

	0.55	1.51	1.94	2.69	1.96	1.94	2.38	2.40	2.13
	0.6	1.55	2.03	2.92	2.09	2.02	2.51	2.58	2.27
	0.65	1.59	2.13	3.15	2.24	2.10	2.64	2.76	2.40
	0.7	1.63	2.24	3.18	2.39	2.18	2.77	2.94	2.53
	0.75	1.66	2.37	3.19	2.56	2.25	2.90	3.12	2.64
	0.8	1.70	2.52	3.20	2.72	2.33	3.04	3.18	2.73
	0.85	1.73	2.69	3.21	2.90	2.40	3.11	3.23	2.80
	0.9	1.76	2.89	3.24	3.07	2.46	3.15	3.25	2.84
	0.95	1.79	3.11	3.28	3.25	2.52	3.17	3.27	2.85
	≥1	1.80	3.30	3.33	3.33	2.57	3.23	3.30	2.82
Overhang	0.25	1.09	1.21	1.28	1.20	1.17	1.26	1.23	1.20
	0.3	1.11	1.26	1.34	1.27	1.22	1.32	1.27	1.24
	0.35	1.13	1.30	1.39	1.33	1.26	1.39	1.32	1.28
	0.4	1.15	1.35	1.46	1.38	1.30	1.46	1.38	1.32
	0.45	1.16	1.40	1.52	1.43	1.33	1.53	1.46	1.36
	0.5	1.18	1.45	1.59	1.48	1.35	1.60	1.54	1.40
	0.55	1.20	1.51	1.66	1.52	1.38	1.67	1.62	1.44
	0.6	1.21	1.56	1.73	1.57	1.40	1.74	1.70	1.47
	0.65	1.22	1.62	1.81	1.61	1.42	1.81	1.79	1.51
	0.7	1.24	1.68	1.88	1.66	1.45	1.88	1.87	1.55
	0.75	1.25	1.74	1.95	1.72	1.48	1.94	1.94	1.58
	0.8	1.26	1.80	2.02	1.77	1.51	2.00	2.01	1.61
	0.85	1.27	1.86	2.09	1.84	1.56	2.06	2.06	1.64
	0.9	1.28	1.92	2.15	1.91	1.61	2.11	2.10	1.67
	0.95	1.29	1.99	2.21	1.98	1.67	2.15	2.13	1.70
	≥1	1.30	2.06	2.26	2.07	1.75	2.19	2.14	1.72
Side Fins	0.25	1.13	1.11	1.18	1.11	1.21	1.14	1.16	1.23
	0.3	1.15	1.13	1.22	1.13	1.22	1.17	1.22	1.27
	0.35	1.17	1.15	1.26	1.15	1.24	1.20	1.26	1.32
	0.4	1.19	1.17	1.29	1.17	1.27	1.23	1.29	1.36
	0.45	1.21	1.19	1.32	1.19	1.30	1.25	1.31	1.41
	0.5	1.22	1.20	1.35	1.20	1.34	1.27	1.33	1.46
	0.55	1.24	1.22	1.38	1.22	1.38	1.29	1.34	1.50
	0.6	1.25	1.23	1.40	1.23	1.42	1.31	1.35	1.55
	0.65	1.27	1.24	1.42	1.25	1.47	1.32	1.36	1.58
	0.7	1.28	1.26	1.44	1.26	1.51	1.34	1.36	1.61
	0.75	1.30	1.27	1.46	1.27	1.55	1.35	1.37	1.64
	0.8	1.31	1.28	1.48	1.29	1.59	1.37	1.38	1.65
	0.85	1.32	1.30	1.49	1.30	1.62	1.38	1.39	1.65
	0.9	1.34	1.31	1.51	1.31	1.65	1.40	1.40	1.64
	0.95	1.35	1.32	1.53	1.32	1.67	1.42	1.42	1.61
	≥1	1.36	1.33	1.55	1.33	1.69	1.44	1.45	1.57

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

Shading Equivalent Factors (SEF) for latitudes less than 15˚N									
SEF	PF	North	East	South	West	North-East	South-East	South-West	North-West
Overhang + Fins	0.25	1.38	1.33	1.30	1.34	1.42	1.41	1.37	1.42
	0.3	1.44	1.42	1.35	1.42	1.49	1.46	1.41	1.52
	0.35	1.50	1.50	1.42	1.50	1.57	1.52	1.47	1.63
	0.4	1.56	1.59	1.50	1.59	1.66	1.59	1.54	1.73
	0.45	1.61	1.67	1.59	1.69	1.76	1.67	1.61	1.84
	0.5	1.67	1.76	1.68	1.80	1.87	1.75	1.70	1.94
	0.55	1.72	1.85	1.79	1.90	1.98	1.85	1.80	2.05
	0.6	1.77	1.94	1.89	2.02	2.09	1.94	1.89	2.15
	0.65	1.82	2.02	1.99	2.13	2.20	2.04	2.00	2.25
	0.7	1.86	2.11	2.08	2.24	2.31	2.15	2.10	2.36
	0.75	1.90	2.19	2.17	2.35	2.42	2.25	2.21	2.46
	0.8	1.94	2.28	2.25	2.46	2.53	2.35	2.31	2.55
	0.85	1.98	2.36	2.31	2.56	2.64	2.45	2.42	2.65
	0.9	2.02	2.44	2.35	2.66	2.74	2.54	2.52	2.74
	0.95	2.05	2.51	2.38	2.75	2.84	2.63	2.61	2.83
	≥1	2.08	2.58	2.38	2.83	2.93	2.71	2.70	2.91
Overhang	0.25	1.15	1.19	1.09	1.20	1.17	1.08	1.04	1.18
	0.3	1.17	1.23	1.07	1.24	1.22	1.12	1.08	1.21
	0.35	1.20	1.28	1.07	1.29	1.26	1.16	1.12	1.25
	0.4	1.22	1.32	1.07	1.33	1.30	1.19	1.17	1.29
	0.45	1.24	1.37	1.09	1.38	1.33	1.23	1.21	1.32
	0.5	1.26	1.42	1.12	1.42	1.37	1.28	1.25	1.35
	0.55	1.28	1.46	1.15	1.46	1.40	1.32	1.29	1.39
	0.6	1.30	1.51	1.18	1.50	1.43	1.36	1.33	1.42
	0.65	1.32	1.55	1.22	1.55	1.46	1.40	1.37	1.45
	0.7	1.33	1.60	1.26	1.59	1.48	1.43	1.40	1.48
	0.75	1.35	1.64	1.29	1.62	1.51	1.47	1.44	1.50
	0.8	1.37	1.67	1.32	1.66	1.53	1.51	1.47	1.53
	0.85	1.38	1.71	1.35	1.70	1.55	1.54	1.51	1.56
	0.9	1.39	1.74	1.37	1.73	1.57	1.56	1.54	1.58
	0.95	1.40	1.77	1.38	1.77	1.59	1.59	1.56	1.61
	≥1	1.41	1.79	1.38	1.80	1.61	1.61	1.59	1.63
Side Fins	0.25	1.17	1.10	1.06	1.10	1.15	1.14	1.16	1.16
	0.3	1.20	1.12	1.11	1.12	1.18	1.18	1.21	1.19
	0.35	1.23	1.13	1.16	1.14	1.21	1.20	1.25	1.22
	0.4	1.26	1.15	1.20	1.15	1.24	1.23	1.29	1.25
	0.45	1.28	1.16	1.23	1.17	1.27	1.25	1.31	1.28
	0.5	1.30	1.18	1.25	1.19	1.30	1.27	1.34	1.30
	0.55	1.32	1.19	1.27	1.20	1.33	1.29	1.36	1.33
	0.6	1.34	1.20	1.29	1.22	1.36	1.31	1.37	1.35

	0.65	1.36	1.21	1.30	1.23	1.38	1.34	1.38	1.38
	0.7	1.38	1.22	1.31	1.24	1.41	1.36	1.40	1.40
	0.75	1.40	1.23	1.33	1.26	1.43	1.38	1.41	1.42
	0.8	1.42	1.24	1.34	1.27	1.46	1.41	1.43	1.44
	0.85	1.43	1.25	1.35	1.28	1.48	1.44	1.45	1.47
	0.9	1.45	1.26	1.37	1.29	1.50	1.47	1.47	1.49
	0.95	1.46	1.27	1.39	1.31	1.52	1.50	1.50	1.51
	≥1	1.47	1.28	1.42	1.32	1.53	1.54	1.53	1.53

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

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

Note 4-1 Equivalent SHGC and Projection Factor

A 5,400 m^2 two story office building in Delhi is trying to achieve ECBC level compliance. It has a rectangular layout (90 m x 30 m) with floor to floor height of 4.0 m and floor area is evenly distributed over the two floors. Windows are either east or west facing and equally distributed on the two floors. The windows are all 1.85m in length and 2.165m in height with an overhang of 0.85 m, sill level is 1.385 m above floor level. The overall glazing area is 384 m^2. SHGC of the glazing in the East/West Fenestration is 0.30; area weighted U-Factor is 3.0 W/m^2.K. VLT of the glazing in all orientation is 0.5. Will the vertical fenestration comply with the ECBC through prescriptive approach?

Solution:

Table 4-10 and §4.3.3 lists the U-factor, SHGC and VLT requirements for vertical fenestration for ECBC compliant buildings. The building is located in Delhi (Latitude: $28^0$70' N, Longitude: $77^0$10'E), which falls under the composite climate, as per Appendix B, Table 12.1. To fulfil prescriptive requirements, Window to Wall ratio ≤ 40%, SHGC ≤ 0.27, U-factor ≤ 3.0 W/m^2.K, and VLT ≥ 0.27.

Total Floor area = 5400 m^2

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

Total Fenestration area = 384 m^2

Window to Wall Ratio (WWR) = 384/1,920 = 20%

As per the calculations, the building has a WWR of 20%, thus complying with the requirement for WWR. The U-factor is also equal to 3.0 W/m^2.K. Similarly, the VLT is 0.5, which is greater than the minimum specified value of 0.27, thus complying with the U-factor and VLT requirement.

Equivalent SHGC Calculation

The window SHGC is 0.3 which is not meet the prescriptive requirement of Table 4-10. However, the windows have an overhang of 0.85 m. As the windows have an overhang, this case will fall under the exception, and the *equivalent SHGC* value will be calculated by dividing fenestration SHGC by Shading Equivalent Factor (SEF).

For projection factor (PF) 0.34, the SEF for east, and west are taken from Table 4-12, as the latitude is greater than 15˚N.

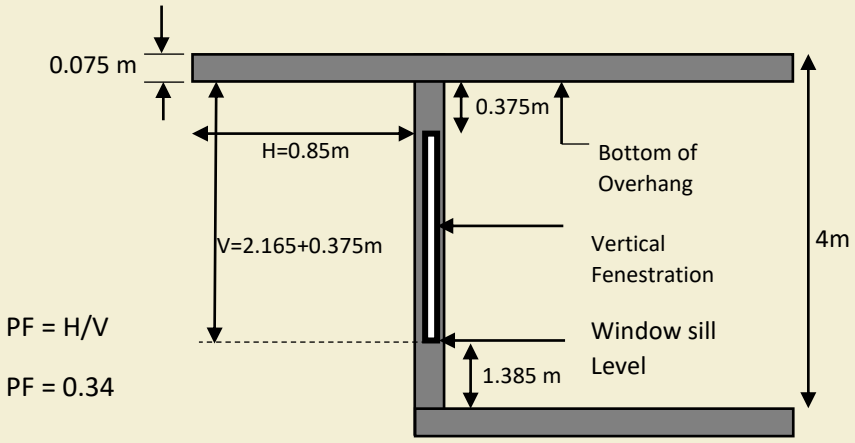
SEF for east for PF = 0.3 (as worst case) = 1.26

Therefore, equivalent $SHGC_{East}$ = 0.3 ÷ 1.26 = 0.24 Hence the vertical fenestration on the east façade will comply as per prescriptive approach, as the equivalent SHGC is less than maximum allowed.

Similarly, for the west façade:

SEF for west for PF = 0.3 (as worst case) = 1.27

Therefore, equivalent $SHGC_{West}$ = 0.3 ÷ 1.27 = 0.24, hence the vertical fenestration on the west façade will comply using the prescriptive approach, as the equivalent SHGC is less than maximum allowed.


0.075 m
0.375m
H=0.85m
Bottom of
Overhang
V=2.165+0.375m
Vertical
Fenestration
4m
PF = H/V
Window sill
Level
PF = 0.34
1.385 m

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

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

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

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

4.3.4 Skylights

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

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

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

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

4.3.5 Building Envelope Trade-Off Method

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

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

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

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

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

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

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

Table 4-16 Envelope Performance Factor Coefficients – Composite Climate

	Daytime Business, Educational, Shopping Complex		*24-hour Business, Hospitality, Health Care, Assembly*	
	C factor $_{U\text{-factor}}$	C factor $_{SHGC}$	C factor $_{U\text{-factor}}$	C factor $_{SHGC}$
Walls	24.3	-	48.1	-
Roofs	40.9	-	71.0	-
North Windows	21.6	201.8	41.0	367.6
South Windows	19.1	342.5	41.0	546.3
East Windows	18.8	295.6	38.4	492.2
West Windows	19.2	295.4	38.3	486.1

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

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

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

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

Table 4-19 Envelope Performance Factor Coefficients – Temperate Climate

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

Table 4-20 Envelope Performance Factor Coefficients – Cold Climate

	Daytime Business, Educational, 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

4.3.5.1.1 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.

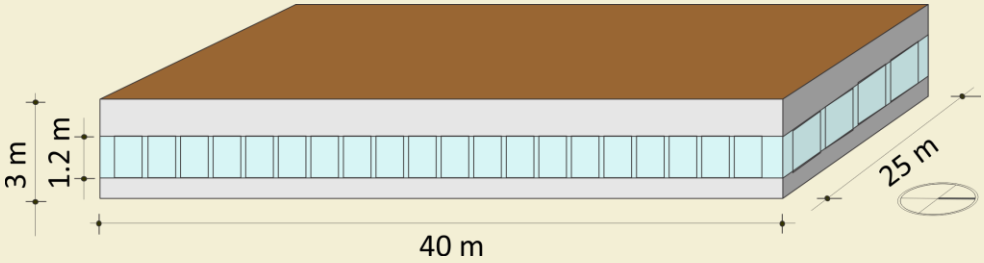
The U-factor of each envelope component shall be equal to the criteria from §4 for each class of construction.

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

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

Application of Building Envelope Trade-off method

A 1,000 m² single story daytime use office building in Ahmedabad is trying to achieve ECBC level compliance. Each side has a band of windows, without shading. The materials for the envelope have already been selected, prior to opting for ECBC compliance. Their thermal properties are: roof assembly U-value= .4 W/m².K, external wall assembly U-value = .25 W/m².K, glazing SHGC = .25, VLT = 0.27, area weighted U-value for glazing = 1.8 W/m².K. Dimensions of the building envelope are as follows:



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

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

	Prescriptive U-factor (W/m².K)			*Proposed U-factor (W/m².K)*			*Area (m²)*
Wall 1– North, South	=<0.63			0.25			90
Wall 2– East, West	=<0.63			0.25			144
Roof	=<0.33			0.4			1000
	U-factor	*SHGC*	*VLT*	*U-factor*	*SHGC*	*VLT*	
Window – South	=<3.0	=<0.27	=>0.27	1.8	0.25	0.27	30
Window – North	=<3.0	=<0.5	=>0.27	1.8	0.25	0.27	30
Window-East	=<3.0	=<0.27	=>0.27	1.8	0.25	0.27	48
Window-West	=<3.0	=<0.27	=>0.27	1.8	0.25	0.27	48

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

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

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

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

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

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

WWR = 156/390= 0.4.

U-value of the roof of the proposed building, at 0.4 W/m².K does not fulfil prescriptive requirements.

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

Compliance through Building Envelope Trade-off method

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

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

Where,

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

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

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

Standard Building EPF will be derived from U-factors, SHGCs and VLTs of walls, roofs and fenestration from Table 4-4, Table 4-7, Table 4-10 and § 4.3.3 for a daytime use building in the hot and dry climate

zone. Values of C are from daytime Office building in hot and dry climatic zone for each class of construction from Table 4-17. Since There is no shading for the windows, SEF_w will not be considered.

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

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

= 43.9 x 0.40 x 1,000 = 17,560

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

= (27.3 x 0.25 x 90) + (27.3 x 0.25 x 144) = 1,597.05

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

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

Hence,

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

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

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

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

Therefore,

EPF_{Fenest} = 19,379.37

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

Step 2: Calculating EPF $_{Standard\ Building}$ from prescriptive envelope requirements

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

= 43.9 x 0.33 x 1000 = 14,487

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

= (27.3 x 0.63 x 90) + (27.3 x 0.63 x 144) = 1,547.91 + 2,476.66 = 4,024.57

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

Now,

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

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

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

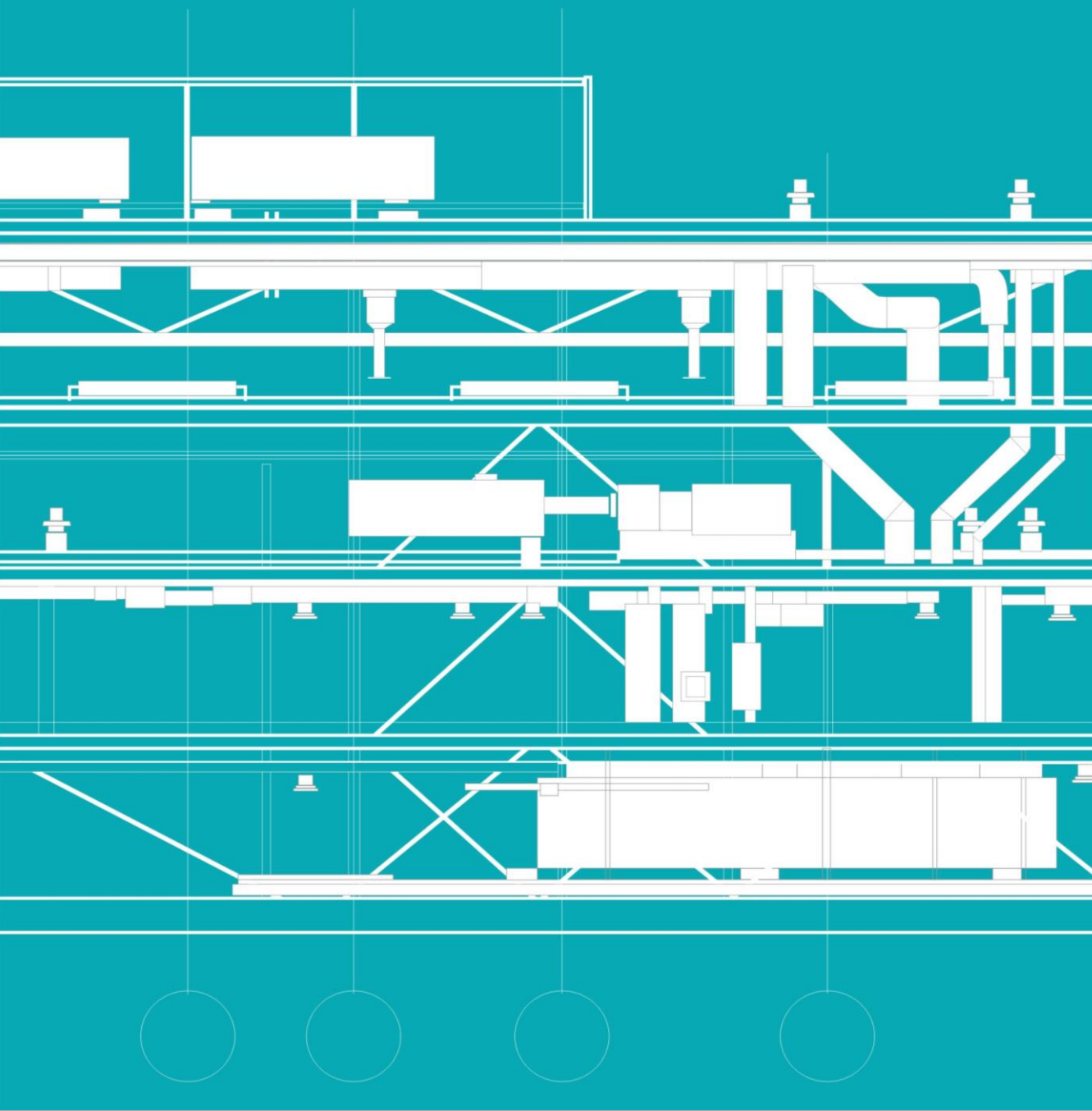
$EPF_{Fenest,}West$ = 21.7 x 3.0 x 48 + 354.1 x 0.27 x 48 = 3,124.8 + 4,589.14 = 7,713.94

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

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

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

5 Comfort Systems & Controls



5. Comfort Systems and Controls

5.1 General

All heating, ventilation, air conditioning equipment and systems, and their controls shall comply with the mandatory provisions of §5.2 and the prescriptive criteria of §5.3 for the respective building energy efficiency level. In case alternative compliance path of Total System Efficiency or Low Energy Systems is used for compliance, respective requirements of §5.3.13 or §5.3.14 and relevant criteria of §5.3 shall be met.

5.2 Mandatory Requirements

5.2.1 Ventilation

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

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.

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

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

5.2.1.2 Mechanical Ventilation Air Quantity Design Requirements

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

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

Have a ventilation system controlled by CO sensors for basement carpark 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
Automatic outdoor modulating control of the outdoor air damper

Exceptions to § 5.2.1.3:

(a) Classrooms in Schools, call centers category under Business
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
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 under BEE Standards and Labelling Program for chillers as and when updated by BEE.
(b) For ECBC compliance, minimum 1 star rated chillier shall be installed.
(c) 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.

