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Eco Niwas Samhita (ENS)

(Energy Conservation and Sustainable Building Code for Residential Buildings)

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CHAPTER 1: INTRODUCTION

1.1 In 2022, India revised its Nationally Determined Contribution under the Paris Agreement. Among others, the revision had two significant components. The first aimed to promote a healthy and sustainable lifestyle based on conservation and moderation. This included a mass movement for 'LIFE' – 'Lifestyle for Environment' to combat climate change. The second aimed to reduce emissions intensity of GDP by 45% by 2030, compared to 2005 levels. Achieving these targets relies on increased adoption of low-carbon, sustainable pathways, especially in the building sector.

1.2 As per Energy Statistics 2023[1] released by the Ministry of Statistics and Programme Implementation (MoSPI), total energy demand by various sectors for FY 2021–22 is about 525.7 Mtoe, out of which the residential (domestic) sector consumes about 58.8 Mtoe, which is 11.2% of total primary energy consumption. The energy demand in the domestic sector has been on the rise since the late 2000s, with increasing demand for appliance ownership, especially of fans and televisions in urban and rural areas, and an increase in refrigerators and air conditioners in urban areas. Further, it is estimated that domestic sector will consume about 98.6 million ton of energy[2].

1.3 The building sector in India is responsible for over 30% of the total electricity consumed in the country, out of which about 70% is consumed in residential buildings. The total electricity demand for FY 2021–22 is about 1296 billion Units (BU)[3], out of which the residential sector consumed about 334 BU which is 25.8% of total electricity consumption. Electricity consumption increased from 183.7 BU in 2012- 13 to 334 BU in 2021-22 with a CAGR of 6.87%. Further, it is estimated that, the electricity consumption of the residential sector will increase to 769 BU by 2031[4].

1.4 According to India Cooling Action Plan 2019, approximately 8% of the households have room air conditioners. This is anticipated to rise to 21% and 40% by 2027-28 and 2037-38 respectively. The demand for air conditioning will continue its exponential growth with improvement in household incomes and will become the dominant contributor of GHG emissions nation-wide owing to increased electricity consumption. This situation calls for an immediate energy conservation action plan.

1.5 As of 2019, the Central Water Commission has assessed the average annual per capita water availability to be 1486 cubic meters and 1367 cubic meters for 2021 and 2031[5], respectively. According to standards, an annual per-capita water availability of less than 1700 cubic meters is considered as a water stressed condition (PIB, 2022). The per capita water availability in the country in reducing due to an increase in population, climate change, rapid urbanisation and uneven distribution of water. Both demand-side and supply side measures to ensure efficient water management, conservation, and augmentation are needed to avoid a water crisis.

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1 Energy Statistics India – 2023, Ministry of Statistics and Programme Implementation, National Statistical Office, Government of India

2 UNlocking National Energy-Efficiency potential (UNNATEE), Bureau of Energy Efficiency, Ministry of Power

3 Energy Statistics India – 2023, Ministry of Statistics and Programme Implementation, National Statistical Office, Government of India

4 UNlocking National Energy-Efficiency potential (UNNATEE), Bureau of Energy Efficiency, Ministry of Power

5 Reassessment of Water Availability in India using Space Inputs, 2019, Central Water Commission, Delhi

1.6 Excessive waste generation and improper waste management is a major environmental concern in India. The per capita waste generation in India varies between 0.2 Kg to 0.6 Kg per day in Tier 1 cities and is expected to increase at a rate of 5% annually. It is dependent on various factors ranging from the size of the city, season and income groups. As of 2021, a total of 1.6 Lakhs tonnes of waste is generated in India on a daily basis[6]. While 50% of this waste is treated, nearly 20% of the waste still reaches the landfill and over 30% of the waste remains unaccounted.

1.7 Indoor environmental quality (IEQ) refers to the conditions inside a building that can affect the health, comfort, and productivity of its occupants. Several factors contribute to IEQ, including ventilation, air quality, thermal comfort, lighting, and acoustics. As we spend 90% of our time indoors, poor IEQ results in discomfort and potential health issues for occupants. Prioritizing and maintaining optimal IEQ within confined buildings is crucial, as it can save people from diseases like chronic obstructive pulmonary disease (COPD), which is the 3rd highest reason for global deaths according to the World Health Organisation (WHO).

1.8 In the illustrated context, Energy Conservation & Sustainable Building Codes for Residential Buildings (ENS) 2023, is an important regulatory measure for ushering in sustainability and energy efficiency in the Indian building sector. The present code integrates the Eco Niwas Samhita 2018 (Part I: Building Envelope), Eco Niwas Samhita 2021 (Part-II: Electro-Mechanical & Renewable Energy Systems) along with measures for sustainable site planning, water conservation, waste management and, indoor environmental quality to ensure that residential buildings in India have a low carbon footprint and provide a healthy environment for the occupants.

1.9 The code also provides the following eight annexures which are recommendatory and envisaged to be added in future revision of the code.

- Annexure 1: Compliance Documents
- Annexure 2: Embodied energy
- Annexure 3: Good construction practices
- Annexure 4: Retrofitting of residential buildings
- Annexure 5: Improved air cooling
- Annexure 6: Smart Home
- Annexure 7: Guidelines to Design for Natural Ventilation
- Annexure 8: Cool Roof and Roof Gardens
- Annexure 9: Climate Zones and Classification of Cities

6 Annual Report on Solid Waste Management (2020-21), CPCB, Delhi

CHAPTER 2: SCOPE

2.1 The amendment of the Energy Conservation (EC) Act in 2022, widens the scope of BEE's Energy Conservation Codes to include other sustainability features. The Eco-Niwas Samhita 2023 is a consolidated energy conservation and sustainable building code that integrates the ENS Part I (Building Envelope) and, Part II (Electro-Mechanical and Renewable Energy Systems) and includes new provisions to improve the overall sustainability of residential buildings.

2.2 The code applies to residential buildings or residential building complexes which has a minimum connected load of 100 kilowatt (kW) or contract demand of 120 kilovolt ampere (kVA)[7]

2.2.1 Where a 'residential building', as defined in National Building Code 2016, includes any building in which sleeping accommodation is provided for normal residential purposes with or without cooking or dining or both facilities. this definition includes:

2.2.1.1 **One- or two-family private dwellings:** these shall include any private dwelling, which is occupied by members of one or two families and has a total sleeping accommodation for not more than 20 persons.

2.2.1.2 **Apartment houses:** these shall include any building or structure in which living quarters are provided for three or more families, living independently of each other and with independent cooking facilities. this also includes 'Group housing'.

2.2.1.3 **Mixed-use building:** In a mixed-use building, having both commercial and residential building use, each category of a building use must be classified separately, and –

a) If a part of the mixed-use building classification (residential or commercial) is less than 10% of the total above grade floor area, the mixed-use building part shall show compliance based on the building sub-classification having higher percentage of above grade floor area.
b) If a part of the mixed-use building has different classification (residential or commercial) and one or more sub-classification is more than 10% of the total above grade floor area, the compliance requirements for each sub-classification, having area more than 10% of above grade floor area of a mixed-use building, shall be determined by the requirements for the respective building classification.
c) Basement and common area services, designed for a particular building use or documented with respective buildings for compliance with authority having jurisdiction, needs to show compliance with the sections for the respective building requirement.

2.3 In accordance with section 14(p) of the Energy Conservation (Amendment) Act 2022 the purpose of the Energy Conservation and Sustainable Building Code (Code) is to provide norms and standards for energy efficiency and its conservation, use of renewable energy and other green building requirements for a building.

2.4 The following are excluded from the definition of 'residential building' for this code.

2.4.1 Lodging and rooming houses: these shall include any building or group of buildings under the same management in which separate sleeping accommodation on

[7] or plot area of 3000 m^2, whichever is more stringent. States and municipal bodies may change the plot area based on the prevalence in their respective areas of jurisdiction.

transient or permanent basis, with or without dining facilities but without cooking facilities for individuals, is provided. this includes inns, clubs, motels, and guest houses.

2.4.2 Dormitories: these shall include any building in which group sleeping accommodation is provided, with or without dining facilities for persons who are not members of the same family, in one room or a series of closely associated rooms under joint occupancy and single management. For example, school and college dormitories, students, and other hostels and military barracks.

2.4.3 Hotels and resorts: these shall include any building or group of buildings under single management, in which sleeping accommodation is provided, with or without dining facilities.

2.5 The code is also applicable for all additions made to existing residential buildings where the existing building exceeds the threshold defined in section 2.2 of this document. For this purpose, the additional building(s) is/are required to show compliance with the authority having jurisdiction.

2.6 The code is also applicable for all alterations made to existing residential buildings where the existing building exceeds the threshold defined in section 2.2 of this document. For this purpose, the part of the building or its systems that are being altered is required to show compliance to the sections 5.2, 5.3 and 8.2 only with the authority having jurisdiction.

2.7 The following codes, programs, and policies or any subsequent revisions shall take precedence over the code in case of conflict.

2.7.1 Rules or codes or bye-laws on buildings, building construction systems, safety, security, health, or environment by Central, State, or Local Governments.

2.7.2 BEE's Standards and Labelling for appliances and Star Rating Program for buildings, or any reference standard prescribed by the Code, provided both or are more stringent than the requirements of this Code.

2.8 The code prescribes the three levels of compliance in ascending order of energy conservation and sustainability. ENS building level of efficiency and sustainability is necessary for demonstrating compliance with the code. The other two levels are voluntary:

2.8.1 **ENS compliance**: ENS compliance Buildings shall demonstrate compliance by adopting the mandatory requirements listed under each of the sections of this code.

2.8.2 **ENS+ compliance**: ENS+ compliance Buildings shall demonstrate compliance by adopting the mandatory requirements and gaining required incremental points from each of the sections of this code.

2.8.3 **Super ENS compliance**: Super ENS compliance Buildings shall demonstrate compliance by adopting the mandatory requirements and gaining required incremental points from each of the sections of this code.

CHAPTER 3: CODE COMPLIANCE

3.1 The mandatory provisions as per chapters 4, 5, 6, 7 and 8 are applicable to all building categories as per section 2.2.

3.2 If a building project has more than one building block, each building block is required to comply with the code unless specified otherwise.

3.3 The code also provides incremental provisions to demonstrate enhanced compliance; ENS + and Super ENS as per Table 1

Table 1: Points required to achieve ENS+ and Super ENS compliance

Project Category	ENS+	Super ENS
All residential buildings	30% of all the total points applicable in each section (4.3, 5.3.1, 5.3.2, 5.3.3, 5.3.4, 6.3, 7.3, 8.3)	50% of all the total points applicable in each section (4.3, 5.3.1, 5.3.2, 5.3.3, 5.3.4, 6.3, 7.3, 8.3)

3.4 A summary of the incremental points available in each chapter is given in Table 2

Table 2: Maximum incremental points in each chapter

Section	Provisions	Maximum Incremental Points available	Compliance for ENS+ (30% of maximum incremental points available)	Compliance for Super ENS (50% of maximum incremental points available)
4.3	**Sustainable Site Management**	**30**	**9**	**15**
4.3.1	Landscaping	16		
4.3.2	Mitigation of Urban Heat Island	14		
5.3.1	**Building Envelope**	**40**	**12**	**20**
5.3.1.1	Roof	4		
5.3.1.2 / 5.3.1.3	Building envelope (except roof)	36		
5.3.2	**Building Services**	**28**	**8**	**14**
5.3.2.1	Common area and exterior lighting	6		
5.3.2.2	Elevators	9		
5.3.2.3	Pumps	8		
5.3.2.4	Electrical Systems	5		
5.3.3	**Indoor Electrical End-use**	**42**	**13**	**21**
5.3.3.1	Indoor Lighting	8		
5.3.3.2	Comfort Systems	34		
5.3.4	**Renewable Energy Systems**	**10**	**3**	**5**
5.3.4.1	Solar Water Heating	5		
5.3.4.2	Solar Photo Voltaic	5		

Section	Provisions	Maximum Incremental Points available	Compliance for ENS+ (30% of maximum incremental points available)	Compliance for Super ENS (50% of maximum incremental points available)
6.3	**Water Conservation and management**	**43**	**13**	**22**
6.3.1	Site Water Use Reduction	17		
6.3.2	Building Water Use Reduction	26		
7.3	**Waste Management**	**7**	**2**	**4**
7.3.1	Construction Waste management	2		
7.3.2	Post Construction Waste Management	5		
8.3	**Indoor Environmental Quality (IEQ)**	**10**	**3**	**5**
8.3.1	Cross Ventilation	4		
8.3.2	Daylight Availability (useful daylight illuminance)	4		
8.3.3	Air Quality in Car Parking (CO sensor)	2		

3.5 A building shall comply if the minimum specifications of all products installed under any category are met as prescribed by this code unless specified otherwise.

3.6 In a mixed-use building, having both commercial and residential building use, each category of a building use must be classified separately, and –

3.6.1 The residential above grade floor area as defined in section 2.2.1 shall comply with this code.

3.6.2 Basement and common area services, designed for a particular building use or documented with respective buildings for compliance with authority having jurisdiction, needs to show compliance with the sections for the respective building requirement.

CHAPTER 4: SUSTAINABLE SITE MANAGEMENT

4.1 INTRODUCTION

4.1.1 The chapter provides requirements to minimize the impact of construction activity on the natural terrain and topography of the site during the construction phase. It consists of four parts- Site Preservation, Universal Accessibility, Landscaping and Mitigating Urban Heat Island.

4.2 MANDATORY PROVISIONS

4.2.1 Site Preservation

4.2.1.1 Ensure to protect or preserve existing mature trees naturally or as per guidelines of local byelaws/authority, whichever is more stringent. Else, in compliance with the Model Building Byelaws, compensatory Plantation for felled/transplanted trees in the ratio 1:3 within the premises under consideration must be ensured.

4.2.1.2 Preservation of fertile topsoil:

a) Fertile topsoil up to 150-200 mm (6-8 inches) must be preserved, stabilized and its fertility must be maintained.

b) The stored topsoil shall be used as finished grade for planting areas within the site or outside. In case the stored topsoil is not being used within the site, proper reuse of the soil must be ensured.

4.2.1.3 In compliance with the Model Building Byelaws, construction shall not hinder existing areas like water bodies, power or communication lines, sewerage lines that are located on or adjacent to the project site.

4.2.2 Universal Accessibility

4.2.2.1 Residential buildings shall be universally accessible with special provisions for children, the elderly and differently abled people in accordance with Chapter 8 of the Model Building Bylaws, 2016.

4.2.3 Landscaping

4.2.3.1 With the exception of low-lying areas, minimise disturbances to the topography & gradient of the site by retaining natural features of the site. Vegetated landscaped area must be developed on a minimum of 20% of the total landscaped area.

4.2.3.2 In compliance with the National Building Code, if turf grasses are to be used, they should not be planted on more than 30% of the total landscaped area. The clause must be adhered to along with clause 6.2.1.4 of this code.

4.2.3.3 In compliance with the National Building Code, to preserve local biodiversity and ecology, a minimum of 30% of the landscaped area must be planted with native/adaptive species of plants/trees. The choice of species for plantation shall be as per Section 8 of the Urban Greening Guidelines, 2014 of the Ministry of Housing and Urban Affairs[8].

[8] Source: https://mohua.gov.in/upload/uploadfiles/files/G%20G%202014(2).pdf

4.2.3.4 In cases where the plot area exceeds 5000 sqm, compliance is required for the notification of the Ministry of Environment, Forest and Climate Change Notification dated 25th February 2022, wherein, a minimum of 1 tree for every 80 sqm. of land shall be planted and maintained to ensure at least 10% of plot area under tree cover is stated. The existing trees will be counted for this purpose.

4.2.3.5 In compliance with the Model Building Byelaws, 2016 compensatory Plantation for felled/transplanted trees in the ratio 1:3 within the premises under consideration must be ensured.

4.2.4 Mitigating Urban Heat Island

4.2.4.1 Limiting the net paved area of the site under parking, roads, paths, or any other use so as not to exceed 25% of the site area, as per the National Building Code.

4.2.4.2 More than 50% of the total paved area shall have pervious paving/grass pavers/open grid pavements, as per National Building Code.

4.3 INCREMENTAL PROVISIONS (MAXIMUM 30 POINTS)

4.3.1 Landscaping (Maximum 16 Points)

4.3.1.1 Minimise disturbances to the topography & gradient of the site by retaining natural features of the site and developing vegetated landscaped spaces as per Table 3.

Table 3: Points for increasing vegetated area on site

Minimum Vegetated Area	Incremental Points
30% of the total landscaped area	6
40% of the total landscaped area	8

4.3.1.2 Minimise the planting of turf grasses as per Table 4. The clause must be adhered to along with clause 6.2.1.4 of this code.

Table 4: Points for Reducing the Turf Area

Maximum Turf Area	Incremental Points
20% of the landscaped area	2
15% of the landscaped area	4

4.3.1.3 Increase the plantation of native/ adaptive species of plants/ trees as per Table 5.

Table 5: Points for Increasing the Landscaped Area planted with Native Plant Species

Minimum Area with Native Plants Species	Incremental Points
40% of the landscaped area	2
50% of the landscaped area	4

4.3.2 Mitigation of Urban Heat Island (Maximum 14 Points)

4.3.2.1 Limiting the net paved area of the site under parking, roads, paths, or any other *as per* Table 6.

Table 6: Points for Reducing Paved Area on Site

Maximum Net Paved Area on Site	Incremental Points
Up to 20% of the site area	4
Up to 15% of the site area	6

4.3.2.2 Increase the pervious paving/grass pavers/open grid pavements as per Table 7.

Table 7: Points for Increasing Pervious Paving

Minimum Pervious Paving	Incremental Points
60% of the total paved area	5
70% of the total paved area	8

CHAPTER 5: ENERGY CONSERVATION AND MANAGEMENT

5.1 INTRODUCTION

5.1.1 The chapter provides requirements for energy management and conservation in a building pre-occupancy through passive measures, active measures, and renewable energy integration. It consists of four parts – building envelope, building services, indoor electrical end use and renewable energy.

5.2 MANDATORY PROVISIONS

5.2.1 Building Envelope

5.2.1.1 Openable Window-To-Floor Area Ratio

The openable window-to-floor area ratio (WFR_{op}), (Refer Chapter 9: Calculations and Formula) for individual building blocks, shall comply with the values[9] given in Table 8.

Table 8: Minimum requirement of window-to-floor area ratio (WFRop)

Climatic zone	Minimum WFR_{op} (%)
Composite	12.50
Hot-Dry	10.00
Warm-Humid	16.66
Temperate	12.50
Cold	8.33

SOURCE: Adapted from Bureau of Indian Standards (BIS). 2016. National Building Code of India 2016. New Delhi: BIS.

5.2.1.2 Visible Light Transmittance

The glass used in non-opaque building envelope components (transparent/translucent panels in windows, doors, etc.) shall comply with the requirements given in Table 9.

Table 9: Minimum visible light transmittance (VLT) requirement

Window-to-wall ratio (WWR)[9]	Minimum VLT[9]
0–0.30	0.27
0.31—0.40	0.20
0.41—0.50	0.16
0.51—0.60	0.13
0.61—0.70	0.11

SOURCE: Bureau of Indian Standards (BIS). 2016. National Building Code of India 2016. New Delhi: BIS.

5.2.1.3 Thermal Transmittance of Roof (U_{roof})

Thermal transmittance of the roof shall comply with the maximum U_{roof} value of 1.2 W/m²·K as prescribed in section 9.4 of this code.

[9] To comply with the Code, WFR_{op} (%) values shall be rounded off to two decimal places in accordance with IS 2: 1960 'Rules for rounding off numerical values'.

5.2.1.4 Residential Envelope Transmittance Value (EETV) for Building Envelope (Except Roof) for Four Climate Zones, namely, Composite Climate, Hot-Dry Climate, Warm-Humid Climate, and Temperate Climate

The RETV for the building envelope (except the roof) for four climate zones, namely, Composite Climate, Hot-Dry Climate, Warm-Humid Climate, and Temperate Climate, shall comply with the maximum[10] RETV value of 15 W/m² as prescribed in section 9.5 of this code.

5.2.1.5 Transmittance of Building Envelope (Except Roof) for Cold Climate ($U_{envelope, Cold}$)

For Cold Climate Zone, the thermal transmittance of the building envelope (except the roof) for the cold climate shall comply with the maximum value of 1.8 W/m2·K as prescribed in section 9.7 of this code.

5.2.2 Building Services

5.2.2.1 Power Factor Correction

All 3 phase power systems shall be designed to maintain a power factor of 0.97 or respective DISCOM guidelines on Power Factor, whichever is more stringent shall be followed at the point of connection.

5.2.2.2 Energy Monitoring

A. Residential buildings exceeding the threshold defined as per section 2.2 of this code shall monitor the total electrical energy use for each of the following sections separately:

a) **Services**

i. Services above 65kVA shall have permanently installed electric metering to record demand (kW/kVA), energy (kWh/kVAh), and total power factor (or kVARh) on half hourly basis.
ii. Services less than 65 kVA shall have permanently installed electrical metering to record energy (kWh) on hourly basis

b) Electricity consumption of the following applicable end-use

i. Common area lighting (Outdoor lighting, corridor lighting, basement lighting)
ii. Elevators
iii. Water pumps
iv. Basement car parking ventilation system
v. Lift pressurization system

c) Electricity Generation

i. Electricity generated from power back-up.
ii. Electricity generated through renewable energy systems.

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[10] BEE plans to improve the RETV norm to 12 W/m² in the near future and the building industry and regulating agencies are encouraged to aim for it.

B. At Building mains, the electrical energy use shall be recorded at a minimum interval of 15 minutes and reported at least on an hourly, daily, monthly and annual basis. The monitoring equipment shall be capable of transmitting the data to the digital control system/ energy monitoring information system. The digital control system shall be capable of maintaining all data collected for a minimum period of 36 months.

a. At Building mains, installed meters shall monitor Energy use (kWh, kVARh, kVAh), Energy Demand (kW/ kVA), THD (V and I). The metering shall also be displaying current (in each phase and the neutral), voltage (between phases and between each phase and neutral).

5.2.2.3 Electric Vehicle Charging System

If an Electric Vehicle Charging Infrastructure is installed on the premises, it shall be as per revised guidelines issued by Ministry of Power for Charging Infrastructure for Electric Vehicles (EV) on 17th Sep 2024, or any subsequent amendments.

5.2.2.4 Electric Systems

A. The power cabling shall be sized so that the distribution losses shall not exceed 3% of the total power usage of the building. A record of design calculation for the losses with possible effects of harmonics shall be maintained and the load calculation up to the panel level shall be documented.

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

C. The conductor used for fixed wiring shall be of class 2 as per IS 8130.

5.2.2.5 Common Area and Exterior Lighting (If Applicable)

A. The Lighting power density (LPD) and Luminous efficacy (LE) of permanently installed lighting fixtures in common area shall meet the requirements of either maximum LPD or minimum LE given in Table 10

Table 10: Common Area Lighting

Common Areas	Maximum LPD (in W/m^2)	Minimum luminous efficacy (lm/W)
Corridor lighting	3.0	All the permanently installed lighting fixtures shall use lamps with an efficacy of at least 95 lumens per Watt
Basement & stilt Parking	1.0	All the permanently installed lighting fixtures shall use lamps with an efficacy of at least 95 lumens per Watt

B. In case of the exterior lighting load being more than 100 W, the permanently installed lighting fixtures shall use lamps with an efficacy of at least 95 lumens per Watt or meet the maximum LPD requirements given in Table 11.

Table 11: Outdoor Lighting Requirement

Exterior Lighting Areas/ Zones	Maximum LPD (in W/m2)
Driveways and parking (open/ external)	1.6
Pedestrian walkways	2.0
Stairways	10.0
Landscaping	0.5
Outdoor sales area	9.0

5.2.2.6 Elevators, If Applicable

Elevators installed in the building shall meet all the following requirements:

i. Install high-efficacy lamps for lift car lighting having a minimum luminous efficacy of 95 lm/W.
ii. Install automatic switch-off controls for lighting and fan inside the lift car when are not occupied.
iii. Install minimum class IE 3 high-efficiency motors.
iv. Group automatic operation of two or more elevators coordinated by supervisory control

5.2.2.7 Pumps, If Applicable

Pumps that are either hydro-pneumatic having a minimum overall pump efficiency of 60% or BEE 4-star rated shall be installed in the building.

5.2.2.8 Electrical System, If Applicable

A. Power transformers with a minimum efficiency at 50% and full load rating shall be installed. The permissible loss shall not exceed the values listed in Table 12 for dry-type transformers and the BEE 4-star rating in Table 13 for mineral oil-type transformers or Ester Oil type transformer as per IS 1180 first published in 2014 and latest amendment issued in 4th march 2021 titled as IS 1180 (PART 1) : 2014 and IS 1180 (Part 3) : 2021 or as revised from time to time for Mineral Oil type or Ester Oil type transformer respectively and shall conform to BEE star rating.

