

**GOVERNMENT OF ASSAM  
POWER (ELECTRICITY) DEPARTMENT  
DISPUR :: GUWAHATI**

**NOTIFICATION**

Dated Dispur, 25<sup>th</sup> February 2021

: In exercise of the powers conferred by clause (1) of section 57 read with clause (a) section 15 of the Energy Conservation Act, 2001 (Central Act 52 of 2001) , the Governor of Assam is hereby pleased to make the following rules in co-ordination with the Bureau of Energy Efficiency, namely: –

**1. Short title and commencement**

- (1) These rules may be called the Assam Energy Conservation Building Code Rules, 2020.
- (2) They shall come into force on the date of their publication in the Official Gazette.

**2. Definitions**

- (1) In these rules, unless the context otherwise requires, –
  - (a) “Act” means the Energy Conservation Act, 2001 (52 of 2001);
  - (b) “best practices” means those measures that allow for optimisation of efficiencies in the identified components and systems to enhance the energy efficiency of the building; or
    - (i) reduce the cost of construction having regard to the safety, stability of the building structure, health and environmental provisions of Central laws or Assam laws; and
    - (ii) includes energy conservation measures approved by the Assam Energy Conservation Building Code Implementation Committee or Assam Energy Conservation Building Code Compliant Technical Grievances Redressal Committee or National Energy Conservation Building Code Implementation Committee;
  - (c) “building complex” means a building or group of buildings constructed in a contiguous area for business, commercial, institutional purposes or assembly of 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;
  - (d) “built-up area” means the total covered areas on all floors of a building from the basement to all storeys covered by walls and parapet measured at the floor levels excluding parking;
  - (e) “bye-laws” means the building bye-laws framed by the Assam Government or any authority under its control to regulate the building

activities in its areas falling in the jurisdiction of –

- (i) all Municipal authorities or Committees or Councils;
- (ii) all Metropolitan areas or Nagar Panchayats;
- (iii) all areas covered under the Development or Planning authorities;

under various development plans notified by the Assam Government and enforced by such authority in its jurisdiction in which the Energy Conservation Building Code compliant building shall be located and includes any regulation or rule framed by the Assam Government or any other authority having jurisdiction established by the Assam Government;

(f) “Certified Energy Auditor (Building)” means a person who fulfils the eligibility criteria specified in the Energy Conservation (Minimum qualification for Energy Auditors and Energy Managers) Rules, 2006 and has qualified National Examination for Energy Conservation Building Codes Compliance;

(g) “Code” means the Assam Energy Conservation Building Code 2020 (Annexure-1) or the latest framed by the State Government under this Act;

(h) “compliance documents” mean the forms specified in Appendix D of the Code and includes certificates from Empanelled Energy Auditors (Building) to conform compliance with these rules,

(i) “connected load” means the total of the rated wattage of all equipment, appliances and devices to be installed or installed in the building or part of the building or building complexes in terms of kiloWatt (kW) that shall be allocated to all applicants for electric power consumption in respect of the proposed building or building complex, as the case may be, on their completion;

(j) “construction documents” mean drawings or documents containing information pertaining to building construction processes and approvals, building materials and equipment specification, architectural details required by the authority having jurisdiction;

(k) “contract demand” means the maximum demand in kiloWatt (kW) or 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;

(l) “Empanelled Energy Auditors (Building)” means a firm consisting of the Certified Energy Auditor certified under Bureau of Energy Efficiency (Certification Procedures for Energy Auditors and Energy Managers) Regulations, 2010 and Certified Energy Auditor (Building),

and empanelled with the Bureau;

(m) “energy conservation measures” mean the measures incorporated in the building design for saving energy, or enhancing comfort in peak electrical or thermal demand, or reducing cooling or heating load covering any element of a component with any other element of the same or other component of the Code and includes any such measure incorporated in the said building design of the proposed or existing building;

(n) “energy performance index” means annual energy consumption of a building in kiloWatt-hours per square meter of the area of the building which shall be calculated as per the following formula:

$$\text{Energy Performance Index} = \frac{\text{Annual energy consumption in kWh}}{\text{Total built up area (excluding storage area and the parking in the basement) in m}^2}$$

(o) “energy performance index ratio” means the ratio of the energy performance index of the proposed building to the energy performance index of the standard baseline building;

(p) “establishment” means a business or other organisation, or the place where an organisation operates and includes a Government establishment and private establishment;

(q) “form” means the forms appended to these rules;

(r) “owner” means a person, group of persons, a company, a trust, an institute, registered body, Assam Government or Central Government and its attached or sub-ordinate departments, undertakings and such other agencies or organisations in whose name the property stands registered in the revenue records for the construction of a building or building complex;

(s) “proposed design” means the computerised design of a building consistent with the actual design of a building which complies with all the requirements of the Code either through prescriptive or whole building performance method;

(t) “State designated agency” means the “Assam State Designated Agency” established under section 15(d) of the Energy Conservation Act, 2001 by the Government of Assam in consultation with the Bureau of Energy Efficiency vide notification no. NO.PEL 81/2002/45 dated 6<sup>th</sup> September 2002

(u) “Authority having jurisdiction” means the concerned municipal committee charged with releasing building permit/licences in the district

(v) “standard baseline design” means the standard design that complies with all the mandatory and prescriptive requirements of the Code and has the same built-up area of the proposed building;

(2) Words and expressions used herein and not defined, but defined in the

Act, or in the Code, shall have the meanings respectively assigned to them in the Act or in the said Code.

### 3. Application

These rules shall apply to every building, which is used or intended to be used for commercial purposes, having a connected load of 100 kiloWatt (kW) or above or a contract demand of 120 kilo-Volt Ampere (kVA) or above and such building shall cover the following components, namely: –

- (a) building envelope;
- (b) comfort systems and controls (heating, ventilation and air conditioning, service hot water system);
- (c) lighting and controls;
- (d) electrical and renewable energy systems;
- (e) any other system, as may be specified from time to time by the Bureau:

Provided that these rules shall not apply to equipment, appliances, devices and parts of building that use energy primarily for manufacturing processes.

Provided further that wherever these rules are in conflict with safety, security, health or environmental codes, or Bureau of Energy Efficiency's Standard and Labelling for equipment or appliances, and Star Rating Program for buildings, and if they are more stringent than the requirement of these rules then they shall prevail over these rules.

Provided, also, that 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 referred to in clauses (a) to (e) of this rule.

### 4. Compliance mechanism.

(1) The compliance of energy performance of a building shall be ensured by the owner by following either of the following methods, namely: –

- (a) Prescriptive Method – The building shall comply with the mandatory requirements and prescriptive requirements as specified in the Code for envelope components, comfort systems and controls, lighting and controls, electrical and renewable energy systems;
- (b) Whole Building Performance Method – The building shall comply with all mandatory measures and the requirements specified in the whole building performance method of the Code and the energy performance index of the proposed design under this method shall be the same or less than the energy performance index of the standard baseline design of building as follows:

$$\text{Energy Performance Index ratio} = \frac{\text{Energy Performance Index of proposed design}}{\text{Energy Performance Index of standard baseline design}} \leq 1$$

(2) The summary covering building envelope, comfort systems and controls, lighting and controls, and electrical and renewable energy systems and their checklists under Prescriptive Method and Whole Building Performance Method shall be as specified in the Appendix D of the Code.

## **5. Procedure for erection of Code compliant building**

(1) Every owner who intends to erect or re-erect a building or make alterations or additions in any building under these rules shall submit to the concerned authority having jurisdiction, an application in Form I accompanied by –

(a) construction documents duly signed by the owner(s) together with an undertaking in Form II;

(b) construction documents shall ensure –

(i) compliance with the applicable building bye-laws in force;

(ii) building design incorporates energy conservation measures and best national and international practices having regard to the climatic conditions of the site and specific needs of the building so as to optimise the energy performance index ratio of the building;

(iii) that all the data, building features, identified energy conservation measures under various building components and systems are shown in detail and in the manner specified in the applicable bye-laws;

(iv) the drawing of plan, colour of plan, dimensions of plan, scale of plan as per requirements of the applicable bye-laws in force;

(c) compliance documents covering the construction of components and systems of the Code, duly certified by Empanelled Energy Auditor(s) (Building) including the following, namely: –

(i) energy performance index ratio report in respect of the proposed building at the design stage;

(ii) certificate in Form III by Empanelled Energy Auditor(s) (Building) certifying the compliance documents as specified in Appendix D of the Code;

(iii) have been scrutinised or verified in respect of the identified energy conservation measures; and

(iv) an application with heading super scribed “Application for permission to erect/re-erect an Energy Conservation Building Code Compliant Building”, duly signed by the owner(s) seeking building permit from the concerned authority having jurisdiction

before starting construction work in respect of the proposed building.

(2) The authority having jurisdiction may require submission of documents in electronic form or hard copy of the documents, referred to in sub-rule (1).

(3) The Empanelled Energy Auditor(s) (Building), at the design stage, shall follow the following procedure of inspection, namely: –

(a) scrutinise the construction documents with respect to–

- (i) floor area;
- (ii) window area;
- (iii) wall area;
- (iv) roof area of the building;
- (v) built-up area of the proposed design of the building;

(b) scrutinise the Code compliance documents and the check list as specified in the Appendix D of the Code and identify –

- (i) the energy conservation measures that are applicable to the proposed design of building;
- (ii) insulation quantities in walls and roof, and the construction assemblies, solar heat gain co-efficient, visible light transmittance and thermal transmittance (U-factor) for window assemblies;
- (iii) heating, ventilation and air-conditioning component tables for air-handling equipment, refrigeration equipment, condensing equipment and air-flow summaries;
- (iv) heating, ventilation and air-conditioning equipment efficiencies and control equipment; tables showing lighting equipment schedules;
- (v) lighting power density calculations in the design documents;
- (vi) lighting controls;
- (vii) motor efficiencies and controls;
- (viii) findings of the document; review to match with the energy model inputs for the proposed building by using the simulation tool approved by the Bureau;

(c) scrutinise energy performance index ratio projected at the design stage;

(d) verify and certify the items from (i) to (ix) of (b) and (c);

(e) fill the check list as specified in the Appendix D of the Code and issue correction list in case the design documents of the proposed design of building provide inadequate information or do not meet the requirements of these rules and shall –

- (i) communicate his/her/their findings in Form IV to the owner(s) of the building under intimation to the concerned authority having jurisdiction;
- (ii) give specified time to the owner(s) to implement its findings;

- (iii) satisfy himself/herself/themselves that the communication received from the owner(s) within the specified time, meet the findings and fulfil the shortcomings;
  - (f) record his/her/their approval and complete the checklist conforming compliance with the Code and these rules, and issue the certificate of approval in Form V to the owner(s) under intimation to the concerned authority having jurisdiction and the Assam State Designated Agency.
- (4) The authority having jurisdiction on receipt of application under sub-rule (1) for issue of permit for construction of proposed building shall –
  - (a) approve the design and sanction building plan only after it has received a certificate in Form II or Form IV from the Empanelled Energy Auditor(s) (Building);
  - (b) grant permit to erect or re-erect the building or add to or make alterations in the building to carry out the construction works subject to the following conditions in its sanction letter, namely: –
    - (i) the construction work shall be in accordance with the sanctioned plan and requirement under the Code and these rules;
    - (ii) the compliance with these rules shall be achieved during construction-in-progress;
    - (iii) the building shall not be occupied before issuance of occupancy certificate to the owner(s);
    - (iv) the authority having jurisdiction may, at any stage, revoke the permit on receipt of non-compliance report from the Empanelled Energy Auditor(s) (Building) or on the notice of any misrepresentation of material facts in the application in respect of the provisions of these rules or the Code after giving a reasonable opportunity of being heard to the owner(s).
- (5) After receiving the permit, the owner(s) shall-
  - (a) give notice of his/her/their intention to start the construction work of the building in Form VI;
  - (b) undertake construction of energy conservation measures incorporated in the construction documents in terms of sub-clause (ii) of clause (b) of sub-rule (1);
  - (c) have flexibility in constructing the building components and systems covered in the construction documents referred to in clause (a) of sub-rule (1) to most effective use of energy by deploying best practices in such components and systems to optimise the energy performance index ratio;
  - (d) take the approval of the Empanelled Energy Auditor(s) (Building) before undertaking such construction referred to in clause (c) if the

components and systems proposed to be constructed are other than those incorporated in the construction and compliance document.

(6) The Empanelled Energy Auditor(s) (Building), at construction stage, shall review, verify the specifications of the parameters specified in sub-rule (3) and,

(a) fill out the checklist specified in the Appendix D of the Code, provide comments if the proposed design of building does not meet the construction requirements and specify the shortcomings in compliance to the Code, these rules and sanctioned plan, and shall-

(i) communicate its shortcomings and finding to the owner(s);

(ii) give specified time to the owner(s) to implement its findings;

(iii) satisfy himself/herself/themselves that the communication received thereafter from the owner(s) meets the specified findings and fulfils shortcomings;

(b) record his/her/their approval and complete the checklist indicating compliance with the Code and these rules, and issue a certificate of compliance in Form VII to the owner(s) under intimation to the authority having jurisdiction;

(c) where it is determined at any stage that construction is not proceeding in accordance with the sanctioned plan or is in violation of any of the provisions of the Code and these rules, Empanelled Energy Auditor(s) (Building) shall notify the owner(s), and request for additional information with respect to his/her/their findings or on the short comings identified by him/her/them as per Form VIII;

(d) in case the Empanelled Energy Auditor(s) (Building) is/are satisfied with the additional information provided by the owner, he/she/they shall record the same in the certificate of compliance in Form VII and communicate the same to the owner under intimation to the authority having jurisdiction;

(e) in case the Empanelled Energy Auditor(s) (Building) is not satisfied with the additional information submitted by the owner(s) he/she/they shall report the same to the authority having jurisdiction to ensure that all further construction is stayed until correction has been effectuated and a certificate of compliance has been issued by the Empanelled Energy Auditor(s) (Building).

(7) Every owner shall submit a notice of completion of the building in Form IX to the authority having jurisdiction on the completion of work including the works related to energy conservation measures specified in the sanctioned permit along with the certificate in Form X issued by the Empanelled Energy Auditor(s) (Building) certifying the completion of the building accompanied by –

(a) the duly completed compliance forms together with check list of various components covered under rule (3) at the completion stage which shall include the following –

(i) review of heating, ventilation and air-conditioning component tables for air-handling equipment, refrigeration equipment, condensing equipment, air-flow summaries, tables showing lighting equipment specifications, and tables showing motor



specifications;

- (ii) inspection of lighting equipment like lamps, ballasts, to confirm fixture wattage and inspection shall include at least random check across according to the type of usage in the building to determine lighting power density;
  - (iii) review the required lighting controls such as manual switching off perimeter, day lighting circuits, automated occupancy-based control, photo sensor controls, and automated timer-based controls;
  - (iv) review of coefficient of performance values of installed heating, ventilation and air-conditioning equipment and control equipment;
  - (v) review of efficiencies of installed motor and controls;
  - (vi) review of power factor and power distribution losses;
  - (vii) review the required check metering and monitoring system.
- (b) a list of the energy related building features in the proposed design, if any, which are different from the sanctioned or standard baseline design;
- (c) all documents and invoices in support of the construction undertaken with respect to all energy conservation measures including insulation, fenestration, heating, ventilation and air-conditioning, lighting and electrical systems, water heating systems of the building.
- (8) If the energy performance index ratio at the completion stage is less than or equal to one as compared to the sanctioned plan of the building, it shall be deemed to have complied with the Code and these rules.
- (9) If there is deviation in the energy performance index ratio of the sanctioned plan, that is, it is more than one as compared to the sanctioned plan of the building, Empanelled Energy Auditor(s) (Building) shall record its findings in Form XI and communicate the same to the owner(s) and seek compliance of the same through incorporation of additional energy conservation measures. The Empanelled Energy Auditor(s) (Building) shall render technical assistance to the owner(s) to ensure that the proposed design of building becomes compliant with these rules.
- (10) The owner(s) shall neither occupy nor allow any other person to occupy the building or part of the building covered under these rules for any purpose until such building or such part thereof has been granted occupancy certificate under the bye-laws of the authority having jurisdiction.
- (11) The owner(s) shall give notice of completion of the building and seek permission for occupancy.
- (12) The authority having jurisdiction on receipt of such notice by the owner accompanied by a certificate by the Empanelled Energy Auditor(s) (Building), issue the occupancy certificate in Form XII incorporating *inter alia* the following conditions, namely: –
- (i) that the energy performance of the building shall be monitored and verified by the Assam Energy Conservation Building Code Implementation Committee;

- (ii) that the owner(s) through the Empanelled Energy Auditor(s) (Building) shall submit to the Assam State Designated Agency, an energy performance index report as per Form XIII under intimation to Bureau for two consecutive years after the building has been fully operational;
- (iii) in case the energy performance index ratio of the building is more than one, the authority having jurisdiction may issue a provisional occupancy certificate subject to the condition that the owner shall undertake energy audit of the building to identify additional energy conservation measures to achieve the energy performance index ratio of the building approved in the sanctioned plan or permit within a period of three years;
- (iv) if the owner(s) fail(s) to achieve the energy performance index ratio as specified in clause (iii) within a period of three years from the date of occupancy of the building, the authority having jurisdiction shall place the matter before the Assam Energy Conservation Building Code Technical Grievances Redressal Committee, which shall hear the owner(s) and the Empanelled Energy Auditor(s) (Building) and make recommendations in the matter accordingly and the authority having jurisdiction shall comply with such recommendations.

(13) The process shall be continued repeatedly till energy performance index ratio of the building comes to less than one or equal to one and Empanelled Energy Auditor(s) (Building) shall fill and submit the compliance documents, as specified in Appendix D of the Code, of various energy conservation measures at each stage namely, design, construction and completion, to achieve conformity with the Code and these rules.

(14) The simulation tool referred in sub-rule (3) shall be based on the standard method of test for the evaluation of building energy analysis computer program.

(15) The owner(s) may approach the Assam Energy Conservation Building Code Compliant Technical Grievances Redressal Committee for redressal of any grievance under the provisions of these rules.

## 6. Committees

(1) Assam State Designated Agency, shall establish –

- (a) Assam Energy Conservation Building Code Implementation Committee shall be constituted with the members as follows:-

|    |  |          |
|----|--|----------|
| 1. | Chief Secretary of Assam or, his/her nominee | Chairman |
|----|--|----------|

|    |  |        |
|----|--|--------|
| 2. | Nominee from Bureau of Energy Efficiency   | Member |
| 3. | Principal Secretary to the Govt. of Assam, Urban Development Department or, his/her nominee    | Member |
| 4. | Principal Secretary to the Govt. of Assam, Guwahati Development Department or, his/her nominee | Member |
| 5. | Commissioner & Special Secretary, Public Works Building & NH Dept or, his/her nominee          | Member |

Together they shall –

- (i) promote energy efficiency standards through optimisation of parameters in the various components and systems of the building in line with the provisions of these rules to enhance the building performance and provide every support to it to make it an effective instrument of promoting energy conservation and energy efficiency in the commercial buildings or establishment;
- (ii) forward its recommendations to the Bureau to assist the National Energy Conservation Building Code Implementation Committee to develop and revise energy consumption standards for buildings, in terms of energy performance index, zone-wise - warm and humid and cold climate zones, classification-wise;
- (iii) create awareness about Assam Energy Conservation Building Code and procedure for erection of Code compliant building;
- (iv) promote construction of energy efficient buildings ensuring quality and consistency in their constructions having regard to the climatic conditions and needs of the building projects;
- (v) promote capacity building of building professionals, developers and contractors to promote energy efficient designs of buildings in close co-ordination with authorities having jurisdiction;
- (vi) undertake performance review of annual work of all Empanelled Energy Auditors (Building) to check their credentials;
- (vii) prepare a summary of violations which shall be provided by the Assam State Designated Agency to the Bureau and review such violations for the purpose of evaluating his/her professional skills;
- (viii) prepare a yearly report and furnish the same to the Bureau indicating *inter alia* the progress made in compliance of these rules in Assam and the steps taken by the Assam State Designated Agency, to improve the rate of compliance of Code in Assam;

(ix) create data base through compilation of data of energy performance index and its ratio achieved by each building constructed after coming into force of these rules;

(b) Assam Energy Conservation Building Code Compliant Technical Grievances Redressal Committee headed by Principal Secretary to the Govt. of Assam, Urban Development Department or his/her nominee, with other members, not exceeding four, nominated by the Assam Energy Conservation Building Code Implementation Committee who are qualified by experience and training to pass judgment upon matters pertaining to construction of Code compliant building in Assam, to–

(i) hear grievance filed by the owner(s) of a Code complaint building within the specified time period given by the authority having jurisdiction relating to the building permit, completion certificate, occupancy certificate of building including determination of the energy performance index ratio at the completion stage and interpretation of these rules or any other grievance arising out of the implementation of the Code and these rules;

(ii) make recommendations to the authority having jurisdiction to reconsider such issue, or for implementation by the authority having jurisdiction, as the case may be.

## **7. Responsibilities and duties of the owner(s)**

(1) The owner(s) of the Code compliant building shall carry out the work of the said building in accordance with the requirements of the Code and these rules.

(2) Every owner shall–

(a) engage Empanelled Energy Auditor(s) (Building) in development of building design, installation of energy conservation measures and equipment to meet with the requirements of these rules and ensure following, namely: –

(i) finalise the compliance approach relevant for his/her/their building project based on the complexity of the building, budget and time constraints;

(ii) finalise the energy conservation measures as per the Code as amended from time to time having regard to the location of the proposed building;

(iii) to integrate the energy conservation measures in the building design in accordance with the provisions of these rules;

(iv) that drawings, specifications and compliance forms are prepared and energy conservation measures are reflected in the building design documents and submitted to the authority having jurisdiction in compliance with the requirements of the rules accompanied by a certificate specifying the energy performance index ratio of the building by the Empanelled

Energy Auditor(s) (Building) that the documents are as per the requirement of these rules;

(v) notice is given within the validity of sanction to the authority having jurisdiction of his/her/their intention to start the construction work at the building site;

(vi) commence the work within the period specified by the authority having jurisdiction from the date of such notice or seek extension of time for starting the construction work, wherever necessary;

(vii) ensure that the designed energy conservation measures are deployed in the construction of the building and installation of its components and systems.

(b) permit the Empanelled Energy Auditor(s) (Building) to enter the building or premises at any reasonable time for the purpose of inspection to ensure compliance of building works with rules and regulations under the Act;

(c) give written notice to the authority having jurisdiction intimating the completion of the construction work along with a certificate from the Empanelled Energy Auditor(s) (Building) to the effect that—

(i) the construction of the building has been done in accordance with the sanction of the building permit;

(ii) all the energy conservation measures have been installed and inspected, and they meet the requirements of the Code and these rules;

(iii) the building design meets with the provisions of the Code and these rules;

(d) give written notice to the authority having jurisdiction as well as to the Assam State Designated Agency, in case of termination of the services of Empanelled Energy Auditor(s) (Building) and appointment of other Empanelled Energy Auditor(s) (Building) in its place;

(e) obtain an occupancy permit from the authority having jurisdiction prior to any occupancy of the building or part thereof after completion of the building;

(f) report the practical difficulties to the Empanelled Energy Auditor(s) (Building), if any, in carrying out the provisions of these rules, who shall take necessary action in consultation with the Assam State Designated Agency, and Assam Energy Conservation Building Code Implementation Committee;

(g) on the receipt of the notice, if any, from the authority having jurisdiction, he/she/they shall discontinue such usage within reasonable time as specified in such notice and in no case he/she/they shall disregard the provisions of these rules;

(h) where he/she/they propose(s) to alter the installation of any system or material or equipment on account of improving the energy efficiency of the building contrary to the system, material or equipment as indicated in the sanction plan he/she/they shall use or install such system or material or equipment after obtaining the necessary approval of the Empanelled Energy Auditors (Building):

- Provided that it does not violate the spirit and intent of the provisions of these rules:
  - Provided further that such change shall not compromise with the building requirements namely, structural stability, safety, health or environmental provisions of Central laws and Assam laws applicable to the buildings covered under these rules.
- (3) The owner may approach the Assam Energy Conservation Building Code Compliant Technical Grievances Redressal Committee for redressal of any grievance under the provisions of these rules.

#### **8. Role, responsibilities and duties of the Empanelled Energy Auditor(s) (Building)**

The Empanelled Energy Auditor(s) (Building), whose services are engaged by the owner(s), shall–

(a) verify and certify–

(i) the design of the building keeping in view the design criteria, energy goals of the project, energy systems performance verification plan, and the modelling approach;

(ii) the energy conservation measures based on the design approach for the project under consideration;

(iii) construction documents and compliance documents, compliance forms and checklists specified to ensure that the building complies with the Code and these rules;

(iv) energy performance index ratio of the proposed building;

(b) furnish a certificate under its seal and authorised signature to the effect that drawings, specifications, construction documents, compliance documents and forms prepared covering building envelope, comfort system and controls, lighting and electrical power systems, wherever applicable, and all other Code related documentation prepared for submission to the authority having jurisdiction ensuring compliance with these rules;

(c) inspect the building works from the design stage to its commissioning stage of buildings including their uses under these rules and based on his/her/their certification, the authority having jurisdiction shall issue building permit, approve construction of building, issue completion and occupancy certificates;

(d) the Empanelled Energy Auditor(s) (Building) shall ensure that none of the professionals or employees working under him/her/them is engaged in any work in connection with the construction or alteration of the concerned building covered under these rules to ensure that there is no conflict of interest of his/her/their official duties with the interests of the authority having jurisdiction;

- (e) report to the Assam State Designated Agency on such unusual technical issues that may arise due to issue of building permit or construction of building or during occupancy stage;
- (f) provide inputs to the National and Assam Energy Conservation Building Code Implementation Committees to facilitate for better implementation of the Code and these rules;
- (g) promote norms and standards specified in the Code.

## **9. Responsibilities and duties of the Assam State Designated Agency**

The Assam State Designated Agency established by Assam Government under clause (d) of section 15 of the Act, in consultation with Bureau, shall–

- (a) coordinate, regulate and enforce provisions of the Code and these rules for efficient use of energy and its conservation under the Act in Assam;
- (b) ensure every commercial building or establishment having a connected load of 100 kW or above, or contract demand of 120 kVA or above, be constructed in compliance with these rules;
- (c) monitor the performance of the Empanelled Energy Auditors (Building) to improve the quality, consistency and rate of compliance of these rules with a view to make the cadre of Empanelled Energy Auditors (Building) as effective instruments for promotion of energy efficiency in the building sector in Assam;
- (d) create a data bank in Assam to measure the compliance rates of the Code compliant buildings and accurately account for the energy savings resulting from the compliance of these rules;
- (e) also create a data bank on energy use per square meter of area of the building under different zones namely, warm & humid and cold, separately for each category in Assam;
- (f) take necessary steps to make energy performance index as a measure to comply with these rules in the various categories of buildings and send its recommendations to the Bureau for the formulation of energy consumption norms and standards in respect of various categories of buildings constructed zone-wise in Assam;
- (g) arrange conduct site visits, if considered necessary, to determine the accuracy of reporting by the Empanelled Energy Auditors (Building) in Assam;
- (h) prepare a report on performance of the Empanelled Energy Auditors (Building) listing out the projects complying with these rules, projects in violation of compliance with these rules and the level of violation, and

provide summary of such violations for each year to the Bureau of Energy Efficiency;

- (i) coordinate with the authority having jurisdiction to amend their building bye-laws incorporating the provisions of these rules for the purpose of construction of buildings in compliance with the Code and these rules;
- (ii) provide necessary support to the authority having jurisdiction to conform to the provisions of these rules with regard to matters concerning design construction including energy conservation measures and occupancy for improving the energy performance of Code compliant buildings and effectiveness in compliance of these rules.

## **10. Miscellaneous**

- (1) The use of any energy conservation measures or method or design or construction not specifically specified under these rules shall not be prevented by the authority having jurisdiction if such energy conservation measures or method or design or construction is found to be satisfactory by the Assam Energy Conservation Building Code Compliant Technical Grievance Redressal Committee and such energy conservation measures or method or design or construction assist the owner(s) in optimising the energy performance index ratio in the use of energy on its occupancy.
- (2) The Code shall be reviewed periodically, at least once in five years, to determine the need for revision or withdrawal of standards specified in the Code, and such standards which in the opinion of the Bureau need no revision or amendment shall be reaffirmed.



**Form I**

**[See rule 6(1)]**

**Application for Seeking Building Permit in Respect of Erection/Re-erection/Making Alteration in the Assam Energy Conservation Building Code Compliant Building**

To

The Commissioner or (name of the competent authority)

Authority having jurisdiction,

Name of the city

Name of the state

Date: \_\_/\_\_/\_\_\_\_

**Subject:** Application for erection of Assam Energy Conservation Building Code compliant building in premises of Plot No. \_\_\_\_\_ Block No. \_\_\_\_\_ Scheme \_\_\_\_\_ Street \_\_\_\_\_ in the town/city of \_\_\_\_\_, Assam

Sir/Madam,

I/We the undersigned hereby give you notice of my/our intention to erect /re-erect/alter the Assam Energy Conservation Building Code Compliant Building under the Assam Energy Conservation Building Code Rules, 2020 in the premises of Plot No. \_\_\_\_\_ Block No. \_\_\_\_\_ Scheme \_\_\_\_\_ in the town/city of \_\_\_\_\_, Assam and request for issue of building permit for the construction of the Assam Energy Conservation Building Code compliant building. The following documents are enclosed:

- (i) Construction Documents and Compliance Forms together with check-lists incorporating the installation of Energy Conservations Measures specified in the aforesaid rules.
- (ii) The Construction Documents and Compliance Forms together with check-lists have been verified by Mr./Ms. \_\_\_\_\_ Registration No. \_\_\_\_\_ Empanelled Energy Auditor(s) (Building). A certificate in Form II duly signed and sealed in this regard is enclosed.

Yours faithfully,

(Name of the owner(s))

Address

Tel. No./Mobile No.

**Form II**

**[See rule 6(1)(a)]**

**[Undertaking by Owner(s) for Construction of the Assam Energy Conservation Building Code Compliant Building]**

I/We am/are the owner(s) of the aforesaid Plot No. \_\_\_\_\_Block No. \_\_\_\_\_, and the proposed building on completion of construction shall have a connected load/contract demand of 100 kW/120 kVA or above and is proposed to be constructed to use or intended to be used for commercial purposes.

The proposed building accordingly attracts the provisions of Assam Energy Conservation Building Code Rules, 2020.

I/we undertake that the aforesaid building shall be constructed in accordance with the bye-laws of the Municipal Authority and the provisions of the Assam Energy Conservation Building Code Rules, 2020. In case any deviation is noticed during the construction of the building, I/we shall indemnify the loss to the authority having jurisdiction.

I/we further undertake that the information supplied in the enclosed drawings and the application is accurate to the best of my/our knowledge and if any of the information supplied is found to be incorrect and such information result in loss to the Central or the Assam Government or any other authority under them, I/ we undertake to indemnify such loss.

Signature

(Name of the owner(s))

Address

Tel. No./Mobile No.

**Form III**

**[(See rule 6(1)(c)(ii) and 6(4)(a)]**

**[Certificate from Empanelled Energy Auditor(s) (Building) to be Enclosed with the Application for Building Permit for Assam Energy Conservation Building Code Compliant Building]**

**Certificate**

I/We am/are Empanelled Energy Auditor(s) (Building) having registration no. \_\_\_\_\_ under the Energy Conservation Act 2001 (52 of 2001) and am/are authorised to scrutinise and verify the design of Assam Energy Conservation Building Code compliant building. I/We certify that –

- (a) I/We have scrutinised the construction documents, undertaking given by the owner(s) duly signed by the owner(s)/design professional(s) showing all the pertinent data and features of the building, equipment and systems in sufficient details covering building envelope, heating, ventilation and air-conditioning, service hot water, lighting and electrical power in accordance with municipal bye-laws and with the Assam Energy Conservation Building Code rules, 2020 in respect of building proposed to be constructed on Plot No. \_\_\_\_\_ Block No. \_\_\_\_\_ Scheme \_\_\_\_\_ in the town/city of \_\_\_\_\_ in the state of Assam;
- (b) I/We have scrutinised the compliance forms with the check-lists to ensure compliance with the bye-laws and the Assam Energy Conservation Building Code Rules, 2020.
- (c) The compliance documents have been duly inspected by the undersigned.
- (d) The energy performance index ratio of the building design as per compliance documents, at the design stage is equal to or less than one and is therefore in compliance with the Assam Energy Conservation Building Code Rules, 2020.
- (e) It is certified that all required scrutiny and verification of the documents submitted have been carried out diligently, truthfully and all reasonable professional skill, care and diligence have been taken in scrutinising and verifying the drawings of the buildings and compliance forms together with check-lists covering the various components of the Assam Energy Conservation Building Code rules, 2020.
- (f) The contents of all the documents submitted along with the application are a true representation of the facts and nothing has been concealed.

