प्रधान मंत्री आवास योजना-शहरी Pradhan Mantri Awas Yojana-Urban | GLOBAL HOUSING TECHNOLOGY CHALLENGE INDIA | Ministry of Housing and Urban Affairs Government of India | आज़ादी का अमृत महोत्सव | bmtpc | giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

RACHNA
RESILIENT, AFFORDABLE AND COMFORTABLE HOUSING THROUGH NATIONAL ACTION

Climate Smart Buildings

Training Program on Innovative Construction Technologies & Thermal Comfort in Affordable Housing

April 20-21, 2022

CRDF CEPT RESEARCH AND DEVELOPMENT FOUNDATION | CEPT UNIVERSITY

1

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RACHNA
RESILIENT, AFFORDABLE AND COMFORTABLE HOUSING THROUGH NATIONAL ACTION

Session 1: Introduction to Rachna Training Programme

10h10, April 20, 2022

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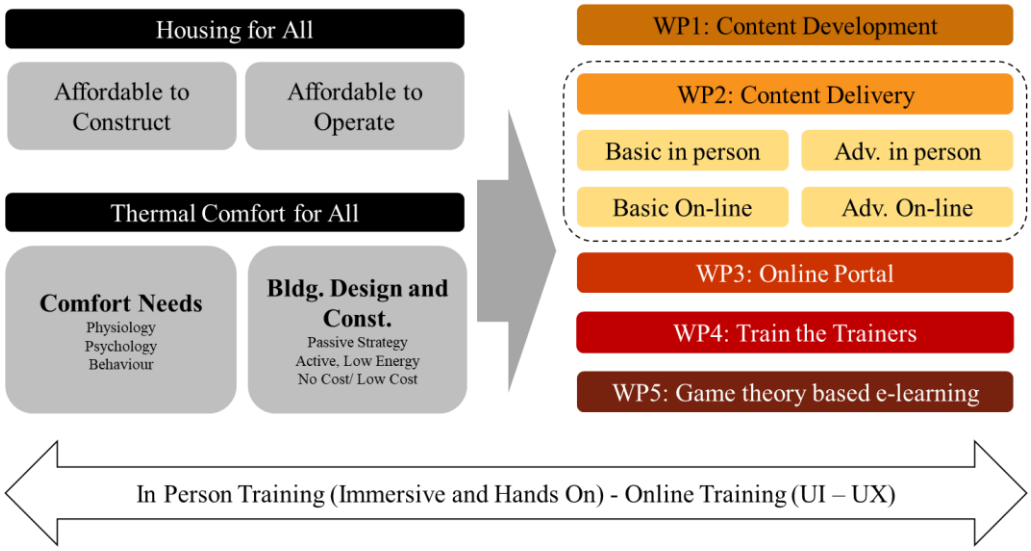
2

Components of Thermal Comfort Training Modules



3

Components of Thermal Comfort Training Modules

Basic Module Senior Officials	**Delivery of the content** • One day 10h30 to 17h00 • Twelve (6+6) training programs • ~15 participants (in person) & ~30 participants (on-line – Virtual delivery) • Content Delivery – Hands On Experiences, Immersive Experiences
Advanced Module Professionals and Technical Officers	**Delivery of the content** • Two days 10h30 to 17h00 • Twelve (6+6) training programs • ~20 participants (in person) & ~30 participants (on-line – Virtual delivery) • Content Delivery – Hands On Experiences, Immersive Experiences

4

प्रधान मंत्री आवास योजना-शहरी
Pradhan Mantri Awas Yojana-Urban

GLOBAL HOUSING TECHNOLOGY CHALLENGE INDIA

Ministry of Housing and Urban Affairs
Government of India

आज़ादी का अमृत महोत्सव

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Thank You

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RACHNA
RESILIENT, AFFORDABLE AND COMFORTABLE HOUSING THROUGH NATIONAL ACTION

Session 2 (Technical): Importance of Thermal Comfort

11h00, April 20, 2022

1

Homo sapiens : Part of the Animal Kingdom

Source: freepik. Happy friends silhouettes jumping on sunset Free Photo [Image]. Retrieved 12 April 2022, from https://www.freepik.com/free-photo/happy-friends-silhouettes-jumping-sunset_13870658.htm#query=youth&position=0&from_view=keyword.