B. All measurements 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 the capacity of 500 kVA and above would be equipped with additional metering class current transformers (CTs) and potential transformers (PTs) in addition to the requirements of Utilities so that periodic loss monitoring studies may be carried out.

Table 12: Permissible Limit for Dry-Type Transformers

Rating kVA	Max. Losses at 50% loading W*	Max. Losses at 100% loading W*	Max. Losses at 50% loading W*	Max. Losses at 100% loading W*
	Up to 22 kV class		33 kV class	
100	940	2400	1120	2400
160	1290	3300	1420	3300
200	1500	3800	1750	4000
250	1700	4320	1970	4600
315	2000	5040	2400	5400
400	2380	6040	2900	6800

500	2800	7250	3300	7800
630	3340	8820	3950	9200
800	3880	10240	4650	11400
1000	4500	12000	5300	12800
1250	5190	13870	6250	14500
1600	6320	16800	7500	18000
2000	7500	20000	8880	21400
2500	9250	24750	10750	26500
*The values as per Indian Standard/BEE Standard & Labeling notification for dry type transformer corresponding to values in this table will supersede as and when the Indian standards/ BEE Standard & Labeling notifications are published.				

Table 13: Permissible Limit for Mineral or Easter Oil Transformers

Max. Total Loss (W)							
Rating (kVA)	Impedance (%)	BEE 3 Star		BEE 4 Star		BEE 5 Star	
		50 % Load	100% Load	50 % Load	100% Load	50 % Load	100% Load
16	4.5	108	364	97	331	87	301
25	4.5	158	541	142	493	128	448
63	4.5	270	956	243	870	219	791
100	4.5	392	1,365	352	1242	317	1,130
160	4.5	513	1,547	462	1408	416	1,281
200	4.5	603	1,911	543	1739	488	1,582
250	4.5	864	2,488	811	2293	761	2,113
315	4.5	890	2,440	829	2164	772	1,920
400	4.5	1,080	3,214	1013	3102	951	2,994
500	4.5	1,354	3,909	1282	3727	1,215	3,554
630	4.5	1,637	4,438	1536	4061	1,441	3,717
1,000	5.0	2,460	6,364	2310	5785	2,170	5,259
1,250	5.0	3,142	7,670	3066	7003	2,991	6,394
1,600	6.25	3,753	10,821	3547	10363	3,353	9,924
2,000	6.25	4,543	13,254	4309	12459	4,088	11,711
2,500	6.25	5,660	16,554	5430	15659	5,209	14,813
Total loss values given in the above table are applicable for thermal classes E, B and F, and have component of load loss at reference temperature according to Section 17 of IS 1180 i.e., average winding temperature rise as given in Column 2 of Table 8.2 plus 300C. An increase of 7% in total for thermal class H is allowed.							
Permissible total loss values shall not exceed: - 5% of the maximum total loss values mentioned in IS 1180 for oil type transformers in voltage class above 11 kV but not more than 22 kV - 7.5% of the maximum total loss values mentioned in above IS 1180 for oil-type transformers in voltage class above 22 kV and up to and including 33 kV							

5.2.3 Indoor Electrical End Use (If Applicable)

5.2.3.1 Indoor Lighting

All the lighting fixtures shall have lamps with a luminous efficacy of a minimum of 95 lm/W installed in all the locations.

5.2.3.2 Comfort System

A. Ceiling Fans:

All ceiling fans installed in all the spaces in all the dwelling units shall have a minimum of BEE 3 star for all sweep sizes.

B. Air Conditioners:

All the air conditioners in all the dwelling units (either unitary, split, VRF, or centralized plant) shall have the following specifications and shall meet or exceed the minimum efficiency requirements under BEE Standards and Labelling Program as and when updated by BEE.

- Unitary Type: 5 Star
- Split AC: 3 Star
- VRF: 3.28 EER, or 4.36 IEER[11] (BEE Standards and Labelling requirements of 3 stars for VRF shall take precedence over the current minimum requirement)
- Chiller: 3 Star

In case, air conditioners installed are of mixed type, the calculation of points will be based on section number 5.3.3.2. of this document.

5.2.4 Renewable Energy Systems

The renewable energy systems, Solar Water Heating as per section 5.2.4.1 or Solar Photo-Voltaic as per section 5.2.4.2 to be installed collectively, or any of them, at the project site as per the total renewable energy installation requirement.

5.2.4.1 Solar Water Heating

The installed solar water heater shall meet the minimum efficiency level mentioned in IS 13129 Part (1&2) and for the evacuated tube collector the storage tanks shall meet the IS 16542:2016, tubes shall meet IS 16543:2016 and IS 16544:2016 for the complete system, and shall comply with requirements as Solar water Heating system of minimum BEE 3-star label installed in at least 10% of the plot area[12]

5.2.4.2 Solar Photo-Voltaic

The Renewable Energy Generation Zone (REGZ) shall be free of any obstructions within its boundaries and from shadows cast by objects adjacent to the zone. It must adhere to the installation standards of solar photovoltaic systems and meet the requirements for a minimum

[11] The revised EER and IEER values as per Indian Standard for VRF corresponding to values will supersede as and when the revised standards are published

[12] 100 lpd= 3 m^2 area as per MNRE guidelines

BEE 3-star label. It shall comply with the requirements of installing Solar photo-voltaic: Equivalent to at least 10% of the plot area.[13]

5.3 INCREMENTAL PROVISIONS (MAXIMUM 120 POINTS)

5.3.1 Building Envelope (Maximum 40 Points)

5.3.1.1 Thermal Transmittance of Roof (U_{roof}) (Maximum 4 Points)

The thermal transmittance of the roof (U_{roof}) shall comply with the requirement as per Table 14.

Table 14: Points for Thermal Transmittance of Roof (U_{roof})

U_{roof} (W/m²·K)	Formula for points calculation	Incremental Points
$0.28 \leq U_{roof} < 1.2$	(1.2 - U_{roof}) / 0.23	Up to 4
$U_{roof} < 0.28$	-	4

5.3.1.2 Residential Envelope Transmittance Value (RETV) for Building Envelope (Except Roof) for Four Climate Zones, namely, Composite Climate, Hot-Dry Climate, Warm-Humid Climate, And Temperate Climate[14] (Maximum 36 Points)

The RETV for building envelope (except roof) for four climate zones, namely, composite climate, Hot-Dry climate, Warm-Humid climate, and Temperate climate, shall comply with the requirement as per Table 15.

Table 15: Points for improved RETV

RETV (W/m²)	Formula for points calculation	Incremental Points
12 ≤ RETV < 15	30 – 2 x (RETV)	Up to 6
6 ≤ RETV < 12	66 – 5 x (RETV)	Up to 36
RETV < 6	-	36

5.3.1.3 Thermal Transmittance of Building Envelope (Except Roof) for Cold Climate ($U_{envelope,Cold}$) (Maximum 36 Points)

The thermal transmittance of the building envelope (except the roof) for cold climate ($U_{ENVELOPE,COLD}$), shall comply with the requirement as per Table 16.

Table 16: Points for Thermal transmittance of the building envelope (except the roof) for cold climate ($U_{ENVELOPE,\ COLD}$)

$U_{envelope,\ cold}$ (W/m².K)	Formula for points calculation	Incremental Points
$1.32 \leq U_{envelope,\ cold} < 1.8$	22.5 - 12.5 x ($U_{envelope,\ cold}$)	Up to 6
$0.36 \leq U_{envelope,\ cold} < 1.32$	47.25 – 31.25 x ($U_{envelope,\ cold}$)	Up to 36
$U_{envelope,\ cold} < 0.36$	-	36

[13] 1 kW_p = 10 m² area as per MNRE guidelines

[14] The project shall meet the requirements of either section 6.4.2 or 6.4.3 depending on the climatic zone

5.3.2 Building Services (Maximum 28 Points)

5.3.2.1 Common Area and Exterior Lighting (Maximum 6 Points)

A. All permanent lighting fixtures with a lamp luminous efficacy of at least 105 lm/Watt with Lumen depreciation > L70B10 for 50000 hrs shall be installed in the areas, as per Table 17.

Table 17: Points for Common Area Lighting

Area/Zones	Incremental Points
Corridor and stilt parking	1
Basement Lighting	1
Exterior Lighting Areas	1

B. All permanent lighting fixtures excluding emergency lighting installed in areas as per Table 18 shall:

   i. Have a luminous efficacy of 115 lm/W with Lumen depreciation > L80B10 for 50000 hrs

   ii. 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.

Table 18: Points for automatic control of exterior lights

Area/Zones	Incremental Points
Corridor and stilt parking	2
Basement Lighting	2
Exterior Lighting Areas	2

5.3.2.2 Elevators (Maximum 9 Points)

The installed elevators shall comply with the requirements as per Table 19.

Table 19: Points for Elevators

Provisions	**Incremental Points**
Installing variable voltage variable frequency dives	4
Installing Regenerative Drives	3
Installing IE4 Motors	2

5.3.2.3 Pumps (Maximum 8 Points)

The installed pumps shall comply with the requirements as per Table 20.

Table 20: Points for Pumps

Provisions	**Incremental Points**
Installation of BEE 5-star rated pumps	5
Installation of a hydro-pneumatic system for water pumping having minimum overall pump efficiency of 70%	3

5.3.2.4 Electrical Systems (Maximum 5 Points)

The installed electrical system shall comply with the requirements as per Table 21.

Table 21: Points for Electrical System

Provisions	Incremental Points
Providing all oil-type transformers with 5-star ratings	5

5.3.3 Indoor Electrical End-Use (If Applicable) (Maximum 42 Points)

5.3.3.1 Indoor Lighting (Maximum 8 Points)

All indoor lighting fixtures installed in all dwelling units shall have lamps luminous efficacy as per Table 22.

Table 22: Points for Lamp Lumen Efficacy of Indoor Lighting

Provisions	Incremental Points
Lamp Lumen Efficacy >105 Lm/W with Lumen depreciation > L70B10 for 50000 hrs	3
Lamp Lumen Efficacy >115 Lm/W with Lumen depreciation > L80B10 for 50000 hrs	8

5.3.3.2 Comfort System (Maximum 34 Points)

A. Ceiling Fans installed in all the bedrooms and hall in all the dwelling units shall comply with the requirements as per Table 23.

Table 23: Points for BEE star rated ceiling fans

Provisions	Incremental Points
Ceiling fans in all the bedrooms and hall with BEE 4-Star	1
Ceiling fans in all the bedrooms and hall with BEE 5-Star	4

B. Air Conditioners (either unitary, split, VRF or centralized plant) installed in all the bedrooms in all the dwelling units, shall comply with requirements as per Table 24 and shall meet or exceed the minimum efficiency requirements under BEE Standards and Labelling Program as and when updated by BEE.

Table 24: Points for BEE Star Rating of Air-Conditioners

Provisions	Incremental Points
a) Split AC: 4-Star b) VRF: 3.6 EER, however, whenever BEE Star labelling for VRF is launched, Star 4 will be applicable (BEE Standards and Labelling requirements of 4-star for VRF shall take precedence) c) Chiller: 4-Star	9
a) Split AC: 5-Star b) VRF: 3.8 EER, however, whenever BEE Star labelling for VRF is launched, Star 5 will be applicable (BEE Standards and Labelling requirements of 5-star for VRF shall take precedence) c) Chiller: 5-Star	30

In case, the air conditioners installed are of mixed types, the points shall be calculated based on the following formula:

$$\text{Points achieved for AC} = \frac{\sum(\text{Installed tonnage of particular system} \times \text{points claimed as per Energy efficiency level})}{\sum \text{Total tonnage installed in the dwelling unit}}$$

5.3.4 Renewable Energy Systems (Maximum 10 Points)

The renewable energy systems, Solar Water Heating as per section 5.2.4.1 and/or Solar Photo-Voltaic as per section 5.2.4.2 to be installed collectively or any of them, at the project site as per the total renewable energy installation requirement.

Table 25: Points for renewable energy systems

Provisions	Incremental Points
Installing renewable energy systems Equivalent to at least 13% of the plot area having minimum BEE-3 star label: • Installing Solar Water Heating system[15] OR • Installing Solar photo-voltaic[16] OR • Installing a combination of Solar Water Heating system and Solar photo-voltaic	4
Installing renewable energy systems Equivalent to at least 16% of the plot area: • Installing Solar Water Heating system[17] OR • Installing Solar photo-voltaic [18] OR • Installing a combination of Solar Water Heating system and Solar photo-voltaic	10

[15] 100 lpd= 3 m^2 area as per MNRE guidelines
[16] 1kW_p=10m^2 area as per MNRE guidelines
[17] 100 lpd= 3 m^2 area as per MNRE guidelines
[18] 1kW_p=10m^2 area as per MNRE guidelines

CHAPTER 6: WATER CONSERVATION AND MANAGEMENT

6.1 Introduction

6.1.1 The chapter provides requirements for water conservation and management post-occupancy of a building to reduce water demand and optimise the supply of water. It consists of five parts- site water use reduction, building water use reduction, water usage monitoring, rainwater harvesting and recycle & reuse of wastewater.

6.2 MANDATORY PROVISIONS

6.2.1 Site Water Use Reduction

6.2.1.1 At least 40% of the total water required for irrigation shall be provided through recycled water or rainwater harvesting.

6.2.1.2 As per the National Building Code, irrigation systems must be designed in a manner to provide 8 litres/sqm/day of water to all landscaped areas.

6.2.1.3 At least 70% of the landscaped planting beds to have drip irrigation, to prevent evaporation.

6.2.1.4 At least 60% of the planted turf grasses must be provided with sprinkler systems. The clause applies after compliance of clause 4.2.3.2 of this code

6.2.2 Building Water Use Reduction

6.2.2.1 Sanitary Fittings

Sanitary Fittings such as faucets (taps) and showerheads for their performance based on water efficiency shall comply with the specifications of 1 star rating criteria of the fixtures, laid down in IS 17650 Part 1, 2021, as specified in Table 26:

Table 26: Sanitary Fittings

Sl No.	Water Consumption Per Unit	Water Consumption Per Unit	Water Efficiency Rating Criteria		
			1- Star	2- Stars	3- Stars
(1)	(2)	(3)	(4)	(5)	(6)
i)	Metered faucets for basin use	litres/use	Not more than 1.0	Not more than 0.8	Not more than 0.6
ii)	Wash basin/ lavatory faucet (also applies to sensor faucets)	litres/use	Not more than 8.0	Not more than 6.0	Not more than 3.0
iii)	Sink faucet	litres/use	Not more than 8.0	Not more than 6.0	Not more than 4.5
iv)	Overhead shower	litres/use	Not more than 10.0	Not more than 8.0	Not more than 6.8
v)	Hand held shower	litres/use	Not more than 8.0	Not more than 6.0	Not more than 4.0
vi)	Handheld ablution spray	litres/use	Not more than 6.0	Not more than 5.0	Not more than 4.0

6.2.2.2 Sanitary Ware

Sanitary ware such as water closets, squatting pans, flush valves, flushing cisterns, and urinals for their performance based on water efficiency shall comply with the specifications as outlined for 1 star rating in IS 17650 Part 2, 2021, as specified in Table 27:

Table 27: Sanitary Wares

Sl No.	Product	Water Consumption Per Unit	Rating Criteria		
			1-Star	2- Stars	3-Stars
(1)	(2)	(3)	(4)	(5)	(6)
i)	Water closet, squatting pan, flushing cistern, and flush valve	a) Full flush, litres/flush	Not more than 6.0 *l* per flush	Not more than 4.8 *l* per flush	Not more than 4.0 *l* per flush
		b) Reduced flush, litres/flush	Not more than 3.0 *l* per flush	Not more than 2.8 *l* per flush	Not more than 2.0 *l* per flush
ii)	Urinal	litres/flush	Not more than 3.0 *l* per flush (inclusive of pre-flush and post-flush, in case of sensor urinal)	Not more than 2.0 *l* per flush (inclusive of pre-flush and post-flush, in case of sensor urinal)	Not more than 1.0 *l* per flush (Inclusive of pre-flush and post-flush, in case of sensor urinal)

6.2.3 Water Usage Monitoring

6.2.3.1 Buildings exceeding the threshold defined under section 2.2 of this code shall install bulk flow meters in the premises to record the flow and demand of the residential premises and the demand requirements of the particular dwelling unit as per Chapter 13 of the Manual on Water Supply and Treatment Systems (Drink from Tap), 2024, published by CPHEEO, MoHUA.

6.2.4 Rainwater Harvesting

6.2.4.1 Ensure to harvest rainwater either by recharging or storage as per guidelines of local byelaws/authority or Model Building Byelaws, whichever is more stringent. The quality of harvested rainwater stored in storage tanks/pit/ sumps at residential level needs to regularly tested as per BIS 10500:2012, particularly used for potable purposes. Residential buildings may have a rainwater harvesting system consisting of:

a) Roof catchment
b) Gutters
c) Downpipes
d) Rainwater/ Storm water drains
e) Filter Chamber
f) Storage Tanks/ Pits/ Sumps.
g) Groundwater recharge structures like pits, trenches, tube wells or a combination of above structures.

6.2.4.2 At least 80% of the rainwater (adjusting the coefficient) falling on roof of the building shall be harvested and stored in a tank for reuse in households through a provision of separate water tank and pipeline to avoid mixing with potable municipal water supply.

6.2.4.3 The quality of harvested rainwater stored in storage tanks/pit/ sumps on the site shall be regularly (once in three months) tested as per BIS 10500:2012, particularly used for potable purposes.

6.2.4.4 The remaining rainwater harvested including the water falling on non-roof areas, after filtering should be recharged back to groundwater through tube well bore or through any other technique in the premise.

6.2.5 Recycle & Reuse of Wastewater

6.2.5.1 Residential complexes having plot area of 1.0 lac sq.ft. or more, which have substantial amount of untreated sewage/ wastewater may be suggested to install on-site wastewater treatment systems, in the absence of centralised sewerage systems and 50% of total wastewater generated shall be recycled and reuse within the premises. The other residential complexes shall also provide onsite wastewater treatment systems for treatment of grey and black water generated by an individual household

6.2.5.2 Separate storage tanks and plumbing lines shall be provided for the reuse of treated water from the on-site wastewater treatment plant following the criteria laid in Section 2 of the National Building Code of India.

6.2.6 Water Quality Requirements

6.2.6.1 Potable/domestic water quality shall comply with the requirements of IS 10500:2012, Drinking Water – Specification, as given in Tables 1 to 4.

6.2.6.2 Varied recycled applications of treated used water quality such as toilet flushing, vehicle exterior washing, non-contact impoundments, and landscape irrigation shall comply with the requirements of updated table 7.19 which has been circulated to the States/UTs by CPHEEO and mentioned under section 9.2.2 (c) of the Sewerage and Sewage Manual released by CPHEEO, Ministry of Housing and Urban Affairs.

6.3 INCREMENTAL PROVISIONS (MAXIMUM 43 POINTS)

6.3.1 Site Water Use Reduction (Maximum 17 Points)

6.3.1.1 Recycled/harvested water shall provide water for irrigation as per the requirements in Table 28.

Table 28: Points for recycled water used for irrigation

Provision	Incremental Points
At least 60% of the total irrigation requirement	5
At least 80% of the total irrigation requirement	8

6.3.1.2 Planting beds shall be provided with a drip irrigation system and shall comply with the requirements as per Table 29.

Table 29: Points for Drip irrigation System

Provision	Incremental Points
A minimum of 80% of the planting bed area has drip irrigation	3
A minimum of 90% of the planting bed area has drip irrigation	5

6.3.1.3 The turf area shall be provided with sprinkler systems and shall comply with requirements as per Table 30. The incremental points are to be awarded only after the compliance of clause 4.2.3.2 of this code.

Table 30: Points for Sprinkler Irrigation System

Provision	Incremental Points
A minimum of 70% of the turf area has a sprinkler system	2
A minimum of 80% of the turf area has a sprinkler system	4

6.3.2 Building Water Use Reduction (Maximum 26 Points)

6.3.2.1 Recycle And Reuse of Water

Recycle and reuse of water shall be ensured on site and shall comply with the specification as per Table 31.

Table 31: Points for Reclamation of Wastewater

Provision	Incremental Points
A minimum of 70% of wastewater reclaimed	6
A minimum of 90% of wastewater reclaimed	10

6.3.2.2 Sanitary Fittings & Ware

Sanitary Fittings such as faucets (taps) and showerheads for their performance based on water efficiency shall comply with the specifications as per Table 32.

Table 32: Points for Star Rated Sanitary Fittings

Provision	Incremental Points
2- star rating as per IS 17650 Part 1, 2021,	5
3- star rating as per IS 17650 Part 1, 2021,	8

Sanitary ware such as water closets, squatting pans, flush valves, flushing cisterns, and urinals for their performance based on water efficiency shall comply with the specifications as per Table 33.

Table 33: Points for Star Rated Sanitary Ware

Provision	Incremental Points
2- star rating as per IS 17650 Part 1, 2021,	5
3- star rating as per IS 17650 Part 1, 2021,	8

CHAPTER 7: WASTE MANAGEMENT

7.1 INTRODUCTION

7.1.1 The chapter provides requirements to minimise the waste generated both during the construction phase and post-occupancy to divert any waste from reaching the landfills. The chapter consists of two parts – Construction Waste Management and Municipal Waste Management.

7.1.2 **Classification of construction waste[19]:** The waste generated during construction shall be classified but not limited to the following categories:

i. **Non-Hazardous waste**: Including but not limited to Excavated earth excluding 150-200 mm (6-8 inches) of the topsoil, Land clearing debris, Metals (Reinforcement bars, Metal beams/girders, Window/Door frames, nuts and bolts, wires, etc.), Cement and Concrete, Masonry materials (Bricks, AAC blocks, stone, any other masonry, etc.), Flooring, Ceiling, Roofing materials, Insulation materials, Cladding materials (Tiles, stones, gypsum, etc.), Glass, Wood, etc.

ii. **Packaging waste**: Including but not limited to cement bags, Wooden crates and pallets, Cardboard boxes, Plastic wrapping and shrink wrap, Foam and bubble wrap, Strapping bands and steel wires, PE film or plastic sheeting, Plastic or metal drums/buckets/containers, Corrugated plastic sheets, specialized packaging etc.

iii. **Construction Hazardous waste:** Including but not limited to lead, tars, adhesives, sealants, broken glass.

7.1.3 **Classification of post-occupancy waste:** The waste generated post-construction shall be classified but not limited to the following categories:

i. **Dry waste:** Including but not limited to, *plastic* items (plastic bottles, containers, packaging, stationary items, etc.), *paper* items (newspapers, magazines, cardboard, packaging, etc.), *metal* items (aluminium cans, used aluminium foil paper/tray, *steel* containers, old metal utensils, pots, metal gardening accessories, etc.), *glass* items (glass bottles, jars, utensils, etc.), *Electronics* items (wires, computer accessories, fluorescents, lamps, other electronics, and electrical devices/appliances).

ii. **Wet waste:** Including but not limited to, vegetable peels, used tea, fruits, food leftovers, horticulture waste, etc. These are biodegradable organic waste that can also be composted.

iii. **Sanitary waste:** Including but not limited to, used diapers, sanitary pads, sweat pads, tampons, condoms, wipes, masks/ gloves, toilet paper, bandages, swabs, and other personal hygiene products etc.

iv. **Hazardous waste:** Including but not limited to, expired medicines, used syringes/needles, chemical containers, broken glass, batteries, etc.

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[19] **Construction Waste:** Construction waste is any substance, matter, or thing that is produced as a result of construction work. Wastes also include surplus and damaged products and materials arising in the course of construction work or used temporarily during on-site activities. (C & D Waste Management Rules, 2016)

7.2 MANDATORY PROVISIONS

7.2.1 Construction Waste Management

7.2.1.1 Segregation And Storage of Waste

Designated areas shall be provided within the site/adjacent site for collection, segregation, and storage of segregated waste as per the classification of waste mentioned in section no. 7.1.2 of this code.

Note: No construction and demolition waste shall be littered or deposited to prevent obstruction to the traffic or the public or drains. (C&D Waste Management Rules, 2016)

7.2.1.2 Minimization of Non-Hazardous Waste

At least 50% (by either weight or volume) of non-hazardous waste generated, shall have to be reused/repurposed/recycled/salvaged [20]. For sample calculation refer to section number 9.15 of this code.

Note: Some types of construction waste can be reused/repurposed on-site as fill material for levelling uneven terrain, filling excavated areas, or creating embankments, as a base or subbase material for road construction, for erosion control measures, constructing retaining walls, as bedding and backfill material for utility pipelines, etc.