5.2.2.2 Unitary, Split, Packaged Air-Conditioners

Unitary air-conditioners shall meet or exceed the efficiency requirements given in Table 5-1. 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 5-1 Minimum Requirements for Unitary, Split, Packaged Air Conditioners in ECBC Building

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 5-2 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 5-2 Minimum Efficiency Requirements for VRF Air conditioners for ECBC Building**

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

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

5.2.2.4 Air Conditioning and Condensing Units Serving Computer Rooms

Air conditioning and condensing units serving computer rooms shall meet or exceed the energy efficiency requirements listed in Table 5-3.

Table 5-3 Minimum Efficiency Requirements for Computer Room Air Conditioners

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

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

5.2.2.5 Boilers

Gas and oil-fired boilers shall meet or exceed the minimum efficiency requirements specified in Table 5-4.

Table 5-4 Minimum Efficiency Requirements for Oil and Gas Fired Boilers for ECBC building

Equipment Type	*Sub Category*	*Size Category*	*Minimum FUE*
Boilers, Hot Water	Gas or oil fired	All capacity	80%

FUE - fuel utilization efficiency

5.2.3 Controls

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

5.2.3.1 Timeclock

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

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

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

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

Exceptions to §5.2.3.1:

(a) Cooling systems less than 17.5 kWr

Heating systems less than 5.0 kWr

Unitary systems of all capacities

5.2.3.2 Temperature Controls

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

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

Where separate heating and cooling equipment serve the same temperature zone, temperature controls shall be interlocked to prevent simultaneous heating and cooling.

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

Each public toilet in a Star Hotel or Business with built up area more than 20,000 m^2
Each conference and meeting room in a Star Hotel or Business
Each room of size more than 30 m^2 in Educational buildings

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

5.2.4 Piping and Ductwork

5.2.4.1 Piping Insulation

Piping for heating, space conditioning, and service hot water systems shall meet the insulation requirements listed in

Table 5-5 through 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
(b) Table 5-5,
(c) Table 5-6 and 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.
(d) Insulation R value shall be increased by 0.2 over and above the requirement stated in Table 5-5 through Table 5-7 for any pipe located in a partition outside a building with direct exposure to weather.

Table 5-5 Insulation Requirements for Pipes in ECBC Building

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

Table 5-6 Insulation Requirements for Pipes in ECBC+ Building

Operating Temperature (ºC)	Pipe size (mm)	
	< 40	>=40
	Insulation R value (m^2.K/W)	
Heating System		
>94°C and <=121°C	1.1	1.3
>60°C and <=94°C	0.8	0.8
>40°C and <=60°C	0.5	0.9
Cooling System		
>4.5°C and <=15°C	0.5	0.9
< 4.5°C	1.1	1.3
Refrigerant Piping (Split systems)		
>4.5°C and <=15°C	0.5	0.9
< 4.5°C	1.1	1.3

Table 5-7 Insulation Requirements for Pipes in SuperECBC Buildings

Operating Temperature (ºC)	Pipe size (mm)	
	< 40	>=40
	Insulation R value (m^2.K/W)	
Heating System		
>94°C and <=121°C	1.5	1.5
>60°C and <=94°C	1.0	1.3
>40°C and <=60°C	0.7	1.1
Cooling System		
>4.5°C and <=15°C	0.7	1.2
< 4.5°C	1.5	1.5
Refrigerant Piping (Split systems)		
>4.5°C and <=15°C	0.4	0.7
< 4.5°C	1.5	1.5

5.2.4.2 Ductwork and Plenum Insulation

Ductwork and plenum shall be insulated in accordance with

Table 5-8.

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

5.2.7 Service Water Heating

5.2.7.1 Solar Water Heating

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

(a) at least 20% of the total hot water design capacity if above grade floor area of the building is less than 20,000 m^2

at least 40% of the total hot water design capacity if above grade floor area of the building is greater than or equal to 20,000 m^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 meet the performance/ minimum efficiency level mentioned in IS 2082.

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

5.2.7.3 Other Water Heating System

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

(a) Maximum heat recovery from hot discharge system like condensers of air conditioning units,

Use of gas fired heaters wherever gas is available, and

Electric heater as last resort.

5.2.7.4 Piping Insulation

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

5.2.7.5 Heat Traps

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

5.2.7.6 Swimming Pools

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

5.3 Prescriptive Requirements

Compliance shall be demonstrated with the prescriptive requirements in this section. Supply, exhaust, and return or relief fans with motor power exceeding 0.37 kW shall meet or exceed the minimum energy efficiency requirements specified in Table 5-9 through Table 5-11 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.

Fans in Health Care buildings having HEPA filters.

Fans inbuilt in energy recovery systems that pre-conditions the outdoor air.

Table 5-9 Mechanical and Motor Efficiency Requirements for Fans in ECBC Buildings

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

Table 5-10 Mechanical and Motor Efficiency Requirements for Fans in ECBC+ Buildings

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

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

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

5.3.1 Chillers

Chillers shall meet or exceed the minimum efficiency requirements as per Standards and Labelling Program of BEE for ECBC+ and Super ECBC buildings. Minimum 3 Star rated chillers is required for ECBC+ compliance and 5 star rated chiller to meet SuperECBC compliance.

5.3.2 Pumps

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

Table **5-12** through Table 5-14. Requirements for pumps in district chiller systems and hot water pumps for space heating are limited to the installed efficiency requirement of individual pump equipment only. To show compliance, calculate the total installed pump capacity in kilo watt and achieve the prescribed limits per kilo watt of refrigeration installed in the building.

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

Table 5-12 Pump Efficiency Requirements for ECBC Building

Equipment	*ECBC*
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%

Table 5-13 Pump Efficiency Requirements for ECBC+ Building

Equipment	*ECBC+ Building*
Chilled Water Pump (Primary and Secondary)	16.9 W/ kW_r with VFD on secondary pump
Condenser Water Pump	16.5 W/ kW_r
Pump Efficiency (minimum)	75%

Table 5-14 Pump Efficiency Requirements for SuperECBC Building

Equipment	*SuperECBC Building*
Chilled Water Pump (Primary and Secondary)	14.9 W/ kW_r with VFD on secondary pump
Condenser Water Pump	14.6 W/ kW_r
Pump Efficiency (minimum)	85%

5.3.3

5.3.4 Cooling Towers

Cooling towers shall meet or exceed the minimum efficiency requirements specified in Table 5-15. ECBC+ and SuperECBC Buildings shall have additional VFD installed in the cooling towers.

Table 5-15 Cooling Tower Efficiency Requirements for ECBC, ECBC+, and SuperECBC Buildings

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

5.3.5 Boilers

Gas and oil-fired boilers shall meet or exceed the minimum efficiency requirements specified in Table 5-16.

Table 5-16 Minimum Efficiency Requirements for Oil and Gas Fired Boilers for ECBC+ and SuperECBC building

Equipment Type	*Sub Category*	*Size Category*	*Minimum FUE*
Boilers, Hot Water	Gas or oil fired	All capacity	85%

FUE - fuel utilization efficiency

5.3.6 Economizers

5.3.6.1 Economizer for ECBC, ECBC+, and SuperECBC Building

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

(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.

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 §5.3.6.1:

(a) Projects in warm-humid climate zones.

Projects with only daytime occupancy in the hot-dry.

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

5.3.6.2 Partial Cooling

Where required by §5.3.6.1 economizers shall be capable of providing partial cooling even when additional mechanical cooling is required to meet the cooling load.

5.3.6.3 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.

capable of automatically reducing outdoor air intake to the design minimum outdoor air quantity when outdoor air intake will no longer reduce cooling energy usage.
Capable of high-limit shutoff at 24 °C dry bulb temperature.

5.3.6.4 Testing

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

Exception to §5.3.6.4: Air economizers installed by the HVAC system equipment manufacturer and certified to the building department as being factory calibrated and tested per the procedures in §12.

5.3.7 Variable Flow Hydronic Systems

5.3.7.1 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
the minimum flow required by the equipment manufacturer for proper operation of the chillers or boilers.

5.3.7.2 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.

5.3.7.3 Variable Speed Drives

Chilled water or condenser water systems that must comply with either §5.3.7.1 or §5.3.7.2 and that have pump motors greater than or equal to 3.7 kW shall be controlled by variable speed drives.

5.3.8 Unitary, Split, Packaged Air-Conditioners

Unitary air-conditioners shall meet or exceed the efficiency requirements given in Table 5-17 and Table 5-18. Window and split air conditioners shall be certified under BEE's Star Labelling Program. EER shall be as per IS 8148 for all unitary, split, packaged air conditioners greater than 10 kWr.

Table 5-17 Minimum Requirements for Unitary, Split, Packaged Air Conditioners in ECBC+ Building

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

Table 5-18 Minimum Requirements for Unitary, Split, Packaged Air Conditioners in SuperECBC Building

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

5.3.9 Controls for ECBC+ and SuperECBC Buildings

ECBC+ building shall comply with requirements of § 5.3.9 in addition to complying with requirements of §5.2.3.

5.3.9.1 Centralized Demand Shed Controls

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

(a) Automatic demand shed controls that can implement a centralized demand shed in non-critical zones during the demand response period on a demand response signal.

Controls that can remotely decrease or increase the operating temperature set points by four degrees or more in all noncritical zones on signal from a centralized control point
Controls that can provide an adjustable rate of change for the temperature setup and reset

The centralized demand shed controls shall have additional capabilities to

(a) Be disabled by facility operators

Be manually controlled from a central point by facility operators to manage heating and cooling set points

5.3.9.2 Supply Air Temperature Reset

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

Exception to § 5.3.9.2 : ECBC+ and SuperECBC Buildings in warm humid climate zone.

5.3.9.3 Chilled Water Temperature Reset

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

Exceptions to §5.3.9.3: Controls to automatically reset chilled water temperature shall not be required where the supply temperature reset controls causes improper operation of equipment.

5.3.10 Controls for SuperECBC Buildings

SuperECBC Buildings shall comply with requirements of § 5.3.10 in addition to complying with requirements of § 5.2.3 and § 5.3.9.

5.3.10.1 Variable Air Volume Fan Control

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

5.3.11 Energy Recovery

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

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

5.3.12 Service Water Heating

For compliance with ECBC+ and SuperECBC,

(a) Hospitality and Healthcare in all climatic zones shall have solar water heating equipment installed to provide at least 40% of the total hot water design capacity.

All buildings in cold climate zone with a hot water system, shall have solar water heating equipment installed to provide at least 60% of the total hot water design capacity.

Exception to §5.3.12: Systems that use heat recovery to provide the hot water capacity required as per the building type, size and efficiency level.

5.3.13 Total System Efficiency – Alternate Compliance Approach

Buildings may show compliance by optimizing the total system efficiency for the plant side comfort system instead of the individual equipment mentioned under the prescriptive requirement. This alternate compliance approach is applicable for central chilled water plant side system in all building types. The total installed capacity per kilo-watt refrigeration load shall be less than or equal to maximum threshold requirements as specified in Table 5-19. Equipment that can be included in central chilled water plant side system for this alternate approach are chillers, chilled water pumps, condenser water pumps, and cooling tower fan. Compliance check will be based on annual hourly simulation refer

Table 9-1 for developing the proposed design.

Table 5-19 Maximum System Efficiency Threshold for ECBC, ECBC+, and SuperECBC Buildings

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

5.3.13.1 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.

Brief description of the project with location, number of stories, space types, conditioned and unconditioned areas, hours of operation.

List of the energy-related building features of the Proposed Design.

List showing compliance with the mandatory requirements of this code.

The input and output report(s) from the simulation program including an energy and chilled water usage components: space cooling and heat rejection equipment, and other HVAC equipment (such as pumps). The output reports shall also show the number of hours any loads are not met by the HVAC system the Proposed Design.

Explanation of any significant modelling assumptions made.

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

The total system efficiency shall be calculated as follows:

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

5.3.14 Low-energy Comfort Systems

Alternative HVAC systems which have low energy use may be installed in place of (or in conjunction with) refrigerant-based cooling systems. Such systems shall be deemed to meet the minimum space conditioning equipment efficiency levels of §5.2.2, but shall comply with all other applicable mandatory provisions of §5.2 as applicable. Wherever applicable, requirements of §5.3 and §5.3.13 will be complied with. The approved list of low energy comfort systems[1] is given below:

(a) Evaporative cooling
Desiccant cooling system
Solar air conditioning
Tri-generation (waste-to-heat)
Radiant cooling system
Ground source heat pump
Adiabatic cooling system

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

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

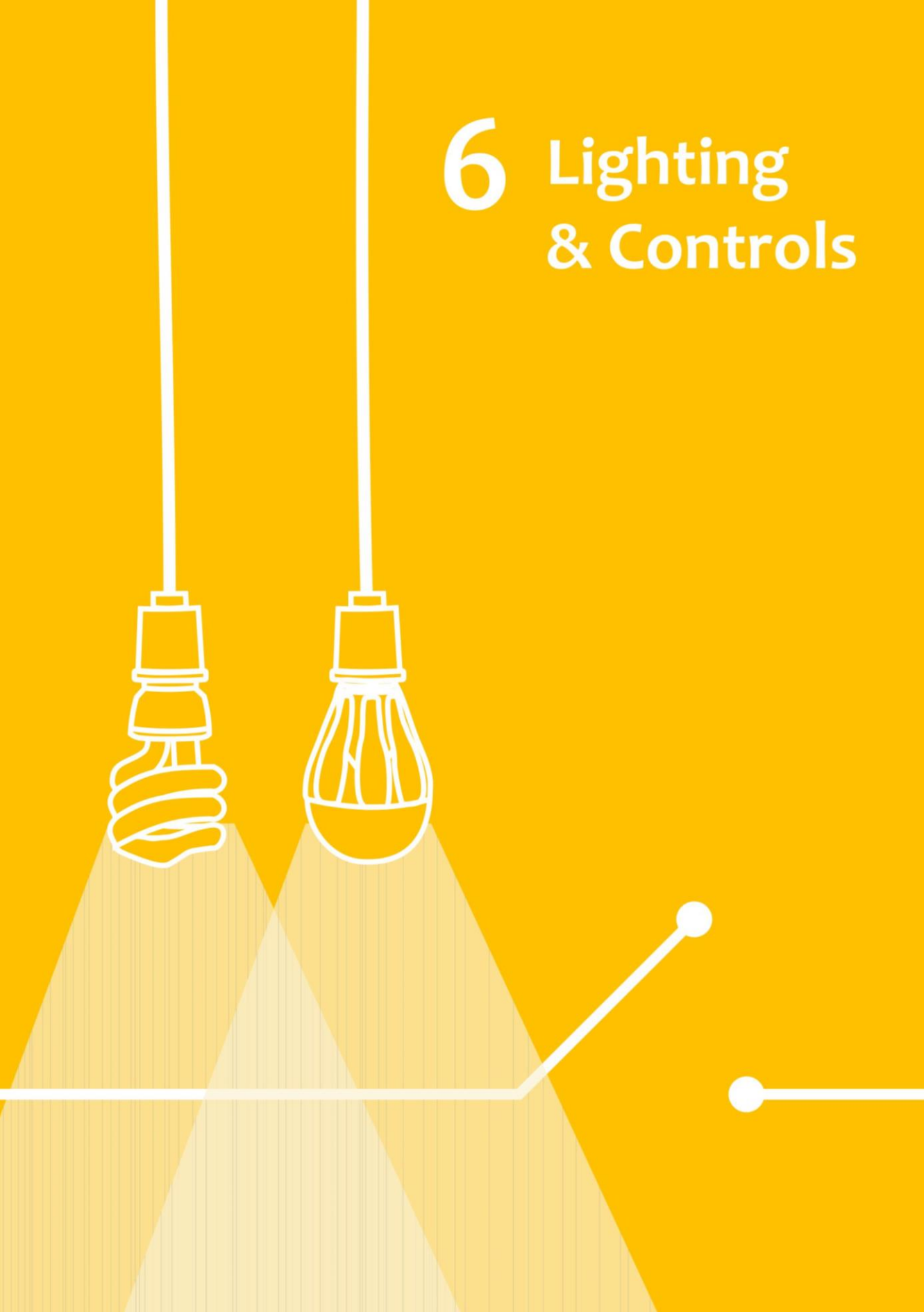
[1] This is not an all-inclusive list. The updated list of low energy comfort systems is available at BEE website (https://www.beeindia.gov.in/).

5.3.14.1 Documentation Requirement

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

(a) Summary describing the low-energy comfort system type, capacity, and efficiency.
(b) List of showing compliance with the mandatory and prescriptive requirements other than exempted in §5.3.14.
(c) Comparison of installed capacity of approved low-energy comfort system with other HVAC system to meet the comfort requirement of the building.

6 Lighting & Controls



6. Lighting and Controls

6.1 General

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

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

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

6.2 Mandatory Requirements

6.2.1 Lighting Control

6.2.1.1 Automatic Lighting Shutoff

(a) 90% of interior lighting fittings by wattage, in building or space of building larger than 300 m^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 lights when the space is occupied.

Additionally, occupancy sensors shall be provided in

iii. 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.

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

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

6.2.1.2 Space Control

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

(a) control a maximum of 250 m^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.

have the capability to override the shutoff control required in § 6.2.1.1 for no more than 2 hours, and
be readily accessible and located so the occupants can see the control.

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

6.2.1.3 Control in Daylight Areas

(a) Luminaires, installed within day lighting extent from the window as calculated in § 4.2.3, shall be equipped with either a manual control device to shut off luminaires, installed within day lit area, during potential daylit time of a day or automatic control device that:

i. Has a delay of minimum 5 minutes, and,
ii. Can dim or step down to 50% of total power.

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.

Lighting for all exterior applications, shall have lamp efficacy not less than 80 lumens per watt for ECBC, unless the luminaire is controlled by a motion sensor or exempt under §6.1.
Façade lighting and façade non-emergency signage of Shopping Complexes shall have separate time switches.

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

6.2.1.5 Additional Control

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

(a) Display/ Accent Lighting. Display or accent lighting greater than 300 m^2 area shall have a separate control device.

Hotel Guest Room Lighting. Guest rooms and guest suites in a hotel shall have a master control device at the main room entry that controls all permanently installed luminaires and switched receptacles.

Task Lighting. Supplemental task lighting including permanently installed under shelf or under cabinet lighting shall have a control device integral to the luminaires or be controlled by a wall-mounted control device provided the control device complies with §6.2.1.2.

Nonvisual Lighting. Lighting for nonvisual applications, such as plant growth and food-warming, shall be equipped with a separate control device.

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,

Lighting that is integral to equipment or instrumentation and is installed by its manufacturer,

Lighting specifically designed for medical or dental procedures and lighting integral to medical equipment,

Lighting integral to food warming and food preparation equipment,

Lighting for plant growth or maintenance,
Lighting in spaces specifically designed for use by the visually impaired,
Lighting in retail display windows, provided the display area is enclosed by ceiling-height partitions,
Lighting in interior spaces that have been specifically designated as a registered interior historic landmark,
Lighting that is an integral part of advertising or directional signage,
Exit signs,
Lighting that is for sale or lighting educational demonstration systems,
Lighting for theatrical purposes, including performance, stage, and film or video production, and
Athletic playing areas with permanent facilities for television broadcasting.

6.3.2 Building Area Method

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

(a) Determine the allowed lighting power density for each appropriate building area type from
(b)
(c) Table 6-1 for ECBC Buildings, from Table 6-2 for ECBC+ Buildings and from Table 6-3 for SuperECBC Buildings.
(d) Calculate the gross lighted area for each building area type.

The interior lighting power allowance is the sum of the products of the gross lighted floor area of each building area times the allowed lighting power density for that building area type.

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

Building Type	*LPD (W/m^2)*	*Building Area Type*	*LPD (W/m^2)*
Office Building	9.5	Motion picture theater	9.43
Hospitals	9.7	Museum	10.2
Hotels	9.5	Post office	10.5
Shopping Mall	14.1	Religious building	12.0
University and Schools	11.2	Sports arena	9.7
Library	12.2	Transportation	9.2
Dining: bar lounge/leisure	12.2	Warehouse	7.08
Dining: cafeteria/fast food	11.5	Performing arts theater	16.3
Dining: family	10.9	Police station	9.9
Dormitory	9.1	Workshop	14.1
Fire station	9.7	Automotive facility	9.0

Gymnasium	10.0	Convention center	12.5
Manufacturing facility	12.0	Parking garage	3.0
In cases where both a general building area type and a specific building area type are listed, the specific building area type shall apply.			

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

Building Area Type	*LPD (W/m²)*	*Building Area Type*	*LPD (W/m²)*
Office Building	7.6	Motion picture theater	7.5
Hospitals	7.8	Museum	8.2
Hotels	7.6	Post office	8.4
Shopping Mall	11.3	Religious building	9.6
University and Schools	9.0	Sports arena	7.8
Library	9.8	Transportation	7.4
Dining: bar lounge/leisure	9.8	Warehouse	5.7
Dining: cafeteria/fast food	9.2	Performing arts theater	13.0
Dining: family	8.7	Police station	7.9
Dormitory	7.3	Workshop	11.3
Fire station	7.8	Automotive facility	7.2
Gymnasium	8.0	Convention center	10.0
Manufacturing facility	9.6	Parking garage	2.4
In cases where both a general building area type and a specific building area type are listed, the specific building area type shall apply.			

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

Building Area Type	*LPD (W/m²)*	*Building Area Type*	*LPD (W/m²)*
Office Building	5.0	Motion picture theater	4.7
Hospitals	4.9	Museum	5.1
Hotels	4.8	Post office	5.3
Shopping Mall	7.0	Religious building	6.0
University and Schools	6.0	Sports arena	4.9
Library	6.1	Transportation	4.6
Dining: bar lounge/leisure	6.1	Warehouse	3.5
Dining: cafeteria/fast food	5.8	Performing arts theater	8.2
Dining: family	5.5	Police station	5.0
Dormitory	4.6	Workshop	7.1

Fire station	4.9	Automotive facility	4.5
Gymnasium	5.0	Convention center	6.3
Manufacturing facility	6.0	Parking garage	1.5
In cases where both a general building area type and a specific building area type are listed, the specific building area type shall apply.			