2

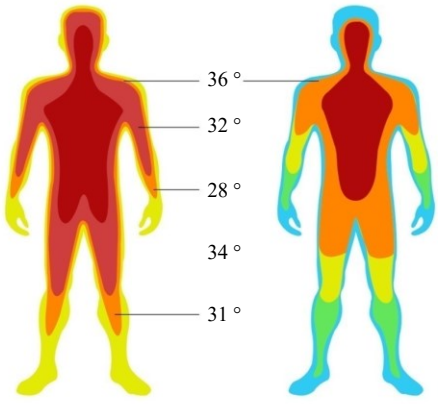
Importance of thermal comfort : Body Requirements

- Homo sapiens primate order of the class of mammals
- Body heat is a by-product of metabolism
- A normal core temperature of ~37° C and skin at ~34° C

Source: Sunil Kumar Singh. (2016). Alert to heatwaves [Image]. Retrieved 12 April 2022, from https://www.downtoearth.org.in/news/climate-change/alert-to-heat-waves-53459
The Telegraph Online. (2020). Cold conditions continue in Delhi [Image]. Retrieved 12 April 2022, from https://www.telegraphindia.com/india/cold-conditions-continue-in-delhi/cid/1732019

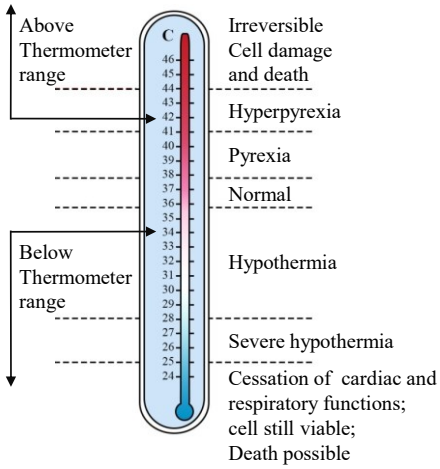
3

Importance of thermal comfort : Conditioning and Comfort



30 °C – Ambient temperature – 20 ° C

Human Body Condition in two sets of environment



Human Body Condition beyond comfort bands

4

Importance of thermal comfort : Conditioning and Comfort

- Inability to shed excess heat leads to a rise in core body temperature
- Increase in heart rate
- Loss of concentration
- Irritation
- Sickness and Vomiting
- Unconsciousness
- Death

Source: freepik. Tired student [Image]. Retrieved 12 April 2022, from https://www.freepik.com/photos/tired-student

Importance of thermal comfort : Ways to achieve it

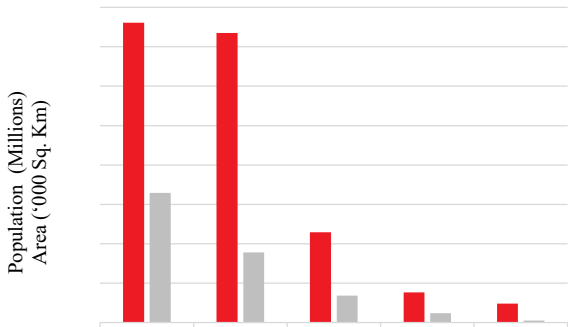
- Electrical – Mechanical Systems
- Change of Air
- Air Velocity
- Cooling
- Heating

Source: freepik. Tired student [Image]. Retrieved 12 April 2022, from https://www.freepik.com/photos/tired-student, toppng. electrical ceiling fan [Image]. Retrieved 12 April 2022, from https://toppng.com/show_download/8026/electrical-ceiling-fan/large, , freepngimg. (2018). Fan Heater [Image]. Retrieved 12 April 2022, from https://freepngimg.com/png/50210-fan-heater-free-download-image

Access to Thermal Comfort is a challenge. Ways and means to achieve comfort impacts the environment negatively

7

Importance of Thermal Comfort



	Warm-Humid	Composite	Hot-Dry	Cold	Temperate
Population (Millions)	152.2	147.0	45.8	15.3	9.5
Area (in '000 sq. km.)	65.8	35.5	13.6	4.6	1.0

Population (Millions) Area (in '000 sq. km.)

- More than 50% of India lives in a warm and humid climate
- Cooling Degree Days
  - Kolkata 3360 (19.7 million)
  - New Delhi 3015 (29.9 million)
  - Mumbai 3469 (24.5 million)
  - Chennai 4108 (10.6 million)

Source: Ministry of Home Affairs, Government of India. Population projection. Census of India. (2011). Retrieved 12 April 2022, from https://www.censusindia.gov.in/2011census/dchb/DCHB.html

8

Impact of need of Thermal Comfort: Lock In Period

Envelop

HVAC

Lighting

Lock-In Period

- Lighting 2-5 Years
- HVAC – Split and Package – 7-12 years
- Buildings – 60-80 years

Better building envelop leads to economic savings and environmental protection

Source: Sustainable and Smart Space Cooling Coalition (2017). Thermal Comfort for All - Sustainable and Smart Space Cooling. New Delhi: Alliance for an Energy-Efficient Economy
freepik. Security metal safe [Image]. Retrieved 12 April 2022, from https://www.freepik.com/free-vector/security-metal-safe-isolated_10601012.htm

