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CHHATTISGARH ENERGY CONSERVATION BUILDING CODE
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CSERC,RAIPUR



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1. Purpose

- (1) This code may be called the Draft Chhattisgarh Energy Conservation Building Code, 2012.(amended in 2014)
- (2) It shall come into force on the date of publication in Chhattisgarh Gazette.

2. Definitions :

- (1) In this code unless the context otherwise requires , -
 - “Appendix” means the Appendix “A” to “M” annexed to this code which have detailed reference of this code .
- (2) All other words and expressions used in this code but not defined shall have the same meaning as respectively assigned to them in the Energy Conservation Act, 2001.

3. Scope

3.1 Scope

- (a) The Chhattisgarh Energy Conservation Building Code (CGECBC) sets forth the requirements for design or retrofit of buildings/building complexes.
- (b) The code is applicable to all buildings/building complexes meeting any of the following criteria.
 - * Connected load of 50 KW or greater or a contact demand of 60 KVa or greater.
 - * total floor area of 500 m² or more.
 - * All Govt buildings in reference with § 3.2 in the state except low rise residential buildings and EWS housing..
- (c) The requirements pertain to all buildings/building complexes as specified in §11 such as offices, hotels, shopping complexes, private

hospitals and others that are not primarily for industrial i.e. manufacturing use and housing for EWS.

(d) The CGECBC covers the building systems as per specified in § 3.2

(e) This code would become mandatory as and when it is notified by the Government of Chhattisgarh in the official Gazette under clause (a) of section 15 of the Energy Conservation Act 2001 (52 of 2001). However it is made mandatory for all types of Govt buildings from a separate date of notification by Govt.

3.2 Applicable Building Systems

The provisions of this code apply to:

- (a) Building envelopes, except for unconditioned storage spaces or warehouses
- (b) Mechanical systems and equipment, including heating, ventilating, and air conditioning,
- (c) Service hot water heating, renewable energy
- (d) Interior and exterior lighting, and
- (e) Electrical power and motor.

3.3 Exemptions.

The provisions of this code do not apply to:

- a) Buildings that do not use either grid electricity or fossil fuel and
- b) Equipment and portions of building systems that use energy primarily for manufacturing processes.
- c) Low rise residential buildings.
- d) EWS housing.

3.4. Safety, Health and Environmental Codes Take Precedence

Where this code is found to conflict with safety, health, or environmental codes, the safety, health, or environmental codes shall take precedence.

3.5 Reference Standards

The Energy Conservation Building Code, 2007 , the National Building Code, 2005 and IS 3792-1978 (reaffirmed in 2008) are the primary reference

document/ standard for lighting levels, HVAC, comfort levels, natural ventilation, pump and motor efficiencies, transformer efficiencies and any other building materials and system performance criteria.

4. Administration and Enforcement.

4.1 Compliance Requirements.

4.1.1 Mandatory Requirements.

Compliance with the requirements of this energy code shall be mandatory for all applicable buildings as specified in §3.

4.1.2. New Buildings

New building shall comply with either the provision of §5 through §10A of this code or the whole building Performance Method of Appendix B§12.

4.1.3 Additions to Existing Buildings.

Where the addition plus the existing building exceeds the floor area of §3, the additions shall comply with the provisions of §5 through §10A. Compliance may be demonstrated in either of the following ways:

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

Exception to § 4.1.3 :

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.

4.1.4. Alterations to Existing Buildings

Where the existing building exceeds the floor area threshold in §2, portions of a building and its systems that are being altered shall meet the provisions of §5 through §10A. The specific requirements for alterations are described in the following subsections.

Exception to § 4.1.4:

When the entire building complies with all of the provisions of §5 through § 10A as if it were a new building.

4.1.4.1 Building Envelope

Alterations to the building envelope shall comply with the requirements of §5 or fenestration, insulation, and air leakage applicable to the portions of the buildings and its systems being altered.

Exception to § 4.1.4.1:

The following alterations need not comply with these requirements provided such alterations do not increase the energy usage of the building:

- (a) Replacement of glass in an existing sash and frame, provided the U-factor and SHGC of the replacement glazing are equal to or lower than the existing glazing,
- (b) Modifications to roof/ceiling, wall, or floor cavities, which are insulated to full depth with insulation,
- (c) Modifications to walls and floors without cavities and where no new cavities are created.

4.1.4.2 Heating, Ventilation and Air Conditioning

Alterations to building heating, ventilating, and air-conditioning equipment or systems shall comply with the requirements of §6 applicable to the portions of the building and its systems being altered. Any new equipment or control devices installed in conjunction with the alteration shall comply with the specific requirements

applicable to that equipment or control device.

4.1.4.3. Service Water Heating, renewable energy

Alterations to building service water heating equipment or systems shall comply with the requirements of §7 applicable to the portions of the building and its systems being altered. Any new equipment or control devices installed in conjunction with the alteration shall comply with the specific requirements applicable to that equipment or control device.

4.1.4.4 Lighting

Alterations to building lighting equipment or systems shall comply with the requirements of §8 applicable to the portions of the building and its systems being altered. New lighting systems, including controls, installed in an existing building and any change of building area type as listed in Table 8.1 shall be considered an alteration. Any new equipment or control devices installed in conjunction with the alteration shall comply with the specific requirements applicable to that equipment or control device.

Exception to §4.1.4.4: Alterations that replace less than 50% of the luminaries in a space need not comply with these requirements provided such alterations do not increase the connected lighting load.

4.1.4.5. Electric Power and Motors

Alterations to building electric power systems and motor shall comply with the requirements of §9 applicable to the portions of the building and its systems being altered. Any new equipment or control devices installed in conjunction with the alteration shall comply with the specific requirements applicable to that equipment or control device.

4.1.4.6. Star Labeling and minimum star rating.

All equipments and materials of type and specification coming under the purview of the star labeling program as notified by BEE shall have minimum star rating as notified by the State Government. Refer to Appendix-K §21 for further details.

4.1.4.7. **Acceptable limit heat gain for Non conditioned spaces**

Alterations to existing buildings or building spaces which are not air conditioned shall comply with §10A and appendix M in confirmation with IS 3792-1978 (reaffirmed in 2008)

4.2 Compliance Approaches

The building shall comply first with all the mandatory provision (§5.2, §6.2, §7.2, §8.2, §9.2 and §10) and either of the following:

(a) Prescriptive Method (§5.3, §6.3, §8.3)

Exception to §4.2 (a): The envelope tread-off option of §5.4 may be used in place of prescriptive criteria of §5.3.

(b) Whole Building Performance Method (Appendix B §12)

The CGECBC compliant buildings in the design stage shall achieve an Energy Performance Index value at least of a three star level building as specified in Appendix H, Annexure-II.

4.3 Administrative Requirements

Administrative requirements relating to permit requirements, enforcement, interpretations, claims of exemption, approved calculation methods, and rights of appeal are specified by the authority having jurisdiction.

4.3.1. Authority Having Jurisdiction.

For the administration and enforcement of the Chhattisgarh ECBC, the state Designated Agency shall act as the “Authority having Jurisdiction” who shall be responsible for specifying permit requirements , code interpretations, approved calculation methods, worksheets and formats, compliance forms, manufacturing literature, rights of appeal, and other

data to demonstrate compliance. The Appendix-J §20 specifies the proposed framework for administration and enforcement of the Chhattisgarh ECBC by State Designated Agency.

4.4 Compliance Documents

4.4.1 General

Plans and specifications shall show all pertinent data and features of the building, equipment, and systems in sufficient detail to permit the local Authority Having Jurisdiction to verify that the building complies with the requirements of this code. Appendix-I §19 specifies the compliance documents. Details shall include, but are not limited to:

(a) Building Envelope:

Insulation materials and their R-values; fenestration U-factors, Solar heat gain coefficients (SHGC), visible light transmittance (if the trade-off procedure is used), and air leakage; overhangs and sidefins, building envelope sealing details

(b) Heating, Ventilation, and Air conditioning system and equipment types, sizes, efficiencies, and controls; economizer; variable speed drives; piping insulation; duct sealing; insulation type and location; requirements for balance report

(c) Service Hot Water and Pumping and renewable installation: Solar water heating system and installation of renewable gadgets

(d) 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

(e) Electrical Power: electric schedules showing transformer losses, motor efficiencies, and power factor correction devices, electric check metering and monitoring system.

(f) Abstract of the building information and energy data along with projected Energy Performance Index in $\text{KWh/m}^2/\text{year}$ and its star rating as specified in Appendix-H §18.

(g) Acceptable limit heat gain for Non conditioned spaces

existing buildings or building spaces which are not air conditioned shall comply with §10A in confirmation with IS 3792-1978 (reaffirmed in 2008). The details to be furnished as per code.

4.4.2 Supplementary 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.

5. Envelope

5.1. General

The building envelope shall comply with the mandatory provisions of §5.2 and either the prescriptive criteria of §5.3 or the trade-off option of option of § 5.4.

5.2 Mandatory Requirements

5.2.1 Fenestration

4.2.1.1 U-factors

U-factors shall be determined for the overall fenestration product (including the sash and frame) in accordance with ISO-15099, as specified in Appendix C §11, by an independent laboratory, labeled and certified by the manufacturer or other responsible party. U-factor for sloped glazing and skylights shall be determined at slope of 20 degrees above the horizontal. For unrated products, use the default table in Appendix C §13.

5.2.1.2 Solar Heat Gain Coefficient (SHGC).

SHGC shall be determined for the overall fenestration product (including the sash and in accordance with ISO-15099, as specified in Appendix C §13, an accredited independent laboratory,

Exceptions to section 4.2.1.2:

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

5.2.1.3 Air Leakage

Air leakage for glazed swinging entrance doors and revolving doors shall not exceed 5.0 l/s-m^2 . Air leakage for other

fenestration and doors shall not exceed 2.0 l/s-m^2 .

5.2.2 Opaque Construction

U-factors shall be determined from the default tables in Appendix C §13 or determined from data or procedures contained in the ASHRAE Fundamentals, 2005.

5.2.3. Building Envelope Sealing

The following areas of the enclosed building envelope shall be sealed, caulked, gasketed, or weather-stripped to minimize air leakage:

- a) Joints around fenestration and door frames,
- b) Openings between walls and foundations and between walls and roof and wall panels,
- c) Openings at penetrations of utility services through, roofs, walls, and floors,
- d) Site-built fenestration and doors,
- e) Building assemblies used as ducts or plenums, and
- f) All other openings in the building envelope.

5.3 Prescriptive Requirements.

5.3.1 Roofs

Roofs shall comply with either the maximum assembly U-factor or the minimum insulation R-value in Table 5.1 R-value is for the insulation alone and does not include building materials or air films. The roof insulation shall not be located on a suspended ceiling with removable ceiling panels.

Table-5. 1 Roof Assembly U-factor and Insulation R-value Requirements*

Climate Zone	24-Hour use Buildings, Hospitals, Call Centers etc.		Daytime use Buildings Other Building Types	
	Maximum U-factor of the overall assembly ($\text{W/m}^2\text{-K}$)	Minimum R-Value of insulation alone ($\text{m}^2\text{-k/W}$)	Minimum U-factor of the overall assembly ($\text{W/m}^2\text{-K}$)	Minimum R-Value of insulation alone ($\text{m}^2\text{-K/W}$)
Composite	U-0.261	R-3.5	U-0.409	R-2.1

Note: Chhattisgarh is covered by "Composite" climate only. For information on other three climate zones, relevant Tables of ECBC may be referred.

5.3.1.1. Cool Roofs

Roofs with slope less than degrees shall have an initial solar reflectance of no less than 0.70 and an initial emittance no less than 0.75. Solar reflectance shall be determined in accordance with ASTM E903-96 and emittance shall be determined in accordance with ASTM E408-71 (RA 1996).

5.3.2 Opaque Walls.

Opaque walls shall comply with either the maximum assembly U-factor or the minimum insulation R-value in Table 5.2. R-value is for the insulation alone and does not include building materials or air films.

Table-5. 2 Opaque Walls, Assembly U-factor and Insulation R-value Requirements*

Climate Zone	24-Hour use Buildings, Hospitals, Call Centers etc.		Daytime use Buildings Other Building Types	
	Maximum U-factor of the overall assembly (W/m ² -K)	Minimum R-Value of insulation alone (m ² -k/W)	Minimum U-factor of the overall assembly (W/m ² -K)	Minimum R-Value of insulation alone (m ² -K/W)
Composite	U-0.440	R-2.10	U-0.440	R-2.10

Note: Chhattisgarh is covered by "Composite" climate only. For information on other three climate zones, relevant Tables of ECBC may be referred.

5.3.3 Vertical Fenestration

Vertical fenestration shall comply with the maximum area weighted U-factor and maximum area weighted SHGC requirements of Table 5.3 Vertical fenestration area is limited to a maximum of 60% of the gross wall area for the prescriptive requirement. .

Table 5.3. Vertical Fenestration U-factor and SHGC Requirements (U-factor in W/m²-°C)

Climate	Maximum U-factor	WWR ≤ 40%	40% ≤ WWR ≤ 60%
		Maximum SHGC	Maximum SHGC
Composite	3.30	0.25	0.20

See Appendix 11.2.1 for typical complying vertical fenestration constructions.

Note: Chhattisgarh is covered by “Composite” climate only. For information on other three climate zones, relevant Tables of ECBC may be referred.

Exception to §5.3.3: Overhangs and/or side fins may be applied in determining the SHGC for the proposed design. An adjusted SHGC, accounting for overhangs and/or sidefins, is calculated by multiplying the SHGC of the unshaded fenestration product times a multiplication (M) factor. If this exception is applied, a separate M Factor shall be determined for each orientation and unique shading condition by equation 14-2 and the overhand and side fine coefficients are available in Table 14.3 §14 .

Table 5.4 SHGC “M” Factor Adjustments for Overhangs and Fins

Project Location	Orientation	Overhang “M” Factors for 4 Projection Factors				Vertical Fin “M” Factors for 4 Projection Factors				Overhang+ Fin “M” Factors for 4 Projection Factors			
		0.25 -	0.50 -	0.75 -	1.00 +	0.25- 0.49	0.50- 0.74	0.75 - 0.99	1.00 +	0.25- 0.49	0.50 - 0.74	0.75- 0.99	1.00+
North latitude 15° or greater	N	0.88	0.80	0.76	0.73	0.74	0.67	0.58	0.52	0.64	0.51	0.39	0.31
	E/W	0.79	0.65	0.56	0.50	0.80	0.72	0.65	0.60	0.60	0.39	0.24	0.16
	S	0.79	0.64	0.52	0.43	0.79	0.69	0.60	0.56	0.60	0.33	0.10	0.02
	N	0.83	0.74	0.69	0.66	0.73	0.65	0.57	0.50	0.59	0.44	0.32	0.23
Less than 15° North latitude	N	0.80	0.67	0.59	0.53	0.80	0.72	0.63	0.58	0.61	0.41	0.26	0.16
	E/W	0.78	0.62	0.55	0.50	0.74	0.65	0.57	0.50	0.53	0.30	0.12	0.04

Exception to SHGC Requirements in § 5.3.3: Vertical Fenestration areas located more than 2.2 m (7 ft) above the level of the floor are exempt from the SHGC requirement in Table 5.3 if the following conditions are complied with:

- a) Total Effective Aperture: The total Effective Aperture for the elevation is less than 0.25, including all fenestration areas greater than 1.0 m (3 ft) above the floor level; and,
- b) An interior light shelf is provided at the bottom of this fenestration area, with an interior projection factor not less than:
 - I. 1.0 for E-W, SE, SW, NE, and NW orientations,
 - II. 0.5 for S orientation, and
 - III. 0.35 for N orientation when latitude is < 23 degrees.

5.3.3.1 Minimum Visible Transmission (VLT) of Glazing for Vertical Fenestration

Vertical fenestration product shall have the minimum Visual Light Transmittance (VLT), defined as function of Window Wall Ratio (WWR), where Effective Aperture > 0.1, equal to or greater than the Minimum VLT requirements of Table 5.5

Table 5.5 Minimum VLT Requirements

Window Wall Ratio	Minimum VLT
0-0.3	0.27
0.31-0.4	0.20
0.41-0.5	0.16
0.51-0.6	0.13

4.3.4 Skylights

Skylight shall comply with the maximum U-factor and maximum SHGC requirements of Table 5.6 Skylight area is limited to a maximum 5% of the gross roof area for the prescriptive requirement.

Table 5.6 Skylight U-factor and SHGC Requirements (U-factor in W/m²-°C)

Climate	Maximum U-factor		Maximum SHGC	
	With Curb	w/o Curb	0-2% SRR	2.1-5% SRR
Composite	11.24	7.71	0.40	0.25

Note: Chhattisgarh is covered by “Composite” climate only. For information on other three climate zones, relevant Tables of ECBC may be referred.

SRR = Skylight roof ratio which is the ratio of the total skylight area of the roof, measured to the outside of the frame, to the gross exterior roof.

See § 13.2.2 for typical complying skylight constructions.

5.4 Building Envelope Trade-Off Option

The building envelope complies with the code if the building envelope performance factor (EPF) of the proposed design is less than the standard design, where the standard design exactly complies with the criteria in §5.3. The envelope trade-off equation is found in Appendix D §14.