6.3.3 Space Function Method

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

(a) Determine the appropriate building type and the allowed lighting power density from Table 6-4 for ECBC Buildings, Table 6-5 for ECBC+ Buildings and, Table 6-6 for SuperECBC Buildings. In cases where both a common space type and building specific space type are listed, building specific space type LPD shall apply.

For each space, enclosed by partitions 80% or greater than ceiling height, determine the gross lighted floor area by measuring to the center of the partition wall. Include the area of balconies or other projections. Retail spaces do not have to comply with the 80% partition height requirements.

The interior lighting power allowance is the sum of the lighting power allowances for all spaces. The lighting power allowance for a space is the product of the gross lighted floor area of the space times the allowed lighting power density for that space.

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

Category	*LPD (W/m²)*	*Lamp category*	*LPD (W/m²)*
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
Laboratory	15.1	Reading Area (Library)	10.0

Category	*LPD (W/m²)*	*Lamp category*	*LPD (W/m²)*
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		

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

Category	*LPD (W/m²)*	*Lamp category*	*LPD (W/m²)*
Common Space Types			
Restroom	6.1	Stairway	4.4
Storage	5.4	Corridor/Transition	3.6
Conference/ Meeting	9.2	Lobby	7.3

Parking Bay (covered/ basement)	1.8	Parking Driveways (covered/ basement)	2.5
Electrical/Mechanical	5.7	Workshop	13.7
Business			
Enclosed	8.6	Open Plan	8.6
Banking Activity Area	9.3	Service/Repair	5.5
Healthcare			
Emergency	18.2	Recovery	7.0
Exam/Treatment	10.9	Storage	4.4
Nurses' Station	7.5	Laundry/Washing	6.0
Operating Room	17.5	Lounge/Recreation	6.4
Patient Room	6.1	Medical Supply	10.9
Pharmacy	8.5	Nursery	4.6
Physical Therapy	7.8	Corridor/Transition	7.3
Radiology/Imaging	7.3		
Hospitality			
Hotel Dining	7.3	Hotel Lobby	8.8
For Bar Lounge/ Dining	11.3	Motel Dining	7.3

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

Museum - Restoration	11.0

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

Category	*LPD (W/m²)*	*Lamp category*	*LPD (W/m²)*
Common Space Types			
Restrooms	3.8	Stairway	2.7
Storage	3.4	Corridor/Transition	2.3
Conference/ Meeting	5.7	Lobby	4.6
Parking Bays (covered/ basement)	1.1	Driveways (covered/ basement)	1.5
Electrical/Mechanical	3.5	Workshop	8.6
Business			
Enclosed	5.4	Open Plan	5.4
Banking Activity Area	5.8	Service/Repair	3.4
Healthcare			
Emergency	11.4	Recovery	4.4
Exam/Treatment	6.8	Storage	2.7
Nurses' Station	5.0	Laundry/Washing	3.8
Category	*LPD (W/m²)*	*Lamp category*	*LPD (W/m²)*
Operating Room	10.9	Lounge/Recreation	4.6
Patient Room	3.8	Medical Supply	6.8
Pharmacy	5.3	Nursery	2.9
Physical Therapy	4.9	Corridor/Transition	4.6
Radiology/Imaging	4.6		
Hospitality			
Hotel Dining	4.6	Hotel Lobby	5.5
For Bar Lounge/ Dining	7.0	Motel Dining	4.6
For food preparation	7.5	Motel Guest Rooms	3.8
Hotel Guest Rooms	4.6		
Shopping Complex			
Mall Concourse	6.4	For Family Dining	5.5
Sales Area	9.2	For food preparation	7.5
Motion Picture Theatre	6.5	Bar Lounge/ Dining	7.0
Educational			
Classroom/Lecture	6.8	Card File and Cataloguing	4.6
For Classrooms	6.9	Stacks (Library)	9.2
Laboratory	7.5	Reading Area (Library)	5.7

Assembly			
Dressing Room	4.6	Seating Area - Performing Arts Theatre	11.3
Exhibit Space – Convention Centre	7.0	Lobby - Performing Arts Theatre	10.8
Seating Area - Gymnasium	3.4	Seating Area – Convention Centre	3.2
Fitness Area - Gymnasium	3.9	Seating Religious Building	8.2
Museum – General Exhibition	5.7	Playing Area - Gymnasium	6.5
Museum – Restoration	5.5		

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

A four-story building has retail on the ground floor and offices on the top three floors. Area is 3,598 m². Space types and their respective areas are mentioned below. Steps for calculating interior lighting power allowance using the space function method for a ECBC building is described below.

For each of the space type, corresponding Lighting Power Density (LPD) values for Business and Shopping complex building type from Table 6-4 are used. Area is multiplied with the LPD values to estimate the lighting power allowance for the whole building. It is 40,242 W.

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

Space Function	LPD (W/ m²)	Area (m²)	Lighting Power Allowance (W)
Office			
Office - enclosed	10.0	720	7,200
Office – open plan	10.0	1,485	14,850
Meeting Rooms	11.5	120	1,380
Lobbies	9.1	93	846
Restrooms	7.7	51	393
Corridors	7.1	125	888
Electrical/ Mechanical	7.1	14	99
Staircase	5.5	84	462
Total			26,118
Retail			
General sales area	18.3	669	12,243
Offices - enclosed	10.0	28	280
Restrooms	7.7	9	69
Corridors	7.1	79	561
Storage	6.8	93	632
Food preparation	12.1	28	339
Total			14,124
Building Total			40,242 W

6.3.4 Installed Interior Lighting Power

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

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

6.3.4.1 Luminaire Wattage

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

(a) The wattage of incandescent luminaires with medium base sockets and not containing permanently installed ballasts shall be the maximum labeled wattage of the luminaires.

The wattage of luminaires containing permanently installed ballasts shall be the operating input wattage of the specified lamp/ballast combination. Operating input wattage can be either values from manufacturers' catalogs or values from independent testing laboratory reports.

The wattage of all other miscellaneous luminaire types not described in (a) or (b) shall be the specified wattage of the luminaires.

The wattage of lighting track, plug-in busway, and flexible-lighting systems that allow the addition and/ or relocation of luminaires without altering the wiring of the system shall be the larger of the specified wattage of the luminaires included in the system or 135 Watt per meter. Systems with integral overload protection, such as fuses or circuit breakers, shall be rated at 100% of the maximum rated load of the limiting device.

6.3.5 Exterior Lighting Power

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

Table 6-7 Exterior Building Lighting Power for ECBC Buildings

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/lin m of door width
Building façade	5.0 W/m² of vertical façade area
Emergency signs, ATM kiosks, Security areas façade	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

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

Exterior lighting application	*Power limits*
Building entrance (with canopy)	8.0 W/m² of canopied area
Building entrance (w/o canopy)	72 W/ linear m of door width
Building exit	48 W/lin m of door width
Building façade	4.0 W/m² of vertical façade area
Emergency signs, ATM kiosks, Security areas façade	0.8 W/m²
Driveways and parking (open/ external)	1.3 W/m²
Pedestrian walkways	1.6 W/m²
Stairways	8.0 W/m²
Landscaping	0.4 W/m²
Outdoor sales area	7.2 W/m²

Table 6-9 Exterior Building Lighting Power for SuperECBC Buildings

Exterior lighting application	*Power limits*
Building entrance (with canopy)	5.0 W/m² of canopied area
Building entrance (w/o canopy)	45 W/ linear m of door width
Building exit	30 W/lin m of door width
Building façade	2.5 W/m² of vertical façade area
Emergency signs, ATM kiosks, Security areas façade	0.5 W/m²
Driveways and parking (open/ external)	0.8 W/m²
Pedestrian walkways	1.0 W/m²
Stairways	5.0 W/m²
Landscaping	0.25 W/m²
Outdoor sales area	4.5 W/m²

6.3.6 Controls for ECBC+ and SuperECBC Buildings

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

6.3.6.1 Centralized Controls

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

6.3.6.2 Exterior Lighting Controls

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

7 Electrical & Renewable Energy Systems

7. Electrical and Renewable Energy Systems

7.1 General

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

7.2 Mandatory Requirements

7.2.1 Transformers

7.2.1.1 Maximum Allowable Power Transformer Losses

Power transformers of the proper ratings and design must be selected to satisfy the minimum acceptable efficiency at 50% and full load rating. The permissible loss shall not exceed to values listed in **Error! Not a valid bookmark self-reference.** for dry type transformers. BEE star rating for dry type transformer shall take precedence over this table once notified by BEE under BEE Standards and Labelling Program.

For oil type transformer BEE star rated transformer (BEE Standards and Labelling Program) shall be used in all compliant buildings. Power transformers to meet compliance shall have:

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

Table 7-1 Permissible Losses for Dry Type Transformers

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

-*The 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 12.7 of IS 11171 i.e. average winding temperature rise as given in Column 4 of Table 4 of IS 11171 plus 30^{0}C. i.e. for F thermal class the total loss values shall be calculated at 120^{0}C and for H thermal class the total loss values shall be calculated at 145^{0}C. An increase of 7% on total loss value for thermal class H is allowed."~~The total loss value 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 12.7 of IS 11171 i.e; average winding temperature rise as given in Column 4 of Table 4 of IS 11171 plus 30^{0}C~~

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

7.2.1.2 Measurement and Reporting of Transformer Losses

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

7.2.1.3 Voltage Drop

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

7.2.2 Energy Efficient Motors

Motors shall comply with the following:

(a) Three phase induction motors shall conform to Indian Standard (IS) 12615 and shall fulfil the following efficiency requirements:

i. ECBC Buildings shall have motors of IE 2 (high efficiency) class or a higher class
ii. ECBC+ Buildings shall have IE 3 (premium efficiency) class motors or higher class
iii. SuperECBC Buildings shall have IE 4 (super premium efficiency) class motors

Motors of horsepower differing from those listed in the table shall have efficiency greater than that of the next listed kW motor.
Motor horsepower ratings shall not exceed 20% of the calculated maximum load being served.
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 (BEE Standards and Labelling Program) shall be used in all compliant buildings. DG sets in buildings greater than 20,000 m^2 BUA shall have:

(a) minimum 3 stars rating in ECBC Buildings
minimum 4 stars rating in ECBC+ Buildings
5 stars rating in SuperECBC Buildings
Provided the building does not use DG sets for captive power generation (no more than 15% of power requirement is being met by the use of DG sets), 3 star rated DG sets may be used for ECBC + and Super ECBC Buildings.

7.2.4 Check-Metering and Monitoring

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

(a) Services exceeding 1,000 kVA shall have permanently installed electrical metering to record demand (kVA), energy (kWh), and total power factor on hourly basis. The metering shall also display current (in each phase and the neutral), voltage (between phases and between each phase and neutral), and total harmonic distortion (THD) as a percentage of total current.

Services not exceeding 1,000 kVA but over 65 kVA shall have permanently installed electric metering to record demand (kW), energy (kWh), and total power factor (or kVARh) on hourly basis.
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 7-2.

Table 7-2 Sub Metering: Minimum requirement for separation of electrical load

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

In addition to requirements stated above, for building types identified in Table 7-3, respective services must be sub-metered.

Table 7-3 Additional sub-metering requirements for specific building types

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

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

7.2.5 Power Factor Correction

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

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

7.2.6 Power Distribution Systems

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

(a) 3% of the total power usage in ECBC Buildings
2% of the total power usage in ECBC+ Buildings
1% of total power usage in SuperECBC Buildings

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

7.2.7 Uninterruptible Power Supply (UPS)

In all buildings, UPS shall meet or exceed the energy efficiency requirements listed in Table 7-4. Any Standards and Labeling program by BEE shall take precedence over requirements listed in this section.

Table 7-4 Energy Efficiency Requirements for UPS for ECBC, ECBC+, SuperECBC building

UPS Size	*Energy Efficiency Requirements at 100% Load*
kVA< 20	90.2%
20<=kVA <= 100	91.9%
kVA > 100	93.8%

7.2.8 Renewable Energy Systems

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

7.2.8.1 Renewable Energy Generating Zone (REGZ)

(a) A dedicated REGZ equivalent to at least 25 % of roof area or area required for generation of energy equivalent to 1% of total peak demand or connected load of the building, whichever is less, shall be provided in all buildings.

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

ECBC+ and SuperECBC building shall fulfil the additional requirements listed in Table 7-5 and Table 7-6 respectively.

Table 7-5 Minimum Renewable Contribution towards meeting Contract Demand in ECBC+ Building

Building Type	*Minimum Capacity to be Installed in REGZ*
All building types except below	Minimum 2% of total Contract Demand
Star Hotel > 20,000 m² AGA Resort > 12,500 m^2 AGA University > 20,000 m² AGA Business >20,000 m² AGA	Minimum 3% of total Contract Demand

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

Building Type	*Minimum Capacity to be Installed in REGZ*
All Building types except below	Minimum 4% of total Contract Demand
Star Hotel > 20,000 m² AGA Resort > 12,500 m^2 AGA University > 20,000 m² AGA Business >20,000 m² AGA	Minimum 6% of total Contract Demand

7.2.8.2 Main Electrical Service Panel

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

7.2.8.3 Demarcation on Documents

The following shall be indicated in design and construction documents:

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

8 Definitions, Abbreviations & Acronyms

8. Definitions, Abbreviations, and Acronyms

8.1 General

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

8.2 Definitions

A

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

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

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

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

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

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

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

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

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

B

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

C

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

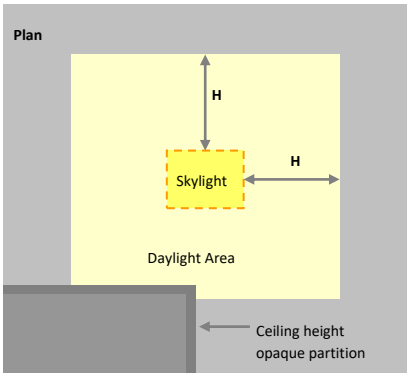
Cumulative design EPI: energy performance index for a building having two or more different functional uses and calculated based on the area weighted average (AWA) method

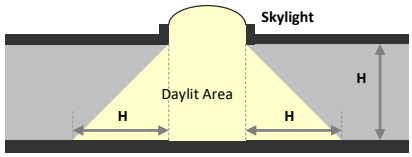
D

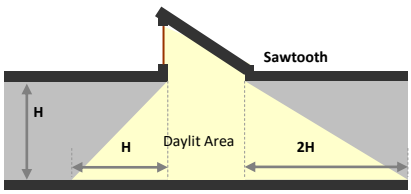
Daylight area: the daylight illuminated floor area under horizontal fenestration (skylight) or adjacent to vertical fenestration (window), described as follows:

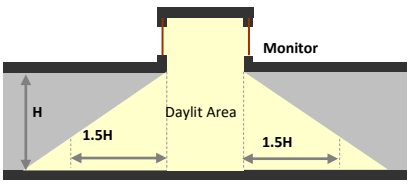
(a) Horizontal Fenestration: the area under a skylight, monitor, or sawtooth configuration with an effective aperture greater than 0.001 (0.1%). The daylight area is calculated as the horizontal dimension in each direction equal to the top

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

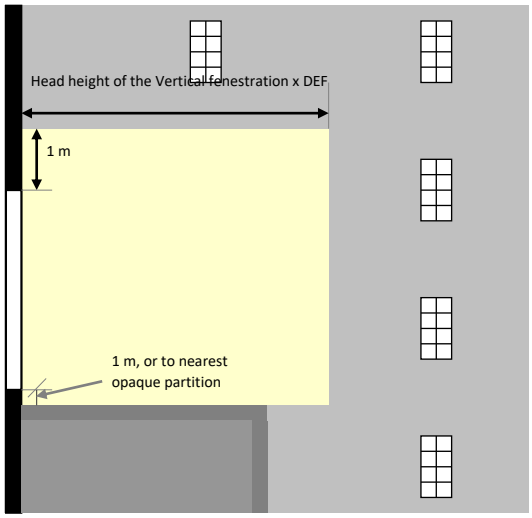








(b) Vertical Fenestration: the floor area adjacent to side apertures (vertical fenestration in walls) with an effective aperture greater than 0.06 (6%). The daylight area extends into the space perpendicular to the side aperture a distance equal to daylight extension factor (DEF) multiplied by the head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



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

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

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

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

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

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

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

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

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

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

E

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

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

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

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

Effective aperture: Visible light transmittance x window-to-wall Ratio. (EA = VLT 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 watt to total rate of electric input in watts under design operating conditions

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

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

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

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

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

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

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

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

Equipment, existing: equipment previously installed in an existing building

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

Exemption: any exception allowed to compliance with ECBC requirements

F

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

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 chillers 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 vapour 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.

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

M

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

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

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

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

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

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

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

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

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

N

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

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

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

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

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

O

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

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

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

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

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

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

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

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

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

P

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

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

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

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

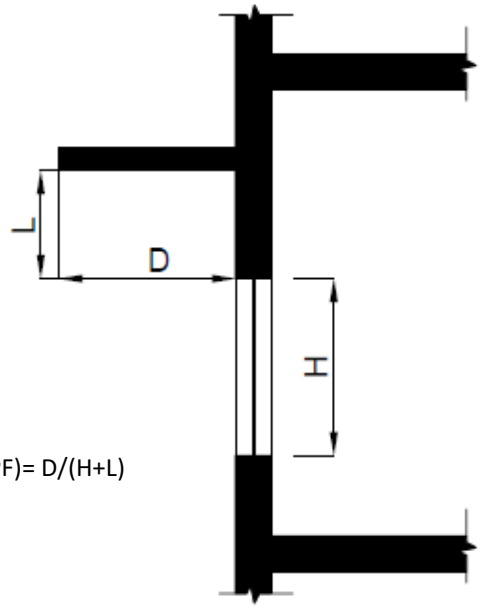
Pool: any structure, basin, or tank containing an artificial body of water for swimming, diving, or recreational bathing. The terms include, but no limited to, swimming pool, whirlpool, spa, hot tub.

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

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

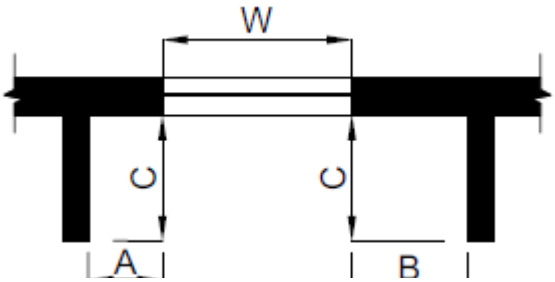
Process load: building loads resulting from the consumption or release of energy due to industrial processes or processes other than those for providing space conditioning, lighting, ventilation, or service hot water heating.

Projection factor, overhang: It is the ratio of the horizontal depth of the external shading projection to the sum of the height of the fenestration and the distance from the top of the fenestration to the bottom of the farthest point of the external shading projection, in consistent units.



Projection factor (PF)= D/(H+L)

Projection factor, side fin: It is the ratio of the horizontal depth of the external shading projection to the distance from the window jamb to the farthest point of the external shading projection, in consistent units.



Projection factor Left Fin(PF_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 –

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

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

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

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

S

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

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

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

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

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

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

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

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

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

Slab-on-grade floor: floor slab of the building that is in contact with ground and that is either above grade or is less than or equal to 300 mm below the final elevation of the nearest exterior grade. **Solar energy source:** source of thermal, chemical, or electrical energy derived from direction conversion of incident solar radiation at the building site.

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

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

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

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

(b) Semi-heated space: an enclosed space within a building that is heated by a heating system whose output capacity is greater or equal to 10.7 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).

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

Super Market (Shopping Complex): supermarkets are large self-service grocery stores that offer customers a variety of foods and household supplies. The merchandise is organized into an organized aisle format, where each aisle has only similar goods placed together.

System: a combination of equipment and auxiliary devices (e.g., controls, accessories, interconnecting means, and terminal elements) by which energy is transformed so it performs a specific function such as HVAC, service water heating, or lighting.

System Efficiency: the system efficiency is the ratio of annual kWh electricity consumption of equipment of water cooled chilled water plant (i.e. chillers, chilled and condenser water pumps, cooling tower) to chiller thermal kWh used in a building.

System, existing: a system or systems previously installed in an existing building.

T

Tenant lease agreement: The formal legal document entered into between a Landlord and a Tenant to reflect the terms of the negotiations between them; that is, the lease terms have been negotiated and agreed upon, and the agreement has been reduced to writing. It constitutes the entire agreement between the parties and sets forth their basic legal rights.

Tenant leased area: area of a building that is leased to tenant(s) as per the tenant lease agreement.

Terminal device: a device through which heated or cooled air is supplied to a space to maintain its temperature. It usually contains dampers and heating and cooling coils. Or a device by which energy 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

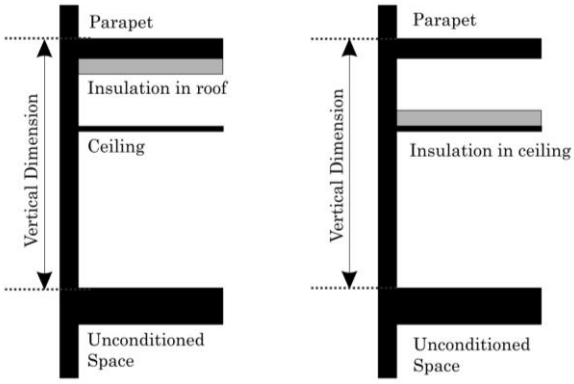
Wall: that portion of the building envelope, including opaque area and fenestration, that is vertical or tilted at an angle of 60° from horizontal or greater. This includes above- and below-grade walls, between floor spandrels, peripheral edges of floors, and foundation walls.