7.2.1.3 Recycling of Packaging Waste

100% of the packaging recyclable waste, shall be handed over to manufacturers/ authorized recyclers or municipal entities for appropriate management and disposal.

7.2.1.4 Divert Construction Waste from Landfill

Ensure that all (100%) the construction waste (by either weight or volume) generated during the construction process is either reused/repurposed/salvaged on-site, diverted to recycling facilities, or safely handed over to municipalities. Diversion efforts shall be tracked throughout the construction process. For sample calculation refer to section number 9.15 of this code.

7.2.2 Post-Construction Waste Management

7.2.2.1 Waste Collection, Segregation And Storage

A designated centralized waste collection area in each building shall be provided with at least **four** colour-coded waste bins from the categories (Dry Waste, Organic Waste, Sanitary Waste,

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[20] **Reusing** is a strategy to return materials for active use in the same or a related capacity.
Repurposing refers to items or substances that were originally intended for one purpose but have been creatively transformed, i.e., broken brick/blocks can be repurposed as road filling.
Recycling is a strategy to put used objects and materials through a process so that they can be used again.
Salvaged materials are construction materials recovered from existing buildings or construction sites / second-hand markets and reused in other buildings.

Hazardous Waste, E-waste). For calculation of waste generation quantity and area required for storage, refer to section number 9.12, 9.13 of this code.

Note:

A. A daily waste collection schedule should be developed to collect the segregated waste from each building and store at a designated centralized storage area in the premises until its transportation to respective recyclers.

B. Dry, sanitary, and hazardous waste shall be transported to/ collected by authorised recyclers/ Municipal Corporation.

7.2.2.2 Organic Waste Treatment

A. Projects having built up area ≥5000 sq.m, an onsite designated area shall be provided to compost (manually or mechanically) at least 50% of projected organic waste (kitchen & horticulture) generated on post-occupancy. The waste generation shall be calculated using the formula as given in section number 9.10 of this code. The area shall be provided as per Table 34.

B. Projects having built up area ≤5000 sq.m, the project authority may hand over the segregated organic waste to the concerned local body if the municipality has a garbage pick-up mechanism in place. If such an arrangement is inadequate or unavailable, the project authority shall engage a professional waste management organisation to pick up the segregated organic waste, where there is no alternate arrangement for disposal of biodegradable waste, Organic waste composter/Vermiculture pit with a minimum capacity of 1.0 kg/150 sqm. of built-up area/day shall be installed & operated.

Table 34: Area requirement for different strategies

S. No.	Type of waste treatment	Area required (m^2 per 10Kg)
1	Composting	Approx. 10 m^2 (including circulation area)
2	Vermi Composting	Approx. 15 m^2 (including circulation area)
3	Mechanical	8-12 m^2 (including circulation area)

7.3 INCREMENTAL PROVISIONS (MAXIMUM 7 POINTS)

7.3.1 Construction Waste Management (Maximum 2 Points)

7.3.1.1 Minimization Of Non-Hazardous Waste

Non-hazardous construction waste generated shall have to be reused/repurposed /recycled/salvaged, to comply with the requirements as per Table 35.

Table 35: Points for reuse of waste generated on-site

Provision	Incremental Points
75%of non-hazardous waste generated is reused/repurposed /recycled/salvaged	1
95% of non-hazardous waste generated is reused/repurposed /recycled/salvaged	2

7.3.2 Post-Construction Waste Management (Maximum 5 Points)

7.3.2.1 Waste Collection, Segregation and Storage (Maximum Points: 2)

Different categories (organic, sanitary, Hazardous, plastic, paper, glass, metal, packaging, E-waste) of colour-coded waste collection bins are provided for waste segregation in the centralized waste collection area, as per Table 36.

Note: Colour coding of wastebins can be implemented based on market availability, along with the installation of permanent signages.

Table 36: Points for waste segregation at the centralized unit

Provision	Incremental Points
100% of recyclable waste shall be segregated into any **six** categories	1
100% of recyclable waste shall be segregated into **eight** categories	2

7.3.2.2 Organic Waste Treatment (Maximum Points: 3)

A designated area on the project site shall be provided to compost (manually or mechanically) to comply with the requirements as per Table 37. The calculation shall be done to calculate the designated area as per 9.12, 9.13, 9.13.

Table 37: Points for Composting of Organic Waste

Provision	Incremental Points
75% of organic waste generated post-occupancy is composted on-site	2
95% of organic waste generated post-occupancy is composted on-site	3

CHAPTER 8: INDOOR ENVIRONMENTAL QUALITY (IEQ)

8.1 INTRODUCTION

8.1.1 The chapter provides provisions related to indoor air quality, thermal comfort, and visual comfort post-occupancy of a building. It consists of eight parts: ventilation potential, low-emitting materials, air quality in car parking, openings for kitchen and bathrooms/toilet ventilation, daylight availability, lighting adequacy for common areas and exterior lighting, lighting quality, and thermal comfort.

8.2 MANDATORY PROVISIONS

8.2.1 Ventilation Potential

8.2.1.1 The building shall meet the minimum criteria for the openable window-to-floor area ratio (WFR_{op}) to ensure an adequate potential for natural ventilation as per Table 8 under provision number 5.2.1.1 of this code.

8.2.2 Low-VOC Emitting Materials

8.2.2.1 Paints used on the interior side of the building envelope shall comply with the Volatile Organic Compound (VOC) content limits as per Table 38

Table 38: VOC Limits of Selected Paints

Type of Material	VOC Limit (g/L less water)
Paints:	
Flat paints	50
Non-flat paints	50

8.2.3 Air Quality in Car Parking

8.2.3.1 For enclosed parking areas, a well-designed ventilation and exhaust system shall be installed that provides a minimum of 6 air changes per hour, as per the National Building Code (NBC), to effectively eliminate vehicle exhaust fumes and pollutants.

Air Change per Hour = Q / V

where,

Q = airflow rate (m^3/h)
V = volume of the space (m^3)

8.2.4 Ventilation Opening in Kitchen and Bathrooms/Toilets

8.2.4.1 An opening and/or ventilator shall be provided, in addition to the window, for the installation of exhaust systems in the kitchen and bathrooms/toilets.

8.2.5 Daylight Availability

8.2.5.1 The building shall meet the minimum criteria for Visible Light Transmittance (VLT) to ensure adequate availability of daylight as per Table 9 under provision number 5.2.1.2 of this code.

8.2.6 Lighting Adequacy for Common Areas and Exterior Lighting

8.2.6.1 Artificial lighting systems complying with the minimum recommended lux levels specified in Table 39 shall be installed.

Table 39: Required Min. Lux Levels as per space

Area Name	Minimum lux level
Corridor Lighting & Stilt Parking	100
Basement lighting	70
Exterior Lighting Areas	
Driveways and parking (open/ external) Pedestrian walkways Stairways	5-20 50 100
Indoor Lighting (If applicable)	
Kitchen Bathroom Reading/ Study	200 100 300

(Source: SP 41 - Handbook on Functional Requirements of Buildings-Part 4 & NBC 2016: Volume 2, part 8, section 1, section 4.1.4)

The lux levels shall be calculated using the formula as given in section number 9.10 of this code.

8.2.7 Lighting Quality - Colour Rendering Index

8.2.7.1 The Colour Rendering Index (CRI) values for each zone within the building shall comply with requirements as per Table 40

Table 40: Required CRI as per space type

Area Name	Ra (General Colour Rendering Index)
Corridor Lighting & Stilt Parking	80
Basement lighting	70
Exterior Lighting Areas	
Driveways and parking (open/ external) Pedestrian walkways Stairways	70 70 80
Indoor Lighting (If applicable)	
Kitchen Bathroom Reading/ Study	90 80 90

8.2.8 Thermal Comfort

8.2.8.1 Buildings in all Climate Zones except Cold Climate shall comply with the following provisions of the code:

A. Maximum Residential Envelope Transmittance Value (RETV) (except the roof) as per provision number 5.2.1.4.
B. Minimum openable window-to-floor area ratio (WFR_{op}) as per provision number 5.2.1.1.
C. Maximum Thermal Transmittance of roof (U_{roof}) as per provision number 5.2.1.3

8.2.8.2 Buildings in Cold Climates, shall comply with the following provisions of the code:

A. Thermal Transmittance value of the building envelope ($U_{Envelope.Cold}$) (except the roof) as per provision number 5.2.1.5.
B. Maximum Thermal Transmittance of roof (U_{roof}) as per provision number 5.2.1.3.

8.3 INCREMENTAL POINTS PROVISIONS (MAXIMUM 10 POINTS)

8.3.1 Cross-Ventilation (Maximum 4 Points)

8.3.1.1 Cross-ventilation is ensured in regularly occupied spaces (kitchen, bedrooms, living, dining areas) with openable doors, windows, or ventilators as per Annexure 6. Incremental points are calculated as per the formula below and points as per Table41.

Percentage of cross ventilation area = (cross ventilation Area / total regularly occupied Area) * 100

Table 41: Cross ventilation requirement for incremental points

Provision	Incremental Points
50% of regularly occupied spaces have cross-ventilation	2
75% of regularly occupied spaces have cross-ventilation	3
90% of regularly occupied spaces have cross-ventilation	4

8.3.2 Daylight Availability (Useful Daylight Illuminance) (Maximum 4 Points)

8.3.2.1 The building shall comply with the useful daylight illuminance requirement as prescribed by the ECBC 2017, section no 4.2.3. Ensure above-grade floor areas shall meet or exceed the useful daylight illuminance (UDI) area requirements listed in Table 56 for 90% of the potential daylit time in a year. (Refer to Chapter 9: Calculations and Formula). Incremental points can be achieved as per Table 42.

Table 42: Daylight Requirement

Provision	Incremental Points
40% of the regularly occupied spaces meeting the UDI requirement	2
50% of the regularly occupied spaces meeting the UDI requirement	3
60% of the regularly occupied spaces meeting the UDI requirement	4

8.3.3 Air Quality in Underground Parking Area (Maximum Points 2)

8.3.3.1 Install a demand control ventilation system to limit CO levels in the underground parking area to ensure safety and air quality. The location of sensors should be followed as prescribed by the NBC 2016, Volume 2, Part 8, section 3, section no 11.5.4. Incremental points can be achieved as per Table 43.

Table 43: Air Quality in Car Parking

Provision	Incremental Points
CO sensors are installed to control the ventilation system to limit CO level	2

CHAPTER 9: CALCULATIONS AND FORMULA

9.1 Calculation of Openable Window-To-Floor Area Ratio (WFR_{OP})

9.1.1 The openable window-to-floor area ratio (WFR_{op}) indicates the potential of using external air for ventilation. The prescribed minimum WFR_{op} helps in ventilation, improvement in thermal comfort, and reduction in cooling energy.

9.1.2 The openable window-to-floor area ratio (WFR_{op}) is the ratio of openable area to the carpet area of dwelling units.

$$WFR_{op} = \frac{A_{openable}}{A_{carpet}} \quad (1)$$

Where:

WFR_{op} : openable window-to-floor area ratio

$A_{openable}$: openable area (m^2); it includes the openable area of all windows and ventilators, opening directly to the external air, an open balcony, 'verandah', corridor, or shaft; and the openable area of the doors opening directly into an open balcony.

Exclusions: All doors opening into corridors. External doors on ground floor, for example, ground floor entrance doors or backyard doors.

A_{carpet}: Carpet Area of dwelling units (m^2); it is the net usable floor area of a dwelling unit, excluding the area covered by the external walls, areas under services shafts, exclusive balcony or verandah areas and exclusive open terrace areas, but includes the area covered by the internal partition walls of the dwelling unit.

9.1.3 The openable area ($A_{openable_{DU}}$) of each dwelling unit (DU) is calculated by adding the openable area of all windows and ventilators, opening directly to the external air, an open balcony, 'veranda', corridor or shaft; and the openable area of the doors opening directly into an open balcony (doors opening into the corridors and ground-floor external doors are not included).

$$A_{openable_{DU}} = A_{openable_{window}} + A_{openable_{ventilator}} + A_{openable_{door}}$$

In case the exact openable area is not known, the default values as per Table 44 can be used:

Table 44: Default openable area to opening area ratio

Type of window/door/ventilator	Percentage openable area
Casement	90%
Sliding (2 panes)	50%
Sliding (3 panes)	67%

9.1.4 Add openable areas of all dwelling units to get the total openable area.

$$A_{openable} = A_{openable_{DU1}} + A_{openable_{DU2}} + A_{openable_{DU3}} + \ldots$$

9.1.5 The total carpet area can be calculated by adding the carpet areas of all the dwelling units (DU). It excludes the areas covered by external walls, areas under service shafts, exclusive balcony or veranda areas and exclusive open terrace areas, but includes the areas covered by the internal partition walls of the dwelling unit.

$$A_{carpet} = A_{carpetDU1} + A_{carpetDU2} + A_{carpetDU3} + \ldots$$

9.2 Calculation of Window-To-Wall Ratio (WWR)

9.2.1 WWR is the ratio of the area of non-opaque building envelope components of dwelling units to the envelope area (excluding roof) of dwelling units.

$$WWR = \frac{A_{non-opaque}}{A_{envelope}}$$

9.2.2 Calculate the total non-opaque (transparent/translucent panels of windows, doors, ventilators, etc.) area of the building envelope for each dwelling unit.

$$A_{non-opaque(DU)} = A_{non-opaque(Window)} + A_{non-opaque(Door)} + A_{non-opaque(Other)}$$

Add non-opaque areas of all dwelling units to get the total non-opaque area of the building block. Non-opaque components facing open corridors and enclosed shafts, as well as walls of common services such as lifts and staircases are to be excluded.

$$A_{non-opaque} = A_{non-opaque(DU1)} + A_{non-opaque(DU2)} + A_{non-opaque(DU3)} + \ldots$$

9.2.3 Calculate the total envelope area (excluding roof) of dwelling units of the building block. For each wall of the building envelope, calculate the gross wall area (i.e., overall area of a wall including openings such as windows, ventilators, and doors, with measurement taken horizontally from outside surface to outside surface and measured vertically from the top of the floor to the top of the roof). Add the gross wall area of all walls to get the total envelope area (excluding roof) for the building. Walls facing open corridors and enclosed shafts, as well as walls of common services such as lifts and staircases are to be excluded.

$$A_{envelope} = A_{gross-wall} + A_{gross-wall} + A_{gross-wall} + \ldots$$

9.3 Calculation of Thermal Transmittance (U Value) of Roof and Wall

Calculate the thermal resistance of each uniform material layer, which constitutes the building component, as follows:

$$R_i = \frac{t_i}{k_i} \tag{2}$$

where,

R_i is the thermal resistance of material layer i, m^2.K/W

t_i is the thickness of material layer i, m

k_i is the thermal conductivity of material layer i, W/(m.K)
Find the total thermal resistance, RT, as follows:

$$R_T = R_{si} + R_{se} + R_1 + R_2 + R_3 + \cdots \qquad (14)$$

Where,
R_T is the total thermal resistance, $m^2.K/W$
R_{si} is the interior surface film thermal resistance, $m^2.K/W$
R_{se} is the exterior surface film thermal resistance, $m^2.K/W$
R_1 is the thermal resistance of material layer 1, $m^2.K/W$
R_2 is the thermal resistance of material layer 2, $m^22.K/W$
R_3 is the thermal resistance of material layer 3, $m^2.K/W$
Using these default values for calculation, the thermal conductivity of commonly used building materials is given in Table 45, which can be used to calculate the thermal resistance (r- value).

Table 45: Values of surface film thermal resistance for U-value calculation

	Wall	**Roof**	
	All climatic Zones	**composite climate, hot-dry climate, warm-humid climate, and temperate climate**	**cold climate**
R_{si} ($m^2.K/W$)	0.13	0.17	0.10
R_{se} ($m^2.K/W$)	0.04	0.04	0.04

Source: adapted from Bureau of Energy Efficiency (BEE), 2009. Energy Conservation Building Code user guide, New Delhi.

Calculate the thermal transmittance (or the overall heat transfer coefficient or U value) of a wall or roof assembly, as follows:

$$U = \frac{1}{R_T} \qquad (15)$$

where,

U is the overall heat transfer coefficient, $W/(m^2.K)$

Table 46 gives typical thermal properties of commonly used building and insulating materials. This is not an all-inclusive list. In case, thermal conductivity values, measured using the appropriate IS codes, are available; than those can also be used for calculations.

Table 46: Type of material and Thermal Conductivity

S. No.	**type of material**	**Density (kg/m^3)**	**thermal conductivity (w/m.K)**	**specific heat capacity (kJ/kg.K)**	**source**
I. Building materials					
1	Solid burnt clay brick	1920	0.980	0.80	(1)
2	Solid burnt clay brick	1760	0.850	NA	(1)
3	Solid burnt clay brick	1600	0.740	NA	(1)
4	Solid burnt clay brick	1440	0.620	NA	(1)
5	Resource efficient (hollow) brick	1520	0.631	0.65	(4)

6	Fly ash brick	1650	0.856	0.93	(2)
7	Solid concrete block 25/50	2427	1.396	0.20	(4)
8	Solid concrete block 30/60	2349	1.411	0.30	(4)
9	Aerated autoclaved concrete (AAC) block	642	0.184	1.24	(4)
10	Cement stabilized soil block (CSEB)	1700	1.026	1.03	(5)
11	Cement stabilized soil block (CSEB)	1800	1.201	1.07	(5)
12	Cement stabilized soil block (CSEB)	1900	1.303	1.07	(5)
13	Dense concrete	2410	1.740	0.88	(3)
14	Reinforced concrete cement (RCC)	2288	1.580	0.88	(3)
15	Brick tile	1892	0.798	0.88	(3)
16	Lime concrete	1646	0.730	0.88	(3)
17	Mud Phuska	1622	0.519	0.88	(3)
18	Cement mortar	1648	0.719	0.92	(3)
19	Cement plaster	1762	0.721	0.84	(3)
20	Gypsum plaster	1120	0.512	0.96	(3)
21	Cellular concrete	704	0.188	1.05	(3)
22	AC sheet	1520	0.245	0.84	(3)
23	GI sheet	7520	61.060	0.50	(3)
24	Timber	480	0.072	1.68	(3)
25	Timber	720	0.144	1.68	(3)
26	Plywood	640	0.174	1.76	(3)
27	Glass	2350	0.814	0.88	(3)
28	Tar felt (2.3 kg/m^2)		0.479	0.88	(3)
II. Insulating materials					
1	Expanded polystyrene	16.0	0.038	1.34	(3)
2	Expanded polystyrene	24.0	0.035	1.34	(3)
3	Expanded polystyrene	34.0	0.035	1.34	(3)
4	Foam glass	127.0	0.056	0.75	(3)
5	Foam glass	160.0	0.055	0.75	(3)
6	Foam concrete	320.0	0.070	0.92	(3)
7	Foam concrete	400.0	0.084	0.92	(3)
8	Foam concrete	704.0	0.149	0.92	(3)
9	Cork slab	164.0	0.043	0.96	(3)
10	Cork slab	192.0	0.044	0.96	(3)
11	Cork slab	304.0	0.055	0.96	(3)
12	Rock wool (unbonded)	92.0	0.047	0.84	(3)
13	Rock wool (unbonded)	150.0	0.043	0.84	(3)
14	Mineral wool (unbonded)	73.5	0.030	0.92	(3)
15	Glass wool (unbonded)	69.0	0.043	0.92	(3)
16	Glass wool (unbonded)	189.0	0.040	0.92	(3)

17	Resin bonded mineral wool	48.0	0.042	1.00	(3)
18	Resin bonded mineral wool	64.0	0.038	1.00	(3)
19	Resin bonded mineral wool	99.0	0.036	1.00	(3)
20	Resin bonded mineral wool	16.0	0.040	1.00	(3)
21	Resin bonded mineral wool	24.0	0.036	1.00	(3)
22	Exfoliated vermiculite (loose)	264.0	0.069	0.88	(3)
23	Asbestos mill board	1397.0	0.249	0.84	(3)
24	Hard board	979.0	0.279	1.42	(3)
25	Straw board	310.0	0.057	1.30	(3)
26	Soft board	320.0	0.066	1.30	(3)
27	Soft board	249.0	0.047	1.30	(3)
28	Wall board	262.0	0.047	1.26	(3)
29	Chip board	432.0	0.067	1.26	(3)
30	Chip board (perforated)	352.0	0.066	1.26	(3)
31	Particle board	750.0	0.098	1.30	(3)
32	Coconut pith insulation board	520.0	0.060	1.09	(3)
33	Jute fibre	329.0	0.067	1.09	(3)
34	Wood wool board (bonded with cement)	398.0	0.081	1.13	(3)
35	Wood wool board (bonded with cement)	674.0	0.108	1.13	(3)
36	Coir board	97.0	0.038	1.00	(3)
37	Saw dust	188.0	0.051	1.00	(3)
38	Rice husk	120.0	0.051	1.00	(3)
39	Jute felt	291.0	0.042	0.88	(3)
40	Closed cell flexible elastomeric foam - NBR	40–55	0.043	1.20	(3)

NA: Not available

Sources

(1) American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). 2009. 2009 ASHRAE Handbook (Fundamentals). Atlanta, United States: ASHRAE

(2) Gourav K, et al. 2017. Studies into structural and thermal properties of building envelope mate- rials. Energy Procedia 122: 104–108

(3) Bureau of Indian Standards (BIS). 1987. Handbook on Functional Requirements of Buildings (Other than Industrial Buildings) SP: 41 (S & T) -1987. New Delhi: BIS.

(4) Thermo-Physical-Optical Property Database of Construction Materials, U.S.- India Joint Centre for Building Energy Research and Development (CBERD) and Ministry of New and Renew- able Energy (MNRE). Available at http://www.carbse.org/wp-content/uploads/2017/10/Data- base-of-Construction-Materials_Oct17.pdf (accessed on 1 May 2018).

(5) Balaji N C, et al. 2015. Influence of varying mix proportions on thermal performance of soil-cement blocks. Building Simulation Applications (BSA). 2nd IBPSA Italy Conference, Building Simulation Application - 2015 (BSA 2015). Available at http://www.ibpsa.org/proceedings/ BSA2015/9788860460745_10.pdf (accessed on 1 May 2018).

In case, the construction has air layer, use values of thermal resistance of air layer given in Table 47 for U value calculation.

Table 47: Values of unventilated air layer thermal resistance for U-value calculation

thickness of air Layer (mm)	thermal resistance (m².K/w)		
	wall in all climatic Zones	Roof in composite climate, hot-Dry climate, warm-humid climate, and temperate climate	Roof in cold climate
5	0.12	0.10	0.10
7	0.12	0.12	0.12
10	0.14	0.14	0.14
15	0.16	0.16	0.16
25	0.18	0.18	0.17
50	0.18	0.20	0.17
100	0.18	0.20	0.17
300	0.18	0.21	0.17

Source: Adapted from Bureau of Energy Efficiency (BEE), 2009. Energy Conservation Building Code User Guide, New Delhi

In case of solid bricks and blocks, where measured thermal conductivity values are not available but measured dry density values (using appropriate IS code) are available then equation 1 and equation 2 can be used to calculate the thermal conductivity value.

Equation 1 gives a correlation between thermal conductivity (k) and dry density (ρ) for solid burnt clay bricks and can be used for dry density ranging from 1250 – 2150 kg/m3.

$$k = 0.0652e^{0.0012\rho} \quad \text{(Equation 1)}$$

Equation 2 gives a correlation for non-fired bricks (AAC block, concrete block, flyash bricks, C&D waste bricks, CSEB, etc.) and can be used for dry density ranging from 600 – 2100 kg/m3.

$$k = 0.1009e^{0.0011\rho} \quad \text{(Equation 2)}$$

(Source: Maithel S, et al. 2023, Thermal Properties of Indian Masonry Units & Masonry for Eco-Niwas Samhita Implementation, Energise 2023)

9.4 Thermal Transmittance of Roof (U_{ROOF})

9.4.1 Thermal transmittance (U_{roof}) characterizes the thermal performance of the roof of a building. Limiting the U_{roof} helps in reducing heat gains or losses from the roof, thereby improving the thermal comfort and reducing the energy required for cooling or heating.