There is no objection for issue of building permit in respect of the aforesaid proposed building in so far as requirements of Assam Energy Conservation Building Code rules, 2020 are concerned.

Signature

Name of the Empanelled Energy Auditor(s) (Building)

Registration No. /Seal

Date

**Form IV**  
**[See rule 6(3)(e)(i) & 6(4)(a)]**

**[Certificate of Inspection by Empanelled Energy Auditor(s) (Building) on Review of Building Permit Application in Respect of the Proposed Building - Communication of Omissions and Non-compliance to Owner(s)]**

To

Mr./Ms. \_\_\_\_\_,

Address

**Subject:** Application for erection of proposed building in premises of Plot No. \_\_\_\_\_ Block No. \_\_\_\_\_ Scheme \_\_\_\_\_ Street \_\_\_\_\_ in the town/city of \_\_\_\_\_, Assam - Details of omission/non-compliance with the Assam Energy Conservation Building Code rules, 2020 on design stage inspection

Sir/Madam,

I/We, ..... (Name), being the authorised Empanelled Energy Auditor(s) (Building) vide order no. \_\_\_\_\_ hereby state that I/we have reviewed and verified the undertaking given by you and have inspected the construction documents, compliance forms, check-lists, submitted along with building permit application in respect of the various elements specified in sub-rule (3) of rule 6 of the various components of the proposed building in respect of the subject building and inform that the following omission(s)/non-compliance have been discovered on inspection –

- (i)
- (ii)
- (iii)
- (iv)

It is requested that the necessary energy conservation measure(s), in consultation with your design team, be carried out in order to bring them in compliance with the Assam Energy Conservation Building Code Rules, 2020. You are accordingly requested to take corrective action within a period of one month from the date of issue of this letter. Further action on your application for issue of building permit shall be taken after satisfactory compliance of the aforesaid omission/non-compliance.

Signature

Empanelled Energy Auditor(s) (Building)

Registration No., Mobile No.

Seal

**Form V**  
**[See rule 6(3)(f)]**

**[Certificate of Inspection by Empanelled Energy Auditor(s) (Building) on Review of Building Permit Application Enclosing Construction Documents and Compliance Forms in Respect of Assam Energy Conservation Building Code Compliant Building]**

I/We, ..... (Name), being the authorised Empanelled Energy Auditor(s) (Building) vide order no. \_\_\_\_\_ hereby state that I/we have reviewed and verified the undertaking given by the owner(s), and have inspected the construction documents, compliance forms, check-lists, submitted along with building permit application in respect of the various elements of the proposed Assam Energy Conservation Building Code compliant building in the premises of Plot No. \_\_\_\_\_ Block No. \_\_\_\_\_ Scheme \_\_\_\_\_ in the town/city of \_\_\_\_\_, Assam and certify that the

- (i) the omission/non-compliance pointed out by the undersigned in the Certificate of Inspection dated \_\_\_\_\_ have been complied with satisfactorily;
- (ii) the energy performance index ratio calculation matches with the data given in the aforesaid documents and is in compliance with the Assam Energy Conservation Building Code Rules, 2020.

I/We further certify that –

- (a) all reasonable professional skill, care, and diligence have been taken in verifying the compliance forms in respect of the various elements of the components covered in Assam Energy Conservation Building Code rules, 2020 and contents thereof are a true representation of the facts and meet the requirements of Assam Energy Conservation Building Code Rules, 2020.
- (b) There is no objection for issue of building permit in respect of the aforesaid proposed building in so far as requirements of Assam Energy Conservation Building Code Rules, 2020 are concerned.

The check-list duly completed and signed by the undersigned is enclosed.

Signature

Authorised/Empanelled Energy Auditor(s) (Building)

Registration No., Mobile No.

Seal

**Form VI**  
**[See rule 6(5)(a)]**

**Notice for Commencement of Construction Work of Assam Energy Conservation Building Code Compliant Building**

To

The Commissioner or (name of the competent authority)

Authority having jurisdiction,

Name of the city

Name of the state

Date: \_\_/\_\_/\_\_\_\_

**Subject:** Erection of Assam Energy Conservation Building Code compliant building on premises of Plot No. \_\_\_\_\_ Block No. \_\_\_\_\_ Scheme \_\_\_\_\_ Street \_\_\_\_\_ in the town/city of \_\_\_\_\_, Assam - Notice for commencement of building construction work

Sir/Madam,

I/We hereby give notice for commencement of building work, including implementation of Assam Energy Conservation Measures, for erection of Assam Energy Conservation Building Code compliant building in the aforesaid site i.e. Plot No. \_\_\_\_\_ Block No. \_\_\_\_\_ Scheme \_\_\_\_\_ Street \_\_\_\_\_ in pursuance of the sanction granted by the authority having jurisdiction/ vide file no./letter no. \_\_\_\_\_

Yours faithfully

Signature of the owner(s)

(Name of the owner(s))

Address of the owner(s)

Tel. No./Mobile No.

**Form VII**  
**[See rule 6(6)(b) and (d)]**

**[Certificate of Inspection by Empanelled Energy Auditor(s) (Building) on Review of Construction Works Enclosing Construction Documents and Compliance Forms in Respect of Assam Energy Conservation Building Code Compliant Building - Issue of Certificate of Compliance]**

To  
The Owner(s),  
Address

I/We, ..... (Name), being the authorised/Empanelled Energy Auditor(s) (Building) vide order no. \_\_\_\_\_ hereby state that I/we have reviewed the undertaking given by the owner(s), energy conservation measures installed during the construction works and have reviewed the construction documents, compliance forms, check-lists, submitted along with progress in construction works in respect of the various elements of the components referred to in sub rule (6) of Rule 6 of the proposed Assam Energy Conservation Building Code compliant building in the premises of Plot No. \_\_\_\_\_ Block No. \_\_\_\_\_ Scheme \_\_\_\_\_ in the town/city of \_\_\_\_\_, Assam and certify that the energy performance index ratio calculation match with the data given in the aforesaid documents;

I/We further certify that all reasonable professional skill, care, and diligence have been taken in verifying the construction document and compliance forms in respect of the various elements of the components covered in Assam Energy Conservation Building Code rules, 2020 and contents thereof are a true representation of the facts and meet the requirements of Assam Energy Conservation Building Code rules, 2020.

The check-list duly completed and signed by the undersigned is enclosed.

Signature

Name

Empanelled Energy Auditor(s) (Building)

Registration No., Mobile No.

Seal

Copy to: Commissioner, Authority having jurisdiction, Name of the City/Town  
Chief Electrical Inspector-cum-Adviser, Assam State Designated Agency, Address

**Form VIII**  
**[See rule 6(6)(c)]**

**[Certificate of Inspection by Empanelled Energy Auditor(s) (Building) on Review of Construction Works Enclosing Construction Documents and Compliance Forms in Respect of Assam Energy Conservation Building Code Compliant Building - Issue of Certificate of Non-compliance]**

To  
Mr./Ms. \_\_\_\_\_  
Owner  
Address \_\_\_\_\_

Date: \_\_/\_\_/\_\_\_\_

**Subject:** Erection of Assam Energy Conservation Building Code Compliant Building on premises of Plot No. \_\_\_\_\_ Block No. \_\_\_\_\_ Scheme \_\_\_\_\_ Street \_\_\_\_\_ in the town/city of \_\_\_\_\_, Assam - Communication of findings by the Empanelled Energy Auditor(s) (Building)

Sir/Madam,

I/We, ..... (Name), being the authorised/Empanelled Energy Auditor(s) (Building) vide order no. \_\_\_\_\_ hereby state that I/we have reviewed the undertaking given by the owner(s), and energy conservation measures under construction, and have reviewed the construction documents, compliance forms, check-lists, submitted along with progress in construction works in respect of the various elements of the components of the proposed Building in the premises of Plot No. \_\_\_\_\_ Block No. \_\_\_\_\_ Scheme \_\_\_\_\_ Street \_\_\_\_\_ in the town/city of \_\_\_\_\_, Assam and have to state that the construction has not proceeded in accordance with the sanctioned plan and has deviated/is deviating from the following provisions of Assam Energy Conservation Building Code rules, 2020 namely: -

- (i)
- (ii)
- (iii)

1. None of the above deviations are covered in the best practices approved by the Assam Energy Conservation Building Code Implementation Committee.

Or

2. The following deviations are covered in the best practices by the Assam Energy Conservation Building Code Implementation Committee.

3. The building owner(s) is/are requested to rectify the above deviations or take the approval of the Assam Energy Conservation Building Code Technical Grievance Redressal Committee.

4. The building owner(s), after obtaining the approval provided in para 3 above or rectifying the deviations notified in para 1 above, may inform the undersigned of the action taken in the matter within one month from the date of approval obtained or rectification completed along with the updated check-list to enable me/us to inspect the works in connection with the issue of certificate of approval provided in clause (d) of sub-rule (6) of rule 6 of the Assam Energy Conservation Building Code Rules, 2020.

Yours faithfully

Signature

Name of Authorised/Empanelled Energy Auditor(s) (Building)

Registration No., Mobile No.

Seal

Copy to: Commissioner, Authority having jurisdiction, Name of the City/Town, Assam



**Form IX**  
**[See rule 6(7)]**

**Notice of Completion**

To

The Commissioner

Authority having jurisdiction

Name of the City/Town, Assam

**Subject:** Construction of Assam Energy Conservation Building Code compliant building on Plot No. \_\_\_\_\_ Block No. \_\_\_\_\_ Scheme \_\_\_\_\_ Street \_\_\_\_\_ in the town/city of \_\_\_\_\_, Assam - Notice of completion of construction of Assam Energy Conservation Building Code compliant works

Sir/Madam,

I/We hereby give notice that the erection of the building in the premises of Plot No. \_\_\_\_\_ Block No. \_\_\_\_\_ Scheme \_\_\_\_\_ Street \_\_\_\_\_ in the town/city of \_\_\_\_\_, Assam including execution and implementation of the energy conservation measures have been completed in accordance with the plans sanctioned vide your office communication no. \_\_\_\_\_, dated \_\_\_\_\_.

The following documents are enclosed:—

- (i) A certificate of inspection on completion of the aforesaid building from Mr./Ms. \_\_\_\_\_, Empanelled Energy Auditor(s) (Building) vide Municipal Authority Order No. \_\_\_\_\_, dated \_\_\_\_\_.

The building is fit for use for which it has been erected/re-erected/constructed.

It is requested that permission to occupy or use the aforesaid building may be granted.

Yours faithfully,

Signature

Name of the owner(s)

Address

**Form X**  
**[See rule 6(7)]**

**[Certificate of Inspection by Empanelled Energy Auditor(s) (Building) on Review of Completion of Construction Works Enclosing Construction Documents and Compliance Forms in Respect of Assam Energy Conservation Building Code Compliant Building - Issue of Certificate of Compliance]**

To

Name

Owner(s) of the Building,

Address

**Subject:** Completion of construction works in respect of Assam Energy Conservation Building Code compliant building certificate

I/We, \_\_\_\_\_ (Name), being the authorised Empanelled Energy Auditor(s) (Building) vide order no. \_\_\_\_\_ hereby state that I/we have verified the undertaking given by the owner(s), and have inspected the construction documents, compliance forms, check-lists, submitted on completion of building of the proposed Assam Energy Conservation Building Code compliant building in the premises of Plot No. \_\_\_\_\_ Block No. \_\_\_\_\_ Scheme \_\_\_\_\_ Street \_\_\_\_\_ in the town/city of \_\_\_\_\_, Assam and certify that the

- (i) The works covered under the Assam Energy Conservation Building Code Rules, 2020 have been completed to the best of my/our satisfaction. The details of the various components/systems completed as per Assam Energy Conservation Building Code rules, 2020 are given below:

Name of the components

- 1.
- 2.
- 3.
- 4.
- 5.

- (ii) The energy performance index ratio of the said building matches with the data given in the aforesaid compliance documents specified in para 1 above.
- (iii) A list of the energy conservation measures deployed in the construction of aforesaid building is enclosed. Necessary approvals required have been taken by the owner(s).
- (iv) The building in my/our view meets the requirements of Assam Energy Conservation Building Code Rules compliant building and is fit for occupancy for which it has been erected, Refer Rule 2(i).
- (v) I/we further certify that all reasonable professional skill, care, and diligence have been taken in verifying the construction document and compliance forms in respect of the various elements of the components covered in the Assam Energy Conservation Building Code rules, 2020 and contents thereof are a true representation of the facts and meet the requirements of the Assam Energy Conservation Building Code rules, 2020.
- (vi) The check-list duly completed, signed and sealed by the undersigned is enclosed.

Yours faithfully

Signature

Name of Authorised/Empanelled Energy Auditor(s) (Building), Registration No., Mobile No.  
Seal, Certification No.

A copy of the certificate is sent herewith to:

- (i) Commissioner, Authority having jurisdiction, Town /city/ Assam
- (ii) Chief Electrical Inspector-cum-Adviser, Assam State Designated Agency, Address

**Form XI**  
**[See rule 6(9)]**

**[Certificate of Inspection by Empanelled Energy Auditor(s) (Building) on Review of Completion of Construction Works in Respect of Assam Energy Conservation Building Code Compliant Building - Communication of Omissions and Non-compliance to Owner]**

To

Mr./Ms. \_\_\_\_\_,

Address

**Subject:** Application for erection of Assam Energy Conservation Building Code Compliant Building in premises of Plot No. \_\_\_\_\_ Block No. \_\_\_\_\_ Scheme \_\_\_\_\_ Street \_\_\_\_\_ in the town/city of \_\_\_\_\_, Assam - Details of omission /non-compliance with the Assam Energy Conservation Building Code Rules, 2020 on design/completion stage inspection.

Sir/Madam,

I/We,.....(Name), being authorised Empanelled Energy Auditor(s) (Building) vide order no. \_\_\_\_\_ hereby state that I/we have reviewed and verified the undertaking given by you and have inspected the construction documents, compliance forms, check-lists, submitted on completion of the proposed Assam Energy Conservation Building Code compliant building in respect of the subject building and inform that the following omission/non-compliance have been found on inspection –

- (i)
- (ii)
- (iii)
- (iv)

You are accordingly requested to take corrective action within a period of three months from the date of issue of this letter. Further action on your application for issue of Completion Certificate shall be taken after satisfactory compliance of the aforesaid omission/non-compliance.

Signature

Empanelled Energy Auditor(s) (Building)

Registration No., Mobile No.

**Form XII**  
**[See rule 6(12)]**  
**Occupancy Certificate**

**(To Be Issued by Authority Having Jurisdiction in Their Occupancy Certificate)**

To

Name of the owner(s)

Address

**Subject:** Issue of Occupancy Certificate

Sir/Madam,

With reference to your notice of completion of an Assam Energy Conservation Building Code compliant building construction dated \_\_\_\_\_ on Plot No. \_\_\_\_\_ Block No. \_\_\_\_\_ Scheme \_\_\_\_\_ Street \_\_\_\_\_ in the town/city of \_\_\_\_\_, Assam, I/we hereby certify that the said building as per description annexed on Plot No. \_\_\_\_\_ Block No. \_\_\_\_\_ Scheme \_\_\_\_\_ whose plans were sanctioned vide no. ....dated.....has been inspected with reference to requirements of Assam Energy Conservation Building Code Rules, 2020.

1. The building is declared fit for occupancy as follows:

Climate Zone

24-Hour use Building / Regular Building

Hospitals/Hotels/Call Centre/Other Building Types

Annexure

Description of the building

|                 | Usage | Connected Load |
|-----------------|-------|----------------|
| i. Ground Floor | ..... | .....          |
| ii. 1st floor   | ..... | .....          |
| iii. 2nd floor  | ..... | .....          |
| iv. 3rd floor   | ..... | .....          |
| v. 4th Floor    | ..... | .....          |
| vi. etc.        | ..... | .....          |

2. The energy performance index ratio of the building on the completion stage is as per the sanction plan. It has been decided by the authority having jurisdiction in consultation with the Assam State Designated Agency, that the building is declared fit for occupancy as specified above, subject to the condition that the owner(s) shall undertake energy audit of the building and identify additional energy conservation measures to achieve the compliance with the energy performance index of the building approved in the sanctioned plan.
3. The energy performance of the Building shall be monitored and verified by the Assam Energy Conservation Building Code Committee for the next two years.

Enclosures: Copy of certified completion plan.

Yours faithfully,

(Signature of building official)  
Authority having jurisdiction

Copy to: Chief Electrical Inspector-cum-Advisor, Assam State Designated Agency, Address

**Form XIII**

[See rule 6(12)(ii)]

**[Energy Performance Index Report Submission by Empanelled Energy Auditor(s) (Building) to the Assam State Designated Agency, After the Building Has Become Fully Operational]**

To

The Chief Electrical Inspector-cum-Advisor,  
Assam State Designated Agency  
Government of Assam

**Subject:** Energy Performance Index Report for Assam Energy Conservation Building Code compliant building constructed on Plot no. \_\_\_\_\_ Block No. \_\_\_\_\_ Scheme \_\_\_\_\_ Street \_\_\_\_\_ in the town/city of \_\_\_\_\_, Assam - Communication by the Empanelled Energy Auditor(s) (Building)

Sir/Madam,

I/We, ..... (Name), being the authorised/Empanelled Energy Auditor(s) (Building) vide order no. \_\_\_\_\_ hereby state that I/we have reviewed the undertaking given by the owner(s), energy consumption for year \_\_\_\_\_ of the proposed building of type \_\_\_\_\_ in the premises of Plot no. \_\_\_\_\_ Block No. \_\_\_\_\_ Scheme \_\_\_\_\_ Street \_\_\_\_\_ in the town/city of \_\_\_\_\_, Assam and certify that the energy performance index ratio is \_\_\_\_\_ which is less than or equal to one. The EPI report is enclosed.

I/we further certify that all reasonable professional skill, care, and diligence have been taken to verify the energy consumption of the aforesaid building.

Copies of the electricity bills have been enclosed for your reference.

Yours faithfully

Signature

Name of Authorised/Empanelled Energy Auditor(s) (Building)

Registration No. /Mobile No.

Seal

Enclosure: Energy performance index ratio report as specified in the Appendix D of the Code.

Copy to: Director, Buildings Programme, Bureau of Energy Efficiency, 4th Floor, Sewa Bhavan,  
R K Puram, New Delhi – 110 066

# ANNEXURE 1

ASSAM ENERGY  
CONSERVATION  
BUILDING CODE  
(ECBC) 2020

# ASSAM ENERGY CONSERVATION BUILDING CODE 2020

A CODE THAT SETS MINIMUM REQUIREMENTS FOR THE ENERGY EFFICIENT DESIGN AND CONSTRUCTION OF BUILDINGS. THIS CODE IS FORMULATED AS PER THE WARM-HUMID AND COLD CLIMATE OF ASSAM STATE.



ASSAM STATE DESIGNATED AGENCY  
GOVERNMENT OF ASSAM



BUREAU OF ENERGY EFFICIENCY  
MINISTRY OF POWER  
GOVERNMENT OF INDIA

## Table of Contents

|   |    |
|---|----|
| List of Tables .....  | vi |
| List of Notes .....   | ix |
| 1 Purpose .....   | 1  |
| 2 Scope .....   | 2  |
| 2.1 Energy Efficiency Performance Levels .....              | 2  |
| 2.2 Building Systems .....                                  | 2  |
| 2.3 Precedence .....  | 3  |
| 2.4 Reference Standards.....                                | 3  |
| 2.5 Building Classification .....                           | 3  |
| 3 Compliance and Approach.....                              | 6  |
| 3.1 General .....   | 6  |
| 3.1.1 Energy Performance Index.....                         | 6  |
| 3.1.2 Determining EPI Ratio .....                           | 6  |
| 3.1.3 EPI Ratio for Core and Shell Buildings .....          | 7  |
| 3.1.4 EPI Ratio for Mixed-use Development .....             | 7  |
| 3.2 Compliance Approaches .....                             | 7  |
| 3.2.1 Mandatory Requirements.....                           | 7  |
| 3.2.2 Prescriptive Method .....                             | 7  |
| 3.2.3 Whole Building Performance Method .....               | 8  |
| 3.3 Compliance Requirements .....                           | 9  |
| 3.3.1 New Building Compliance .....                         | 9  |
| 3.3.2 Additions and Alterations to Existing Buildings ..... | 9  |
| 3.4 Approved Compliance Tools.....                          | 10 |
| 3.5 Administrative Requirements.....                        | 10 |
| 3.6 Compliance Documents.....                               | 10 |
| 3.6.1 Compliance Documents .....                            | 10 |
| 3.6.2 Supplemental Information.....                         | 11 |
| 4 Building Envelope .....                                   | 12 |



|       |   |    |
|-------|---|----|
| 4.1   | General .....   | 12 |
| 4.2   | Mandatory Requirements .....                            | 12 |
| 4.2.1 | Fenestration .....                                      | 12 |
| 4.2.2 | Opaque Construction .....                               | 13 |
| 4.2.3 | Daylighting .....                                       | 13 |
| 4.2.4 | Building Envelope Sealing .....                         | 17 |
| 4.3   | Prescriptive Requirements .....                         | 22 |
| 4.3.1 | Roof .....  | 22 |
| 4.3.2 | Opaque External Wall .....                              | 23 |
| 4.3.3 | Vertical Fenestration .....                             | 24 |
| 4.3.4 | Skylights .....   | 31 |
| 4.3.5 | Building Envelope Trade-Off Method .....                | 31 |
| 5     | Comfort Systems and Controls .....                      | 39 |
| 5.1   | General .....   | 39 |
| 5.2   | Mandatory Requirements .....                            | 39 |
| 5.2.1 | Ventilation .....                                       | 39 |
| 5.2.2 | Minimum Space Conditioning Equipment Efficiencies ..... | 40 |
| 5.2.3 | Controls .....  | 43 |
| 5.2.4 | Piping and Ductwork .....                               | 45 |
| 5.2.5 | System Balancing .....                                  | 47 |
| 5.2.6 | Condensers .....  | 47 |
| 5.2.7 | Service Water Heating .....                             | 47 |
| 5.3   | Prescriptive Requirements .....                         | 49 |
| 5.3.1 | Chillers .....  | 50 |
| 5.3.2 | Pumps .....   | 50 |
| 5.3.3 | Cooling Towers .....                                    | 51 |
| 5.3.4 | Boilers .....   | 52 |
| 5.3.5 | Economizers .....                                       | 52 |
| 5.3.6 | Variable Flow Hydronic Systems .....                    | 53 |



|        |   |    |
|--------|---|----|
| 5.3.7  | Unitary, Split, Packed Air-Conditioners.....                  | 54 |
| 5.3.8  | Controls for ECBC+ and SuperECBC Buildings .....              | 54 |
| 5.3.9  | Controls for SuperECBC Buildings .....                        | 55 |
| 5.3.10 | Energy Recovery.....  | 56 |
| 5.3.11 | Service Water Heating .....                                   | 56 |
| 5.3.12 | Total System Efficiency – Alternate Compliance Approach ..... | 56 |
| 5.3.13 | Low-energy Comfort Systems .....                              | 57 |
| 6      | Lighting and Controls .....                                   | 59 |
| 6.1    | General .....   | 59 |
| 6.2    | Mandatory Requirements .....                                  | 59 |
| 6.2.1  | Lighting Control.....   | 59 |
| 6.2.2  | Exit Signs .....  | 61 |
| 6.3    | Prescriptive Requirement .....                                | 62 |
| 6.3.1  | Interior Lighting Power .....                                 | 62 |
| 6.3.2  | Building Area Method .....                                    | 62 |
| 6.3.3  | Space Function Method .....                                   | 65 |
| 6.3.4  | Installed Interior Lighting Power.....                        | 71 |
| 6.3.5  | Exterior Lighting Power .....                                 | 71 |
| 6.3.6  | Controls for ECBC+ and SuperECBC Buildings .....              | 73 |
| 7      | Electrical and Renewable Energy Systems.....                  | 74 |
| 7.1    | General .....   | 74 |
| 7.2    | Mandatory Requirements .....                                  | 74 |
| 7.2.1  | Transformers.....   | 74 |
| 7.2.2  | Energy Efficient Motors .....                                 | 76 |
| 7.2.3  | Diesel Generator (DG)Sets .....                               | 76 |
| 7.2.4  | Check-Metering and Monitoring.....                            | 77 |
| 7.2.5  | Power Factor Correction .....                                 | 78 |
| 7.2.6  | Power Distribution Systems .....                              | 78 |
| 7.2.7  | Uninterruptible Power Supply (UPS).....                       | 78 |

|       |  |     |
|-------|--|-----|
| 7.2.8 | Renewable Energy Systems .....   | 78  |
| 8     | Definitions, Abbreviations, and Acronyms.....  | 80  |
| 8.1   | General .....  | 80  |
| 8.2   | Definitions .....  | 80  |
| 8.3   | SI to IP Conversion Factors .....  | 105 |
| 8.4   | Abbreviations and Acronyms.....  | 106 |
| 9     | Whole Building Performance Method .....  | 108 |
| 9.1   | General .....  | 108 |
| 9.1.1 | Scope.....   | 108 |
| 9.1.2 | Compliance .....   | 108 |
| 9.1.3 | Annual Energy Use .....  | 108 |
| 9.1.4 | Trade-offs Limited to Building Permit .....  | 108 |
| 9.1.5 | Documentation Requirements.....  | 108 |
| 9.2   | Mandatory Requirements.....  | 109 |
| 9.3   | Simulation Requirements .....  | 109 |
| 9.3.1 | Energy Simulation Program .....  | 109 |
| 9.3.2 | Climate Data.....  | 110 |
| 9.3.3 | Compliance Calculations .....  | 110 |
| 9.4   | Calculating Energy Consumption of Proposed Design and Standard Design<br>110   |     |
| 9.4.1 | Energy Simulation Model.....   | 110 |
| 9.4.2 | HVAC Systems .....   | 119 |
| 9.4.3 | Compliance Thresholds for ECBC compliant, ECBC+ and SuperECBC<br>Buildings.....  | 124 |
| 9.5   | Maximum Allowed EPI Ratios .....   | 124 |
| 9.6   | Schedules.....   | 126 |
| 10    | Appendix A: Default Values for Typical Constructions .....   | 151 |
| 10.1  | Procedure for Determining Fenestration Product U-factor and Solar Heat<br>Gain Coefficient .....                           | 151 |
| 10.2  | Default U-factors, Visible Light Transmittance and Solar Heat Gain<br>Coefficients for Unrated Fenestration Products ..... | 152 |

|        |  |     |
|--------|--|-----|
| 10.2.1 | Unrated Vertical Fenestration .....                                | 152 |
| 10.3   | Typical Roof Constructions .....                                   | 153 |
| 10.4   | Typical Wall Constructions .....                                   | 153 |
| 11     | Appendix B: Climate Zone Map of India .....                        | 179 |
| 11.1   | Climate Zone Map of Assam .....                                    | 179 |
| 11.2   | Regional map of Assam.....   | 180 |
| 12     | Appendix C: Air-Side Economizer Acceptance Procedures .....        | 182 |
| 12.1   | Construction Inspection.....                                       | 182 |
| 12.2   | Equipment Testing.....   | 182 |
| 13     | Appendix D: Compliance Forms .....                                 | 183 |
| 14     | Appendix E: BEE approved list of software to show compliance ..... | 198 |