(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 surface and measured vertically from the top of the floor to the top of the roof. If roof insulation is installed at the ceiling level rather than the roof, then the vertical measurement is made to the top of the ceiling. The gross wall area includes the area between the ceiling and the floor for multi-story buildings.



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

Z

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

Zone, Critical: a zone serving a process where reset of the zone temperature set point during a demand shed event might disrupt the process, including but not limited to data centres, telecom and private branch exchange (PBX) rooms, and laboratories.

Zone, Non-Critical: a zone that is not a critical zone.

8.3 SI to IP Conversion Factors

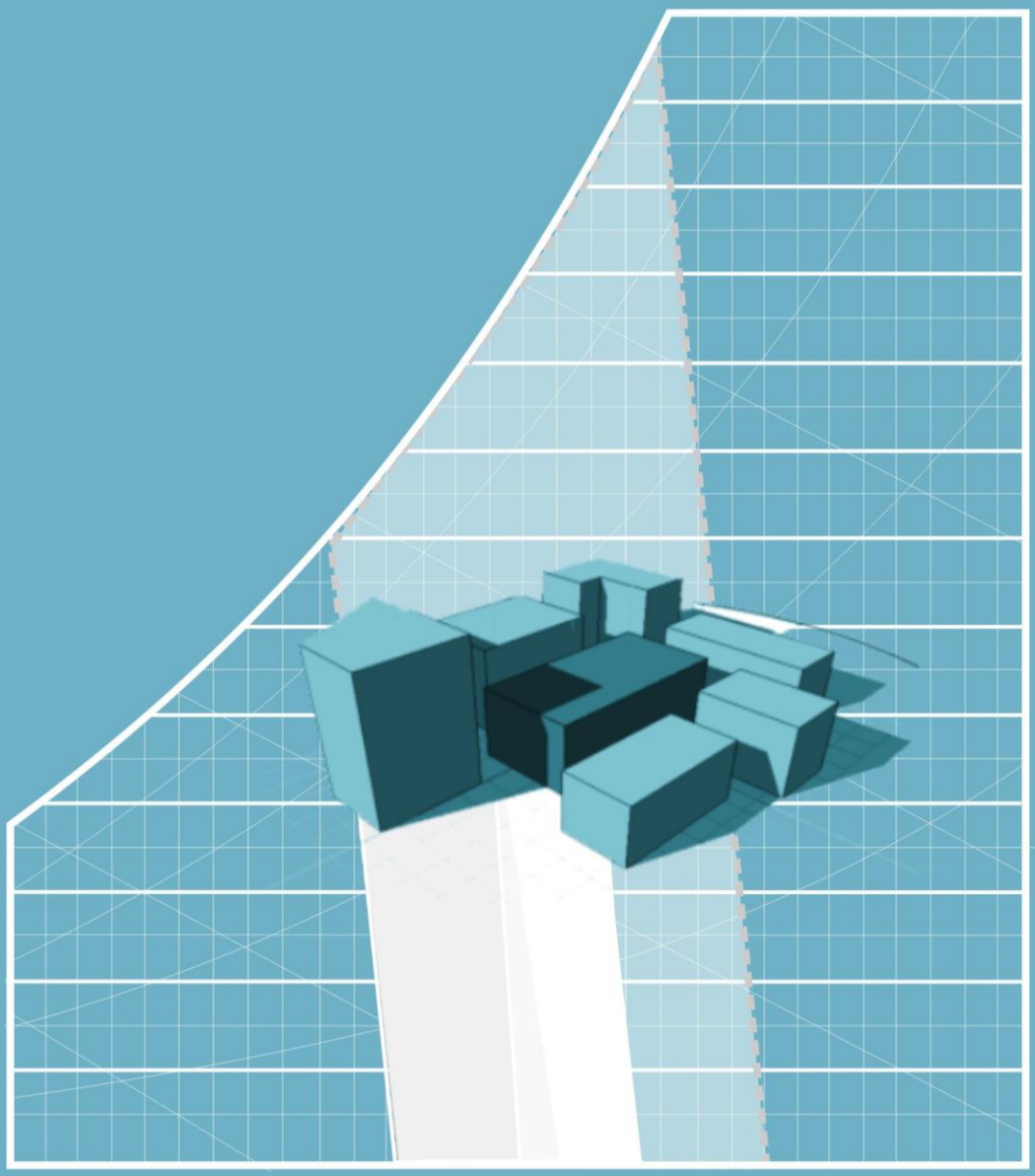
SI Unit	IP Unit
1 cmh	1.7 cfm
1 Pa	0.0040 inch of water gauge
1m	3.28 ft
1m	39.37 in
1mm	0.039 in
1 l/s	2.12 cfm
1 m^2	10.76 ft^2
1 W/m^2	10.76 W/ ft^2
1 W/ lin m	3.28 W/ ft
1 $W/m^2.K$	5.678 Btu/ h-ft^2-°F
1 W/ $l\text{-}s^{-1}$	0.063 W/ gpm
1 m^2.K/W	0.1761 ft^2-h-ºF/ Btu
1 ºC	((ºC X 9/5) + 32) ºF
1 kW_r	0.284 TR
1 kW	1.34 hp
1 kW	3412.142 Btu/hr

8.4 Abbreviations and Acronyms

AFUE	Annual fuel utilization efficiency
AHRI	Air-conditioning, Heating and Refrigeration Institute
ANSI	American National Standards Institute
ARI	Air-Conditioning and Refrigeration Institute
ASHRAE	American Society of Heating, Refrigerating and Air-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
cmh	cubic meter per hour
cm	centimeter
COP	coefficient of performance
DEF	daylight extent factor
EER	energy efficiency ratio
EPI	energy performance index
F	Fahrenheit
ft	foot
h	hour
h-ft^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
kW$_r$	kilowatt of refrigeration
kWh	kilowatt-hour
l/s	liter per second

LE	luminous efficacy
lin	linear
lin ft	linear foot
lin m	linear meter
lm	lumens
Lm/W	lumens per watt
LPD	lighting power density
m	meter
mm	millimeter
m^2	square meter
m^2.K/W	square meter Kelvin per watt
NBC	National Building Code 2016
Pa	pascal
PF	projection factor
R	R-value (thermal resistance)
SC	shading coefficient
SEF	Shading equivalent factor
SHGC	solar heat gain coefficient
TR	tons of refrigeration
UPS	uninterruptible power supply
VAV	variable air volume
VLT	visible light transmission
W	watt
W/ l-s^{-1}	watt per litre per second
W/m^2	watts per square meter
W/m^2.K	watts per square meter per Kelvin
W/m^2	watts per hour per square meter
W/m.K	watts per lineal meter per Kelvin
Wh	watthour

9 Whole Building Performance Method



9. Whole Building Performance Method

9.1 General

9.1.1 Scope

The Whole Building Performance Method is an alternative to the Prescriptive Method compliance path contained in §4 through §7 of this Code. It applies to all building types covered by the Code as mentioned in §2.5.

9.1.2 Compliance

A building complies with the Code using the Whole Building Performance (WBP) Method, when the estimated EPI Ratio is equal to or less than 1, even though it may not comply with the specific provisions of the prescriptive requirements in §4 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.

9.1.3 Annual Energy Use

Annual energy use for the purposes of the WBP Method shall be calculated in kilowatt-hours (kWh) of electricity use per year per unit area. Energy sources other than electricity that are used in the building shall be converted to kWh of electric energy at the rate of 0.75 kWh per megajoule.

Note: *The annual energy use calculation as per the Whole Building Performance Method is not a prediction of the actual energy use of the building once it gets operational. Actual energy performance of a building depends on a number of factors like weather, occupant behaviour, equipment performance and maintenance, among others, which are not covered by this Code.*

9.1.4 Trade-offs Limited to Building Permit

The WBP Method may be used for building permit applications that include less than the whole building; however, any design parameters that are not part of the building permit application shall be identical for both the Proposed Design and the Standard Design. Future improvements to the building shall comply with both the mandatory and prescriptive requirements of concurrent code.

9.1.5 Documentation Requirements

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

(a) Summary describing the results of the analysis, including the annual energy use for the Proposed Design and the Standard Design, and software used.

Brief description of the project with location, number of stories, space types, conditioned and unconditioned areas, hours of operation.

List of the energy-related building features of the Proposed Design. This list shall also document features different from the Standard Design.

List showing compliance with the mandatory requirements of this code.

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.

Explanation of any significant modelling assumptions made.

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

Building floor plans, building elevations, and site plan.

9.2 Mandatory Requirements

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

9.3 Simulation Requirements

9.3.1 Energy Simulation Program

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

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

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,

Thermal mass effects,

Ten or more thermal zones,

Part-load and temperature dependent performance of heating and cooling equipment,

Air-side and water-side economizers with integrated control.

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

The simulation program shall be tested according to ASHRAE Standard 140 Method of Test

for the Evaluation of Building Energy Analysis Computer Programs (ANSI approved) and the results shall be furnished by the software provider.

9.3.2 Climate Data

The simulation program shall use hourly values of climatic data, such as temperature and humidity, from representative climatic data for the city in which the Proposed Design is to be located. For cities or urban regions with several climate data entries, and for locations where weather data are not available, the designer shall select available weather data that best represent the climate at the construction site.

9.3.3 Compliance Calculations

The Proposed Design and Standard Design shall be calculated using the following:

(a) Same simulation program,
Same weather data, and
Identical building operation assumptions (thermostat set points, schedules, equipment and occupant loads, etc.) unless an exception is allowed by this Code or the authority having jurisdiction for a given category.

9.4 Calculating Energy Consumption of Proposed Design and Standard Design

9.4.1 Energy Simulation Model

The simulation model for calculating the Proposed Design and the Standard Design shall be developed in accordance with the requirements in

Table 9-1. The Standard Design is based on the mandatory and prescriptive requirements of the ECBC compliant building. The Standard Design will be the same for all compliance levels (ECBC, ECBC+, Super ECBC).

Table 9-1 Modelling Requirements for Calculating Proposed and Standard Design

Case	*Proposed Design*	*Standard Design*

1. 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.
2. Space Use Classification	The building type or space type classifications shall be chosen in accordance with §2.5. More than one building type category may be used in a building if it is a mixed-use facility.	Same as Proposed Design.
3. Schedules	Operational schedules (hourly variations in occupancy, lighting power, equipment power, HVAC equipment operation, etc.) suitable for the building and/or space type shall be modeled for showing compliance. Schedules must be modeled as per §9.6. In case a schedule for an occupancy type is missing in §9.6, appropriate schedule may be used. Temperature and humidity schedules and set points shall be identical in the Standard and Proposed Designs. Temperature control/thermostat throttling ranges shall also be modeled identically in both the Designs.	Same as Proposed Design. Exception: Schedules may be allowed to differ between the Standard and Proposed models wherever it is necessary to model nonstandard efficiency measures and/or measures which can be best approximated by a change in schedule. Measures that may warrant a change in operating schedules include but are not limited to automatic controls for lighting, natural ventilation, demand controlled ventilation systems, controls for service water heating load reduction. Schedule change is not allowed for manual controls under any category. This is subject to approval by the authority having jurisdiction.

4. Building Envelope	All components of the building envelope in the Proposed Design shall be modeled as shown on architectural drawings or as installed for existing building envelopes. Exceptions: The following building elements are permitted to differ from architectural drawings. (a) Any envelope assembly that covers less than 5% of the total area of that assembly type (e.g., exterior walls) need not be separately described. If not separately described, the area of an envelope assembly must be added to the area of the adjacent assembly of that same type. (b) Exterior surfaces whose azimuth orientation and tilt differ by no more than 45 degrees and are otherwise the same may be described as either a single surface or by using multipliers. (c) For exterior roofs, other than roofs with ventilated attics, the reflectance and emittance of the roof surface shall be modeled in accordance with §4.3.1.1. (d) Manually operated fenestration shading devices such as blinds or shades shall not be modeled. Permanent shading devices such as fins, overhangs, and light shelves shall be modeled. (e) The exterior roof surface shall be modeled using the solar reflectance in accordance with ASTM E903-96 and thermal emittance determined in accordance with ASTM E408-71. Where cool roof is proposed, emittance and reflectance shall be modeled as per ASTM E408-71 and ASTM E903-96 respectively. Where cool roof is not proposed, the exterior roof surfaces shall be modeled as per §4.3.1.1 i.e. the exterior roof surface shall be modeled with a solar reflectance of 0.70 and a thermal emittance of 0.75.	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 with the maximum U-factor allowed in §4.3.1 and §4.3.2. (c) Fenestration. Fenestration areas shall equal that in the Proposed Design or 40% of gross above grade wall area, whichever is smaller, and shall be distributed on each face in the same proportions as in the Proposed Design No shading projections are to be modeled; fenestration shall be assumed to be flush with the exterior wall or roof. Manually operated fenestration shading devices such as blinds or shades shall not be modeled. Fenestration U-factor shall be the maximum allowed for the climate, and the solar heat gain coefficient shall be the maximum allowed for the climate and orientation. (d) 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.as per §4.3.1.1

5. Lighting	Lighting power in the Proposed Design shall be determined as follows: Where a complete lighting system exists, the actual lighting power shall be used in the model. Where a lighting system has been designed, lighting power shall be determined in accordance with either §6.3.4. Where no lighting exists, or is specified, lighting power shall be determined in accordance with the §6.3.2 or §6.3.3 for the appropriate building type. 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 9-3.	Interior lighting power in the Standard Design shall be determined using the same categorization procedure (building area or space function) and categories as the Proposed Design with lighting power set equal to the maximum allowed for the corresponding method and category in either §6.3.2 or §6.3.3. Power for fixtures not included in the lighting power density calculation shall be modeled identically in the Proposed Design and Standard Design. Lighting controls shall be as per the ECBC requirements of §6.2.1. 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 spaces. Perimeter spaces are defined as spaces located within 5 meters of an exterior or semi exterior wall. Core spaces are defined as spaces located greater than 5 meters of an exterior or semi exterior wall. Separate thermal blocks shall be modeled for floors in contact with ground and for floors which have a ceiling/roof exposure to the ambient.	Same as Proposed Design

7. HVAC Systems	The HVAC system type and all related performance parameters, such as equipment capacities and efficiencies, in the Proposed Design shall be determined as follows: (a) Where a complete HVAC system exists, the model shall reflect the actual system type using actual component capacities and efficiencies. (b) Where an HVAC system has been designed, the HVAC model shall be consistent with design documents. Mechanical equipment efficiencies shall be adjusted from actual design conditions to the rating conditions specified in §5, if required by the simulation model. (c) Where no heating system has been specified, the heating system shall be assumed to be electric. The system characteristics shall be identical to the system modeled in the Standard Design. (d) Where no cooling system has been specified, the cooling system and its characteristics shall be identical to the system modeled in the Standard Design.	The HVAC system type shall be as per Table 9-2 and related performance parameters for the Standard Design shall be determined from requirements of §9.4.2. 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.

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. Modelling 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. Whichever method is selected, the component shall be modeled identically for both the Proposed Design and Standard Design models.	Same as Proposed Design.

Table 9-2 HVAC Systems Map for Standard Design

	Hotel/Motel, Hospital Patient Rooms, Hotel Guest Rooms, Resorts, Villas, Sleeping Quarters in Mixed-use Buildings, Schools, Classrooms/Lecture Rooms[1]	Buildings with Less than or Equal to 12,500 m² of Conditioned Area	Buildings with More than 12,500 m² of Conditioned Area	Data Centre/ Server/Computer Rooms
Name	System **A**	System **B**	System **C**	System **D**
System Type[2]	Split AC	VRF: Variable Refrigerant Flow	VAV: Central cooling plant with variable volume AHU[3]	Computer Room air conditioners
Fan Control	Constant Volume	Constant volume	Variable volume	Constant volume
Cooling Type	Direct expansion with air cooled condenser	Direct expansion with air cooled condenser	Chilled Water with water cooled condenser	Direct expansion with air cooled condenser
Heating Type	1. Heat Pump: Where no heating system has been specified or where an electric heating system has been specified in the Proposed Design 2. Fossil Fuel Boiler, 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 m² of conditioned floor area. Use additional system type for non-predominant conditions if those conditions apply to more than 1,000 m² of conditioned floor area.

Use additional system type for any space which has a substantial difference in peak loads and/or operational hours compared to the predominant space type. Such spaces may include but are not limited to computer/server rooms, retail areas in residential, or office buildings.

3. One AHU per floor at a minimum.

Table 9-3 Power Adjustment Factors for Automatic Lighting Controls

Automatic Control Device	*Daytime occupancy and area <300 m²*	*All Others*
Programmable Timing Control	10%	0%
Occupancy Sensor	10%	10%
Occupancy Sensor and Programmable Timing Control	15%	10%

9.4.2 HVAC Systems

The HVAC system type and related performance parameters for the Standard Design shall be determined from

Table 9-2 and the following rules:

(a) Other components: Components and parameters not listed in
(b)
(c)

(d) Table 9-2 or otherwise specifically addressed in this subsection shall be identical to those in the Proposed Design.

Exception to § 9.4.2(a): Where there are specific requirements in §5.2.2, the component efficiency in the Standard Design shall be adjusted to the

lowest efficiency level allowed by the requirement for that component type.

(e) 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.
(f) 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.
(g) Minimum outdoor air ventilation rates shall be the same for both the Standard Design and the Proposed Design except for conditions specified in §9.4.2.1.
(h) 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.
(i) Unmet load hours for the Proposed Design shall not differ from unmet load hours for the Standard Design by more than 50 hours. Maximum number of unmet hours shall not exceed 300 for either case.

9.4.2.1 Minimum Outdoor air rates:

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

(a) when modeling demand controlled ventilation (DCV) in the Proposed Design (DCV is not required in the Standard Design as per §5.2.1.3.

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

9.4.2.2 Fan Schedules

Supply and return fans shall operate continuously whenever the spaces are occupied and shall be cycled to meet heating and cooling loads during unoccupied hours.

9.4.2.3 Fan Power

(a) For Systems Types A, B and D,

P_{fan} = cmh x .51

Where P_{fan} = Standard Design fan power in watts

cmh = Standard Design supply airflow rate auto-sized by the simulation software

(b) For System Type C

Fan power shall be modeled as per efficiency limits specified in Table 5-9 using a static pressure of 622 Pa or the design static pressure, whichever is higher. The simulation

software shall automatically calculate the Standard Design fan power based on the above inputs.

9.4.2.4 Design Airflow Rates

Design airflow rates for the Standard Design shall be sized based on a supply air to room air temperature difference of 11 °C for cooling and 18°C for heating. The Proposed Design airflow rates shall be as per design.

9.4.2.5 Economizers (airside and waterside)

Airside economizers shall be modeled in the Standard Design as per the requirements of §5.3.6.

Exception to §9.4.2.5: Airside economizer shall not be modeled for Standard Design HVAC System Type A.

9.4.2.6 Energy Recovery

Energy recovery shall be modeled in the Standard Design as per the requirements of §5.3**.**

9.4.2.7 Chilled Water Design Supply Temperatures

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

9.4.2.8 Chillers

Only electric chillers shall be modeled in the Standard Design for System C. Chillers shall meet the minimum efficiency requirements indicated in Table 9-4 and Table 9-5. Chillers in the Standard Design shall be selected as per Table 9.6 below:

Table 9-4 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 9-5 Minimum Energy Efficiency Requirements for air cooled Chillers

Chiller Capacity (kWr)	COP	IPLV
<260	2.8	*3.5*
≥260	3.0	*3.7*

Table 9-6 Types and Number of Chillers for Standard Design

Peak Building Cooling Load (kW_r)	*Chiller Type*
< 1,055	1 Water Cooled Screw Chiller
1,055 to 2,110	2 Water Cooled Screw Chillers equally sized
> 2,110	2 or more Water Cooled Centrifugal Chillers, equally sized such that no Chiller is greater than 2,813 kW_r

Exception to 9.4.2.8: Air cooled chillers are allowed to be modeled in the Standard Design if the Proposed Design has air cooled chillers. If the proposed building has a mix of air and water cooled chillers, then the Standard Design shall be modeled with a mix of air and water cooled chillers in the same proportion as in the Proposed Design.

9.4.2.9 Chilled Water Pumps

Chilled and condenser water pumps for the Standard Design shall be modeled as per power and efficiency limits specified in

Table 5-12. Standard Design chilled water pumps shall be modeled as primary-secondary with variable secondary flow.

9.4.2.10 Cooling Tower

Standard Design cooling tower shall be modeled as an open circuit axial flow tower with power and efficiency as per §5.3.3. The fans shall be modeled as two speed.

Condenser water design supply temperature shall be 29.4°C or 5.6°C approach to wet bulb temperature, whichever is lower, with a design temperature rise of 5.6°C.

9.4.2.11 Boiler

Standard Design boilers shall be modeled as natural draft boilers and shall use the same fuel as the Proposed Design. Boiler efficiency shall be modeled as per Table 5-4.

9.4.2.12 Hot Water Design Supply Temperatures

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

9.4.2.13 Hot Water Pumps

The Standard Design hot water pumps shall be modeled with a minimum efficiency of 70% and a pump power of 300 $W/l\text{-}s^{-1}$.

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

9.4.2.14 Campus/District Cooling Systems

All district cooling plants shall be assumed to be on grid electricity, unless otherwise specified and supported through pertinent documents. New district plants shall comply with

the mandatory requirements of ECBC irrespective of who owns and/or operates the district plant.

Projects may choose either option A or option B given below for modelling campus/district cooling systems.

Option A

The cooling source shall be modeled as purchased chilled water in both the Standard Design and Proposed Design. For the Standard Design,

Table 9-2, shall be modified as follows:

(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 = 1,000,000 Btu = 293 kWh

Option B

The Standard Design shall be modeled as per

Table 9-2 HVAC Systems Map.