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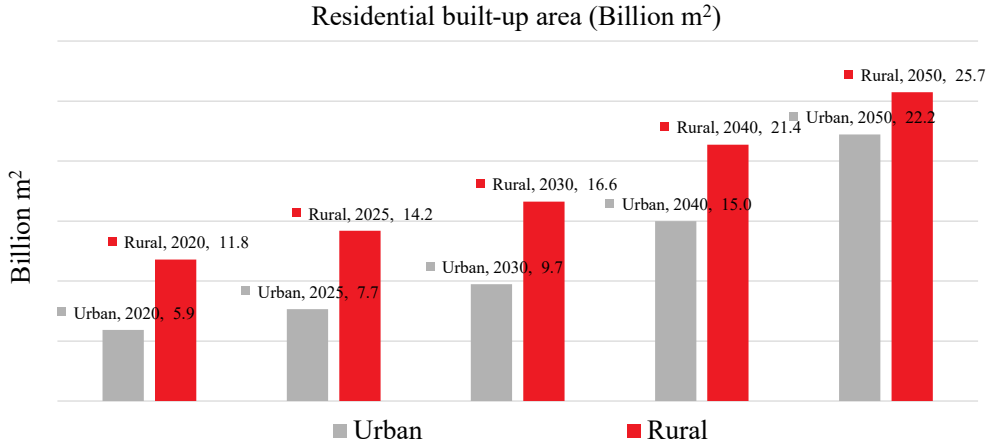
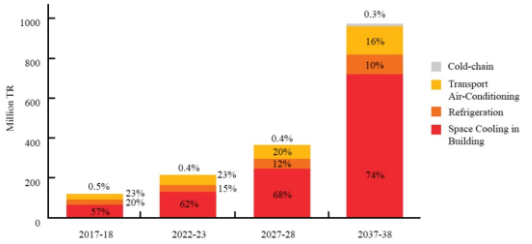
Residential Built-up Area growth projections



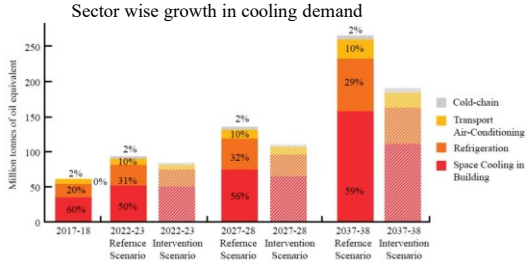
- The total urban residential built-up area increases from 5.9 billion m^2 (2020) to 22.2 billion m^2 (2050).
- The per capita residential built-up area in an urban area to increase from 12.6 m^2 (2020) to 24.2 m^2 in (2050)

10

Impact of the need of Thermal Comfort: India Cooling Action Plan



Sector wise growth in cooling demand



India's TPES for cooling

India's cooling demand

- 8 times by 2037-38
- 11 times for Building Sector compared to the baseline 2017-18
- India's Total Primary Energy Supply (TPES) for Cooling
  4.5 times in 2037-38
- 30% reduction possible due to intervention – from better design and technology

Source: Ministry of Environment, Forest & Climate Change, & Government of India. (2019, March). India Cooling Action Plan. Retrieved from http://ozonecell.nic.in/wp-content/uploads/2019/03/INDIA-COOLING-ACTION-PLAN-e-circulation-version080319.pdf

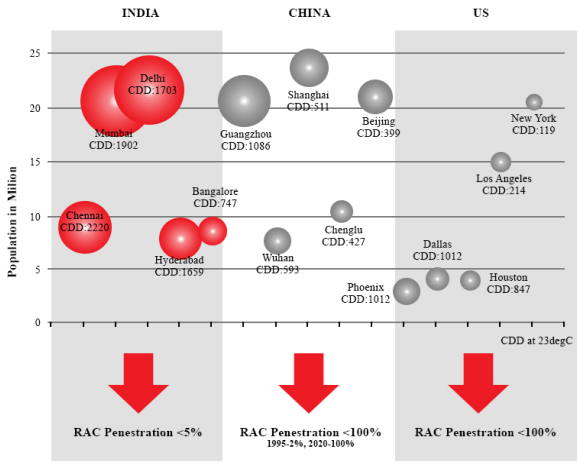
Impact of need of Thermal Comfort: India Cooling Action Plan

ICAP Goals

- Reduction of cooling demand across sectors by 20-25%, by 2037-38
- Reduction of refrigerant demand by 25-30%, by 2037-38
- Reduction of cooling energy requirements by 25-40%, by 2037-38
- Training and certification of 1,00,000 service technicians by 2022-23
- Recognizing "cooling and related areas" as a thrust area of research

Source: Ministry of Environment, Forest & Climate Change, & Government of India. (2019, March). India Cooling Action Plan. Retrieved from http://ozonecell.nic.in/wp-content/uploads/2019/03/INDIA-COOLING-ACTION-PLAN-e-circulation-version080319.pdf

Impact of need of Thermal Comfort: International Perspective



Cooling Demand in India, China, and the US

- To combat uncomfortable conditions
- Leads to increased peak
- Leads to higher consumption

Source: Ministry of Environment, Forest & Climate Change (2019). India Cooling Action Plan. New Delhi: Ministry of Environment, Forest & Climate Change.