9.4.2 The calculation[21] for thermal transmittance of roof shall be carried out, using Equation as shown below,

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

$$U_{roof} = \frac{1}{A_{roof}}\left[\sum_{i=1}^{n}(U_i\ x\ A_i)\right]$$

Where,

U_{roof} : thermal transmittance of roof (W/m[2].K)

A_{roof} : total area of the roof (m[2])

U_i : thermal transmittance values of different values of different roof construction (W/m[2].K)

A_i : areas of different roof constructions (m[2])

9.5 Residential Envelope Transmittance Value (RETV) for Building Envelope (Except Roof) for Four Climate Zones, namely, Composite Climate, Hot-Dry Climate, Warm-Humid Climate, and Temperate Climate

9.5.1 Residential envelope heat transmittance (RETV) is the net heat gain rate (over the cooling period) through the building envelope (excluding roof) of the dwelling units divided by the area of the building envelope (excluding roof) of the dwelling units. Its unit is W/m[2].

RETV characterizes the thermal performance of the building envelope (except roof). Limiting the RETV value helps in reducing heat gains from the building envelope, thereby improving the thermal comfort and reducing the electricity required for cooling.

RETV formula takes into account the following:

a) Heat conduction through opaque building envelope components (wall, opaque panels in doors, windows, ventilators, etc.),
b) Heat conduction through non-opaque building envelope components (transparent/translucent panels of windows, doors, ventilators, etc.),
c) Solar radiation through non-opaque building envelope components (transparent/translucent panels of windows, doors, ventilators, etc.)

9.5.2 The RETV for the building envelope (except roof) for four climate zones, namely, Composite Climate, hot-Dry Climate, Warm-humid Climate, and temperate Climate, shall comply with the maximum RETV of 15 W/m[2].

9.5.3 The RETV calculation of the building envelope (except roof) shall be carried out, using Equation 4 as shown below. [22]

$$RETV = \frac{1}{A_{envelope}} \times \left[\left\{a \times \sum_{i=1}^{n}\left(A_{opaque_i} \times U_{opaque_i} \times \omega_i\right)\right\} + \left\{b \times \sum_{i=1}^{n}\left(A_{non-opaque_i} \times U_{non-opaque_i} \times \omega_i\right)\right\} + \left\{c \times \sum_{i=1}^{n}\left(A_{non-opaque_i} \times SHGC_{eq_i} \times \omega_i\right)\right\}\right] \quad (3)$$

where,

BEE plans to improve the RETV norm to 12 W/m[2] in the near future and the building industry and regulating agencies are encouraged to aim for it.

22 To comply with the Code, RETV value shall be rounded off to nearest integer value in accordance with IS 2: 1960 'Rules for rounding off numerical values'.

$A_{envelope}$:	envelope area (excluding roof) of dwelling units (m[2]). It is the gross external wall area (includes the area of the walls and the openings such as windows and doors).
A_{opaque_i}:	areas of different opaque building envelope components (m[2])
U_{opaque_i}:	thermal transmittance values of different opaque building envelope components (W/m[2].K)
$A_{non-opaque_i}$:	areas of different non-opaque building envelope components (m[2])
$U_{non-opaque_i}$:	thermal transmittance values of different non-opaque building envelope components (W/m[2].K)
$SHGC_{eq_i}$:	equivalent solar heat gain coefficient values of different non-opaque building envelope components (values are given in section 9.9)

ω_i: orientation factor of respective opaque and non-opaque building envelope components; it is a measure of the amount of direct and diffused solar radiation that is received on the vertical surface in a specific orientation

The coefficients of RETV formula, for different climate zones are given in Table 48

Table 48: Coefficients (a, b, and c) for RETV formula

Climate zone	a	b	c
Composite	6.06	1.85	68.99
Hot-Dry	6.06	1.85	68.99
Warm-Humid	5.15	1.31	65.21
Temperate	3.38	0.37	63.69
Cold	Not Applicable (Refer section 5.2.1.4)		

9.5.4 If a proposed building development comprises two or more residential building blocks having different RETV. The weighted average RETV of the total residential project shall be computed (using method mentioned in Chapter 9).

9.6 Calculation of the Weighted Average RETV of The Total Residential Project

9.6.1 The weighted average RETV of the total residential project shall be computed using following equation

$$RETV_{Weighted\ average} = \sum (RETV_{bldg.} \times EA_{bldg.}) / EA_{total}$$

$$= \frac{(RETV_{bldg1.} \times EA_{bldg1}) + (RETV_{bldg2} \times EA_{bldg2}) + (RETV_{bldg3} \times EA_{bldg3})}{(EA_{total})}$$

Where,

$RETV_{Weighted\ average}$ is the combined RETV of the overall residential development project.
$RETV_{bldg.\ i}$: is the individual RETV of each residential block.
$EA_{bldg\ i}$: is the total envelope area of the individual building or the total residential project.
EA_{total}: is the total envelope area of the individual building or the total residential project.

$A_{envelope}$: envelope area (excluding roof) of dwelling units (m^2). It is the gross external wall area (includes the area of the walls and the openings such as windows and doors)

9.7 Thermal Transmittance Of Building Envelope (Except Roof) for Cold Climate ($U_{envelope,Cold}$)

9.7.1 Thermal transmittance ($U_{envelope,cold}$) characterizes the thermal performance of the building envelope (except roof). Limiting the $U_{envelope,cold}$ helps in reducing heat losses from the building envelope, thereby improving the thermal comfort and reducing the energy required for heating.

$U_{envelope,cold}$ takes into account the following:

- Heat conduction through opaque building envelope components (wall, opaque panels in door, window, ventilators, etc.)
- Heat conduction through non-opaque building envelope components (trans-parent/translucent panels in windows, doors, ventilators, etc.).

9.7.2 The thermal transmittance of the building envelope (except roof) for cold climate shall comply with the maximum of 1.8 W/m².K.

9.7.3 The calculation of the building envelope (except roof) shall be carried out, using the following equation

$$U_{envelope,cold} = \frac{1}{A_{envelope}} \sum_{i=1}^{n} (U_i \times A_i)$$

Where,

$U_{envelope,cold}$	: Thermal transmittance of building envelope (except roof) for cold climate (W/m².K)
$A_{envelope}$	: envelope area (excluding roof) of dwelling units (m²). It is the gross external wall area (includes the area of the walls and the openings such as windows and doors)
U_i	: thermal; transmittance of different opaque and non-opaque building envelope components (W/m².K)
A_i	: area of different opaque and non-opaque building envelope components (m²)

9.8 Orientation Factor

9.8.1 The orientation factor (ω) is a measure of the amount of direct and diffused solar radiation that is received on the vertical surface in a specific orientation. This factor accounts for and gives weightage to the fact that the solar radiation falling on different orientations of walls is not same. It has been defined for the latitudes ≥23.5˚N and latitudes <23.5˚N (Table 49). Table 49 should be read in conjunction with Figure 1.

Table 49: Orientation factor (ω) for different orientations

Orientation	Orientation factor (ω)	
	Latitudes ≥23.5˚N	Latitudes <23.5˚N
North (337.6˚–22.5˚)	0.550	0.659
North-east (22.6˚–67.5˚)	0.829	0.906
East (67.6˚–112.5˚)	1.155	1.155
South-east (112.6˚–157.5˚)	1.211	1.125
South (157.6˚–202.5˚)	1.089	0.966
South-west (202.6˚–247.5˚)	1.202	1.124
West (247.6˚–292.5˚)	1.143	1.156
North-west (292.6˚–337.5˚)	0.821	0.908

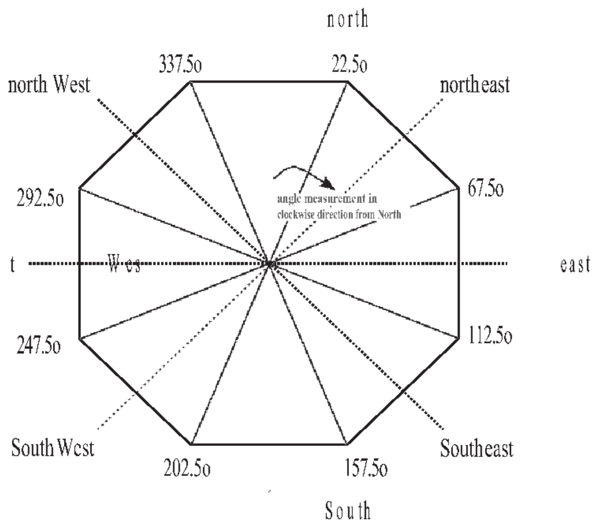


Figure 1: Primary orientations for determining the orientation factor ω

Example:
What is the orientation factor (ω) for a vertical surface oriented towards the East in a building situated in Chandigarh (30.73° N latitude).

From Table 49
For latitudes ≥23.5˚N, the orientation factor (ω) for an East orientation is 1.155.

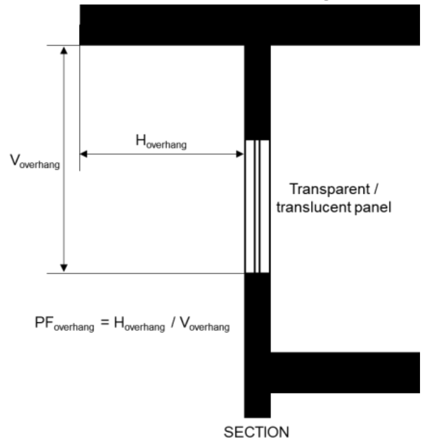
9.9 Calculation Of Equivalent SHGC

9.9.1 SHGC Equivalent is the SHGC for a non-opaque component with a permanent external shading projection (overhang and side fins). It is calculated by multiplying the External Shading Factor (ESF) with the SHGC of unshaded non-opaque component. ESF values are defined based on the projection factor (PF). the procedure for calculation is given below:

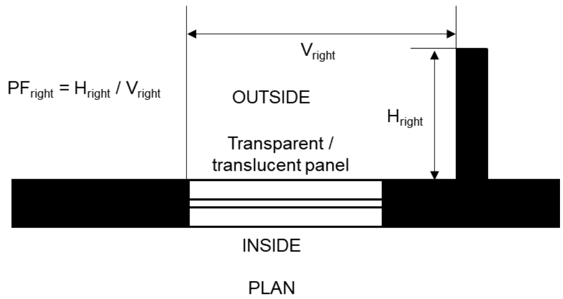
A. Calculate the projection factor (PF) for permanent external projection, including but not limited to overhangs, side fins, box frame, verandah, balcony, and fixed canopies, using the formula:

i. Projection factor, overhang: the ratio of the horizontal depth of the external shading projection ($H_{overhang}$) to the sum of the height of a non-opaque component and the distance from the top of the same component to the bottom of the farthest point of the external shading projection ($V_{overhang}$), in consistent units.

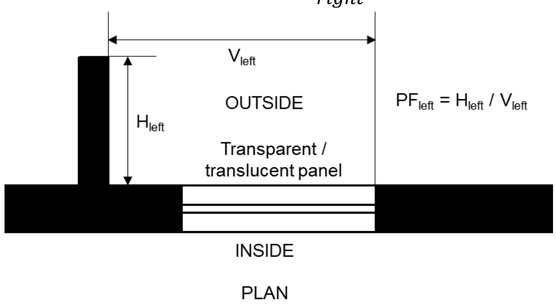
$$PF_{overhang} = \frac{H_{overhang}}{V_{overhang}} \tag{16}$$



ii. Projection factor, side/vertical fin: the ratio of the horizontal depth of the external shading projection to the distance from a non-opaque component to the farthest point of the external shading projection, in consistent units. In case of single side/ vertical fin, it could be on the 'Right' or 'Left' or there could be side/vertical fins on both the sides. A 'Right' side/vertical fin would be located on the right side of the window while looking out from the building and similarly, a 'Left' side/ vertical fin would be located on the left side of the window while looking out from the building.



$$PF_{right} = \frac{H_{right}}{V_{right}} \tag{17}$$



$$PF_{left} = \frac{H_{left}}{V_{left}} \tag{18}$$

B. Select the ESF value for each shading element as:

i. Overhang (ESFoverhang): Refer Table 50 and Table 51.

ii. Side fin-right (ESFright): Refer Table 52 and Table 53.

iii. Side fin-left (ESFleft): Refer Table 54 and Table 55.

Table 50: External Shading Factor for Overhang ($ESF_{overhang}$) for LAT ≥ 23.5°N

External Shading Factor for Overhang ($ESF_{overhang}$) for LAT ≥ 23.5˚N								
Orientation / $PF_{overhang}$	North (337.6˚– 22.5˚)	North-east (22.6˚– 67.5˚)	East (67.6˚– 112.5˚)	South-east (112.6˚– 157.5˚)	South (157.6˚– 202.5˚)	South-west (202.6˚– 247.5˚)	West (247.6˚– 292.5˚)	North-west (292.6˚– 337.5˚)
<0.10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
0.10-0.19	0.955	0.930	0.922	0.906	0.881	0.905	0.922	0.930
0.20-0.29	0.922	0.876	0.855	0.824	0.789	0.823	0.853	0.875
0.30-0.39	0.897	0.834	0.796	0.755	0.719	0.753	0.794	0.834
0.40-0.49	0.877	0.803	0.745	0.697	0.665	0.695	0.743	0.802
0.50-0.59	0.860	0.779	0.702	0.652	0.626	0.650	0.700	0.778
0.60-0.69	0.846	0.761	0.666	0.617	0.598	0.614	0.663	0.760
0.70-0.79	0.834	0.747	0.635	0.590	0.580	0.587	0.632	0.746
0.80-0.89	0.825	0.737	0.609	0.569	0.569	0.566	0.606	0.736
0.90-0.99	0.817	0.729	0.587	0.554	0.563	0.551	0.585	0.728
≥1	0.810	0.722	0.569	0.542	0.559	0.539	0.566	0.721

Table 51: External Shading Factor for Overhang ($ESF_{overhang}$) for LAT<23.5°N

orientation / $PF_{overhang}$	External shading Factor for overhang ($ESF_{overhang}$) for Lat < 23.5°N							
	North (337.6°– 22.5°)	North-east (22.6°– 67.5°)	East (67.6°– 112.5°)	south-east (112.6°– 157.5°)	south (157.6°– 202.5°)	south-west (202.6°– 247.5°)	west (247.6°– 292.5°)	North-west (292.6°– 337.5°)
<0.10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
0.10-0.19	0.931	0.924	0.922	0.910	0.896	0.910	0.922	0.924
0.20-0.29	0.888	0.864	0.855	0.834	0.816	0.834	0.854	0.864
0.30-0.39	0.860	0.818	0.797	0.771	0.754	0.771	0.796	0.818
0.40-0.49	0.838	0.782	0.747	0.721	0.708	0.720	0.746	0.782
0.50-0.59	0.820	0.755	0.705	0.682	0.675	0.681	0.705	0.755
0.60-0.69	0.806	0.734	0.670	0.651	0.653	0.651	0.670	0.734
0.70-0.79	0.793	0.718	0.641	0.628	0.638	0.627	0.640	0.717
0.80-0.89	0.783	0.706	0.616	0.610	0.628	0.609	0.615	0.705
0.90-0.99	0.775	0.696	0.596	0.596	0.621	0.596	0.595	0.695
≥1	0.768	0.688	0.579	0.585	0.616	0.585	0.578	0.688

Table 52: External Shading Factor for Side Fin-Right (ESF_{right}) for LAT ≥ 23.5°N

orientation / PF_{right}	External shading Factor for side Fin-Right (EsF_{right}) for Lat ≥ 23.5°N							
	North (337.6°–22.5°)	North-east (22.6°–67.5°)	East (67.6°–112.5°)	south-east (112.6°–157.5°)	south (157.6°–202.5°)	south-west (202.6°–247.5°)	west (247.6°–292.5°)	North-west (292.6°–337.5°)
<0.10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
0.10-0.19	0.968	0.942	0.972	0.982	0.961	0.965	0.988	0.985
0.20-0.29	0.943	0.894	0.949	0.968	0.933	0.934	0.977	0.972
0.30-0.39	0.924	0.855	0.931	0.957	0.912	0.907	0.968	0.961
0.40-0.49	0.911	0.824	0.917	0.950	0.898	0.884	0.960	0.953
0.50-0.59	0.899	0.798	0.905	0.944	0.887	0.865	0.954	0.945
0.60-0.69	0.890	0.777	0.895	0.939	0.880	0.849	0.948	0.939
0.70-0.79	0.883	0.762	0.887	0.936	0.875	0.837	0.943	0.934
0.80-0.89	0.877	0.750	0.881	0.933	0.872	0.827	0.939	0.930
0.90-0.99	0.871	0.739	0.875	0.930	0.868	0.819	0.935	0.926
≥1	0.865	0.731	0.870	0.927	0.865	0.812	0.932	0.922

Table 53: External Shading Factor for Side Fin-Right (ESF_{right}) for LAT<23.5°N

orientation / PF_{right}	External shading Factor for side Fin-Right (EsF_{right}) for Lat < 23.5°N							
	North (337.6°–22.5°)	North-east (22.6°–67.5°)	East (67.6°–112.5°)	south-east (112.6°–157.5°)	south (157.6°–202.5°)	south-west (202.6°–247.5°)	west (247.6°–292.5°)	North-west (292.6°–337.5°)
<0.10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
0.10-0.19	0.962	0.948	0.975	0.982	0.962	0.959	0.984	0.984
0.20-0.29	0.934	0.904	0.954	0.968	0.932	0.924	0.970	0.970
0.30-0.39	0.913	0.868	0.937	0.957	0.911	0.894	0.958	0.959
0.40-0.49	0.900	0.840	0.924	0.949	0.896	0.870	0.949	0.950
0.50-0.59	0.888	0.816	0.912	0.942	0.885	0.849	0.940	0.942
0.60-0.69	0.879	0.797	0.903	0.936	0.877	0.832	0.933	0.936
0.70-0.79	0.872	0.782	0.896	0.932	0.872	0.820	0.927	0.931
0.80-0.89	0.866	0.770	0.889	0.929	0.867	0.810	0.922	0.927
0.90-0.99	0.860	0.760	0.884	0.925	0.863	0.801	0.917	0.923
≥1	0.855	0.752	0.878	0.922	0.859	0.794	0.913	0.919

Table 54: External Shading Factor for Side Fin-Left (ESF_{left}) for LAT ≥ 23.5°N

orientation	External shading Factor for side Fin-Left (EsF_{left}) for Lat ≥ 23.5°N							
PF_{left}	North (337.6°–22.5°)	North-east (22.6°–67.5°)	East (67.6°–112.5°)	south-east (112.6°–157.5°)	south (157.6°–202.5°)	south-west (202.6°–247.5°)	west (247.6°–292.5°)	North-west (292.6°–337.5°)
<0.10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
0.10-0.19	0.968	0.985	0.988	0.965	0.961	0.982	0.972	0.942
0.20-0.29	0.943	0.972	0.977	0.933	0.932	0.967	0.949	0.895
0.30-0.39	0.925	0.961	0.968	0.906	0.911	0.957	0.931	0.857
0.40-0.49	0.912	0.953	0.961	0.883	0.897	0.949	0.916	0.826
0.50-0.59	0.900	0.946	0.954	0.863	0.886	0.943	0.904	0.801
0.60-0.69	0.890	0.939	0.948	0.846	0.879	0.938	0.895	0.781
0.70-0.79	0.884	0.935	0.944	0.834	0.874	0.935	0.887	0.766
0.80-0.89	0.877	0.931	0.940	0.824	0.871	0.932	0.881	0.754
0.90-0.99	0.871	0.927	0.936	0.815	0.867	0.929	0.875	0.744
≥1	0.866	0.923	0.932	0.808	0.864	0.927	0.870	0.736

Table 55: External Shading Factor for Side Fin-Left (ESF_{left}) for LAT<23.5°N

orientation	External shading Factor for side Fin-Left (EsF_{left}) for Lat < 23.5°N							
PF_{left}	North (337.6°–22.5°)	North-east (22.6°–67.5°)	East (67.6°–112.5°)	south-east (112.6°–157.5°)	south (157.6°–202.5°)	south-west (202.6°–247.5°)	west (247.6°–292.5°)	North-west (292.6°–337.5°)
<0.10	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
0.10-0.19	0.962	0.984	0.984	0.959	0.962	0.982	0.975	0.948
0.20-0.29	0.933	0.970	0.970	0.924	0.932	0.968	0.954	0.904
0.30-0.39	0.912	0.959	0.958	0.895	0.911	0.956	0.937	0.868
0.40-0.49	0.899	0.950	0.949	0.870	0.896	0.948	0.924	0.840
0.50-0.59	0.887	0.942	0.941	0.849	0.885	0.942	0.913	0.816
0.60-0.69	0.878	0.935	0.933	0.833	0.877	0.936	0.903	0.797
0.70-0.79	0.871	0.931	0.928	0.820	0.871	0.932	0.896	0.783
0.80-0.89	0.865	0.926	0.923	0.810	0.867	0.928	0.890	0.771
0.90-0.99	0.859	0.922	0.918	0.801	0.863	0.925	0.884	0.761
≥1	0.854	0.919	0.913	0.794	0.859	0.922	0.879	0.752

A. Calculate the total external shading factor (ESF_{total}) using the formula:

$$ESF_{total} = ESF_{overhang} \times ESF_{sidefin} \quad (19)$$

Where,

$$ESF_{sidefin} = 1 - \left[\left(1 - ESF_{right}\right) + \left(1 - ESF_{left}\right)\right] \quad (20)$$

B. Calculate the equivalent ShGC of the fenestration ($ShGC_{eq}$) by multiplying the ShGC of the unshaded fenestration product ($ShGC_{Unshaded}$) with the total external shading factor (ESF_{total}), using the formula:

$$SHGC_{eq} = SHGC_{Unshaded} \times ESF_{total} \tag{21}$$

Example:
The building (located in Chandigarh, 30.9°N latitude) has a window, oriented in East orientation, with overhang and both side fins, shown in Figure 2-Figure 4. Calculate the equivalent SHGC.

Considerations:

a) $SHGC_{Unshaded}$ = 0.6
b) $H_{overhang}$ = 2 m
c) Height of window = 2.5 m
d) $V_{overhang}$ = 3 m
e) Horizontal depth of side fin (H_{right} and H_{left}) = 1.5 m
f) V_{right} and V_{left} = 2 m

Step 1: Calculate Projection Factors

1. Projection Factor for overhang:

   $PF_{overhang} = H_{overhang} / V_{overhang}$ / = 2 /3 ≈ 0.67

2. Projection Factors for side fins:

   $PF_{right} = H_{right} / V_{right}$ = 1.5/ 2 = 0.75
   $PF_{left} = H_{left} / V_{left}$ = 1.5/2 = 0.75

Step 2: Determine External Shading Factors (ESF)

Using tables (Table 50-Table 55) based on orientation and projection factors:
For overhang, $ESF_{overhang}$ ≈ 0.666
For side fin-right, ESF_{right} ≈ 0.887
For side fin-left, ESF_{left} ≈ 0.944

Step 3: Calculate Total External Shading Factor (ESFtotal)

$ESF_{sidefin} = 1 - [(1 - ESF_{right}) + (1 - ESF_{left})]$
= 1 - [(1 - 0.887) + (1 - 0.944)] = 0.831
$ESF_{total} = ESF_{overhang} \times ESF_{sidefin}$
≈ 0.666 × 0.831 ≈ 0.553

Step 4: Calculate Equivalent SHGC (SHGCeq)

$SHGC_{eq} = SHGC_{Unshaded} \times ESF_{total}$
≈ 0.6 × 0.553 ≈ 0.331
So, the Equivalent SHGC for the non-opaque component with permanent external shading projection is approximately 0.331.

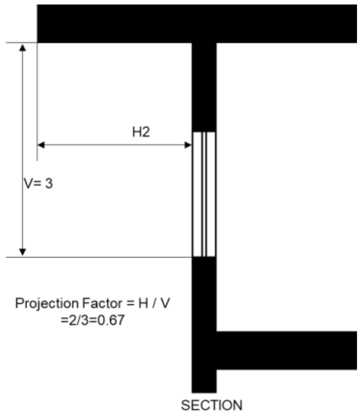


Figure 2: Section showing overhang

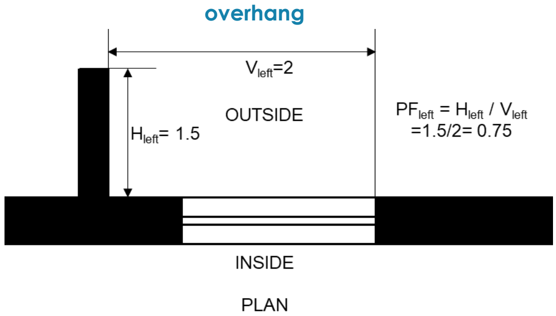


Figure 3: Plan showing left side fin

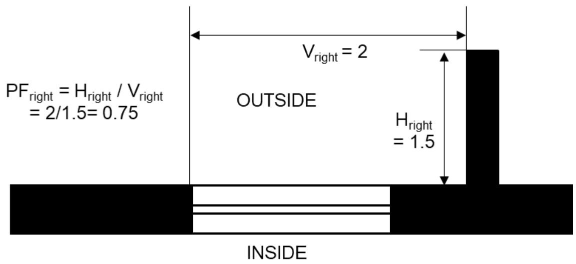


Figure 4: Plan showing right side fin

9.10 LUX LEVEL CALCULATION

The following simplified[23] formula shall be used to calculate the lux levels:

Formula:
Total luminous flux (Lumens) = number of light fixtures * lumens per fixture
Average lux level = Total luminous flux *Utilization factor* Maintenance factor / Total floor area

[23] For simplification, the utilisation factor and maintenance factor are taken as 1.