For the Proposed Design, model a virtual onsite chilled water plant with Chiller, Pumps and cooling towers modeled at minimum efficiency levels as per §9.4.2.7 to §9.4.2.10. Airside/low side capacities shall be modeled as per design and the plant capacities shall be auto-sized by the software.

9.4.3 Compliance Thresholds for ECBC compliant, ECBC+ and SuperECBC Buildings

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

The EPI Ratio for ECBC+ and SuperECBC Buildings shall be equal to or less than the EPI Ratios listed under the applicable climate zone in Table 9-7 through Table 9-11 of §9.5.

9.5 Maximum Allowed EPI Ratios

Table 9-7 Maximum Allowed EPI Ratios for Building in Composite Climate

Building Type	*Composite*		
	ECBC	ECBC+	SuperECBC
Hotel (No Star and Star)	1	0.91	0.81
Resort	1	0.88	0.76
Hospital	1	0.85	0.77
Outpatient	1	0.85	0.75
Assembly	1	0.86	0.77
Office (Regular Use)	1	0.86	0.78
Office (24Hours)	1	0.88	0.76
Schools and University	1	0.77	0.66
Open Gallery Mall	1	0.85	0.76
Shopping Mall	1	0.86	0.74
Supermarket	1	0.81	0.70
Strip retail	1	0.82	0.68

Table 9-8 Maximum Allowed EPI Ratios for Buildings in Hot and Dry Climate

Building Type	*Hot and Dry*		
	ECBC	ECBC+	SuperECBC
Hotel (No Star and Star)	1	0.90	0.81
Resort	1	0.88	0.76
Hospital	1	0.84	0.76
Outpatient	1	0.85	0.75
Assembly	1	0.86	0.78
Office (Regular Use)	1	0.86	0.78
Office (24Hours)	1	0.88	0.76
Schools and University	1	0.77	0.66
Open Gallery Mall	1	0.85	0.77
Shopping Mall	1	0.84	0.72
Supermarket	1	0.73	0.69
Strip retail	1	0.82	0.68

Table 9-9 Maximum Allowed EPI Ratios for Buildings in Temperate Climate

Building Type	*Temperate*		
	ECBC	ECBC+	SuperECBC
Hotel (No Star and Star)	1	0.90	0.80
Resort	1	0.88	0.75
Hospital	1	0.82	0.73
Outpatient	1	0.85	0.75
Assembly	1	0.85	0.76
Office (Regular Use)	1	0.85	0.75
Office (24Hours)	1	0.87	0.74
Schools and University	1	0.77	0.66
Open Gallery Mall	1	0.83	0.74
Shopping Mall	1	0.84	0.71
Supermarket	1	0.81	0.69
Strip retail	1	0.81	0.67

Table 9-10 Maximum Allowed EPI Ratios for Buildings in Warm and Humid Climate

Building Type	*Warm and Humid*		
	ECBC	ECBC+	SuperECBC
Hotel (No Star and Star)	1	0.91	0.81
Resort	1	0.88	0.75
Hospital	1	0.86	0.77
Outpatient	1	0.86	0.76
Assembly	1	0.88	0.80
Office (Regular Use)	1	0.86	0.76
Office (24Hours)	1	0.88	0.76
Schools and University	1	0.77	0.66
Open Gallery Mall	1	0.86	0.77
Shopping Mall	1	0.85	0.72
Supermarket	1	0.82	0.70
Strip retail	1	0.83	0.68

Table 9-11 Maximum Allowed EPI Ratios for Buildings in Cold Climate

Building Type	*Cold*		
	ECBC	ECBC+	SuperECBC
Hotel (No Star and Star)	1	0.91	0.82
Resort	1	0.88	0.75
Hospital	1	0.88	0.80
Outpatient	1	0.85	0.75
Assembly	1	0.87	0.81
Office (Regular Use)	1	0.88	0.80
Office (24Hours)	1	0.87	0.75
Schools and University	1	0.85	0.73
Open Gallery Mall	1	0.82	0.73
Shopping Mall	1	0.96	0.93
Supermarket	1	0.80	0.68
Strip retail	1	0.80	0.66

9.6 Schedules

Table 9-12 Schedules for Business - Office Buildings

Business - Office							
Time Period	Elevator Schedules		External Lighting Schedule	Basement Ventilation		Basement Lighting	
	Daytime Business	24 Hours Business	7 Days / week	Daytime Business	24 Hours Business	Daytime Business	24 Hours Business
00:00-01 00	0.05	0.55	0.80	0.00	1.00	0.05	1.00
01:00-02:00	0.05	0.25	0.80	0.00	1.00	0.05	1.00
02:00-03:00	0.05	0.25	0.80	0.00	1.00	0.05	1.00
03:00-04:00	0.05	0.15	0.80	0.00	1.00	0.05	1.00
04:00-05:00	0.05	0.35	0.80	0.00	1.00	0.05	1.00
05:00-06:00	0.05	0.50	0.80	0.00	1.00	0.05	1.00
06:00-07:00	0.20	0.20	0.00	0.00	1.00	0.05	1.00
07:00-08:00	0.40	0.40	0.00	0.00	1.00	0.05	1.00
08:00-09:00	0.80	0.80	0.00	1.00	1.00	1.00	1.00
09:00-10:00	0.80	0.80	0.00	1.00	1.00	1.00	1.00
10:00-11:00	0.55	0.55	0.00	1.00	1.00	1.00	1.00
11:00-12:00	0.35	0.35	0.00	1.00	1.00	1.00	1.00
12:00-13:00	0.25	0.25	0.00	1.00	1.00	1.00	1.00
13:00-14:00	0.95	0.95	0.00	1.00	1.00	1.00	1.00
14:00-15:00	0.95	0.95	0.00	1.00	1.00	1.00	1.00
15:00-16:00	0.35	0.35	0.00	1.00	1.00	1.00	1.00
16:00-17:00	0.15	0.35	0.00	1.00	1.00	1.00	1.00
17:00-18:00	0.75	0.70	0.00	1.00	1.00	1.00	1.00
18:00-19:00	0.95	0.95	0.80	1.00	1.00	1.00	1.00
19:00-20:00	0.50	0.50	0.80	1.00	1.00	1.00	1.00
20:00-21:00	0.30	0.35	0.80	1.00	1.00	1.00	1.00
21:00-22:00	0.20	0.25	0.80	0.00	1.00	0.05	1.00
22:00-23:00	0.05	0.25	0.80	0.00	1.00	0.05	1.00
23:00-24:00	0.05	0.55	0.80	0.00	1.00	0.05	1.00

Table 9-13: 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	Office	Corridor/ Lobby	Conference / Meeting	Office	Conference / Meeting Room	Office/ Corridor/ Lobby	Conference / Meeting
00:00-01:00	0.00	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0	0
01:00-02:00	0.00	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0	0
02:00-03:00	0.00	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0	0
03:00-04:00	0.00	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0	0
04:00-05:00	0.00	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0	0
05:00-06:00	0.00	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0	0
06:00-07:00	0.00	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0	0
07:00-08:00	0.00	0.00	0.00	0.10	0.10	0.00	0.00	0.00	1	0
08:00-09:00	0.20	0.70	0.00	0.90	0.90	0.00	0.10	0.00	1	1
09:00-10:00	0.95	0.80	0.00	0.90	0.90	0.00	0.90	0.00	1	1
10:00-11:00	0.95	0.70	0.75	0.90	0.90	0.90	0.90	0.90	1	1
11:00-12:00	0.95	0.30	0.75	0.90	0.90	0.90	0.90	0.90	1	1
12:00-13:00	0.95	0.30	0.75	0.90	0.90	0.90	0.90	0.90	1	1
13:00-14:00	0.50	0.80	0.5	0.50	0.90	0.50	0.80	0.50	1	1
14:00-15:00	0.95	0.50	0.75	0.90	0.90	0.90	0.90	0.90	1	1
15:00-16:00	0.95	0.30	0.75	0.90	0.90	0.90	0.90	0.90	1	1
16:00-17:00	0.95	0.30	0.75	0.90	0.90	0.90	0.90	0.90	1	1
17:00-18:00	0.95	0.80	0.75	0.95	0.90	0.90	0.90	0.90	1	1
18:00-19:00	0.30	0.70	0.50	0.50	0.90	0.90	0.50	0.90	1	1
19:00-20:00	0.00	0.30	0.00	0.30	0.90	0.00	0.10	0.00	1	0
20:00-21:00	0.00	0.00	0.00	0.10	0.10	0.00	0.10	0.00	1	0
21:00-22:00	0.00	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0	0
22:00-23:00	0.00	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0	0
23:00-24:00	0.00	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0	0

Table 9-14: Schedules for Business - Office Building 24-hours Business

Business – Office 24-hour Business									
Time Period	Occupancy Schedule			Lighting Schedule			Equipment Schedule		HVAC Fan Schedule (On/Off)
	Office	Corridor/ Lobby	Conference/ Meeting	Office	Corridor/ Lobby	Conference/ Meeting	Office	Conference/ Meeting	Office/ Corridor/ Lobby/ Conference/ Meeting
00:00-01:00	0.90	0.20	0.00	0.90	0.90	0.00	0.95	0.00	1
01:00-02:00	0.90	0.50	0.00	0.90	0.90	0.00	0.95	0.00	1
02:00-03:00	0.90	0.20	0.00	0.90	0.90	0.00	0.95	0.00	1
03:00-04:00	0.90	0.20	0.00	0.90	0.90	0.00	0.95	0.00	1
04:00-05:00	0.50	0.20	0.50	0.50	0.90	0.50	0.00	0.90	1
05:00-06:00	0.20	0.50	0.50	0.05	0.90	0.50	0.00	0.90	1
06:00-07:00	0.10	0.50	0.50	0.05	0.50	0.50	0.00	0.90	1
07:00-08:00	0.10	0.50	0.00	0.90	0.50	0.00	0.95	0.00	1
08:00-09:00	0.90	0.70	0.00	0.90	0.90	0.00	0.95	0.00	1
09:00-10:00	0.90	0.80	0.50	0.90	0.90	0.50	0.95	0.90	1
10:00-11:00	0.90	0.70	0.75	0.90	0.90	0.90	0.95	0.90	1
11:00-12:00	0.90	0.30	0.75	0.90	0.90	0.90	0.95	0.90	1
12:00-13:00	0.90	0.30	0.75	0.90	0.90	0.90	0.95	0.90	1
13:00-14:00	0.20	0.80	0.25	0.50	0.50	0.50	0.20	0.50	1
14:00-15:00	0.90	0.50	0.75	0.90	0.90	0.90	0.95	0.90	1
15:00-16:00	0.90	0.30	0.75	0.90	0.90	0.90	0.95	0.90	1
16:00-17:00	0.90	0.30	0.75	0.90	0.90	0.90	0.95	0.90	1
17:00-18:00	0.90	0.80	0.75	0.90	0.90	0.90	0.95	0.90	1
18:00-19:00	0.90	0.70	0.50	0.90	0.90	0.90	0.20	0.90	1
19:00-20:00	0.20	0.30	0.00	0.90	0.90	0.00	0.95	0.00	1
20:00-21:00	0.90	0.20	0.00	0.90	0.90	0.00	0.95	0.00	1
21:00-22:00	0.90	0.20	0.50	0.90	0.90	0.50	0.95	0.90	1
22:00-23:00	0.90	0.20	0.50	0.90	0.90	0.50	0.95	0.90	1
23:00-24:00	0.90	0.20	0.50	0.90	0.90	0.50	0.20	0.90	1

Table 9-15: Schedules for Business - Server Room

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

Table 9-16: 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/ Conferenc e Room			
00:00-01:00	0.00	0	0	0	0.80	0.00	0.05
01:00-02:00	0.00	0	0	0	0.80	0.00	0.05
02:00-03:00	0.00	0	0	0	0.80	0.00	0.05
03:00-04:00	0.00	0	0	0	0.80	0.00	0.05
04:00-05:00	0.00	0	0	0	0.80	0.00	0.05
05:00-06:00	0.00	0	0	0	0.80	0.00	0.05
06:00-07:00	0.00	0	0	1	0.00	0.00	0.05
07:00-08:00	0.00	1	1	1	0.00	0.00	0.05
08:00-09:00	0.20	1	1	1	0.00	1.00	1.00
09:00-10:00	0.50	1	1	1	0.00	1.00	1.00
10:00-11:00	0.50	1	1	1	0.00	1.00	1.00
11:00-12:00	0.50	1	1	1	0.00	1.00	1.00
12:00-13:00	0.50	1	1	1	0.00	1.00	1.00
13:00-14:00	0.50	1	1	1	0.00	1.00	1.00
14:00-15:00	0.50	0	1	1	0.00	1.00	1.00
15:00-16:00	0.50	0	1	0	0.00	1.00	1.00
16:00-17:00	0.50	0	1	0	0.00	1.00	1.00
17:00-18:00	0.50	0	0	0	0.00	1.00	0.50
18:00-19:00	0.50	0	0	0	0.80	0.00	0.05
19:00-20:00	0.40	0	0	0	0.80	0.00	0.05
20:00-21:00	0.20	0	0	0	0.80	0.00	0.05
21:00-22:00	0.20	0	0	0	0.80	0.00	0.05
22:00-23:00	0.00	0	0	0	0.80	0.00	0.05
23:00-24:00	0.00	0	0	0	0.80	0.00	0.05

Table 9-17: Schedules for Assembly Buildings (B)

Assembly Buildings								
Time Period	Occupancy Schedule			Lighting Schedule			Equipment Schedule	
	Seating/ Public Space	Exhibit Space	Meeting/ Conference	Seating/ Public Space	Exhibit Space	Meeting/ Conference	Exhibit Space	Meeting/ Conference
00:00-01:00	0.00	0.00	0.00	0.10	0.10	0.10	0.00	0.00
01:00-02:00	0.00	0.00	0.00	0.10	0.10	0.10	0.00	0.00
02:00-03:00	0.00	0.00	0.00	0.10	0.10	0.10	0.00	0.00
03:00-04:00	0.00	0.00	0.00	0.10	0.10	0.10	0.00	0.00
04:00-05:00	0.00	0.00	0.00	0.10	0.10	0.10	0.00	0.00
05:00-06:00	0.00	0.00	0.00	0.10	0.10	0.10	0.00	0.00
06:00-07:00	0.00	0.00	0.00	0.10	0.10	0.10	0.00	0.00
07:00-08:00	0.00	0.00	0.00	0.10	0.10	0.10	0.00	0.00
08:00-09:00	0.50	0.50	0.00	0.90	0.90	0.10	0.00	0.00
09:00-10:00	0.60	0.50	0.50	0.90	0.90	0.90	0.90	0.80
10:00-11:00	0.70	0.80	0.75	0.90	0.90	0.90	0.90	0.80
11:00-12:00	0.70	0.80	0.75	0.90	0.90	0.90	0.90	0.80
12:00-13:00	0.70	0.80	0.75	0.90	0.90	0.90	0.90	0.80
13:00-14:00	0.90	0.25	0.50	0.90	0.50	0.50	0.50	0.50
14:00-15:00	0.90	0.25	0.75	0.90	0.50	0.90	0.90	0.80
15:00-16:00	0.70	0.80	0.75	0.90	0.90	0.90	0.90	0.80
16:00-17:00	0.70	0.80	0.75	0.90	0.90	0.90	0.90	0.80
17:00-18:00	0.70	0.80	0.75	0.90	0.90	0.90	0.90	0.80
18:00-19:00	0.80	0.50	0.50	0.90	0.90	0.50	0.00	0.00
19:00-20:00	0.80	0.00	0.00	0.90	0.10	0.10	0.00	0.00
20:00-21:00	0.80	0.00	0.00	0.90	0.10	0.10	0.00	0.00
21:00-22:00	0.70	0.00	0.00	0.90	0.10	0.10	0.00	0.00
22:00-23:00	0.60	0.00	0.00	0.90	0.10	0.10	0.00	0.00
23:00-24:00	0.50	0.00	0.00	0.90	0.10	0.10	0.00	0.00

Table 9-18: Schedules for Assembly Buildings (C)

Assembly Buildings - Museum								
Time Period	Occupancy Schedule		Lighting Schedule		Equipment Schedule		HVAC Fan Schedule (ON/OFF)	
	Museum Exhibition	Museum Restoration	Museum Exhibition	Museum Restoration	Museum Exhibition	Museum Restoration	Museum Exhibition	Museum Restoration
00:00-01:00	0.00	0.00	0.10	0.10	0.00	0.00	0	0
01:00-02:00	0.00	0.00	0.10	0.10	0.00	0.00	0	0
02:00-03:00	0.00	0.00	0.10	0.10	0.00	0.00	0	0
03:00-04:00	0.00	0.00	0.10	0.10	0.00	0.00	0	0
04:00-05:00	0.00	0.00	0.10	0.10	0.00	0.00	0	0
05:00-06:00	0.00	0.00	0.10	0.10	0.00	0.00	0	0
06:00-07:00	0.00	0.00	0.10	0.10	0.00	0.00	0	0
07:00-08:00	0.00	0.00	0.10	0.10	0.00	0.00	1	1
08:00-09:00	0.50	0.80	0.90	0.90	0.00	0.90	1	1
09:00-10:00	0.50	0.25	0.90	0.50	0.90	0.25	1	1
10:00-11:00	0.80	0.25	0.90	0.50	0.90	0.25	1	1
11:00-12:00	0.80	0.25	0.90	0.50	0.90	0.25	1	1
12:00-13:00	0.80	0.25	0.90	0.50	0.90	0.25	1	1
13:00-14:00	0.25	0.80	0.50	0.90	0.50	0.90	1	1
14:00-15:00	0.25	0.80	0.50	0.90	0.90	0.90	1	1
15:00-16:00	0.80	0.25	0.90	0.50	0.90	0.25	1	1
16:00-17:00	0.80	0.25	0.90	0.50	0.90	0.25	1	1
17:00-18:00	0.80	0.25	0.90	0.50	0.90	0.25	1	1
18:00-19:00	0.25	0.80	0.90	0.90	0.00	0.90	1	1
19:00-20:00	0.00	0.00	0.10	0.10	0.00	0.00	1	1
20:00-21:00	0.00	0.00	0.10	0.10	0.00	0.00	0	0
21:00-22:00	0.00	0.00	0.10	0.10	0.00	0.00	0	0
22:00-23:00	0.00	0.00	0.10	0.10	0.00	0.00	0	0
23:00-24:00	0.00	0.00	0.10	0.10	0.00	0.00	0	0

Table 9-19: 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
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 9-20: Schedules for Healthcare - Hospital Buildings (A)

Healthcare - Hospital											
Time Period	Occupancy Schedule				Lighting Schedule				Equipment Schedule		
	In Patient & ICU	Public Spaces	OPD & Offices	Diagnostic, emergency & OT	Public Spaces	In Patient & ICU	Diagnostic, emergency & OT	OPD & Offices	In Patient & ICU	Diagnostic, emergency & OT	OPD & Offices
	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week
00:00-01:00	0.90	0.00	0.00	0.50	0.10	0.10	0.50	0.05	0.40	0.00	0.00
01:00-02:00	0.90	0.00	0.00	0.40	0.10	0.10	0.50	0.05	0.40	0.00	0.00
02:00-03:00	0.90	0.00	0.00	0.40	0.10	0.10	0.50	0.05	0.40	0.00	0.00
03:00-04:00	0.90	0.00	0.00	0.40	0.10	0.10	0.50	0.05	0.40	0.00	0.00
04:00-05:00	0.90	0.00	0.00	0.40	0.10	0.10	0.50	0.05	0.40	0.00	0.00
05:00-06:00	0.90	0.00	0.00	0.40	0.10	0.10	0.50	0.05	0.40	0.00	0.00
06:00-07:00	0.90	0.00	0.00	0.50	0.10	0.10	0.50	0.10	0.40	0.00	0.00
07:00-08:00	0.90	0.10	0.10	0.70	0.50	0.20	0.50	0.30	0.70	0.70	0.70
08:00-09:00	0.90	0.50	0.30	0.70	0.90	0.20	0.90	0.90	0.90	0.90	0.90
09:00-10:00	0.90	0.95	0.90	0.95	0.90	0.20	0.90	0.90	0.90	0.90	0.90
10:00-11:00	0.90	0.95	0.90	0.95	0.90	0.20	0.90	0.90	0.90	0.90	0.90
11:00-12:00	0.90	0.95	0.50	0.95	0.90	0.20	0.90	0.90	0.90	0.90	0.90
12:00-13:00	0.90	0.95	0.20	0.95	0.90	0.20	0.90	0.90	0.90	0.90	0.90
13:00-14:00	0.90	0.95	0.50	0.95	0.90	0.20	0.90	0.50	0.90	0.90	0.90
14:00-15:00	0.90	0.95	0.90	0.95	0.90	0.20	0.90	0.90	0.90	0.90	0.90
15:00-16:00	0.90	0.95	0.90	0.95	0.90	0.20	0.90	0.90	0.90	0.90	0.90
16:00-17:00	0.90	0.95	0.90	0.95	0.30	0.20	0.90	0.90	0.60	0.60	0.90
17:00-18:00	0.90	0.70	0.90	0.95	0.30	0.70	0.90	0.90	0.60	0.60	0.90
18:00-19:00	0.90	0.50	0.50	0.95	0.30	0.90	0.90	0.50	0.60	0.60	0.60
19:00-20:00	0.90	0.30	0.50	0.95	0.30	0.90	0.90	0.50	0.60	0.60	0.60
20:00-21:00	0.90	0.10	0.50	0.70	0.30	0.90	0.50	0.30	0.60	0.60	0.60
21:00-22:00	0.90	0.00	0.10	0.70	0.30	0.90	0.50	0.20	0.60	0.00	0.00
22:00-23:00	0.90	0.00	0.00	0.50	0.30	0.70	0.50	0.10	0.60	0.00	0.00
23:00-24:00	0.90	0.00	0.00	0.50	0.10	0.10	0.50	0.05	0.40	0.00	0.00