6. Heating, Ventilation and Air Conditioning

6.1 General

All heating, ventilation and air conditioning equipment and systems shall comply with the mandatory provisions of §6.2 and the prescriptive criteria of §6.3.

6.2 Mandatory Requirements

6.2.1 Natural Ventilation.

Natural ventilation shall comply with the design guidelines provided for natural ventilation in the National Building Code of India 2005 Part 8, section 1, 5.4.3 and 5.7.1

6.2.1 Minimum Equipment Efficiencies

Cooling equipment shall meet or exceed the minimum efficiency requirements presented in Tables 6.1. Heating and cooling equipment not listed here shall comply with ASHRAE 90.1-2004 §6.4.1.

Unitary Air Conditioner shall meet IS 1391 (Part 1), Split air conditioner shall meet IS 1391 (Part 2), Packaged air conditioner shall meet IS 8148 and Boilers shall meet IS 13980 with above 75% thermal efficiency. All cooling equipments shall comply the provisions of §4.1.4.6.

Table 6.1 Chillers

Equipment Class	Minimum COP	Minimum IPLV	Test Standard
Air Cooled Chiller<530kW(<150tons)	2.90	3.16	ARI 550 / 590-1998
Air Cooled Chiller≥530kW(≥15 tons)	3.05	3.32	ARI 550 / 590-1998
*Centrifugal Water Cooled Chiller<530kW(<150tons)	5.80	6.09	ARI 550 / 590-1998
*Centrifugal Water Cooled Chiller ≥530 and < 1050 kW (≥150 and < 300tons)	5.80	6.17	ARI 550 / 590-1998
*Centrifugal Water Cooled Chiller ≥ 1050 kW(≥300 tons)	6.30	6.61	ARI 550 / 590-1998
Reciprocating Compressor, Water Cooled Chiller all sizes	4.20	5.05	ARI 550 / 590-1998
Rotary Screw Scroll Compressor, Water Cooled chiller<530 kW(<150 tons)	4.70	5.49	ARI 550 / 590-1998
Rotary Screw Scroll Compressor, Water Cooled chiller	5.40	6.17	ARI 550 / 590-

≥ 530 and <1050 kW(≥150 and < 300tons)			1998
Rotary Screw Scroll Compressor, Water Cooled chiller ≥ 1050 kW(≥300 tons)	5.75	6.43	ARI 550 / 590-1998
*These are aspirational values. For mandatory values refer to ASHRAE 90.1-2004			

6.2.2.1 Ceiling Fan Efficiencies

All fans shall comply with the provisions of §4.1.4.6.

6.2.3 Controls

6.2.3.1 All mechanical cooling and heating systems shall be controlled by a time Clock that:

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

Exceptions to §6.2.3.1:

- (a) Cooling systems < 28 kW (8 tons)
- (b) Heating systems < 7 kW (2 tons)

6.2.3.2 All heating and cooling equipment shall be temperature controlled. Where a unit provides both heating and cooling, controls shall be capable of providing a temperature dead band of 3°C (5°F) within which the supply of heating and cooling energy to the zone is shut off or reduced to a minimum. Where separate heating and cooling equipment serve the same temperature zone, thermostats shall be interlocked to prevent simultaneous heating and cooling.

6.2.3.3 All cooling towers and closed circuit fluid coolers shall have either two speed motors, pony motors, or variable speed drives controlling the fans. All cooling towers shall have indicators for measuring the inlet and outlet

temperature.

6.2.3.4. Each air conditioned room/space/zone shall have a digital temperature indicator to indicate the operating temperature of the area.

6.2.3.5. Each air conditioned space shall be provided with ceiling fans/ wall mounted fans/ air circulators so that effective cooling is maintained in the space.

6.2.3.6. Each room air conditioners shall be provided with at least one control device for display and regulation of temperature. The thermostat temperature of rooms/spaces can be preferably set to 25°C when air conditioning is used for comfort cooling.

6.2.3.7. Where HVAC is used to control comfort cooling, temperature controllers will be set locally or remotely by adjustment of sensors at 25°C temperature in accordance with local conditions.

6.2.3.8. Zone control: The supply of cooling energy to each zone shall be controlled by individual thermostatic controls responding to temperature within the zone. Zone controls should be set no lower than indoor design conditions (25°C). Temperature sensors shall be located in the zone or the return air path.

6.2.3.9. Off-Hour Controls: Equipments Shutdown during Non-Use: AC systems shall be equipped with automatic controls capable of accomplishing a reduction of energy use through equipment shutdown, or increase in the temperature set point, during periods of non-use or alternative use of the space served by the system.

Exceptions to §6.2.3.9:

(a) System serving areas that are expected to operate continuously.

(b) Equipment with a connected load of 2 kW or less may be controlled by readily accessible manual off-hour controls.

6.2.3.10. Outside Air Control during Non-Use: air intake and exhaust systems

be provided with motorized gravity dampers or other means of automatic volume shutoff or reduction during periods of non-use or alternative use of the spaces served by the system.

Exceptions to §6.2.3.10:

- (a) System serving areas that are expected to operate continuously.
- (b) Systems that have a design air flow of 500 L/s or less.
- (c) Gravity and other non-electrical ventilation systems may be controlled by readily accessible manual damper controls.
- (d) Where restricted by process equipments such as combustion-air intakes.

6.2.4 Piping and Ductwork

6.2.4.1 Piping for heating systems with a design operating temperature of 60°C (140°F) or greater shall have at least R-0.70 (R-4) insulation. Piping for heating systems with a design operating temperature less than 60°C (140°F) but greater than 40°C (104°F), piping for cooling systems with a design operating temperature less than 15°C (59°F), and refrigerant suction piping on split systems shall have at least R-0.35 (R-2) insulation. 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.

6.2.4.2 Ductwork shall be insulated in accordance with Table 6.2

Table 6.2 Ductwork Insulation (m²-°C/W)

Duct Location	Required Insulation ^a	
	Supply Ducts	Return Ducts
Exterior	R-1.4	R-0.6
Ventilated Attic	R-1.4	R-0.6
Unventilated Attic with Roof Insulation	R-0.6	No requirement
Unventilated Attic without	R-1.4	R-0.6

Roof Insulation		
Unconditioned Space ^b	R-1.4	No requirement
Indirectly Conditioned Space ^c	No requirement	No requirement
Buried	R-0.6	No requirement

a Insulation R-value is measured on a horizontal plane in accordance with ASTM C518 at a mean temperature of 24°C (75°F) at the installed thickness

b Includes crawlspaces, both ventilated and non-ventilated

c Includes return air plenums with or without exposed roofs above.

6.2.5 System Balancing

6.2.5.1 General

Construction documents shall require that all HVAC systems be balanced in accordance with generally accepted engineering standards. Construction documents shall require that a written balance report be provided to the owner or the designated representative of the building owner for HVAC systems serving zones with a total conditioned area exceeding 250 m² (2,500ft²).

6.2.5.1.1 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 (1.0 hp), fan speed shall be adjusted to meet design flow conditions.

6.2.5.1.2 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.

Exceptions to §6.2.5.1.2:

- (a) Impellers need not be trimmed nor pump speed adjusted for pumps with pump motors of 7.5 kW (10 hp) or less,
- (b) Impellers need not be trimmed when throttling results in no greater than

5% of the nameplate horsepower draw, or 2.2 kW (3 hp), whichever is greater.

6.2.6 Condensers

6.2.6.1 Condenser Locations

Care shall be exercised in locating the condensers in such a manner that the heat sink is free of interference from heat discharge by devices located in adjoining spaces and also does not interfere with such other systems installed nearby.

The condensers (outdoor units) especially of single unit room split air conditioners shall be located in shaded and well ventilated area closest to the evaporator (indoor unit). In case of unavailability of shaded area, the condensers shall be provided with artificial shading to prevent direct heating of the unit during day time by the Sun light. The unitary air conditioners shall also be installed in suitable locations to avoid direct sunlight and shading may be provided for improved performance. The piping system connecting the outdoor and indoor units shall be insulated as per §6.2.4.1 and the length of such pipes shall not exceed the length as specified by the manufacture.

6.2.6.2 Treated Water for Condensers

All high-rise buildings using centralized cooling water system shall use soft water for the condenser and chilled water system.

6.3 Prescriptive Requirements

Compliance shall be demonstrated with the requirements in §6.3.1 through § 6.3.3 for each HVAC system that meets the following criteria:

- (a) Serves a single zone
- (b) Cooling (if any) is provided by a unitary packaged or split-system air conditioner or heat pump;
- (c) Heating (if any) is provided by a unitary packaged or split-system heat pump, fuel-fired furnace, electric resistance

- heater, or baseboards connected to a boiler and
- (d) Outside air quantity is less than 1,400 l/s (3,000 cfm) and less than 70% of supply air at design conditions

Other HVAC systems shall comply with ASHRAE 90.1-2004, §6.5.

6.3.1 Economizers

6.3.1.1 Air Side Economizer

Each individual cooling fan system that has a design supply capacity over 1,200 l/s (2,500 cfm) and a total mechanical cooling capacity over 22 kW (6.3 tons) shall include either:

- (a) An air economizer capable of modulating outside-air and return-air dampers to supply 100 percent of the design supply air quantity as outside-air; or
- (b) A water economizer capable of providing 100% of the expected system cooling load at outside air temperatures of 10°C (50°F) dry-bulb/7.2°C (45°F) wet-bulb and below.

Exception to §6.3.1.1:

- (a) Projects in the Warm-Humid climate zones are exempt.
- (b) Individual ceiling mounted fan systems < 3,200 l/s (6,500 cfm) are exempt.

6.3.1.2 Where required by §6.3.1.1 economizers shall be capable of providing partial cooling even when additional mechanical cooling is required to meet the cooling load.

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

Exception to §6.3.1.3: 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 Appendix F §16.

6.3.2. Variable Flow Hydronic Systems

6.3.2.1. Chilled or hot-water systems shall be designed for variable fluid flow and shall be capable of reducing pump flow rates to no more than the larger of;

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

6.3.2.2. Water cooled air-conditioning or heat pump units with a circulation pump motor greater than or equal to 3.7 kW (5 hp) 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.

6.3.2.3. Chilled water or condenser water systems that must comply with either §6.3.2.1 or §6.3.2.2 and that have pump motors greater than or equal to 3.7 kW (5 hp) shall be controlled by variable speed drives.

6.3.3. HVAC Fan System Design Criteria.

The following design criteria shall apply to all HVAC fan system used for comfort ventilating and/or air conditioning. For this purpose, the energy demand of a fan system is the sum of demand of fans that are required to operate at design conditions to supply air from cooling source to the conditioned space(s) and return it back to the source or exhaust it to the outdoors.

Exceptions: Systems with total fans system motor power of 4 kW or less.

6.3.3.1. Constant Volume fan Systems.

For fan systems that provide a constant air volume whenever the fans are operating, there shall be at least 5000L/S of supply air volume per kw of

total input power required by the motors for the combined fan system at design conditions.

6.3.3.2. Variable Air Volume (VAV) Fan Systems.

For fan systems that are able to vary system air volume automatically as a function of load, there shall be at least 420L/S of supply air volume per KW of total input power required by the motors for the combined fan system at design conditions.

7. Service Hot Water, Pumping and Renewable Energy

7.1 General

All service hot water heating equipment and systems shall comply with the mandatory provisions of §7.2.

7.2 Mandatory Requirements

7.2.1 Solar Water Heating

Residential facilities, hotels and hospitals with a centralized system shall have solar water heating for at least 1/5 of the design capacity.

Exception to §7.2.1:

Systems that use heat recovery for at least 1/5 of the design capacity.

7.2.2 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% thermal efficiency.
- (c) Electric water heater shall meet the performance / minimum efficiency level mentioned in IS 2082. All heating equipments shall comply with the provisions of §4.1.4.6.

7.2.3 Supplementary 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.

7.2.4 Piping Insulation

Piping insulation shall comply with §6.2.4.1. The entire hot water system including the storage tanks, pipelines shall be insulated conforming to the relevant IS standards on materials and applications.

7.2.5 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 as close as practical to the storage tank.

7.2.6 Swimming Pools

Heated pools shall be provided with a vapor retardant pool cover on or at the water surface. Pools heated to more than 32°C (90°F) shall have a pool cover with a minimum insulation value of R-2.1 (R-12).

Exception to §7.2.6:

Pools deriving over 60% of their energy from site-recovered energy or solar energy source.

7.2.7 Compliance Documentation

The application for approval shall furnish detailed calculation showing the design to ensure that at least 20% of the heating requirement shall be met from solar heat/heat recovery and not more than 80% of the heat shall be met from electrical heating. Wherever gas is available, not more than 20% of the heat shall be met from electrical heating. At least 25% of the total connected load shall be harnessed through renewable Energy installation like solar, Biomass etc.

8. Lighting

8.1 General

Lighting systems and equipment shall comply with the mandatory provisions of §8.2 and the prescriptive criteria of §8.3 and §8.4. 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 §8.1:

- a) Emergency lighting that is automatically off during normal building operation and is powered by battery, generator, or other alternate power source; and,
- b) Lighting in dwelling units.

8.2 Mandatory Requirements

8.2.1 Lighting Control

8.2.1.1 Automatic Lighting Shutoff

Interior lighting systems in buildings larger than 250 m² (2,500 ft²) shall be equipped with an automatic control device. Within these buildings, all office areas less than 30 m² (300 ft²) enclosed by walls or ceiling-height partitions, all meeting and conference rooms, all school classrooms, and all storage spaces shall be equipped with occupancy sensors. For other spaces, this automatic control device shall function on either

- a. A scheduled basis at specific programmed times. An independent program schedule shall be provided for areas of no more than 2,500 m² (25,000 ft²) and not more than one floor or,
- b. Occupancy sensors that shall turn the lighting off within 10 minutes of an occupant leaving the space. Light fixtures controlled by occupancy sensors shall have a wall-mounted or ceiling mounted, manual switch capable of turning off lights when the space is occupied.

Exception to §8.2.1.1: Lighting systems designed for 24-hour use.

8.2.1.2 Space Control

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

- a. Control a maximum of 250 m² (2,500 ft²) for a space less than or equal to 1,000 m² (10,000 ft²), and a maximum of 1,000 m² (10,000 ft²) for a space greater than 1,000 m² (10,000 ft²).
- b. Be capable of overriding the shutoff control required in §8.2.1.1 for no more than 2 hours, and
- c. Be readily accessible and located so the occupant can see the control.

Exception to §8.2.1.2(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.

8.2.1.3 Control in Day lighted Areas

Luminaries in day lighted areas greater than 25 m² (250 ft²) shall be equipped with either a manual or automatic control device that:

- (a) Is capable of reducing the light output of the luminaries in the day lighted areas by at least 50%, and
- (b) Controls only the luminaries located entirely within the day lighted area.

8.2.1.4 Exterior Lighting Control

Lighting for all exterior applications not exempted in §8.3.4 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.

8.2.1.5 Additional Control

The following specialty lighting spaces are required to have a control device that separates lighting control from that of the general lighting. The following lighting applications shall be equipped with a control device to control such lighting independently of general lighting:

- (a) Display/Accent Lighting: Display or accent lighting greater than 300 m² (3,000 ft²) area shall have a separate control device.
- (b) Case Lighting: Lighting in cases used for display purposes greater than 300 m² (3,000 ft²) area shall be equipped with a separate control device.
- (c) Hotel and Motel Guest Room Lighting: Hotel and motel guest rooms and guest suites shall have a master control device at the main room entry that controls all permanently installed luminaries and switched receptacles.
- (d) Task Lighting: Supplemental task lighting including permanently installed under-shelf or under-cabinet lighting shall have a control device integral to the luminaries or be controlled by a wall-mounted control device provided the control device complies with §8.2.1.2(c). LED of appropriate specification shall be used for the task lighting.

- (e) Non-visual Lighting: Lighting for non-visual applications, such as plant growth and food-warming, shall be equipped with a separate control device.
- (f) 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

8.2.2 Exit Signs

Internally-illuminated exit signs shall not exceed 5W per face and shall use LEDs.

8.2.3 Exterior Building Grounds Lighting

Lighting for exterior building grounds luminaries which operate at greater than 100W shall contain lamps having a minimum efficacy of 60 lm/W unless the luminaire is controlled by a motion sensor or exempt under §8.1

8.2.4 Control of outdoor lighting and advertisements.

The illumination level of outdoor lighting shall be reduced by at least 50% or as notified from time to time by Government using astronomical time switch and/or illumination control devices that is capable of automatically reducing the exterior lighting level by the specified level.

Suitable astronomical time switch shall be installed for all outdoor advertisements, bill boards and other illuminated displays using more than 500 watts so as to switch off these after 11:10PM or as notified by the Govt. from time to time.

Exception to §8.2.4: Outdoor lights used during festival period, functions, ceremonies, used for safety or during emergency shall be exempt from such control.

8.2.5. Use of daylight

At least 90% of building illumination requirement during day time should be met using natural daylight/solar photo voltaic or other renewable sources. If required solar passive architecture may be followed for natural day lighting.

8.3 Perspective Requirements

8.3.1 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 §8.3.4 and shall not exceed the interior lighting power allowance determined in accordance with either §8.3.2 or §8.3.3. Tradeoffs of interior lighting power allowance among portions of the building for which a different method of calculation has been used are not permitted.

Exception to §8.3:

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.