## List of Tables

|   |    |
|---|----|
| Table 4-1 Daylight Requirement.....   | 14 |
| Table 4-2 Default Values for Surface Reflectance .....  | 15 |
| Table 4-3 Daylight Extent Factors (DEF) for Manually Calculating Daylight Area.....                               | 16 |
| Table 4-4 Roof Assembly U-factor (W/m <sup>2</sup> . K) Requirements for ECBC Compliant Building.....             | 22 |
| Table 4-5 Roof Assembly U-factor (W/m <sup>2</sup> . K) Requirements for ECBC+ Compliant Building.....            | 22 |
| Table 4-6 Roof Assembly U-factor (W/m <sup>2</sup> . K) Requirements for SuperECBC Building ...                   | 22 |
| Table 4-7 Opaque Assembly Maximum U-factor (W/m <sup>2</sup> .K) Requirements for an ECBC compliant Building..... | 23 |
| Table 4-8 Opaque Assembly Maximum U-factor (W/m <sup>2</sup> .K) Requirements for ECBC+ Compliant Building .....  | 24 |
| Table 4-9 Opaque Assembly Maximum U-factor (W/m <sup>2</sup> .K) Requirements for SuperECBC Building.....         | 24 |
| Table 4-10 Vertical Fenestration Assembly U-factor and SHGC requirements for ECBC Buildings .....                 | 25 |
| Table 4-11 Vertical Fenestration U-factor and SHGC Requirements for ECBC+ buildings and SuperECBC buildings.....  | 25 |
| Table 4-12 Shading Equivalent Factors for Latitudes greater than or equal to 15°N.....                            | 27 |
| Table 4-13 U-factor (W/m <sup>2</sup> .K) Exemption Requirements for Shaded Building.....                         | 31 |
| Table 4-14 Skylight U-factor (W/m <sup>2</sup> .K) and SHGC Requirements .....                                    | 31 |
| Table 4-15 Envelope Performance Factor Coefficients – Warm and Humid Climate.....                                 | 33 |
| Table 4-16 Envelope Performance Factor Coefficients – Cold Climate .....  | 33 |
| Table 5-1 Minimum Energy Efficiency Requirements for water cooled Chillers.....                                   | 41 |
| Table 5-2 Minimum Energy Efficiency Requirements for air cooled Chillers .....                                    | 41 |
| Table 5-3 Minimum Requirements for Unitary, Split, Packaged Air Conditioners in ECBC Building.....                | 41 |
| Table 5-4 Minimum Efficiency Requirements for VRF Air conditioners for ECBC Building* .....                       | 42 |
| Table 5-5 Minimum Efficiency Requirements for Computer Room Air Conditioners. ....                                | 42 |
| Table 5-6 Minimum Efficiency Requirements Oil and Gas fired Boilers for ECBC building .....                       | 43 |
| Table 5-7 Insulation Requirements for Pipes in ECBC Building .....  | 45 |
| Table 5-8 Insulation Requirements for Pipes in ECBC+ Building .....   | 46 |
| Table 5-9 Insulation Requirements for Pipes in SuperECBC Buildings .....  | 46 |
| Table 5-10 Ductwork Insulation (R value in m <sup>2</sup> . K/W) Requirements .....                               | 47 |
| Table 5-11 Mechanical and Motor Efficiency Requirements for Fans in ECBC Buildings                                | 49 |
| Table 5-12 Mechanical and Motor Efficiency Requirements for Fans in ECBC+ Buildings .....                         | 49 |

|   |     |
|---|-----|
| Table 5-13 Mechanical and Motor Efficiency Requirements for Fans in SuperECBC Buildings .....                   | 49  |
| Table 5-14 Minimum Energy Efficiency Requirements for water cooled Chillers. ....                               | 50  |
| Table 5-15 Minimum Energy Efficiency Requirements for air cooled Chillers. ....                                 | 50  |
| Table 5-16 Pump Efficiency Requirements for ECBC Building .....   | 51  |
| Table 5-17 Pump Efficiency Requirements for ECBC+ Building .....  | 51  |
| Table 5-18 Pump Efficiency Requirements for SuperECBC Building.....   | 51  |
| Table 5-19 Cooling Tower Efficiency Requirements for ECBC, ECBC+, and SuperECBC Buildings .....                 | 52  |
| Table 5-20 Minimum Efficiency Requirements for Oil and Gas fired Boilers for ECBC+ and SuperECBC building ..... | 52  |
| Table 5-21 Minimum Requirements for Oil Unitary, Split, Packaged Air Conditioners in ECBC+ Building.....        | 54  |
| Table 5-22 Minimum Requirements for Oil Unitary, Split, Packaged Air Conditioners in SuperECBC building .....   | 54  |
| Table 5-23 Maximum System Efficiency Threshold for ECBC, ECBC+ and SuperECBC Buildings .....                    | 56  |
| Table 6-1 Interior Lighting Power for ECBC Buildings – Building Area Method .....                               | 63  |
| Table 6-2 Interior Lighting Power for ECBC+ Buildings – Building Area Method .....                              | 64  |
| Table 6-3 Interior Lighting Power for SuperECBC Buildings – Building Area Method ....                           | 64  |
| Table 6-4 Interior Lighting Power for ECBC Buildings – Space Function Method [ANS11] [MB12].....                | 66  |
| Table 6-5 Interior Lighting Power for ECBC+ Buildings – Space Function Method.....                              | 67  |
| Table 6-6 Interior Lighting Power for SuperECBC Buildings – Space Function Method..                             | 68  |
| Table 6-7 Exterior Building Lighting Power for ECBC Buildings .....   | 72  |
| Table 6-8 Exterior Building Lighting Power for ECBC+ Buildings .....  | 72  |
| Table 6-9 Exterior Building Lighting Power for SuperECBC Buildings.....   | 72  |
| Table 7-1 Permissible Losses for Dry Type Transformers .....  | 74  |
| Table 7-2 Permissible Losses for Oil Type Transformers .....  | 75  |
| Table 7-3 Sub Metering: Minimum requirement for separation of electrical load.....                              | 77  |
| Table 7-4 Additional sub-metering requirements for specific building types.....                                 | 77  |
| Table 7-5 Energy Efficiency Requirements for UPS for ECBC, ECBC+, SuperECBC building .....                      | 78  |
| Table 7-6 Minimum Renewable Contribution towards meeting Contract Demand in ECBC+ Building.....                 | 79  |
| Table 7-7 Minimum Renewable Contribution towards meeting Contract Demand in SuperECBC Building .....            | 79  |
| Table 9-1 Modelling Requirements for Calculating Proposed and Standard Design.....                              | 110 |
| Table 9-2 HVAC Systems map for standard Design .....  | 118 |
| Table 9-3 Power Adjustment Factors for Automatic Lighting Controls .....  | 119 |
| Table 9-4 Types and Number of Chillers for Standard Design.....   | 122 |
| Table 9-5 Maximum Allowed EPI Ratios for Buildings in Warm and Humid Climate ....                               | 124 |

|   |     |
|---|-----|
| Table 9-6 Maximum Allowed EPI Ratios for Buildings in Cold Climate.....                                   | 124 |
| Table 9-7 Schedules for Business - Office Buildings .....   | 126 |
| Table 9-8 Schedules for Business - Office Building Daytime Business.....                                  | 127 |
| Table 9-9 Schedules for Business - Office Building 24-hours Business.....                                 | 128 |
| Table 9-10 Schedules for Business - Server Room.....  | 129 |
| Table 9-11 Schedules for Assembly Buildings (A).....  | 130 |
| Table 9-12 Schedules for Assembly Buildings (B).....  | 131 |
| Table 9-13 Schedules for Assembly Buildings (C).....  | 132 |
| Table 9-14 Schedules for Assembly Buildings (D).....  | 133 |
| Table 9-15 Schedules for Healthcare - Hospital Buildings (A) .....  | 134 |
| Table 9-16 Schedules for Healthcare - Hospital Buildings (B) .....  | 135 |
| Table 9-17 Schedules for Shopping Complex – Out-patient Healthcare Buildings (A)..                        | 136 |
| Table 9-18 Schedules for Healthcare – Out-patient Healthcare Buildings (B).....                           | 137 |
| Table 9-19 Schedules for Educational School Building (A) .....  | 138 |
| Table 9-20 Schedules for Educational - School Buildings (B).....  | 139 |
| Table 9-21 Schedules for Educational - University Building (A).....                                       | 140 |
| Table 9-22 Schedules for Educational - University Buildings (B) .....                                     | 141 |
| Table 9-23 Schedules for Hospitality Buildings (A).....   | 142 |
| Table 9-24 Schedules for Hospitality Buildings (B) .....  | 143 |
| Table 9-25 Schedules for Hospitality Buildings (C) .....  | 144 |
| Table 9-26 Schedules for Hospitality Buildings (D).....   | 145 |
| Table 9-27 Schedules for Hospitality Buildings (E) .....  | 146 |
| Table 9-28 Schedules for Shopping Complexes Buildings (A).....  | 147 |
| Table 9-29 Schedules for Shopping Complexes Buildings (B).....  | 148 |
| Table 9-30 Schedules for Shopping Complexes Buildings – Food Court .....                                  | 149 |
| Table 9-31 Schedules for Shopping Complex- Strip Retail & Supermall Buildings .....                       | 150 |
| Table 10-1 Defaults for Unrated Fenestration (Overall Assembly including the Sash and Frame) .....        | 152 |
| Table 10-2 Typical Thermal Properties of Common Building and Insulating Materials <sup>3,a</sup><br>..... | 154 |
| Table 11-1 Details of latitude and longitude of Assam.....  | 181 |
| Table 14-1 Bureau of Energy Efficiency Approved Software for Demonstrating Compliance with ECBC.....      | 198 |



**List of Notes**

|  |    |
|--|----|
| Note 2-1 Building Typologies for Assam ECBC .....                          | 5  |
| Note 4- 1 Daylight Extent Factor and Useful Daylight Illuminance .....     | 18 |
| Note 4-2 Equivalent SHGC and Projection Factor .....                       | 29 |
| Note 4-3 Building Envelope Trade-off Method .....                          | 35 |
| Note 6-1 Calculating Interior Lighting Power – Space Function Method ..... | 70 |

## 1 Purpose

In accordance with section 14(p) of the Energy Conservation Act 2001 the purpose of the Energy Conservation Building Code (ECBC) 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

The Code is applicable to buildings or building complexes that have a connected load of 100 kW or greater or a contract demand of 120kVA or greater, with plot area more than 1000m<sup>2</sup> or built-up area of 2000m<sup>2</sup> and are intended to be used for commercial purposes.

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

This code would become mandatory as and when the Assam ECBC Rules 2020 are notified in the official Gazette by the State Government.

### 2.1 Energy Efficiency Performance Levels

The code prescribes the following three levels of energy efficiency:

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

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

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

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

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

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

### 2.2 Building Systems

The provisions of this code apply to:

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

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

### 2.3 Precedence

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

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

### 2.4 Reference Standards

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

### 2.5 Building Classification

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

- a) **Hospitality:** Any building in which sleeping accommodation is provided for commercial purposes, except any building classified under Health Care. Buildings and structures under Hospitality shall include the following:
  - i. No-star Hotels-like Lodging-houses, dormitories, no-star hotels/motels
  - ii. Resort
  - iii. Star Hotel
- b) **Health Care:** Any building or part thereof, which is used for purposes such as medical or other treatment or care of persons suffering from physical or mental illness, disease, or infirmity; care of infants, convalescents, or aged persons, and for penal or correctional detention in which the liberty of the inmates is restricted. Health Care buildings ordinarily provide sleeping accommodation for the occupants. Buildings and structures like hospitals, sanatoria, out-patient healthcare, laboratories, research establishments, and test houses are included under this type.
- c) **Assembly:** Any building or part of a building, where number of persons

congregate or gather for amusement, recreation, social, religious, patriotic, civil, travel and similar purposes. Buildings like theatres or motion picture halls, gathering halls, and transport buildings like airports, railway stations, bus stations, and underground and elevated mass rapid transit system are included in this group.

- d) **Business:** Any building or part thereof which is used for transaction of business, for keeping of accounts and records and similar purposes, professional establishments, and service facilities. There are two subcategories under Business – Daytime Business and 24-hour Business. Unless otherwise mentioned, Business buildings shall include both Daytime and 24-hour subcategories.
- e) **Educational:** Any building used for schools, colleges, universities, and other training institutions for day-care purposes involving assembly for instruction, education, or recreation for students. If residential accommodation is provided in the schools, colleges, or universities or coaching/ training institution, that portion of occupancy shall be classified as a No-star Hotel. Buildings and structures under Educational shall include following types-
- i. Schools
  - ii. All other types of institutes, e.g. – college, university, training institutes etc.
- f) **Shopping Complex:** Any building or part thereof, which is used as shops, stores, market, for display and sale of merchandise, either wholesale or retail. Buildings like shopping malls, stand-alone retails, open gallery malls, super markets, or hyper markets are included in this type.
- g) **Mixed-use Building:** In a mixed-use building, each commercial part of a building must be classified separately, and
- i. If a part of the mixed-use building has different classification and is less than 10% of the total above grade floor area, the mixed-use building shall show compliance based on the building sub-classification having higher percentage of above grade floor area.
  - ii. If a part of the mixed-use building has different classification and one or more sub-classification is more than 10% of the total above grade floor area, the compliance requirements for each sub-classification, having area more than 10% of above grade floor area of a mixed-use building shall be determined by the requirements for the respective building classification in §4 to §7.

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

*Note 2-1 Building Typologies for Assam ECBC*



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

|                         |   |
|-------------------------|---|
| <b>Hospitality</b>      | <ol style="list-style-type: none"> <li>1. Star Hotel</li> <li>2. No Star Hotel</li> <li>3. Resort</li> </ol>  |
| <b>Educational</b>      | <ol style="list-style-type: none"> <li>1. College</li> <li>2. University</li> <li>3. Institution</li> <li>4. School</li> </ol>                              |
| <b>Health Care</b>      | <ol style="list-style-type: none"> <li>1. Hospital</li> <li>2. Out-patient Healthcare</li> </ol>  |
| <b>Shopping Complex</b> | <ol style="list-style-type: none"> <li>1. Shopping Mall</li> <li>2. Stand-alone Retails</li> <li>3. Open Gallery Malls</li> <li>4. Super Markets</li> </ol> |
| <b>Business</b>         | <ol style="list-style-type: none"> <li>1. Daytime use</li> <li>2. 24-hours use</li> </ol>   |
| <b>Assembly</b>         | <ol style="list-style-type: none"> <li>1. Multiplex</li> <li>2. Theatre</li> <li>3. Building used for Transport Services</li> </ol>                         |

### 3 Compliance and Approach

#### 3.1 General

To comply with the Code, buildings shall

- (a) have an Energy Performance Index Ratio (EPI Ratio) as defined in §3.1.2 that is less than or equal to 1 and,
- (b) meet all mandatory requirements mentioned under §4.2, §5.2, §6.2, and §7.2.

##### 3.1.1 Energy Performance Index

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

$$EPI = \frac{\text{Annual energy consumption in kWh}}{\text{Total built up area (excluding unconditioned basements) m}^2}$$

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

##### 3.1.2 Determining EPI Ratio

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

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

Where,

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

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

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

- a) Prescriptive Method (see§3.2.2)

b) Whole Building Performance Method (see§3.2.3)



### 3.1.3 EPI Ratio for Core and Shell Buildings

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

### 3.1.4 EPI Ratio for Mixed-use Development

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

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

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

## 3.2 Compliance Approaches

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

### 3.2.1 Mandatory Requirements

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

### 3.2.2 Prescriptive Method

A building complies with the Code using the Prescriptive Method if it meets the prescribed minimum (or maximum) values for envelope components (§4.3), comfort

systems and controls (§5.3, §5.3.12, §5.3.13), and lighting and controls (§6.3), in addition to meeting all the mandatory requirements.

### **3.2.2.1 EPI Ratio through Prescriptive Method**

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

### **3.2.2.2 Building Envelope Trade-off Method**

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

### **3.2.2.3 Total System Efficiency Method**

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

### **3.2.2.4 Low Energy Comfort System**

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

### **3.2.3 Whole Building Performance Method**

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

### **3.2.3.1 EPI Ratio through Whole Building Performance Method**

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

## **3.3 Compliance Requirements**

### **3.3.1 New Building Compliance**

#### **3.3.1.1 Full building compliance**

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

#### **3.3.1.2 Core and Shell building Compliance**

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

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

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

### **3.3.2 Additions and Alterations to Existing Buildings**

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

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

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

### **3.4 Approved Compliance Tools**

A building following the whole building performance method of §9 or Total System Efficiency – Alternate compliance approach of §5.4 shall show compliance through online BEP-EMIS or whole building energy simulation software endorsed by BEE.

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

### **3.5 Administrative Requirements**

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

### **3.6 Compliance Documents**

#### **3.6.1 Compliance Documents**

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

- a) Building Envelope: opaque construction materials and their thermal properties including thermal conductivity, specific heat, density along with thickness; fenestration U-factors, solar heat gain coefficients (SHGC), visible light transmittance (VLT) and building envelope sealing documentation; overhangs and side fins, building envelope sealing details;
- b) Heating, Ventilation, and Air Conditioning: system and equipment types, sizes, efficiencies, and controls; economizers; variable speed drives; piping insulation; duct sealing, insulation and location; solar water heating system; requirement for balance report;
- c) Lighting: lighting schedule showing type, number, and wattage of lamps and ballasts; automatic lighting shutoff, occupancy sensors, and other lighting controls; lamp efficacy for exterior lamps;

- d) Electrical Power: electric schedule showing transformer losses, motor efficiencies, and power factor correction devices; electric check metering and monitoring system.
- e) Renewable energy systems: system peak generation capacity, technical specifications, solar zone area

### **3.6.2 Supplemental Information**

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

## 4 Building Envelope

### 4.1 General

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

### 4.2 Mandatory Requirements

#### 4.2.1 Fenestration

##### 4.2.1.1 U-Factor

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

##### 4.2.1.2 Solar Heat Gain Coefficient

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

##### Exceptions to §4.2.1.2:

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

##### 4.2.1.3 Visible Light Transmittance

Visible light transmittance (VLT) shall be determined for the fenestration product in accordance with ISO-15099 by an accredited independent laboratory and labelled 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 labelled 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 labelled 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 labelled 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 §4.2.3.1 or the manual method in §4.2.3.2. Assembly buildings and other buildings where daylighting will interfere with the functions or processes of 50% (or more) of the building floor area, are exempted from meeting the requirements listed in Table 4-1.

### **Exceptions to §4.2.3:**

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

Table 4-1 Daylight Requirement

| <i>Building Category</i>                  | <i>Percentage of above grade floor area meeting the UDI requirement</i> |       |           |
|---|---|-------|-----------|
|   | ECBC  | ECBC+ | SuperECBC |
| Business,<br>Educational                  | 40%   | 50%   | 60%       |
| No Star Hotel<br>Star Hotel<br>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 daylight time. Illuminance levels for all spaces enclosed by permanent internal partitions (opaque, translucent, or transparent) with height greater or equal to 2 m from the finished floor, shall be measured as follows:

- (a) Measurements shall be taken at a work plane height of 0.8 m above the finished floor.
- (b) The period of analysis shall be fixed for continuously 8 hours per day, anytime between 7:00 AM IST to 5:00 PM IST, resulting in 2,920 hours in total for all building types except for Schools. Schools shall be analyzed continuously for 7 hours per day, anytime between 7:00 AM IST to 3:00 PM IST.
- (c) Available useful daylight across a space shall be measured based on point-by-point grid values. UDI shall be calculated for at least one point for each square meter of floor area.
- (d) Fenestration shall be modeled with actual visible light transmission (VLT) as per the details provided in the material specification sheet.
- (e) All surrounding natural or man-made daylight obstructions shall be modeled if the distance between the façade of the building (for which compliance is shown) and surrounding natural or man-made daylight obstructions is less than or equal to twice the height of the man-made or natural sunlight



obstructers. If the reflectance of the surfaces is not known, default reflectance of 30% and 0% shall be used for all vertical surfaces of man-made and natural obstructers respectively.

- (f) Interior surface reflectance shall be modeled based on the actual material specification. If material specification is not available, the following 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 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 modelled).
- 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

| <i>Surface Type</i>                | <i>Reflectance</i> |
|------------------------------------|--------------------|
| 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

- (a) To calculate the daylit area:
- i. In a direction perpendicular to the fenestration, multiply daylight extent factor (DEF) by the head height of the fenestration or till an opaque partition higher than head height of the fenestration, whichever is less.
  - ii. In the direction parallel to the fenestration, daylit area extends a horizontal dimension equal to the width of the fenestration plus either 1 meter on each side of the aperture, or the distance to an opaque partition of 2m high, or one-half the distance to an adjacent fenestration, whichever is least.
  - iii. For skylights, calculate the horizontal dimension in each direction equal to the top aperture dimension in that direction plus either the floor-to-ceiling height (H) for skylights, or 1.5 H for monitors, 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 facades, with non-cardinal orientation, shall be categorized under a particular cardinal direction if its orientation is within ±45 degrees of that cardinal direction.
  - v. Daylit area overlap: For overlapping daylit areas such as windows on different orientations or in case of skylights the overlapping daylit area shall be subtracted from the sum of daylit area.

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

#### **4.2.4 Building Envelope Sealing**

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

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

#### Note 4- 1 Daylight Extent Factor and Useful Daylight Illuminance



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

#### Calculating Useful Daylight Illuminance (UDI)

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

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

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

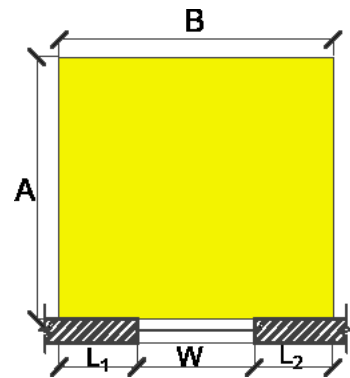


UDI Analysis with a Daylighting Analysis Software

**(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 Guwahati (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) A: In the direction perpendicular to the fenestration, daylit area extends to head height of the fenestration multiplied by the daylight extent factor (DEF) or distance till an opaque partition higher than head height of the fenestration, whichever is less.
  - (b) B: In the direction parallel to the fenestration daylit area extends a horizontal dimension equal to the width of the fenestration plus either one meter on each side of the aperture or the distance to an opaque partition, or one-half the distance to an adjacent fenestration, whichever is least.



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



UDI Analysis with manual calculations

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

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

| <b>Orientation – NORTH, DEF-3.5, Fenestration Head Height H-3m</b> |                                 |  |  |  |
|--|---------------------------------|--|--|--|
| <i>Window without opaque obstructions</i>                          | <i>Fenestration Width W (m)</i> | <i>A= H x DEF (m)</i>                            | <i>B=L<sub>1</sub>+W+L<sub>2</sub>(m)<br/>L<sub>1</sub> = L<sub>2</sub> = 1m</i>                                     | <i>Area meeting the UDI requirements =<br/>AxB (m<sup>2</sup>)</i> |
| 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   |
| <i>Window with opaque obstructions</i>                             | <i>Fenestration Width W (m)</i> | <i>A= Distance till parallel Obstruction (m)</i> | <i>B=L<sub>1</sub>+W+L<sub>2</sub>(m)<br/>L<sub>1</sub> = L<sub>2</sub> = Distance to perpendicular obstructions</i> | <i>Area meeting the UDI requirements =<br/>AxB (m<sup>2</sup>)</i> |
| 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   |
| Daylight area meeting UDI requirement                              |                                 |  |  | 213.2  |
| <b>Orientation – SOUTH, DEF-3, Fenestration Head Height H-3m</b>   |                                 |  |  |  |
| <i>Window without opaque obstructions</i>                          | <i>Fenestration Width W (m)</i> | <i>A= H x DEF (m)</i>                            | <i>B=L<sub>1</sub>+W+L<sub>2</sub>(m)<br/>L<sub>1</sub> = L<sub>2</sub> = 1m</i>                                     | <i>Area meeting the UDI requirements =<br/>AxB (m<sup>2</sup>)</i> |
| 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  |
| Daylight area meeting UDI requirement                              |                                 |  |  | 254.7  |
| <b>Orientation – EAST, DEF-2.1, Fenestration Head Height H-3m</b>  |                                 |  |  |  |
| <i>Window without opaque obstructions</i>                          | <i>Fenestration Width W (m)</i> | <i>A= H x DEF (m)</i>                            | <i>B=L<sub>1</sub>+W+L<sub>2</sub>(m)<br/>L<sub>1</sub> = L<sub>2</sub> = 1m</i>                                     | <i>Area meeting the UDI requirements =<br/>AxB (m<sup>2</sup>)</i> |
| 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   |
| <i>Adjacent fenestration</i>                                       | <i>Fenestration Width W (m)</i> | <i>A= H x DEF (m)</i>                            | <i>B=L<sub>1</sub>+W+L<sub>2</sub>(m)<br/>L<sub>1</sub> = L<sub>2</sub> = one half of</i>                            | <i>Area meeting the UDI requirements =</i>                         |

|  |                                 |                       |  |  |
|--|---------------------------------|-----------------------|--|--|
| <i>less than two meter apart</i>                                       |                                 |                       | <i>distance to adjacent fenestration</i>   | <i>AxB (m<sup>2</sup>)</i>                                     |
| E2   | 2                               | 6.3                   | $1.0+2.0+0.2=3.2$  | 20.2   |
| E3   | 2                               | 6.3                   | $0.2+2+0.2=2.4$  | 15.1   |
| E4   | 2                               | 6.3                   | $0.2+2_{-1}=3.2$   | 20.2   |
| Daylight area meeting UDI requirement                                  |                                 |                       |  | 124.9  |
| <b>Orientation – WEST, DEF-1.8, Fenestration Head Height H-3m</b>      |                                 |                       |  |  |
| <i>Window without opaque obstructions</i>                              | <i>Fenestration Width W (m)</i> | <i>A= H x DEF (m)</i> | <i>B=L<sub>1</sub>+W+L<sub>2</sub>(m)<br/>L<sub>1</sub> = L<sub>2</sub> = 1m</i>                                     | <i>Area meeting the UDI requirements = AxB (m<sup>2</sup>)</i> |
| 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   |
| <i>Window with opaque obstructions in daylight area</i>                | <i>Fenestration Width W (m)</i> | <i>A= H x DEF (m)</i> | <i>B=L<sub>1</sub>+W+L<sub>2</sub>(m)<br/>L<sub>1</sub> = L<sub>2</sub> = Distance to perpendicular obstructions</i> | <i>Area meeting the UDI requirements = AxB (m<sup>2</sup>)</i> |
| 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  |
| Daylight area meeting UDI requirement                                  |                                 |                       |  | 56.1   |
| <b>Overlapping area calculations</b>                                   |                                 |                       |  |  |
| <i>Window with overlap areas</i>                                       | <i>Width (m)</i>                | <i>Depth (m)</i>      | <i>Area (m<sup>2</sup>)</i>  |  |
| N4 and S1  | 3.3                             | 3.3                   | 10.9   |  |
| S3 and E5  | 3.3                             | 6.5                   | 21.5   |  |
| Overlapping daylight area (b)  |                                 |                       | 32.4   |  |
| <b>Total Daylit area</b>   |                                 |                       |  |  |
| ORIENTATION  |                                 |                       | <i>Daylight area (m<sup>2</sup>)</i>   |  |
| NORTH  |                                 |                       | 213.2  |  |
| SOUTH  |                                 |                       | 254.7  |  |
| EAST   |                                 |                       | 124.9  |  |
| WEST   |                                 |                       | 56.1   |  |
| Total daylight area (a)  |                                 |                       | 648.9  |  |
| Total overlapping daylit area (b)                                      |                                 |                       | 32.4   |  |
| Total daylit area meeting UDI requirement during 90% of the year (a-b) |                                 |                       | 616.5  |  |

### 4.3 Prescriptive Requirements

#### 4.3.1 Roof

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

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

|   | <i>Warm and Humid</i> | <i>Cold</i> |
|---|-----------------------|-------------|
| All building types, except below        | 0.33                  | 0.28        |
| School <10,000 m <sup>2</sup> AGA       | 0.47                  | 0.33        |
| Hospitality > 10,000 m <sup>2</sup> AGA | 0.20                  | 0.20        |

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

|   | <i>Warm and Humid</i> | <i>Cold</i> |
|---|-----------------------|-------------|
| Hospitality,<br>Healthcare,<br>Assembly       | 0.20                  | 0.20        |
| Business,<br>Educational,<br>Shopping Complex | 0.26                  | 0.20        |

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

|                    | <i>Warm and Humid</i> | <i>Cold</i> |
|--------------------|-----------------------|-------------|
| All Building Types | 0.20                  | 0.20        |



#### 4.3.1.1 Vegetated and Cool Roof

All roofs that are not covered by solar photovoltaic, 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 (RA1996).
- (b) For qualifying as a vegetated roof, roof areas shall be covered by living vegetation of >50 mm high.

#### 4.3.2 Opaque External Wall

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

Table 4-7 Opaque Assembly Maximum U-factor (W/m<sup>2</sup>.K) Requirements for an ECBC compliant Building

|  | <i>Warm and Humid</i> | <i>Cold</i> |
|--|-----------------------|-------------|
| All building types, except below         | 0.40                  | 0.34        |
| No Star Hotel <10,000 m <sup>2</sup> AGA | 0.63                  | 0.40        |
| Business < 10,000 m <sup>2</sup> AGA     | 0.63                  | 0.40        |
| School < 10,000 m <sup>2</sup> AGA       | 0.85                  | 0.40        |

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

|  |      |      |      |
|--|------|------|------|
| All building types, except below         | 0.34 | 0.55 | 0.22 |
| No Star Hotel <10,000 m <sup>2</sup> AGA | 0.44 | 0.44 | 0.34 |
| Business <10,000 m <sup>2</sup> AGA      | 0.44 | 0.55 | 0.34 |
| School <10,000 m <sup>2</sup> AGA        | 0.63 | 0.75 | 0.44 |

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

|                    | <i>Warm and Humid</i> | <i>Cold</i> |
|--------------------|-----------------------|-------------|
| All Building Types | 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 Warm and Humid climatic zones, shall have a maximum assembly U-factor of 0.8  $W/m^2K$ .

### 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, excluding Building Envelope Trade-off Method)
- (b) Minimum allowable Visible Light Transmittance (VLT) is 0.27.
- (c) Assembly U-factor shall be determined for the overall fenestration product (including the sash and frame).

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

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

|   | <i>Warm and Humid</i> | <i>Cold</i> |
|---|-----------------------|-------------|
| Maximum U-factor (W/m <sup>2</sup> .K)                    | 3.00                  | 3.00        |
| Maximum SHGC Non-North                                    | 0.27                  | 0.62        |
| Maximum SHGC North for latitude $\geq$ 15°N               | 0.50                  | 0.62        |
| Maximum SHGC North for latitude < 15°N                    | 0.27                  | 0.62        |
| See Appendix A for default values of unrated fenestration |                       |             |

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

|   | <i>Warm and Humid</i> | <i>Cold</i> |
|---|-----------------------|-------------|
| Maximum U-factor (W/m <sup>2</sup> .K)      | 2.20                  | 1.80        |
| Maximum SHGC Non- North                     | 0.25                  | 0.62        |
| Maximum SHGC North for latitude $\geq$ 15°N | 0.50                  | 0.62        |
| Maximum SHGC North for latitude < 15°N      | 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 Shading Equivalent Factor (SEF) is  $0.25 \leq PF \leq 1.0$ . The SEF is applicable for both side fins shading only other than the 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 modelled through the Whole Building Performance Method in §9.
- ii. A shaded vertical fenestration on a non-cardinal direction, shall be categorized either under a particular cardinal direction or a primary inter-cardinal direction if its orientation is within the range of  $\pm 22.5$  degrees of the cardinal or primary inter-cardinal direction.
- iii. Any surrounding man-made or natural sunlight 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.
- 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 |                   |      |      |      |      |      |      |      |      |
|--|-------------------|------|------|------|------|------|------|------|------|
|  | Projection Factor | N    | E    | S    | W    | NE   | SE   | SW   | NE   |
| 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 |      |

|             |      |      |      |      |      |      |      |      |
|-------------|------|------|------|------|------|------|------|------|
| <b>0.55</b> | 1.24 | 1.22 | 1.38 | 1.22 | 1.38 | 1.29 | 1.34 | 1.50 |
| <b>0.6</b>  | 1.25 | 1.23 | 1.40 | 1.23 | 1.42 | 1.31 | 1.35 | 1.55 |
| <b>0.65</b> | 1.27 | 1.24 | 1.42 | 1.25 | 1.47 | 1.32 | 1.36 | 1.58 |
| <b>0.7</b>  | 1.28 | 1.26 | 1.44 | 1.26 | 1.51 | 1.34 | 1.36 | 1.61 |
| <b>0.75</b> | 1.30 | 1.27 | 1.46 | 1.27 | 1.55 | 1.35 | 1.37 | 1.64 |
| <b>0.8</b>  | 1.31 | 1.28 | 1.48 | 1.29 | 1.59 | 1.37 | 1.38 | 1.65 |
| <b>0.85</b> | 1.32 | 1.30 | 1.49 | 1.30 | 1.62 | 1.38 | 1.39 | 1.65 |
| <b>0.9</b>  | 1.34 | 1.31 | 1.51 | 1.31 | 1.65 | 1.40 | 1.40 | 1.64 |
| <b>0.95</b> | 1.35 | 1.32 | 1.53 | 1.32 | 1.67 | 1.42 | 1.42 | 1.61 |
| <b>≥1</b>   | 1.36 | 1.33 | 1.55 | 1.33 | 1.69 | 1.44 | 1.45 | 1.57 |

- (b) Vertical fenestration, located such that its bottom is more than 2.2 m above the level of the floor, is exempt from the SHGC requirements in Table 4-10 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 4-2 Equivalent SHGC and Projection Factor



A 5,400 m<sup>2</sup> two story office building in Guwahati, Assam 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 2.165 m 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<sup>2</sup>.

SHGC of the glazing in the East/West Fenestration is 0.30; area weighted U-Factor is 3.0 W/m<sup>2</sup> K. VLT of the glazing in all orientation is 0.5. Will the vertical fenestration comply with the ECBC through prescriptive approach?

#### Solution:

Table 4-10 and §4.3.3 lists the U-factor, SHGC and VLT requirements for vertical fenestration for ECBC compliant buildings. The building is located in Guwahati (Latitude: 26°11' N, Longitude: 91°73'E), which falls under the warm & humid climate. To fulfil prescriptive requirements, Window to Wall ratio ≤ 40%, SHGC ≤ 0.27, U-factor ≤ 3.0 W/m<sup>2</sup>.K, and VLT ≥ 0.27.

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

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

Total Fenestration area = 384 m<sup>2</sup>

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<sup>2</sup>.K. Similarly, the VLT is 0.45, 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.

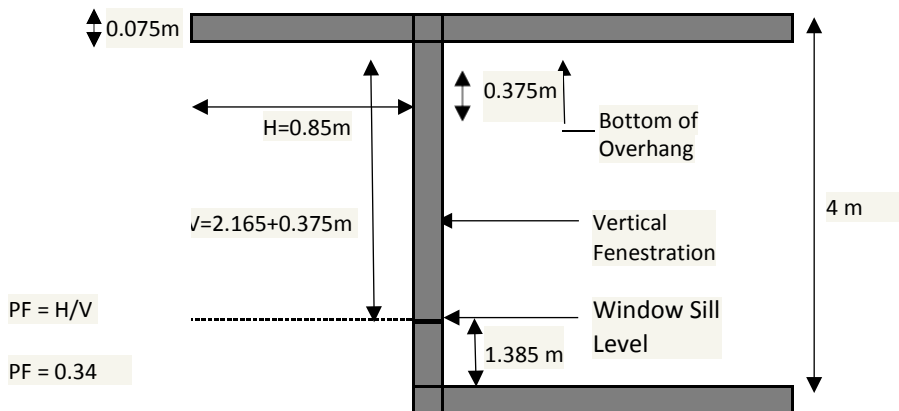
SEF for east for PF = 0.3 (as worst case) = 1.26

Therefore, equivalent  $SHGC_{East} = 0.3 \div 1.26 = 0.24$ . 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  $SHGC_{West} = 0.3 \div 1.27 = 0.24$ , hence the vertical fenestration on the west façade will comply as per prescriptive approach, as the equivalent SHGC is less than maximum allowed.





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

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

Table 4-13 U-factor (W/m<sup>2</sup>.K) Exemption Requirements for Shaded Building

| <i>Building Type</i>                            | <i>Climate zone</i> | <i>Orientation</i>                                       | <i>Maximum Effective SHGC</i> | <i>Minimum VLT</i> | <i>PF</i> |
|---|---------------------|--|-------------------------------|--------------------|-----------|
| 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 4-14 Skylight U-factor (W/m<sup>2</sup>.K) and SHGC Requirements

| <i>Climate</i>     | <i>Maximum U-factor</i> | <i>Maximum SHGC</i> |
|--------------------|-------------------------|---------------------|
| All climatic zones | 4.25                    | 0.35                |

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

**4.3.5 Building Envelope Trade-Off Method**

The building envelope complies with the code if the Envelope Performance Factor (EPF) of the Proposed Building is less than the EPF of the Standard Building, where the Standard Building exactly complies with the prescriptive requirements of building envelope. This method shall not

be used for buildings with WWR > 40%. Trade-off is not permitted for skylights. Skylights shall meet requirements of 4.3.4. The envelope performance factor shall be calculated using the following equations.