Table 9-21: Schedules for Healthcare - Hospital Buildings (B)

Healthcare - Hospital										
Time Period	HVAC Fan Schedule (On/Off)				Lighting External 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
19:00-20:00	1	1	1	1	1.00	0.50	0.00	0.35	1.00	1.00
20:00-21:00	1	1	1	1	1.00	0.50	0.00	0.35	1.00	1.00
21:00-22:00	1	1	1	0	1.00	0.30	0.00	0.30	0.50	0.50
22:00-23:00	0	1	1	0	1.00	0.20	0.00	0.30	0.50	0.50
23:00-24:00	0	1	1	0	1.00	0.20	0.00	0.30	0.50	0.50

Table 9-22: Schedules for Healthcare – Out-patient Healthcare Buildings (A)

Healthcare – Out-patient Healthcare							
Time Period	Occupancy Schedule			Lighting Schedule		Equipment Schedule	
	Lobby	Diagnostic & Emergency	OPD & Back Office	Diagnostic & Emergency	OPD & Back Office	Diagnostic & Emergency	OPD & Back Office
	6 days/ week	6 days/ week	6 days/ week	6 days/ week	6 days/ week	6 days/ week	6 days/ week
00:00-01:00	0.00	0.00	0.00	0.10	0.00	0.00	0.00
01:00-02:00	0.00	0.00	0.00	0.10	0.00	0.00	0.00
02:00-03:00	0.00	0.00	0.00	0.10	0.00	0.00	0.00
03:00-04:00	0.00	0.00	0.00	0.10	0.00	0.00	0.00
04:00-05:00	0.00	0.00	0.00	0.10	0.00	0.00	0.00
05:00-06:00	0.00	0.00	0.00	0.10	0.00	0.00	0.00
06:00-07:00	0.00	0.20	0.20	0.10	0.10	0.00	0.00
07:00-08:00	0.10	0.20	0.20	0.50	0.30	0.50	0.00
08:00-09:00	0.50	0.30	0.20	0.90	0.90	0.95	0.95
09:00-10:00	0.80	0.90	0.90	0.90	0.90	0.95	0.95
10:00-11:00	0.80	0.90	0.90	0.90	0.90	0.95	0.95
11:00-12:00	0.80	0.90	0.90	0.90	0.90	0.95	0.95
12:00-13:00	0.80	0.90	0.50	0.90	0.90	0.95	0.95
13:00-14:00	0.80	0.90	0.20	0.90	0.50	0.95	0.95
14:00-15:00	0.80	0.90	0.50	0.90	0.90	0.95	0.95
15:00-16:00	0.80	0.90	0.90	0.90	0.90	0.95	0.95
16:00-17:00	0.80	0.90	0.90	0.90	0.90	0.95	0.95
17:00-18:00	0.80	0.90	0.90	0.90	0.95	0.95	0.95
18:00-19:00	0.80	0.90	0.50	0.90	0.95	0.95	0.95
19:00-20:00	0.80	0.90	0.50	0.90	0.30	0.95	0.95
20:00-21:00	0.20	0.65	0.20	0.90	0.30	0.80	0.80
21:00-22:00	0.20	0.20	0.20	0.50	0.20	0.00	0.00
22:00-23:00	0.00	0.00	0.00	0.30	0.00	0.00	0.00
23:00-24:00	0.00	0.00	0.00	0.10	0.00	0.00	0.00

Table 9-23: Schedules for Healthcare – Out-patient Healthcare Buildings (B)

Healthcare - Out-patient Healthcare							
Time Period	Elevator Schedule	HVAC Fan Schedule (On/Off)	External Lighting Schedule	Service Hot Water (SHW)		Basement Ventilation	Basement Lighting
		All Spaces		Building Summer	Building Winters		
	6 days/ week	6 days/ week	7 Days/ week	6 days/ week	6 days/ week	6 days/ week	6 days/ week
00:00-01:00	0.05	0	0.20	0.00	0.00	0.00	0.00
01:00-02:00	0.05	0	0.20	0.00	0.00	0.00	0.00
02:00-03:00	0.05	0	0.20	0.00	0.00	0.00	0.00
03:00-04:00	0.05	0	0.20	0.00	0.00	0.00	0.00
04:00-05:00	0.05	0	0.20	0.00	0.00	0.00	0.00
05:00-06:00	0.05	0	0.20	0.00	0.00	0.00	0.00
06:00-07:00	0.05	0	0.00	0.00	0.00	0.00	0.00
07:00-08:00	0.50	0	0.00	0.00	0.20	0.00	0.00
08:00-09:00	0.75	1	0.00	0.20	0.60	1.00	1.00
09:00-10:00	1.00	1	0.00	0.30	0.60	1.00	1.00
10:00-11:00	1.00	1	0.00	0.30	0.80	1.00	1.00
11:00-12:00	1.00	1	0.00	0.30	0.80	1.00	1.00
12:00-13:00	0.75	1	0.00	0.25	0.70	1.00	1.00
13:00-14:00	1.00	1	0.00	0.25	0.80	1.00	1.00
14:00-15:00	1.00	1	0.00	0.25	0.80	1.00	1.00
15:00-16:00	1.00	1	0.00	0.25	0.70	1.00	1.00
16:00-17:00	1.00	1	0.00	0.25	0.70	1.00	1.00
17:00-18:00	1.00	1	0.00	0.10	0.50	1.00	1.00
18:00-19:00	0.50	1	0.50	0.01	0.20	1.00	1.00
19:00-20:00	0.50	1	0.50	0.01	0.20	1.00	1.00
20:00-21:00	0.50	1	0.50	0.01	0.20	1.00	1.00
21:00-22:00	0.30	0	0.50	0.01	0.10	1.00	1.00
22:00-23:00	0.05	0	0.20	0.01	0.01	0.00	0.00
23:00-24:00	0.05	0	0.20	0.01	0.01	0.00	0.00

Table 9-24: 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			
	Days/ 7 week	Days/ 5 week	Days/ 5 week	Days/ 5 week	Days/ 7 week	Days/ 7 week	Days/ 7 week
00:00-01:00	0.00	0	0	0	0.80	0.00	0.05
01:00-02:00	0.00	0	0	0	0.80	0.00	0.05
02:00-03:00	0.00	0	0	0	0.80	0.00	0.05
03:00-04:00	0.00	0	0	0	0.80	0.00	0.05
04:00-05:00	0.00	0	0	0	0.80	0.00	0.05
05:00-06:00	0.00	0	0	0	0.80	0.00	0.05
06:00-07:00	0.05	0	0	1	0.00	0.00	0.05
07:00-08:00	0.80	1	1	1	0.00	0.00	0.05
08:00-09:00	0.80	1	1	1	0.00	1.00	1.00
09:00-10:00	0.25	1	1	1	0.00	1.00	1.00
10:00-11:00	0.25	1	1	1	0.00	1.00	1.00
11:00-12:00	0.25	1	1	1	0.00	1.00	1.00
12:00-13:00	0.25	1	1	1	0.00	1.00	1.00
13:00-14:00	0.90	1	1	1	0.00	1.00	1.00
14:00-15:00	0.60	0	1	1	0.00	1.00	1.00
15:00-16:00	0.20	0	1	0	0.00	1.00	1.00
16:00-17:00	0.30	0	1	0	0.00	1.00	1.00
17:00-18:00	0.40	0	0	0	0.00	1.00	0.50
18:00-19:00	0.00	0	0	0	0.80	0.00	0.05
19:00-20:00	0.00	0	0	0	0.80	0.00	0.05
20:00-21:00	0.00	0	0	0	0.80	0.00	0.05
21:00-22:00	0.00	0	0	0	0.80	0.00	0.05
22:00-23:00	0.00	0	0	0	0.80	0.00	0.05
23:00-24:00	0.00	0	0	0	0.80	0.00	0.05

Table 9-25: 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 9-26: Schedules for Educational - University Building (A)

Educational – University Buildings									
Time Period	Elevator Schedule		HVAC Fan Schedule (On/Off)				Lighting External 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
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 9-27: Schedules for Educational - University Buildings (B)

Educational – University Buildings											
Time Period	Occupancy Schedule				Lighting Schedule				Equipment Schedule		
	Student Zone	Back Office	Library & Computer Centre	Corridor/ Lobby	Student Zone	Back Office	Library & Computer Centre	Corridor/ Lobby	Student Zone	Back Office	Library & Computer Centre
	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
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 9-28: Schedules for Hospitality Buildings (A)

Hospitality									
Time Period	Elevator Schedule		External Lighting Schedule	Service Hot Water (SHW)				Basement Ventilation	Basement Lighting
				Guest rooms		Kitchen	Laundry		
	Week Days	Weekends	7 Days/ week	Week Days	Weekends	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week
00:00-01:00	0.10	0.10	1.00	0.01	0.01	0.00	0.00	0.50	0.50
01:00-02:00	0.10	0.10	1.00	0.01	0.01	0.00	0.00	0.50	0.50
02:00-03:00	0.10	0.10	1.00	0.01	0.01	0.00	0.00	0.50	0.50
03:00-04:00	0.10	0.10	1.00	0.01	0.01	0.00	0.00	0.50	0.50
04:00-05:00	0.10	0.10	1.00	0.01	0.01	0.00	0.00	0.50	0.50
05:00-06:00	0.20	0.20	1.00	0.01	0.01	0.00	0.00	0.50	0.50
06:00-07:00	0.40	0.50	0.00	0.50	0.70	0.60	0.00	0.50	0.50
07:00-08:00	0.50	0.60	0.00	0.50	0.70	0.80	0.00	0.50	0.50
08:00-09:00	0.50	0.60	0.00	0.30	0.50	0.80	1.00	1.00	1.00
09:00-10:00	0.35	0.40	0.00	0.15	0.30	0.60	1.00	1.00	1.00
10:00-11:00	0.15	0.20	0.00	0.15	0.20	0.60	1.00	1.00	1.00
11:00-12:00	0.15	0.20	0.00	0.15	0.20	0.80	1.00	1.00	1.00
12:00-13:00	0.15	0.20	0.00	0.15	0.20	0.80	1.00	1.00	1.00
13:00-14:00	0.15	0.20	0.00	0.15	0.20	0.80	1.00	1.00	1.00
14:00-15:00	0.15	0.20	0.00	0.15	0.20	0.60	1.00	1.00	1.00
15:00-16:00	0.15	0.20	0.00	0.15	0.20	0.60	1.00	1.00	1.00
16:00-17:00	0.35	0.40	0.00	0.15	0.20	0.60	0.00	1.00	1.00
17:00-18:00	0.50	0.60	0.00	0.30	0.30	0.80	0.00	1.00	1.00
18:00-19:00	0.50	0.60	1.00	0.50	0.50	0.80	0.00	1.00	1.00
19:00-20:00	0.50	0.60	1.00	0.50	0.70	0.80	0.00	1.00	1.00
20:00-21:00	0.50	0.60	1.00	0.65	0.70	0.80	0.00	1.00	1.00
21:00-22:00	0.30	0.40	1.00	0.65	0.90	0.80	0.00	0.50	0.50
22:00-23:00	0.20	0.30	1.00	0.01	0.01	0.60	0.00	0.50	0.50
23:00-24:00	0.10	0.10	1.00	0.01	0.01	0.60	0.00	0.50	0.50

Table 9-29: 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
07:00-08:00	0.50	0.70	0.30	0.40	0.40	0.70	0.30	0.30	0.20	0.20	0.00	0.80
08:00-09:00	0.30	0.50	0.40	0.70	0.40	0.70	0.30	0.30	0.20	0.20	0.20	0.80
09:00-10:00	0.15	0.30	0.40	0.70	0.40	0.70	0.30	0.30	0.95	0.50	0.50	0.50
10:00-11:00	0.15	0.20	0.40	0.70	0.40	0.70	0.30	0.30	0.95	0.50	0.90	0.50
11:00-12:00	0.15	0.20	0.40	0.70	0.20	0.30	0.30	0.30	0.95	0.50	0.90	0.80
12:00-13:00	0.15	0.20	0.40	0.70	0.20	0.30	0.80	0.80	0.95	0.50	0.90	0.80
13:00-14:00	0.15	0.20	0.20	0.20	0.20	0.30	0.80	0.80	0.50	0.30	0.90	0.80
14:00-15:00	0.15	0.20	0.20	0.20	0.20	0.30	0.80	0.80	0.95	0.50	0.90	0.50
15:00-16:00	0.15	0.20	0.20	0.20	0.40	0.70	0.30	0.30	0.95	0.50	0.90	0.50
16:00-17:00	0.15	0.20	0.20	0.20	0.40	0.70	0.30	0.30	0.95	0.50	0.90	0.50
17:00-18:00	0.30	0.30	0.40	0.40	0.40	0.70	0.30	0.30	0.95	0.50	0.50	0.80
18:00-19:00	0.50	0.50	0.40	0.40	0.50	0.70	0.50	0.50	0.30	0.30	0.20	0.80
19:00-20:00	0.50	0.70	0.40	0.40	0.80	0.70	0.80	0.90	0.20	0.20	0.20	0.80
20:00-21:00	0.65	0.70	0.30	0.30	0.90	0.70	0.80	0.90	0.20	0.20	0.00	0.80
21:00-22:00	0.65	0.90	0.20	0.20	0.80	0.70	0.80	0.90	0.20	0.20	0.00	0.80
22:00-23:00	0.65	0.90	0.10	0.10	0.60	0.60	0.80	0.90	0.20	0.20	0.00	0.50
23:00-24:00	0.65	0.90	0.10	0.10	0.30	0.30	0.50	0.90	0.20	0.20	0.00	0.50

Table 9-30: 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
07:00-08:00	0.55	0.40	0.30	0.40	0.50	0.30	0.50	0.50	0.30	0.30	0.00	0.30
08:00-09:00	0.45	0.55	0.40	0.70	0.40	0.40	0.50	0.50	0.90	0.60	0.50	0.90
09:00-10:00	0.20	0.20	0.40	0.70	0.20	0.40	0.50	0.50	0.90	0.60	0.80	0.90
10:00-11:00	0.20	0.20	0.40	0.70	0.20	0.40	0.50	0.50	0.90	0.60	0.90	0.90
11:00-12:00	0.20	0.20	0.40	0.70	0.20	0.40	0.50	0.50	0.90	0.60	0.90	0.90
12:00-13:00	0.20	0.20	0.40	0.70	0.20	0.40	0.90	0.90	0.90	0.60	0.90	0.90
13:00-14:00	0.20	0.20	0.40	0.40	0.20	0.40	0.90	0.90	0.50	0.50	0.90	0.50
14:00-15:00	0.20	0.20	0.40	0.40	0.20	0.40	0.90	0.90	0.90	0.60	0.90	0.90
15:00-16:00	0.20	0.20	0.40	0.40	0.20	0.40	0.50	0.50	0.90	0.60	0.90	0.90
16:00-17:00	0.20	0.20	0.40	0.40	0.20	0.40	0.50	0.50	0.90	0.60	0.90	0.90
17:00-18:00	0.30	0.30	0.40	0.40	0.25	0.40	0.50	0.50	0.95	0.60	0.50	0.95
18:00-19:00	0.70	0.85	0.40	0.40	0.60	0.60	0.90	0.90	0.50	0.50	0.50	0.95
19:00-20:00	0.90	1.00	0.40	0.40	0.80	0.70	0.90	0.90	0.30	0.30	0.50	0.95
20:00-21:00	1.00	1.00	0.30	0.30	0.90	0.70	0.90	0.90	0.30	0.30	0.00	0.95
21:00-22:00	0.90	1.00	0.40	0.40	0.80	0.70	0.90	0.90	0.20	0.20	0.00	0.95
22:00-23:00	0.70	0.85	0.30	0.30	0.60	0.60	0.90	0.90	0.10	0.10	0.00	0.95
23:00-24:00	0.30	0.40	0.30	0.30	0.30	0.30	0.90	0.90	0.05	0.05	0.00	0.95

Table 9-31: 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
09:00-10:00	0.20	0.20	0.50	0.60	0.60	0.95	0.70	0.50	0.30
10:00-11:00	0.20	0.20	0.35	0.60	0.60	0.95	0.70	0.90	0.30
11:00-12:00	0.20	0.20	0.35	0.60	0.60	0.95	0.70	0.90	0.30
12:00-13:00	0.20	0.20	0.35	0.80	0.80	0.95	0.70	0.90	0.30
13:00-14:00	0.20	0.20	0.35	0.80	0.80	0.50	0.70	0.90	0.30
14:00-15:00	0.20	0.20	0.35	0.80	0.80	0.95	0.70	0.90	0.30
15:00-16:00	0.20	0.20	0.35	0.60	0.60	0.95	0.70	0.90	0.30
16:00-17:00	0.20	0.20	0.35	0.60	0.60	0.95	0.70	0.90	0.30
17:00-18:00	0.30	0.30	0.35	0.60	0.60	0.95	0.70	0.50	0.30
18:00-19:00	0.50	0.50	0.70	0.80	0.80	0.30	0.30	0.50	0.30
19:00-20:00	0.50	0.50	0.90	0.80	0.90	0.10	0.10	0.50	0.30
20:00-21:00	0.50	0.70	0.90	0.80	0.90	0.10	0.10	0.00	0.30
21:00-22:00	0.70	0.70	0.90	0.80	0.90	0.10	0.10	0.00	0.30
22:00-23:00	0.40	0.40	0.70	0.80	0.90	0.05	0.05	0.00	0.30
23:00-24:00	0.20	0.20	0.40	0.80	0.90	0.05	0.05	0.00	0.30

Table 9-32: 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
	Days/ 7 week	Days/ 7 week	Days/ 7 week	Days/ 7 week	Days/ 7 week	Days/ 7 week	Days/ 7 week
00:00-01:00	1	0	0	0	0	0	0
01:00-02:00	1	0	0	0	0	0	0
02:00-03:00	1	0	0	0	0	0	0
03:00-04:00	1	0	0	0	0	0	0
04:00-05:00	1	0	0	0	0	0	0
05:00-06:00	1	1	1	0	0	0	1
06:00-07:00	1	1	1	1	0	0	1
07:00-08:00	1	1	1	1	0	0	1
08:00-09:00	1	1	1	1	1	1	1
09:00-10:00	1	1	1	1	1	1	1
10:00-11:00	1	1	1	1	1	1	1
11:00-12:00	1	1	1	1	1	1	1
12:00-13:00	1	1	1	1	1	1	1
13:00-14:00	1	1	1	1	1	1	1
14:00-15:00	1	1	1	1	1	1	1
15:00-16:00	1	1	1	1	1	1	1
16:00-17:00	1	1	1	1	1	1	1
17:00-18:00	1	1	1	1	1	1	1
18:00-19:00	1	1	1	1	1	1	1
19:00-20:00	1	1	1	1	0	1	1
20:00-21:00	1	1	1	1	0	1	1
21:00-22:00	1	1	1	1	0	0	1
22:00-23:00	1	0	1	1	0	0	1
23:00-24:00	1	0	1	1	0	0	1

Table 9-33: Schedules for Shopping Complexes Buildings (A)

Shopping Complex								
Time Period	HVAC Fan Schedule (ON/OFF)			External Lighting Schedule	Basement Ventilation	Basement Lighting	Elevator Schedule	
	Retail	Corridor & Atrium	Special Zones					
	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	Weekdays	Weekends
00:00-01:00	0	0	0	1.00	1.00	1.00	0.20	0.20
01:00-02:00	0	0	0	0.50	0.00	0.05	0.05	0.20
02:00-03:00	0	0	0	0.50	0.00	0.05	0.05	0.05
03:00-04:00	0	0	0	0.50	0.00	0.05	0.05	0.05
04:00-05:00	0	0	0	0.50	0.00	0.05	0.05	0.05
05:00-06:00	0	0	0	0.50	0.00	0.05	0.05	0.05
06:00-07:00	0	0	0	0.00	0.00	0.05	0.05	0.05
07:00-08:00	0	0	0	0.00	0.00	0.05	0.10	0.10
08:00-09:00	0	0	0	0.00	0.00	0.05	0.10	0.10
09:00-10:00	0	1	1	0.00	1.00	1.00	0.20	0.20
10:00-11:00	1	1	1	0.00	1.00	1.00	0.40	0.40
11:00-12:00	1	1	1	0.00	1.00	1.00	0.70	0.70
12:00-13:00	1	1	1	0.00	1.00	1.00	0.70	0.80
13:00-14:00	1	1	1	0.00	1.00	1.00	0.70	0.95
14:00-15:00	1	1	1	0.00	1.00	1.00	0.70	0.95
15:00-16:00	1	1	1	0.00	1.00	1.00	0.70	0.95
16:00-17:00	1	1	1	0.00	1.00	1.00	0.70	0.95
17:00-18:00	1	1	1	0.00	1.00	1.00	0.80	0.95
18:00-19:00	1	1	1	1.00	1.00	1.00	0.80	0.95
19:00-20:00	1	1	1	1.00	1.00	1.00	0.80	0.95
20:00-21:00	1	1	1	1.00	1.00	1.00	0.80	0.95
21:00-22:00	0	1	1	1.00	1.00	1.00	0.80	0.80
22:00-23:00	0	1	1	1.00	1.00	1.00	0.50	0.60
23:00-24:00	0	1	1	1.00	1.00	1.00	0.30	0.40

Table 9-34: Schedules for Shopping Complexes Buildings (B)