8.3.2 Building Area Method

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

- a) Determine the allowed lighting power density from Table 8.1 for each appropriate building area type.
- (b) Calculate the gross lighted floor area for each building area type.

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

Table 7.3.1 Interior Lighting Power - Building Area Method

Building Area Type	LPD(W/ m ²) As per national code	Proposed LPD(W/ m ²)	Proposed Reduction in %
Automatic Facility	9.7	8.5	12.4%
Convention Centre	12.9	11	14.7%
Dining: Bar Lounge/Leisure	14.0	12	14.3%
Dining: cafeteria/Fast Food	15.1	13	14.9%
Dining: Family	17.2	15	12.8%
Dormitory/Hostel	10.8	10	7.4%
Gymnasium	11.8	10	15.3%
Healthcare-Clinic	10.8	10	7.4%
Hospital/Health Care	12.9	12	7.0%

Hotel	10.8	10	7.4%
Library	14.0	13	7.1%
Manufacturing Facility	14.0	14.0	0.0%
Motel	10.8	10	7.4%
Motion Picture Theatre	12.9	12	7.0%
Multifamily residential	7.5	7	6.7%
Museum	11.8	11	6.8%
Office	10.8	10	7.4%
Parking Garage	3.2	3	6.3%
Performing arts Theatre	17.2	17	1.2%
Police/Fire Station	10.8	0	7.4%
Post Office/Town hall	11.8	11	6.8%
Religious Building	14.0	12	14.3%
Retail/Mall	16.1	16	0.6%
School/University	12.9	12	7.0%
Sports arena	11.8	11	6.8%
Transportation	10.8	10	7.4%
Warehouse	8.6	8	7.0%
Workshop	15.1	15	0.7%

In cases where both a general building area type and a specific building area type are listed, the specific building area type shall apply.

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 from Table 8.2 and the allowed lighting power density :
- (b) For each space enclosed by partitions 80% or greater than ceiling height, determine the gross interior floor area by measuring to the center of the partition wall. Include the floor area of balconies or other projections. Retail spaces do not have to comply with the 80% partition height requirements; and
- (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.

Space Function	LPD(W/m ²) As per national code	LPD(W/m ²)	Space Function	LPD(W/m ²) As per national code	LPD(W/m ²) As per national code
<i>Office-enclosed</i>	11.8	10	• For Reading Area	12.9	11
<i>Office-open plan</i>	11.8	10	Hospital		
<i>Conference/Meeting/Multipurpose</i>	14.0	12	• For Emergency	29.1	29
<i>Classroom/Lecture/Training</i>	15.1	13	• For Recovery	8.6	8
Lobby*	14.0	12	• For Nurse Station	10.8	10
• For Hotel	11.8	10	• For Exam Treatment	16.1	16
• For Performing Arts Theatre	35.5	34	• For Pharmacy	12.9	12
• For Motion Picture Theater	11.8	12	• For Patient Room	7.5	7
Audience/Seating Area*	9.7	9	• For Operating Room	23.7	23
• For Gymnasium	4.3	4	• For Nursery	6.5	6
• For Convention Center	7.5	7	• For Medical Supply	15.1	15
• For Religious Buildings	18.3	15	• For Physical therapy	9.7	9
• For Sports Arena	4.3	4	• For Radiology	4.3	4
• For performing Arts Theater	28.0	26	• For Laundry-Washing	6.5	6
• For Motion Picture Theater	12.9	12	• Automotive-Service Repair	7.5	7
• For Transportation	5.4	5	Manufacturing Facility		
Atrium-first three floors	6.5	6	• For low Bay(<8M ceiling)	12.9	12
Atrium-each additional floor	2.2	2	• For High Bay(>8m ceiling)	18.3	18
Lounge/Recreation*	12.9	12	• For Detailed Manufacturing	22.6	22

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• For Hospital	8.6	8	• For Equipment Room	12.9	12
Dining Area *	9.7	8	• For Control Room	5.4	5
• For Hotel	14.0	12	Hotel/ Motel Guest Room	11.8	10
• For Motel	12.9	11	Dormitory- Living Quarters	11.8	10
• For Bar Lounge Leisure Dining	15.1	13	Museum		
• For Family Dining	22.6	20	• For General Exhibition	10.8	10
• Food Preparation	12.9	11	• For Restoration	18.3	18
Laboratory	15.1	15	Bank Office – Banking Area	16.1	15
Restrooms	9.7	9	Retail		
Dressing /Locker /Fitting Room	6.5	6	• For Sales Area	18.3	16
Corridor Transaction	5.4	5	• For Mall Concourse	18.3	18
• For Hospital	10.8	10	Sports Arena		
• For Manufacturing Facility	5.4	5	• For Ring Sports Area	29.1	27
Stairs –active	6.5	6	• For Court Sports Area	24.8	24
Active Storage*	8.6	8	• For indoor Field Area	15.1	15
• For Hospital	9.7	9	Ware house		
Inactive Storage*	3.2	3	• For Fine Material Storage	15.1	15
• For Museum	8.6	8	• For Medium/Bulky Material Storage	9.7	9
Electrical/Mechanical Facility	16.1	15	Parking Garage – Garage Area	2.2	2
Workshop	20.5	20	Transportation		
Convention Center- Exhibit Space	14.0	13	• For Airport - Concourse	6.5	6
Library			• For Air/Train/Bus– Baggage Area	10.8	10
• For Card File and Cataloging	11.8	10	• For Ticket Counter Terminal	16.1	15
• For Stacks	18.3	18			

* For all facilities except the following.

8.3.4 Installed Interior Lighting Power

The installed interior lighting power calculated for compliance with § 8.3 shall include all power used by the luminaires, including lamps, ballasts, current regulators, and control devices except as specifically exempted in §8.1.

Exception to §8.3.4: 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.

8.3.4.1 Luminaire Wattage.

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 based on values from manufacturers' catalogs or values from independent testing laboratory reports.
- (c) The wattage of all other miscellaneous luminaire types not described in (a) or (b) shall be the specified wattage of the luminaires.
- (d) The wattage of lighting track, plug-in bus way, and flexible-lighting systems that allow the addition and/or relocation of luminaires without altering the wiring of the system shall be the larger of the specified wattage of the luminaires included in the system or 135 W/m (45 W/ft). 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.

8.3.5. Exterior Lighting Power

For building exterior lighting applications specified in Table 8.3, the connected lighting power shall not exceed the specified lighting power limits

specified for each of these applications. Trade-offs between applications is not permitted. Exterior lighting for all other applications (except those included in the Exceptions to §8.3.4) shall comply with the requirements of §8.2.3.

Table 8.3 Exterior Building Lighting Power

Exterior Lighting Applications	Power Limits
Building Entrance(With Canopy)	13 W/ m ² (1.3 W/ m ²) on canopied area.
Building Entrance(Without Canopy)	90 W/lin m(20 W/lin f) of door width
Building exit	60 W/lin m(20 W/lin f) of door width
Building facades	2 W/ m ² (0.2 W/ m ²) of vertical façade area

Exceptions to §8.3.5:

Lighting used for the following exterior applications is exempt when equipped with an independent control device:

- (a) Specialized signal, directional, and marker lighting associated with transportation;
- (b) Lighting used to highlight features of public monuments and registered historic landmark structures or buildings;
- (c) Lighting that is integral to advertising signage; or
- (d) Lighting that is specifically designated as required by a health or life Safety statute, ordinance, or regulation.

8.3.6. Lighting Type and Efficiency.

All fluorescent tube lights shall be of T-5 type or BEE star rated as specified in §4.1.4.6. No incandescent bulb shall be used for ordinary lighting applications. A list of all types of lights proposed to be used along with their design efficiency in lumen/ watt, CRI value shall be furnished in the lighting summary report §17.5. Justification for used of lights with lumen/watt is below 50 needs to be furnished.

Exceptions to §8.3.6: Lighting equipments and application as specified under §8.3(a)-(m).

9. Electrical Power

9.1 General

Electrical equipment and systems shall comply with the mandatory requirements of the §9.2.

9.2 Mandatory Requirements

9.2.1. Transformers.

9.2.1.1 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. In addition, the transformer must be selected such that it minimizes the total of its initial cost in addition to the present value of the cost of its total lost energy while serving its estimated loads during its respective life span. All distribution transformers shall comply with the provisions of §4.1.4.6.

Table 9.1: Dry type transformers-Total losses for dry type transformers should conform as per the draft standard of Indian Standards IS 2026: part 11 2007.

Rating KVA	Maximum Losses at 50% Loading [kW] Upto 22 kV class	Maximum Losses at 100% Loading [kW]	Maximum Losses at 50% Loading [kW] 33 kV class	Maximum Losses at 50% Loading [kW] 33 kV class
100	0.94	2.4	1.12	2.4
160	1.29	3.3	1.42	3.3
200	1.5	3.8	1.75	4
250	1.7	4.32	1.97	4.6
315	2	5.04	2.4	5.4
400	2.38	6.04	2.9	6.8
500	2.8	7.25	3.3	7.8
630	3.34	8.82	3.95	9.2
800	3.88	10.24	4.65	11.4
1000	4.5	12	5.3	12.8

1250	5.19	13.87	6.25	14.5
1600	6.32	16.8	7.5	18
2000	7.5	20	8.88	21.4
2500	9.25	24.75	10.75	26.5

Table 9. Oil-filled transformers-Total losses for oil filled transformers should conform as per the following table as specified in Central Electricity Authority norms.

Rating KVA	Maximum Losses at 50% Loading [kW] Upto 22 kV class	Maximum Losses at 100% Loading [kW]	Maximum Losses at 50% Loading [kW] 33 kV class	Maximum Losses at 50% Loading [kW] 33 kV class
100	0.52	1.80	0.56	1.82
160	0.77	2.20	0.78	2.58
200	0.89	2.70	0.90	3.00
250	1.05	3.32	—	—
315	1.10	3.63	1.30	4.30
400	1.45	4.63	1.52	5.10
500	1.60	5.50	1.95	6.45
630	2.00	6.64	2.30	7.60
1000	3.00	9.00	3.45	11.35
1250	3.60	12.00	4.00	13.25
1600	4.50	15.00	4.85	16.00
2000	5.40	18.40	5.70	18.05
2500	6.50	22.50	7.05	23.00

For Table 9.1, 9.2:*Total loss values given in the above table are applicable for thermal classes E, B and F and have component of load loss reference temperature according to clause 17 of IS 2026: Part 11, i.s , average winding temperature rise as given in column 2 of Table 9.2 plus 30⁰C. An increase of 7% on total for thermal class H is allowed.

9.2.1.2 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 160 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.

9.2.2 Energy Efficient Motors

Motors shall comply with the following:

- (a) All permanently wired polyphase motors of 0.375 kW or more serving the building and expected to operate more than 1,500 hours per year and all permanently wired polyphase motors of 50kW or more serving the building and expected to operate more than 500 hours per year shall have a minimum acceptable nominal full load motor efficiency not less than IS 12615 for energy efficient motors.
- (b) Motors of horsepower differing from those listed in the table shall have efficiency greater than that of the next listed kW motor.
- (c) Motor horsepower ratings shall not exceed 20% of the calculated maximum load being served.
- (d) Motor nameplates shall list the nominal full-load motor efficiencies and the full-load power factor.
- (e) Motor users should insist on proper rewinding practices for any rewind motors. If the proper rewinding practices cannot be assured, the damaged motor should be replaced with a new, efficient one rather than suffer the significant efficiency penalty associated with typical rewind practices; and
- (f) Certificates shall be obtained and kept on record indicating the motor efficiency. Whenever a motor is rewound, appropriate measures shall be taken so that the core

characteristics of the motor is not lost due to thermal and mechanical stress during removal of damaged parts. After rewinding, a new efficiency test shall be performed and a similar record shall be maintained;

- (g) All motors and pump sets shall comply with the provisions of §4.1.4.6.

9.2.3 Power Factor Correction

All electricity supplies exceeding 100 A, 3 phase shall maintain their power factor between 0.95 lag and unity at the point of connection.

9.2.4 Check-Metering and Monitoring

- a) Services exceeding 60 kVA shall have permanently installed electrical metering to record demand (kVA), energy (kWh), and total power factor. 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 60 kVA shall have permanently installed electric metering to record demand (kW), energy (kWh), and total reactive power (or kVARh)
- c) Services not exceeding 65 kVA shall have permanently installed static electrical metering to record energy (kWh).

9.2.4.1 Sub-metering and Check-metering

Buildings whose designed connected electrical load is over 60 kVA shall have the distribution system designed to include sub-metering facilities.

The electrical power feeders for each facility of the building for which sub-metering is required shall be subdivided into the following categories:

- (a) Lighting and receptacle outlets;
- (b) Power system (for ventilation and air conditioning, elevators, computers, etc.).

The feeders for each category in §9.2.4.1 may include provisions for check metering for energy conservation monitoring.

9.2.5 Power Distribution Systems

9.2.5.1 Power Distribution System Losses

The power cabling shall be adequately sized as to maintain the distribution losses not to exceed 1% of the total power usage. Record of design calculation for the losses shall be maintained.

9.2.5.2 Load balancing.

Transformer load grouping schemes shall be so designed such that the transformers are loaded to not less than 75% of their full load ratings and that no-load circuits or partially loaded circuit combinations should be minimized as much as possible.

The load in all phases shall be balanced in such a way that the difference in loading of each phase does not exceed 5% of average loading between the phases .

10. Energy Auditing, Reporting and Star Rating.

10.1. Mandatory Requirements.

10.1.1. Auditing of Building.

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

10.1.2. Reporting.

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

10.1.3. Star Rating of Buildings and Display of Star Labeling.

It shall be mandatory to obtain the star rating of building/building complexes and display the star label of the building / building complexes in such manner and format as notified by BEE from time to time.

10A Acceptable limit heat gain for Non conditioned spaces

Existing buildings or building spaces which are not air conditioned shall comply with appendix 23 § M in confirmation with IS 3792-1978 (reaffirmed in 2008)

Thermal behavior of a building can be judged by the total peak heat flow resulting from individual heat flows. An index known as Building index has thus been defined as ratio of the total heat gain, averaged over entire surface area of the building envelope, to the acceptable limit of heat gain for achieving comfortable condition indoors. Acceptable limit of heat gain has been taken as 40 kcal / m² /hr.. Maximum limit of Building index for different thermal comfort condition and corresponding indoor air temperature with fan is given in table - 10A-1

table -10A-1

SI No	Building index	Indoor air temperature	Comfort condition with fan
1	0-50	32	Comfortable
2	51-100	32.36	Slightly warm
3	101-150	36.40	Hot

It is the clear from the Table-1 that a Building Index up to 50 gives comfortable condition.

11. APPENDIX A:

11.1 General

Certain terms, abbreviations, and acronyms are defined in this § 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. Webster's Third New International Dictionary of English Language, Unabridged, copyright 1986, shall be considered as providing ordinarily accepted meanings.

11.2 Definitions

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

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

Annual fuel utilization efficiency (AFUE): an efficiency description of the ratio of annual output energy to annual input energy as developed in accordance with requirements of U.S. Department of Energy (DOE) 10CFR Part 430.

Area: see roof and wall, conditioned floor, day lighted, façade, fenestration, lighted floor

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 standard

Automatic: self-acting, operating by its own mechanism when actuated by some non-manual influence, such as a change in current strength, pressure, temperature, or mechanical configuration.

Automatic control device: a device capable of automatically turning loads off and on without manual intervention.

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.

BEE: The Bureau of Energy Efficiency, Ministry of Power, Govt. of India.

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

Boiler, packaged : a boiler that is shipped complete with heating equipment, mechanical draft equipment, and automatic controls; usually shipped in one or more sections.

A packaged boiler includes factory-built boilers manufactured as a unit or system, disassembled for shipment, and reassembled at the site.

Building: means any structure or erection or part of a structure or erection, after the rules relating to energy conservation building codes have been notified under clause (a) of §15 or clause (I) of sub-§(2) of §56, which is having a connected load of 50 kW or contract demand of 60 kVA and above and / OR 500 sqmt total floor area under the category of commercial building (pl refer page no:..... for definition of commercial building).

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

Building complex: a group of buildings in a contiguous area under single ownership.

Building entrance: any doorway, set of doors, turnstiles, or other form of portal that is ordinarily used to gain access to the building by its users and occupants.

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

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

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

Building exit: any doorway, set of doors, or other form of portal that is ordinarily used only for emergency egress or convenience exit.

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

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

Circuit breaker: a device designed to open and close a circuit by non-automatic means and to open the circuit automatically at a predetermined over-current without damage to itself when properly applied within its rating.

Class of construction: for the building envelope, a subcategory of roof, wall, floor, slab-on-grade floor, opaque door, vertical fenestration, or 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.

Commercial building: all buildings more than or equal to 500 sqmt except for multi-family buildings of three stories or fewer above grade and single-family buildings.

Construction documents: drawings and specifications used to construct a building, building systems, or portions thereof.