Example:

The illuminance level in the room, with a floor area of 100 sq.m and equipped with 10 lighting fixtures, each emitting 1500 lumens, is calculated to be __________ lux.

Considerations:

Number of light fixtures: 10

Lumens per fixture: 1500 lumens

Total floor area: 100 square meters

Step 1: Calculate the total luminous flux:

Total luminous flux = Number of light fixtures x Lumens per fixture

= 10 fixtures x 1500 lumens/fixture = 15000 lumens

Step 2: Calculate the average lux level:

Average lux level = Total luminous flux x UF x MF / Total floor area

= 15000 lumens x 1x 1 / 100 square meters = 150 lux

So, the average lux level in this scenario is 150 lux.

For simplification, the utilisation factor and maintenance factor are taken as 1.

9.11 Day Light Availability Calculation

This method can be used for demonstrating compliance with daylighting requirements without simulation. Daylight extent factors (DEF) mentioned in Table 56 shall be used for manually calculating percentage of above grade floor area meeting the UDI requirement for 90% of the potential daylit time in a year.

Table 56: Daylight Extent Factors (DEF) for Manually Calculating Daylight Area

Shading	Latitude	Window Type	VLT < 0.3				VLT ≥ 0.3			
			North	South	East	West	North	South	East	West
No shading or PF < 0.4	≥ 15°N	All window types	2.5	2.0	0.7	0.5	2.8	2.2	1.1	0.7
	< 15°N		2.4	2.0	1.3	0.6	1.7	2.2	1.5	0.8
Shading with PF ≥ 0.4	All latitudes	All window types without light shelf	2.8	2.3	1.5	1.1	3.0	2.5	1.8	1.5
		Window with light shelf	3.0	2.5	1.8	1.6	3.5	3.0	2.1	1.8

A. To calculate the daylit area:

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

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

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

B. A separate architectural plan shall be prepared with all daylit areas marked on the floor plans. A summary shall be provided showing compliance as per Table 59.

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

D. Any surrounding natural or man-made daylight obstructions shall not be considered in this method.

Example:

Considerations:

Window VLT: 0.6

DEF (Daylight Extent Factor)

North: 3

South: 2.5

East: 1.8

West: 1.5

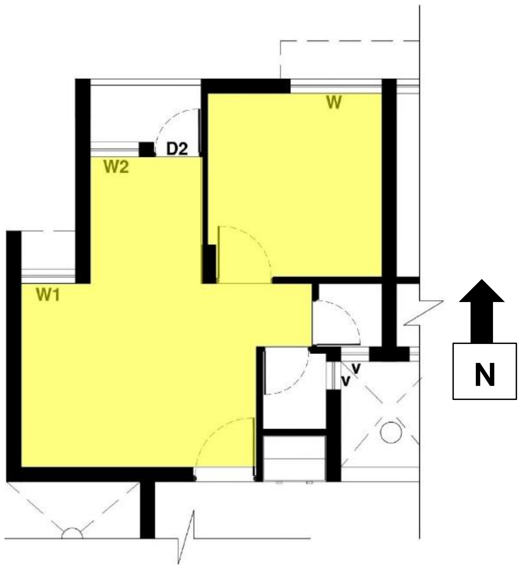


Figure 5: Regularly occupied area (yellow rendered)

Window nomenclature	Width	Height	B (Width+1)
W	1.45	1.23	2.45
W1	0.86	1.23	1.86
W2	0.77	1.23	1.77

Calculate the daylight compliant area in North orientation:

North		
Window nomenclature	A (Window height X North DEF)	A X B
W	3.7	7.1
W1	3.7	6.9
W2	3.7	6.5

Regularly occupied area : 23.14 m² (see Figure 5)
Total daylit area: 20.5m² (From drawing calculation) (see Figure 6)

Overlap Area: 1.44m² (From drawing calculation) (see Figure 6)

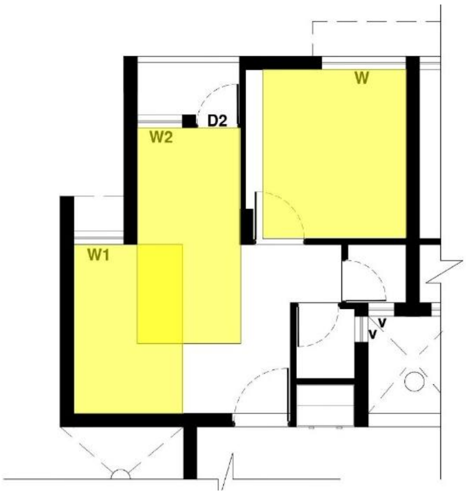


Figure 6: Daylight compliant area (yellow rendered)

Net compliant area: Total daylit area - Overlap Area = 19.1m²

Regularly occupied Compliant area percentage: Total compliant area/ Regularly occupied area X 100 = 82.37%

9.12 Example for Post Occupancy Waste Generation

A residential housing complex having area 3000 sq.m, consisting of 60 dwelling units, considering 4.5 occupants each housing. According to the National Building Code (NBC) guidelines, the recommended range of waste generation is between 0.3 to 0.6 kilograms per capita per day, comprises 40% organic waste and 60% inorganic waste.

Calculation for estimation of waste generation:
Step 1: Calculate the total number of occupants in the residential complex:
Total number of occupants = Number of dwelling units x occupants/unit
=60 x 4.5 = 270

Step 2: Calculate the total waste generation per day Considering the upper range [24] of the NBC guidelines:
Total waste generation = Total number of occupants x waste generation per capita
= 270 occupants x 0.6 kg/person/day
=162 kilograms per day

Step 3: Calculate the organic and inorganic waste generation:
Organic waste generation = Total waste generation x Organic waste percentage
=162 kg/day x 40% = 64.8 kilograms per day (say 10 Kg)
Inorganic waste generation = Total waste generation x Inorganic waste percentage
=162 kg/day x 60% = 97.2 kilograms per day

24 Considering the upper range of waste generation, the range is given in NBC 2016 edition. According to Mohua (Ministry of Housing and Urban Affairs), there is an annual increase in per capita waste generation of about 1.3%.

9.13 Calculation of Area Requirement for Storing Organic Waste

The volume required to store **1 kg** of organic waste depends on the density of the waste and how compacted it is. Organic waste's density can vary based on its composition, moisture content, and packing method.

Let's consider an example where the organic waste has a density of 0.5 kg/L. Remember that this is an approximate value, as organic waste density typically ranges from 0.2 kg/L to 0.8 kg/L, depending on the specific waste composition.

To calculate the volume required:

Volume = Mass / Density
Volume = 1 kg / 0.5 kg/L = 2 L
As a rule of thumb, 1000 litres require 1 cubic meter of volume
Then 2 L waste required = **0.002 m^3**
(For a thumb rule, it is calculated that 1 kg waste required 0.002 $m^{3)}$
So, if the organic waste has a density of 0.5 kg/L, you would need approximately 2 litres of volume to store 1 kg of organic waste.

9.14 Organic Waste Calculation (Vermi Composting Method)

Quantity of waste per day (Kg)	64.8	(From 9.12)
Volume required to store 1 Kg	0.002	
Retention time: days	60	
Worm density:	0.5 kg/m^2	
Vermi bed depth(m):	0.6	(Should not be more than 600mm for better efficiency)
Vermi bed width (m):	1.5	(Should not be more than 1500mm for easy turning and rotation)

Calculation:

Calculate the total waste produced during the retention time:
Total waste generated in 60 days = Daily waste generation x Retention time
Total waste Kg 3888.00
Calculate the volume of vermi beds required to handle this waste:
Total vermi bed volume required = Total waste / Storage density
Volume: m3 7.78
Calculate the total area of vermi beds required:
Vermi bed area = Vermi bed volume / Vermi bed depth=13.0
Length of vermi beds = Vermi bed area / Vermi bed width= 8.6

Hence, size of required pit/bed per cycle: 0.6 m X 1.5 m X 2.6 m
Number of beds 2
Total area required for per day organic waste (m^2) =25.9

Area (Sq.m) Required for Mandatory section	**50%**	**12.96**
Area (Sq.m) Required for 2 points	**75%**	**19.44**
Area (Sq.m) Required for 3 points	**95%**	**24.62**

Area provided on site for organic composting 25
Meeting the requirement 100%

9.15 INORGANIC WASTE CALCULATION

Quantity of waste per day (Kg)	97.20	(From 9.12)
Volume required to store 1 Kg	0.0033	
Volume of waste (m3)	0.3240	
Volume of waste to store at least 2 days waste	0.6480	
Conversion into litres	648	
Assume standard wastebin size (Litres), as per market availability	240	
Dimensions		
Length	0.5	
Breadth	0.5	
Height	1	
Area required for 1 wastebin (240 ltrs)	0.25	
Area with Circulation/ handling space	1.5	
Area (Sq.m) Required for Mandatory section	**4 bins**	**6.00**
Area (Sq.m) Required for 1 point	**6 bins**	**9.00**
Area (Sq.m) Required for 2 points	**8 bins**	**12.00**
Area provided on site for waste segregation at centralized level	15	
Meeting the requirement	100%	

9.16 Example for Construction Waste Diversion Estimation

Table 57: Calculation example for construction waste management

Classification of waste	Type of waste	Quantity (Kg)	% Of total waste [25]	Density(kg/m3)	Volume (m3)	Diverted from landfills (Kg)	Method of Diversion
As per CPCB 2016, new construction generates approx. 40-60 kg per sqm of built-up area							
Total Construction waste Quantity		**257621.5** (Considering 50 kg waste per sq.m of built-up area)					
Non-Hazardous	Soil, Sand and Gravel	66981.6	26%	1600	41.86	66981.6	Reused/ repurposed on site
	Brick & Masonry	82438.9	32%	1900	43.39	82438.9	Reused/ repurposed on site
	Concrete	72134.0	28%	1200	60.11	72134.0	Reused/ repurposed on site
	Metals	15457.3	6%	7850	2.0	15457.3	Sold to recycler
	Wood	7728.6	3%	400	19.3	7728.6	Sold to recycler
Packaging	Others	7728.6	3%			7728.6	Sold to recycler
Hazardous	Bitumen	5152.4	2%	1040	5.0	5152.4	Handover To municipal authority

[25] BMTPC, Ready reckoner, 2018

Table 58: Construction waste calculation as per ENS Provisions

Classification of waste as per ENS Provisions	Quantity (Kg)	% Of diversion
Non-Hazardous	**244740.425**	
Sent to recycling units	23185.9	
Reused/ repurposed on site	221554.5	
Hazardous	**5152.43**	
To municipalities	5152.4	
Packaging	**7728.645**	
Sent to recycling units	7728.6	
Minimization of Non-Hazardous waste (reused on site, to recycling units)	**244740.4**	**100%**
Recycling of packaging waste	**7728.6**	**100%**
Total waste diverted from landfills (Kg)	**257621.5**	**100%**

CHAPTER 10: TERMINOLOGY, DEFINITIONS & ABBREVIATIONS

10.1 Terminology and Definitions

A

Above Grade area: It is the carpet area plus the thickness of outer walls and the area covered by balcony, expressed in meters, and subtracting the basement area.

Addition: An extension or increase in the carpet area or height of a building or structure.

Affordable Housing Projects: Affordable houses are Dwelling Units (DUs) with Carpet Area less than 60 sqm. It also includes Economically Weaker Section (EWS) category and Lower Income Group (LIG) category (LIG-A: 28-40 sq. m. and LIG-B 41- 60 Sq.m). Projects using at least 60 percent of the FAR/ FSI for dwelling units of Carpet Area not more than 60 sqm. will be considered as Affordable housing projects. This definition could be changed time to time by Ministry of Housing & Urban Affairs and respective states and latest definition for the respective state shall be considered.

Affordable housing scheme: The Pradhan Mantri Awas Yojana (PMAY), also known as, Affordable housing scheme, including any notification of change in name of the aforesaid scheme, is an initiative provided by the Government of India which aims at providing affordable housing to the urban poor.

Air Changes per Hour (ACH): Air Changes per Hour (ACH) is a measurement that quantifies the number of times the air within a space is completely replaced with fresh air within a one-hour time period. It indicates the effectiveness of ventilation or air exchange in a given space.

Alteration: A change from one type of occupancy to another or the removal of part of a building, or any change to the structure, such as the construction of, cutting into or removal of any wall, partition, column, beam, joist, floor or other support, or a change to or closing of any required means of ingress or egress or a change to the fixtures or equipment.

Authority Having Jurisdiction: The Authority which has been created by a statute and which, for the purpose of administering the Code, may authorize a committee or an official or an agency to act on its behalf.

B

Building Envelope: The elements of a building that separate the habitable spaces of dwelling units from the exterior and are exposed to the ambient (i.e., exposed directly to external air and opening into balconies). It does not include walls facing open corridors and enclosed shafts, as well as walls of common services such as lifts and staircase. (See Figure 7: Walls included in the definition of building envelope. Dotted lines show the walls included in the definition of building envelope in this code.)

Figure 7: Walls included in the definition of building envelope

Building services: Basic MEP services such as firefighting systems, elevators and escalators, HVAC systems, gas supply systems, building management systems, power backup, water supply, water recycling etc. that are provided for the comfort and available to all dwelling units/apartments of the building or building complex.

Built-up area: It is the carpet area plus the thickness of outer walls and the area covered by balcony, expressed in meters.

C

Carpet Area[26]: Carpet area is the net usable floor area of a dwelling unit, excluding the area covered by the external walls, areas under services shafts, exclusive balcony or verandah area and exclusive open terrace area, but includes the area covered by the internal partition walls of the dwelling unit.

Color Rendering Index (CRI): Color Rendering Index (CRI) is a quantitative measure of the ability of a light source to accurately reveal the true colors of objects compared to a reference light source. It is a scale ranging from 0 to 100, with higher values indicating better color rendering.

Common Area: Amenities such as corridors, hallways, lobby, staircases, lifts, pool, parking areas etc. provided for the comfort and available for use to all occupants, owners, tenants, or users of the building or building complex expressed in m^2.

Construction Waste: Construction waste is any substance, matter, or thing that is produced as a result of construction work.

Cool roof: A cool roof is one that reflects most of the incident sunlight and efficiently emits some of the absorbed radiation back into the atmosphere, instead of conducting it to the building below. The 'coolness' of a roof is influenced by its solar reflectance and thermal emittance.

D

Dwelling unit: An Independent housing unit with separate facilities for Living, Cooking and sanitary requirement.

E

ENS 2024 building: Any building in which all covered spaces comply with the requirements of §3 of the Eco- Niwas Samhita 2024.

ENS 2024 point: It is the algebraic sum of the points that are obtained by meeting the requirements of Eco- Niwas Samhita 2024.

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

Envelope Area: Envelope area (excluding roof) of dwelling units is the overall area of the building envelope (see definition 'Building Envelope'). It is the gross external wall area (includes the area of the walls and the openings such as windows and doors), with measurement taken horizontally from outside surface to outside surface and measured vertically from the top of the floor to the top of the roof.

F

Floor area: The net enclosed area expressed in m2 of a floor in the building including circulation spaces like lobby or corridors, service areas and semi-open spaces such as verandah or balcony.

H

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26 Source: The Real Estate (Regulation and Development) Bill, 2016 as passed by the Rajya Sabha on the 10 March 2016. Available at http://164.100.47.4/BillsTexts/RSBillTexts/PassedRajyaSabha/realest-238-RSP-E.pdf (accessed on 1 May 2018)

High Rise Buildings: A building above 4 stories, and/or a building exceeding 15 meters or more in height (without stilt) and 17.5 meters (including stilt).

I

Integrated Energy Efficiency Ratio (IEER): It is a single-number cooling part load efficiency figure of merit calculated as specified by the method described in ANSI/AHRI Standard 340/360/1230.

Indian Seasonal Energy Efficiency Ratio (ISEER): It is the ratio of the total annual amount of heat that the equipment can remove from the indoor air when operated for cooling in active mode to the total annual amount of energy consumed by the equipment during the same period.

L

Lighting Power Density (LPD): It is the total of the maximum power rating of the lamps (in Watts) in a space, other than those that are plugged into socket outlets for intermittent use such as floor standing lamps, desk lamps, divided by the area of the space (in m^2).

Low Rise Buildings: A building equal or below 4 stories, and/or a building up to 15 meters in height (without stilt) and up to 17.5 meters (including stilt).

Low energy comfort systems: Space conditioning or ventilation systems that are less energy intensive then vapor compression-based systems.

Luminous Efficacy (LE): Total luminous flux emitted from a luminaire upon input power, expressed in lumens per Watt.

M

Mechanical Efficiency: It is a dimensionless number that measures the effectiveness of a machine in transforming the power input to the device to power output.

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

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

N

Non-opaque Building Envelope Components: Non-opaque building envelope components include transparent/translucent panels in windows, doors, ventilators, etc.

O

Openable area of dwelling unit: The total openable area expressed in m^2 of a dwelling unit is the sum of openable area of all windows and ventilators opening directly to the external ambience, open balcony, verandah, corridor and or shaft.

Exclusions: Doors opening into corridors and external doors on ground floor (for e.g., ground floor entrance doors or back-yard doors).

Opaque Building Envelope Components: Opaque building envelope components include walls, opaque panels in doors, windows, ventilators, etc.

Openable Window-to-Floor Ratio (WFRop): The openable window-to-floor ratio (WFrop) is the ratio of the total openable area to the total carpet area of dwelling units. the total openable area of a dwelling unit is the addition of openable area of all windows and ventilators, opening directly to the external air, an open balcony, 'verandah', corridor or shaft; and the openable area of the doors opening directly into an open balcony.

Exclusions: Doors opening into corridors and external doors on ground floor (for e.g., ground floor entrance doors or back-yard doors).

Organic waste: Including but not limited to, kitchen waste (food scraps, fruit and vegetable peels, tea leaves, and coffee grounds etc.), garden waste (pruning/ cutting waste, shredded leaves, mulches, flowers etc.).

Orientation Factor (ω): It is a measure of the amount of direct and diffused solar radiation that is received on the vertical surface in a specific orientation. This factor accounts for and gives weightage to the fact that the solar radiation falling on different orientations of walls is not same.

P

Packaging construction waste: Including but not limited to cement bags, Wooden crates and pallets, Cardboard boxes, Plastic wrapping and shrink wrap, Foam and bubble wrap, Strapping bands and steel wires, PE film or plastic sheeting, Plastic or metal drums/buckets/containers, Corrugated plastic sheets, specialized packaging etc.

Plot Area: A parcel (piece) of land enclosed by definite boundaries expressed in m^2.

Projection Distance: It is the horizontal depth, expressed in meters, of the external shading projection

Projection Factor, Overhang: Projection factor (overhang) is the ratio of the horizontal depth of the external shading projection to the sum of the height of a non-opaque component and the distance from the top of the same component to the bottom of the farthest point of the external shading projection, in consistent units (Figure 8).

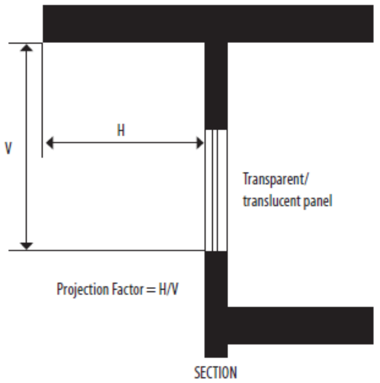

Figure 8: Projection factor, overhang

Projection Factor, Side Fin: Project factor (side fin) is the ratio of the horizontal depth of the external shading projection to the distance from a non-opaque component to the farthest point of the external shading projection, in consistent units (Figure 9).

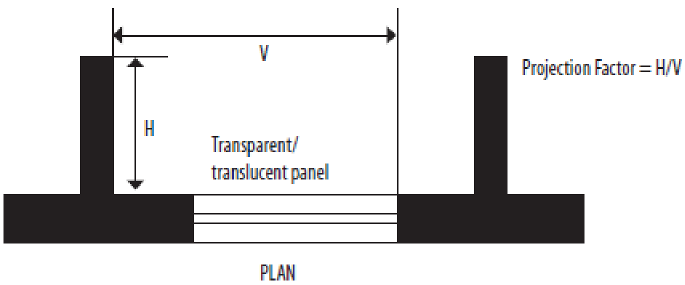

Figure 9: Projection factor, side fin

Residential Envelope Heat Transmittance (RETV): RETV is the net heat gain rate (over the cooling period) through the building envelope of dwelling units (excluding roof) divided by the area of the building envelope (excluding roof) of dwelling units. Its unit is W/m^2.

Solar Heat Gain Coefficient (SHGC)[27]: SHGC is the fraction of incident solar radiation admitted through non-opaque components, both directly transmitted, and absorbed and subsequently released inward through conduction, convection, and radiation (Figure 10).

27 Bureau of Indian Standards (BIS). 2016. National Building Code of India 2016. New Delhi: BIS.

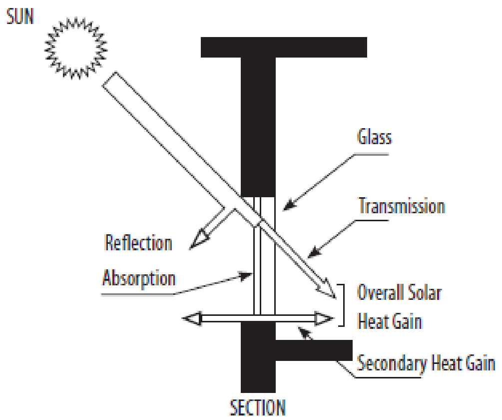

Figure 10: Solar heat gain through a non-opaque component

R

Regularly Occupied Spaces: Regularly occupied spaces include living room, bed rooms, dining room, kitchen, etc.,

Renewable Energy Systems: Energy from renewable non-fossil energy sources, e.g., solar energy (thermal and photovoltaic), wind, hydropower, biomass, geothermal, wave, tidal, landfill gas, sewage treatment plant gas and biogases. A resource that is available naturally, harnessed, and can be replenished.

Residential Building(s): Residential building(s) (including affordable housing) include any building in which sleeping accommodation is provided for normal residential purposes with or without cooking or dining or both facilities. This includes:

i. One- or two-family private dwellings: These shall include any private dwelling, which is occupied by members of one or two families and has a total sleeping accommodation for not more than 20 persons.

ii. Apartment houses: These shall include any building or structure in which living quarters are provided for three or more families, living independently of each other and with independent cooking facilities. This also includes group housing.

However, following buildings are excluded for the purpose of this code.

Lodging and rooming houses: these shall include any building or group of buildings under the same management in which separate sleeping accommodation on transient or permanent basis, with or without dining facilities but without cooking facilities for individuals, is provided. This includes inns, clubs, motels, and guest houses.

Dormitories: these shall include any building in which group sleeping accommodation is provided, with or without dining facilities for persons who are not members of the same family, in one room or a series of closely associated rooms under joint occupancy and single management. For example, school and college dormitories, students, and other hostels and military barracks.

Hotels: these shall include any building or group of buildings under single management, in which sleeping accommodation is provided, with or without dining facilities.

Retrofit: providing or adding something with a building component or feature not fitted when the building or building complex was first constructed.

Roof Gardens: In the case of roofs with roof gardens on earth fill for plantation or lawn, the thermal resistance of the earth fill can be taken into the calculation of the thermal transmittance (U value) of the roof. Some of the heat absorbed by the earth fill is also released into the atmosphere due to evapotranspiration of irrigation water from the roof garden, thus giving additional benefit.

R – Value: The measurement of the thermal resistance of a material which is the effectiveness of the material to resist the flow of heat, i.e., the thermal resistance ($m^2·K/W$) of a component calculated by dividing its thickness by its thermal conductivity.

S

Service Value: The Service value is the ratio of air delivery to power input.

SHGC Equivalent: SHGC Equivalent is the SHGC for a non-opaque component with a permanent external shading projection. It is calculated by multiplying the External Shading Factor (ESF) with the SHGC of unshaded non-opaque component.