**Equation 4.1: EPF<sub>Total</sub> = EPF<sub>Roof</sub> + EPF<sub>Wall</sub> + EPF<sub>Fenest</sub>**

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

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

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

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

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

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

EPF<sub>Roof</sub> Envelope performance factor for roofs. Other subscripts include walls and fenestration.

A<sub>s</sub>, A<sub>w</sub> The area of a specific envelope component referenced by the subscript "s" or for windows the subscript "w".

SHGC<sub>w</sub> The solar heat gain coefficient for windows (w).

SEF<sub>w</sub> A multiplier for the window SHGC that depends on the projection factor of an overhang or side fin.

U<sub>s</sub> The U-factor for the envelope component referenced by the subscript "s".

C<sub>Roof</sub> A coefficient for the "Roof" class of construction.

C<sub>wall</sub> A coefficient for the "Wall".

C<sub>1Fenes</sub> A coefficient for the "Fenestration U-factor".

C<sub>2Fenes</sub> A coefficient for the "Fenestration SHGC".

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

Table 4-15 Envelope Performance Factor Coefficients – Warm and Humid Climate

|               | <i>Daytime Business, Educational, Shopping Complex</i> |                          | <i>24-hour Business, Hospitality, Health Care, Assembly</i> |                          |
|---------------|--|--------------------------|---|--------------------------|
|               | C factor <sub>U-factor</sub>                           | C factor <sub>SHGC</sub> | C factor <sub>U-factor</sub>                                | C factor <sub>SHGC</sub> |
| 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 4-16 Envelope Performance Factor Coefficients – Cold Climate

|               | <i>Daytime Business, Educational, Shopping Complex</i> |                          | <i>24-hour Business, Hospitality, Health Care, Assembly</i> |                          |
|---------------|--|--------------------------|---|--------------------------|
|               | C factor <sub>U-factor</sub>                           | C factor <sub>SHGC</sub> | C factor <sub>U-factor</sub>                                | C factor <sub>SHGC</sub> |
| 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.
- b) The U-factor of each envelope component shall be equal to the criteria from

§4 for each class of construction.

- c) The SHGC of each window shall be equal to the criteria from §4.3.3.
- d) Shading devices shall not be considered for calculation EPF for Standard Building. (i.e. SEF=1).

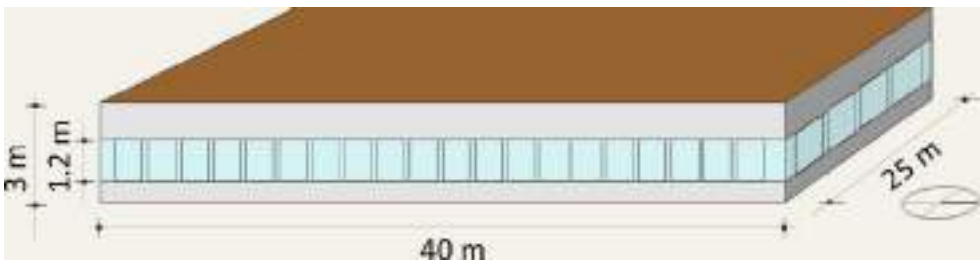
*Note 4-3 Building Envelope Trade-off Method*



**Application of Building Envelope Trade-off method**

A 1,000 m<sup>2</sup> single story daytime use office building in Guwahati, Assam is trying to achieve ECBC level compliance. Each side has a band of windows, without shading. The materials for the envelope have already been selected, prior to opting for ECBC compliance. Their thermal properties are: roof assembly U- value= 0.4 W/m<sup>2</sup>.K, external wall assembly U-value = 0.25 W/m<sup>2</sup>.K, glazing SHGC = 0.25, VLT = 0.27, area weighted U-value for glazing = 1.8 W/m<sup>2</sup>.K.

Dimensions of the building envelope are as follows:



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

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

|                      | Prescriptive U-factor<br>(W/m <sup>2</sup> .K) |      |      | Proposed U-factor<br>(W/m <sup>2</sup> .K) |      |      | Area (m <sup>2</sup> ) |
|----------------------|--|------|------|--|------|------|------------------------|
|                      | U-factor                                       | SHGC | VLT  | U-factor                                   | SHGC | VLT  |                        |
| Wall 1– North, South |  |      | 0.63 |  |      | 0.25 | 150                    |
| Wall 2– East, West   |  |      | 0.63 |  |      | 0.25 | 240                    |
| Roof                 |  |      | 0.33 |  |      | 0.4  | 1000                   |
| Window – South       | 3  | 0.5  | 0.27 | 1.8  | 0.25 | 0.27 | 30                     |
| Window – North       | 3  | 0.27 | 0.27 | 1.8  | 0.25 | 0.27 | 30                     |
| Window-East          | 3  | 0.27 | 0.27 | 1.8  | 0.25 | 0.27 | 48                     |
| Window-West          | 3  | 0.27 | 0.27 | 1.8  | 0.25 | 0.27 | 48                     |

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

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

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

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

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

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

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

U-value of the roof of the proposed building, at  $0.4 \text{ W/m}^2\cdot\text{K}$  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 = EPFRoof + EPFWall + EPFFenest

Where,

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

$$EPF_{\text{wall}} = C_{\text{Wall}} \sum_{S=1}^n U_S A_S$$

$$EPF = C \sum^n U_w A_w + C \sum^n \frac{SHGC_w}{A_w}$$

*Fenest*    1 *Fenest, North*     $w=1$

2 *Fenest, North*     $w=1$  *SEFW*

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

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

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

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

$$= 40.1 \times 0.4 \times 1,000 = 16,040$$

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

$$= (24.5 \times 0.25 \times 390) = 2,388.75$$

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

$$\begin{aligned}
 EPF_{Fenest} &= C \sum_{w=1}^n U_w A_w + C \sum_{w=1}^n \frac{SHGC_w}{SEF_w} A_w \\
 &\quad \quad \quad 1Fenest \quad \quad \quad 2Fenest
 \end{aligned}$$

Hence,



$$EPF_{Fenest, North} = 20.7 \times 1.8 \times 30 + 230.7 \times 0.25 \times 30 = 1,117.8 + 1,730.5 = 2,848.05$$

$$EPF_{Fenest, South} = 20.10 \times 1.8 \times 30 + 347.1 \times 0.25 \times 30 = 1,085.4 + 2,603.25 = 3,688.65$$

$$EPF_{Fenest, East} = 19.0 \times 1.8 \times 48 + 301.8 \times 0.25 \times 48 = 1,641.6 + 3,621.6 = 5,263.2$$

$$EPF_{Fenest, West} = 18.7 \times 1.8 \times 48 + 303.1 \times 0.25 \times 48 = 1,615.68 + 3,637.2 = 5,252.88$$

Therefore,

$$EPF_{Fenest} = 17,052.78$$

$$EPF_{Proposed} = 16,040 + 2,388.75 + 17,052.78 = 35,481.53$$

### **Step 2: Calculating EPF Standard building from prescriptive envelope requirements**

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

$$= 40.1 \times 0.33 \times 1000 = 13,233$$

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

$$= (24.5 \times 0.63 \times 390) = 6,019.65$$

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

Now,

$$EPF_{Fenest, North} = 20.7 \times 3.0 \times 30 + 230.7 \times 0.5 \times 30 = 1,863.0 + 3,460.5 = 5,323.5$$

$$EPF_{Fenest, South} = 20.1 \times 3.0 \times 30 + 347.1 \times 0.27 \times 30 = 1,809.0 + 2,811.51 = 4,620.51$$

$$EPF_{Fenest, East} = 19.0 \times 3.0 \times 48 + 301.8 \times 0.27 \times 48 = 2,736.0 + 3,911.33 = 6,647.33$$

$$EPF_{Fenest, West} = 18.7 \times 3.0 \times 48 + 303.1 \times 0.27 \times 48 = 2,692.8 + 3,928.18 = 6,620.98$$

$$\text{Therefore, } EPF_{Fenest} = 23,212.31$$

$$EPF_{Baseline} = 13,233 + 6,019.65 + 23,212.31 = 42,464.96$$

Since  $EPF_{Baseline} \geq EPF_{Proposed}$ , therefore the building is compliant with ECBC building

envelope requirements.

## 5 Comfort Systems and Controls

### 5.1 General

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

### 5.2 Mandatory Requirements

#### 5.2.1 Ventilation

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

##### 5.2.1.1 Natural Ventilation Design Requirements

Naturally ventilated building shall:

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

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

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

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

### 5.2.1.3 Demand Control Ventilation

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

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

#### Exceptions to § 5.2.1.3:

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

## 5.2.2 Minimum Space Conditioning Equipment Efficiencies

### 5.2.2.1 Chillers

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

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

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

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

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

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

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

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

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

### 5.2.2.3 Variable Refrigerant Flow

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

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

| For Heating or cooling or both   |                                  |           |      |
|--|----------------------------------|-----------|------|
| Type   | Size category (kW <sub>r</sub> ) | EER (W/W) | IEER |
| VRF Air Conditioners, Air cooled   | < 40                             | 3.28      | 4.36 |
|  | >= 40 and < 70                   | 3.26      | 4.34 |
|  | >= 70                            | 3.02      | 4.07 |
| * The revised EER and IEER values as per Indian Standard for VRF corresponding to values in this table will supersede as and when the revised standards are published. |                                  |           |      |

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

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

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

| Equipment type  | Net Sensible Cooling Capacity * | Minimum SCOP-127 <sup>b</sup> |         |
|---|---------------------------------|-------------------------------|---------|
|   |                                 | Down flow                     | Up flow |
| All types of computer room ACs Air/ Water/ Glycol   | All capacity                    | 2.5                           | 2.5     |
| <p>a. Net Sensible cooling capacity = Total gross cooling capacity - latent cooling capacity – Fan power</p> <p>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)</p> |                                 |                               |         |

### 5.2.2.5 Boilers

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

Table 5-6 Minimum Efficiency Requirements 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 Time clock

Mechanical cooling and heating systems in Universities and Training Institutions of all sizes and all Shopping Complexes with built up area greater than 20,000 m<sup>2</sup> 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,
- (b) Are capable of retaining programming and time setting during loss of power for a period of at least 10 hours, and
- (c) Include an accessible manual override that allows temporary operation of the system for up to 2 hours.

#### Exceptions to §5.2.3.1:

- (a) Cooling systems less than 17.5 kW<sub>r</sub>
- (b) Heating systems less than 5.0 kW<sub>r</sub>
- (c) Unitary systems of all capacities

#### 5.2.3.2 Temperature Controls

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



These controls should meet the following requirements:

- (a) Where a unit provides both heating and cooling, controls shall be capable of providing a temperature dead band of 3.0°C within which the supply of heating and cooling energy to the zone is shut off or reduced to a minimum.
- (b) Where separate heating and cooling equipment serve the same temperature zone, temperature controls shall be interlocked to prevent simultaneous heating and cooling.
- (c) Separate thermostat control shall be installed in each
  - i. guest room of Resort and Star Hotel,
  - ii. room less than 30 m<sup>2</sup> in Business,
  - iii. air-conditioned class room, lecture room, and computer room of Educational,
  - iv. in-patient and out-patient room of Healthcare

#### 5.2.3.3 Occupancy Controls

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

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

#### 5.2.3.4 Fan Controls

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

- (a) Two speed motors, pony motors, or variable speed drives controlling the fans, or
- (b) Controls capable of reducing the fan speed to at least two third of installed fan power [ANS1] [MB2]

#### 5.2.3.5 Dampers

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

- (a) Fan shutdown, or,
- (b) When spaces served are not in use
- (c) Backdraft gravity damper is acceptable in the system with design outdoor air of the system is less than 150 liters per second in all climatic zones except cold climate, provided backdraft dampers for ventilation air intakes are protected

- from direct exposure to wind.
- (d) Dampers are not required in ventilation or exhaust systems serving naturally conditioned spaces.
  - (e) Dampers are not required in exhaust systems serving kitchen exhaust hoods.

## 5.2.4 Piping and Ductwork

### 5.2.4.1 Piping Insulation

Piping for heating, space conditioning, and service hot water systems shall meet the insulation requirements listed in Table 5-7 through Table 5-9. Insulation exposed to weather shall be protected by aluminum sheet metal, painted canvas, or plastic cover. Cellular foam insulation shall be protected as above or be painted with water retardant paint.

#### Exceptions to § 5.2.4.1:

- (a) Reduction in insulation R value by 0.2 (compared to values in Table 5-7, Table 5-8 and Table 5-9) to a minimum insulation level of R-0.4 shall be permitted for any pipe located in partition within a conditioned space or buried. [ANS3] [MB4]
- (b) Insulation R value shall be increased by 0.2 over and above the requirement stated in Table 5-7 through Table 5-9 for any pipe located in a partition outside a building with direct exposure to weather.

Table 5-7 Insulation Requirements for Pipes in ECBC Building

| Operating Temperature (°C)                | Pipe size (mm)                           |      |
|---|--|------|
|   | < 40                                     | ≥ 40 |
|   | Insulation R value (m <sup>2</sup> .K/W) |      |
| <b>Heating System</b>                     |  |      |
| >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  |
| <b>Cooling System</b>                     |  |      |
| >4.5°C and ≤15°C                          | 0.4                                      | 0.7  |
| < 4.5°C                                   | 0.9                                      | 1.2  |
| <b>Refrigerant Piping (Split Systems)</b> |  |      |
| >4.5°C and ≤15°C                          | 0.4                                      | 0.7  |
| < 4.5°C                                   | 0.9                                      | 1.2  |

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

| Operating Temperature (°C)                | Pipe size (mm)                           |      |
|---|--|------|
|   | < 40                                     | ≥ 40 |
|   | Insulation R value (m <sup>2</sup> .K/W) |      |
| <b>Heating System</b>                     |  |      |
| >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  |
| <b>Cooling System</b>                     |  |      |
| >4.5°C and ≤15°C                          | 0.5                                      | 0.9  |
| < 4.5°C                                   | 1.1                                      | 1.3  |
| <b>Refrigerant Piping (Split Systems)</b> |  |      |
| >4.5°C and ≤15°C                          | 0.5                                      | 0.9  |
| < 4.5°C                                   | 1.1                                      | 1.3  |

Table 5-9 Insulation Requirements for Pipes in SuperECBC Buildings

| Operating Temperature (°C)                | Pipe size (mm)                           |      |
|---|--|------|
|   | < 40                                     | ≥ 40 |
|   | Insulation R value (m <sup>2</sup> .K/W) |      |
| <b>Heating System</b>                     |  |      |
| >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  |
| <b>Cooling System</b>                     |  |      |
| >4.5°C and ≤15°C                          | 0.7                                      | 1.2  |
| < 4.5°C                                   | 1.5                                      | 1.5  |
| <b>Refrigerant Piping (Split Systems)</b> |  |      |
| >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 5-10.

Table 5-10 Ductwork Insulation (R value in  $m^2 \cdot K/W$ ) 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 climate zones and all buildings in cold climate zone with a hot water system, shall have solar water heating equipment installed to provide for:

- a) at least 20% of the total hot water design capacity if above grade floor area of

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

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

### 5.2.7.2 Heating Equipment Efficiency

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

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

### 5.2.7.3 Other Water Heating System

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

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

### 5.2.7.4 Piping Insulation

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

### 5.2.7.5 Heat Traps

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

### 5.2.7.6 Swimming Pools

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

## 5.3 Prescriptive Requirements

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

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

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

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

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

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

Table 5-13 Mechanical and Motor Efficiency Requirements for Fans in 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 for ECBC+ and SuperECBC Buildings are presented in Table 5-14 through Table 5-16 under ANSI/ AHRI 550/ 590 conditions.

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

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

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

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

### 5.3.2 Pumps

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

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

Table 5-16 Pump Efficiency Requirements for ECBC Building

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

Table 5-17 Pump Efficiency Requirements for ECBC+ Building

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

Table 5-18 Pump Efficiency Requirements for SuperECBC Building

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

### 5.3.3 Cooling Towers

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



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

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

### 5.3.4 Boilers

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

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

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

### 5.3.5 Economizers

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

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

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

#### Exception to § 5.3.5.1:

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

### 5.3.5.2 Partial Cooling

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

### 5.3.5.3 Economizer Controls

Air economizer shall be equipped with controls

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

### 5.3.5.4 Testing

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

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

## 5.3.6 Variable Flow Hydronic Systems

### 5.3.6.1 Variable Fluid Flow

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

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

### 5.3.6.2 Isolation Valves

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

### 5.3.6.3 Variable Speed Drives

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

### 5.3.7 Unitary, Split, Packed Air-Conditioners

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

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

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

Table 5-22 Minimum Requirements for Oil Unitary, Split, Packaged Air Conditioners in SuperECBC building

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

### 5.3.8 Controls for ECBC+ and SuperECBC Buildings

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

#### 5.3.8.1 Centralized Demand Shed Controls

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

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

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

The centralized demand shed controls shall have additional capabilities to

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

### 5.3.8.2 Supply Air Temperature Reset

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

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

### 5.3.8.3 Chiller Water Temperature Reset

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

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

### 5.3.9 Controls for SuperECBC Buildings

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

#### 5.3.9.1 Variable Air Volume Fan Control

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

### 5.3.10 Energy Recovery

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

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

### 5.3.11 Service Water Heating

For compliance with ECBC+ and SuperECBC,

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

**Exception to §5.3.1** Systems that use heat recovery to provide the hot water capacity required as per the building type, size and efficiency level.

### 5.3.12 Total System Efficiency – Alternate Compliance Approach

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

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

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

### 5.3.12.1 Documentation Requirement

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

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

The total system efficiency shall be calculated as follows:

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

### 5.3.13 Low-energy Comfort Systems

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

- a) Evaporative cooling
- b) Desiccant cooling system
- c) Solar air conditioning

<sup>1</sup>This is not an all-inclusive list. The updated list of low energy comfort systems is available at BEE website

(<https://www.beeindia.gov.in/>)

- d) Tri-generation(waste-to-heat)
- e) Radiant cooling system
- f) Ground source heat pump
- g) Adiabatic cooling system

Buildings with an approved low-energy comfort system installed for more than 50% [ANS5] [MB6] of the sum of cooling and heating capacity requirement [ANS7] [MB8] of the building shall be deemed equivalent to the ECBC+ building standard prescribed in § 5.2.2.

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

### **5.3.13.1 Documentation Requirement**

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

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



## 6 Lighting and Controls

### 6.1 General

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

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

#### Exceptions to §6.1:

- a) Emergency or security lighting that is automatically off during normal building operations.

### 6.2 Mandatory Requirements

#### 6.2.1 Lighting Control

##### 6.2.1.1 Automatic Lighting Shutoff

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

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

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

### 6.2.1.2 Space Control

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

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

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

### 6.2.1.3 Control in Daylight Areas

- a) Luminaires, installed within day lighting extent from the window as calculated in § 4.2.3, shall be equipped with either a manual control device to shut off luminaires, installed within daylight area, during potential daylight time of a day or automatic control device that:
  - i. Has a delay of minimum 5 minutes, and,
  - ii. Can dim or step down to 50% of total power.
- b) Overrides to the daylight controls shall not be allowed.

#### 6.2.1.4 Exterior Lighting Control

- a) Lighting for all exterior applications [ANS9] [MB10] shall be controlled by a photo sensor or astronomical time switch that is capable of automatically turning off the exterior lighting when daylight is available, or the lighting is not required.
- b) Lighting for all exterior applications, shall have lamp efficacy not less than 80 lumens per watt, 90 lumens per watt, and 100 lumens per watt, for ECBC, unless the luminaire is controlled by a motion sensor or exempt under §6.1.
- c) Façade lighting and façade non-emergency signage of Shopping Complexes shall have separate time switches.

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

#### 6.2.1.5 Additional Control

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

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

#### 6.2.2 Exit Signs

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

## 6.3 Prescriptive Requirement

### 6.3.1 Interior Lighting Power

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

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

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

### 6.3.2 Building Area Method

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

Determine the allowed lighting power density for each appropriate building area type from Table 6-1 for ECBC Buildings, from Table 6-2 for ECBC+ Buildings and from Table 6-3 for SuperECBC Buildings.

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

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

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

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

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

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

| Building Type                 | LPD (W/m <sup>2</sup> ) | Building Area Type     | LPD (W/m <sup>2</sup> ) |
|-------------------------------|-------------------------|------------------------|-------------------------|
| <b>Office Building</b>        | 5.0                     | Motion picture theater | 4.7                     |
| <b>Hospitals</b>              | 4.9                     | Museum                 | 5.1                     |
| <b>Hotels</b>                 | 4.8                     | Post office            | 5.3                     |
| <b>Shopping Mall</b>          | 7.0                     | Religious building     | 6.0                     |
| <b>University and Schools</b> | 6.0                     | Sports arena           | 4.9                     |

|   |     |                         |     |
|---|-----|-------------------------|-----|
| <b>Library</b>  | 6.1 | Transportation          | 4.6 |
| <b>Dining: bar lounge/leisure</b>   | 6.1 | Warehouse               | 3.5 |
| <b>Dining: cafeteria/fast food</b>  | 5.8 | Performing arts theater | 8.2 |
| <b>Dining: family</b>   | 5.5 | Police station          | 5.0 |
| <b>Dormitory</b>  | 4.6 | Workshop                | 7.1 |
| <b>Fire station</b>   | 4.9 | Automotive facility     | 4.5 |
| <b>Gymnasium</b>  | 5.0 | Convention center       | 6.3 |
| <b>Manufacturing facility</b>   | 6.0 | Parking garage          | 1.5 |
| <b>*In cases where both a general building area type and a specific building area type are listed, the specific building area type shall apply.</b> |     |                         |     |

### 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.
- (b) For each space, enclosed by partitions 80% or greater than ceiling height, determine the gross lighted floor area by measuring to the center of the partition wall. Include the area of balconies or other projections. Retail spaces do not have to comply with the 80% partition height requirements.
- (c) The interior lighting power allowance is the sum of the lighting power allowances for all spaces. The lighting power allowance for a space is the product of the gross lighted floor area of the space times the allowed lighting power density for that space.

Table 6-4 Interior Lighting Power for ECBC Buildings – Space Function Method [ANS11] [MB12]

| Category                            | LPD (W/m <sup>2</sup> ) | Lamp category                            | LPD (W/m <sup>2</sup> ) |
|-------------------------------------|-------------------------|--|-------------------------|
| <b>Common Space Types</b>           |                         |  |                         |
| Restroom                            | 7.7                     | Stairway                                 | 5.5                     |
| Storage                             | 6.8                     | Corridor/Transition                      | 7.1                     |
| Conference/ Meeting                 | 11.5                    | Lobby                                    | 9.1                     |
| Parking Bays (covered/<br>basement) | 2.2                     | Parking Driveways<br>(covered/ basement) | 3.0                     |
| Electrical/Mechanical               | 7.1                     | Workshop                                 | 17.1                    |
| <b>Business</b>                     |                         |  |                         |
| Enclosed                            | 10.0                    | Open Plan                                | 10.0                    |
| Banking Activity Area               | 12.6                    | Service/Repair                           | 6.8                     |
| <b>Healthcare</b>                   |                         |  |                         |
| 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                     |  |                         |
| Category                            | LPD (W/m <sup>2</sup> ) | Lamp category                            | LPD (W/m <sup>2</sup> ) |
| <b>Hospitality</b>                  |                         |  |                         |
| 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                     |  |                         |
| <b>Shopping Complex</b>             |                         |  |                         |
| 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                    |
| <b>Educational</b>                  |                         |  |                         |
| Classroom/Lecture                   | 13.7                    | Card File and                            | 9.1                     |
| For Classrooms                      | 13.8                    | Stacks (Lib)                             | 18.3                    |
| Laboratory                          | 15.1                    | Reading Area (Library)                   | 10.                     |
| <b>Assembly</b>                     |                         |  |                         |



|                                      |      |   |      |
|--------------------------------------|------|---|------|
| Dressing Room                        | 9.1  | Seating Area -<br>Performing Arts Theatre | 22.6 |
| Exhibit Space -<br>Convention Centre | 14.  | Lobby - Performing Arts<br>Theatre        | 21.5 |
| Seating Area -<br>Gymnasium          | 4.6  | Seating Area -<br>Convention Centre       | 6.4  |
| Fitness Area -                       | 13.7 | Seating Religious                         | 16.4 |
| Museum - General<br>Exhibition       | 16.4 | Playing Area -<br>Gymnasium               | 18.8 |
| Museum - Restoration                 | 18.3 |   |      |

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

| Category                            | LPD (W/m <sup>2</sup> ) | Lamp category                            | LPD (W/m <sup>2</sup> ) |
|-------------------------------------|-------------------------|--|-------------------------|
| <b>Common Space Types</b>           |                         |  |                         |
| Restroom                            | 6.1                     | Stairway                                 | 4.4                     |
| Storage                             | 5.4                     | Corridor/Transition                      | 3.6                     |
| Conference/ Meeting                 | 9.2                     | Lobby                                    | 7.3                     |
| Parking Bays (covered/<br>basement) | 1.8                     | Parking Driveways<br>(covered/ basement) | 2.5                     |
| Electrical/Mechanical               | 5.7                     | Workshop                                 | 13.7                    |
| <b>Business</b>                     |                         |  |                         |
| Enclosed                            | 8.6                     | Open Plan                                | 8.6                     |
| Banking Activity Area               | 9.3                     | Service/Repair                           | 5.5                     |
| <b>Healthcare</b>                   |                         |  |                         |
| Emergency                           | 18.2                    | Recovery                                 | 7.0                     |
| Exam/Treatment                      | 10.9                    | Storage                                  | 4.4                     |
| Nurses' Station                     | 7.5                     | Laundry/Washing                          | 6.0                     |
| Operating Room                      | 17.5                    | Lounge/Recreation                        | 6.4                     |
| Patient Room                        | 6.1                     | Medical Supply                           | 10.9                    |
| Pharmacy                            | 8.5                     | Nursery                                  | 4.6                     |
| Physical Therapy                    | 7.8                     | Corridor/Transition                      | 7.3                     |
| Radiology/Imaging                   | 18.2                    |  |                         |
| Category                            | LPD (W/m <sup>2</sup> ) | Lamp category                            | LPD (W/m <sup>2</sup> ) |
| <b>Hospitality</b>                  |                         |  |                         |
| Hotel Dining                        | 7.3                     | Hotel Lobby                              | 8.8                     |
| For Bar Lounge/ Dining              | 11.3                    | Motel Dining                             | 7.3                     |
| For food preparation                | 12.1                    | Motel Guest Rooms                        | 6.1                     |

|                                      |      |   |      |
|--------------------------------------|------|---|------|
| Hotel Guest Rooms                    | 7.3  |   |      |
| <b>Shopping Complex</b>              |      |   |      |
| Mall Concourse                       | 10.2 | For Family Dining                         | 8.80 |
| Sales Area                           | 14.6 | For food preparation                      | 12.1 |
| Motion Picture Theatre               | 10.3 | Bar Lounge/ Dining                        | 11.3 |
| <b>Educational</b>                   |      |   |      |
| Classroom/Lecture                    | 10.9 | Card File and                             | 7.3  |
| For Classrooms                       | 11.0 | Stacks (Lib)                              | 14.6 |
| Laboratory                           | 12.1 | Reading Area (Library)                    | 9.2  |
| <b>Assembly</b>                      |      |   |      |
| Dressing Room                        | 7.3  | Seating Area -<br>Performing Arts Theatre | 18.1 |
| Exhibit Space - Convention<br>Centre | 11.2 | Lobby - Performing Arts<br>Theatre        | 17.2 |
| Seating Area - Gymnasium             | 3.6  | Seating Area -<br>Convention Centre       | 5.1  |
| Fitness Area - Gymnasium             | 7.9  | Seating Religious                         | 13.1 |
| Museum - General<br>Exhibition       | 11.3 | Playing Area -<br>Gymnasium               | 12.9 |
| Museum - Restoration                 | 11.0 |   |      |

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

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

|                                      |                              |   |                              |
|--------------------------------------|------------------------------|---|------------------------------|
| Operating Room                       | 10.9                         | Lounge/Recreation                         | 4.6                          |
| Patient Room                         | 3.8                          | Medical Supply                            | 6.8                          |
| Pharmacy                             | 5.3                          | Nursery                                   | 2.9                          |
| Physical Therapy                     | 4.9                          | Corridor/Transition                       | 4.6                          |
| Radiology/Imaging                    | 4.6                          |   |                              |
| <b>Category</b>                      | <b>LPD (W/m<sup>2</sup>)</b> | <b>Lamp category</b>                      | <b>LPD (W/m<sup>2</sup>)</b> |
| <b>Hospitality</b>                   |                              |   |                              |
| Hotel Dining                         | 4.60                         | Hotel Lobby                               | 5.50                         |
| For Bar Lounge/ Dining               | 7.00                         | Motel Dining                              | 4.60                         |
| For food preparation                 | 7.50                         | Motel Guest Rooms                         | 3.80                         |
| Hotel Guest Rooms                    | 4.6                          |   |                              |
| <b>Shopping Complex</b>              |                              |   |                              |
| Mall Concourse                       | 6.4                          | For Family Dining                         | 5.5                          |
| Sales Area                           | 9.2                          | For food preparation                      | 7.5                          |
| Motion Picture Theatre               | 6.5                          | Bar Lounge/ Dining                        | 7.0                          |
| <b>Educational</b>                   |                              |   |                              |
| Classroom/Lecture                    | 6.8                          | Card File and                             | 4.6                          |
| For Classrooms                       | 6.9                          | Stacks (Lib)                              | 9.2                          |
| Laboratory                           | 7.5                          | Reading Area (Library)                    | 5.7                          |
| <b>Assembly</b>                      |                              |   |                              |
| Dressing Room                        | 4.6                          | Seating Area -<br>Performing Arts Theatre | 11.3                         |
| Exhibit Space - Convention<br>Centre | 7.0                          | Lobby - Performing Arts<br>Theatre        | 10.8                         |
| Seating Area - Gymnasium             | 3.4                          | Seating Area -<br>Convention Centre       | 3.20                         |
| Fitness Area - Gymnasium             | 3.9                          | Seating Religious                         | 8.2                          |
| Museum - General<br>Exhibition       | 5.7                          | Playing Area -<br>Gymnasium               | 6.5                          |
| Museum - Restoration                 | 5.5                          |   |                              |

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



A four-story building has retail on the ground floor and offices on the top three floors. Area is 3,598 m<sup>2</sup>. Space types and their respective areas are mentioned below. Steps for calculating interior lighting power allowance using the space function method for an ECBC building is described below. For each of the space type, corresponding Lighting Power Density (LPD) values for Business and Shopping complex building type from Table 6-4 are used. Area is multiplied with the LPD values to estimate the lighting power allowance for the whole building. It is 40,242 W.