Control: to regulate the operation of equipment

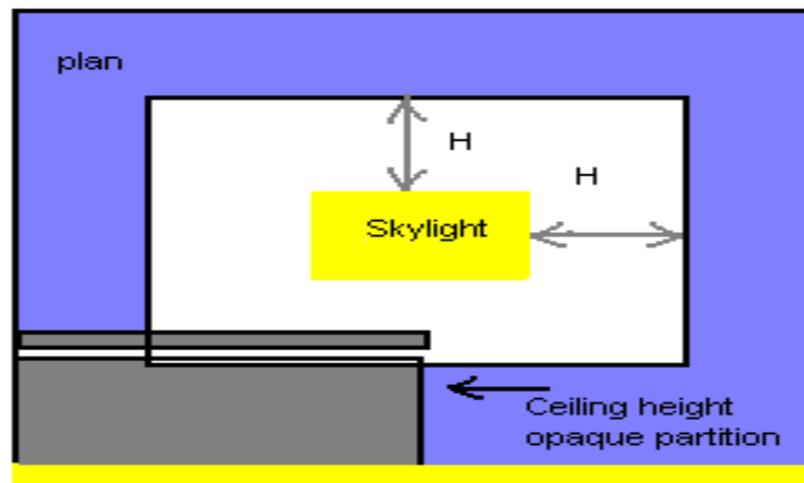
Control device: a specialized device used to regulate the operation of equipment.

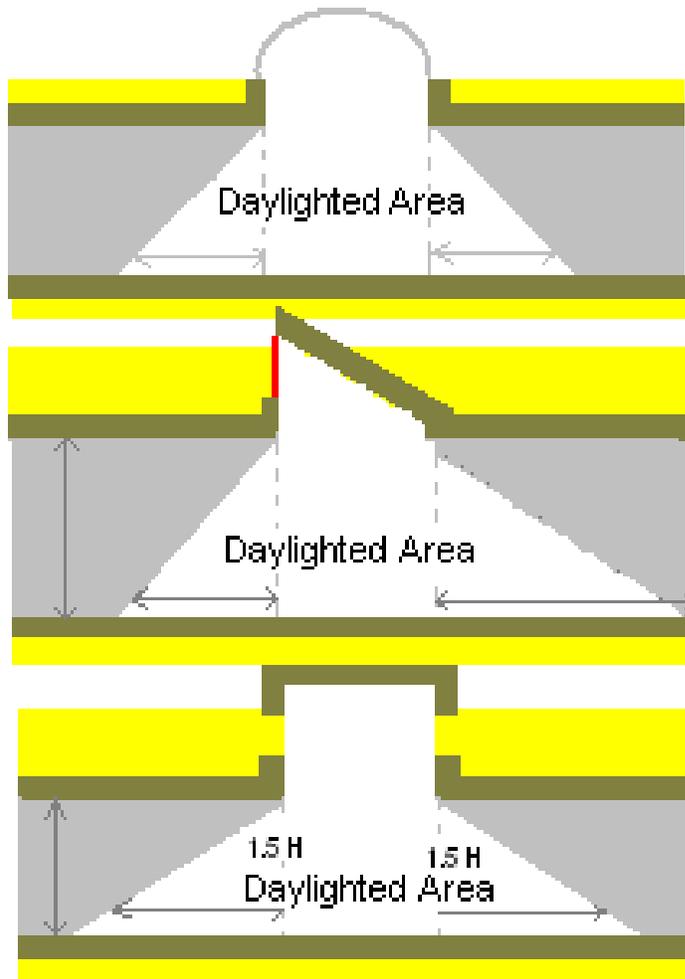
Cool roof: a property of a surface that describes its ability to reflect and reject heat. Cool roof surfaces have both a light color (high solar reflectance) and a high emittance (can reject heat back to the environment).

CRI: Color rendering index

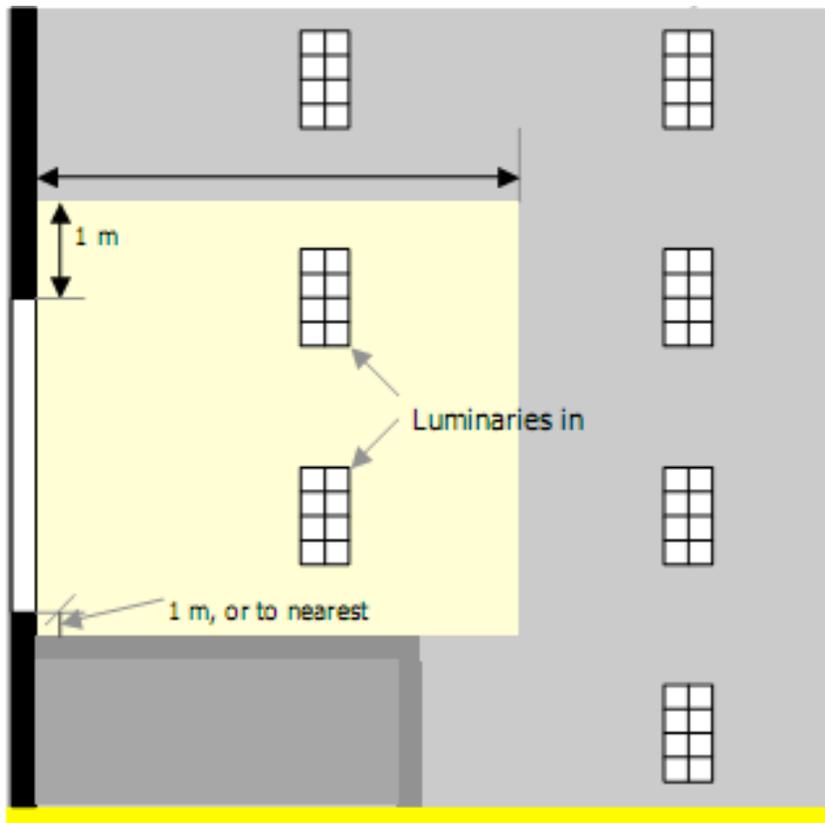
Day lighted area: the daylight illuminated floor area under horizontal fenestration (skylight) or adjacent to vertical fenestration (window), described as follows.

- i. **Horizontal Fenestration:** the area under a skylight, monitor, or sawtooth configuration with an effective aperture greater than 0.001 (0.1%). The day lighted 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 1000 mm (42 in) 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.





- ii. Vertical Fenestration: the floor area adjacent to side apertures (vertical fenestration in walls) with an effective aperture greater than 0.06 (6%). The day lighted area extends into the space perpendicular to the side aperture a distance either two times the head height of the side aperture or to the nearest 1.35 m (54 in) or higher opaque partition, whichever is less. In the direction parallel to the window, the day lighted area extends a horizontal dimension equal to the width of the window plus either 1 m (3.3 ft) on each side of the aperture, the distance to an opaque partition, or one-half the distance to an adjacent skylight or window, whichever is least.



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

Demand: the highest amount of power (average Btu/h over an interval) recorded for a building or facility in a selected time frame.

Design capacity: output capacity of a system or piece of equipment at design conditions.

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

Distribution system: a device or group of devices or other means by which the conductors of a circuit can be disconnected from their source of supply.

Door: all operable opening areas (which are not fenestration) in the building envelope, including swinging and roll-up doors, fire doors, and access hatches. Doors that are more than one-half glass are considered fenestration. For the purposes of determining building envelope requirements, the classifications are defined as follows:

- a) **Door, non-swinging:** roll-up sliding, and all other doors that are not swinging doors.
- b) **Door, swinging:** all operable opaque panels with hinges on one side and opaque revolving doors.

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

Dwelling unit: a single unit providing complete independent living facilities for one or more persons, including permanent provisions for living, sleeping, eating, cooking, and sanitation.

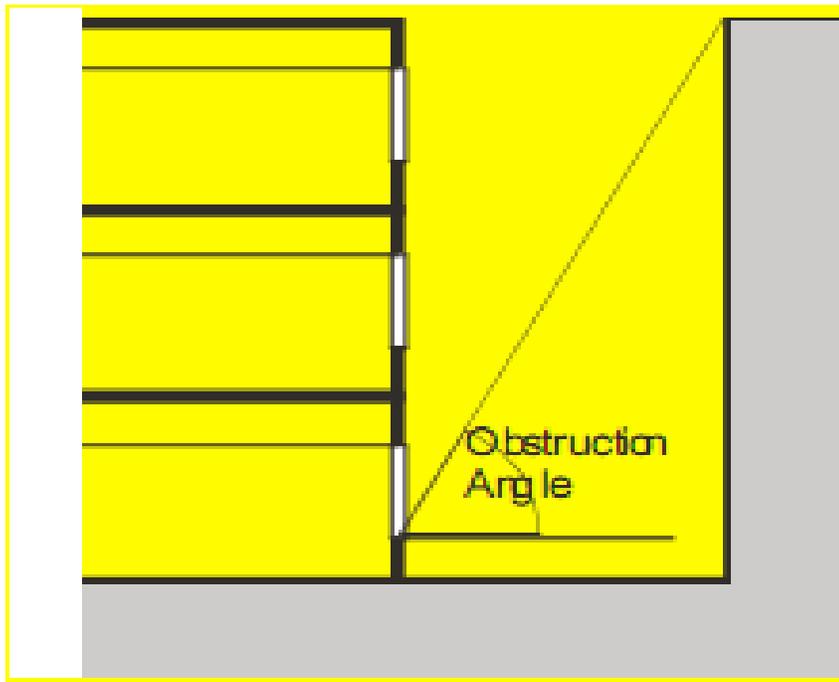
Economizer, air: a duct and damper arrangement and automatic control system that together allow a cooling system to supply outdoor air to reduce or eliminate the need for mechanical cooling during mild or cold weather.

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.

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

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

Effective aperture, vertical fenestration: a measure of the amount of daylight that enters a space through vertical fenestration. It is the ratio of the daylight window area times its visible light transmission plus half the vision glass area times its visible light transmission and the sum is divided by the gross wall area. Daylighted window area is located 2.2 m (7 ft) or more above the floor and vision window area is located above 1 m (3 ft) but below 2.2 m (7 ft). The window area, for the purposes of determining effective aperture shall not include windows located in light wells when the angle of obstruction (α) of objects obscuring the sky dome is greater than 70° , measured from the horizontal, nor shall it include window area located below a height of 1 m (3 ft). See also daylighted area.



Efficacy: the lumens produced by a lamp/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.

Remittance: 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.

Enclosed building: a building that is totally enclosed by walls, floors, roofs, and openable devices such as doors and operable windows.

Energy: the capacity for doing work. It takes a number of forms that may be transformed from one into another such as thermal (heat), mechanical (work), electrical, and chemical. Customary measurements are watts (W).

Energy Efficiency Ratio (EER): the ratio of net cooling capacity in Btu/h to total rate of electric input in watts under designated operating conditions.

Energy Factor (EF): a measure of water heater overall efficiency.

Envelope performance factor: the trade-off value for the building envelope performance compliance option calculated using the procedures specified in Appendix 13. For the purposes of determining building envelope requirements the classifications are defined as follows:

- a) **Base envelope performance factor:** the building envelope performance factor for the base design
- b) **Proposed envelope performance factor:** the building envelope performance factor for the proposed design

Equipment: devices for comfort conditioned, electric power, lighting, transportation, or service water heating including, but not limited to, furnaces, boilers, air conditioners, heat pumps, chillers, water heaters, lamps, luminaries, ballasts, elevators, escalators, or other devices or installations.

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

Facade area: area of the façade, including overhanging soffits, cornices, and protruding columns, measured in elevation in a vertical plane, parallel to the plane of the face of the building. Non-horizontal roof surfaces shall be included in the calculations of vertical façade area by measuring the area in a plane parallel to the surface.

Fan system power: the 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 source of exhaust it to the outdoors.

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 (12 in). 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.

Floor area gross: the sum of the floor areas of the spaces within the building including basements, mezzanine and intermediate-floored tiers, and penthouses with headroom height of 2.5 m (7.5 ft) or greater. It is measured from the

exterior faces of exterior walls or from the centerline of walls separating buildings, but excluding covered walkways, open roofed-over areas, porches and similar spaces, pipe trenches, exterior terraces or steps, chimneys, roof overhangs, and similar features.

- (a) Gross building envelope floor area: the gross floor area of the building envelope, but excluding slab-on-grade floors.
- (b) gross conditioned floor area: the gross floor area of conditioned spaces
- (c) Gross lighted floor area: the gross floor area of lighted spaces.
- (d) Gross semi-heated floor area: the gross floor area of semi-heated spaces.

Flue damper: a device in the flue outlet or in the inlet of or upstream of the draft control device of an individual, automatically operated, fossil fuel-fired appliance that is designed to automatically open the flue outlet during appliance operation and to automatically close the flue outlet when then appliance is in standby condition.

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.

Generally accepted engineer standard: a specification, rule, guide, or procedure in the filed of engineer, or related thereto, recognized and accepted as authoritative.

Grade: the 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.

Heat capacity: the amount of heat necessary to raise the temperature of a given mass 1°C (1°F). Numerically, the heat capacity per unit area of surface ($W/m^2-^{\circ}C$ [Btu/ft²-°F]) is the sum of the products of the mass per unit area of each individual material in the roof, wall, or floor surface multiplied by its individual specific heat.

Heating Seasonal Performance Factor (HSPF): the total heating output of a heat pump during its normal annual usage period for heating (in Btu) divided by the total electric energy input during the same period.

Historic: a building or space that has been specifically designed as historically significant.

HVAC system: the equipment, distribution systems, and terminals that provide, either collectively or individually, the processes of heating, ventilating, or air conditioned to a building or portion of a building.

Infiltration: the uncontrolled inward air leakage through cracks and crevices in any building element and around windows and doors of a building caused by pressure differences across these elements due to factors such as wind, inside and outside temperature differences (stack effect), and imbalance between supply and exhaust air systems.

Installed interior lighting power; the power in watts of all permanently installed general, task, and furniture lighting systems and luminaries.

Integrated part-load value (IPLV): a single number figure of merit based on part-load EER, COP, or KW/ton expressing part-load efficiency for air-conditioning and heat pump equipment on the basis of weighted operation at various load capacities for the equipment.

Kilovolt-ampere (kVA): where the term “kilovolt-ampere” (kVA) is used in this standard, 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: a generic term for man-made light source often called bulb or tube.

LED: Light Emitting Diodes.

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

Lighting, decorative: lighting that is purely ornamental and installed for aesthetic effect. Decorative lighting shall not include general lighting.

Lighting, emergency: lighting that provides illumination only when there is a general lighting failure.

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 Efficacy (LE): the quotient of the total lumens emitted from a lamp or lamp/ballast combination divided by the watts of input power, expressed in lumens per watt.

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

Lighting power allowance:

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

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

Low-rise residential: single-family houses, multi-family structures of three stories or fewer above grade, manufactured houses (mobile homes), and manufactured houses (modular).

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

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

Manufacturer: the company engaged in the original production and assembly of products or equipment or a company that purchases such products and equipment manufactured in accordance with company specifications.

Mean temperature: one-half the sum of the minimum daily temperature and maximum daily temperature.

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

Metering: instruments that measure electric voltage, current, power, etc.

Multifamily high-rise: multifamily structures of four or more stories above grade

Multifamily low-rise: multifamily structures of three or less stories above grade

Multiplication factor (M): indicates the relative reduction in annual solar cooling load from overhangs and/or side fins with given projection factors, relative to the respective horizontal and vertical fenestration dimensions.

Non-automatic: see *manual*.

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

CSERC: The Chhattisgarh State Electricity Regulatory Commission.

Opaque: all areas in the building envelope, except fenestration and building service openings such as vents and grilles.

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

Outdoor (outside) air: air that is outside the building envelope or is taken from outside the building that has not been previously circulated through the building.

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

Packaged Terminal Air Conditioner (PTAC): a factory-selected wall sleeve and separate unencased combination of heating and cooling components, assemblies, or sections. It may include heating capability by hot water, steam, or electricity, and is intended for mounting through the wall to service a single room or zone.

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

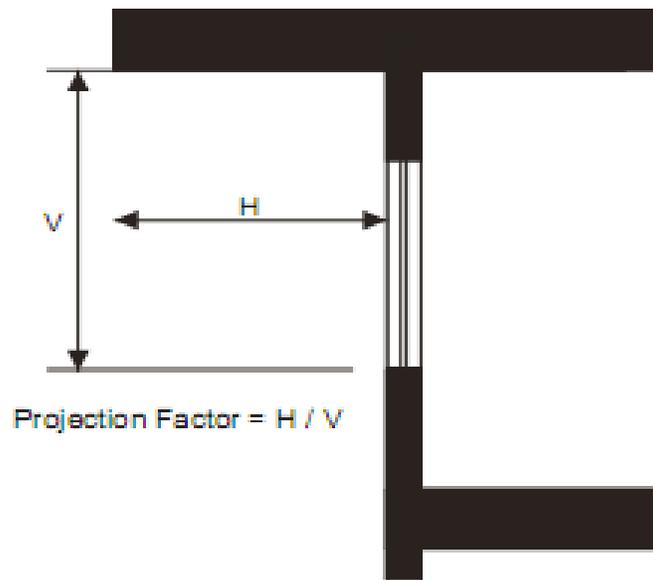
Permanently installed: equipment that is fixed in place and is not portable or movable.

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. A plenum often is formed in part or in total by portions for the building.

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.

Process load: the load on a building resulting form the consumption or release of process energy.

Projection factor, overhang: the ratio of the horizontal depth of the external shading projection divided by 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, sidefins: the ratio of the horizontal depth of the external shading projection divided by the distance from the window jamb to the farthest point of the external shading projection, in consistent units.