Solar reflectance: Solar reflectance is the ratio of solar radiation reflected by a surface to the solar radiation incident upon it. Solar reflectance is measured on a scale of 0 to 1. A reflectance value of 0 indicates that the surface absorbs all incident solar radiation, and a value of 1 denotes a surface that reflects all incident solar radiation. The term 'albedo' is often used inter-changeably with solar reflectance.

Solar reflectance Index (SRI): That incorporates both solar reflectance and emittance in a single value and quantifies how hot a surface would get relative to standard black and standard white surfaces. It is the ability of a material to reject solar radiation, as shown by a small temperature rise.28 The SRI's of a standard black surface (having reflectance of 0.05 and emittance of 0.9) and a standard white surface (of reflectance 0.8 and emittance 0.9) are taken as 0 and 100, respectively.

For more detailed information on cool roof, please refer Cool roofs for Cool Delhi: Design Manual.[29]

T

Thermal Insulation: A material used to reduce heat loss or gain through thermal envelope component.

Thermal emittance: Thermal emittance is the relative ability of a material to reradiate absorbed heat as invisible infrared radiation. Emittance, measured from 0 to 1, is defined as the ratio of the radiant flux emitted by a body to that emitted by a black body at the same temperature and under the same conditions.

According to ECBC 2017 cool roof requirement, roofs with slopes less than 20 degrees shall have an initial solar reflectance of at least 0.6 and an initial emittance of 0.9.

Thermal Transmittance (U-Value): Also known as U-Factor, thermal transmittance (U-value) is the heat transmission in a unit of time through a unit of area of an envelope component or insulating material, induced by a unit of temperature difference between conditioned and unconditioned spaces. The U-value for an envelope component indicates its ability to reduce heat transfer through conduction. U-value is expressed as $W/m^2·K$.

U

U Value: Thermal transmittance (U value) is the 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 either side. Unit of U value is W/m^2 K. The U value for a wall/roof/glazing indicates its ability to transfer heat through conduction.

V

Visible Light Transmittance (VLT): VLT is the ratio of the total transmitted light to the total incident light. It is a measure of the transmitted light in the visible portion of the spectrum through a material.

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28 Bureau of India Standards (BIS). 2016. National Building Code 2016. Part 11. New Delhi: BIS

29 Shakti Foundation. 2017. Cool Roofs for Cool Delhi: Design Manual. Available at http://shaktifoundation.in/ wp-content/uploads/2017/06/cool-roofs-manual.pdf (accessed on 01 May 2018)

Volatile Organic Compounds (VOC): Volatile Organic Compounds (VOCs) are a group of organic chemicals that easily evaporate at room temperature. They are commonly found in various products such as paints, solvents, cleaning agents, adhesives, and building materials.

W

Window-to-Wall Ratio (WWR): WWR is the ratio of the non-opaque building envelope components area to the envelope area (excluding roof) of dwelling units.

Waste Management: Waste management refers to the activities and actions required to manage waste from its start till its disposal. This includes collection, transport, treatment and disposal of waste together with monitoring and regulation.

10.2 Abbreviations

AFUE	Annual fuel utilization efficiency
ANSI	American National Standards Institute
AHRI	Air-Conditioning, Heating and Refrigeration Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
AAC Block	Autoclaved Aerated Concrete Block
ACH	Air Changes per Hour
BIS	Bureau of Indian Standards
Btu	British thermal unit
Btu/h	British thermal units per hour
Btu/h-ft2-°F	British thermal units per hour per square foot per degree Fahrenheit
BEE	Bureau of Energy Efficiency
BUA	Built up area
C	Celsius
cmh	cubic meter per hour
cm	centimetre
CO	Carbon monoxide
COP	coefficient of performance
CPHEEO	Central Public Health & Environmental Engineering Organisation
CRI	Colour Rendering Index
C&D waste	Construction and Demolition Waste
CPCB	Central Pollution Control Board
DISCOM	Distribution Company
DEF	daylight extent factor
DEC	Direct Evaporative cooling
EER	energy efficiency ratio
ENS	Eco Niwas Samhita
EPI	energy performance index
ESF	External Shading Factor
EWS	Economically Weaker Section
F	Fahrenheit
ft	foot
GDP	Gross Domestic Product
GHG	Greenhouse gases
h	hour
h-ft2-°F/Btu	hour per square foot per degree Fahrenheit per British thermal unit
h-m2-	hour per square meter per degree Celsius per Watt
hp	horsepower
HVAC	heating, ventilation, and air conditioning
HUDCO	Housing and Urban Development Corporation
I-P	inch-pound
in.	inch
IPLV	integrated part-load value
IS	Indian Standard
ISO	International Organization for Standardization
IEER	Integrated Energy Efficiency Ratio
kVA	kilovolt-ampere
kW	Kilowatt of electricity
kWr	kilowatt of refrigeration
kWh	kilowatt-hour
l/s	liter per second
LE	luminous efficacy
Lin	linear
lin ft	linear foot
lin m	linear meter
Lm	lumens
Lm/W	lumens per watt
LPD	Lighting power density
MoHUA	Ministry of Housing and Urban Affairs
LPD	lighting power density
M	meter
Mm	millimetre
m2	square meter
m2.K/W	square meter Kelvin per watt

MNRE	Ministry of New and Renewable Energy
NBC	National Building Code 2016
Pa	pascal
PF	projection factor for SHGC Value
PIB	Press Information Bureau
PF	Projection factor
RETV	Residential Envelope Transmittance Value
R	R-value (thermal resistance)
SC	shading coefficient
SEF	Shading equivalent factor
SHGC	solar heat gain coefficient
THD	Total Harmonic Distortion
TR	tons of refrigeration
UPS	uninterruptible power supply
VAV	variable air volume
VLT	visible light transmission
VRF	Variable Refrigerant Flow
VOC	Volatile Organic Compound
WFRop	Window-to-floor area ratio
W	watt
W/ l-s-1	watt per litre per second
W/m2	watts per square meter
W/m2.K	watts per square meter per Kelvin
W/m2	watts per hour per square meter
W/m.K	watts per lineal meter per Kelvin
Wh	watthour
WWR	Window-To-Wall-Ratio
ω	orientation factor
BEP	Best Efficiency Point
BMS	Building Management System
BOD	Biological Oxygen Demand
BWUE	Bureau of Water Use Efficiency
COD	Chemical Oxygen Demand
COP	Coefficient of Performance
CPCB	Central Pollution Control Board
CPHEEO	Central Public Health & Environmental Engineering Organization
ECSBC	Energy Conservation and Sustainability Building Code
ETC	Evacuated Tube Collectors
FPC	Flat Plate Collectors
IE Motors	International Efficiency Motors
IoT	Internet of Things
IPA	Indian Plumbing Association
IS	Indian Standard
LPCD	Litres per capita per day
LPD	Litres per day
LPF	Litres per flush
LPM	Litres per minute
LPS	Litres per second
MoEFCC	Ministry of Environment, Forests & Climate Change
MoUD	Ministry of Urban Development
NGT	National Green Tribunal
NWM	National Water Mission
pH	Hydrogen Ion Concentration
PLC	Programmable Logic Controller
RO	Reverse Osmosis
RWH	Rainwater Harvesting
S&L	Standards and Labelling Program of BEE
Solar PV	Solar Photo-Voltaic panels
SDG	Sustainable Development Goal
SRI	Solar reflectance Index
TDS	Total Dissolved Solid
TMV	Thermostatic Mixing Valves
TSS	Total suspended Solids
U VALUE	THERMAL TRANSMITTANCE (reciprocal of R-value
ULB	Urban Local Body
VFD	Variable Frequency Drive
WBD	Water Balance Diagram
WPI	Water Performance Index

ANNEXURES

ANNEXURE 1: COMPLIANCE DOCUMENTS

The building project can demonstrate compliance using the software/toolkit that has been approved by the BEE or authority having jurisdiction and submit the following list of documents to show compliance with the code.

S.No.	Compliance Documents	
Specification sheet (or cut sheet) from manufacturers for materials/ products/ installed fixtures along with copy of purchase invoice/ BOQ/ tender documents, wherever possible.		
	1. Sustainable Site Management	
1a.	Site Plan highlighted trees (existing mature trees, preserved trees, transplanted, removed), along with highlighting top soil excavation and top soil storage and preservation area with volume.	☐
1b.	Fertility report of soil from a certified lab.	☐
1c.	Survey-plan highlighted existing features of the site like existing water bodies, power or communication lines, sewerage lines.	☐
1d.	Accessibility Plan highlighted measures (ramps with handrails on entrances and grade change, tactile guiding system, easily accessible play areas etc.) to ensure universal accessibility including features for differently abled, children and elderly.	☐
1e.	Landscape Plan highlighted the following: • Plant/tree schedule for all vegetated species being planted along with measures taken to preserve local biodiversity and ecology; • All type of finishes used on site with legend • Waterbodies/ water features, Vegetated areas, paved areas, building footprint.	☐
	2. Envelope and Electro-Mechanical and Renewable Energy System	
2a.	Construction drawings and specifications shall show all pertinent data and features of the building, equipment, and systems in sufficient detail to permit the authority having jurisdiction to verify that the building complies with the requirements of this code.	☐
2b.	Details shall include, but are not limited to: • Building envelope: opaque construction materials and their thermal properties including thermal conductivity, specific heat, density along with thickness; fenestration U-factors, solar heat gain	☐

	coefficients (SHGC), visible light transmittance (VLT); overhangs and side fins and operable window area; • Building services: Common area lighting (lamp efficacy for lamps and their controls); pump efficiencies; elevator technologies and their controls; transformer losses; power distribution losses; power factor correction devices; basement ventilation controls; efficiency of EV charging infrastructure and electric check metering and monitoring system. • Indoor electrical end-use: Indoor lighting (type, number, and wattage of lamps and ballasts; automatic lighting shutoff, occupancy sensors, and other lighting controls); ceiling fans star labelling; service hot water type and their efficiency; air- conditioners (system and equipment types, sizes, efficiencies, and controls); • Renewable energy systems: system peak generation capacity, solar water heating system; technical specifications, renewable energy zone area.	
3.	**Water Conservation**	
3a.	Landscape irrigation layout highlighted areas with different type of irrigation system and efficiency.	☐
3b.	Good for construction plan and sections of the building highlighting the plumbing layout along with the dual pipes system, water recycling & reuse provisions.	☐
3c.	Good for construction site plan and building plans highlighting the rainwater harvesting system, storage tanks and recharge provisions.	☐
3d.	Specifications of various sanitary fitting and sanitary ware used along with copy of purchase invoice/ BoQ/ tender documents.	☐
4.	**Waste Management**	
4a.	Declaration for safe handling and disposing C&D waste as per CPCB guidelines/ (C & D Waste Management Rules, 2016).	☐
4b.	An inventory of the waste generated during construction by either weight or volume, but not both shall be developed. The inventory shall classify the quantities of waste generated as per section 7.2.1.	☐
4c.	**During Construction** A waste management plan shall be developed which include: i. Estimate the quantum of waste generated daily ii. Designate an area for collection of daily waste	☐

	iii. Site Logistics plan including; designated collection, segregation and storage areas for construction waste as per categories as mentioned in Chapter 7: section 7.2.1.2. iv. Detailed implementation plan for reuse of waste on site as per section, Chapter 7: section 7.2.1.3. a) Detailed implementation plan for resale of recyclable waste to recyclers or municipal authorities as per Chapter 7: section 7.2.1.4.	
4d.	**Post Occupancy:** Site and Building floor plans, highlighted area for floor wise waste collection, with different color bins, organic waste composting location, type and catering capacity.	☐
5.	**Indoor Environmental Quality**	
5a.	Good for construction plan highlighted openings (doors, windows and ventilators), and enclosed parking with ventilation and exhaust systems.	☐
5b.	Calculation of lux levels for common areas, exterior lighting and interior lighting (if applicable).	☐
5c.	Calculation of RETV and WFR_{op} for each typical block.	☐
5d.	Specifications of VOC content in paints, coatings, adhesives, and sealants (With copy of purchase invoice/ BoQ/ tender documents).	☐
5e.	Specifications of glass provided by the manufacturer (With copy of purchase invoice/ BoQ/ tender documents).	☐
5f.	Specifications of various lighting fixtures used (With copy of purchase invoice/ BoQ/ tender documents).	☐
5g.	Description of ventilation and exhaust system installed in the enclosed parking with showing ACH calculation.	☐
5h.	Good for construction floor plan highlighted enclosed parking with the placement of sensors	☐

ANNEXURE 2: EMBODIED ENERGY

RATIONALE

Embodied energy in construction in India (especially in "formal' residential buildings of the sort that are covered by the ENS 2024 code) can sometimes be of the order of magnitude of many decades of operating energy use[30] and therefore is very significant to consider when such a code is being developed.

However, this was true for non-air-conditioned housing stock, and it seems likely that, like in the developed economies, increasing consumption of operating energy (e.g., for appliances, common area services, air-conditioning etc.) may cause the embodied energy to become less significant compared to operating energy. Still, this is an important area to include in the code.

Embodied energy is also important because much of it is consumed in the form of primary energy (coal, oil, fuels) causing direct pollution and carbon emissions.
Embodied energy is the sum of all energy used in the construction process, i.e., in the product, transport and installation: from the extraction of raw materials, manufacture of materials and fabrication of products, to their transportation and installation in buildings. It is often measured in megajoules per square meter. But its units can also be kWh(th) (Thermal Kilowatt hours, with 1kWh(th) being equivalent of 3600 kJ) per sqm of built-up-area, making it more easily comparable with EPI of the ENS 2024 code.

Cement and steel are the major contributors of embodied energy in residential building construction in India. According to the study conducted by Jadavpur University[31], 98% of the embodied energy is attributed to the embodied energy of the materials used and 2% is the contribution of actual erection of the building. Unfortunately, embodied energy is often "hidden" in industry for the manufacture and transport of materials, and the transportation of workers.

Institutes of technological research need to be tasked with creating standards for embodied energy benchmarks based on average and best practice. If necessary, this research needs to attract funds from the building industry and foundations.

Embodied Energy measured in kWh(th)/sqm and Operating Energy measured in kWh(th)/sqm. year can be combined. In order to combine the (capital) embodied energy with the operating energy, it is necessary to merge the two to units equivalent of kWh(th)/sqm. year so that a single number can represent the energy performance of a project.

In a recent piece of research for Technology Information Forecasting and Assessment Council of India[32], it was found that the best way to translate from kWh(th)/sqm (Embodied Energy) to

30 The Mud Village project, sponsored by HUDCO, entry by Studio Plus, 1987
31 Embodied Energy Analysis of Multi-storied Residential Buildings in Urban India, S Bardhan - WIT Transactions on Ecology and the Environment, 2011
32 Technology Vision 2035, Technology Information Forecasting and Assessment Council (TIFAC) 2014

kWh(th)/sqm. year (equivalent Operating Energy) would be to set up a notional or actual discount/ replacement rate of construction taking its nominal life, say, as:

- 50 years life leading to a 2% replacement rate of stock for mainstream buildings
- 20 years life leading to a 5% replacement rate of stock for temporary industrial materials (steel) buildings.
- And so, on

According to a study by HUDCO[33], affordable housing uses 4257 MJ/sqm of embodied energy and so at a rated life of 50 years (or 2% replacement rate), this is equivalent of 85 MJ/sqm.year or 23.6 kWh(th)/sqm.year which is substantial for a building without air-conditioning but low for a building with various mechanical systems using up substantial operating energy.

This can be codified along with other benchmarks in the ENS 2024 code after suitable characterisation, study, analysis of best practices, and benchmarking.

NOTES

- Embodied energy is given less importance in the affluent regions of the world since their operating energy is high. There are two methods to evaluate this energy: by process or by input-output.
- Researchers in the Indian Institute of Science[34] identified process analysis as appropriate for embodied energy assessment in the Indian context.
- One of the earliest researchers using process-based analysis of embodied energy, Dr. Mohan Rai, carried out studies at CBRI Roorkee in the early 1960s and made the first listing of embodied energy, sorted in descending order, as follows in Table 59: Materials and Embodied energy consumption:

Table 59: Materials and Embodied energy consumption

Materials	Unit	kWh(th)	MJ
Sheet Glass	sqm	74.199	267.1
Linoleum	sqm	46.287	166.6
Aluminium	kg	39.891	143.6
PVC	kg	32.273	116.2
Sanitaryware	kg	9.071	32.7
Mild Steel	kg	7.327	26.4
L.D. Polyethylene	kg	6.048	21.8
Stoneware Pipes	kg	5.896	21.2
Cement	kg	2.245	8.1
Quick Lime	kg	1.756	6.3
Bloated Clay Aggregate	kg	1.477	5.3
Burnt Clay Roofing Tiles	each	1.233	4.4
Burnt Clay Bricks	each	1.187	4.3

33 Accessed in December 2019 at https://www.slideshare.net/sslele456/embodied-energy-in-residential-cost-effective-units.

34 K.I. Praseeda, B.V. Venkatarama Reddy, Monto Mani, 2015. Embodied energy assessment of building materials in India using process and input–output analysis, Energy and Buildings, 86 (677-686), ISSN 0378-7788

Wood Particle Board	kg	0.861	3.1
Sand Lime Bricks	each	0.773	2.8
Clay Fly-Ash Bricks	each	0.643	2.3
Gypsum (Calcined)	kg	0.420	1.5
Brick Dust (Surkhi)	kg	0.384	1.4
Crushed Aggregate	kg	0.060	0.216

The table above shows (as is well-known) that the embodied energy of processed industrial materials like aluminium, steel and cement is much higher than relatively unprocessed and mined materials extracted from nature (like crushed aggregates). Natural and renewable materials such as timber may be deemed to have zero renewable energy. Therefore, all other things being equal, a concrete framed structure with cement and steel is worse than a load bearing structure with hardly any cement and steel and masonry (preferably non-fired) and funicular forms holding up the roof.

ANNEXURE 3: CONSTRUCTION MANAGEMENT

3.1 Good construction practices

3.1.1 Air and Soil Pollution During Construction

- **Boundary Barricading Requirement:** Erect continuous barricading at a minimum height of 3 meters along the perimeter of the construction site to contain dust and debris within the premises.
- **Vehicular Entrance and Exit Protocol:** All vehicular entrances and exits must be equipped with wheel washing facilities or gravel beds to prevent the dispersion of pollutants onto surrounding roads.
- **Diesel Generator Compliance Standard:** Diesel generator sets must conform to stipulated CPCB norms, including the installation of exhaust stacks with a minimum height of 2 meters from the generator's apex, each fitted with a cap to mitigate emissions.
- **Spill Containment Protocol:** Develop and enforce a spill prevention plan for the proper storage of hazardous materials such as diesel, admixtures, curing compounds, and bitumen to avert potential leaks or spills that could contaminate soil and air.
- **Covering or Sprinkling of Construction Materials:** Ensure that fine aggregate, excavated earth, and other potentially airborne construction materials are either adequately covered or regularly sprinkled with non-potable sewage treatment plant (STP) water to suppress dust emissions.
- **Water Sprinkling on Unpaved Pathways**: Implement a water sprinkling regimen on unpaved pathways within the construction site using non-potable water sources to mitigate dust-related air pollution.
- **Vehicular Speed Limitation Protocol**: Enforce a maximum vehicular speed limit of 10 km/h within the construction site to minimize the generation of dust and soil disturbance.
- **Covering of Waste-Transporting Vehicles:** All vehicles transporting waste materials out of the site must be fully covered to prevent the dissemination of dust, debris, and pollutants during transit.
- **Soil Erosion Control Measures:** Construct designated soil erosion channels throughout the site and interconnect them with sedimentation tanks to impede soil movement beyond the construction site boundaries, effectively curbing soil erosion and sediment runoff.

3.1.2 Energy Conservation During Construction

Energy usage may result from poor practices observed at construction sites. While it is imperative to address and curtail such practices, they currently fall beyond the purview of the ENS 2023 code. Typical practices include an over- or under-reliance on assisted manual labour (which may be seen as a form of renewable energy), an excessive requirement for the transportation of materials (like mixed concrete) or solids (like steel) on site. This is primarily due to poor layout and improper sizing of pipes to save on capital expenses, subsequently causing greater pumping power due to friction losses. Moreover, the industry has become acquainted to fuel-based services or energy-on-tap (firm energy) and is therefore not willing to switch to renewable energy such as solar photovoltaic systems.

Often machinery is also designed so as to have very high starting surge loads, thereby making it impractical to invest in capital-intensive technologies (renewable) instead of fuel-based technologies, causing emissions and/or pollution. These areas need to be improved and then can be codified.

Although according to the study conducted by Jadavpur University[35] 98% of the embodied energy is attributed to the embodied energy of the materials used and 2% is the contribution of actual erection of the building, it is important to look at this seemingly trivial 2% for the main reason that there can be a lot of energy wasted and emissions and pollution created by bad site practices, and also because better site practices lead to better buildings and saves cost for the builder, thereby (ultimately) resulting in more affordable construction.

- **Efficient Machinery Usage:** Opt for energy-efficient construction equipment and machinery, including electric or hybrid vehicles, to minimize fuel consumption and emissions during construction activities.

- **On-Site Power Generation:** Utilize portable renewable energy sources such as solar generators or wind turbines to power construction operations, reducing reliance on grid electricity.

- **Timely Equipment Maintenance:** Regularly maintain construction equipment to ensure optimal performance, reducing energy waste due to inefficient machinery operation.

- **Proper Equipment Sizing:** Select appropriately sized equipment for construction tasks to avoid oversized machinery that consumes excess energy during operation.

- **Optimized Heating and Cooling Systems**: Temporarily install energy-efficient heating, ventilation, and air conditioning (HVAC) systems in construction trailers or temporary offices to provide comfortable working conditions with minimal energy consumption.

- **Temporary Lighting Solutions:** Use temporary lighting fixtures equipped with energy-efficient bulbs, such as LED lights, to illuminate construction sites during low-light conditions while minimizing electricity usage.

- **Construction Material Management:** Implement efficient material management practices to minimize energy-intensive transportation and handling processes, reducing fuel consumption and emissions associated with material delivery.

- **Job Site Layout Optimization:** Plan the layout of the construction site to minimize the distance travelled by workers and equipment, reducing fuel consumption and energy usage during transportation activities.

- **Energy-Aware Construction Processes:** Train construction workers and supervisors to prioritize energy conservation practices, such as turning off equipment when not in use and minimizing idling time for vehicles and machinery.

- **Waste Reduction and Recycling:** Implement waste reduction and recycling programs to minimize the energy required for waste disposal and processing, promoting a more sustainable approach to construction activities.

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35 Embodied Energy Analysis of Multi-storied Residential Buildings in Urban India, S Bardhan - WIT Transactions on Ecology and the Environment, 2011

3.1.3 Water Conservation During Construction

- **Utilization of Water-Saving Techniques:** Implement the use of gunny bags, ponding technique, or curing compound to reduce water usage during construction activities.
- **Monitoring Water Consumption:** Install meters to accurately monitor and track water consumption throughout the construction process, ensuring accountability and facilitating the identification of areas for improvement.
- **Incorporation of Water-Reducing Admixtures:** Integrate water-reducing admixtures into concrete mixes to enhance workability while simultaneously reducing the overall water content required for construction activities.
- **Utilization of Treated Wastewater and Stormwater:** Prioritize the use of treated wastewater and captured stormwater for construction purposes, thereby conserving potable water resources and promoting sustainable water management practices.

3.1.4 Education and Research Enhancement for Good Construction Practices

- The layout planning of sites should be incorporated as a course in civil engineering, and project managers should be required to complete at least one semester of study in this subject.
- Civil engineers need to be able to engage with concepts of renewable energy through manual labour and solar and wind energy systems and they, along with project managers, need to, by mandate, graduate in at least one-semester course in this subject.
- Total energy losses due to waste and friction on site (per unit area of building being made) need to be analysed, benchmarked, and codified.
- All these point to research directions that need to be undertaken (again by Civil Engineering departments in our Engineering Institutes).
- Best industry standards for ratios of running energy: starting surge, need to be analysed, benchmarked, and codified, so that infirm energy sources such as solar photovoltaics may be able to be considered to meet the demand of energy on site. It may be noted that infirm energy sources such as solar photovoltaics could be seen to be a form of production of energy, and if managed well and with sufficient open area, with a good rental market created for solar photovoltaics or wind turbines, sites can in the future become energy-neutral for construction of buildings.

Since research in this area is nascent, it has been kept out of the ENS 2024 code for now.

ANNEXURE 4: RETROFITTING OF RESIDENTIAL BUILDINGS

Retrofitting consists of additions and alterations to existing (and, in the context of the ENS 2024 code, residential) building stock and typically this is set into motion by building owners.