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

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

### 6.3.4 Installed Interior Lighting Power

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

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

#### 6.3.4.1 Luminaire Wattage

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

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

### 6.3.5 Exterior Lighting Power

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

Table 6-7 Exterior Building Lighting Power for ECBC Buildings

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

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

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

Table 6-9 Exterior Building Lighting Power for SuperECBC Buildings

| Exterior lighting application               | Power limits                                 |
|---|--|
| Building entrance (with canopy)             | 5.0 W/m <sup>2</sup> of canopied area        |
| Building entrance (w/o canopy)              | 45 W/ linear m of door width                 |
| Building exit                               | 30 W/lin m of door width                     |
| Building façade                             | 2.5 W/m <sup>2</sup> of vertical façade area |
| Emergency signs, ATM kiosks, Security areas | 0.5 W/m <sup>2</sup>                         |

|  |                       |
|--|-----------------------|
| Driveways and parking (open/ external) | 0.8 W/m <sup>2</sup>  |
| Pedestrian walkways                    | 1.0 W/m <sup>2</sup>  |
| Stairways                              | 5.0 W/m <sup>2</sup>  |
| Landscaping                            | 0.25 W/m <sup>2</sup> |
| Outdoor sales area                     | 4.5 W/m <sup>2</sup>  |

### 6.3.6 Controls for ECBC+ and SuperECBC Buildings

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

#### 6.3.6.1 Centralized Controls

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

#### 6.3.6.2 Exterior Lighting Controls

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

## 7 Electrical and Renewable Energy Systems

### 7.1 General

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

### 7.2 Mandatory Requirements

#### 7.2.1 Transformers

##### 7.2.1.1 Maximum Allowable Power Transformer Losses

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

Table 7-1 Permissible Losses for Dry Type Transformers

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

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



Table 7-2 Permissible Losses for Oil Type Transformers.

| Rating (kVA) | Impedance (%) | Max. Total Loss (W) for transformers up to 11 kV class |           |                |           |           |           |
|--------------|---------------|--|-----------|----------------|-----------|-----------|-----------|
|              |               | ECBC Building  |           | ECBC+ Building |           | SuperECBC |           |
|              |               | 50 % Load  | 100% Load | 50 % Load      | 100% Load | 50 % Load | 100% Load |
| 16           | 4.5           | 150  | 480       | 135            | 440       | 120       | 400       |
| 25           | 4.5           | 210  | 695       | 190            | 635       | 175       | 595       |
| 63           | 4.5           | 380  | 1250      | 340            | 1140      | 300       | 1050      |
| 100          | 4.5           | 520  | 1800      | 475            | 1650      | 435       | 1500      |
| 160          | 4.5           | 770  | 2200      | 670            | 1950      | 570       | 1700      |
| 200          | 4.5           | 890  | 2700      | 780            | 2300      | 670       | 2100      |
| 250          | 4.5           | 1050   | 3150      | 980            | 2930      | 920       | 2700      |
| 315          | 4.5           | 1100   | 3275      | 1025           | 3100      | 955       | 2750      |
| 400          | 4.5           | 1300   | 3875      | 1225           | 3450      | 1150      | 3330      |
| 500          | 4.5           | 1600   | 4750      | 1510           | 4300      | 1430      | 4100      |
| 630          | 4.5           | 2000   | 5855      | 1860           | 5300      | 1745      | 4850      |
| 1000         | 5             | 3000   | 9000      | 2790           | 7700      | 2620      | 7000      |
| 1250         | 5             | 3600   | 10750     | 3300           | 9200      | 3220      | 8400      |
| 1600         | 6.25          | 4500   | 13500     | 4200           | 11800     | 3970      | 11300     |
| 2000         | 6.25          | 5400   | 17000     | 5050           | 15000     | 4790      | 14100     |
| 2500         | 6.25          | 6500   | 20000     | 6150           | 18500     | 5900      | 17500     |

Total loss values given in above table are applicable for thermal classes E, B and F and have component of load loss at reference temperature according to Clause 17 of IS 1180 i.e., average winding temperature rise as given in Column 2 of Table 8.2 plus 30°C. An increase of 7% on total for thermal class H is allowed.

Permissible total loss values shall not exceed:

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

### 7.2.1.2 Measurement and Reporting of Transformer Losses

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

### 7.2.1.3 Voltage Drop

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

## 7.2.2 Energy Efficient Motors

Motors shall comply with the following:

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

### 7.2.3 Diesel Generator (DG)Sets

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

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

### 7.2.4 Check-Metering and Monitoring

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

- (a) Services exceeding 1,000 kVA shall have permanently installed electrical metering to record demand (kVA), energy (kWh), and total power factor on hourly basis. The metering shall also display current (in each phase and the neutral), voltage (between phases and between each phase and neutral), and total harmonic distortion (THD) as a percentage of total current.
- (b) Services not exceeding 1000 kVA but over 65 kVA shall have permanently installed electric metering to record demand (kW), energy (kWh), and total power factor (or kVARh) on hourly basis.
- (c) Services not exceeding 65 kVA shall have permanently installed electrical metering to record energy (kWh) on hourly basis

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

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

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

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

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

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

### 7.2.5 Power Factor Correction

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

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

### 7.2.6 Power Distribution Systems

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

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

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

### 7.2.7 Uninterruptible Power Supply (UPS)

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

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

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

### 7.2.8 Renewable Energy Systems

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

#### 7.2.8.1 Renewable Energy Generating Zone (REGZ)

- (a) A dedicated REGZ equivalent to at least 25 % of roof area or area required for generation of energy equivalent to 15% of total peak demand or connected load of the building, whichever is less, shall be provided in all buildings.
- (b) The REGZ shall be free of any obstructions within its boundaries and from shadows cast by objects adjacent to the zone.
- (c) ECBC+ and SuperECBC building shall fulfil the additional requirements listed in Table 7-6 and Table 7-7 respectively.

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

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

Table 7-7 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 m <sup>2</sup> AGA<br>Resort > 12,500 m <sup>2</sup> AGA<br>University > 20,000 m <sup>2</sup> AGA<br>Business>20,000 m <sup>2</sup> 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 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,
- b) Pathway for routing of conduit from the REGZ to the point of inter connection with the electrical service,
- c) Routing of plumbing from the REGZ to the water-heating system and,
- d) Structural design loads for roof dead and live load.

## 8 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

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

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

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

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

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

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

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

**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.

**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 airfilms 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.

**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

**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 HealthCare 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. [ANS15]

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 users 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.

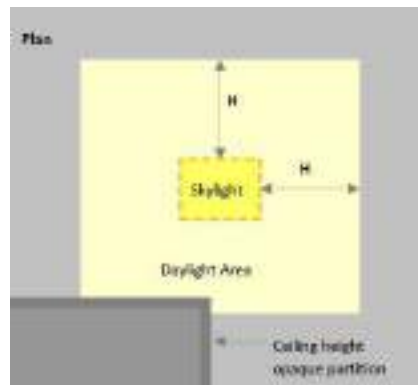
**Controls or control device:** manually operated or automatic device or software to regulate the operation of building equipment

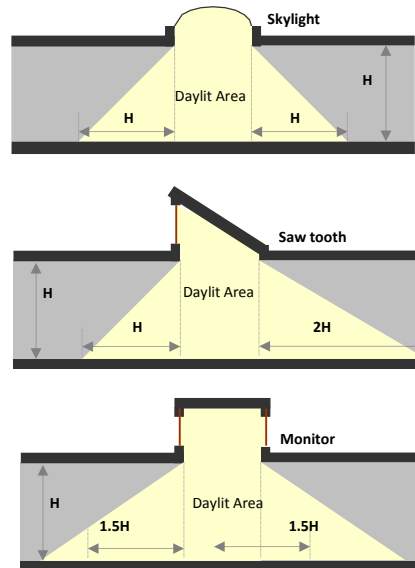
**Cool roof:** roof with top layer of material that has high solar reflectance and high thermal emittance properties. Cool roof surfaces are characterized by light colors so that heat can be rejected back to the environment.

**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

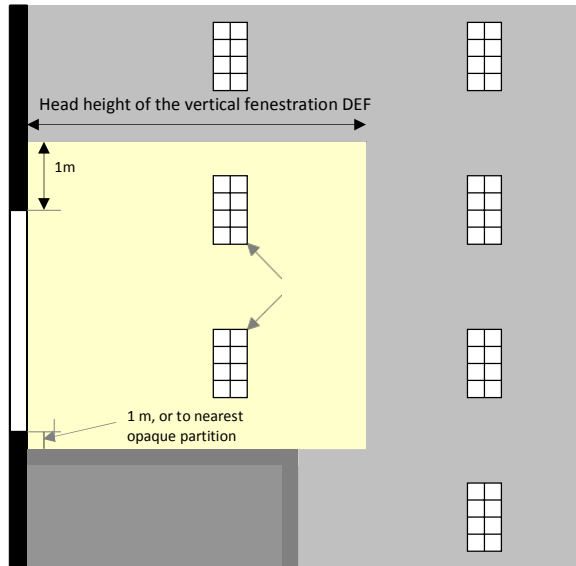
**Daylight area:** the daylight illuminated floor area under horizontal fenestration (skylight) or adjacent to vertical fenestration (window), described as follows:

- (a) Horizontal Fenestration: the area under a skylight, monitor, or saw-tooth configuration with an effective aperture greater than 0.001 (0.1%). The daylight area is calculated as the horizontal dimension in each direction equal to the top aperture dimension in that direction plus either the floor-to-ceiling height (H) for skylights, or 1.5 H for monitors, or H or 2H for the saw-tooth configuration, or the distance to the nearest 1 meter or higher opaque partition, or one-half the distance to an adjacent skylight or vertical glazing, whichever is least, as shown in the plan and section figures below.





- (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 up to 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

**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.

**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.

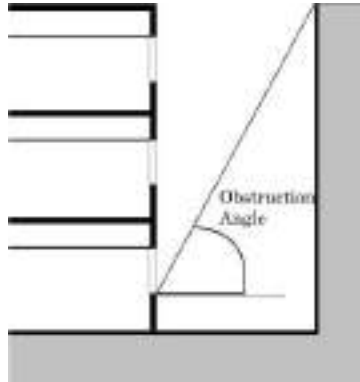
**Economizer, air:** a duct and damper arrangement with automatic controls that allow a cooling system to supply outdoor air to reduce or eliminate the need for mechanical cooling during mild or cold weather

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

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

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

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



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

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

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

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

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

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

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

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

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

**Envelope Performance Factor (EPF):** value for the building envelope performance

compliance option calculated using the procedures specified in 4.3.5 and 4.3.5.1.1. 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, verticals fenestrations and roofs

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

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

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

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

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

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

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

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

**Fenestration:** all areas (including the frames) in the building envelope that let in light, including windows, plastic panels, clerestories, skylights, glass doors that are more

than one-half glass, and glass block walls.

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

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

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

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

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

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

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

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



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

**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.

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

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

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

**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.

**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:** [MB17] a device for giving light consisting of electric bulb with its holder and shade or cover.

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

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

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

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

**Lighting power allowance:**

- (a) Interior lighting power allowance: the maximum lighting power in watts allowed for the interior of a building
- (b) Exterior lighting power allowance: the maximum lighting power in watts allowed for the exterior of a building. Building

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

**Low energy comfort systems:** space conditioning or ventilation systems that are less energy intensive than vapor compression based space conditioning systems. These primarily employ alternate heat transfer methods or materials (adiabatic cooling,

radiation, desiccant, etc.), or renewable sources of energy (solar energy, geothermal) so that minimal electrical energy input is required to deliver heating or cooling to spaces.

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

**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

**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 a cardinal direction is not, 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 house 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.

**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 there.

**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.

**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.).

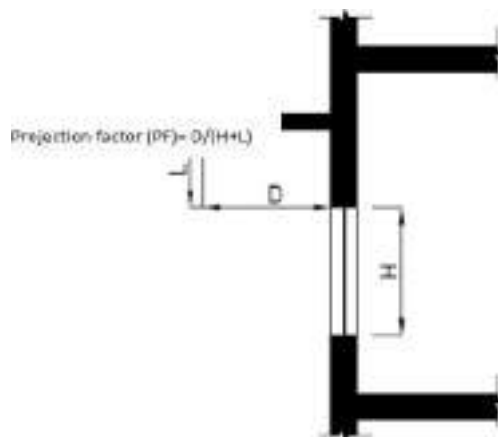
**Pool:** any structure, basin, or tank containing an artificial body of water for swimming, diving, or recreational bathing. The terms include, but no limited to, swimming pool, whirlpool, spa, hot tub.

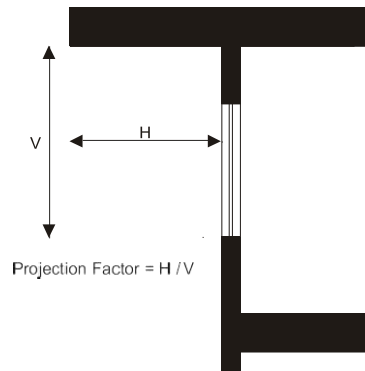
**Potential daylit time:** amount of time in a day when there is daylight to light a space adequately without using artificial lighting. Potential daylit time is fixed for 8 hours per day from 09:00 AM to 5:00 PM local time, resulting 2920 hours in total for all building types except for TypeE-1-Educational,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

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

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

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





**Projection factor, side fin:** the ratio of the horizontal depth of the external shading projection to the distance from the window jamb to the farthest point of the external shading projection, in consistent units. [ANS19] [MB20]

**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.

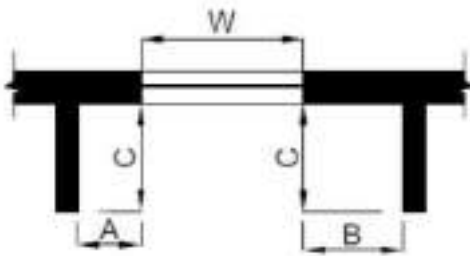
Projection factor Left Fin ( $PF_L$ ) =  $C / (A + W)$  Projection factor Right Fin ( $PF_R$ ) =  $C / (B + W)$

**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  $m^2 \cdot K / W$ .

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

**Recirculating system:** a domestic or service hot water distribution system that includes a close circulation circuit designed to maintain usage temperatures in hot water pipes near terminal devices (e.g., lavatory faucets, shower heads) in order to

reduce the time required to obtain hot water when the terminal device valve is opened. The motive force for circulation is either natural (due to water density variations with temperature) or mechanical (recirculation pump).



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

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

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

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

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

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

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



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

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

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

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

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

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

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

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

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

**Solar energy source:** source of thermal, chemical, or electrical energy derived from direction conversion of incident solar radiation at the building site.

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

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

**Space:** an enclosed area within a building. The classifications of spaces are as follows

for purpose of determining building envelope requirements:

- (a) **Conditioned space:** a cooled space, heated space, or directly conditioned space.
- (b) **Semi-heated space:** an enclosed space within a building that is heated by a heating system whose output capacity is greater or equal to  $10.7 \text{ W/m}^2$  but is not a conditioned space.
- (c) **Non-conditioned space:** an enclosed space within a building that is not conditioned space or a semi-heated space. Crawlspace, attics, and parking garages with natural or mechanical ventilation are not considered enclosed spaces.

**Star Hotels/motels (Star Hotel):** any building or group of buildings under single management and accredited as a starred hotel by the Hotel and Restaurant Approval and Classification Committee, Ministry of Tourism, in which sleeping accommodation, with or without dining facilities is provided.

**Stand-alone Retail (Shopping Complex):** a large retail store owned or sublet to a single management which may offer customers a variety of products under self-branding or products of different brands. The single management shall have a complete ownership of all the spaces of the building and no space within the building is further sold or sublet to a different management.

**Standard Building:** a building that minimally complies with all the mandatory and prescriptive requirements of Energy Conservation Building Code and has same floor area, gross wall area, and gross roof area of the Proposed Building.

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

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

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

**SuperECBC Building:** a building that complies with the mandatory requirements of

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

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

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

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

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

**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 condition that influences thermal comfort air and radiant temperature, humidity, and airspeed.

**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.

**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  $W/m^2.K$ .

**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.

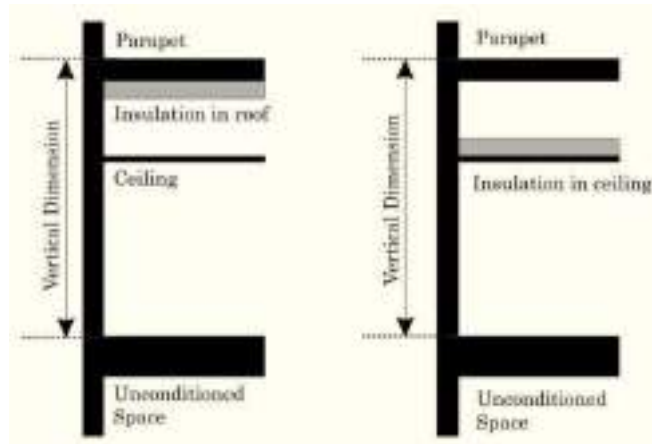
**Vision Windows:** windows or area of large windows that are primarily for both daylight and exterior views. Typically, their placement in the wall is between 1 meter and 2.2 meter above the floor level.

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

- (a) Wall, above grade: a wall that is not below grade
- (b) Wall, below grade: that portion of a wall in the building envelope that is entirely below the finish grade and in contact with the ground

**Wall area, gross:** the overall area off a wall including openings such as windows and doors measured horizontally from outside surface to outside service and measured vertically from the top of the floor to the top of the roof. If roof insulation is installed at the ceiling level rather than the roof, then the vertical measurement is made to

the top of the ceiling. The gross wall area includes the area between the ceiling and the floor for multi-story buildings.



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

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

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

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

### 8.3 SI to IP Conversion Factors

| SI Unit                | IP Unit                           |
|------------------------|-----------------------------------|
| 1 cmh                  | 1.7 cfm                           |
| 1 Pa                   | 0.0040 inch of water gauge        |
| 1m                     | 3.28 ft                           |
| 1m                     | 39.37 in                          |
| 1mm                    | 0.039 in                          |
| 1 l/s                  | 2.12 cfm                          |
| 1 m <sup>2</sup>       | 10.76 ft <sup>2</sup>             |
| 1 W/m <sup>2</sup>     | 10.76 W/ ft <sup>2</sup>          |
| 1 W/ lin m             | 3.28 W/ ft                        |
| 1 W/m <sup>2</sup> .K  | 5.678 Btu/ h-ft <sup>2</sup> -°F  |
| 1 W/ l-s <sup>-1</sup> | 0.063 W/ gpm                      |
| 1 m <sup>2</sup> .K/W  | 0.1761 ft <sup>2</sup> -h-°F/ Btu |
| 1 °C                   | ((°C X 9/5) + 32) °F              |
| 1 kW <sub>r</sub>      | 0.284 TR                          |
| 1 kW                   | 1.34 hp                           |
| 1 kW                   | 3412.142 Btu/hr                   |

## 8.4 Abbreviations and Acronyms

|                           |   |
|---------------------------|---|
| AFUE                      | Annual fuel utilization efficiency  |
| AHRI                      | Air-conditioning, Heating and Refrigeration Institute                     |
| ANSI                      | American National Standards Institute                                     |
| ARI                       | Air-Conditioning and Refrigeration Institute                              |
| ASHRAE                    | American Society of Heating, Refrigerating and Air-Conditioning Engineers |
| ASTM                      | American Society for Testing and Materials                                |
| BIS                       | Bureau of Indian Standards  |
| Btu                       | British thermal unit  |
| Btu/h                     | British thermal units per hour  |
| Btu/h-ft <sup>2</sup> -°F | British thermal units per hour per square foot per degree                 |
| BUA                       | Built up area   |
| C                         | Celsius   |
| cmh                       | cubic meter per hour  |
| cm                        | centimeter  |
| COP                       | coefficient of performance  |
| DEF                       | daylight extent factor  |
| EER                       | energy efficiency ratio   |
| EPI                       | energy performance index  |
| F                         | Fahrenheit  |
| ft                        | foot  |
| h                         | hour  |
| h-ft <sup>2</sup> -°F/Btu | hour per square foot per degree Fahrenheit per British                    |
| h-m <sup>2</sup> -°C/W    | hour per square meter per degree Celsius per Watt                         |
| hp                        | horsepower  |
| HVAC                      | heating, ventilation, and air conditioning                                |
| I-P                       | inch-pound  |
| in.                       | inch  |
| IPLV                      | integrated part-load value  |
| IS                        | Indian Standard   |
| ISO                       | International Organization for Standardization                            |
| kVA                       | kilovolt-ampere   |
| kW                        | Kilowatt of electricity   |
| kW <sub>r</sub>           | kilowatt of refrigeration   |
| kWh                       | kilowatt-hour   |
| l/s                       | Liter per second  |



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

## 9 Whole Building Performance Method

### 9.1 General

#### 9.1.1 Scope

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

#### 9.1.2 Compliance

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

#### 9.1.3 Annual Energy Use

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

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

#### 9.1.4 Trade-offs Limited to Building Permit

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

#### 9.1.5 Documentation Requirements

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

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

- (a) Brief description of the project with location, number of stories, space types, conditioned and unconditioned areas, hours of operation.
- (b) List of the energy-related building features of the Proposed Design. This list shall also document features different from the Standard Design.
- (c) List showing compliance with the mandatory requirements of this code.
- (d) 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.
- (e) Explanation of any significant modelling assumptions made.
- (f) Explanation of any error messages noted in the simulation program output.
- (g) Building floor plans, building elevations, and site plan.

## 9.2 Mandatory Requirements

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

## 9.3 Simulation Requirements

### 9.3.1 Energy Simulation Program

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

- a) Energy flows on an hourly basis for all 8,760 hours of the year,
- b) Hourly variations in occupancy, lighting power, miscellaneous equipment power, thermostat set points, and HVAC system operation, defined separately for each day of the week and holidays,
- c) Thermal mass effects,
- d) Ten or more thermal zones,
- e) Part-load and temperature dependent performance of heating and cooling equipment,
- f) Air-side and water-side economizers with integrated control.

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

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

**9.3.2 Climate Data**

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

**9.3.3 Compliance Calculations**

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

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

**9.4 Calculating Energy Consumption of Proposed Design and Standard Design**

**9.4.1 Energy Simulation Model**

The simulation model for calculating the Proposed Design and the Standard Design shall be developed in accordance with the requirements in Table 9-1. The Standard Design is based on the mandatory and prescriptive requirements of the ECBC compliant building. The Standard Design will be the same for all compliance levels (ECBC, ECBC+, and SuperECBC).

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

| <i>Case</i>        | <i>Proposed Design</i>  | <i>Standard Design</i>   |
|--------------------|---|--|
| 1.<br>Design Model | (a) The simulation model of the Proposed Design shall be consistent with the design | The Standard Design shall be developed by modifying the Proposed Design as |

|   |   |  |
|---|---|--|
|   | <p>documents, including proper accounting of fenestration and opaque envelope types and area; interior lighting power and controls; HVAC system types, sizes, and controls; and service water heating systems and controls.</p> <p>(b) When the whole building performance method is applied to buildings in which energy-related features have not been designed yet (e.g., a lighting system), those yet-to-be-designed features shall be described in the Proposed Design so that they minimally comply with applicable mandatory and prescriptive requirements of §4.2, §5.2, §6.2, and §7.2 and §4.3, §5.3, and §6.3 respectively.</p> | <p>described in this table. Unless specified in this table, all building systems and equipment shall be modeled identically in the Standard Design and Proposed Design</p>   |
| <p><b>2.</b><br/>Space Use Classification</p> | <p>The building type or space type classifications shall be chosen in accordance with §2.5. More than one building type category may be used in a building if it is a mixed-use facility.</p>   | <p>Same as Proposed Design.</p>  |
| <p><b>3.</b><br/>Schedules</p>                | <p>Operational schedules (hourly variations in occupancy, lighting power, equipment power, HVAC equipment operation, etc.). Suitable for the building and /or space type shall be modeled for showing compliance. Schedules must be modeled as per §9.6. In case a schedule for an occupancy type is missing in §9.6, appropriate schedule may be used. Temperature and humidity schedules and set points shall be identical in the Standard and</p>  | <p>Same as Proposed Design. <b>Exception:</b> 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</p> |

|                                 |  |   |
|---------------------------------|--|---|
|                                 | <p>Proposed Designs. Temperature control / thermostat throttling ranges shall also be modeled identically in both the Designs.</p>   | <p>automatic controls for lighting, natural ventilation, demand controlled ventilation systems, controls for service water heating load reduction. Schedule change is not allowed for manual controls under any category. This is subject to approval by the authority having jurisdiction.</p>   |
| <p>4.<br/>Building Envelope</p> | <p>All components of the building envelope in the Proposed Design shall be modeled as shown on architectural drawings or as installed for existing building envelopes.<br/>         Exceptions: The following building elements are permitted to differ from architectural drawings.<br/> <b>(a)</b> Any envelope assembly that covers less than 5% of the total area of that assembly type (e.g., exterior walls) need not be separately described. If not separately described, the area of an envelope assembly must be added to the area of the adjacent assembly of that same type.<br/> <b>(b)</b> Exterior surfaces whose azimuth orientation and tilt differ by no more than 45 degrees and are otherwise the same may be described as either a single surface or by using multipliers.<br/> <b>(c)</b> For exterior roofs, other than roofs with ventilated attics, the reflectance and emittance of the roof surface shall be modeled in accordance with §4.3.1.1.</p> | <p>The Standard Design shall have identical conditioned floor area and identical exterior dimensions and orientations as the Proposed Design, except as noted in (a), (b), (c), and (d) and (e) below.<br/> <b>(a) Orientation.</b> The Standard Design performance shall be generated by simulating the building with its actual orientation and again after rotating the entire building 90, 180, 270 degrees, then averaging the results. The building shall be modeled so that it does not shade itself.<br/> <b>(b) Opaque assemblies</b> such as roof, floors, doors, and walls shall be modeled with the maximum U-factor allowed in §4.3.1 and §4.3.2.<br/> <b>(c) Fenestration</b> - Fenestration areas shall equal that in the Proposed Design or 40% of gross above grade wall area,</p> |

|                        |   |  |
|------------------------|---|--|
|                        | <p>(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 modelled.</p> <p>(e) The exterior roof surface shall be modeled using the solar reflectance in accordance with ASTM E903-96 and thermal emittance determined in accordance with ASTM E408-71. Where cool roof is proposed, emittance and reflectance shall be modeled as per ASTM E408-71 and ASTM E903-96 respectively. Where cool roof is not proposed, the exterior roof surfaces shall be modeled as per §4.3.1.1 the exterior roof surface shall be modeled with a solar reflectance of 0.30 and a thermal emittance of 0.75.</p> | <p>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.</p> <p>Manually operated fenestration shading devices such as blinds or shades shall not be modeled. Fenestration U-factor shall be the maximum allowed for the climate, and the solar heat gain coefficient shall be the maximum allowed for the climate and orientation.</p> <p>(d) Skylight areas shall equal that in the Proposed Design or 5% of gross roof area, whichever is smaller.</p> <p>(e) Roof Solar Reflectance and Thermal Emittance: The exterior roof surfaces shall be modeled using a solar reflectance of 0.70 and a thermal emittance of 0.75 as per §4.3.1.1</p> |
| <p>5.<br/>Lighting</p> | <p>Lighting power in the Proposed Design shall be determined as follows:<br/>Where a complete lighting system exists, the actual lighting power shall be used in the model.<br/>Where a lighting system has been designed, lighting power shall be determined in accordance with either §6.3.4.<br/>Where no lighting exists, or is</p>   | <p>Interior lighting power in the Standard Design shall be determined using the same categorization procedure (building area or space function) and categories as the Proposed Design with lighting power set equal to the maximum allowed for the corresponding method and category in either §6.3.2 or</p>   |

|                                  |   |  |
|----------------------------------|---|--|
|                                  | <p>specified, lighting power shall be determined in accordance with the §6.3.2 or §6.3.3 for the appropriate building type.</p> <p>Lighting system power shall include all lighting system components shown or provided for on plans (including lamps, ballasts, task fixtures, and furniture-mounted fixtures).</p> <p>Lighting power for parking garages, exterior spaces and building facades shall be modeled.</p> <p>Minimum Lighting controls, as per the ECBC requirements of §6.2.1, shall be modeled in the Proposed case.</p> <p>Automatic daylighting controls shall be modeled directly in the software or through schedule adjustments determined by a separate daylight analysis approved by the authority having jurisdiction.</p> <p>Other automatic lighting controls shall be modeled directly in the software by adjusting the lighting power.</p> | <p>§6.3.3. Power for fixtures not included in the lighting power density calculation shall be modeled identically in the Proposed Design and Standard Design. Lighting controls shall be as per the ECBC requirements of §6.2.1.</p> <p>Exterior lighting power in the standard design shall be set equal to the maximum allowed in §6.3.5</p> |
| <p>6.<br/>HVAC Thermal Zones</p> | <p><b>HVAC Zones Designed:</b> Where HVAC zones are defined on design drawings, each HVAC zone shall be modeled as a separate thermal block.</p> <p><b>Exception:</b> 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</p>   | <p>Same as Proposed Design</p>   |



|                            |  |  |
|----------------------------|--|--|
|                            | <p>simplicity.</p> <p>HVAC Zones Not Designed: Where HVAC zones are not defined on design drawings, HVAC zones shall be defined based on similar occupancy and usage, similar internal loads, similar set points and type of HVAC system, glazed exterior walls that face the same orientation or vary by less than 45° in combination with the following rules:</p> <p><b>Perimeter Core Zoning:</b> Separate thermal block shall be modeled as spaces located within 5 meters of an exterior or semi exterior wall. Core spaces are defined as spaces located greater than 5 meters of an exterior or semi exterior wall. Separate thermal blocks shall be modeled for floors in contact with ground and for floors which have a ceiling/roof exposure to the ambient.</p> |  |
| <p>7.<br/>HVAC Systems</p> | <p>The HVAC system type and all related performance parameters, such as equipment capacities and efficiencies, in the Proposed Design shall be determined as follows:</p> <p>(a) Where a complete HVAC system exists, the model shall reflect the actual system type using actual component capacities and efficiencies.</p> <p>(b) Where an HVAC system has been designed, the HVAC model shall be consistent with design documents. Mechanical equipment efficiencies shall be</p>   | <p>The HVAC system type shall be as per Table 9-2 and related performance parameters for the Standard Design shall be determined from requirements of §9.4.2. Equipment performance shall meet the requirements of §5 for code compliant building.</p> |

|  |  |  |
|--|--|--|
|  | <p>adjusted from actual design conditions to the rating conditions specified in §5, if required by the simulation model.</p> <p>(c) Where no heating system has been specified, the heating system shall be assumed to be electric. The system characteristics shall be identical to the system modeled in the Standard Design.)</p> <p>Where no cooling system has been specified, the cooling system and its characteristics shall be identical to the system modeled in the Standard Design.</p>  |  |
| <p><b>8.</b><br/>Service Hot Water</p>   | <p>The service hot water system type and all related performance parameters, such as equipment capacities and efficiencies, in the Proposed Design shall be determined as follows:</p> <p>(a) Where a complete service hot water system exists, the model shall reflect the actual system type using actual component capacities and efficiencies.</p> <p>(b) Where a service hot water system has been designed, the service hot water model shall be consistent with design documents.</p> <p>Where no service hot water system exists, or is specified, no service hot water heating shall be modeled</p> | <p>The service water heating system shall be of the same type as the Proposed Design. For residential facilities, hotels and hospitals the Standard Design shall have a solar hot water system capable of meeting 20% of the hot water demand. Systems shall meet the efficiency requirements of §5.2.7.5.</p> |
| <p><b>9.</b><br/>Miscellaneous Loads</p> | <p>Receptacle, motor, and process loads shall be modeled and estimated based on the building type or space type category.</p>  | <p>Receptacle, motor and process loads shall be modeled the same as the Proposed Design.</p>   |

|   |   |                                 |
|---|---|---------------------------------|
|   | <p>These loads shall be included in simulations of the building and shall be included when calculating the Standard Design and Proposed Design. All end-use load components within and associated with the building shall be modeled, unless specifically excluded by this Table, but not limited to, exhaust fans, parking garage ventilation fans, exterior building lighting, swimming pool heaters and pumps, elevators and escalators, refrigeration equipment, and cooking equipment.</p>   |                                 |
| <p><b>10.</b><br/>Modelling<br/>Limitations to<br/>the Simulation<br/>Program</p> | <p>If the simulation program cannot model a component or system included in the Proposed Design, one of the following methods shall be used with the approval of the authority having jurisdiction:</p> <ul style="list-style-type: none"> <li><b>(a)</b> Ignore the component if the energy impact on the trade-offs being considered is not significant.</li> <li><b>(b)</b> Model the component substituting a thermodynamically similar component model.</li> <li><b>(c)</b> Model the HVAC system components or systems using the HVAC system of the Standard Design in accordance with Section 6 of this table.</li> </ul> <p>Whichever method is selected, the component shall be modeled identically for both the Proposed Design and Standard Design models.</p> | <p>Same as Proposed Design.</p> |

Table 9-2 HVAC Systems map for standard Design

|                          | <b>Hotel/Motel, Hospital Patient Rooms, Hotel Guest Rooms, Resorts, Villas, Sleeping Quarters in Mixed- use Buildings, Schools, Classrooms/ Lecture Rooms</b>   | <b>Buildings with Less than or Equal to 12,500 m<sup>2</sup> of Conditioned Area</b>  | <b>Buildings with More than 12,500 m<sup>2</sup> of Conditioned Area</b>  | <b>Data Centre/ Server/Computer Rooms</b>  |
|--------------------------|---|---|---|--|
| Name                     | System A  | System B  | System C  | System D                                   |
| System Type <sup>2</sup> | Split AC  | VRF: Variable Refrigerant Flow  | VAV: Central cooling plant with variable volume AHU   | Computer Room air conditioners             |
| Fan Control              | Constant Volume   | Constant volume   | Variable volume   | Constant volume                            |
| Cooling Type             | Direct expansion with air cooled condenser  | Direct expansion with air cooled condenser  | Chilled Water with water cooled condenser   | Direct expansion with air cooled condenser |
| Heating Type             | 1 Heat Pump: Where no heating system has been specified or where an electric heating system has been specified in the Proposed Design<br>2 Fossil Fuel Boiler, Fossil/Electrical Hybrid: Where a heating system exists, and a | 1. Heat Pump: Where no heating system has been specified or where an electric heating system has been specified in the Proposed Design<br>2. Fossil Fuel Boiler Fossil/Electrical Hybrid: Where a heating | 1. Electric resistance: Where no heating system has been specified or where an electric heating system has been specified in the Proposed Design<br>2. Fossil Fuel Boiler Fossil/Electrical Hybrid: Where | NA   |

|   |  |   |   |  |
|---|--|---|---|--|
|   | fossil fuel hot water boiler has been specified in the Proposed Design | system exists, and a fossil fuel hot water boiler has been specified in the Proposed Design | a heating system exists, and a fossil fuel hot water boiler has been specified in the Proposed Design |  |
| <p><b>Notes:</b></p> <p>1. Buildings of the listed occupancy types or spaces in Mixed-use Buildings with the listed occupancy types.</p> <p>2. Where attributes make a building eligible for more than one system type; use the predominant condition to determine the Standard Design system type provided the non-predominant conditions apply to less than 1,000 m<sup>2</sup> of conditioned floor area. Use additional system type for non-predominant conditions if those conditions apply to more than 1,000 m<sup>2</sup> of conditioned floor area. Use additional system type for any space which has a substantial difference in peak loads and/or operational hours compared to the predominant space type. Such spaces may include but are not limited to computer/server rooms, retail areas in residential, or office buildings.</p> <p>3. One AHU per floor at a minimum.</p> |  |   |   |  |

Table 9-3 Power Adjustment Factors for Automatic Lighting Controls

| Automatic Control Device                         | Daytime occupancy and area <300 m <sup>2</sup> | 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 Table 9-or otherwise specifically addressed in this subsection shall be identical to those in the Proposed Design.