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 are $m^2 \cdot ^\circ C/W$ ($h \cdot ft^2 \cdot ^\circ F/Btu$). For the prescriptive building envelope option, R-value is for the insulation alone and does not include building materials or air films.

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).

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

Resistance, electric: the property of an electric circuit or of any object used as part of an electric circuit that determines for a given circuit the rate at which electric energy is converted into heat or radiant energy and that has a value such that the product of the resistance and the square of the current gives the rate

of conversion of energy.

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

Residential: spaces in buildings used primarily for living and sleeping. Residential spaces include, but are not limited to, dwelling units, hotel/motel guest rooms, dormitories, nursing homes, patient rooms in hospitals, lodging houses, fraternity/sorority houses, hostels, prisons, and fire stations.

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.

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

SDA: The State Designated Agency as notified under Section 15(e) of the Energy Conservation Act 2012 by the State Govt.

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

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

Set point: point at which the desired temperature (°F) of the heated or cooled space is set.

Shading Coefficient (SC): the ratio of solar heat gain at normal incidence through glazing to that occurring through 3 mm (1/8 in) thick clear, double-strength glass. Shading coefficient, as used herein, does not include interior, exterior, or integral shading devices

Simulation program: a computer program that is capable of simulating the energy performance of building systems.

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

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

slab-on-grade floor: that portion of a slab floor of the building envelope that is in contact with ground and that is either above grade or is less than or equal to 24 in 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.

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

- a) **Conditioned space:** a cooled space, heated space, or directly conditioned space for human comfort.
- b) **Semi-heated space:** an enclosed space within a building that is heated by a heating system whose output capacity is greater or equal to 10.7 W/m^2 (3.4 Btu/h-ft^2) of floor area but is not a conditioned space.
- c) **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.

Standard Design: a computer representation of a high pathological design based on the actual proposed design as per Appendix B §12-Whole Building performance method .

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

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

Terminal: a device by which energy form a system is finally delivered, e.g., registers, diffusers, lighting fixtures, faucets, etc.

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.

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. Units of U are $\text{W/m}^2\text{-}^\circ\text{C}$ ($\text{Btu/h-ft}^2\text{-}^\circ\text{F}$).

Thermostat: an automatic control device used to maintain temperature at a fixed or adjustable set point.

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.

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 supply air to the space.

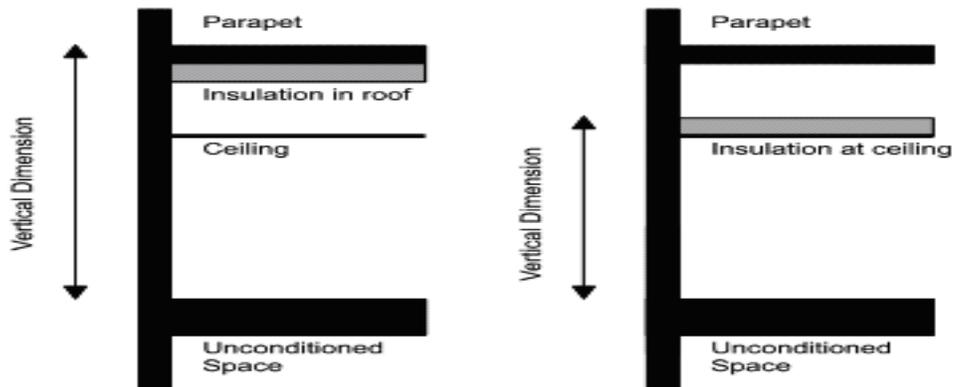
Vent damper: a device intended for installation in the venting system or an individual, automatically operated, fossil fuel-fired appliance in the outlet or downstream of the appliance draft control device, which is designed to automatically open the venting system when the appliance is in operation and to automatically close off the venting system when the appliance is in standby or shutdown condition.

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.

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

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

Wall area, gross: the overall area off a wall including openings such as windows and doors, measured horizontally from outside surface to outside service and measured vertically from the top of the floor to the top of the roof. If roof insulation is installed at the ceiling level rather than the roof, then the vertical measurement is made to the top of the ceiling. (Note that §5.3.1 does not allow roof insulation to be located on a suspended ceiling with removable ceiling panels.) 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 is 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).

11.3 Abbreviations and Acronyms

AFUE	Annual fuel utilization efficiency
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/ft ² -°F	British thermal units per square foot per degree Fahrenheit
Btu/h-ft ²	British thermal units per hour per square foot

Btu/h-ft-°F	British thermal units per lineal foot per degree Fahrenheit
Btu/h-ft ² -°F	British thermal units per hour per square foot per degree Fahrenheit
DOE	US Department of Energy
EER	Energy Efficiency Ratio
EF	Energy Factor
ft	foot
h	hour
HC	heat capacity
h-ft ² -°F/Btu	hour per square foot per degree Fahrenheit per British thermal unit
h-m ² -°C/W	hour per square meter per degree Celsius per Watt
hp	horsepower
HSPF	heating seasonal performance factor
HVAC	heating, ventilation, and air conditioning
I-P	Inch-pound
in.	inch
IPLV	integrated part-load value
kVA	kilovolt-ampere
kW	kilowatt
kWh	kilowatt-hour
LE	lighting efficacy
lin	linear
lin ft	linear foot
lm	lumen
LPD	lighting power density
m	meter
mm	millimeter
NAECA	National Appliance Energy Conservation Act
OPWD	Chhattisgarh Public Works Department
PF	projection factor
PTAC	packaged terminal air conditioner
R	R-value (thermal resistance)
SC	shading coefficient
SHGC	solar heat gain coefficient
SL	standby loss
VAV	variable air volume
VLT	visible light transmission
W	watt
W/ft ²	watts per square foot
W/m ²	watts per square meter
W/m ² -°C	watts per square meter per degree Celsius
W/m ₂	watts per hour per square meter
W/m-°C	watts per lineal meter per degree Celsius
W/m ² -°C	watts per hour per square meter per degree Celsius
Wh	watthour

12. Appendix-B: Whole Building Performance Method

12.1 General

12.1.1 Scope

The whole building performance method is an alternative to the prescriptive requirements contained in § 1 through §10 of this standard. It applies for all building types covered by the code.

12.1.2 Compliance

A building complies with the whole building performance method when the estimated annual energy use of the proposed design is less than the standard design, even though it may not comply with the specific requirements of the prescriptive requirements in §2 through §10.

The mandatory requirements of §2 through §10 (§.2, 5.2, §6.2, §7.2 §8.2, §9.2 and §10.1) shall be satisfied with the whole building performance method.

12.1.3 Annual Energy Use

Annual energy use for the purposes of the whole building performance method shall be calculated in kilowatt-hours (kWh) of electricity use per year. Energy sources other than electricity which are used in the building shall be converted to kWh of electric energy at the rate of 0.75 kWh per mega Joule.

12.1.4 Trade-offs Limited to Building Permit

The whole building performance 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.

12.1.5 Documentation Requirements

Compliance shall be documented and submitted to the authority having jurisdiction.

The information submitted shall include the following:

- (a) The annual energy use for the proposed design and the standard design.
- (b) A list of the energy-related building features in the proposed design those are different from the standard design.
- (c) 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 amount of time any loads

are not met by the HVAC system for both the proposed design and standard design.

- (d) An explanation of any error messages noted in the simulation program output.

12.2 Simulation General Requirements

12.2.1 Energy Simulation Program

The simulation program 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 and shall model the following:

- i. Energy flows on an hourly basis for all 8,760 hours in the year,
- ii. 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,
- iii. Thermal mass effects,
- iv. Ten or more thermal zones,
- v. Part-load and temperature dependent performance of heating and cooling equipment,
- vi. Air-side and water-side economizers with integrated control, and
- vii. All of the standard design characteristics specified in this chapter.

12.2.2 Climatic 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 climatic 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.

12.2.3 Compliance Calculations

The proposed design and standard design shall be calculated using the following:

- (a) Same simulation program,
- (b) Same weather data, and
- (c) Same building operation assumptions (thermostat set points, schedules, internal gains, occupant loads, etc.).

12.3 Calculating the Energy Consumption of the Proposed Design and the Standard Design.

12.3.1 The simulation model for calculating the proposed design and the

standard design shall be developed in accordance with the requirements in Table 10.1 of ECBC

12.3.2 HVAC Systems

The HVAC system type and related performance parameters for the standard design shall be determined from Table 12.1 and the following rules:

- (a) Other Components: Components and parameters not listed in Table 12.2 or otherwise specifically addressed in this subsection shall be identical to those in the proposed design.
(Exception to §12.3.2(a): Where there are specific requirements, 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 §6.22.
- (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.
- (e) The equipment capacities for the standard design shall be sized proportionally to the capacities in the proposed design based on sizing runs; i.e., the ratio between the capacities used in the annual simulations and the capacities determined by the sizing runs shall be the same for both the proposed design and standard design. Unmet load hours for the proposed design shall not differ from unmet load hours for the standard design by more than 50 hours. The maximum number of unmet hours shall not exceed 300 for either case.

Table 12.1 Modeling Requirements for Calculating Proposed and Standard Design:

Refer to table 10.1 of ECBC-2007.

Table 12. HVAC System Map: Refer to table 10.2 of ECBC-2007.

13. Appendix C-Default Values for Typical Constructions

13.1 Procedure for Determining Fenestration Product U-Factor and Solar Heat Gain Coefficient

§5.2.1.1 and §5.2.1.2 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. The building envelope trade-off option in §5.4 requires the use of visible light transmittance (VLT).

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) §.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 refer the issue of material properties to national standards. Material conductivities and emissivities shall be determined in accordance with Indian standards.
- (d) § 7 of ISO 15099 on shading systems are currently excluded.
- (e) § 8.2 of ISO 15099 addresses environmental conditions. The following are defined for India:

For U-factor calculations:

$$T_{in} = 24^{\circ}\text{C } 75\text{F}$$

$$T_{out} = 32^{\circ}\text{C } 89\text{F}$$

$$V = 3.35 \text{ m/s } 7.5\text{mph}$$

$$T_{r,m,out} = T_{out}$$

$$T_{r,m,in} = T_{in}$$

$$I_s = 0 \text{ W/m}^2 \text{ (248 Btu/Hr/Ft}^2\text{)}$$

For SHGC calculations:

$$T_{in} = 24^{\circ}\text{C}$$

$$T_{out} = 32^{\circ}\text{C}$$

$$V = 2.75 \text{ m/s}$$

$$T_{r,m,out} = T_{out}$$

$$T_{r,m,in} = T_{in}$$

$$I_s = 783 \text{ W/m}^2$$

- (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 § 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.

13.2 Default U-Factors 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.

13.2.1 Unrated Vertical Fenestration. Unlabeled vertical fenestration, both operable and fixed, shall be assigned the U-factors, SHGCs, and visible light transmittances in Table 13.1.

Table 13.1 Defaults for Unrated Vertical Fenestration (Overall Assembly including the Sash and Frame)

Clear Glass					Tinted Glass		
Frame Type	Glazing type	U-Factor W/m-°C	SHGC	VLT	U-Factor W/m-°C	SHGC	VLT
All frame types	Single Glazing	7.1	0.82	0.76	7.1	0.70	0.58
Wood, Vinyl or fiberglass frame	Double Glazing	3.3	0.59	0.64	3.4	0.42	0.39
Metal and other frame type	Double Glazing	5.1	0.68	0.66	5.1	0.50	0.40

13.2.2 Unrated Sloped Glazing and Skylights

Unrated sloped glazing and skylights, both operable and fixed, shall be assigned the SHGCs and visible light transmittances in Table 13.1. To determine the default U-factor for unrated sloped glazing and skylights without a curb, multiply the values in Table 13.1 by 1.2. To determine the default U-factor for unrated skylights on a curb, multiply the values in Table 13.1 by 1.6.

13.3 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:

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

Where

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

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

$U_{\text{Typical Insulation}}$ U-factor of the effective insulation from Table 13.2.

Table 13.2 Defaults for Effective U-factor for Exterior Insulation Layers

Thickness	R-Value	U-factor W/m-°K
15 mm(0.5")	0.70(4)	1.420
20 mm(0.75")	1.06(6)	0.946
25 mm(1.0")	1.41(8)	0.710
40 mm(1.5")	2.11(12)	0.568
50 mm(2.0")	2.82(16)	0.406
65 mm(2.5")	3.52(20)	0.284
75 mm(3.0")	3.70(21)	0.270

13.4 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:

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

where

$U_{\text{TotalWall}}$ Total U-factor of the wall with insulation

$U_{\text{Typical Wall}}$ U-factor of the wall from Table 13.3 or Table 13.4

$U_{\text{Typical Insulation}}$ U-factor of the effective insulation from Table 13.3 or Table 13.4

Table 13.3 Defaults for Effective U-factor for Exterior Insulation Layers

Thickness	R-Value	U-factor W/m-°K
15 mm(0.5")	0.70(4)	1.262
20 mm(0.75")	1.06(6)	0.874
25 mm(1.0")	1.41(8)	0.668
40 mm(1.5")	2.11(12)	0.454
50 mm(2.0")	2.82(16)	0.344
65 mm(2.5")	3.52(20)	0.277
75 mm(3.0")	3.70(21)	0.264

Table 13.4 Typical Thermal Properties of Common Building and Insulating Materials
(Source: ASHRAE Fundamentals Handbook, 2001)

Description	Density kg/m ³	Conductivity ^a (K), W/(m K)	Conductance (C), W/(m ² K)	Resistance ^c (R)		Specific Heat kJ/(kg K)
				1/k, K m ² /W	For Thickness Listed (1/C), K m ² /W	
BUILDING BOARD						
Asbestos cement board.....	1900	0.58	—	1.73	—	1.00
Asbestos-cement board....3.2 mm	1900	—	187.4	—	0.05	—
Asbestos-cement board....6.4 mm	1900	—	93.7	—	0.011	—
Gypsum or plaster board. 9.5 mm	800	—	17.6	—	0.056	1.09
Gypsum or plaster board12.7 mm	800	—	12.6	—	0.079	—
Gypsum or plaster board15.9 mm	800	—	10.1	—	0.099	—
Plywood (Douglas fir) ^d	540	0.12	—	8.66	—	1.21
Plywood or wood panels.19.0 mm	540	—	6.1	—	0.16	1.21
Vegetable fiber board						
Sheathing, regular density ^e12.7mm	290	—	4.3	—	0.23	1.30
.....19.8 mm	290	—	2.8	—	0.36	—
Sheathing intermediate density ^e12.7 mm	350	—	5.2	—	0.19	1.30
Nail-base sheathing ^e12.7 mm	400	—	5.3	—	0.19	1.30
Shingle backer.....9.5 mm	290	—	6.0	—	0.17	1.30
Sound deadening board12.7mm	240	—	4.2	—	0.24	1.26
Tile and lay-in panels, plain or acoustic	290	0.058	—	17.	—	0.59
.....12.7 mm	290	—	4.5	—	0.22	—
.....19.0 mm	290	—	3.0	—	0.33	—
Laminated paperboard	480	0.072	—	13.9	—	1.38
Homogeneous board from re pulped paper.....	480	0.072	—	13.9	—	1.17
Hardboard^g						
Medium density	800	0.105	—	9.50	—	1.30
High density, service-tempered grade and service grade.....	880	0.82	—	8.46	—	1.34
High density, standard- tempered grade.....	1010	0.144	—	6.93	—	1.34

Description	Density kg/m ³	Conductivity ^b (K), W/(m K)	Conductance (C), W/(m ² K)	Resistance ^c (R)		Specific Heat kJ/(kg K)
				1/k, K m ² /W	For Thickness Listed (1/C), K m ² /W	
Particle board^d						
Low density.....	590	0.102	—	9.77	—	1.30
Medium density	800	0.135	—	7.35	—	1.30
High density.....	1000	0.170	—	5.90	—	1.30
Underlayment.....15.9 mm	640	—	6.9	—	0.14	1.21
Waferboard.....	590	0.01	—	11.0	—	—
Wood subfloor.....19.0 mm	—	—	6.0	—	0.17	1.38
BUILDING MEMBRANE						
Vapor—permeable felt.....	—	—	94.9	—	0.011	—
Vapor—seal, 2 layers of mopped 0.73 kg/m ² felt.....	—	—	47.4	—	0.21	—
Vapor—seal, plastic film.....	—	—	—	—	Negl.	—
FINISH FLOORING MATERIALS						
Carpet and fibrous pad	—	—	2.73	—	0.37	1.42
Carpet and rubber pad.....	—	—	4.60	—	0.22	1.38
Cork tile,3.2 mm	—	—	20.4	—	0.049	2.01
Terrazzo.....25 mm	—	—	71.0	—	0.014	0.80
Tile—asphalt, linoleum, vinyl, rubber.....	—	—	113.6	—	0.009	1.26
vinyl asbestos.....	—	—	—	—	—	1.01
ceramic.....	—	—	—	—	—	0.80
Wood, hardwood finish.....19mm	—	—	8.35	—	0.12	—
INSULATING MATERIALS						
<i>Blanket and Batt^e</i>						
Mineral fiber, fibrous form processed						
from rock, slag, or glass						
approx. 75-100 mm.....	6.4-32	—	0.52	—	1.94	—
approx. 90 mm	6.4-32	—	0.44	—	2.29	—
approx. 90 mm	19-26	—	0.38	—	2.63	—
approx. 140-165 mm.....	6.4-32	—	0.30	—	3.32	—
approx. 140 mm	10-16	—	0.27	—	3.67	—
approx. 150-190 mm.....	6.4-32	—	0.26	—	3.91	—