Shopping Complex											
Time Period	Occupancy Schedule						Lighting Schedule			Equipment Schedule	
	Retail		Corridors & Atrium		Special Zone		Retail	Corridors & Atrium	Special Zone	Retail	Special Zone
	Weekday	Weekend	Weekday	Weekend	Weekday	Weekend	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week	7 Days/ week
00:00-01:00	0.00	0.00	0.00	0.10	0.00	0.00	0.05	0.05	0.05	0.05	0.05
01:00-02:00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.05	0.05
02:00-03:00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.05	0.05
03:00-04:00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.05	0.05
04:00-05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.05	0.05
05:00-06:00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.05	0.05
06:00-07:00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.05	0.05
07:00-08:00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.05	0.05
08:00-09:00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.05	0.50
09:00-10:00	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.05	0.50
10:00-11:00	0.40	0.40	0.40	0.40	0.20	0.20	0.50	0.50	0.40	0.90	0.90
11:00-12:00	0.60	0.60	0.60	0.60	0.30	0.50	0.95	0.50	0.60	0.90	0.90
12:00-13:00	0.60	0.70	0.60	0.70	0.50	0.70	0.95	0.50	0.60	0.90	0.90
13:00-14:00	0.60	0.90	0.60	0.90	0.50	0.70	0.95	0.50	0.60	0.90	0.90
14:00-15:00	0.70	0.90	0.70	0.90	0.50	0.70	0.95	0.50	0.60	0.90	0.90
15:00-16:00	0.70	0.90	0.70	0.90	0.50	0.80	0.95	0.50	0.40	0.90	0.90
16:00-17:00	0.70	0.90	0.70	0.90	0.50	0.80	0.95	0.70	0.40	0.90	0.90
17:00-18:00	0.70	0.90	0.70	0.90	0.50	0.80	0.95	0.95	0.40	0.90	0.90
18:00-19:00	0.90	0.95	0.90	0.95	0.60	0.95	0.95	0.95	0.80	0.90	0.90
19:00-20:00	0.90	0.95	0.90	0.95	0.60	0.95	0.95	0.95	0.80	0.90	0.90
20:00-21:00	0.90	0.95	0.90	0.95	0.60	0.95	0.95	0.95	0.80	0.50	0.90
21:00-22:00	0.00	0.00	0.40	0.40	0.60	0.95	0.05	0.50	0.80	0.05	0.90
22:00-23:00	0.00	0.00	0.30	0.30	0.60	0.95	0.05	0.30	0.80	0.05	0.90
23:00-24:00	0.00	0.00	0.10	0.10	0.30	0.95	0.05	0.30	0.80	0.05	0.90

Table 9-35: Schedules for Shopping Complexes Buildings – Food Court

Shopping Complex - Food Court												
Time Period	Occupancy Schedule			Lighting Schedule			Equipment Schedule			HVAC Fan Schedule		
	Family Dining	Food Preparation	Bar Lounge	Family Dining	Food Preparation	Bar Lounge	Family Dining	Food Preparation	Bar Lounge	Family Dining	Food Preparation	Bar Lounge
00:00-01:00	0.00	0.50	0.70	0.50	0.70	0.70	0.50	0.60	0.70	1	0	1
01:00-02:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0
02:00-03:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0
03:00-04:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0
04:00-05:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0
05:00-06:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0
06:00-07:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0
07:00-08:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0
08:00-09:00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0
09:00-10:00	0.00	0.20	0.00	0.00	0.50	0.00	0.00	0.60	0.00	0	0	0
10:00-11:00	0.20	0.50	0.00	0.50	0.70	0.00	0.60	0.70	0.00	0	1	0
11:00-12:00	0.20	0.80	0.00	0.50	0.90	0.00	0.60	0.70	0.00	1	1	0
12:00-13:00	0.70	0.80	0.00	0.90	0.90	0.00	0.80	0.70	0.00	1	1	0
13:00-14:00	0.70	0.80	0.00	0.90	0.90	0.00	0.80	0.70	0.00	1	1	0
14:00-15:00	0.70	0.80	0.00	0.90	0.90	0.00	0.80	0.70	0.00	1	1	0
15:00-16:00	0.20	0.50	0.00	0.50	0.70	0.00	0.60	0.40	0.00	1	1	0
16:00-17:00	0.20	0.30	0.00	0.50	0.50	0.00	0.60	0.40	0.00	1	1	1
17:00-18:00	0.20	0.30	0.50	0.50	0.50	0.70	0.60	0.40	0.70	1	1	1
18:00-19:00	0.50	0.50	0.70	0.90	0.70	0.80	0.80	0.40	0.70	1	1	1
19:00-20:00	0.80	0.90	0.80	0.90	0.90	0.80	0.80	0.70	0.70	1	1	1
20:00-21:00	0.80	0.90	0.80	0.90	0.90	0.80	0.80	0.70	0.70	1	1	1
21:00-22:00	0.80	0.90	0.80	0.90	0.90	0.80	0.80	0.70	0.70	1	1	1
22:00-23:00	0.80	0.90	0.80	0.90	0.90	0.80	0.80	0.70	0.70	1	1	1
23:00-24:00	0.50	0.50	0.80	0.90	0.90	0.80	0.80	0.40	0.70	1	1	1

Table 9-36: 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
16:00-17:00	0.70	0.90	0.95	0.90	1	0.70	0.95	0.00	1.00	1.00
17:00-18:00	0.70	0.90	0.95	0.90	1	0.80	0.95	0.00	1.00	1.00
18:00-19:00	0.90	0.95	0.95	0.90	1	0.80	0.95	1.00	1.00	1.00
19:00-20:00	0.90	0.95	0.95	0.90	1	0.80	0.95	1.00	1.00	1.00
20:00-21:00	0.90	0.95	0.95	0.50	1	0.80	0.95	1.00	1.00	1.00
21:00-22:00	0.00	0.00	0.05	0.05	0	0.00	0.00	1.00	0.20	0.50
22:00-23:00	0.00	0.00	0.05	0.05	0	0.00	0.00	0.20	0.00	0.05
23:00-24:00	0.00	0.00	0.05	0.05	0	0.00	0.00	0.20	0.00	0.05

Appendices

10. Appendix A: Default Values for Typical Constructions

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

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

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

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

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

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

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

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

For U-factor calculations:

T_{in} = 24 °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.

10.2 Default U-factors, Visible Light Transmittance and Solar Heat Gain Coefficients for Unrated Fenestration Products

All fenestration with U-factors, SHGC, or visible light transmittance determined, certified, and labeled in accordance ISO 15099 shall be assigned those values.

10.2.1 Unrated Vertical Fenestration.

For unrated vertical fenestration, both operable and fixed, the glass VLT reported by manufacturer must meet or exceed 0.37 (as it accounts for framing). The SHGC values reported by glass manufacturer must meet or exceed the prescriptive requirements in Table 4-10 and Table 4-11 for compliance.

U-factors for unrated vertical fenestration, both operable and fixed, shall be assigned as per Table 10-1.

Table 10-1 Defaults for Unrated Fenestration (Overall Assembly including the Sash and Frame)

Frame Type	*Glazing Type*	*U-Factor ($W/m^2.K$)*
All frame types	Single Glazing	7.1
Wood, vinyl, or fiberglass frame or metal frame with thermal break	Double Glazing (COG U value >1.6 $W/m^2.K$)	3.4
Wood, vinyl, or fiberglass frame or metal frame with thermal break	Double Glazing (COG U value <1.6 $W/m^2.K$)	3.0
Metal and other frame type	Double Glazing	5.1

10.3 Typical Roof Constructions

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

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

where

$U_{TotalRoof}$	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

10.4 Typical Wall Constructions

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

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

where

$U_{TotalWall}$	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 10-2 Typical Thermal Properties of Common Building and Insulating Materials[2,a]

Description	Density	Conductivity[b] k,	esistance R,	Specific Heat,
	kg/m3	W/(m·K)	(m^2·K)/W	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-base sheathing[e] 12.7 mm	400	-	0.19	1.3
Shingle backer 9.5 mm	290	-	0.17	1.3
Sound deadening board. 12.7 mm	240	-	0.24	1.26
Tile and lay-in panels, plain or acoustic	290	0.058	-	0.59
Laminated paperboard	480	0.072	-	1.38
Homogeneous board from repulped paper	480	0.072	-	1.17
Hardboard[e]				
Medium density	800	0.105	-	1.3
High density, service-tempered	880	0.12	-	1.34
Grade and service grade				
High density, standard-tempered grade	1010	0.144	-	1.34
Particleboard[e]				

[2] ASHRAE- Handbook of Fundamentals

Low density	590	0.102	-	1.3
Medium density	800	0.135	-	1.3
High density	1000	0.18	-	-
Underlayment 15.9 mm	640	-	1.22	1.21
Waferboard	700	0.072	-	1.88
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/m^2 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[c,d]				
Glass-fiber batts 85 to 90 mm	10 to 14	0.043	-	0.84
Glass-fiber batts 50 mm	8 to 13	0.045 to 0.048	-	0.84
Mineral fiber 140 mm	30	0.036	-	0.84
Mineral wool, felted	16 to 48	0.04	-	-
	65 to 130	0.035	-	-
Slag wool .	50 to 190	0.038	-	-
	255	0.04	-	-
	305	0.043	-	-
	350	0.048	-	-
	400	0.05	-	-
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[g]	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)[d] approx. 95 to 130 mm	10 to 30	-	1.92	0.71
Mineral fiber (rock, slag, or glass)[d] approx. 170 to 220 mm	11 to 30	-	3.33	-
Mineral fiber (rock, slag, or glass)[d] approx. 190 to 250 mm	12 to 30	-	3.85	-
Mineral fiber (rock, slag, or glass)[d] approx. 260 to 350 mm	13 to 30	-	5.26	-
Mineral fiber (rock, slag, or glass)[d] 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
	40	0.026	-	1.47
Polyurethane foam (low density) aged and dry 40 mm	30	-	1.6	1.47
Polyurethane foam (low density) 50 mm	55	-	1.92	1.47
Polyurethane foam (low density) 120 mm	30	-	3.69	-
Ureaformaldehyde foam, dry	8 to 20	0.030 to 0.032	-	-
Roofing				
Asbestos/cement shingles	1120	-	0.037	1
Asphalt (bitumen with inert fill)	1600	0.43	-	-
	1900	0.58	-	-
	2300	1.15	-	-
Asphalt roll roofing	920	-	0.027	1.51
Asphalt shingles	920	-	0.078	1.26
Built-up roofing	920	-	0.059	1.47
Mastic asphalt (heavy, 20% grit)	950	0.19	-	-
Reed thatch	270	0.09	-	-
Roofing felt	2250	1.2	-	-
Slate 13 mm	-	-	0.009	1.26
Straw thatch	240	0.07	-	-

Wood shingles, plain and plastic-film-faced	-	-	0.166	1.3
Plastering Materials				
Cement plaster, sand aggregate	1860	0.72	-	0.84
Sand aggregate 10 mm	-	-	0.013	0.84
Sand aggregate 20 mm	-	-	0.026	0.84
Gypsum plaster	1120	0.38	-	-
	1280	0.46	-	-
Lightweight aggregate	720	-	0.056	-
Lightweight aggregate	720	-	0.066	-
Lightweight aggregate	-	-	0.083	-
Perlite aggregate	720	0.22	-	1.34
Sand aggregate	1680	0.81	-	0.84
Sand aggregate on metal lath 19 mm	-	-	0.023	-
Vermiculite aggregate	480	0.14	-	-
	600	0.2	-	-
	720	0.25	-	-
	840	0.26	-	-
	960	0.3	-	-
Perlite plaster	400	0.08	-	-
	600	0.19	-	-
Pulpboard or paper plaster	600	0.07	-	-
Sand/cement plaster, conditioned	1560	0.63	-	-
Sand/cement/lime plaster, conditioned	1440	0.48	-	-
Sand/gypsum (3:1) plaster, conditioned	1550	0.65	-	-
Masonry Materials				
Masonry units				
Brick, fired clay	2400	1.21 to 1.47	-	-
	2240	1.07 to 1.30	-	-
	2080	0.92 to 1.12	-	-
	1920	0.81 to 0.98	-	0.8
	1760	0.71 to 0.85	-	-
	1600	0.61 to 0.74	-	-
	1440	0.52 to 0.62	-	-
	1280	0.43 to 0.53	-	-
	1120	0.36 to 0.45	-	-
Clay tile, hollow 1 cell deep 75 mm	-	-	0.14	0.88
Clay tile, hollow 1 cell deep 100 mm	-	-	0.2	-
Clay tile, hollow 2 cells deep 150 mm	-	-	0.27	-

Clay tile, hollow 2 cells deep 200 mm	-	-	0.33	-
Clay tile, hollow 2 cells deep 250 mm	-	-	0.39	-
Clay tile, hollow 3 cells deep 300 mm	-	-	0.44	-
Lightweight brick	800	0.2	-	-
	770	0.22	-	-
Concrete blocks[h,i] Limestone aggregate ~200 mm, 16.3 kg, 2200 kg/m^3 concrete, 2 cores ..	-	-	-	-
Concrete blocks[h,i] Limestone aggregate ~200 mm, 16.3 kg, 2200 kg/m^3 concrete with perlite-filled cores	-	-	0.37	-
Concrete blocks[h,i] Limestone aggregate ~300 mm, 25 kg, 2200 kg/m^3 concrete, 2 cores	-		-	-
Normal-weight aggregate (sand and gravel)~200 mm, 16 kg, 2100 kg/m^3 concrete, 2 or 3 cores ..	-	-	0.20 to 0.17	0.92
Normal-weight aggregate (sand and gravel)~200 mm, 16 kg, 2100 kg/m^3 with perlite-filled cores	-	-	0.35	-
Normal-weight aggregate (sand and gravel)~200 mm, 16 kg, 2100 kg/m^3 with vermiculite-filled cores	-	-	0.34 to 0.24	-
Normal-weight aggregate (sand and gravel)~200 mm, 16 kg, 2100 kg/m^3 ~300 mm, 22.7 kg, 2000 kg/m^3 concrete, 2 cores ..	-	-	0.217	0.92
Medium-weight aggregate (combinations of normal and lightweight aggregate) ~200 mm, 13 kg, 1550 to 1800 kg/m^3 concrete, 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/m^3 with perlite-filled cores	-	-	0.65 to 0.41	-
Medium-weight aggregate (combinations of normal and lightweight aggregate) ~200 mm, 13 kg, 1550 to 1800 kg/m^3 with vermiculite-filled cores	-	-	0.58	-
Medium-weight aggregate (combinations of normal and lightweight aggregate) ~200 mm, 13 kg, 1550 to 1800 kg/m^3 with molded-EPS-filled (beads) cores	-	-	0.56	-
Medium-weight aggregate (combinations of normal and lightweight aggregate) ~200 mm, 13 kg, 1550 to 1800 kg/m^3 with molded EPS inserts in cores	-	-	0.47	-
Low-mass aggregate (expanded shale, clay, slate or slag, pumice) ~150 mm, 7 1/2 kg, 1400 kg/m^{2}concrete, 2 or 3 cores	-	-	0.34 to 0.29	-
Low-mass aggregate (expanded shale, clay, slate or slag, pumice) ~150 mm, 7 1/2 kg, 1400 kg/m^{2}with perlite-filled cores	-	-	0.74	-

Low-mass aggregate (expanded shale, clay, slate or slag, pumice) ~150 mm, 7 1/2 kg, 1400 kg/m^{2}with vermiculite-filled cores	-	-	0.53	-
Low-mass aggregate (expanded shale, clay, slate or slag, pumice) 200 mm, 8 to 10 kg, 1150 to 1380 kg/m^2 concrete	-	-	0.56 to 0.33	0.88
Low-mass aggregate (expanded shale, clay, slate or slag, pumice) 200 mm, 8 to 10 kg, 1150 to 1380 kg/m^2 concrete with perlite-filled cores	-	-	1.20 to 0.77	-
Low-mass aggregate (expanded shale, clay, slate or slag, pumice) 200 mm, 8 to 10 kg, 1150 to 1380 kg/m^2 concrete with vermiculite-filled cores	-	-	0.93 to 0.69	-
Low-mass aggregate (expanded shale, clay, slate or slag, pumice) 200 mm, 8 to 10 kg, 1150 to 1380 kg/m^2 concrete with molded-EPS-filled (beads) cores	-	-	0.85	-
Low-mass aggregate (expanded shale, clay, slate or slag, pumice) 200 mm, 8 to 10 kg, 1150 to 1380 kg/m^2 concrete with UF foam-filled cores	-	-	0.79	-
Low-mass aggregate (expanded shale, clay, slate or slag, pumice) 200 mm, 8 to 10 kg, 1150 to 1380 kg/m^2 concrete with molded EPS inserts in cores	-	-	0.62	-
Low-mass aggregate (expanded shale, clay, slate or slag, pumice) 300 mm, 16 kg, 1400 kg/m^3,concrete, 2 or 3 cores	-	-	0.46 to 0.40	-
Low-mass aggregate (expanded shale, clay, slate or slag, pumice) 300 mm, 16 kg, 1400 kg/m^3,with perlite-filled cores	-	-	1.6 to 1.1	-
Low-mass aggregate (expanded shale, clay, slate or slag, pumice) 300 mm, 16 kg, 1400 kg/m^3,with vermiculite-filled cores	-	-	1	-
Stone, lime, or sand	2800	10.4	-	-
Quartzitic and sandstone	2560	6.2	-	-
	2240	3.46	-	-
	1920	1.88	-	0.88
Calcitic, dolomitic, limestone, 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				
Sand and gravel or stone aggregate concretes (concretes with >50% quartz or quartzite sand have conductivities in higher end of range)	2400	1.4 to 2.9	-	-
	2240	1.3 to 2.6	-	0.80 to 1.00
	2080	1.0 to 1.9	-	-
Low-mass aggregate or limestone concretes	1920	0.9 to 1.3	-	-
Low-mass aggregate or limestone concretes Expanded shale, clay, or slate; expanded slags ;cinders; pumice (with density up to 1600 kg/m^3); scoria (sanded concretes have conductivities in higher end of range)	1600	0.68 to 0.89	-	0.84
	1280	0.48 to 0.59	-	0.84
	960	0.30 to 0.36	-	-
	640	0.18	-	-
Gypsum/fiber concrete (87.5% gypsum, 12.5% wood chips)	800	0.24	-	0.84
Cement/lime, mortar, and stucco	1920	1.4	-	-
	1600	0.97	-	-
	1280	0.65	-	-
Perlite, vermiculite, and polystyrene beads	800	0.26 to 0.27	-	-
	640	0.20 to 0.22	-	0.63 to 0.96
	480	0.16	-	-
	320	0.12	-	-
Foam concretes	1920	0.75	-	-
	1600	0.6	-	-
	1280	0.44	-	-
	1120	0.36	-	-
Foam concretes and cellular concretes	960	0.3	-	-
	640	0.2	-	-
	320	0.12	-	-
Aerated concrete (oven-dried)	430 to 800	0.2	-	0.84
Polystyrene concrete (oven-dried)	255 to 800	0.37	-	0.84
Polymer concrete	1950	1.64	-	-
	2200	1.03	-	-
Polymer cement	1870	0.78	-	-
Slag concrete	960	0.22	-	-
	1280	0.32	-	-
	1600	0.43	-	-
	2000	1.23	-	-

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	0.1	-	-
Douglas fir/larch	535 to 580	0.14 to 0.15	-	-
Southern cypress	500 to 515	0.13	-	-
Hem/fir, spruce/pine/fir	390 to 500	0.11 to 0.13	-	-
Spruce	400	0.09	-	-
Western red cedar	350	0.09	-	-
West coast woods, cedars	350 to 500	0.10 to 0.13	-	-
Eastern white cedar	360	0.1	-	-
California redwood	390 to 450	0.11 to 0.12	-	-
Pine (oven-dried)	370	0.092	-	1.88
Spruce (oven-dried)	395	0.1	-	1.88

[a]Values are for mean temperature of 24°C. Representative values for dry materials are intended as design (not specification) values for materials in normal use. Thermal values of insulating materials may differ from design values depending on in-situ properties (e.g., density and moisture content, orientation, etc.) and manufacturing variability. For properties of specific product, use values supplied by manufacturer or unbiased tests.

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

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

[d]Conductivity varies with fiber diameter. Batt, blanket, and loose-fill mineral fiber insulations are manufactured to achieve specified R-values, the most common of which are listed in the table. Because of differences in manufacturing processes and materials, the product thicknesses, densities, and thermal conductivities vary over considerable ranges for a specified R-value.

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

[f]Cellular phenolic insulation may no longer be manufactured. Thermal conductivity and resistance values do not represent aged insulation, which may have higher thermal conductivity and lower thermal resistance.

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

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

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

[j]Values for metal or vinyl siding applied over flat surfaces vary widely, depending on ventilation of the airspace beneath the siding; whether airspace is reflective or nonreflective; and on thickness, type, and application of insulating backing-board used. Values are averages for use as design guides, and were obtained from several guarded hot box tests (ASTM *Standard* C236) or calibrated hot box (ASTM *Standard* C976) on hollow-backed types and types made using backing of wood fiber, foamed plastic, and glass fiber. Departures of ±50% or more from these values may occur.

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

[l]See Adams (1971), MacLean (1941), and Wilkes (1979). Conductivity values listed are for heat transfer across the grain. Thermal conductivity of wood varies linearly with density, and density ranges listed are those normally found for wood species given. If

density of wood species is not known, use mean conductivity value. For extrapolation to other moisture contents, the following empirical equation developed by Wilkes (1979) may be used:

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

where ρ is density of moist wood in kg/m3, 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.