Exception to § 9.4.2(a): Where there are specific requirements in §5.2.2, the component efficiency in the Standard Design shall be adjusted to the lowest efficiency level allowed by the requirement for that component type.

- (b) All HVAC and service water heating equipment in the Standard Design shall be modeled at the minimum efficiency levels, both part load and full load, in accordance with §5.2.2.
- (c) Where efficiency ratings, such as EER and COP, include fan energy, the descriptor shall be broken down into its components so that supply fan energy can be modeled separately.
- (d) Minimum outdoor air ventilation rates shall be the same for both the Standard Design and the Proposed Design except for conditions specified in §9.4.2.1.
- (e) The equipment capacity for the standard design shall be based on sizing runs for each orientation and shall be oversized by 15% for cooling and 25% for heating, i.e., the ratio between the capacities determined by the sizing runs shall be 1.15 for cooling and 1.25 for heating.
- (f) Unmet load hours for the Proposed Design shall not differ from unmet load hours for the Standard Design by more than 50 hours. Maximum number of unmet hours shall not exceed 300 for either case.

#### **9.4.2.1 Minimum Outdoor Air Rates:**

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

- (a) when modeling demand-controlled ventilation (DCV) in the Proposed Design (DCV is not required in the Standard Design as per §5.2.1.3.
- (b) when the Proposed Design has a ventilation flow higher than the minimum required by the applicable code, the Standard Design shall be modeled as per the minimum ventilation rate required by the applicable code and the Proposed Design shall be modeled as per actual design (higher than Standard Design)

#### **9.4.2.2 Fan Schedules**

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

### 9.4.2.3 Fan Power

- (c) For Systems Types A, B and D,

$$P_{\text{fan}} = \text{cmh} \times .51$$

Where,  $P_{\text{fan}}$  = Standard Design fan power in watts

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

- (d) For System Type C

Fan power shall be modelled as per power and efficiency limits specified in 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 modelled in the Standard Design as per the requirements of §5.3.5.

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

### 9.4.2.6 Energy Recovery

Energy recovery shall be modelled in the standard design as per the requirement of §5.3.

### 9.4.2.7 Chilled Water Design Supply Temperatures

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

### 9.4.2.8 Chillers

Only electric chillers shall be modelled in the Standard Design for System C. Chillers shall meet the minimum efficiency requirements indicated in Table 5-1 and Table 5-2. Chillers

in the Standard Design shall be selected as per Table 9-4 below:

Table 9-4 Types and Number of Chillers for Standard Design

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

**Exception to 9.4.2.8:** Air cooled chillers are allowed to be modelled 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 modelled 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 modelled as per power and efficiency limits specified in Table 5-16.

Standard Design chilled water pumps shall be modelled as primary-secondary with variable secondary flow.

**9.4.2.10 Cooling Tower**

Standard Design cooling tower shall be modelled as an open circuit axial flow tower with power and efficiency as per §5.3.3. The fans shall be modelled 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 modelled as natural draft boilers and shall use the same fuel as the Proposed Design. Boiler efficiency shall be modelled.

**9.4.2.12 Hot Water Design Supply Temperatures**

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



#### 9.4.2.13 Hot Water Pumps

The Standard Design hot water pumps shall be modelled with a minimum efficiency of 70% and a pump power of 300 W/l-s<sup>-1</sup>.

Standard Design hot water pumps shall be modelled 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 modelled 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 modelled 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 modelled 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 modelled at minimum efficiency levels as per §9.4.2.7 to §9.4.2.10.

Airside/low side capacities shall be modelled as per design and the plant capacities shall be auto-sized by the software.

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

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

The EPI Ratio for ECBC+ and SuperECBC Buildings shall be equal to or less than the EPI Ratios listed under the applicable climate zone in Table 9-5 through Table 9-9 of §9.5.

## 9.5 Maximum Allowed EPI Ratios

Table 9-5 Maximum Allowed EPI Ratios for 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 9-6 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 9-7 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 9-8 Schedules for Business - Office Building Daytime Business

| Business – Office Daytime Business |                    |                    |                         |                   |                    |                         |                    |                         |   |                         |
|------------------------------------|--------------------|--------------------|-------------------------|-------------------|--------------------|-------------------------|--------------------|-------------------------|---|-------------------------|
| Time Period                        | Occupancy Schedule |                    |                         | Lighting Schedule |                    |                         | Equipment Schedule |                         | HVAC Fan Schedule (On/Off)                      |                         |
|                                    | Office             | Corridor/<br>Lobby | Conference<br>/ Meeting | Office            | Corridor/<br>Lobby | Conference<br>/ Meeting | Office             | Conference<br>/ Meeting | Office/<br>Corridor/<br>Conference<br>/ Meeting | Conference<br>/ 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 9-9 Schedules for Business - Office Building 24-hours Business

| Business – Office 24-hour Business |                    |                 |                          |                   |                 |                          |                    |                          |   |
|------------------------------------|--------------------|-----------------|--------------------------|-------------------|-----------------|--------------------------|--------------------|--------------------------|---|
| Time Period                        | Occupancy Schedule |                 |                          | Lighting Schedule |                 |                          | Equipment Schedule |                          | HVAC Fan Schedule (On/Off)                        |
|                                    | Office             | Corridor/ Lobby | Conference/ Meeting Room | Office            | Corridor/ Lobby | Conference/ Meeting Room | Office             | Conference/ Meeting Room | Office/ Corridor/ Lobby/ Conference/ Meeting Room |
| 00:00-01:00                        | 0.90               | 0.20            | 0.00                     | 0.90              | 0.90            | 0.00                     | 0.95               | 0.00                     | 1   |
| 01:00-02:00                        | 0.90               | 0.50            | 0.00                     | 0.90              | 0.90            | 0.00                     | 0.95               | 0.00                     | 1   |
| 02:00-03:00                        | 0.90               | 0.20            | 0.00                     | 0.90              | 0.90            | 0.00                     | 0.95               | 0.00                     | 1   |
| 03:00-04:00                        | 0.90               | 0.20            | 0.00                     | 0.90              | 0.90            | 0.00                     | 0.95               | 0.00                     | 1   |
| 04:00-05:00                        | 0.50               | 0.20            | 0.50                     | 0.50              | 0.90            | 0.50                     | 0.00               | 0.90                     | 1   |
| 05:00-06:00                        | 0.20               | 0.50            | 0.50                     | 0.05              | 0.90            | 0.50                     | 0.00               | 0.90                     | 1   |
| 06:00-07:00                        | 0.10               | 0.50            | 0.50                     | 0.05              | 0.50            | 0.50                     | 0.00               | 0.90                     | 1   |
| 07:00-08:00                        | 0.10               | 0.50            | 0.00                     | 0.90              | 0.50            | 0.00                     | 0.95               | 0.00                     | 1   |
| 08:00-09:00                        | 0.90               | 0.70            | 0.00                     | 0.90              | 0.90            | 0.00                     | 0.95               | 0.00                     | 1   |
| 09:00-10:00                        | 0.90               | 0.80            | 0.50                     | 0.90              | 0.90            | 0.50                     | 0.95               | 0.90                     | 1   |
| 10:00-11:00                        | 0.90               | 0.70            | 0.75                     | 0.90              | 0.90            | 0.90                     | 0.95               | 0.90                     | 1   |
| 11:00-12:00                        | 0.90               | 0.30            | 0.75                     | 0.90              | 0.90            | 0.90                     | 0.95               | 0.90                     | 1   |
| 12:00-13:00                        | 0.90               | 0.30            | 0.75                     | 0.90              | 0.90            | 0.90                     | 0.95               | 0.90                     | 1   |
| 13:00-14:00                        | 0.20               | 0.80            | 0.25                     | 0.50              | 0.50            | 0.50                     | 0.20               | 0.50                     | 1   |
| 14:00-15:00                        | 0.90               | 0.50            | 0.75                     | 0.90              | 0.90            | 0.90                     | 0.95               | 0.90                     | 1   |
| 15:00-16:00                        | 0.90               | 0.30            | 0.75                     | 0.90              | 0.90            | 0.90                     | 0.95               | 0.90                     | 1   |
| 16:00-17:00                        | 0.90               | 0.30            | 0.75                     | 0.90              | 0.90            | 0.90                     | 0.95               | 0.90                     | 1   |
| 17:00-18:00                        | 0.90               | 0.80            | 0.75                     | 0.90              | 0.90            | 0.90                     | 0.95               | 0.90                     | 1   |
| 18:00-19:00                        | 0.90               | 0.70            | 0.50                     | 0.90              | 0.90            | 0.90                     | 0.20               | 0.90                     | 1   |
| 19:00-20:00                        | 0.20               | 0.30            | 0.00                     | 0.90              | 0.90            | 0.00                     | 0.95               | 0.00                     | 1   |
| 20:00-21:00                        | 0.90               | 0.20            | 0.00                     | 0.90              | 0.90            | 0.00                     | 0.95               | 0.00                     | 1   |
| 21:00-22:00                        | 0.90               | 0.20            | 0.50                     | 0.90              | 0.90            | 0.50                     | 0.95               | 0.90                     | 1   |
| 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 9-10 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 9-11 Schedules for Assembly Buildings (A)

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



Table 9-12 Schedules for Assembly Buildings (B)

| Assembly Buildings |                       |               |                          |                       |               |                          |                    |                          |
|--------------------|-----------------------|---------------|--------------------------|-----------------------|---------------|--------------------------|--------------------|--------------------------|
| Time Period        | Occupancy Schedule    |               |                          | Lighting Schedule     |               |                          | Equipment Schedule |                          |
|                    | Seating/ Public Space | Exhibit Space | Meeting/ Conference Room | Seating/ Public Space | Exhibit Space | Meeting/ Conference Room | Exhibit Space      | Meeting/ Conference Room |
| 00:00-01:00        | 0.00                  | 0.00          | 0.00                     | 0.10                  | 0.10          | 0.10                     | 0.00               | 0.00                     |
| 01:00-02:00        | 0.00                  | 0.00          | 0.00                     | 0.10                  | 0.10          | 0.10                     | 0.00               | 0.00                     |
| 02:00-03:00        | 0.00                  | 0.00          | 0.00                     | 0.10                  | 0.10          | 0.10                     | 0.00               | 0.00                     |
| 03:00-04:00        | 0.00                  | 0.00          | 0.00                     | 0.10                  | 0.10          | 0.10                     | 0.00               | 0.00                     |
| 04:00-05:00        | 0.00                  | 0.00          | 0.00                     | 0.10                  | 0.10          | 0.10                     | 0.00               | 0.00                     |
| 05:00-06:00        | 0.00                  | 0.00          | 0.00                     | 0.10                  | 0.10          | 0.10                     | 0.00               | 0.00                     |
| 06:00-07:00        | 0.00                  | 0.00          | 0.00                     | 0.10                  | 0.10          | 0.10                     | 0.00               | 0.00                     |
| 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 9-13 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 9-14 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 9-15 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 & | Public Spaces     | In Patient & ICU | Diagnostic, emergency, & | OPD & Offices | In Patient & ICU   | Diagnostic, emergency, & | 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 9-16 Schedules for Healthcare - Hospital Buildings (B)

| Healthcare - Hospital |                            |              |                    |               |                   |           |                   |                  |                      |                   |
|-----------------------|----------------------------|--------------|--------------------|---------------|-------------------|-----------|-------------------|------------------|----------------------|-------------------|
| Time Period           | HVAC Fan Schedule (On/Off) |              |                    |               | External Lighting | Elevators | Service Hot Water |                  | Basement Ventilation | Basement Lighting |
|                       | Public Spaces              | Beds & ICU   | Diagn, emerg, & OT | OPD & Offices |                   |           | Building Summer   | Building Winters |                      |                   |
|                       | 7 Days/ week               | 7 Days/ week | 7 Days/ week       | 7 Days/ week  |                   |           | 7 Days/ week      | 7 Days/ week     |                      |                   |
| 00:00-01:00           | 0                          | 1            | 1                  | 0             | 1.00              | 0.20      | 0.00              | 0.30             | 0.50                 | 0.50              |
| 01:00-02:00           | 0                          | 1            | 1                  | 0             | 1.00              | 0.20      | 0.00              | 0.30             | 0.50                 | 0.50              |
| 02:00-03:00           | 0                          | 1            | 1                  | 0             | 1.00              | 0.20      | 0.00              | 0.30             | 0.50                 | 0.50              |
| 03:00-04:00           | 0                          | 1            | 1                  | 0             | 1.00              | 0.20      | 0.00              | 0.30             | 0.50                 | 0.50              |
| 04:00-05:00           | 0                          | 1            | 1                  | 0             | 1.00              | 0.20      | 0.00              | 0.30             | 0.50                 | 0.50              |
| 05:00-06:00           | 0                          | 1            | 1                  | 0             | 1.00              | 0.20      | 0.00              | 0.30             | 0.50                 | 0.50              |
| 06:00-07:00           | 0                          | 1            | 1                  | 0             | 0.00              | 0.20      | 0.00              | 0.30             | 0.50                 | 0.50              |
| 07:00-08:00           | 1                          | 1            | 1                  | 0             | 0.00              | 0.50      | 0.00              | 0.20             | 0.50                 | 0.50              |
| 08:00-09:00           | 1                          | 1            | 1                  | 1             | 0.00              | 0.75      | 0.20              | 0.60             | 1.00                 | 1.00              |
| 09:00-10:00           | 1                          | 1            | 1                  | 1             | 0.00              | 1.00      | 0.30              | 0.60             | 1.00                 | 1.00              |
| 10:00-11:00           | 1                          | 1            | 1                  | 1             | 0.00              | 1.00      | 0.30              | 0.80             | 1.00                 | 1.00              |
| 11:00-12:00           | 1                          | 1            | 1                  | 1             | 0.00              | 1.00      | 0.30              | 0.80             | 1.00                 | 1.00              |
| 12:00-13:00           | 1                          | 1            | 1                  | 1             | 0.00              | 0.75      | 0.25              | 0.70             | 1.00                 | 1.00              |
| 13:00-14:00           | 1                          | 1            | 1                  | 1             | 0.00              | 1.00      | 0.25              | 0.80             | 1.00                 | 1.00              |
| 14:00-15:00           | 1                          | 1            | 1                  | 1             | 0.00              | 1.00      | 0.25              | 0.80             | 1.00                 | 1.00              |
| 15:00-16:00           | 1                          | 1            | 1                  | 1             | 0.00              | 1.00      | 0.25              | 0.70             | 1.00                 | 1.00              |
| 16:00-17:00           | 1                          | 1            | 1                  | 1             | 0.00              | 1.00      | 0.25              | 0.70             | 1.00                 | 1.00              |
| 17:00-18:00           | 1                          | 1            | 1                  | 1             | 0.00              | 1.00      | 0.10              | 0.50             | 1.00                 | 1.00              |
| 18:00-19:00           | 1                          | 1            | 1                  | 1             | 1.00              | 0.50      | 0.00              | 0.35             | 1.00                 | 1.00              |
| 19:00-20:00           | 1                          | 1            | 1                  | 1             | 1.00              | 0.50      | 0.00              | 0.35             | 1.00                 | 1.00              |
| 20:00-21:00           | 1                          | 1            | 1                  | 1             | 1.00              | 0.50      | 0.00              | 0.35             | 1.00                 | 1.00              |
| 21:00-22:00           | 1                          | 1            | 1                  | 0             | 1.00              | 0.30      | 0.00              | 0.30             | 0.50                 | 0.50              |
| 22:00-23:00           | 0                          | 1            | 1                  | 0             | 1.00              | 0.20      | 0.00              | 0.30             | 0.50                 | 0.50              |
| 23:00-24:00           | 0                          | 1            | 1                  | 0             | 1.00              | 0.20      | 0.00              | 0.30             | 0.50                 | 0.50              |

Table 9-17 Schedules for Shopping Complex – Out-patient Healthcare Buildings (A)

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

Table 9-18 Schedules for Healthcare – Out-patient Healthcare Buildings (B)

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

Table 9-19 Schedules for Educational School Building (A)

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



Table 9-20 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 9-21 Schedules for Educational - University Building (A)

| Educational – University Buildings |                        |                         |                            |              |                        |                 |                            |                      |                   |
|------------------------------------|------------------------|-------------------------|----------------------------|--------------|------------------------|-----------------|----------------------------|----------------------|-------------------|
| Time Period                        | Elevator Schedule      |                         | HVAC Fan Schedule (On/Off) |              |                        |                 | External Lighting Schedule | Basement Ventilation | Basement Lighting |
|                                    | Library & Comp. Centre | Student and Back office | Student Area               | Back Office  | Library & Comp. Centre | Corridor/ Lobby |                            |                      |                   |
|                                    | 7 days/ week           | 7 days/ week            | 5 days/ week               | 5 days/ week | 7 days/ week           | 5 days/ week    |                            |                      |                   |
| 00:00-01:00                        | 0.00                   | 0.00                    | 0                          | 0            | 0                      | 0               | 0.80                       | 0.00                 | 0.05              |
| 01:00-02:00                        | 0.00                   | 0.00                    | 0                          | 0            | 0                      | 0               | 0.80                       | 0.00                 | 0.05              |
| 02:00-03:00                        | 0.00                   | 0.00                    | 0                          | 0            | 0                      | 0               | 0.80                       | 0.00                 | 0.05              |
| 03:00-04:00                        | 0.00                   | 0.00                    | 0                          | 0            | 0                      | 0               | 0.80                       | 0.00                 | 0.05              |
| 04:00-05:00                        | 0.00                   | 0.00                    | 0                          | 0            | 0                      | 0               | 0.80                       | 0.00                 | 0.05              |
| 05:00-06:00                        | 0.00                   | 0.00                    | 0                          | 0            | 0                      | 0               | 0.80                       | 0.00                 | 0.05              |
| 06:00-07:00                        | 0.00                   | 0.05                    | 0                          | 0            | 0                      | 0               | 0.00                       | 0.00                 | 0.05              |
| 07:00-08:00                        | 0.00                   | 0.25                    | 1                          | 1            | 1                      | 1               | 0.00                       | 0.00                 | 0.05              |
| 08:00-09:00                        | 0.50                   | 0.85                    | 1                          | 1            | 1                      | 1               | 0.00                       | 1.00                 | 1.00              |
| 09:00-10:00                        | 0.50                   | 0.25                    | 1                          | 1            | 1                      | 1               | 0.00                       | 1.00                 | 1.00              |
| 10:00-11:00                        | 0.30                   | 0.25                    | 1                          | 1            | 1                      | 1               | 0.00                       | 1.00                 | 1.00              |
| 11:00-12:00                        | 0.20                   | 0.25                    | 1                          | 1            | 1                      | 1               | 0.00                       | 1.00                 | 1.00              |
| 12:00-13:00                        | 0.20                   | 0.25                    | 1                          | 1            | 1                      | 1               | 0.00                       | 1.00                 | 1.00              |
| 13:00-14:00                        | 0.40                   | 0.90                    | 1                          | 1            | 1                      | 1               | 0.00                       | 1.00                 | 1.00              |
| 14:00-15:00                        | 0.30                   | 0.60                    | 1                          | 1            | 1                      | 1               | 0.00                       | 1.00                 | 1.00              |
| 15:00-16:00                        | 0.30                   | 0.25                    | 1                          | 1            | 1                      | 1               | 0.00                       | 1.00                 | 1.00              |
| 16:00-17:00                        | 0.30                   | 0.25                    | 1                          | 1            | 1                      | 1               | 0.00                       | 1.00                 | 1.00              |
| 17:00-18:00                        | 0.50                   | 0.90                    | 1                          | 0            | 1                      | 1               | 0.00                       | 1.00                 | 1.00              |
| 18:00-19:00                        | 0.50                   | 0.15                    | 0                          | 0            | 1                      | 1               | 0.80                       | 1.00                 | 1.00              |
| 19:00-20:00                        | 0.50                   | 0.05                    | 0                          | 0            | 1                      | 0               | 0.80                       | 1.00                 | 1.00              |
| 20:00-21:00                        | 0.50                   | 0.00                    | 0                          | 0            | 1                      | 0               | 0.80                       | 0.00                 | 0.50              |
| 21:00-22:00                        | 0.50                   | 0.00                    | 0                          | 0            | 1                      | 0               | 0.80                       | 0.00                 | 0.05              |
| 22:00-23:00                        | 0.50                   | 0.00                    | 0                          | 0            | 1                      | 0               | 0.80                       | 0.00                 | 0.05              |
| 23:00-24:00                        | 0.00                   | 0.00                    | 0                          | 0            | 0                      | 0               | 0.80                       | 0.00                 | 0.05              |

Table 9-22 Schedules for Educational - University Buildings (B)

| Educational – University Buildings |                    |             |                    |                |                   |             |                    |                |                    |             |                    |
|------------------------------------|--------------------|-------------|--------------------|----------------|-------------------|-------------|--------------------|----------------|--------------------|-------------|--------------------|
| Time Period                        | Occupancy Schedule |             |                    |                | Lighting Schedule |             |                    |                | Equipment Schedule |             |                    |
|                                    | Student Zone       | Back Office | Library & Computer | Corridor/Lobby | Student Zone      | Back Office | Library & Computer | Corridor/Lobby | Student Zone       | Back Office | Library & Computer |
|                                    | 5 Days/week        | 5 Days/week | 7 Days/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 9-23 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 9-24 Schedules for Hospitality Buildings (B)

| Hospitality - Occupancy |                    |          |              |          |               |          |              |          |              |          |                             |                 |
|-------------------------|--------------------|----------|--------------|----------|---------------|----------|--------------|----------|--------------|----------|-----------------------------|-----------------|
| Time Period             | Occupancy Schedule |          |              |          |               |          |              |          |              |          |                             |                 |
|                         | Guest Room         |          | Lobby        |          | Public Spaces |          | Restaurant   |          | Back Office  |          | Conference/<br>Banquet Room | Kitchen         |
|                         | Week<br>Days       | Weekends | Week<br>Days | Weekends | Week<br>Days  | Weekends | Week<br>Days | Weekends | Week<br>Days | Weekends | 7 Days/<br>week             | 7 Days/<br>week |
| 00:00-01:00             | 0.65               | 0.90     | 0.10         | 0.10     | 0.00          | 0.00     | 0.00         | 0.00     | 0.20         | 0.20     | 0.00                        | 0.00            |
| 01:00-02:00             | 0.65               | 0.90     | 0.10         | 0.10     | 0.00          | 0.00     | 0.00         | 0.00     | 0.20         | 0.20     | 0.00                        | 0.00            |
| 02:00-03:00             | 0.65               | 0.90     | 0.10         | 0.10     | 0.00          | 0.00     | 0.00         | 0.00     | 0.20         | 0.20     | 0.00                        | 0.00            |
| 03:00-04:00             | 0.65               | 0.90     | 0.10         | 0.10     | 0.00          | 0.00     | 0.00         | 0.00     | 0.20         | 0.20     | 0.00                        | 0.00            |
| 04:00-05:00             | 0.65               | 0.90     | 0.10         | 0.10     | 0.00          | 0.00     | 0.00         | 0.00     | 0.20         | 0.20     | 0.00                        | 0.00            |
| 05:00-06:00             | 0.65               | 0.90     | 0.10         | 0.10     | 0.20          | 0.50     | 0.00         | 0.00     | 0.20         | 0.20     | 0.00                        | 0.00            |
| 06:00-07:00             | 0.50               | 0.70     | 0.20         | 0.20     | 0.40          | 0.70     | 0.00         | 0.00     | 0.20         | 0.20     | 0.00                        | 0.50            |
| 07:00-08:00             | 0.50               | 0.70     | 0.30         | 0.40     | 0.40          | 0.70     | 0.30         | 0.30     | 0.20         | 0.20     | 0.00                        | 0.80            |
| 08:00-09:00             | 0.30               | 0.50     | 0.40         | 0.70     | 0.40          | 0.70     | 0.30         | 0.30     | 0.20         | 0.20     | 0.20                        | 0.80            |
| 09:00-10:00             | 0.15               | 0.30     | 0.40         | 0.70     | 0.40          | 0.70     | 0.30         | 0.30     | 0.95         | 0.50     | 0.50                        | 0.50            |
| 10:00-11:00             | 0.15               | 0.20     | 0.40         | 0.70     | 0.40          | 0.70     | 0.30         | 0.30     | 0.95         | 0.50     | 0.90                        | 0.50            |
| 11:00-12:00             | 0.15               | 0.20     | 0.40         | 0.70     | 0.20          | 0.30     | 0.30         | 0.30     | 0.95         | 0.50     | 0.90                        | 0.80            |
| 12:00-13:00             | 0.15               | 0.20     | 0.40         | 0.70     | 0.20          | 0.30     | 0.80         | 0.80     | 0.95         | 0.50     | 0.90                        | 0.80            |
| 13:00-14:00             | 0.15               | 0.20     | 0.20         | 0.20     | 0.20          | 0.30     | 0.80         | 0.80     | 0.50         | 0.30     | 0.90                        | 0.80            |
| 14:00-15:00             | 0.15               | 0.20     | 0.20         | 0.20     | 0.20          | 0.30     | 0.80         | 0.80     | 0.95         | 0.50     | 0.90                        | 0.50            |
| 15:00-16:00             | 0.15               | 0.20     | 0.20         | 0.20     | 0.40          | 0.70     | 0.30         | 0.30     | 0.95         | 0.50     | 0.90                        | 0.50            |
| 16:00-17:00             | 0.15               | 0.20     | 0.20         | 0.20     | 0.40          | 0.70     | 0.30         | 0.30     | 0.95         | 0.50     | 0.90                        | 0.50            |
| 17:00-18:00             | 0.30               | 0.30     | 0.40         | 0.40     | 0.40          | 0.70     | 0.30         | 0.30     | 0.95         | 0.50     | 0.50                        | 0.80            |
| 18:00-19:00             | 0.50               | 0.50     | 0.40         | 0.40     | 0.50          | 0.70     | 0.50         | 0.50     | 0.30         | 0.30     | 0.20                        | 0.80            |
| 19:00-20:00             | 0.50               | 0.70     | 0.40         | 0.40     | 0.80          | 0.70     | 0.80         | 0.90     | 0.20         | 0.20     | 0.20                        | 0.80            |
| 20:00-21:00             | 0.65               | 0.70     | 0.30         | 0.30     | 0.90          | 0.70     | 0.80         | 0.90     | 0.20         | 0.20     | 0.00                        | 0.80            |
| 21:00-22:00             | 0.65               | 0.90     | 0.20         | 0.20     | 0.80          | 0.70     | 0.80         | 0.90     | 0.20         | 0.20     | 0.00                        | 0.80            |
| 22:00-23:00             | 0.65               | 0.90     | 0.10         | 0.10     | 0.60          | 0.60     | 0.80         | 0.90     | 0.20         | 0.20     | 0.00                        | 0.50            |
| 23:00-24:00             | 0.65               | 0.90     | 0.10         | 0.10     | 0.30          | 0.30     | 0.50         | 0.90     | 0.20         | 0.20     | 0.00                        | 0.50            |

Table 9-25 Schedules for Hospitality Buildings (C)

| Hospitality – Lighting |                   |          |              |          |               |          |              |          |              |          |                             |                 |
|------------------------|-------------------|----------|--------------|----------|---------------|----------|--------------|----------|--------------|----------|-----------------------------|-----------------|
| Time Period            | Lighting Schedule |          |              |          |               |          |              |          |              |          |                             |                 |
|                        | Guest Room        |          | Lobby        |          | Public Spaces |          | Restaurant   |          | Back Office  |          | Conference/<br>Banquet Room | Kitchen         |
|                        | Week<br>Days      | Weekends | Week<br>Days | Weekends | Week<br>Days  | Weekends | Week<br>Days | Weekends | Week<br>Days | Weekends | 7 Days/<br>week             | 7 Days/<br>week |
| 00:00-01:00            | 0.20              | 0.30     | 0.30         | 0.30     | 0.20          | 0.20     | 0.50         | 0.50     | 0.05         | 0.05     | 0.00                        | 0.50            |
| 01:00-02:00            | 0.20              | 0.25     | 0.30         | 0.30     | 0.15          | 0.20     | 0.10         | 0.10     | 0.05         | 0.05     | 0.00                        | 0.05            |
| 02:00-03:00            | 0.10              | 0.10     | 0.30         | 0.30     | 0.10          | 0.10     | 0.10         | 0.10     | 0.05         | 0.05     | 0.00                        | 0.05            |
| 03:00-04:00            | 0.10              | 0.10     | 0.30         | 0.30     | 0.10          | 0.10     | 0.10         | 0.10     | 0.05         | 0.05     | 0.00                        | 0.05            |
| 04:00-05:00            | 0.10              | 0.10     | 0.30         | 0.30     | 0.10          | 0.10     | 0.10         | 0.10     | 0.05         | 0.05     | 0.00                        | 0.05            |
| 05:00-06:00            | 0.20              | 0.10     | 0.30         | 0.30     | 0.20          | 0.10     | 0.10         | 0.10     | 0.05         | 0.05     | 0.00                        | 0.05            |
| 06:00-07:00            | 0.45              | 0.40     | 0.40         | 0.40     | 0.40          | 0.30     | 0.10         | 0.10     | 0.10         | 0.10     | 0.00                        | 0.10            |
| 07:00-08:00            | 0.55              | 0.40     | 0.30         | 0.40     | 0.50          | 0.30     | 0.50         | 0.50     | 0.30         | 0.30     | 0.00                        | 0.30            |
| 08:00-09:00            | 0.45              | 0.55     | 0.40         | 0.70     | 0.40          | 0.40     | 0.50         | 0.50     | 0.90         | 0.60     | 0.50                        | 0.90            |
| 09:00-10:00            | 0.20              | 0.20     | 0.40         | 0.70     | 0.20          | 0.40     | 0.50         | 0.50     | 0.90         | 0.60     | 0.80                        | 0.90            |
| 10:00-11:00            | 0.20              | 0.20     | 0.40         | 0.70     | 0.20          | 0.40     | 0.50         | 0.50     | 0.90         | 0.60     | 0.90                        | 0.90            |
| 11:00-12:00            | 0.20              | 0.20     | 0.40         | 0.70     | 0.20          | 0.40     | 0.50         | 0.50     | 0.90         | 0.60     | 0.90                        | 0.90            |
| 12:00-13:00            | 0.20              | 0.20     | 0.40         | 0.70     | 0.20          | 0.40     | 0.90         | 0.90     | 0.90         | 0.60     | 0.90                        | 0.90            |
| 13:00-14:00            | 0.20              | 0.20     | 0.40         | 0.40     | 0.20          | 0.40     | 0.90         | 0.90     | 0.50         | 0.50     | 0.90                        | 0.50            |
| 14:00-15:00            | 0.20              | 0.20     | 0.40         | 0.40     | 0.20          | 0.40     | 0.90         | 0.90     | 0.90         | 0.60     | 0.90                        | 0.90            |
| 15:00-16:00            | 0.20              | 0.20     | 0.40         | 0.40     | 0.20          | 0.40     | 0.50         | 0.50     | 0.90         | 0.60     | 0.90                        | 0.90            |
| 16:00-17:00            | 0.20              | 0.20     | 0.40         | 0.40     | 0.20          | 0.40     | 0.50         | 0.50     | 0.90         | 0.60     | 0.90                        | 0.90            |
| 17:00-18:00            | 0.30              | 0.30     | 0.40         | 0.40     | 0.25          | 0.40     | 0.50         | 0.50     | 0.95         | 0.60     | 0.50                        | 0.95            |
| 18:00-19:00            | 0.70              | 0.85     | 0.40         | 0.40     | 0.60          | 0.60     | 0.90         | 0.90     | 0.50         | 0.50     | 0.50                        | 0.95            |
| 19:00-20:00            | 0.90              | 1.00     | 0.40         | 0.40     | 0.80          | 0.70     | 0.90         | 0.90     | 0.30         | 0.30     | 0.50                        | 0.95            |
| 20:00-21:00            | 1.00              | 1.00     | 0.30         | 0.30     | 0.90          | 0.70     | 0.90         | 0.90     | 0.30         | 0.30     | 0.00                        | 0.95            |
| 21:00-22:00            | 0.90              | 1.00     | 0.40         | 0.40     | 0.80          | 0.70     | 0.90         | 0.90     | 0.20         | 0.20     | 0.00                        | 0.95            |
| 22:00-23:00            | 0.70              | 0.85     | 0.30         | 0.30     | 0.60          | 0.60     | 0.90         | 0.90     | 0.10         | 0.10     | 0.00                        | 0.95            |
| 23:00-24:00            | 0.30              | 0.40     | 0.30         | 0.30     | 0.30          | 0.30     | 0.90         | 0.90     | 0.05         | 0.05     | 0.00                        | 0.95            |