Description	Density kg/m ³	Conductivity ^a (K), W/(m·K)	Conductance (C) _c W/(m ² ·K)	Resistance ^c (R)		Specific Heat kJ/(kg·K)
				1/k, K·m ² /W	For Thickness Listed (1/C), K·m ² /W	
approx. 210-250 mm.....	6.4-32	—	0.19	—	5.34	—
approx. 250-330 mm.....	6.4-32	—	0.15	—	6.77	—
<i>Board and Slabs</i>						
Cellular glass.....	136	0.050	—	19.8	—	0.75
Glass fiber, organic bonded.....	64-140	0.036	—	27.7	—	0.96
Expanded perlite, organic bonded	16	0.052	—	19.3	—	1.26
Expanded rubber (rigid).....	72	0.032	—	31.6	—	1.68
Expanded polystyrene, extruded (smooth skin surface) (CFC-12 exp.).....	29-56	—	—	—	—	—
Expanded polystyrene, extruded (smooth skin surface) (HCFC- 142b exp.) ^b	29-56	0.029	—	34.7	—	1.21
Expanded polystyrene, molded beads.....	16	0.037	—	26.7	—	—
	20	0.036	—	27.7	—	—
	24	0.035	—	28.9	—	—
	28	0.035	—	28.9	—	—
	32	0.033	—	30.2	—	—
Cellular polyurethane/ polyisocyanurate ^c (CFC-11 exp.) (unfaced).....	24	0.023-0.026	—	43.3-38.5	—	1.59
Cellular polyisocyanurate ^c (CFC-11 exp.) (gas-permeable facers).....	24-40	0.023-0.026	—	43.3-38.5	—	0.92
Cellular polyisocyanurate ^c (CFC-11 exp.) (gas-impermeable facers).....	32	0.020	—	48.8	—	0.92
Cellular phenolic (closed cell) (CFC-11, CFC-113 exp.) ^d	32	0.017	—	56.8	—	—
Cellular phenolic (open cell).....	29-35	0.033	—	30.5	—	—
Mineral fiber with resin binder ...	240	0.042	—	23.9	—	0.71
<i>Mineral fiberboard, wet felted</i>						
Core or roof insulation.....	260-270	0.049	—	20.4	—	—
Acoustical tile	290	0.050	—	19.8	—	0.80
Acoustical tile	340	0.053	—	18.7	—	—

Description	Density kg/m ³	Conductivity ^b (K), W/(m·K)	Conductance (C), W/(m ² ·K)	Resistance ^c (R)		Specific Heat kJ/(kg·K)
				1/k, K·m ² /W	For Thickness Listed (1/C), K·m ² /W	
<i>Mineral fiberboard, wet molded</i>						
Acoustical tile ¹	370	0.060	—	16.5	—	0.59
<i>Wood or cane fiberboard</i>						
Acoustical tile ¹12.7 mm	—	—	4.5	—	0.22	1.30
Acoustical tile ¹19.0 mm	—	—	3.0	—	0.33	—
Interior finish (plank, tile).....	240	0.050	—	19.8	—	1.34
Cement fiber slabs (shredded wood with Portland cement binder)	400-430	0.072-0.076	—	13.9-13.1	—	—
Cement fiber slabs (shredded wood with magnesia oxysulfide binder).....	350	0.082	—	12.1	—	1.30
<i>Loose Fill</i>						
Cellulosic insulation (milled paper or wood pulp)	37-51	0.039-0.046	—	25.6-21.7	—	1.38
Perlite, expanded.....	32-66	0.039-0.045	—	25.6-22.9	—	1.09
	66-120	0.045-0.052	—	22.9-19.4	—	—
	120-180	0.052-0.060	—	19.4-16.6	—	—
<i>Mineral fiber (rock, slag, or glass)²</i>						
approx. 95-130 mm.....	9.6-32	—	—	—	1.94	0.71
approx. 170-220 mm.....	9.6-32	—	—	—	3.35	—
approx. 190-250 mm.....	9.6-32	—	—	—	3.87	—
approx. 260-350 mm.....	9.6-32	—	—	—	5.28	—
<i>Mineral fiber (rock, slag, or glass)³</i>						
approx. 90 mm (closed sidewall application)	32-56	—	—	—	2.1-2.5	—
Vermiculite, exfoliated.....	110-130	0.068	—	14.8	—	1.34
	64-96	0.063	—	15.7	—	—
<i>Spray Applied</i>						
Polyurethane foam	24-40	0.023-0.026	—	43.3-38.5	—	—
Urea formaldehyde foam	11-26	0.032-0.040	—	31.5-24.7	—	—
Cellulosic fiber.....	56-96	0.042-0.049	—	23.9-20.4	—	—
Glass fiber	56-72	0.038-0.039	—	26.7-25.6	—	—
<i>Reflective Insulation</i>						

Description	Density kg/m ³	Conductivity ^b (K), W/(m K)	Conductance (C) _z W/(m ² K)	Resistance ^c (R)		Specific Heat kJ/(kg K)
				1/k, K-m ² /W	For Thickness Listed (1/C), K-m ² /W	
Reflective material (ε<0.5) in center of 20mm cavity forms two 10 mm vertical air spaces ^m	—	—	1.76	—	0.57	—
METALS						
(See Chapter 38, Table 3 of ASHRAE Fundamentals Handbook 2001)						
ROOFING						
Asbestos-cement shingles	1900	—	27.0	—	0.037	1.00
Asphalt roll roofing.....	1100	—	36.9	—	0.026	1.51
Asphalt shingles.....	1100	—	12.9	—	0.077	1.26
Built-up roofing10 mm	1100	—	17.0	—	0.058	1.46
Slate13 mm	—	—	114	—	0.009	1.26
Wood shingles, plain and plastic film faced	—	—	6.0	—	0.166	1.30
PLASTERING MATERIALS						
Cement plaster, sand aggregate...	1860	0.72	—	1.39	—	0.84
Sand aggregate.....10 mm	—	—	75.5	—	0.013	0.84
Sand aggregate.....20 mm	—	—	37.8	—	0.026	0.84
Gypsum plaster:						
Lightweight aggregate ...13 mm	720	—	17.7	—	0.056	—
Lightweight aggregate ...16 mm	720	—	15.2	—	0.066	—
Lightweight aggregate on metal lath19 mm	—	—	12.1	—	0.083	—
Perlite aggregate.....	720	0.22	—	4.64	—	1.34
Sand aggregate.....	1680	0.81	—	1.25	—	0.84
Sand aggregate.....13 mm	1680	—	63.0	—	0.016	—
Sand aggregate.....16 mm	1680	—	51.7	—	0.019	—
Sand aggregate on metal lath19 mm	—	—	43.7	—	0.023	—
Vermiculite aggregate	720	0.24	—	4.09	—	—
MASONRY MATERIALS						
<i>Masonry Units</i>						
Brick, fired clay	2400	1.21-1.47	—	0.83-0.68	—	—
	2240	1.07-1.30	—	0.94-0.77	—	—

Appendix C: Default Values for Typical Constructions

Description	Density kg/m ³	Conductivity ^b (K), W/(m-K)	Conductance (C), W/(m ² -K)	Resistance ^c (R)		Specific Heat kJ/(kg K)
				1/k, K-m ² /W	For Thickness Listed (1/C), K-m ² /W	
	2080	0.92-1.12	—	1.08-0.89	—	—
	1920	0.81-0.98	—	1.24-1.02	—	0.79
	1760	0.71-0.85	—	1.42-1.18	—	—
	1600	0.61-0.74	—	1.65-1.36	—	—
	1440	0.52-0.62	—	1.93-1.61	—	—
	1280	0.43-0.53	—	2.31-1.87	—	—
	1120	0.36-0.45	—	2.77-2.23	—	—
Clay tile, hollow						
1 cell deep75 mm	—	—	7.10	—	0.14	0.88
1 cell deep100 mm	—	—	5.11	—	0.20	—
2 cells deep..... 150 mm	—	—	3.75	—	0.27	—
2 cells deep..... 200 mm	—	—	3.07	—	0.33	—
2 cells deep..... 250 mm	—	—	2.56	—	0.39	—
3 cells deep.....300 mm	—	—	2.27	—	0.44	—
Concrete blocks ^{c, d}						
Limestone aggregate						
200 mm, 16.3 kg, 2210 kg/m ³ concrete, 2 cores.....	—	—	—	—	—	—
Same with perlite filled cores	—	—	2.73	—	0.37	—
300 mm, 25 kg, 2210 kg/m ³ concrete, 2 cores.....	—	—	—	—	—	—
Same with perlite filled cores	—	—	1.53	—	0.65	—
Normal mass aggregate (sand and gravel) 200 mm						
15-16 kg, 2020-2180 kg/m ³ concrete, 2 or 3 cores	—	—	5.1-5.8	—	0.20-0.17	0.92
Same with perlite filled cores	—	—	2.84	—	0.35	—
Same with vermiculite filled cores	—	—	3.0-4.1	—	0.34-0.24	—
300 mm, 22.7 kg, 2000 kg/m ³ concrete, 2 cores.....	—	—	4.60	—	0.217	0.92

Description	Density kg/m ³	Conductivity ^a (K), W/(m·K)	Conductance (C), W/(m ² ·K)	Resistance ^b (R)		Specific Heat kJ/(kg·K)
				1/k _e K m ² /W	For Thickness Listed (1/C), K m ² /W	
Medium mass aggregate (combinations of normal and low mass aggregate) 200 mm, 12-13 kg, 1550-1790 kg/m ³ concrete, 2 or 3 cores.....	—	—	3.3-4.4	—	0.30-0.22	—
Same with perlite filled cores	—	—	1.5-2.5	—	0.65-0.41	—
Same with vermiculite filled cores	—	—	1.70	—	0.58	—
Same with molded EPS (beads) filled cores	—	—	1.82	—	0.56	—
Same with molded EPS inserts in cores.....	—	—	2.10	—	0.47	—
Low mass aggregate (expanded shale, clay, slate or slag, pumice) 150 mm 7.3-7.7 kg, 1360-1390 kg/m ³ concrete, 2 or 3 cores.....	—	—	3.0-3.5	—	0.34-0.29	—
Same with perlite filled cores	—	—	1.36	—	0.74	—
Same with vermiculite filled cores	—	—	1.87	—	0.53	—
200 mm, 8.6-10.0 mm, 1150-1380 kg/m ³ concrete	—	—	1.8-3.1	—	0.56-0.33	0.88
Same with perlite filled cores	—	—	0.9-1.3	—	1.20-0.77	—
Same with vermiculite filled cores.....	—	—	1.1-1.5	—	0.93-0.69	—
Same with molded EPS (beads) filled cores	—	—	1.19	—	0.85	—
Same with UF foam filled cores.	—	—	1.25	—	0.79	—
Same with molded EPS inserts in cores.....	—	—	1.65	—	0.62	—
300 mm, 14.5-16.3 kg, 1280-1440 kg/m ³ concrete, 2 or 3 cores...	—	—	2.2-2.5	—	0.46-0.40	—
Same with perlite filled cores	—	—	0.6-0.9	—	1.6-1.1	—
Same with vermiculite filled cores	—	—	0.97	—	1.0	—
Stone, lime, or sand						
Quartzitic and sandstone.....	2880	10.4	—	0.10	—	—
	2560	6.2	—	0.16	—	—
	2240	3.5	—	0.29	—	—
	1920	1.9	—	0.53	—	0.79

Description	Density kg/m ³	Conductivity ^a (K), W/(m K)	Conductance (C), W/(m ² K)	Resistance ^c (R)		Specific Heat kJ/(kg K)
				1/k, K m ² /W	For Thickness Listed (1/C), K m ² /W	
Calcitic, dolomitic, limestone, marble, and granite	2880	4.3	—	0.23	—	—
	2560	3.2	—	0.32	—	—
	2240	2.3	—	0.43	—	—
	1920	1.6	—	0.63	—	0.79
	1600	1.1	—	0.90	—	—
Gypsum partition tile						
75 by 300 by 760 mm, solid.....	—	—	4.50	—	0.222	0.79
75 by 300 by 760 mm, 4 cells ...	—	—	4.20	—	0.238	—
100 by 300 by 760 mm, 3 cells	—	—	3.40	—	0.294	—
<i>Concretes^b</i>						
Sand and gravel or stone aggregate concretes (concretes with more than	2400	1.4-2.9	—	0.69-0.35	—	—
50% quartz or quartzite sand have conductivities in the higher end of the range).....	2240	1.3-2.6	—	0.77-0.39	—	0.8-1.0
2080	1.0-1.9	—	0.99-0.53	—	—	
Limestone concretes	2240	1.60	—	0.62	—	—
	1920	1.14	—	0.88	—	—
	1600	0.79	—	1.26	—	—
Gypsum-fiber concrete (87.5% gypsum, 12.5% wood chips)	816	0.24	—	4.18	—	0.88
Cement/lime, mortar, and stucco	1920	1.40	—	0.71	—	—
	1600	0.97	—	1.04	—	—
	1280	0.65	—	1.54	—	—
Lightweight aggregate concretes						
Expanded shale, clay, or slate; expanded slags;	1920	0.9-1.3	—	1.08-0.76	—	—
cinders; pumice (with density up to 1600 kg/m ³);	1600	0.68-0.89	—	1.48-1.12	—	0.84
and scoria (sanded concretes have conductivities in	1280	0.48-0.59	—	2.10-1.69	—	0.84
the higher end of the range)	960	0.30-0.36	—	3.30-2.77	—	—
640	0.18	—	5.40	—	—	

Description	Density kg/m ³	Conductivity ^a (K), W/(m K)	Conductance (C), W/(m ² K)	Resistance ^c (R)		Specific Heat kJ/(kg K)
				1/k, K m ² /W	For Thickness Listed (1/C), K m ² /W	
Perlite, vermiculite, and polystyrene beads	800	0.26-0.27	—	3.81-3.68	—	—
	640	0.20-0.22	—	4.92-4.65	—	0.63-0.96
	480	0.16	—	6.31	—	—
	320	0.12	—	8.67	—	—
Foam concretes	1920	0.75	—	1.32	—	—
	1600	0.60	—	1.66	—	—
	1280	0.44	—	2.29	—	—
	1120	0.36	—	2.77	—	—
Foam concretes and cellular concretes.....	960	0.30	—	3.33	—	—
	640	0.20	—	4.92	—	—
	320	0.12	—	8.67	—	—
SIDING MATERIALS (on flat surface)						
<i>Shingles</i>						
Asbestos-cement	1900	—	27.0	—	0.037	—
Wood, 400 mm, 190 mm exposure	—	—	6.53	—	0.15	1.30
Wood, double, 400 mm, 300 mm exposure	—	—	4.77	—	0.21	1.17
Wood, plus insul. backer board,8 mm	—	—	4.03	—	0.25	1.30
<i>Siding</i>						
Asbestos-cement, 6.4 mm, lapped	—	—	27.0	—	0.037	1.01
Asphalt roll siding.....	—	—	36.9	—	0.026	1.47
Asphalt insulating siding (12.7 mm bed.).....	—	—	3.92	—	0.26	1.47
Hardboard siding, 11 mm	—	—	8.46	—	0.12	1.17
Wood, drop, 20 by 200 mm.....	—	—	7.21	—	0.14	1.17
Wood, bevel, 13 by 200 mm, lapped.....	—	—	6.98	—	0.14	1.17
Wood, bevel, 19 by 250 mm, lapped.....	—	—	5.40	—	0.18	1.17
Wood, plywood, 9.5 mm, lapped	—	—	9.60	—	0.10	1.22

Description	Density kg/m ³	Conductivity ^b (K), W/(m·K)	Conductance (C), W/(m ² ·K)	Resistance ^c (R)		Specific Heat kJ/(kg·K)
				1/k, K·m ² /W	For Thickness Listed (1/C), K·m ² /W	
Aluminum, steel, or vinyl ^d over sheathing						
Hollow-backed.....	—	—	9.31	—	0.11	1.22 ^e
Insulating-board backed.....	—	—	—	—	—	—
9.5 mm nominal	—	—	3.12	—	0.32	1.34
9.5 mm nominal, foil backed	—	—	1.93	—	0.52	—
Architectural (soda-lime float) glass	—	—	56.8	—	0.018	0.84
WOODS (12% moisture content)^{b,c}						
<i>Hardwoods</i>						
Oak.....	659-749	0.16-0.18	—	6.2-5.5	—	1.63 ^f
Birch.....	682-726	0.167-0.176	—	6.0-5.7	—	—
Maple	637-704	0.157-0.171	—	6.4-5.8	—	—
Ash	614-670	0.153-0.164	—	6.5-6.1	—	—
<i>Softwoods</i>						
Southern pine	570-659	0.144-0.161	—	6.9-6.2	—	1.63 ^f
Douglas fir-Larch.....	536-581	0.137-0.145	—	7.3-6.9	—	—
Southern cypress	502-514	0.130-0.132	—	7.7-7.6	—	—
Hem-Fir, Spruce-Pine-Fir	392-502	0.107-0.130	—	9.3-7.7	—	—
West coast woods, Cedars.....	347-502	0.098-0.130	—	10.3-7.7	—	—
California redwood	392-448	0.107-0.118	—	9.4-8.5	—	—
*For referencing a, b, c, etc. of the above table, refer to the notes on next pages						

***Notes of Table 13.4**

^aValues are for a 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 their in-situ properties (e.g., density and moisture content, orientation, etc.) and variability experienced during manufacture. For properties of a particular product, use the value supplied by the manufacturer or by unbiased tests.