For reasons of poor research and difficult practice, this code is currently silent on retrofit provisions and this appendix is created because given the right conditions this situation may change. This code does not mention provisions for retrofit cases because of the principle that laws (and codes) should preferably not be applied retroactively (so we cannot declare a building not meeting standards before the standard was even made), but in doing so we lose out a large potential of building stock (say over 50% of the residential building stock in 2030 if we read the McKenzie report[36] that "nearly 70% of building stock that will be there in 2030 is yet to be built in India" and geometrically extrapolate it from 2010 when it was written to 2019 today).

The following market innovations need to be encouraged to cover a large part of India's existing residential building stock even when they are not being added to or being altered:

- For apartment dwellers, before enforcing this code, there need to be financial (low-interest loan) instruments available or created whereby collective retrofitting may take place through collective action, for example changing of window or wall specifications through RWA action to comply with provisions of the ENS 2024 so that capital cost of such retrofits may be kept low per month.
- For individual house owners, there need to be encouragement of vendors who can audit and retrofit because until that is done the implementation of ENS 2024 code shall be resisted or "loopholed" by homeowners.
- For rental stock, these audits and retrofit companies can undertake audit and retrofit to meet the ENS 2024 code provisions either through RWA or through apartment owners' associations (this is more difficult but can be eased by easy upgrade costs accompanied by strict compliance demands).

It would help a lot if the improvements effected by RWAs or contractors can be documented in a standardized way and the improvements in performance recorded numerically on a plaque or certificate for the owners to take pride in retrofitting their homes. This can be designed like the BEE star labels for various appliances.

It is anticipated that since the primary means of enforcing the ENS 2024 code is at the time of municipal approval and completion, this code could be immediately applied at the time of application for addition and alterations of buildings as per section 2.5 and 2.6 of this code. However, It would exempt minor addition and alterations (such as raising internal walls, painting, etc.) For reference, these "minor" retrofits in existing buildings that do not need any permission according to Delhi Development Authority (DDA), similar to changes in buildings all over the country, are provided below:

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36 India's Urban Awakening: Building inclusive cities, sustaining economic growth (McKinsey Global Institute, April 2010)

Except from DDA[37]

1. To convert existing barsati into room provided the wall is made of only 115 mm thick.
2. Grills and glazing in verandah with proper fixing arrangement.
3. Raising height of front and rear courtyard wall up to 7' height by putting up jali/ fencing.
4. Providing door in courtyard wherever not provided.
5. Providing sunshades on doors and windows wherever not provided with proper fixing arrangements.
6. Closing the door.
7. If the bathroom or WC are not having roof, these may be treated as open urinals and allowed.
8. Raising the wall of balcony/terrace parapet with grill or glazing up to 5' height.
9. Construction of open staircase (cat ladder) where no staircase has been provided for approach to the terrace.
10. To put provide additional PVC water tank at ground floor area without disturbing the common passage.
11. To provide an additional PVC water tank in the scooter/car garage at the surface level.
12. To provide loft /shelf in the rooms without chase in the walls.
13. To change the flooring with water proofing treatment.
14. To remove half (41/2) brick wall.
15. To make a ramp at front gate without disturbing the common passage /storm water drain.
16. To provide sunshades or the outer windows up to 2'wide projection.
17. To provide false ceiling in rooms.
18. To make an opening of maximum size of 2'6" x1'9" for exhaust fan or air- conditioner in existing walls.
19. Fixing of door in back and front courtyard.
20. Converting of window into Almirah subject to availability of light and ventilation as per building byelaws provided that no structural elements are disturbed and there is no projection extending beyond the external wall.
21. Shifting of water storage tank/raising of parapet wall up to 5' height and putting additional water storage tank. Wherever the existing water storage tank capacity is less than 500 litres in a flat, a 500 litres tank can either replace the existing water storage tank or if possible, the additional tank can be added so as to make the total storage capacity up to 550 litres. However, such replacement/provision of additional tank will be done only on the locations specified for such tanks and the supporting beams will be required to be strengthened suitably. Parapet wall around terrace can be increased to a height of 5'.
22. To shift the front glazing, rooms/windows up to existing chajja.

Not implementing retrofit cases for, say, 5 years, it can then be suggested that the ENS 2024 code could be made applicable to all Addition and Alterations cases that come for approval to ULBs. This will cover at least some 5% of existing building stock (say 10% of 50%) and simultaneously measures (1) through (3) in the last page need to be actively pursued in the market to make alterations proactively possible for existing building stock, even when not undertaking additions and alterations.

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37 http://www.dda.org.in/housing/pending_cases/permissible_alteration_housing.htm, accessed December 2019.

Generally, alterations in themselves do not require municipal approval. The key changes that require getting municipal approval is increase of height / FAR / Ground Coverage, all of these are related to increasing the size of the home.

Studying codes from other countries[38], it can be seen that whenever a project comes up for municipal sanction, the codes require the renovated project to comply with the code provisions. This should be recommended in India also.

This will leave out only that part of the existing building stock that has a completion certificate from the ULB and remains unchanged. In time it shall be added to (requiring ULB approval) or demolished and rebuilt (requiring ULB approval). Therefore, by the later part of this century the entire residential building stock shall become ENS 2024 compliant, even if market forces do not already make it so.

38 There are many references. See for instance, the Residential Compliance Manual for the 2019 Building Energy Efficiency Standards, California, at https://ww2.energy.ca.gov/2018publications/CEC-400-2018-017/CEC-400-2018-017-CMF. pdf, or https://www.buildwaikato.co.nz/building-projects/additions-alterations/ from the Waikato Building Consent Group (WBCG) in New Zealand, both accessed in December 2019

ANNEXURE 5: IMPROVED AIR COOLING

The Indian residential building sector accounts for approximately 24% of the country's total energy consumption and is the second largest consumer after industries. Within the building sector, the residential electricity consumption amounts to 259 TWh. As the Indian middle-class experiences growing prosperity, there is a trend toward seeking comfort by installing air-conditioners, particularly in warm-humid, hot-dry, composite, and even moderate climates. The capital costs of air conditioning are relatively lower than those of building. Even inexpensive and inefficient air-conditioning systems can constitute as little as 5% of the total building cost. With the availability of EMI-based loans, it has become feasible for such families to afford split air-conditioners, often at a monthly cost lower than the energy expenses required to operate them.

The adoption of air conditioning poses a significant challenge to achieving energy efficiency in residential buildings in India. This is because it undeniably offers superior comfort across a range of conditions, including warm humid, hot dry, composite, and moderate climates.

For lower-middle-class families, who are acutely aware of the challenges associated with managing energy bills, the common approach is to use air conditioning sparingly. This may involve restricting usage to nighttime or extreme weather conditions, or adjusting the thermostat to higher temperatures. However, the effectiveness of air conditioning in managing humidity levels often leads to increased reliance on its usage, often exceeding the users' financial capacity.

Compounding this issue is the tendency within this economic class to opt for inexpensive, lower-rated, and inefficient air conditioning units. These are then installed in poorly insulated homes, resulting in even higher electricity consumption than necessary.

This causes residential air-conditioning to become a major barrier in energy efficiency (USAID, 2014)[39]. This issue is a major guzzler of energy in houses and needs to be mitigated by codification. However, since the research on this is ongoing, this has not yet been included in the ENS 2024 code.

On November 15, 2019, the Rocky Mountain Institute (RMI) in collaboration with the Ministry of Housing and Urban Affairs (MoHUA) of the Government of India (GoI) announced the results of a Global Cooling Prize competition, for Incentivizing the development of a residential cooling solution that will have at least five times less climate impact than standard residential/room air conditioners (RAC) units in the market today. This technology could prevent up to 100 gigatons (GT) of CO_2-equivalent emissions by 2050, and put the world on a pathway to mitigate up to 0.5°C of global warming by 2100, all while enhancing living standards for people in developing countries around the globe.[40]

39 HVAC Market Assessment and Transformation Approach for India, PACE-D Technical Assistance Program, USAID, August 2014

40 https://globalcoolingprize.org/ accessed in December 2019

Hence, there is an urgent need to conduct research and implement the following measures to ensure that Indian households achieve comfort while maintaining energy efficiency, at affordable capital costs or through the facilitation of fiscal incentives or financial mechanisms:

- Air-conditioning systems that can be used at higher set-point temperatures (say, up to 28 °C) in combination with ceiling fans. These require higher cfm of air to be pushed through (rather than the industry standard of 400 cfm per Ton) and a balance between refrigerant temperature, air flow, and set point since currently air-conditioning industry has optimised all systems for 22°C - 24°C. As the set point temperature is increased, the other parameters need to change. This kind of device will be ideal for bill- conscious lower middle classes even if they can progressively afford air-conditioning capex.

- Fiscal incentives or financial instruments to lower capex for improving house thermal performance to ENS 2024 code levels so that optimum (not too much) air-conditioning is installed. Unfortunately, at this point, the ENS 2024 code has been developed assuming that the cooling system is some form of air-conditioning.

- Rapid development and deployment of effective an acceptable intermediate technologies including adiabatic technologies, such as passive hybrid and active evaporative coolers, better natural ventilation, indirect evaporative coolers, or chilled coil indirect evaporative coolers, combined with fiscal incentives or financial instruments to lower capex for improving houses to a level so that sufficient passive cooling is managed and the number of days of usage of cooling or conditioning can be brought down.

- Alternative desiccant and evaporative systems for cooling (which are not yet well-developed). This may require fundamental research and cannot be expected to be rapidly deployed.

- Promotion of all these above alternatives through some cultural or social incentives (such as the BEE star rating system or TV promotions) so that they are not perceived as inferior to “complete” air-conditioning. This requires a major social change in attitude from progress seen as consumption only to progress seen as sufficiency, but is probably the most effective instrument for meeting and even bettering the EPI targets of the ENS 2024 code.

NATURAL AND ENS 2024 POINT VENTILATION

If buildings can achieve comfort by natural or sense Point ventilation, this would entirely avoid the use of energy for mechanical cooling, and needs to be highly encouraged.

Natural ventilation fulfils two primary needs: first, it gives fresh air for satisfactory indoor quality; and, second when the outdoor temperature is comfortable (during night and transition seasons), it expels heat from inside the structure and facilitates cooling.

Natural ventilation is of course not useful for cooling when the outdoor air is at a temperature higher than the set-point or desired indoor temperatures. This leads us to another very important concept of ventilation, ENS Point ventilation, opening the building very much to the outdoor air whenever the temperature outside is more comfortable than the inside, namely summer nights and winter days.

The National Building Code 2016 (Part 8; 1; 5. Ventilation) or ASHRAE 62.1–2016 provide standard ventilation rates for acceptable indoor quality.

To aid cooling a larger volume of airflow is required than the standard ventilation rates. The rate of ventilation by natural means through windows or other openings depends on, direction and velocity of wind outside and sizes and disposition of openings (wind action); and convection effects arising from temperature of vapour pressure difference (or both) between inside and outside the room and the difference of height between the outlet and inlet openings (stack effect).

One of the parameters to quantify the adequacy of natural ventilation is hourly air change rate (ACH), which is a proportion of how frequently the air volume inside a room is supplanted by outside air in 60 minutes. The larger the number, the better is the cooling potential through common ventilation. As a rule, 5 to 20 ACH gives good natural ventilation.

NBC 2016 discusses the design guidelines for natural ventilation in the 5.4.3 of Part 8: Building Services of the code.

Once the promotion of naturally ventilated buildings can be successfully undertaken, it should be possible to eliminate the use of air-conditioning or at least drastically reduce its use in all but the most affluent residences.

Ventilation in residential buildings can be provided by one of the following methods:

a) Natural supply and natural exhaust of air (natural ventilation)
b) Natural supply and mechanical exhaust of air (mechanical ventilation, see below)
c) Mechanical supply and natural exhaust of air (mechanical ventilation, see below)
d) Mechanical supply and mechanical exhaust of air (mechanical ventilation, see below).

MECHANICAL VENTILATION

There are a range of circumstances in which natural ventilation may not be possible or sufficient to attain thermal comfort:

- The building is too deep to ventilate from the perimeter.
- Local air quality is poor, for example if a building is next to a busy road. Local noise levels mean that windows cannot be opened.
- The local urban structure is very dense and shelters the building from the wind. Privacy or security requirements prevent windows from being opened.
- Internal partitions block air paths.
- The density of occupation, equipment, lighting and so on creates very high heat loads or high levels of contaminants.

Some of these issues can be avoided or mitigated by careful design, and mixed mode or assisted ventilation might be possible, where natural ventilation is supplemented by mechanical systems. Naturally it is not desirable to go with mechanical ventilation where natural ventilation could achieve the similar results.

Where mechanical ventilation is necessary it can be:

- A circulation system such as a ceiling fan, which creates internal air movement, but does not introduce fresh air.
- A pressure system, in which fresh outside air is blown into the building by inlet fans, creating a higher internal pressure than the outside air.
- A vacuum system, in which stale internal air is extracted from the building by an exhaust fan, creating lower pressure inside the building than the outside air.
- A balanced system that uses both inlet and extract fans, maintaining the internal air pressure at a similar level to the outside air and so reducing air infiltration and draughts.
- A local exhaust system that extracts local sources of heat or contaminants at their source, such as cooker hoods, fume cupboards and so on.

KITCHEN VENTILATION

Kitchen is always the hottest space in a flat on account of the huge amount of heat produced due to cooking. The arrangement of a decent ventilation framework that can proficiently separate hot air from the kitchen before it blends with the encompassing air can help lessen the heat in the kitchen and adjoining spaces.

For powerful natural ventilation of the kitchen, notwithstanding the window, an extra louvre opening ought to be given to further aid the movement of air.

If the kitchen is ventilated utilizing a fume hood, the distance of the hood from the gas fire and the fume flow rate should be appropriately chosen for best ventilation of the kitchen.

EVAPORATIVE COOLING

Evaporative cooling is a process that uses the effect of evaporation of water as a natural heat sink. The amount of sensible heat absorbed depends on the amount of water that can be evaporated. Currently this is the most promising area of reducing energy for cooling, except that it is largely ineffective in warm and humid seasons or climates. Sensible heat from the air is absorbed to be used as latent heat necessary to evaporate water.

- **Direct Evaporative cooling (DEC):** In this system, commonly used in the form of a 'desert' cooler, the outdoor air is brought into direct contact with water, cooling the air by converting sensible heat to latent heat. DEC systems could be divided into: Active DECs which are electrically powered to operate and Passive DECs that are naturally operated systems with zero power consumption. In DEC, the water content of the cooled air increases because air is in contact with the evaporated water. This strategy is useful in dry and hot climates.

- **Indirect Evaporative Cooling:** Indirect evaporative coolers operate by decreasing air sensible heat without changing its humidity, which is a distinct advantage over DEC systems (the final temperature approached can be dew point instead of wet bulb temperatures). In indirect evaporative cooling, evaporation occurs inside a heat exchanger and the absolute humidity of the cooled air remains unchanged. This strategy is even more effective in hot and dry climates that DEC and fairly effective for warm and humid climates, too.

EPI FOR EVAPORATIVE COOLER

The efficiency of the evaporative coolers is measured based on the evaporative efficiency which depends on the outside dry bulb temperature and relative humidity of the airstream.

The EPI shall be estimated for Evaporative Coolers as shown below:

> EPI = [Total Wattage of fan(s) + Total wattage of pump(s)]
> * Hours of operation/ (1000 * Built-up area)

Rationale for EPI calculation for evaporative cooler

Parameters influencing EPI for evaporative cooler are:

Design Parameters	Technology Parameters
• Location (climate) • Air Delivery Rate • Pump Water Circulation rate • Fan and Pump efficiencies	• Direct evaporative cooling • Fan and Pump motor types
Controls	
• Dew Point based shut-off controller	

User inputs in calculating the EPI shall include:

- Power rating of the fan motor (From nameplate) in watts
- Power rating of the pump motor (From nameplate) in watts.

If a household employs DEC, IEC, or any natural, ENS 2024 point, or mechanical ventilation strategies for cooling, thereby circumventing Carnot cycle-based air conditioning entirely, it is suggested that it should inherently meet the ENS 2024 code requirements without necessitating the exhaustive process of demonstrating full EPI calculation procedures. While this aspect has not been codified, it is included in this appendix as a suggestion open for consideration.

DISTRICT COOLING

District cooling systems, which typically require about 15% less capacity than conventional distributed cooling systems for the same cooling loads due to load diversity and flexibility in capacity design and installation. District cooling helps in greatly reducing the peak demands and provide new generation capacity to meet cooling demand. District cooling systems are appropriate for densely populated urban areas having mixed uses of buildings with high cooling requirement. It provides enhanced level of reliability and flexibility, as individual building's cooling demand can increase or decrease without the need to change the main plant's capacity.

District cooling entails the centralized production and distribution of cooling energy. Chilled water is produced at a central plant and then conveyed to buildings via underground insulated pipelines to cool the interiors within a neighbourhood or zone. Specially designed equipment such as heat exchangers, pumps, and air handling units (AHUs) in each building utilize this chilled water to lower the temperature of the air circulated through the building's cooling system

THERMAL ENERGY STORAGE

Thermal storage may be used for limiting maximum demand, by controlling peak electricity load through reduction of chiller capacity, and by taking advantage of high system efficiency during low ambient conditions. Thermal storage would also help in reducing operating cost by using differential time-of-the day power tariff, where applicable.

The storage medium can consist of either ice or water. Water storage typically requires stratified storage tanks and is most feasible with large storage capacities. It offers the advantage of operating the plant at higher efficiencies but necessitates larger storage volumes. In the case of a central plant equipped with thermal energy storage, the location should be determined in consultation with the air conditioning engineer.

For rooftop installations, structural provisions should accommodate the additional load imposed on the building or structure. When opting for open-area surface installations, considerations should be made regarding horizontal or vertical system options, and access ladders for manholes should be provided. Buried installations must account for the loads resulting from vehicle movement above the area.

ANNEXURE 6: SMART HOME

The concept of smart homes has been around for several decades, but its significance has grown exponentially in recent times. This heightened importance can be attributed to various factors, including the increasing demand for comfort and convenience, driven by rising disposable incomes, greater reliance on household appliances, and a corresponding uptick in per capita electricity consumption. Additionally, the availability of rooftop solar photovoltaic (PV) systems and electric vehicles (EVs) for potential on-site generation and storage has further amplified the relevance of smart home technology.

In parallel with these consumer-driven drivers, technological advancements have played a crucial role in fuelling the demand for smart home products and services. The widespread adoption of high-speed computing devices such as smartphones, coupled with affordable internet data, has democratized access to smart technology. Furthermore, the shrinking size of Internet of Things (IoT) devices and sensors, coupled with the migration of sophisticated computing functions to the cloud, has facilitated the development of complex algorithms powered by artificial intelligence. These advancements enable the customization of home systems according to user preferences and requirements, thereby enhancing the appeal of smart home solutions.

Moreover, the evolving energy landscape has underscored the need for utility-based demand response programs to balance variable consumer demand, resulting from the diverse use of appliances, with dynamic electricity supply stemming from the increased penetration of renewable energy sources into the grid. As a result, smart home solutions are increasingly being recognized as essential products/services in every household, ensuring readiness for demand response initiatives.

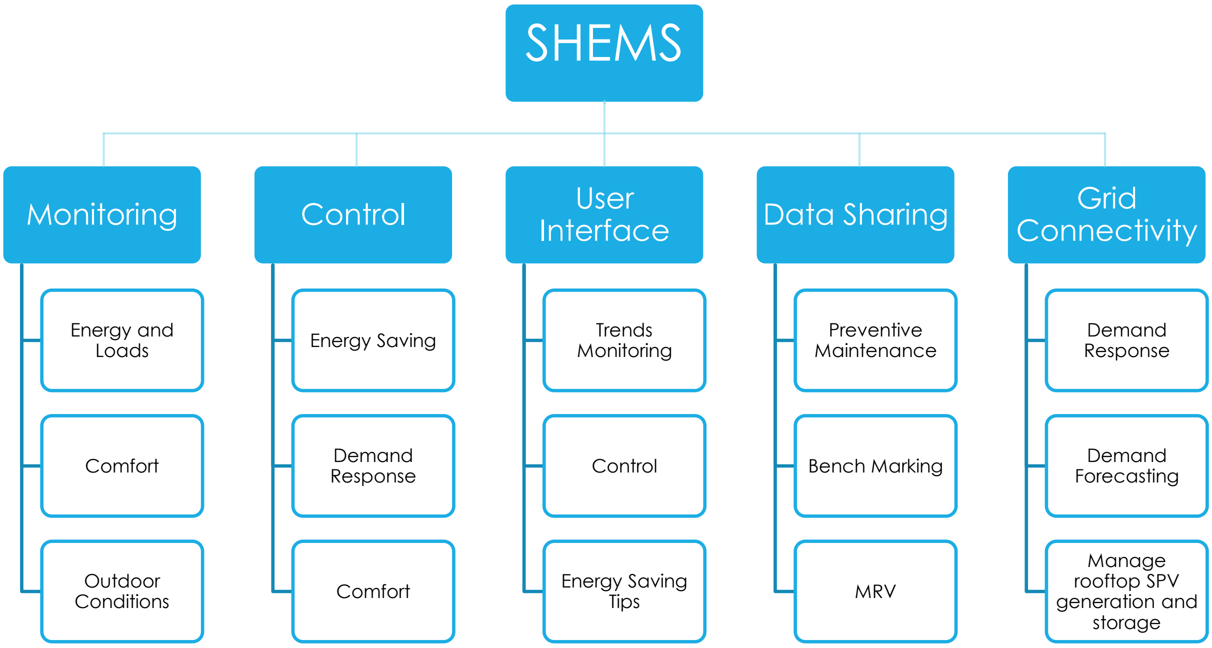
To manage the energy use in a home in order to make optimum use of these opportunities and for minimizing the demand supply gap, there is a need of Smart Home Energy Management System (SHEMS). SHEMS can be defined[41] as the combination of a service and devices that are designed to work together to deliver occupancy-based optimization of energy use. SHEMS[42] consist of hardware and software, which are linked and integrated to, monitor energy usage, provide feedback on energy consumption, enhance control and provide remote access and automation provisions over appliances and devices that use energy in the home. SHEMS can deliver a range of services and benefits to households, which includes:

- Energy management (energy efficiency)
- Demand response (contribute to regulating energy demand)
- Electricity generation, storage and delivery to the grid
- Comfort and convenience.

41 Source: ENERGY STAR® Program Requirements, Product Specification for Smart Home Energy Management Systems, https://www.energystar.gov/sites/default/files/ENERGY%20STAR%20SHEMS%20Version%201.0%20Program%20 Requirements_0.pdf

42 Source: Sustainable Now, https://sustainable-now.eu/guide-to-home-energy-management-systems/

The functionality of SHEMS can be broadly categorized in five areas that include monitoring, control, user interface, data sharing and grid connectivity. Schematics indicating the functionality of SHEMS and purpose of each functionality is given below:



The above-mentioned functionalities of SHEMS[43] can be operationalized with the support of:

- Physical sensors and devices
- Communication network for data transfer across smart devices, computation and data storage systems
- Data processing, decision making and relay commands as per defined logic or preference
- Smart appliances, devices and actuators to align the physical parameters to required level
- User interface to enable user to monitor, interact with smart home components and convey preferences
- Smart meter to monitor, record the energy consumption, load variation and to facilitate implementation of demand response program

In smart home, energy and cost savings is achieved by:

- Preventing idle running of energy consuming system
- Optimization of adjustable building envelope elements to minimize energy demand Optimization of operating parameters to match user preference

43 Source: Based on the analysis conducted as part of BEE-GIZ study on Smart Home: Technology Assessment Study and Pilot Design through technical support of Deloitte Touche Tohmatsu India LLP and Prof. Vishal Garg (IIIT Hyderabad, India)

- Shifting the operation of non-essential energy consuming systems to off peak time
- Making use of renewable energy generation source, whenever available to meet the energy demand
- Optimization of charging and discharging of storage for cost saving
- Smart home has significant potential for saving energy, however, the net energy savings depends on a range of factors, which include:
- The rationale behind automation (comfort or energy saving)
- Level and type of automation used (i.e., occupancy based on/off control or fine tuning of operating parameters based on user preference and weather conditions)
- User behaviour (whether the user just looks at energy monitoring information or uses this information to change settings or change behaviour)
- Power consumption by monitoring and control devices
- Additional power consumption by appliances in standby mode due to inclusion of smart communication features.

Several studies have been undertaken at international level by various public and private agencies, including manufacturer associations, to estimate the energy savings from smart home solutions (product and services). Based on one of them, conducted by the Connected Device Alliance (CDA)[44], energy savings potential in a dwelling enabled with smart home devices and services could be in the range of 20-30% of the present household energy use, subject to the factors mentioned above.