Table 9-26 Schedules for Hospitality Buildings (D)

| Hospitality – Equipment |                    |          |               |            |          |             |          |                             |              |
|-------------------------|--------------------|----------|---------------|------------|----------|-------------|----------|-----------------------------|--------------|
| Time Period             | Equipment Schedule |          |               |            |          |             |          |                             |              |
|                         | Guest Room         |          | Public Spaces | Restaurant |          | Back Office |          | Conference/<br>Banquet Room | Kitchen      |
|                         | Week Days          | Weekends | 7 Days/ week  | Week Days  | Weekends | Week Days   | Weekends | 7 Days/ week                | 7 Days/ week |
| 00:00-01:00             | 0.20               | 0.20     | 0.30          | 0.50       | 0.50     | 0.05        | 0.05     | 0.00                        | 0.30         |
| 01:00-02:00             | 0.20               | 0.20     | 0.20          | 0.00       | 0.00     | 0.05        | 0.05     | 0.00                        | 0.10         |
| 02:00-03:00             | 0.20               | 0.20     | 0.20          | 0.00       | 0.00     | 0.05        | 0.05     | 0.00                        | 0.10         |
| 03:00-04:00             | 0.20               | 0.20     | 0.20          | 0.00       | 0.00     | 0.05        | 0.05     | 0.00                        | 0.10         |
| 04:00-05:00             | 0.20               | 0.20     | 0.20          | 0.00       | 0.00     | 0.05        | 0.05     | 0.00                        | 0.10         |
| 05:00-06:00             | 0.20               | 0.20     | 0.30          | 0.00       | 0.00     | 0.05        | 0.05     | 0.00                        | 0.10         |
| 06:00-07:00             | 0.30               | 0.30     | 0.50          | 0.00       | 0.00     | 0.05        | 0.05     | 0.00                        | 0.30         |
| 07:00-08:00             | 0.40               | 0.60     | 0.50          | 0.60       | 0.60     | 0.10        | 0.10     | 0.00                        | 0.30         |
| 08:00-09:00             | 0.70               | 0.90     | 0.50          | 0.60       | 0.60     | 0.30        | 0.30     | 0.50                        | 0.30         |
| 09:00-10:00             | 0.20               | 0.20     | 0.50          | 0.60       | 0.60     | 0.95        | 0.70     | 0.50                        | 0.30         |
| 10:00-11:00             | 0.20               | 0.20     | 0.35          | 0.60       | 0.60     | 0.95        | 0.70     | 0.90                        | 0.30         |
| 11:00-12:00             | 0.20               | 0.20     | 0.35          | 0.60       | 0.60     | 0.95        | 0.70     | 0.90                        | 0.30         |
| 12:00-13:00             | 0.20               | 0.20     | 0.35          | 0.80       | 0.80     | 0.95        | 0.70     | 0.90                        | 0.30         |
| 13:00-14:00             | 0.20               | 0.20     | 0.35          | 0.80       | 0.80     | 0.50        | 0.70     | 0.90                        | 0.30         |
| 14:00-15:00             | 0.20               | 0.20     | 0.35          | 0.80       | 0.80     | 0.95        | 0.70     | 0.90                        | 0.30         |
| 15:00-16:00             | 0.20               | 0.20     | 0.35          | 0.60       | 0.60     | 0.95        | 0.70     | 0.90                        | 0.30         |
| 16:00-17:00             | 0.20               | 0.20     | 0.35          | 0.60       | 0.60     | 0.95        | 0.70     | 0.90                        | 0.30         |
| 17:00-18:00             | 0.30               | 0.30     | 0.35          | 0.60       | 0.60     | 0.95        | 0.70     | 0.50                        | 0.30         |
| 18:00-19:00             | 0.50               | 0.50     | 0.70          | 0.80       | 0.80     | 0.30        | 0.30     | 0.50                        | 0.30         |
| 19:00-20:00             | 0.50               | 0.50     | 0.90          | 0.80       | 0.90     | 0.10        | 0.10     | 0.50                        | 0.30         |
| 20:00-21:00             | 0.50               | 0.70     | 0.90          | 0.80       | 0.90     | 0.10        | 0.10     | 0.00                        | 0.30         |
| 21:00-22:00             | 0.70               | 0.70     | 0.90          | 0.80       | 0.90     | 0.10        | 0.10     | 0.00                        | 0.30         |
| 22:00-23:00             | 0.40               | 0.40     | 0.70          | 0.80       | 0.90     | 0.05        | 0.05     | 0.00                        | 0.30         |
| 23:00-24:00             | 0.20               | 0.20     | 0.40          | 0.80       | 0.90     | 0.05        | 0.05     | 0.00                        | 0.30         |

Table 9-27 Schedules for Hospitality Buildings (E)

| Hospitality – HVAC Fan Schedules |                   |              |               |              |              |                         |              |
|----------------------------------|-------------------|--------------|---------------|--------------|--------------|-------------------------|--------------|
| Time Period                      | HVAC Fan Schedule |              |               |              |              |                         |              |
|                                  | Guest Room        | Lobby        | Public Spaces | Restaurants  | Back Office  | Conference/Banquet Room | Kitchen      |
|                                  | 7 Days/ week      | 7 Days/ week | 7 Days/ week  | 7 Days/ week | 7 Days/ week | 7 Days/ week            | 7 Days/ week |
| 00:00-                           | 1                 | 0            | 0             | 0            | 0            | 0                       | 0            |
| 01:00-                           | 1                 | 0            | 0             | 0            | 0            | 0                       | 0            |
| 02:00-                           | 1                 | 0            | 0             | 0            | 0            | 0                       | 0            |
| 03:00-                           | 1                 | 0            | 0             | 0            | 0            | 0                       | 0            |
| 04:00-                           | 1                 | 0            | 0             | 0            | 0            | 0                       | 0            |
| 05:00-                           | 1                 | 1            | 1             | 0            | 0            | 0                       | 1            |
| 06:00-                           | 1                 | 1            | 1             | 1            | 0            | 0                       | 1            |
| 07:00-                           | 1                 | 1            | 1             | 1            | 0            | 0                       | 1            |
| 08:00-                           | 1                 | 1            | 1             | 1            | 1            | 1                       | 1            |
| 09:00-                           | 1                 | 1            | 1             | 1            | 1            | 1                       | 1            |
| 10:00-                           | 1                 | 1            | 1             | 1            | 1            | 1                       | 1            |
| 11:00-                           | 1                 | 1            | 1             | 1            | 1            | 1                       | 1            |
| 12:00-                           | 1                 | 1            | 1             | 1            | 1            | 1                       | 1            |
| 13:00-                           | 1                 | 1            | 1             | 1            | 1            | 1                       | 1            |
| 14:00-                           | 1                 | 1            | 1             | 1            | 1            | 1                       | 1            |
| 15:00-                           | 1                 | 1            | 1             | 1            | 1            | 1                       | 1            |
| 16:00-                           | 1                 | 1            | 1             | 1            | 1            | 1                       | 1            |
| 17:00-                           | 1                 | 1            | 1             | 1            | 1            | 1                       | 1            |
| 18:00-                           | 1                 | 1            | 1             | 1            | 1            | 1                       | 1            |
| 19:00-                           | 1                 | 1            | 1             | 1            | 0            | 1                       | 1            |
| 20:00-                           | 1                 | 1            | 1             | 1            | 0            | 1                       | 1            |
| 21:00-                           | 1                 | 1            | 1             | 1            | 0            | 0                       | 1            |
| 22:00-                           | 1                 | 0            | 1             | 1            | 0            | 0                       | 1            |
| 23:00-                           | 1                 | 0            | 1             | 1            | 0            | 0                       | 1            |



Table 9-28 Schedules for Shopping Complexes Buildings (A)

| Shopping Complex |                            |                    |               |                            |                      |                   |                   |          |
|------------------|----------------------------|--------------------|---------------|----------------------------|----------------------|-------------------|-------------------|----------|
| Time Period      | HVAC Fan Schedule (ON/OFF) |                    |               | External Lighting Schedule | Basement Ventilation | Basement Lighting | Elevator Schedule |          |
|                  | Retail                     | Corridors & Atrium | Special Zones |                            |                      |                   | Weekdays          | Weekends |
|                  | 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 9-29 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 9-30 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 9-31 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              |

## 10 Appendix A: Default Values for Typical Constructions

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

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

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

- a) § 4.1 of ISO 15099: For calculating the overall U-factor, ISO 15099 offers a choice between the linear thermal transmittance (4.1.2) and the area weighted method (4.1.3). The area weighted method (4.1.3) shall be used.
- b) § 4.2.2 of ISO 15099: Frame and divider SHGC's shall be calculated in accordance with § 4.2.2. The alternate approach in § 8.6 shall not be used.
- c) § 6.4 of ISO 15099 refers the issue of material properties to national standards. Material conductivities and emissivity shall be determined in accordance with Indian standards.
- d) § 7 of ISO 15099 on shading systems is currently excluded.
- e) § 8.2 of ISO 15099 addresses environmental conditions. The following are defined for India:

For U-factor calculations:

$$T_{in} = 24 \text{ }^{\circ}\text{C}, T_{out} = 32 \text{ }^{\circ}\text{C}, V = 3.35 \text{ m/s},$$

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

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

$$I_s = 0 \text{ W/m}^2$$

For SHGC calculations:

$$T_{in} = 24 \text{ }^{\circ}\text{C}, T_{out} = 32 \text{ }^{\circ}\text{C}, V = 2.75 \text{ m/s}$$

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

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

$$I_s = 783 \text{ W/m}^2$$

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

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

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

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

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

### 10.2.1 Unrated Vertical Fenestration.

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

U-factors for unrated vertical fenestration, both operable and fixed, shall be assigned as per Table 10.2.1.

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

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

### 10.3 Typical Roof Constructions

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

$$U_{\text{TotalRoof}} = \frac{1}{\frac{1}{U_{\text{Typical Roof}}} + \frac{1}{U_{\text{Typical Insulation}}}}$$

Where,

|                                 |  |
|---------------------------------|--|
| $U_{\text{Total, Roof}}$        | Total U-factor of the roof with insulation |
| $U_{\text{Typical Roof}}$       | U-factor of the roof                       |
| $U_{\text{Typical Insulation}}$ | 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:

$$U_{\text{Total Wall}} = \frac{1}{\frac{1}{U_{\text{Typical Wall}}} + \frac{1}{U_{\text{Typical Insulation}}}}$$

Where,

|                                 |  |
|---------------------------------|--|
| $U_{\text{Total, Wall}}$        | Total U-factor of the Wall with insulation |
| $U_{\text{Typical Wall}}$       | U-factor of the Wall                       |
| $U_{\text{Typical Insulation}}$ | U-factor of the effective insulation       |

Table 10-2 Typical Thermal Properties of Common Building and Insulating Materials <sup>3,a</sup>

| Description of Class                            | Density           | Conductivity k, | Resistance R,         | Specific Heat |
|---|-------------------|-----------------|-----------------------|---------------|
|   | kg/m <sup>3</sup> | W/(m·K)         | (m <sup>2</sup> ·K)/W | kJ/(kg·K)     |
| <b>Building Board and Siding</b>                |                   |                 |                       |               |
| <b>Board</b>                                    |                   |                 |                       |               |
| Asbestos/cement board                           | 1900              | 0.57            | -                     | 1             |
| Cement board                                    | 1150              | 0.25            | -                     | 0.84          |
| Fiber/cement board                              | 1400              | 0.25            | -                     | 0.84          |
|   | 1000              | 0.19            | -                     | 0.84          |
|   | 400               | 0.07            | -                     | 1.88          |
|   | 300               | 0.06            | -                     | 1.88          |
| Gypsum or plaster board                         | 640               | 0.16            | -                     | 1.15          |
| Oriented strand board (OSB) 9 to 11 mm          | 650               | -               | 0.11                  | 1.88          |
| Oriented strand board (OSB) 12.7 mm             | 650               | -               | 0.12                  | 1.88          |
| Plywood (Douglas fir) 12.7 mm                   | 460               | -               | 0.14                  | 1.88          |
| Plywood (Douglas fir) 15.9 mm                   | 540               | -               | 0.15                  | 1.88          |
| Plywood/wood panels 19.0 mm                     | 550               | -               | 0.19                  | 1.88          |
| <i>Vegetable fiber board</i>                    |                   |                 |                       | -             |
| Sheathing, regular density <sup>e</sup> 12.7 mm | 290               | -               | 0.23                  | 1.3           |
| Intermediate density <sup>e</sup> 12.7 mm       | 350               | -               | 0.19                  | 1.3           |
| Nail-base sheathing <sup>e</sup> 12.7 mm        | 400               | -               | 0.19                  | 1.3           |
| Shingle backer 9.5 mm                           | 290               | -               | 0.17                  | 1.3           |
| Sound deadening board. 12.7 mm                  | 240               | -               | 0.24                  | 1.26          |
| Tile and lay-in panels, plain or acoustic       | 290               | 0.058           | -                     | 0.59          |
| Laminated paperboard                            | 480               | 0.072           | -                     | 1.38          |
| Homogeneous board from re pulped paper          | 480               | 0.072           | -                     | 1.17          |
| <b>Hardboard <sup>e</sup></b>                   |                   |                 |                       |               |
| Medium density                                  | 800               | 0.105           | -                     | 1.3           |



|  |      |       |       |      |
|--|------|-------|-------|------|
| High density, service-tempered   | 880  | 0.12  | -     | 1.34 |
| Grade and service grade  |      |       |       |      |
| High density, standard-tempered grade  | 1010 | 0.144 | -     | 1.34 |
| <b>Particleboard<sup>e</sup></b>   |      |       |       |      |
| 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 |
| <b>Shingles</b>  |      |       |       |      |
| 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  |
| Asbestos/cement lapped 6.4 mm  | -    | -     | 0.037 | 1.01 |
| Asphalt roll siding  | -    | -     | 0.026 | 1.47 |
| <b>Siding</b>  |      |       |       |      |
| Asphalt insulating siding (12.7 mm bed)  | -    | -     | 0.26  | 1.47 |
| Hardboard siding 11 mm   | -    | -     | 0.12  | 1.17 |
| Wood, drop, 200 mm 25 mm   | -    | -     | 0.14  | 1.17 |
| Wood, bevel 200 mm, lapped 13 mm   | -    | -     | 0.14  | 1.17 |
| Wood, bevel 250 mm, lapped 19 mm   | -    | -     | 0.18  | 1.17 |
| Wood, plywood, lapped 9.5 mm   | -    | -     | 0.1   | 1.22 |
| Aluminum, steel, or vinyl, <sup>i,k</sup> over sheathing<br>Hollow-backed                    | -    | -     | 0.11  | 1.22 |
| Aluminum, steel, or vinyl, <sup>i,k</sup> over sheathing<br>Insulating-board-backed 9.5 mm   | -    | -     | 0.32  | 1.34 |
| Aluminum, steel, or vinyl, <sup>i,k</sup> over sheathing<br>Hollow-backed Foil-backed 9.5 mm | -    | -     | 0.52  | -    |
| Architectural (soda-lime float) glass  | 2500 | 1     | -     | 0.84 |

| <b>Building Membrane</b>                                    |           |                |            |      |
|---|-----------|----------------|------------|------|
| Vapor-permeable felt  | -         | -              | 0.011      | -    |
| Vapor: seal, 2 layers of mopped 0.73 kg/m <sup>2</sup> felt | -         | -              | 0.21       | -    |
| Vapor: seal, plastic film                                   | -         | -              | Negligible | -    |
| <b>Finish Flooring Materials</b>                            |           |                |            |      |
| 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  |
| <b>Insulating Materials</b>                                 |           |                |            |      |
| <b>Blanket and batt <sup>c,d</sup></b>                      |           |                |            |      |
| 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           | - | -    |
| <b>Board and slabs</b>  |            |                |   |      |
| 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       | - | 0.84 |
| Expanded rubber (rigid)   | 70         | 0.032          | - | 1.67 |
| Expanded polystyrene extruded (smooth skin)                       | 25 to 40   | 0.022 to 0.030 | - | 1.47 |
| Expanded polystyrene, molded beads                                | 15 to 25   | 0.032 to 0.039 | - | 1.47 |
| Mineral fiberboard, wet felted                                    | 160        | 0.038          | - | 0.84 |
| Mineral fiberboard, core or roof insulation                       | 255 to 270 | 0.049          | - | -    |
| Mineral fiberboard, acoustical tile <sup>g</sup>                  | 290        | 0.05           | - | 0.8  |
|   | 335        | 0.053          | - | -    |
| Mineral fiberboard, wet-molded, acoustical tile                   | 370        | 0.061          | - | 0.59 |
| <b>Perlite board</b>  | 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          | - | -    |
| <b>Loose fill</b>   |            |                |   |      |
| Cellulosic (milled paper or wood pulp)                            | 35 to 50   | 0.039 to 0.045 | - | 1.38 |

|   |            |                |            |      |
|---|------------|----------------|------------|------|
| Perlite expanded  | 30 to 65   | 0.039 to 0.046 | -          | 1.09 |
|   | 65 to 120  | 0.045 to 0.052 | -          | -    |
|   | 120 to 180 | 0.052 to 0.061 | -          | -    |
| Mineral fiber (rock, slag, or glass) <sup>d</sup> approx. 95 to 130 mm                | 10 to 30   | -              | 1.92       | 0.71 |
| Mineral fiber (rock, slag, or glass) <sup>d</sup> approx. 170 to 220 mm               | 11 to 30   | -              | 3.33       | -    |
| Mineral fiber (rock, slag, or glass) <sup>d</sup> approx. 190 to 250 mm               | 12 to 30   | -              | 3.85       | -    |
| Mineral fiber (rock, slag, or glass) <sup>d</sup> approx. 260 to 350 mm               | 13 to 30   | -              | 5.26       | -    |
| Mineral fiber (rock, slag, or glass) <sup>d</sup> 90 mm (closed sidewall application) | 30 to 55   | -              | 2.1 to 2.5 | -    |
| Vermiculite exfoliated  | 110 to 130 | 0.068          | -          | 1.34 |
|   | 64 to 96   | 0.063          | -          | -    |
| <b><i>Spray-applied</i></b>   |            |                |            |      |
| 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  | -    |
| Urea formaldehyde foam, dry                 | 8 to 20 | 0.030 to 0.032 | -     | -    |
| <b>Roofing</b>                              |         |                |       |      |
| 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  |
| <b>Plastering Materials</b>                 |         |                |       |      |
| 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            | -    | -    |
| <b>Masonry Materials</b>  |      |                 |      |      |
| <b>Masonry units</b>  |      |                 |      |      |
| Brick fired clay  | 2400 | 1.21 to         | -    | -    |
|   | 2240 | 1.07 to<br>1.30 | -    | -    |
|   | 2080 | 0.92 to<br>1.12 | -    | -    |
|   | 1920 | 0.81 to<br>0.98 | -    | 0.8  |
|   | 1760 | 0.71 to<br>0.85 | -    | -    |
|   | 1600 | 0.61 to<br>0.74 | -    | -    |
|   | 1440 | 0.52 to<br>0.62 | -    | -    |
|   | 1280 | 0.43 to<br>0.53 | -    | -    |
|   | 1120 | 0.36 to<br>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 block <sup>h,i</sup> Limestone aggregate ~200 mm, 16.3 kg, 2200 kg/m <sup>3</sup> concrete, 2 cores. | -    | -               | -    | -    |

|  |   |   |              |      |
|--|---|---|--------------|------|
| Concrete block <sup>h,i</sup> Limestone aggregate~200 mm, 16.3 kg, 2200 kg/m <sup>3</sup> concrete with perlite-filled cores                 | - | - | 0.37         | -    |
| Concrete block Limestone <sup>h,i</sup> aggregate ~300 mm, 25 kg, 2200 kg/m <sup>3</sup> concrete, 2 cores                                   | - | - | -            | -    |
| Normal-weight aggregate (sand and gravel) ~200 mm, 16 kg, 2100 kg/m <sup>3</sup> 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 <sup>3</sup> with perlite-filled cores                                   | - | - | 0.35         | -    |
| Normal-weight aggregate (sand and gravel) ~200 mm, 16 kg, 2100 kg/m <sup>3</sup> with vermiculite-filled cores                               | - | - | 0.34 to 0.24 | -    |
| Normal-weight aggregate (sand and gravel) ~200 mm, 16 kg, 2100 kg/m <sup>3</sup> ~300 mm, 22.7 kg, 2000 kg/m <sup>3</sup> 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 <sup>3</sup> 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 <sup>3</sup> 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 <sup>3</sup> with vermiculite-filled cores        | - | - | 0.58         | - |
| Medium-weight aggregate (combinations of normal and lightweight aggregate) ~200 mm, 13 kg, 1550 to 1800 kg/m <sup>3</sup> with molded-EPS-filled (beads) cores | - | - | 0.56         | - |
| Medium-weight aggregate (combinations of normal and lightweight aggregate) ~200mm, 13 kg, 1550 to 1800 kg/m <sup>3</sup> 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 <sup>2</sup> concrete, 2 or 3 cores                              | - | - | 0.34 to 0.29 | - |
| Low-mass aggregate (expanded shale, clay, slate or slag, pumice) ~150 mm, 7 1/2 kg, 1400 kg/m <sup>2</sup> with perlite-filled cores                           | - | - | 0.74         | - |



|  |   |   |                 |      |
|--|---|---|-----------------|------|
| Low-mass aggregate (expanded shale, clay,<br>slate or slag, pumice) ~150 mm, 7 1/2 kg, 1400<br>kg/m <sup>2</sup> with vermiculite-filled cores                               | - | - | 0.53            | -    |
| Low-mass aggregate (expanded shale, clay,<br>slate or slag, pumice) 200 mm, 8 to 10 kg, 1150<br>to 1380 kg/m <sup>2</sup> concrete   | - | - | 0.56 to<br>0.33 | 0.88 |
| Low-mass aggregate (expanded shale, clay,<br>slate or slag, pumice) 200 mm, 8 to 10 kg, 1150<br>to 1380 kg/m <sup>2</sup> concrete with perlite- filled<br>cores             | - | - | 1.20 to<br>0.77 | -    |
| Low-mass aggregate (expanded shale, clay,<br>slate or slag, pumice) 200 mm, 8 to 10 kg, 1150<br>to 1380 kg/m <sup>2</sup> concrete with vermiculite-filled<br>cores          | - | - | 0.93 to<br>0.69 | -    |
| Low-mass aggregate (expanded shale, clay,<br>slate or slag, pumice) 200 mm, 8 to 10 kg, 1150<br>to 1380 kg/m <sup>2</sup> concrete with molded- EPS-<br>filled (beads) cores | - | - | 0.85            | -    |
| Low-mass aggregate (expanded shale, clay,<br>slate or slag, pumice) 200 mm, 8 to 10 kg, 1150<br>to 1380 kg/m <sup>2</sup> concrete with UF foam-filled<br>cores              | - | - | 0.79            | -    |
| Low-mass aggregate (expanded shale, clay,<br>slate or slag, pumice) 200 mm, 8 to 10 kg, 1150<br>to 1380 kg/m <sup>2</sup> concrete with molded EPS<br>inserts in cores       | - | - | 0.62            | -    |
| Low-mass aggregate (expanded shale, clay,<br>slate or slag, pumice) 300 mm, 16 kg, 1400<br>kg/m <sup>3</sup> , concrete, 2 or 3 cores  | - | - | 0.46 to<br>0.40 | -    |

|  |      |              |            |             |
|--|------|--------------|------------|-------------|
| Low-mass aggregate (expanded shale, clay, slate or slag, pumice) 300 mm, 16 kg, 1400 kg/m <sup>3</sup> , with perlite-filled cores     | -    | -            | 1.6 to 1.1 | -           |
| Low-mass aggregate (expanded shale, clay, slate or slag, pumice) 300 mm, 16 kg, 1400 kg/m <sup>3</sup> , with vermiculite-filled cores | -    | -            | 1          | -           |
| Stone, lime, or sand   | 2800 | 10.4         | -          | -           |
| Quartz 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, 3cells  | -    | -            | 0.294      | -           |
| Limestone  | 2400 | 0.57         | -          | 0.84        |
|  | 2600 | 0.93         | -          | 0.84        |
| <b>Concretes</b>   |      |              |            |             |
| Sand and gravel or stone aggregate concretes (concretes with >50% quartz or quartzite sand have conductivities in higher end of range) | 2400 | 1.4 to 2.9   | -          | -           |
|  | 2240 | 1.3 to 2.6   | -          | 0.8 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<br>Expanded shale, clay, or slate; expanded slags; cinders; pumice (with density up to 1600  | 1600 | 0.68 to 0.89 | -          | 0.84        |
|  | 960  | 0.30 to 0.36 | -          | -           |

|   |            |              |       |              |
|---|------------|--------------|-------|--------------|
| kg/m <sup>3</sup> ); scoria (sanded concretes have conductivities in higher end of range) | 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     | 0.37         | -     | 0.84         |
|   | 800        |              |       |              |
| Polymer concrete  | 1950       | 1.64         | -     | -            |
|   | 2200       | 1.03         | -     | -            |
| Polymer cement  | 1870       | 0.78         | -     | -            |
| Slag concrete   | 960        | 0.22         | -     | -            |
|   | 1280       | 0.32         | -     | -            |
|   | 1600       | 0.43         | -     | -            |
|   | 2000       | 1.23         | -     | -            |
| <b>Woods (12% moisture content)</b>   |            |              |       |              |
| <i>Hardwoods</i>  | -          | -            | -     | 1.63         |
| Oak   | 660 to 750 | 0.16 to 0.18 | -     | -            |

|                          |            |              |   |      |
|--------------------------|------------|--------------|---|------|
| Birch                    | 680 to 725 | 0.17 to 0.18 | - | -    |
| Maple                    | 635 to 700 | 0.16 to 0.17 | - | -    |
| Ash                      | 615 to 670 | 0.15 to 0.16 | - | -    |
| <i>Softwoods</i>         | -          | -            | - | 1.63 |
| Southern pine            | 570 to 660 | 0.14 to 0.16 | - | -    |
| Southern yellow pine     | 500        | 0.13         | - | -    |
| Eastern white pine       | 400        | 0.1          | - | -    |
| Douglas fir/larch        | 535 to 580 | 0.14 to 0.15 | - | -    |
| Southern cypress         | 500 to 515 | 0.13         | - | -    |
| Hem/fir, spruce/pine/fir | 390 to 500 | 0.11 to 0.13 | - | -    |
| Spruce                   | 400        | 0.09         | - | -    |
| Western red cedar        | 350        | 0.09         | - | -    |
| West coast woods, cedars | 350 to 500 | 0.10 to 0.13 | - | -    |
| Eastern white cedar      | 360        | 0.1          | - | -    |
| California redwood       | 390 to 450 | 0.11 to 0.12 | - | -    |
| Pine (oven-dried)        | 370        | 0.092        | - | 1.88 |
| Spruce (oven-dried)      | 395        | 0.1          | - | 1.88 |

| <b>Building Membrane</b>                                    |           |                |            |      |
|---|-----------|----------------|------------|------|
| Vapor-permeable felt  | -         | -              | 0.011      | -    |
| Vapor: seal, 2 layers of mopped 0.73 kg/m <sup>2</sup> felt | -         | -              | 0.21       | -    |
| Vapor: seal, plastic film                                   | -         | -              | Negligible | -    |
| <b>Finish Flooring Materials</b>                            |           |                |            |      |
| 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  |
| <b>Insulating Materials</b>                                 |           |                |            |      |
| <b>Blanket and batt <sup>c,d</sup></b>                      |           |                |            |      |
| 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           | - | -    |
| <b>Board and slabs</b>  |            |                |   |      |
| 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       | - | 0.84 |
| 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                               | 290        | 0.05           | - | 0.8  |
|   | 335        | 0.053          | - | -    |
| Mineral fiberboard, wet-molded, acoustical tile                   | 370        | 0.061          | - | 0.59 |
| <b>Perlite board</b>  | 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          | - | -    |
| <b>Loose fill</b>   |            |                |   |      |
| 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) approx. 95 to 130 mm                | 10 to 30   | -              | 1.92       | 0.71 |
| Mineral fiber (rock, slag, or glass) approx. 170 to 220 mm               | 11 to 30   | -              | 3.33       | -    |
| Mineral fiber (rock, slag, or glass) approx. 190 to 250 mm               | 12 to 30   | -              | 3.85       | -    |
| Mineral fiber (rock, slag, or glass) approx. 260 to 350 mm               | 13 to 30   | -              | 5.26       | -    |
| Mineral fiber (rock, slag, or glass) 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          | -          | -    |
| <b><i>Spray-applied</i></b>  |            |                |            |      |
| 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  | -    |
| Urea formaldehyde foam, dry                 | 8 to 20 | 0.030 to 0.032 | -     | -    |
| <b>Roofing</b>                              |         |                |       |      |
| 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  |
| <b>Plastering Materials</b>                 |         |                |       |      |
| 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         | -    | -    |
| <b>Masonry Materials</b>  |      |              |      |      |
| <b>Masonry units</b>  |      |              |      |      |
| 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 block Limestone aggregate ~200 mm,<br>16.3 kg, 2200 kg/m <sup>3</sup> concrete, 2 cores. | -    | -            | -    | -    |