^bThe symbol λ is also used to represent thermal conductivity.

^cResistance values are the reciprocals of C before rounding off C to two decimal places.

^dLewis (1967).

^eU.S. Department of Agriculture (1974).

^fDoes not include paper backing and facing, if any. Where insulation forms a boundary (reflective or otherwise) of an airspace, see Tables 2 and 3 for the insulating value of an airspace with the appropriate effective emittance and temperature conditions of the space.

^gConductivity varies with fiber diameter. (See Chapter 23, Factors Affecting Thermal Performance.) 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. Due to differences in manufacturing processes and materials, the product thicknesses, densities, and thermal conductivities vary over considerable ranges for a specified R-value.

^hThis material is relatively new and data are based on limited testing.

ⁱFor additional information, see Society of Plastics Engineers (SPI) *Bulletin* U108. Values are for aged, unfaced board stock. For change in conductivity with age of expanded polyurethane/polyisocyanurate, see Chapter 23, Factors Affecting Thermal Performance.

^jValues are for aged products with gas-impermeable facers on the two major surfaces. An aluminium foil facer of 25 μm thickness or greater is generally considered impermeable to gases. For change in conductivity with age of expanded polyisocyanurate, see Chapter 23, Factors Affecting Thermal Performance, and SPI *Bulletin* U108.

^kCellular phenolic insulation may no longer be manufactured. The thermal conductivity and resistance values do not represent aged insulation, which may have a higher thermal conductivity and lower thermal resistance.

^lInsulating values of acoustical tile vary, depending on density of the board and on type, size, and depth of perforations.

^mCavity is framed with 20 mm wood furring strips. Caution should be used in applying this value for other framing materials. The reported value was derived from tests and applies to the reflective path only. The effect of studs or furring strips must be included in determining the overall performance of the wall.

ⁿValues for fully grouted block may be approximated using values for concrete with a similar unit density.

^oValues for concrete block and concrete are at moisture contents representative of normal use.

^pValues for metal or vinyl siding applied over flat surfaces vary widely, depending on amount of ventilation of 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 C 236) or calibrated hot box (ASTM C 976) on hollow-backed types and types made using backing of wood fiber,

foamed plastic, and glass fiber. Departures of ±50% or more from these values may occur.

^qVinyl specific heat=1.0 kJ/(kg.K)

^rSee Adams (1971), MacLean (1941), and Wilkes (1979). The conductivity values listed are for heat transfer across the grain. The thermal conductivity of wood varies linearly with the density, and the density ranges listed are those normally found for the wood species given. If the density of the wood species is not known, use the mean conductivity value. For extrapolation to other moisture contents, the following empirical equation developed by Wilkes (1979) may be used:

$$k = 0.7494 + \frac{(4.895 \times 10^{-3} + 1.503 \times 10^{-4}M)\rho}{1 + 0.01M}$$

where ρ is density of the moist wood in kg/m³, and M is the moisture content in percent.

^sFrom Wilkes (1979), an empirical equation for the specific heat of moist wood at 24°C is as follows:

$$c_p = 0.1442 \times \frac{(0.299 + 0.01M)}{(1 + 0.01M)} + \Delta c_p$$

where Δc_p accounts for the heat of absorption and is denoted by Δc_p = M (0.008037 - 1.325 × 10⁻⁴M)

where M is the moisture content in percent by mass.

Assuming parallel heat flow only, the calculated resistance is higher than that calculated on the assumption of isothermal planes. The actual resistance generally is some value between the two calculated values. In the absence of test values, examination of the construction usually reveals whether a value closer to the higher or lower calculated R-value should be used. Generally, if the construction contains a layer in which lateral conduction is high compared with transmittance through the construction, the calculation with isothermal planes should be used. If the construction has no layer of high lateral conductance, the parallel heat flow calculation should be used.

Hot box tests of insulated and uninsulated masonry walls constructed with block of conventional configuration show that thermal resistances calculated using the isothermal planes heat flow method agree well with measured values (Van Geem 1985, Valore 1980, Shu et al. 1979). Neglecting horizontal mortar joints in conventional block can result in thermal transmittance values up to 16% lower than actual, depending on the density and thermal properties of the masonry, and 1 to 6% lower, depending on the core insulation material (Van Geem 1985, McIntyre 1984). For aerated concrete block walls, other solid masonry, and multicore block walls with full mortar joints, neglecting mortar joints can cause errors in R-values up to 40% (Valore 1988). Horizontal mortar joints usually found in concrete block wall construction are neglected in Example 2.

Constructions Containing Metal

Curtain and metal stud-wall constructions often include metallic and other thermal bridges, which can significantly reduce the thermal resistance. However, the capacity of the adjacent facing materials to transmit heat transversely to the metal is limited, and some contact resistance between all materials in contact limits the reduction. Contact resistances in building structures are only 0.01 to 0.1 K.m²/W—too small to be of concern in many cases. However, the contact resistances of steel framing members may be important. Also, in many cases (as illustrated in Example 3), the area of metal in contact with the facing greatly exceeds the thickness of the metal, which mitigates the contact resistance effects.

Thermal characteristics for panels of sandwich construction can be computed by combining the thermal resistances of the various layers. R-values for the assembled sections should be determined on a representative sample by using a hot box method. If the sample is a wall section with air cavities on both sides of fibrous insulation, the sample must be of representative height since convective airflow can contribute significantly to heat flow through the test section. Computer modeling can also be useful, but all heat transfer mechanisms must be considered. In Example 3, the metal member is only 0.5 mm thick, but it is in contact with adjacent facings over a 32 mm-wide area. The steel

member is 90 mm deep, has a thermal resistance of approximately 0.0019 K.m²/W, and is virtually isothermal. The calculation involves careful selection of the appropriate thickness for the steel member. If the member is assumed to be 0.5 mm thick, the fact that the flange transmits heat to the adjacent facing is ignored, and the heat flow through the steel is underestimated. If the member is assumed to be 32 mm thick, the heat flow through the steel is overestimated. In Example 3, the steel member behaves in much the same way as a rectangular member 32 mm thick and 90 mm deep

14. Appendix D-Building Envelope Tradeoff Method

14.1 Equation 14.1

14.1.1 The envelope performance factor shall be calculated using the following equations.

Equations 14.1:

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

Where

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

$$EPF_{Wall} = C_{Wall,Mass} \sum_{S=1}^n U_s A_s + C_{Wall,Other} \sum_{S=1}^n U_s A_s$$

$$EPF_{Fenest} = C_{1Fenest,North} \sum_{S=1}^n SHGC_w M_w A_w + C_{2Fenest,North} \sum_{S=1}^n U_w A_w +$$

$$C_{1Fenest,NonNorth} \sum_{S=1}^n SHGC_w M_w A_w + C_{2Fenest,NonNorth} \sum_{S=1}^n U_w A_w +$$

$$C_{1Fenest,Skylight} \sum_{S=1}^n SHGC_s A_s + C_{2Fenest,Skylight} \sum_{S=1}^n U_s A_s$$

where

EPF_{Roof} Envelope performance factor for roofs. Other subscripts include walls and fenestration.

A_s, A_w The area of a specific envelope component referenced by the subscript "s" or for windows the subscript "w".

$SHGC_w$ The solar heat gain coefficient for windows (w). $SHGC_s$ refers to skylights.

M_w A multiplier for the window SHGC that depends on the projection factor of an overhang or sidefin.

U_s The U-factor for the envelope component referenced by the subscript "s".

C_{Roof} A coefficient for the "Roof" class of construction. Values of "c" are taken from Table 14-1 through Table 14.2 for each class of construction.

Table 14-1 – Envelope Performance Factor Coefficients – Composite Climate

	Daytime Occupancy		24-Hour Occupancy	
	U-Factor	SHGC	U-Factor	SHGC
Mass Walls	5.48	-	15.01	-
Curtain Wall, Other	6.38	-	22.06	-
Roofs	11.14	-	26.98	-
North Windows	-2.40	36.57	-1.49	56.09
Non-Worth windows	-1.86	46.79	-1.187	81.79
Skylights	-96.27	309.33	-295.81	923.01

Table 14-2 – Envelope Performance Factor Coefficients – Hot Humid Climate

	Daytime Occupancy		24-Hour Occupancy	
	U-Factor	SHGC	U-Factor	SHGC
Mass Walls	6.42	-	9.60	-
Curtain Wall,	14.77	-	19.71	-

Other				
Roofs	9.86	-	14.11	-
North Windows	-1.58	34.95	-7.29	84.19
Non-Worth windows	-1.00	43.09	-6.48	76.83
Skylights	-96.11	305.45	-295.45	893.55

14.2 Overhang and Side Fin Coefficients

The “M” multiplication factor can also be calculated using Equation 4.2. If the equation is used, a separate calculation shall be made for each orientation and unique shading condition.

$$\text{Equation 14-2: } M = a.PF_2 + b.PF_1 + 1$$

Table 43.3 - Overhang and Side Fin Coefficients

Device	Coefficient	North	South	East-West
Overhangs	A	0.16	0.21	0.10
	B	-0.61	-0.83	-0.58
Sidefins	A	0.23	0.12	0.14
	B	-0.74	-0.59	-0.52

14.3 Baseline Building Definition

The following rules shall be used to define the Baseline building for Envelope Tread Off .

- (a) The Baseline building shall have the same building floor area, gross wall area and gross roof area as the proposed design. If the building has both 24-hour and daytime occupancies, the distribution between these shall be the same as the proposed design.
- (b) The U-factor of each envelope component shall be equal to the criteria from §5.3 for each class of construction.
- (c) The vertical fenestration area shall be equal to the proposed design or 40% of the gross exterior wall area, which ever is less. The skylight area shall be equal to the proposed design or 5% of the gross exterior roof area, which ever is less.
- (d) The SHGC of each window or skylight component shall be equal to the criteria from §5.3.

15. Appendix- E:Climatic Zones of Chhattisgarh

The first step for applying the Chhattisgarh Energy Conservation Building Code for an energy efficient design is determining the appropriate climate zone of the building site which will prescribe the specific requirements for design and construction of the building systems and its components.

Chhattisgarh possesses an uniform climate, and falls under Composite Climatic zone. characteristics of climatic zones of Chhattisgarh.

Temperature

Summer: 25 to 45 degree Celsius,

Winter: 05 to 25 degree Celsius,

Other Climatic Conditions

High temperature in summer and cold in winter. Low humidity in summer and higher in monsoons. High direct solar radiation in all seasons except monsoons high diffused radiations. Occasional hazy sky. Hot winds in summer, cold winds in winter and strong wind in monsoons. Variable landscape and seasonal vegetation.

16. Appendix F- Air-Side Economizer Acceptance Procedures

16.1 Construction Inspection

Prior to Performance Testing, verify and document the following:

- System controls are wired correctly to ensure economizer is fully integrated (i.e. economizer will operate when mechanical cooling is enabled).
- 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 m [25 ft] away from cooling towers).
- System is provided with barometric relief, relief fan or return fan to control building pressure.

16.2 Equipment Testing

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

- Economizer damper modulates opens to 100% outside air.
- Return air damper modulates closed and is completely closed when economizer damper is 100% open.
- Economizer damper is 100% open before mechanical cooling is enabled.
- 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:

- Economizer damper closes to minimum ventilation position.
- Return air damper opens to at or near 100%.
- Relief fan (if applicable) shuts off or barometric relief dampers close. Return fan (if applicable) may still operate even when economizer is disabled.

17. Appendix G - Compliance Forms

17.1. Envelope summary.

Envelope Summary

Orissa Energy Conservation Building Code, 2011 Compliance Forms

Project Info	Project Address	Date
		For Building Department Use
	Applicant Name:	
	Applicant Address:	
	Applicant Phone:	

Project Description New Building Addition Alteration Change of Use

Compliance Option Prescriptive Envelope Trade Off (Appendix D) Systems Analysis

	<input type="radio"/> Hospital, Hotel, call center (24 hour)		<input type="radio"/> Other Building types (daytime)	
Vertical Fenestration Area Calculation	Total Vertical Fenestration Area (rough opening)	divided by	Gross Exterior Wall area	% Vertical Fenestration
	+		Times 100 equals	X100=
Note: Vertical fenestration area can not exceed 40% area for prescriptive compliance.				
Skylight Area Calculation	Total Vertical Fenestration Area (rough opening)	divided by	Gross Exterior Wall area	% Vertical Fenestration
	+		Times 100 equals	X100=
Note: Skylight area cannot exceed 5% of the gross roof area for prescriptive compliance.				

Hospital, hotel, call center (24 hour)

OPAQUE ASSEMBLY	
Roof	m Insulation R-value
Wall	m Insulation R-value
FENESTRATION	
Vertical	
	Maximum U-factor
	Maximum SHGC (or SC)
Overhang (yes or no)	
	If yes, enter Projection Factor
Side fins (yes or no)	
	If yes, enter Projection Factor
Skylight	
	Maximum U-factor
	Maximum SHGC (or SC)

Hospital, hotel, call center (24 hour)

OPAQUE ASSEMBLY	
Roof	m Insulation R-value
Wall	m Insulation R-value
FENESTRATION	
Vertical	
	Maximum U-factor
	Maximum SHGC (or SC)
Overhang (yes or no)	
	If yes, enter Projection Factor
Side fins (yes or no)	
	If yes, enter Projection Factor
Skylight	
	Maximum U-factor
	Maximum SHGC (or SC)

17.4 Mechanical Checklist						
Mechanical Permit Checklist				MECHANICAL Checklist		
Orissa Energy Conservation Building Code, 2011 Compliance Forms						
Project Address					Date	
The following information is necessary to check a building permit application for compliance with the mechanical requirements in the Orissa Energy Conservation Building Code.						
Applicability Yes, no, n.a.)	Code Section	Component	Information Required	Location on Plans	Building Department Notes	
HEATING, VENTILATING, AND AIR CONDITIONING (Chapter 6)						
MANDATORY PROVISIONS (Section 6.2)						
	6.2.2	Equipment efficiency	Provide equipment schedule with type, capacity, efficiency			
	6.2.3	Controls				
	6.2.3.1	Time clocks	Indicate thermostat with night setback, 3 different day types, and 2-hour manual override			
	6.2.3.2	Temp. & dead band	Indicate temperature control with 3 degree C dead band minimum			
	6.2.3.3	Cooling tower, fluid cooler	Indicate two-speed motor, pony motor or variable speed drive to control the fans			
	6.2.4	Piping & ductwork	Indicate sealing, caulking, gasketing and weather-stripping			
	6.2.4.1	Piping insulation	Indicate R-value of insulation			
	6.2.4.1	Ductwork insulation	Indicate R-value of insulation			
	6.2.4.1	Ductwork sealing	Specify sealing types and locations			
	6.2.5	System balancing	Specify system balancing			
PRESCRIPTIVE COMPLIANCE OPTION (Section 6.3)						
	6.3		Indicate whether project is complying with ECBC Prescriptive Option OR with ASHRAE Standard 90.1.2004			
	6.3.1	Economizer				
	6.3.1.1	Air economizer	Indicate 100% capability on schedule			
	6.3.1.2	Integrated operation	Indicate capability for partial cooling			
	6.3.1.3	Field testing	Specify tests			
	6.3.2	Variable flow hydronic				
	6.3.2.1	Pump flow rates	Indicate variable flow capacity on schedules			
	6.3.2.2	Isolation valves	Indicate two-way automatic isolation valves			
	6.3.2.3	Variable speed drive	Indicate variable speed drive			
SERVICE WATER HEATING AND PUMPING (Chapter 7)						
MANDATORY PROVISIONS (Section 7.2)						
	7.2.1	Solar water heating	Provide calculations to justify capacity to meet 20% threshold			
	7.2.2	Equipment efficiency	Provide Equipment schedule with type, capacity, efficiency			
	7.2.4	Piping insulation	Indicate R-value of insulation			
	7.2.5	Heat traps	Indicate heat trap on drawings or provide manufacturers specifications to show that equipment has internal heat trap			
	7.2.6	Pool covers	Provide vapor retardant cover for pools			
	7.2.6	Pool over 32 C	Provide R-2.1 insulation			

17.5 Lighting Summary

Lighting Summary

Orissa Energy Conservation Building Code, 2011 Compliance Forms

Project Info	Project Address	Date
	Applicant Name:	For Building Dept. Use
	Applicant Address:	
	Applicant Phone:	

Project Description	<input type="checkbox"/> New Building <input type="checkbox"/> Addition <input type="checkbox"/> Alteration <input type="checkbox"/> Change of Use
----------------------------	--

Compliance Option	<input type="checkbox"/> Prescriptive <input type="checkbox"/> Systems Analysis
--------------------------	---

Alteration Exceptions (Check box, if appropriate)	<input type="checkbox"/> Less than 50% of the fixtures are new and installed lighting wattage is not being increased
---	--

Maximum Allowed Lighting Wattage (Interior, Section 8.3)