11. Appendix B: Climate Zone Map of India

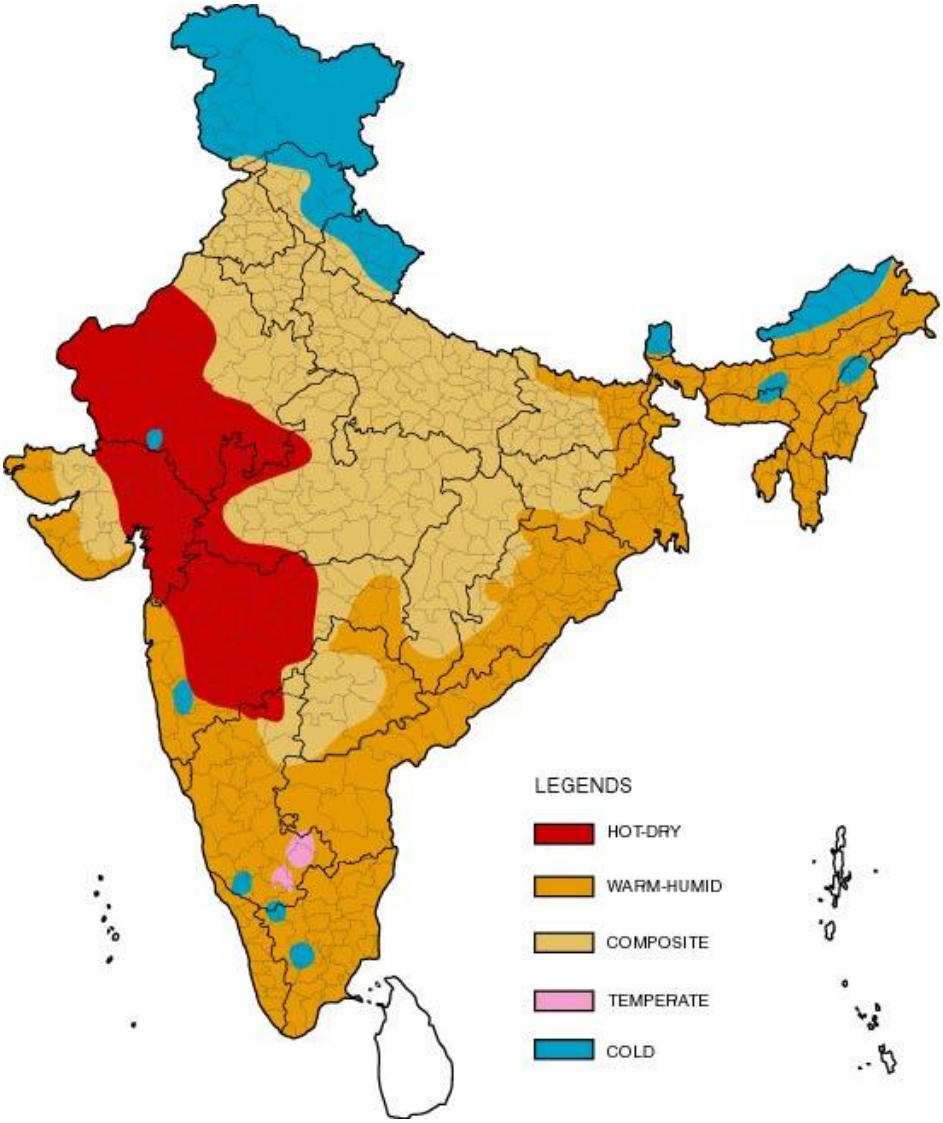


Table 11-1 Climate Zone for Major Indian Cities

City	Climate Type	City	Climate Type
Ahmedabad	Hot & Dry	Kurnool	Warm & Humid
Allahabad	Composite	Leh	Cold
Amritsar	Composite	Lucknow	Composite
Aurangabad	Hot & Dry	Ludhiana	Composite
Bangalore	Temperate	Chennai	Warm & Humid
Barmer	Hot & Dry	Manali	Cold
Belgaum	Warm & Humid	Mangalore	Warm & Humid
Bhagalpur	Warm & Humid	Mumbai	Warm & Humid
Bhopal	Composite	Nagpur	Composite
Bhubaneshwar	Warm & Humid	Nellore	Warm & Humid
Bikaner	Hot & Dry	New Delhi	Composite
Chandigarh	Composite	Panjim	Warm & Humid
Chitradurga	Warm & Humid	Patna	Composite
Dehradun	Composite	Pune	Warm & Humid
Dibrugarh	Warm & Humid	Raipur	Composite
Guwahati	Warm & Humid	Rajkot	Composite
Gorakhpur	Composite	Ramgundam	Warm & Humid
Gwalior	Composite	Ranchi	Composite
Hissar	Composite	Ratnagiri	Warm & Humid
Hyderabad	Composite	Raxaul	Warm & Humid
Imphal	Warm & Humid	Saharanpur	Composite
Indore	Composite	Shillong	Cold
Jabalpur	Composite	Sholapur	Hot & Dry
Jagdelpur	Warm & Humid	Srinagar	Cold
Jaipur	Composite	Sundernagar	Cold
Jaisalmer	Hot & Dry	Surat	Hot & Dry
Jalandhar	Composite	Tezpur	Warm & Humid
Jamnagar	Warm & Humid	Tiruchirappalli	Warm & Humid
Jodhpur	Hot & Dry	Trivandrum	Warm & Humid
Jorhat	Warm & Humid	Tuticorin	Warm & Humid
Kochi	Warm & Humid	Udhagamandalam	Cold
Kolkata	Warm & Humid	Vadodara	Hot & Dry
Kota	Hot & Dry	Veraval	Warm & Humid
Kullu	Cold	Vishakhapatnam	Warm & Humid

12. Appendix C: Air-Side Economizer Acceptance Procedures

12.1 Construction Inspection

Prior to Performance Testing, verify and document the following:

(a) System controls are wired correctly to ensure economizer is fully integrated (i.e. economizer will operate when mechanical cooling is enabled).
(b) Economizer lockout control sensor location is adequate (open to air but not exposed to direct sunlight nor in an enclosure; away from sources of building exhaust; at least 8 meters away from cooling towers).
(c) System is provided with barometric relief, relief fan or return fan to control building pressure.

12.2 Equipment Testing

Step 1: Simulate a cooling load and enable the economizer by adjusting the lockout control set point. Verify and document the following:

(a) Economizer damper modulates opens to 100% outside air.
(b) Return air damper modulates closed and is completely closed when economizer damper is 100% open.
(c) Economizer damper is 100% open before mechanical cooling is enabled.
(d) Relief fan or return fan (if applicable) is operating or barometric relief dampers freely swing open.

Step 2: Continue from Step 1 and disable the economizer by adjusting the lockout control set point. Verify and document the following:

(a) Economizer damper closes to minimum ventilation position.

(b) Return air damper opens to at or near 100%.

(c) Relief fan (if applicable) shuts off or barometric relief dampers close. Return fan (if applicable) may still operate even when economizer is disabled.

13. Appendix D: Compliance Forms

Envelope Summary

Energy Conservation Building Code 2017 Compliance Forms

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

Building Classification	☐ Hospitality	☐ Business
	☐ Health Care	☐ 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	◯ ECBC+ Compliant	◯ SuperECBC Compliant
		EPI Ratio	

Compliance Approach	Prescriptive Method	Whole Building Performance Method	Building Trade-off Method-Envelope Compliance

Building Envelope				
Vertical Fenestration Area Calculation	Total Vertical Fenestration Area (rough opening)	/	Gross Exterior Wall Area	X 100 = % Window to Wall Ratio (WWR)
			X 100 =	
Skylight Area Calculation	Total Skylight Area (rough opening)	/	Gross Exterior Roof Area	times 100 equals % Skylight to roof ratio (SRR)
		÷	X 100 =	

Opaque Assembly	
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 floor area meeting the UDI requirement for 90% of the potential daylit time in a year	

Fenestration	
Vertical	
Maximum U-factor	
Maximum SHGC (or SC)	
Minimum VLT	
Overhang / Sidefins / Box Frame Projection (yes or no)	
If yes, enter Projection Factor for each orientation and effective SHGC	
Skylight	
Maximum U-factor	
Maximum SHGC (or SC)	

Envelope Checklist

Energy Conservation Building Code 2017 Compliance Forms

Project Address		Date	

Applicability			Code Section	Component	Information Required	Location on Plans	Building Department Notes
Yes	No	N/A					
Mandatory Provisions (Section 4.2)							
			4.2.1	Fenestration			
			4.2.1.1	U-factor	Specify reference standard		
			4.2.1.2	SHGC	Specify reference standard		
			4.2.1.3	Visible light transmittance	Specify reference standard		
			4.2.2	Opaque Construction			
			4.2.2.1	U-factors	Specify reference standard		
			4.2.2.2	Solar Reflectance	Specify reference standard		
			4.2.2.3	Emittance	Specify reference standard		
			4.2.3	Daylighting	Specify simulation approach or prescriptive		
			4.2.4	Building envelope sealing	Indicate sealing, caulking, gasketing, and weather stripping		

Prescriptive Compliance Option (Section 4.3)							
			4.3.1	Roofs	Specify implemented U factor		
			4.3.1.1	Vegetative cool roof	Specify the solar reflectance, emittance, and reference standards		
			4.3.2	Opaque External Wall	Specify implemented U factor		
			4.3.3	Vertical fenestration	(1) Indicate U-factors on fenestration schedule. Indicate if values are rated or default. If values are default, then specify frame type, glazing layers, gapwidth, low-e. (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 specifications		
			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.		

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

Comfort System and Control Summary

Energy Conservation Building Code 2017 Compliance Forms

Project Info	Project Address:	Date
		For Building Department Use
	Project Built-up Area (sq.m):	
	Project Above-grade area (sq.m):	
	Project Conditioned Area (sq.m):	
	Applicant Name and Address:	
	Project Climatic Zone:	

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

Compliance Option	System efficiency	Prescriptive Method	Whole Building Performance Method

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

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

Heating Equipment Schedule								
Equip. ID	Brand Name	Model No.	Capacity kW	Testing Standards	OSA CFM 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

Energy Conservation Building Code 2017 Compliance Forms

Project Address	Date

The following information is necessary to check a building permit application for compliance with the mechanical requirements in the Energy Conservation Building Code.

Applicability			Code Section	Component	Information Required	Location on Plans	Building Department Notes
Yes	No	N/A					
Comfort Systems and Control							
Mandatory Provisions (Section 5.2)							
			5.2.1	Ventilation	Indicate all habitable spaces are ventilated with outdoor air in accordance with § 5.2.1 and guidelines specified in NBC		
			5.2.2	Minimum Space Conditioning Equipment Efficiencies	Provide equipment schedule with type, capacity, efficiency		
			5.2.3	Controls			
			5.2.3.1	Timeclock	Indicate thermostat with night setback, 3 different day types per week, and 2-hour manual override, capable of retaining programming and time setting during loss of power for a period of at least 10 hours		
			5.2.3.2	Temperature Controls	Indicate temperature control with 3°C deadband minimum if the system provides both heating and cooling.		
					Indicate thermostats are interlocked to prevent simultaneous heating and cooling, where separate heating and cooling systems are there		
					Indicate separate thermostat control for space types mentioned in § 5.2.3.2.(c)		
			5.2.3.3	Occupancy Controls	Indicate occupancy controls for space types mentioned in § 5.2.3.3		
			5.2.3.4	Fan Controls	Indicate two-speed motor, pony motor, or variable speed drive to control the fans and controls shall be capable to reduce the fan speed to at least two third of installed fan power		
			5.2.3.5	Dampers	Indicate all air supply and exhaust equipment's having VFD shall have dampers that automatically close upon the situations mentioned in § 5.2.3.5		
			5.2.4	Piping & ductwork	Indicate sealing, caulking, gasketing, and weatherstripping		
			5.2.4.1	Piping insulation	Indicate R-value of insulation		
			5.2.4.2	Ductwork and Plenum insulation	Indicate R-value of insulation		
			5.2.5	System Balancing	Show written balance report for HVAC systems serving zones with a total conditioned area exceeding 500 m2		
			5.2.6	Condensers	Indicate location of condenser and source of water used for condenser		
			5.2.7	Service Hot Water Heating			
			5.2.7.1	Solar Water Heating	Indicate all Hotels and hospitals have solar water heating equipment installed for hot water design capacity as per § 5.2.9.1		

			5.2.7.2	Heating Equipment Efficiency	Indicate service water heating equipment shall meet the performance and efficiency as per § 5.2.9.2		
			5.2.7.3	Other Water Heating System	Indicate supplementary heating system is designed in consideration with § 5.2.9.3		
			5.2.7.4	Piping Insulation	Indicate the Piping insulation is compliant with § 5.2.6.1.		
			5.2.7.5	Heat Traps	Indicate vertical pipe risers serving water heaters and storage tanks are as per § 5.2.9.5		
			5.2.7.6	Swimming Pools	Indicate the heated pools are provided with a vapor retardent pool cover on the water surface and temperature control and minimum insulation value as per § 5.2.9.6		

Prescriptive Compliance Option (Section 5.3)							
			5.3.1	Chillers	Indicate chiller type, capacity, COP & IPLV		
			5.3.2	Pumps	Indicate pump type (Primary, secondary, and condenser), its total installed capacity and efficiency		
			5.3.3	Cooling Towers	Indicate cooling tower type and installed capacity		
			5.3.4	Boilers	Indicate boiler type, capacity and efficiency		
			5.3.5.1	Air-Economizer (ECBC/ECBC+/SuperECBC)	Indicate air economizer is capable of modulating outside-air and return-air dampers to supply 50% of design supply air quantity as outside-air for respective building type.		
			5.3.5.1	Water-economizer (ECBC/ECBC+/SuperECBC)	Indicate water economizer is capable of providing 50% of the expected system cooling load at outside air temperatures of 10°C dry-bulb/7.2°C wet-bulb and below, if the designed building is a respective building type.		
			5.3.5.2	Partial Cooling	Indicate where required by § 5.3.4 economizers shall be capable of providing partial cooling even when additional mechanical cooling is required to meet the cooling load.		
			5.3.5.3	Economizer Controls	Indicate air economizers are equipped with controls as specified in § 5.3.4.4		
			5.3.5.4	Testing	Indicate air-side economizers have been tested as per the requirement specified		
			5.3.6	Variable Flow Hydronic Systems			
			5.3.6.1	Variable Fluid Flow	Indicate design flow rate of HVAC pumping system		
			5.3.6.2	Isolation Valves	Indicate water cooled air-conditioning have two-way automatic isolation valves and pump motors greater than or equal to 3.7 kW is controlled by variable speed drives		
			5.3.6.3	Variable Speed Drives	Indicate Chilled water or condenser water systems comply with either § 5.3.5.1 or § 5.3.5.2		
			5.3.7	Unitary, Split, Packaged Air-Conditioners	Indicate the type of system, cooling capacity.		
			5.3.8	Controls for ECBC+ & SuperECBC Building			
			5.3.8.1	Centralized Demand Shed Controls	Indicate the building has a Building Management System, with all Mechanical cooling and heating systems having PLC to the zone level shall have the control capabilities mentioned in § 5.2.4.1		
			5.3.8.2	Supply Air temperature reset	Indicate multi zone mechanical cooling and heating systems shall have controls to automatically reset supply air temperature in response to building loads or outdoor air		

					temperature by at least 25% of the difference between design supply air temperature and the design room air temperature.		
			5.3.8.3	Chilled Water Temperature	Indicate chilled water systems exceeding 350 kW shall have controls to automatically reset supply water temperatures by representative building loads or by outdoor air temperature		
			5.3.9	Controls for SuperECBC Building	Indicate that the mechanical systems comply with § 5.2.4 and § 5.2.5		
			5.3.9.1	Variable Air Volume Fan Control	Indicate Fans in VAV systems shall have controls or devices to limit fan motor demand as per § 5.2.5.1		
			5.3.10	Heat Recovery	Indicate for all Hospitality and Healthcare, heat recovery effectiveness, and efficiency of oil and gas fired boilers		
			5.3.11	Service Water Heating	Indicate all Buildings, Hotels and hospitals have solar water heating equipment installed for hot water design capacity as per § 5.3.11		
			5.3.12	Total System Efficiency-Alternate Compliance approach	Attach simulation report		
			5.3.13	Low Energy Comfort Systems	Indicate system type and list the exemption claimed		

Lighting and Controls Summary

Energy Conservation Building Code 2017 Compliance Forms

Project Info	Project Address:	Date
		For Building Department 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	Allowed x 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, Section 6.3.5)

Location	Description	Allowed Watts per m^2 or per lm	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 & Controls Checklist

Energy Conservation Building Code 2017 Compliance Forms

Project Address						Date	
The following information is necessary to check a building permit application for compliance with the lighting requirements in the Energy Conservation Building Code 2017.							
Applicability			Code Section	Component	Information Required		
Yes	No	N/A				Location on Plans	Building Department Notes
Lighting and Controls							
Mandatory Provisions (Section 6.2)							
			6.2.1	Lighting Controls			
			6.2.1.1	Automatic shutoff	Indicate automatic shutoff locations or occupancy sensors		
			6.2.1.2	Space control	Provide schedule with type, indicate locations		
			6.2.1.3	Control in Daylight Areas	Provide manual or automatic control device schedule with type and features, indicate locations		
			6.2.1.4	Ext. lighting control	Indicate photosensor or astronomical time switch		
			6.2.1.5	Additional control	Provide schedule with type, indicate locations		
			6.2.2	Exit signs	Indicate wattage per face of Exit signs		
Prescriptive Interior Lighting Power Compliance Option (Section 6.3)							
			6.3.1	LPD complaince	Indicate whether project is complying with the Building Area Method (6.3.2) or the Space Function Method (6.3.3)		
			6.3.2	Building area method	Provide lighting schedule with wattage of lamp and ballast and number of fixtures. Document all exceptions.		
			6.3.3	Space function method	Provide lighting schedule with wattage of lamp and ballast and number of fixtures. Document all exceptions.		
			6.3.4.1	Luminaire wattage	Indicate the wattage of installed luminaires on the floor plan. In case of luminaires containing permanently installed ballasts, the operating input wattage has to be provided, either from manufacturers catalogs or values from independent testing laboratory reports.		
			6.3.6	Controls_ECBC+ and SuperECBC Buildings	Provide centralized control system schedule with type and features, indicate locations		
Prescriptive Exterior Lighting Power Compliance Option (Section 6.3.5)							
			6.3.5	External light power	Provide lighting schedule with wattage of lamp and ballast and number of fixtures. Document all exceptions.		

Electrical and Renewable Energy Systems Summary

Energy Conservation Building Code 2017 Compliance Forms

Project Info	Project Address	Date
		For Building Department Use
	Project Built-up Area [m^2]	
	Project Above-grade Area [m^2]	
	Project Conditioned Area [m^2]	
	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 / Transformer	Losses at 50% Loading in kW	/ Losses at 100% Loading in kW
Diesel Generator Sets			
Star Rating of DG set	3 Star / 4 Star / 5 Star		
Uninterruptible Power Supply			
Efficiency at 100% Load			
Renewable Energy Systems			
Capacity and Type of newable Energy Installed			

Electrical and Renewable Energy Systems Checklist

Energy Conservation Building Code 2017 Compliance Forms

Project Address						Date	
The following information is necessary to check a building permit application for compliance with the Electrical and Renewable Energy requirements in the Energy Conservation Building Code.							
Applicability			Code Section	Component	Information Required	Location on Plans	Building Department Notes
Yes	No	N/A					
Electrical and Renewable Energy Systems							
Mandatory Provisions (Section 5.2)							
			7.2.1	Transformers			
			7.2.1.1	Maximum Allowable Power Transformer Losses	Provide losses at 50% load and 100% load, capacity and efficiency		
			7.2.1.2	Measurement and Reporting of Transformer Losses	For less than 500 kVA transformer meters are calibrated of 0.5 class accuracy and digital meters		
					For above 500 kVA additional Ct's and PT's are installed		
			7.2.1.3	Voltage Drop	Indicate the Voltage drop for feeders shall not exceed 2% at design load. Voltage drop for branch circuit shall not exceed 3% at design load.		
			7.2.2	Energy Efficient Motors	Indicate the motor class IE2/IE3/IE4.		
					Indicate the motors capacity more than 0.375 kW have efficiency according to the latest version of IS 12615.		
					Motor nameplate indicates nominal full-load motor efficiencies and full-load power factor.		
					Indicate the motor horsepower ratings does not exceed 20% of the calculated maximum load being served.		
			7.2.3	Diesel Generator Sets	Indicate the star rating of the Diesel Generator Set		
			7.2.4	Check-Metering and Monitoring	Indicate the services exceeding 1000 kVA have permanently installed electrical metring to record kVA, kWh and total power factor. And provision for display of current in each phase, voltage between each phase and between each phase and neutral and total harmonic distortion as a percentage of total current.		

					Indicate the services not exceeding 1000 kVA but over 65 kVA shall have permanently installed electric metering to record kW, kWh and power factor or kVARh on hourly basis.
					Indicate the services not exceeding 65 kVA shall have permanently installed electric metering to record kWh on hourly basis.
					Indicate in case of tenant based building, for recording metering should be provided at a location from where each tenant could attach the services.
			7.2.5	Power Factor Correction	Indicate that the power factor correction has been maintained at the point of connection.
			7.2.6	Power Distribution System	Indicate the power cable has been sized so that the distribution losses do not exceed the values mentioned in the code.
			7.2.7	Uninterruptible Power Supply	Indicate the UPS meets or exceed the energy efficiency requirements listed in the table 7-4.
			7.2.8	Renewable Energy Systems	Indicate the buildings have provision for installation of renewable energy systems in the future on rooftop or the site.
			7.2.8.1	Renewable Energy Generating Zone	Indicate a dedicated REGZ equivalent to at least 25 % of roof area or area required for generation of energy equivalent to 1% of total peak demand or connected load of the building, whichever is less, shall be provided in all buildings.
					Indicate the REGZ shall is free of any obstructions within its boundaries and from shadows cast by objects adjacent to the zone
			7.2.8.2	Main Electrical Service Panel	Indicate the minimum rating is displayed on the main electrical service panel. And space is reserved for the installation of double pole circuit breaker for future solar electric installation.
			7.2.8.3	Demarcation on Documents	Location for inverters and metering equipment, 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.

14. Appendix E: BEE approved list of software to show compliance[3]

Table 14-1 Bureau of Energy Efficiency Approved Software for Demonstrating Compliance with ECBC

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

[3] This is not an all-inclusive list. The current list of approved software is available at BEE website (https://www.beeindia.gov.in/).