|   |   |   |              |      |
|---|---|---|--------------|------|
| Concrete block Limestone aggregate ~200 mm, 16.3 kg, 2200 kg/m <sup>3</sup> concrete with perlite-filled cores                              | - | - | 0.37         | -    |
| Concrete block Limestone aggregate ~300 mm, 25 kg, 2200 kg/m <sup>3</sup> concrete, 2 cores   | - | - | -            | -    |
| Normal-weight aggregate (sand and gravel) ~200 mm, 16 kg, 2100 kg/m <sup>3</sup> 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 <sup>3</sup> with perlite-filled cores                                  | - | - | 0.35         | -    |
| Normal-weight aggregate (sand and gravel) ~200 mm, 16 kg, 2100 kg/m <sup>3</sup> with vermiculite-filled cores                              | - | - | 0.34 to 0.24 | -    |
| Normal-weight aggregate (sand and gravel) ~200 mm, 16 kg, 2100 kg/m <sup>3</sup> ~300 mm, 22.7 kg, 2000 kg/m <sup>3</sup> 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 <sup>3</sup> 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 <sup>3</sup> 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 <sup>3</sup> with vermiculite-filled cores        | - | - | 0.58         | - |
| Medium-weight aggregate (combinations of normal and lightweight aggregate) ~200 mm, 13 kg, 1550 to 1800 kg/m <sup>3</sup> with molded-EPS-filled (beads) cores | - | - | 0.56         | - |
| Medium-weight aggregate (combinations of normal and lightweight aggregate) ~200mm, 13 kg, 1550 to 1800 kg/m <sup>3</sup> 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 <sup>2</sup> concrete, 2 or 3 cores                              | - | - | 0.34 to 0.29 | - |
| Low-mass aggregate (expanded shale, clay, slate or slag, pumice) ~150 mm, 7 1/2 kg, 1400 kg/m <sup>2</sup> with perlite-filled cores                           | - | - | 0.74         | - |

|  |   |   |                 |      |
|--|---|---|-----------------|------|
| Low-mass aggregate (expanded shale, clay,<br>slate or slag, pumice) ~150 mm, 7 1/2 kg, 1400<br>kg/m <sup>2</sup> with vermiculite-filled cores                               | - | - | 0.53            | -    |
| Low-mass aggregate (expanded shale, clay,<br>slate or slag, pumice) 200 mm, 8 to 10 kg, 1150<br>to 1380 kg/m <sup>2</sup> concrete   | - | - | 0.56 to<br>0.33 | 0.88 |
| Low-mass aggregate (expanded shale, clay,<br>slate or slag, pumice) 200 mm, 8 to 10 kg, 1150<br>to 1380 kg/m <sup>2</sup> concrete with perlite- filled<br>cores             | - | - | 1.20 to<br>0.77 | -    |
| Low-mass aggregate (expanded shale, clay,<br>slate or slag, pumice) 200 mm, 8 to 10 kg, 1150<br>to 1380 kg/m <sup>2</sup> concrete with vermiculite-filled<br>cores          | - | - | 0.93 to<br>0.69 | -    |
| Low-mass aggregate (expanded shale, clay,<br>slate or slag, pumice) 200 mm, 8 to 10 kg, 1150<br>to 1380 kg/m <sup>2</sup> concrete with molded- EPS-<br>filled (beads) cores | - | - | 0.85            | -    |
| Low-mass aggregate (expanded shale, clay,<br>slate or slag, pumice) 200 mm, 8 to 10 kg, 1150<br>to 1380 kg/m <sup>2</sup> concrete with UF foam-filled<br>cores              | - | - | 0.79            | -    |
| Low-mass aggregate (expanded shale, clay,<br>slate or slag, pumice) 200 mm, 8 to 10 kg, 1150<br>to 1380 kg/m <sup>2</sup> concrete with molded EPS<br>inserts in cores       | - | - | 0.62            | -    |
| Low-mass aggregate (expanded shale, clay,<br>slate or slag, pumice) 300 mm, 16 kg, 1400<br>kg/m <sup>3</sup> , concrete, 2 or 3 cores  | - | - | 0.46 to<br>0.40 | -    |

|  |      |              |            |             |
|--|------|--------------|------------|-------------|
| Low-mass aggregate (expanded shale, clay, slate or slag, pumice) 300 mm, 16 kg, 1400 kg/m <sup>3</sup> , with perlite-filled cores     | -    | -            | 1.6 to 1.1 | -           |
| Low-mass aggregate (expanded shale, clay, slate or slag, pumice) 300 mm, 16 kg, 1400 kg/m <sup>3</sup> , with vermiculite-filled cores | -    | -            | 1          | -           |
| Stone, lime, or sand   | 2800 | 10.4         | -          | -           |
| Quartz 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, 3cells  | -    | -            | 0.294      | -           |
| Limestone  | 2400 | 0.57         | -          | 0.84        |
|  | 2600 | 0.93         | -          | 0.84        |
| <b>Concretes</b>   |      |              |            |             |
| Sand and gravel or stone aggregate concretes (concretes with >50% quartz or quartzite sand have conductivities in higher end of range) | 2400 | 1.4 to 2.9   | -          | -           |
|  | 2240 | 1.3 to 2.6   | -          | 0.8 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;  | 1600 | 0.68 to 0.89 | -          | 0.84        |
|  | 960  | 0.30 to 0.36 | -          | -           |

|  |            |              |       |              |
|--|------------|--------------|-------|--------------|
| cinders; pumice (with density up to 1600 kg/m <sup>3</sup> ); scoria (sanded concretes have conductivities in higher end of range) | 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     | 0.2          | -0.84 | -            |
| Polystyrene concrete (oven-dried)  | 255 to     | 0.37         | -     | 0.84         |
|  | 800        |              |       |              |
| Polymer concrete   | 1950       | 1.64         | -     | -            |
|  | 2200       | 1.03         | -     | -            |
| Polymer cement   | 1870       | 0.78         | -     | -            |
| Slag concrete  | 960        | 0.22         | -     | -            |
|  | 1280       | 0.32         | -     | -            |
|  | 1600       | 0.43         | -     | -            |
|  | 2000       | 1.23         | -     | -            |
| <b>Woods (12% moisture content)</b>  |            |              |       |              |
| <i>Hardwoods</i>   | -          | -            | -     | 1.63         |
| Oak  | 660 to 750 | 0.16 to 0.18 | -     | -            |

|                          |            |              |   |      |
|--------------------------|------------|--------------|---|------|
| Birch                    | 680 to 725 | 0.17 to 0.18 | - | -    |
| Maple                    | 635 to 700 | 0.16 to 0.17 | - | -    |
| Ash                      | 615 to 670 | 0.15 to 0.16 | - | -    |
| <i>Softwoods</i>         | -          | -            | - | 1.63 |
| Southern pine            | 570 to 660 | 0.14 to 0.16 | - | -    |
| Southern yellow pine     | 500        | 0.13         | - | -    |
| Eastern white pine       | 400        | 0.1          | - | -    |
| Douglas fir/larch        | 535 to 580 | 0.14 to 0.15 | - | -    |
| Southern cypress         | 500 to 515 | 0.13         | - | -    |
| Hem/fir, spruce/pine/fir | 390 to 500 | 0.11 to 0.13 | - | -    |
| Spruce                   | 400        | 0.09         | - | -    |
| Western red cedar        | 350        | 0.09         | - | -    |
| West coast woods, cedars | 350 to 500 | 0.10 to 0.13 | - | -    |
| Eastern white cedar      | 360        | 0.1          | - | -    |
| California redwood       | 390 to 450 | 0.11 to 0.12 | - | -    |
| Pine (oven-dried)        | 370        | 0.092        | - | 1.88 |
| Spruce (oven-dried)      | 395        | 0.1          | - | 1.88 |

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

<sup>b</sup>. Symbol also used to represent thermal conductivity.

<sup>c</sup>. Does not include paper backing and facing, if any. Where insulation forms boundary (reflective or otherwise) of airspace Conductivity varies with fiber diameter. Batt, blanket, and loose-fill mineral fiber insulations are manufactured to achieve specified R-values, the most common of which are listed in the table. Because of differences in manufacturing processes and materials, the product thicknesses, densities, and thermal conductivities vary over considerable ranges for a specified R-value.

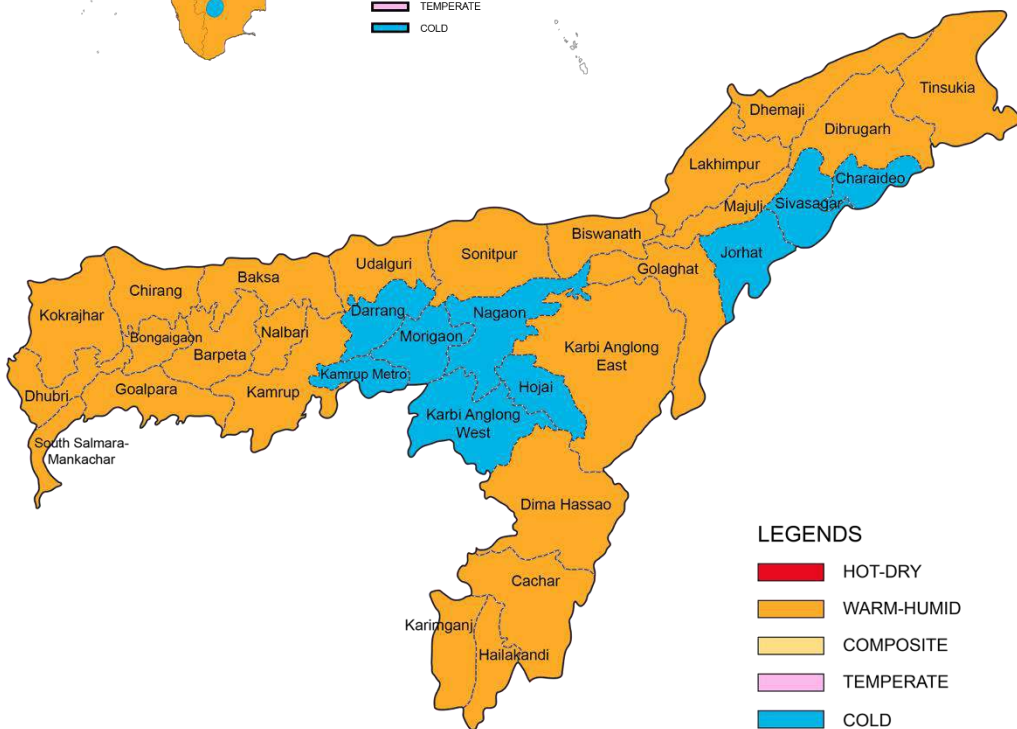
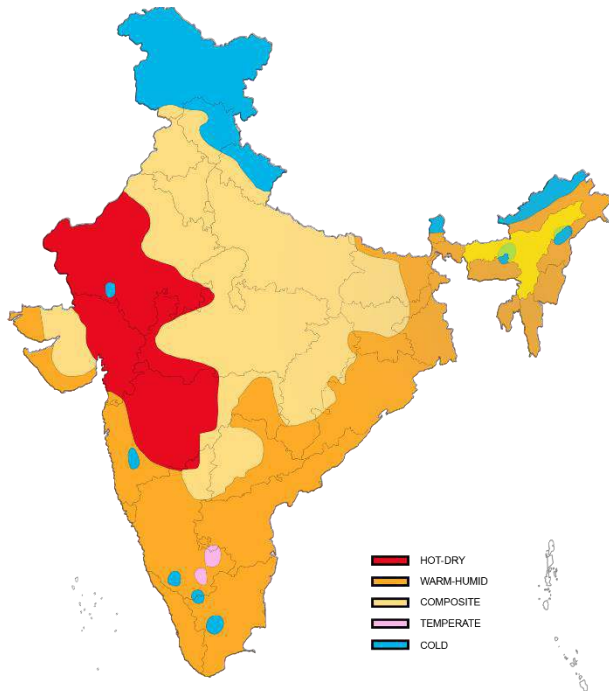
<sup>d</sup>. Conductivity varies with fiber diameter. Batt, blanket, and loose-fill mineral fiber insulations are manufactured to achieve specified R-values, the most common of which are listed in the table. Because of differences in manufacturing processes and materials, the product thicknesses, densities,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

|   |
|---|
| e. Values are for aged products with gas-impermeable facers on the two major surfaces. An aluminum foil facer of 25mm thickness or greater is generally considered impermeable to gases. For change in conductivity with age of expanded poly-iso-cyanurate.  |
| f. Cellular phenolic insulation may no longer be manufactured. Thermal conductivity and resistance values do not represent aged insulation, which may have higher thermal conductivity and lower thermal resistance.  |
| g. Insulating values of acoustical tile vary, depending on density of board and on type, size, and depth of perforations.   |
| h. Values for fully grouted block may be approximated using values for concrete with similar unit density.  |
| i. Values for concrete block and concrete are at moisture contents representative of normal use.  |
| j. Values for metal or vinyl siding applied over flat surfaces vary widely, depending on ventilation of the airspace beneath the siding; whether airspace is reflective or non-reflective; and on thickness, type, and application of insulating backing-board used. Values are averages for use as design guides and were obtained from several guarded hot box tests (ASTM <i>Standard</i> C236) or calibrated hot box (ASTM <i>Standard</i> C976) on hollow-backed types and types made using backing of wood fiber, foamed plastic, and glass fiber. Departures of $\pm 50\%$ or more from these values may occur.                                    |
| 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:<br>$k = 0.1791 + \frac{(1.874 * 10^{-2} + 5.733 * 10^{-4} * M) * \rho}{1 + 0.01 * M}$ Where, $\rho$ is density of moist wood in kg/m <sup>3</sup> , 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:<br>$C_p = \frac{(0.299 + 0.01 * M)}{(1 + 0.011 * M)} + \Delta C_p$ Where, $c_p$ accounts for heat of sorption and is denoted by:<br>$\Delta C_p = M * (1.921 * 10^{-3} - 3.168 * 10^{-5} * M)$ Where, $M$ is moisture content in percent by mass.   |
| n. Blank space in reference column indicates historical values from previous volumes of <i>ASHRAE Handbook</i> . Source of information could not be determined.   |
| <sup>3</sup> ASRAE – Handbook of Fundamentals   |



# 11 Appendix B: Climate Zone Map of India

## 11.1 Climate Zone Map of Assam



## 11.2 Regional map of Assam



Table 11-1 Details of latitude and longitude of Assam

| S.No. | CITIES/TOWNS    | LATITUDE | LONGITUDE |
|-------|-----------------|----------|-----------|
| 1     | Barpeta         | 26° 19'N | 91° 00'E  |
| 2     | Bilasipara      | 26° 14'N | 90° 14'E  |
| 3     | Bongaigaon      | 26° 28'N | 90° 34'E  |
| 4     | Dhekiajuli      | 26° 42'N | 92° 30'E  |
| 5     | Dhubri          | 26° 02'N | 89° 58'E  |
| 6     | Dibrugarh       | 27° 29'N | 94° 54'E  |
| 7     | Digboi          | 27° 23'N | 95° 38'E  |
| 8     | Diphu           | 25° 50'N | 93° 26'E  |
| 9     | Gauripur        | 26° 05'N | 89° 58'E  |
| 10    | Goalpara        | 26° 10'N | 90° 37'E  |
| 11    | Golaghat        | 26° 31'N | 93° 58'E  |
| 12    | Guwahati        | 26° 11'N | 91° 44'E  |
| 13    | Haflong         | 25° 11'N | 93° 02'E  |
| 14    | Hailakandi      | 24° 41'N | 92° 34'E  |
| 15    | Hojai           | 26° 00'N | 92° 52'E  |
| 16    | Jorhat          | 26° 45'N | 94° 13'E  |
| 17    | Karimganj       | 24° 52'N | 92° 21'E  |
| 18    | Kokrajhar       | 26° 24'N | 90° 16'E  |
| 19    | Lanka           | 25° 55'N | 92° 57'E  |
| 20    | Margherita      | 27° 17'N | 95° 41'E  |
| 21    | Mariani         | 26° 40'N | 94° 20'E  |
| 22    | Nagaon          | 26° 21'N | 92° 41'E  |
| 23    | Nalbari         | 26° 25'N | 91° 26'E  |
| 24    | North Lakhimpur | 27° 14'N | 94° 07'E  |
| 25    | Rangia          | 26° 28'N | 91° 38'E  |
| 26    | Sibsagar        | 26° 59'N | 94° 38'E  |
| 27    | Silchar         | 24° 49'N | 92° 48'E  |
| 28    | Tezpur          | 26° 38'N | 92° 48'E  |

## 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 2020 Compliance Forms

|              |  |                             |
|--------------|--|-----------------------------|
| Project Info | Project Address                            | Date                        |
|              |  | For Building Department Use |
|              | Project Built-up Area [m <sup>2</sup> ]    |                             |
|              | Project Above-grade Area [m <sup>2</sup> ] |                             |
|              | Project Conditioned Area [m <sup>2</sup> ] |                             |
|              | Applicant Name and Address                 |                             |
|              |  |                             |
|              | Project Climatic Zone                      |                             |

|                         |                                      |   |
|-------------------------|--------------------------------------|---|
| Building Classification | <input type="checkbox"/> Hospitality | <input type="checkbox"/> Business         |
|                         | <input type="checkbox"/> Health Care | <input type="checkbox"/> Educational      |
|                         | <input type="checkbox"/> Assembly    | <input type="checkbox"/> Shopping Complex |

|  |   |  |  |
|--|---|--|--|
| Project Description                              | <input type="checkbox"/> New Building   | <input type="checkbox"/> Addition        | <input type="checkbox"/> Alteration          |
|  | <input type="checkbox"/> Self-occupied  | <input type="checkbox"/> Core and Shell  | <input type="checkbox"/> Mixed-Use           |
| Compliance is sought for Energy efficiency level | ECBC Compliant<br><input type="radio"/> | ECBC+ Compliant<br><input type="radio"/> | SuperECBC Compliant<br><input type="radio"/> |
|  | <b>EPI Ratio</b>                        |  |  |

|                     |   |   |  |
|---------------------|---|---|--|
| Compliance Approach | <input type="radio"/> Prescriptive Method | <input type="radio"/> Whole Building Performance Method | <input type="radio"/> Building Trade-off Method- Envelope Compliance |
|---------------------|---|---|--|

|  |  |   |                          |  |
|--|--|---|--------------------------|--|
| Building Envelope                      |  |   |                          |  |
| Vertical Fenestration Area Calculation | Total Vertical Fenestration Area (rough opening) | / | Gross Exterior Wall Area | X 100 = % Window to Wall Ratio (WWR)   |
|  | X 100 =  |   |                          |  |
| Skylight Area Calculation              | Total Skylight Area (rough opening)              | / | Gross Exterior Roof Area | X 100 = % Skylight to roof Ratio (WWR) |
|  | X 100 =  |   |                          |  |

|                                       |         |                   |
|---------------------------------------|---------|-------------------|
| <b>Opaque Assembly</b>                |         |                   |
| Wall<br>(Minimum Insulation U-factor) |         |                   |
| Roof<br>(Minimum Insulation U-factor) |         |                   |
| <b>Cool Roof</b>                      |         |                   |
| Solar Reflectance                     |         |                   |
| Emittance                             |         |                   |
| <b>Wall Assembly</b>                  |         |                   |
| Material                              | R-value | Assembly U-Factor |
|                                       |         |                   |
|                                       |         |                   |
|                                       |         |                   |
|                                       |         |                   |

|   |  |
|---|--|
| <b>Daylighting Summary</b>  |  |
| % above-grade floor area meeting the UDI requirement for 90% of the potential daylight time in a year |  |
| <b>Fenestration</b>   |  |
| Vertical  |  |
| Maximum U-factor  |  |
| Maximum SHGC (or SC)  |  |
| Minimum VLT   |  |
| Overhang / Side fins / Box Frame Projection (yes or no)   |  |
| If yes, enter Projection Factor for each orientation and effective SHGC                               |  |
| Skylight  |  |
| Maximum U-factor  |  |
| Maximum SHGC (or SC)  |  |

## Envelope Checklist

Energy Conservation Building Code 2020 Compliance Forms

|                 |  |      |  |
|-----------------|--|------|--|
| Project Address |  | Date |  |
|-----------------|--|------|--|

| Applicability                             |    |     | Code Section | Component                   | Information Required   | Location on Plans | Building Department Notes |
|---|----|-----|--------------|-----------------------------|--|-------------------|---------------------------|
| Yes                                       | No | N/A |              |                             |  |                   |                           |
| <b>Mandatory Provisions (Section 4.2)</b> |    |     |              |                             |  |                   |                           |
|   |    |     | 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 |                   |                           |

| <b>Prescriptive Compliance Option (Section 4.3)</b> |  |  |         |                      |   |  |  |
|---|--|--|---------|----------------------|---|--|--|
|   |  |  | 4.3.1   | Roofs                | Specify implemented U factor                                      |  |  |
|   |  |  | 4.3.1.1 | Vegetated Cool Roof  | Specify the solar reflectance, emittance, and reference standards |  |  |
|   |  |  | 4.3     | Opaque External Wall | Specify implemented U factor                                      |  |  |

|  |  |  |     |                       |   |  |  |
|--|--|--|-----|-----------------------|---|--|--|
|  |  |  | 4.3 | Vertical fenestration | <p>(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.</p> <p>(2) Indicate SHGC or SC on fenestration schedule. Indicate if values are rated or default.</p> <p>(3) Indicate VLT of fenestration schedule. Indicate if values are rated or default.</p> <p>(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</p> |  |  |
|--|--|--|-----|-----------------------|---|--|--|

|  |  |  |       |                                 |  |  |  |
|--|--|--|-------|---------------------------------|--|--|--|
|  |  |  | 4.3.3 | fenestration U factor exemption | Specify if applicable, specify unconditioned space percentage, and specify incorporated specifications   |  |  |
|  |  |  | 4.3.4 | Skylights                       | <p>(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.</p> <p>(2) Indicate SHGC or SC on fenestration schedule. Indicate if values are rated or default.</p> |  |  |

|   |  |  |  |  |                      |  |  |
|---|--|--|--|--|----------------------|--|--|
| <b>Building Envelope Trade-Off Option (Section 4.3.4)</b> |  |  |  |  |                      |  |  |
|   |  |  |  |  | Provide calculations |  |  |



## Comfort Systems and Controls Summary

Energy Conservation Building Code 2020 Compliance Forms

|              |   |                             |
|--------------|---|-----------------------------|
| Project Info | Project Address:                            | Date                        |
|              | Project Built-up Area (m <sup>2</sup> ):    | For Building Department Use |
|              | Project Above-grade area (m <sup>2</sup> ): |                             |
|              | Project Conditioned Area (m <sup>2</sup> ): |                             |
|              | 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 |
|-------------------|-------------------|---------------------|-----------------------------------|
|-------------------|-------------------|---------------------|-----------------------------------|

|                            |  |
|----------------------------|--|
| <b>Equipment Schedules</b> | 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 Systems & Controls Checklist

Energy Conservation Building Code 2020 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 Plan | Building Department Notes |
| Yes   | No | N/A |              |   |  |                  |                           |
| <b>Comfort Systems and Control</b>  |    |     |              |   |  |                  |                           |
| <b>Mandatory Provisions (Section 5.2)</b>   |    |     |              |   |  |                  |                           |
|   |    |     | 5.2.1        | Ventilation                                       | Indicate all habitable spaces are ventilated with outdoor air in accordance with § 5.2.1 and guidelines specified in NBC   |                  |                           |
|   |    |     | 5.2.2        | Minimum Space Conditioning Equipment Efficiencies | Provide equipment schedule with type, capacity, efficiency   |                  |                           |
|   |    |     | 5.2.3        | Controls  |  |                  |                           |
|   |    |     | 5.2.3.1      | Time clock  | Indicate thermostat with night setback, 3 different day types per week, and 2-hour manual override, capable of retaining programming and time setting during loss of power for a period of at least 10 hours |                  |                           |
|   |    |     | 5.2.3.2      | Temperature Controls                              | Indicate temperature control with 3°C dead band 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 weather stripping   |                  |                           |
|   |    |     | 5.2.4.1      | Piping insulation                                 | Indicate R-value of insulation   |                  |                           |
|   |    |     | 5.2.4.2      | Ductwork and Plenum insulation                    | Indicate R-value of insulation   |                  |                           |

|   |  |  |         |  |  |
|---|--|--|---------|--|--|
|   |  |  | 5.2.5   | System Balancing                         | Show written balance report for HVAC systems serving zones with a total conditioned area exceeding 500 m <sup>2</sup>  |
|   |  |  | 5.2.6   | Condensers                               | Indicate location of condenser and source of water used for condenser  |
|   |  |  | 5.2.9   | 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 retardant pool cover on the water surface and temperature control and minimum insulation value as per § 5.2.9.6  |
| <b>Prescriptive Compliance Option (Section 5.3)</b> |  |  |         |  |  |
|   |  |  | 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 & efficiency  |
|   |  |  | 5.3.5.1 | Air-Economizer (ECBC/ECBC+/Super ECBC)   | 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+/Super ECBC) | 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 2020 Compliance Forms

|              |   |                             |
|--------------|---|-----------------------------|
| Project Info | Project Address:                            | Date                        |
|              |   | For Building Department Use |
|              | Project Built-up Area (m <sup>2</sup> ):    |                             |
|              | Project Above-grade area (m <sup>2</sup> ): |                             |
|              | Project Conditioned Area (m <sup>2</sup> ): |                             |
|              | Applicant Name and Address:                 |                             |
|              | Project Climatic Zone:                      |                             |

|                   |  |  |
|-------------------|--|--|
| Compliance Option | <input type="checkbox"/> Space by Space method | <input type="checkbox"/> Whole Building Method |
|-------------------|--|--|

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

| Location (floor/room no.)  | Occupancy Description | Allowed Watts per m <sup>2</sup> ** | Area in m <sup>2</sup> | 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 <sup>2</sup> or lm | Area in m <sup>2</sup> (or lm for perimeter) | Allowed Watts x m <sup>2</sup> (or lm) |
|---------------------|-------------|--|--|--|
|                     |             |  |  |  |
|                     |             |  |  |  |
|                     |             |  |  |  |
| Total Allowed Watts |             |  | Total Allowed Watts                          |  |

Proposed Lighting Wattage (Exterior)

| 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 Allowed Watts |                |

## Lighting & Controls Checklist

Energy Conservation Building Code 2020 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  | Location on Plans | Building Department Notes |
| Yes  | No | N/A |              |  |   |                   |                           |
| <b>Lighting and Controls</b>   |    |     |              |  |   |                   |                           |
| <b>Mandatory Provisions (Section 6.2)</b>  |    |     |              |  |   |                   |                           |
|  |    |     | 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 photo sensor or astronomical time switch   |                   |                           |
|  |    |     | 6.2.1.5      | Additional control                     | Provide schedule with type, indicate locations  |                   |                           |
|  |    |     | 6.2.2        | Exit signs                             | Indicate wattage per face of Exit signs   |                   |                           |
| <b>Prescriptive Interior Lighting Power Compliance Option (Section 6.3)</b>  |    |     |              |  |   |                   |                           |
|  |    |     | 6.3.1        | LPD compliance                         | Indicate whether project is complying with the Building Area Method (6.3.2) or the Space Function Method (6.3.3)  |                   |                           |
|  |    |     | 6.3.2        | Building area method                   | Provide lighting schedule with wattage of lamp and ballast and number of fixtures. Document all exceptions.   |                   |                           |
|  |    |     | 6.3.3        | Space function method                  | Provide lighting schedule with wattage of lamp and ballast and number of fixtures. Document all exceptions.   |                   |                           |
|  |    |     | 6.3.4.1      | Luminaire wattage                      | Indicate the wattage of installed luminaires on the floor plan. In case of luminaires containing permanently installed ballasts, the operating input wattage has to be provided, either from manufacturer's catalogues 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  |                   |                           |
| <b>Prescriptive Exterior Lighting Power Compliance Option (Section 6.3.5)</b>  |    |     |              |  |   |                   |                           |
|  |    |     | 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 2020 Compliance Forms

|              |  |  |                             |
|--------------|--|--|-----------------------------|
| Project Info | Project Address                            |  | Date                        |
|              |  |  | For Building Department Use |
|              | Project Built-up Area [m <sup>2</sup> ]    |  |                             |
|              | Project Above-grade Area [m <sup>2</sup> ] |  |                             |
|              | Project Conditioned Area [m <sup>2</sup> ] |  |                             |
|              | Applicant Name and Address                 |  |                             |
|              |  |  |                             |
|              | Project Climatic Zone                      |  |                             |

|  |   |
|--|---|
| <b>Project Description</b><br>Briefly describe electrical systems and renewable energy installed in the facility | Transformers, Diesel Generator sets, Uninterruptible Power Supply, Renewable Energy Systems and related information |
|--|---|

| Compliance Approach                             | Prescriptive Method  | Whole Building Performance Method |
|---|--|-----------------------------------|
| Transformers                                    |  |                                   |
| Type of Transformer                             | Dry Type Transformer / Oil Type Transformer<br>X 100 =                                 |                                   |
| Transformer Losses                              | kVA Rating of / Losses at 50% Loading in kW / Losses at 100% Loading in kW Transformer |                                   |
| Diesel Generator Sets                           |  |                                   |
| Star Rating of DG set                           | 3 Star / 4 Star / 5 Star   |                                   |
| Uninterruptible Power Supply                    |  |                                   |
| Efficiency at 100% Load                         |  |                                   |
| Renewable Energy Systems                        |  |                                   |
| Capacity and Type of Renewable Energy Installed |  |                                   |



## Electrical and Renewable Energy Systems Checklist

Energy Conservation Building Code 2020 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  | Location on Plans | Building Department Notes |
| Yes  | No | N/A |              |   |   |                   |                           |
| <b>Electrical and Renewable Energy Systems</b>   |    |     |              |   |   |                   |                           |
| <b>MANDATORY PROVISIONS (Section 7.2)</b>  |    |     |              |   |   |                   |                           |
|  |    |     | 7.2.1        | Transformers                                    | Provide schedule with transformer losses  |                   |                           |
|  |    |     | 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 Motor                          | Indicate the motor class IE2/IE3/IE4.   |                   |                           |
|  |    |     |              |   | Indicate the motors capacity more than 0.375 kW have efficiency according to the latest version of IS 12615.                                  |                   |                           |
|  |    |     |              |   | Motor nameplate indicates nominal full-load motor efficiencies and full-load power factor.  |                   |                           |
|  |    |     |              |   | Indicate the motor horsepower ratings does not exceed 20% of the calculated maximum load being served.  |                   |                           |
|  |    |     | 7.2.3        | Diesel Generator Sets                           | Indicate the star rating of the Diesel Generator Set  |                   |                           |

|  |  |  |       |                               |  |  |  |
|--|--|--|-------|-------------------------------|--|--|--|
|  |  |  | 7.2.4 | Check-Metering and Monitoring | Indicate the services exceeding 1000 kVA have permanently installed electrical metering to record kVA, kWh and total power factor. And provision for display of current in each phase, voltage between each phase and between each phase and neutral and total harmonic distortion as a percentage of total current. |  |  |
|  |  |  |       |                               | Indicate the services not exceeding 1000 kVA but over 65 kVA shall have permanently installed electric metering to record kW, kWh and power factor or kVARh on hourly basis.   |  |  |
|  |  |  |       |                               | Indicate the services not exceeding 65 kVA shall have permanently installed electric metering to record kWh on hourly basis.   |  |  |
|  |  |  |       |                               | Indicate in case of tenant-based building, for recording metering should be provided at a location from where each tenant could attach the services.   |  |  |
|  |  |  | 7.2.5 | Power factor correction       | Indicate that the power factor correction has been maintained at the point of connection.  |  |  |
|  |  |  | 7.2.6 | Power Distribution System     | Indicate the power cable has been sized so that the distribution losses do not exceed the values mentioned in the code.  |  |  |
|  |  |  | 7.2.7 | Uninterruptible Power 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 (REGZ) | Indicate a dedicated REGZ equivalent to at least 25 % of roof area or area required for generation of energy equivalent to 1% of total peak demand or connected load of the building, whichever is less, shall be provided in all buildings.  |  |  |
|  |  |  |         |   | Indicate the REGZ shall be free of any obstructions within its boundaries and from shadows cast by objects adjacent to the zone   |  |  |
|  |  |  | 7.2.8.2 | Main Electrical Service Panel           | Indicate the minimum rating is displayed on the main electrical service panel. And space is reserved for the installation of double pole circuit breaker for future solar electric installation.  |  |  |
|  |  |  | 7.2.8.3 | Demarcation on Documents                | Location for inverters and metering equipment,<br>Pathway for routing of conduit from the REGZ to the point of interconnection with the electrical service,<br>Routing of plumbing from the REGZ to the water-heating system and,<br>Structural design loads for roof dead and live load. |  |  |

## 14 Appendix E: BEE approved list of software to show compliance

Table 14-1 Bureau of Energy Efficiency Approved Software for Demonstrating Compliance with ECBC

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

\*\* This is not an all-inclusive list. The current list of approved software is available at BEE website (<https://www.beeindia.gov.in/>).

0