Location (floor/room no.)	Occupancy Description	Allowed Watts per m ² **	Area in m ²	Allowed x Area
**Document all exceptions			Total Allowed Watts	

Proposed Lighting Wattage (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 Allowed Watts	

Maximum Allowed Lighting Wattage (Exterior, Section 8.3.5)

Location	Occupancy Description	Allowed Watts per m ² or per lm	Area in m ² (or lm for perimeter)	Allowed Watts x m ² (Or x lm)
Total Allowed Watts				

Proposed Lighting Wattage (Exterior)

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

Chhattisgarh Energy Conservation Building Code, 2012

17.6 Lighting Permit Checklist						
Lighting Permit Checklist					Lighting Checklist	
Orissa Energy Conservation Building Code, 2011 Compliance Forms						
Project Address					Date	
The following information is necessary to check a building permit application for compliance with the lighting requirements in the Orissa Energy Conservation Building Code 2011.						
Applicability (yes, no, n.a.)	Code Section	Component	Information Required	Location of Plans	Building Department Notes	
LIGHTING (Chapter 8)						
MANDATORY PROVISIONS (Section 8.2)						
	8.2.1	Lighting Controls				
	8.2.1.1	Automatic shutoff	Indicate automatic shutoff locations or occupancy sensors			
	8.2.1.2	Space control	Provide schedule with type, indicate locations			
	8.2.1.3	Daylight zones	Provide schedule with type and features, indicate locations			
	8.2.1.4	Ext. lighting control	Indicate photo sensor or astronomical time switch			
	8.2.1.5	Additional control	Provide schedule with type, indicate locations			
	8.2.2	Exit Signs	Indicate 5 watts maximum			
	8.2.3	Ext. bldg. grounds lgt.	Indicate minimum efficacy of 60 lumens/Watt			
	8.2.4	Control of outdoor lgt.	Indicate automatic controls			
	8.2.5	Use of daylight	Indicate minimum 20% daylight illumination			
PRESCRIPTIVE INTERIOR LIGHTING POWER COMPLIANCE OPTION (Section 8.3)						
	8.3		Indicate whether project is complying with Building Area Method (8.3.1) or the Space Function Method (8.3.2)			
	8.3.2	Building area method	Provide lighting schedule with wattage lamp and number of fixtures. Document all exceptions.			
	8.3.3	Space function method	Provide lighting schedule with wattage lamp and number of fixtures. Document all exceptions.			
	8.3.4.1	Luminaire wattage	Indicate on plans			
PRESCRIPTIVE INTERIOR LIGHTING POWER COMPLIANCE OPTION (Section 8.3.5)						
	8.3.5	Exterior Lighting Power	Provide lighting schedule with wattage of lamp and number of fixtures. Document all exceptions.			
	8.3.6	Lighting type and efficiency	Provide lighting schedule with type of lamp, CRI, design efficiency and number of fixtures. Document all exceptions.			
ELECTRICAL POWER (Chapter 9)						
MANDATORY PROVISIONS (Section 9.2)						
	9.2.1	Transformers	Provide schedule with transformer losses			
	9.2.2	Motor efficiency	Provide equipment schedule with motor capacity, efficiency			
	9.2.3	Power factor correction	Provide schedule with power factor correction			
	9.2.4	Check metering	Provide check metering and monitoring			
	9.2.5.1	Distribution system losses	Provide design calculation for losses			
	9.2.5.2	Load balancing	Provide phase wise transformer load and balancing			
ENERGY AUDITING, REPORTING AND STAR RATING (Chapter 10)						
MANDATORY PROVISIONS (Section 10.1)						
	10.1.1	Auditing of building	Provide copy of audit reports certified by BEE accredited energy auditor			
	10.1.2	Energy reporting	Provide building information and energy data in prescribed format			
	10.1.3	Star rating and display of star labeling	Indicate the star labeling approved by BEE and location of display in the building as per BEE guidelines.			

18. APPENDIX-H: BEE Star Rating for buildings.

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

Name of the Building:

City:

Table 1: Building Information and Energy Data

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

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

Signature of the building owner or authorized

18.2. Annexure-II: Contact Details.

Table 2: Contact Details of the Organization and the Contact Person.

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

a)	Name of the Architect	
b)	Postal Address	
c)	Phone No.	

a)	Name of the Contractor	
b)	Postal Address	
c)	Phone No.	

18.3. EPI and Star label for buildings *

Annexure-II

Table for Building Energy Star Rating Programme More than 50 % air conditioned built up area		Table for Building Energy Star Rating Programme Less than 50 % air conditioned built up area	
Climatic Zone- Composite		Climatic Zone- Composite	
EPI(Kwh/sqm/year)	Star Label	EPI(Kwh/sqm/year)	Star Label
190-165	1 Star	80-70	1 Star
165-140	2 Star	70-60	2 Star
140-115	3 Star	60-50	3 Star
115-90	4 Star	50-40	4 Star
Below 90	5 Star	Below 40	5 Star
Climatic Zone - Warm and Humid		Climatic Zone - Warm and Humid	
EPI(Kwh/sqm/year)	Star Label	EPI(Kwh/sqm/year)	Star Label
200-175	1 Star	85-75	1 Star
175-150	2 Star	75-65	2 Star
150-125	3 Star	65-55	3 Star
125-100	4 Star	55-45	4 Star
Below 100	5 Star	Below 45	5 Star
Climatic Zone - Hot and Dry		Climatic Zone - Hot and Dry	
EPI(Kwh/sqm/year)	Star Label	EPI(Kwh/sqm/year)	Star Label
180-155	1 Star	75-65	1 Star
155-130	2 Star	65-55	2 Star
130-105	3 Star	55-45	3 Star
105-80	4 Star	45-35	4 Star
Below 80	5 Star	Below 35	5 Star

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

19. Appendix I-Compliance Documents

Details of compliance documents shall include but not limited to:

19.1 Building Envelope.

The following shall provided to the building owner by the engineer/architect as per Appendix- G (17.1 and 17.2) scrutiny by the Authority having jurisdiction.

- (a) Overall Thermal Transfer Value (OTTV) calculation for the exterior walls along with supporting data and drawings.
- (b) U-Value calculations for the roof along with supporting data and drawings.
- (c) Plan to minimize air leakage and supporting data.
- (d) Calculation of Heat gain and Building Index for NON air conditioned areas.
As per IS 3792-1978

19.2. HVAC.

The plans of a building owner should have following elements as per Appendix-G(17.3 and 17.4) for scrutiny by the Authority having jurisdiction.

- (a) Types of systems and equipments, including their sizes, efficiencies and controls and the detail layout plan.
- (b) The cooling capacity in KW of each air-handling unit and Air- Conditioning plant.
- (c) The capacity in L/s of each fan.
- (d) The location and capacity of each fresh air intake.
- (e) A summary of air-conditioning load calculations and equipment performance figures.
- (f) Report o HVAC balancing.

19.3. Service Hot Water, Pumping, renewable energy

The engineer responsible for the service hot water system installation shall provide complete details to the building owner as per Appendix-G (17.4) including the following information for security by the Authority having jurisdiction.

- (a) Layout plan showing equipments and connections.
- (b) Input energy consumption rate (KW/kcal).
- (c) Design operating temperature range.
- (d) Type of fule used.
- (e) Listing of equipment.
- (f) Storage tank capacity.
- (g) Maximum draw of rate(l/s)
- (h) Renewable energy details.

19.4. Lighting.

The engineer/architect responsible for the lighting installation shall provide complete details to the building owner as per Appendix-G (17.5 &17.6) showing the installed lighting devices which also includes the following information for scrutiny if the Authority having jurisdiction.

- (a) Layout plan indicating lighting equipments and controls.

- (b) The design standard service illuminance.
- (c) The number of each type of lighting device.
- (d) The total wattage of each type of lighting device, and
- (e) The installed lighting load for interior and exterior.
- (f) Single line diagram showing the lighting system.
- (g) Day light calculations in functional spaces..

19.5 Electrical Power.

Building owners shall be provided to with written information that provides basic data relating to the design, operation and maintenance of the electrical distribution system for the building. This shall include:

- (a) A single-line diagram of the building electrical system, inclusive of all the metering equipment.
- (b) Floor plan showing location of the equipment, distribution gear, power factor correction and metering equipment.
- (c) Schematic diagrams of electrical control systems used for power saving.
- (d) Manufacturer's data sheets so as to confirm the maximum losses allowed as applicable for transformers and motors.

19.6 Acceptible limit heat gain for Non air conditioned spaces

buildings or building spaces which are not air conditioned shall comply with §10A and appendix M in confirmation with IS 3792-1978 (reaffirmed in 2008).

19.7. Energy performance (EPI)calculation for star rating

Building owners shall provide expected energy usage calculations in terms of EPI for proposed design / construction so as to obtain min. 3 star label.

20. Appendix J- Framework for administration and enforcement.

The process of designing code-complaint buildings will involve different agencies and include different stages that begin with the design process, obtaining a building permit, completing the compliance submittals, the construction of the building followed by periodic inspections to make sure that construction is making place as per the requirement of the code.

A model framework for administration, implementation and enforcement of the code is proposed.

- An apex committee under the chairmanship of Secy, Energy Dept and CEO CREDA, Director CREDA shall be responsible for the overall administration and implementation of the CGECBC , Representatives of CGPWD, CG Housing and Environment Dept and Finance Development, Govt. of Chhattisgarh, shall be the members.
- The apex committee shall suggest the approve relevant option of ensuring compliance after the code has been made mandatory. CGECBC compliance can be based on any of the option recommended by BEE such as (i) EPI values computed from simulation software provided by BEE, (ii) Using EPI along with physical verification of key construction parameters and (iii) Verification of EPI by auditors and mandatory requirements by inspectors or checking the design EPI against the actual EPI after the building is in operation. The apex committee shall ensure that the compliance procedures are made simpler and user friendly as far as practicable.
- The apex committee shall nominate an Expert Group under the Chairmanship of Director CREDA comprising of national experts of ECBC and representatives from Indian Institute of Architects / builder association and Govt. Technical Universities. The Expert Group shall be responsible for recommending the methodology, timeframe and other guidelines to the Apex Committee for approval. The service charges payable to CREDA for preparation, Verification, approval of plans of buildings under the scope of CGECBC and for other allied activities shall also be recommended by the Expert Group for approval by the Apex committee.
- The Expert Group shall also recommend the approving Authority(s) for

- CGECBC to the Apex committee for approval.
- The SDA Chhattisgarh shall also appoint/nominate inspecting Officers Section 17(1) of the Energy Conservation Act 2001 who shall be responsible to ensure compliance to the CGECBC during construction of the building or its subsequent use.
 - SDA, Chhattisgarh and EIC, CGPWD, shall work in close coordination with the Expert Group for implementation of CGECBC compliance of their buildings. The energy calculation and method of such calculations shall be vetted by the SDA as per the Guideline of the Expert Group.
 - The service charges for the purpose shall be paid as prescribed by the Apex committee.
 - The service charges to SDA, Chhattisgarh for the purpose shall be deposited with CREDA for utilization in various energy conservation activities of the state.
 - No power distribution company will give power connection to any building under the scope of CGECBC unless the energy calculations and maximum annual energy consumption are duly approved by SDA. Disciplinary action as per rules will be taken against the concerned official responsible for the inaction or the action violating the norms of CGECBC over providing power connection to un certified buildings. Similarly customers may have to pay higher power tariff for violating CGECBC norms.
 - An empanelled list of architects and engineers meeting such qualification and experience requirements as decided by the Apex committee shall be created who shall act as state level experts shall render paid services to the SDA for CGECBC compliance.
 - The Apex Committee and Expert Group shall meet at interval of 30 days and 15 days respectively as approved by the Apex Committee to resolve issues and to facilitate smooth implementation of the CGECBC in state.
 - The SDA website shall extend to provide online services to all the applicants for CGECBC compliance.
 - SDA shall organize workshops and training programmes for the architects and engineers working with Government/ Semi Government /Private

Organizations and PSU of Chhattisgarh on the code requirements and implementation mechanism for their skill enhancement and capacity building.

• **Road Map for implementation in all Govt buildings:**

In Chhattisgarh various Govt agencies/ Govt executing agencies are involved with building construction. Where as CREDA is the State agency to monitor, implement and enforce CGECBC in the state. CREDA has activated and full Phased wing called as EC cell to design, to provide support services for such purpose. The functions of CREDA would be as under. All Govt agencies undertaking construction activity in the state may follow the following instructions strictly.

1. CREDA will provide support services during finalization of bids submitted by architects/ consultants to be selected through competitive bidding called by any Govt executing bodies at preparatory stage. Services by CREDA for the said support shall be free of cost. All Govt bodies inviting applications for consultants for building design and planning should keep the criteria for CGECBC compliance in the EOI/ RFP documents/ tender documents etc.
2. Govt agencies have to take final approval from CREDA at different stages for CGECBC intervention.
 - a. At concept finalization.
 - b. At detail specification and working drawing.
 - c. After construction and during power connection.CREDA would charge 1% of project cost for above services from respective agencies.
3. Interested Govt agencies can also avail CREDA's services for drawing, design, detailing, specification and supervision comprising of comprehensive Architectural services including CGECBC intervention and compliance at the total fees of 2.5% of project cost.
4. Administrative approval for concerned building would be given, if the drawings are vetted by CREDA.
5. CEO /Director, CREDA is the nodal officer for all communication matters related to CG Energy Conservation building Code.

21. APPENDIX-K:

Equipments, materials and minimum star labeling (*)

Equipment	Details	Minimum Star labeling
Air Conditioning	Single-phase split and unitary air conditioners of vapour compression type up to a rated cooling capacity of 11 kW or as amended from time to time	Four star
Ceiling fans	All ceiling fans of sweep 1200mm or as amended from time to time shall be BEE star labeled.	Four star
Electric Water Heaters	Electric water heaters of capacity up to 200 liters or as amended from time to time	Four star
Distribution Transformers	Distribution transformers of rating 16kVA to 200 kVA or as amended from time to time.	One star
squirrel cage induction motors	Three phase squirrel cage induction motors in 2 Pole and 4 Pole for continuous duty (S1) operation suitable for voltage and frequency variation as per IS 12615:2004 with the following output rating 0.75 kW, 1.1 kW, 1.5 kW, 2.2 kW, 3.7 kW, 5.5 kW, 7.5 kW, 9.3 kW, 11 kW and 15 kW or as amended from time.	One star
Electric Pump Sets	Pump sets covering Electric mono set pumps, submersible pump sets and open well submersible pump sets used for clear, cold water and water supply purposes of ratings 1.1kW to 15kW or as amended from time to time	One star

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

22.APPENDIX L : SELECTED REFERENCES.

1. ASHRAE/ANSI Standard 62(2004), "Ventilation for Acceptable Air Quality", American Society of Heating, Refrigerating and Air-conditioning Engineers, Atlanta, USA
2. ASHRAE Handbook (2005), "Thermal Environmental Conditions for Human Occupancy", American Society of Heating, Refrigerating and Air-conditioning Engineers, Atlanta, USA
3. ASHRAE/ANSI Standard 62(2004), "Fundamentals (SI)", American Society of Heating, Refrigerating and Air-conditioning Engineers, Atlanta, USA
4. Building Research Note-57, CBRI, 2002-03
5. National Building Code of India, 2005, Bureau of Indian Standard, Second Revision, New Delhi, India
6. Energy Conservation Code, 2007, Bureau of Energy Efficiency, Ministry of Power, Govt. of India
7. Energy Conservation Code: User Guide 2009 BEE, Govt. of India.
8. Naik and Prajapati (2006), Handbook on Energy Conscious Buildings
9. Orissa Energy Conservation Building-2011.
10. Indian Standard – Guide for Heat Insulation of Non Industrial Buildings. IS- 3792-1978 (reaffirmed on 2008)

23. APPENDIX M: EXTRACTS OF Indian Standard – Guide for Heat Insulation of Non Industrial Buildings. IS- 3792-1978 (reaffirmed on 2008)

Note on Chhattisgarh Energy Conservation Building Code 2012 (amended -2014).

The State Designated Agency, Chhattisgarh has taken up the activity of amending the Energy Conservation Building Code for the State of Chhattisgarh as per deliverable 17.1 of the State Level Action Plan as prescribed by the Bureau of Energy efficiency, Government of India. The Section 15(a) of the Energy Conservation Act, 2001 indicates that the State Government may by notification, in consultation with the Bureau amend the Energy Conservation Building Codes to suit the regional and local climatic conditions and may by rules made by it, specify and notify Energy Conservation Building Codes with respect to use of energy in the buildings. The draft was presented before high powered technical committee of CREDA for approval. Various State Level Workshops were organized with the support of various departments to review the draft CGECBC and obtain suggestion from different Stake holders. SDA after extensive consultation with different stakeholders has finalized the Chhattisgarh Energy Conservation Building Code (CGECBC) which aim at improving the Energy efficiency and utilization in the building sector of the State.

The overall objective of the CGECBC is to provide technical details for the designers / architects to apply energy conservation principles and techniques in their designs for new buildings as well as for alternation to existing buildings.

The CGECBC follows the same structures as the National ECBC. A new sections have been added to include auditing , reporting and star rating of building, renewable energy, IS 3792-1978 etc so as ensure that the applicable buildings adhere to the code. The ECBC Use Guide and IS 3792-1978 to be referred for a detail explanation on the technical aspects.