As technologies are optimised, developed and linked with the implementation of further energy efficiency opportunities in homes, the energy savings potential may increase. Smart Home requirement can be added to code along with other benchmarks in the ENS 2024 code after suitable characterisation, study, analysis of best practices, and benchmarking.

NOTES

MINIMUM FUNCTIONALITY REQUIREMENT FOR SMART HOME

To ensure availability of minimum capabilities (regarding monitoring, control, user-interface, data sharing and grid connectivity) and to successfully deliver basic smart home experience to user, a minimum set of smart home devices should to be installed in a home. Table indicating the minimum device/capability requirement for each functionality of SHEMS is provided below in Table 60:

Table 60: Functionality Requirement for smart Home

Functionality	Smart home device and/or solution
Monitoring	Home level phase-wise energy and load monitoring Two 15A outlets for energy use monitoring of two appliances One temperature and humidity sensor One occupancy sensor
	One AC Controller to control set point, mode of operations, ON/OFF with provision of receiving control signals

44 A case study of barriers and solutions – Smart Home by Connected Device Alliance (CDA), which is a network of more than 350 government and industry participants that have come together to work on the energy efficiency opportunities provided by networked devices. Further information on the CDA is available at: https://cda.iea-4e.org

Control*	One Geyser Controller for ON/OFF, with provision of receiving control signals One Controllable light with provision of receiving control signal
User interface	Common user interface (app, voice or gesture based), to connect smart home devices over single software package for energy use monitoring and control
Grid connectivity	Able to participate in utility demand response program
Data sharing	Typical daily indoor conditions, and device-wise energy consumption, and hours of usage to be reported once a month in anonymous way

*All controllable devices to be able take control signals from hub/cloud
Data privacy, cyber security, interoperability, safety and energy efficiency - minimum requirement for smart home devices and components.

- All components, devices or elements of smart home that connects "directly or indirectly" to the internet must be equipped with "reasonable" security features, designed to prevent unauthorized access, modification, or information disclosure.
- All components, devices or elements of smart home should follow common standards (for hardware and software), as prescribed by the concerned department for connected devices, enabling them to discover and communicate with one another, regardless of manufacturer, operating system, chipset or physical transport.
- All components, devices or elements of smart home should have adequate level of fire, electricity and other user health related safety features to avoid potential accidents, hazards and discomfort.
- All components, devices or elements of smart home should be energy efficient and should meet the minimum energy efficiency criteria set by concerned government department.

ANNEXURE 7: GUIDELINES FOR DESIGN FOR NATURAL VENTILATION

This annexure provides a simple and illustrative interpretation of provisions for the location of windows in a room and its impact on natural ventilation. A detailed design guideline for natural ventilation is available in the NBC 2016[45] (Volume II, Part 8 Building Services, Section 1 Lighting and Natural Ventilation).

The code gives the following provision for minimum WFR_{op} values for natural ventilation Table 61:

Table 61: Minimum requirement of window-to-floor area ratio, WFR_{op}

Climatic Zone	Minimum Wfr_{op} (%)
Composite	12.50
Hot-Dry	10.00
Warm-Humid	16.66
Temperate	12.50
Cold	8.33

SOURCE: Bureau of Indian Standards (BIS). 2016. National Building Code of India 2016. New Delhi: BIS.

Openable window-to-floor area ratio (WFR_{op}) indicates the potential of using external air for ventilation. the openable area allows external air, when the ambient temperature is cooler than the inside air, into the internal spaces, which helps in ventilation, improvement in thermal comfort, and consequent reduction in cooling energy.

This openable area can be distributed on the external wall in a number of ways. rooms may have openings on only one external wall or multiple external walls (usually two external walls). Some guidelines for design of these openings are given below. It is to be noted that internal doors cannot be relied for enhancing ventilation and are assumed to be closed.[46]

1. Distribution of the openable area on the external walls of a dwelling unit must be done to maximize cross-ventilation, i.e., the air inlet and outlet openings should be separate and positioned on different walls in a way that optimizes the air flow path through the space. this can be done by placing openings on adjacent walls or on opposite walls, where possible (Figure 11).

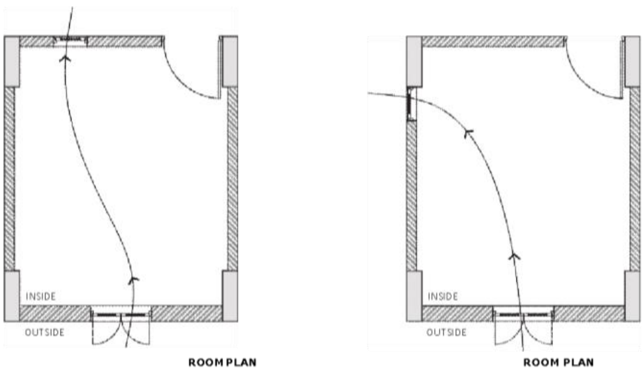


Figure 11: Openings on adjacent or opposite external walls for cross ventilation (Guideline)

45 Bureau of Indian Standards (BIS). 2016. National Building Code of India 2016. New Delhi: BIS.
46 Heat exchange during night-time in hot/warm climates has greater value for thermal comfort. At this time, it is generally seen now that people keep the doors of their private rooms, i.e., the internal doors, closed.

In rooms that have openable area on only one external wall, cross ventilation can be achieved by having an opening at a higher level on one of the internal walls (Figure 12). this will enhance cross ventilation through the habitable space. this principle can be extended from room to room, for instance, from a bedroom into a living room which is cross-ventilated, thus enhancing cross ventilation through the entire dwelling unit.

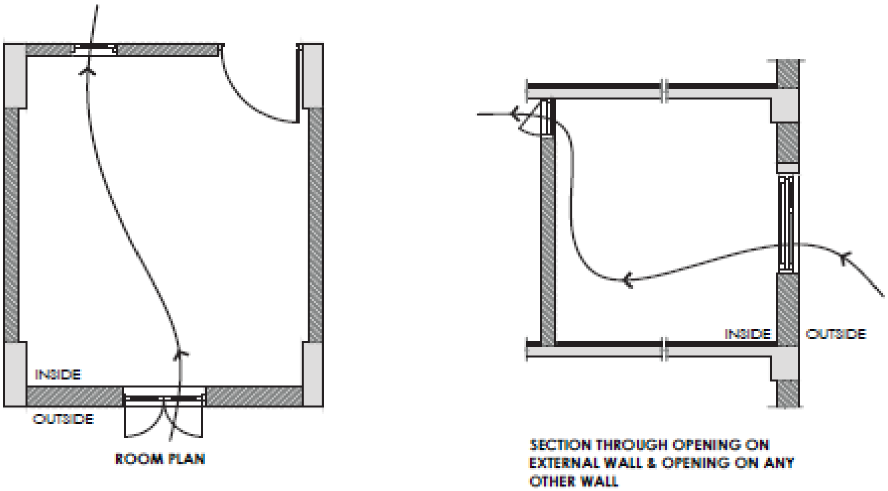


Figure 12: Openings on external wall and internal wall for cross ventilation (Guideline)

3. In rooms with only one external wall, and where cross ventilation is not possible (see point 2, above), provision of multiple windows on the external wall is preferred to that of a single window (Figure 13). the farther apart these windows are placed on the wall, the better is the effect of air movement across the room.

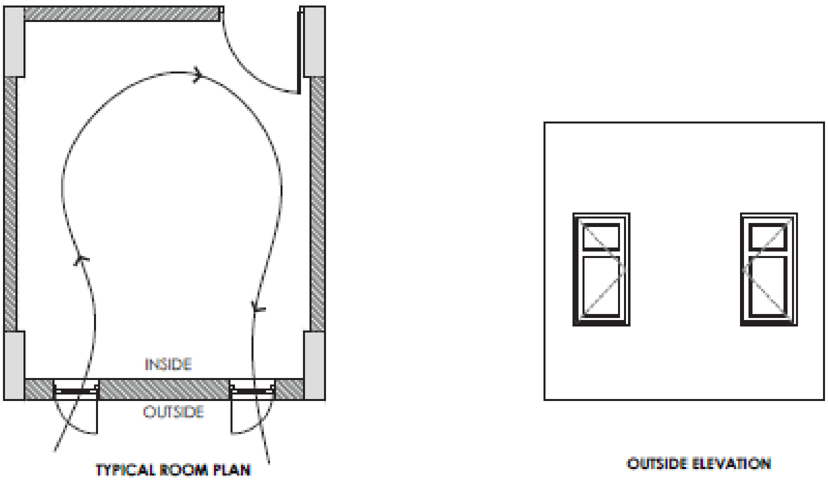


Figure 13: Two windows on single external wall (Guideline)

4. Adding a ventilator above the windows on the external wall helps increase the rate of convective heat exchange (Figure 14). this is especially helpful in cases where windows are available on only one external wall and there is no means of cross ventilation.

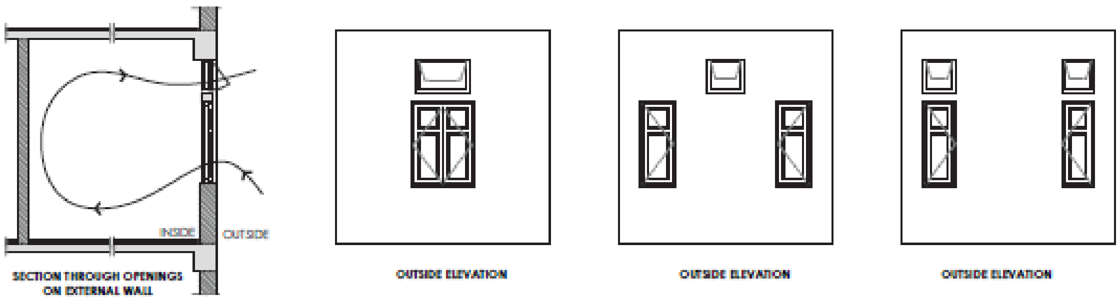


Figure 14: Adding ventilators above windows improves ventilation especially when only single external wall is available for openings (Guideline)

The following illustrative diagrams recommend good design strategies to help achieve better air exchange and increase the rate of heat loss through the buildings.

SINGLE-SIDED VENTILATION

Case 1: Room with only one opening on the external wall (Figure 15 **)**

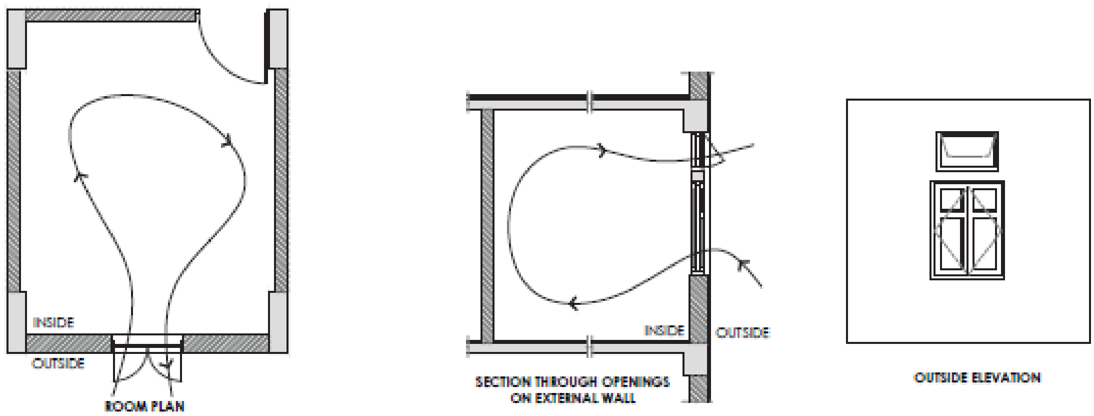


Figure 15: Room with only one opening on the external wall

Addition of ventilator at an upper level increases the rate of convective heat exchange with the outside air.

Case 2: Room with multiple openings on the external wall (Figure 16 **)**

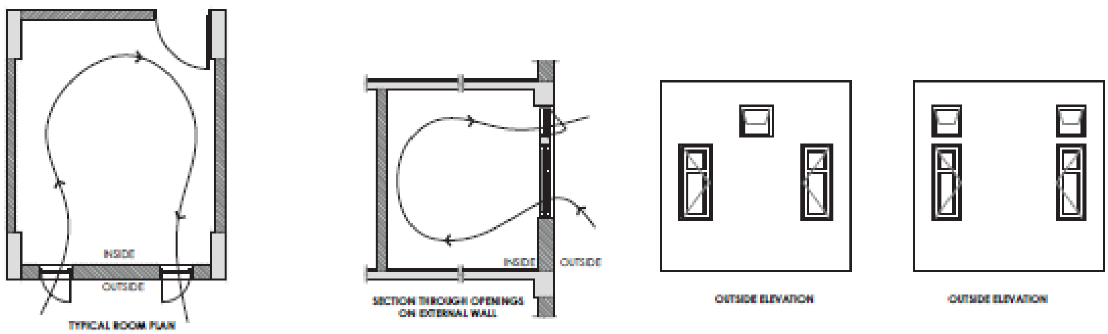


Figure 16: Room with multiple openings on the external wall

Cross ventilation

Case 1: Room with openings on both the external wall and another internal or external wall. (Figure 17 **)**

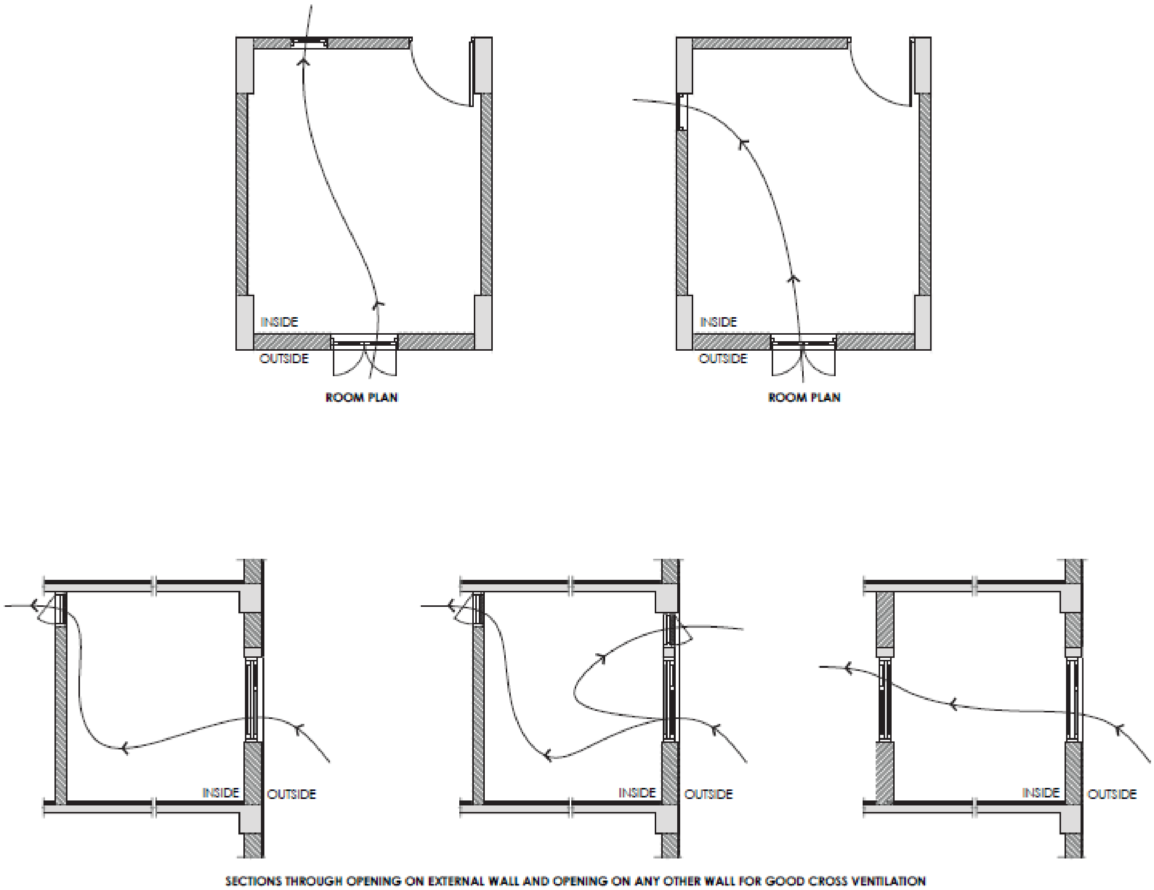


Figure 17: Room with openings on both the external wall and another internal or external wall.

Comparison (Figure 18 **)**

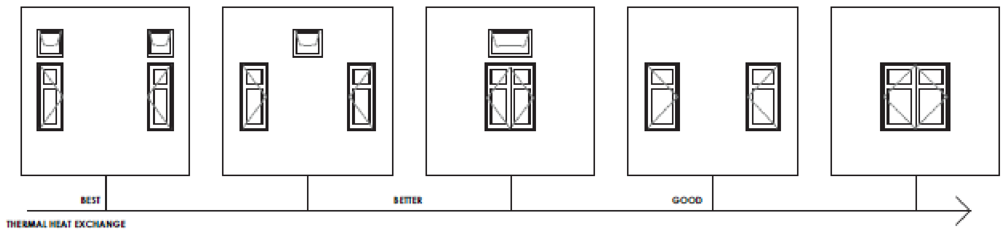


Figure 18: Comparison of different cases

For the same ratio of area of openings to floor area of a room, the thermal heat exchange increases as the number of openings increases on the wall.[47] It is thus recommended to have openable ventilators to aid better ventilation.

47 This conclusion is generally valid for hot-dry, warm-humid climates. For cold regions, this may vary.

ANNEXURE 8: COOL ROOF AND ROOF GARDENS

A cool roof is one that reflects most of the incident solar radiation and efficiently emits some of the absorbed radiation back into the atmosphere, instead of conducting it to the building below.[48] The term specifically refers to the outer layer or exterior surface of the roof, which acts as the key reflective surface.[49] A cool roof minimizes the solar heat gain of a building by first reflecting a considerable amount of incoming radiation and then by quickly re-emitting the absorbed portion. Cool roof encompasses an extensive array of applications including roof coatings, colours, textures, and finishes such as broken China mosaic, tiles, and even metals.

However, cool roofs are not to be seen as an alternative to the thermal transmittance requirement of the roof (U_{roof}) as given in this code. It is encouraged to have any cool roof application over a roof assembly complying with the maximum thermal transmittance value given in the code.

Defining a cool roof

The 'coolness' of a roof is influenced by its solar reflectance and thermal emittance.

- Solar reflectance: Solar reflectance is the ratio of solar radiation reflected by a surface to the solar radiation incident upon it. Solar reflectance is measured on a scale of 0 to 1. A reflectance value of 0 indicates that the surface absorbs all incident solar radiation, and a value of 1 denotes a surface that reflects all incident solar radiation. The term 'albedo' is often used inter-changeably with solar reflectance.
- Thermal emittance: Thermal emittance is the relative ability of a material to reradiate absorbed heat as invisible infrared radiation. Emittance, measured from 0 to 1, is defined as the ratio of the radiant flux emitted by a body to that emitted by a black body at the same temperature and under the same conditions.

According to ECBC 2017 cool roof requirement, roofs with slopes less than 20 degrees shall have an initial solar reflectance of at least 0.6 and an initial emittance of 0.9.

The Solar Reflectance Index (SRI) is a term that incorporates both solar reflectance and emittance in a single value and quantifies how hot a surface would get relative to standard black and standard white surfaces. It is the ability of a material to reject solar radiation, as shown by a small temperature rise.[50] The SRIs of a standard black surface (having reflectance of 0.05 and emittance of 0.9) and a standard white surface (of reflectance 0.8 and emittance 0.9) are taken as 0 and 100, respectively.

IGBC Green Homes requires a minimum SRI value of 78 for roof slopes with gradient ≤1:6 and 29 for steeper roof.

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48 Shakti Foundation. 2017. Cool Roofs for Cool Delhi: Design Manual. Available at http://shaktifoundation.in/ wp-content/uploads/2017/06/cool-roofs-manual.pdf (accessed on 1 May 2018)

49 ibid

50 Bureau of India Standards (BIS). 2016. National Building Code 2016. Part 11. New Delhi: BIS

For more detailed information on cool roof, please refer Cool Roofs for Cool Delhi: Design Manual.[51]

Roof Gardens

In the case of roofs with roof gardens on earth fill for plantation or lawn, the thermal resistance of the earth fill can be taken into the calculation of the thermal transmittance (U value) of the roof. Some of the heat absorbed by the earth fill is also released into the atmosphere due to evapotranspiration of irrigation water from the roof garden, thus giving additional benefit.

51 Shakti Foundation. 2017. Cool Roofs for Cool Delhi: Design Manual. Available at http://shaktifoundation.in/wp-content/uploads/2017/06/cool-roofs-manual.pdf (accessed on 01 May 2018)

ANNEXURE 9: CLIMATE ZONE AND CLASSIFICATION OF CITIES

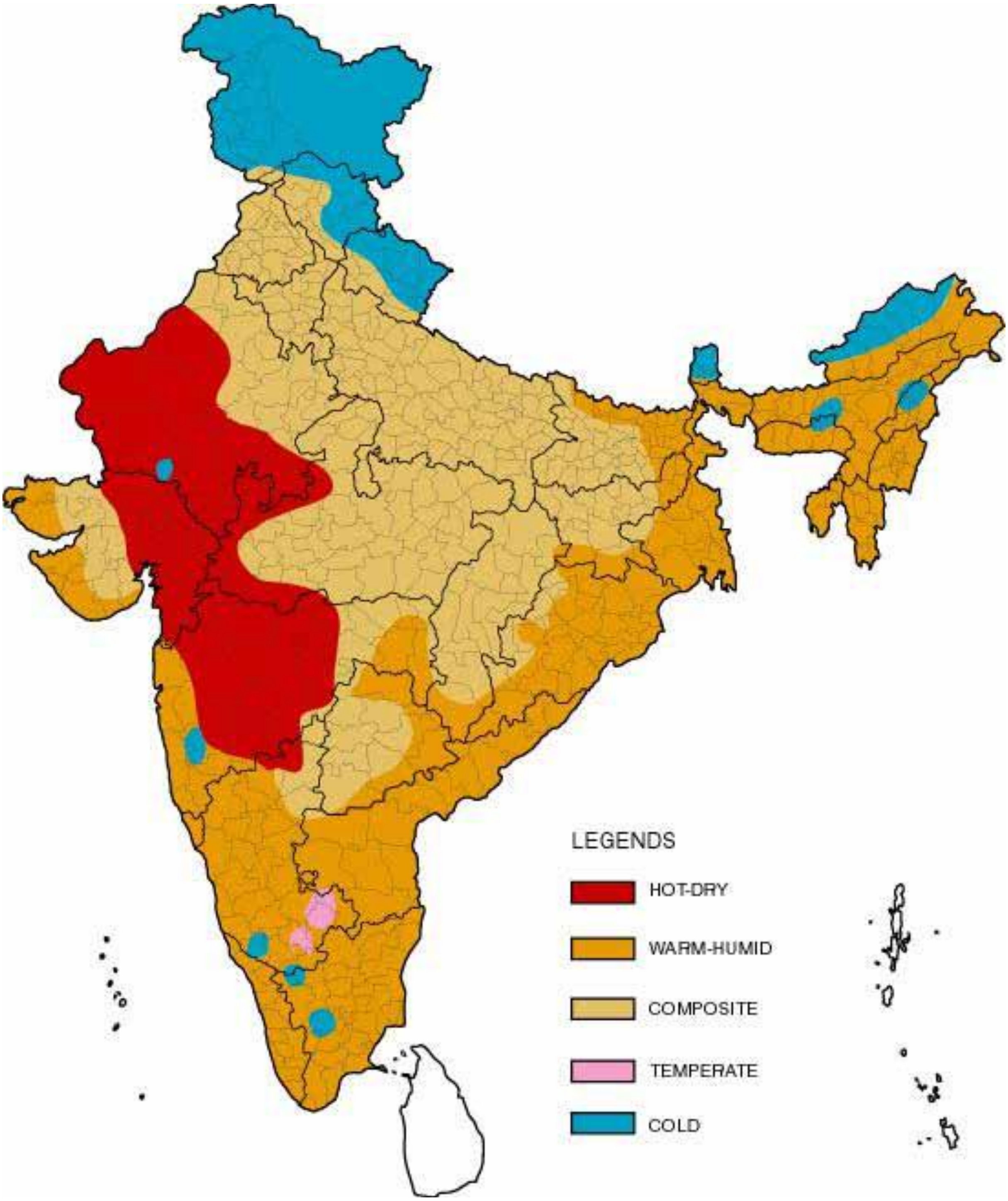

Figure 19: Climate Zone map of India

Table 62: Climate Zone for major Indian Cities

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