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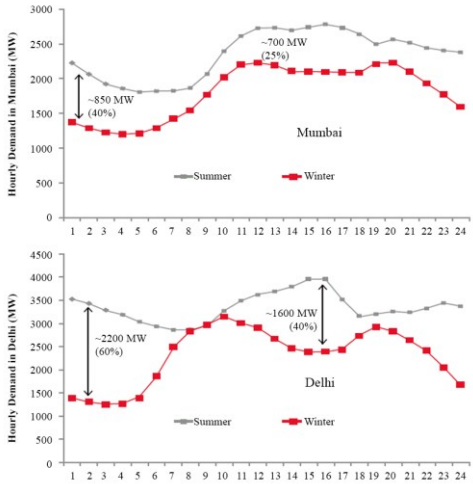
Impact of need of Thermal Comfort: Peak Demand



- Summer and Winter Day Profile of Electricity use
- Mumbai and Delhi Comparison
- Leads to higher consumption

Late-night 850 MW to late afternoon 700 in Mumbai
Late-night 2200 MW to late afternoon 1600 in Delhi

SourcePhadke, A., Abhyankar, N., & Shah, N. (2014). Avoiding 100 New Power Plants by Increasing Efficiency of Room Air Conditioners in India: Opportunities and Challenges.
https://international.lbl.gov/publications/avoiding-100-new-power-plants

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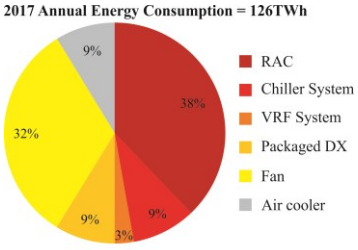
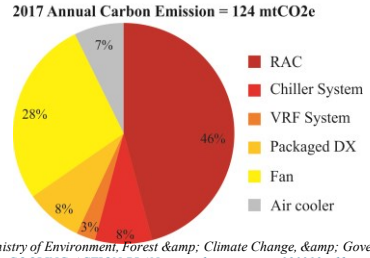
Impact of need of Thermal Comfort: Consumption and Emission





- Total Consumption 126 TWh and 124 $MTCO_{2e}$
- Room Air Conditioners 48.8 TWh (38%) consumption
- Room Air Conditioners 57.0 $MTCO_{2e}$ (46%) Carbon Emission

Source: Ministry of Environment, Forest & Climate Change, & Government of India. (2019, March). India Cooling Action Plan. Retrieved from http://ozonecell.nic.in/wp-content/uploads/2019/03/INDIA-COOLING-ACTION-PLAN-e-circulation-version080319.pdf

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Impact of need of Thermal Comfort: Consumption and Emission

- In 2017, approximately 272 million households were estimated in India
- Expected to increase to 328 by 2027
- 386 million by 2037

Source: Ministry of Environment, Forest & Climate Change, & Government of India. (2019, March). India Cooling Action Plan. Retrieved from http://ozonecell.nic.in/wp-content/uploads/2019/03/INDIA-COOLING-ACTION-PLAN-e-circulation-version080319.pdf

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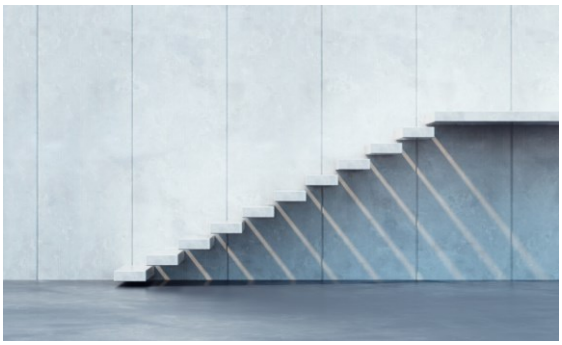
Impact of need of Thermal Comfort: Consumption and Emission

- In 2017, approximately 8% of the households were estimated to have room air conditioners
- Anticipated to rise to 21% by 2027-28
- And 40% by 2037-38

Source: Ministry of Environment, Forest & Climate Change, & Government of India. (2019, March). India Cooling Action Plan. Retrieved from http://ozonecell.nic.in/wp-content/uploads/2019/03/INDIA-COOLING-ACTION-PLAN-e-circulation-version080319.pdf

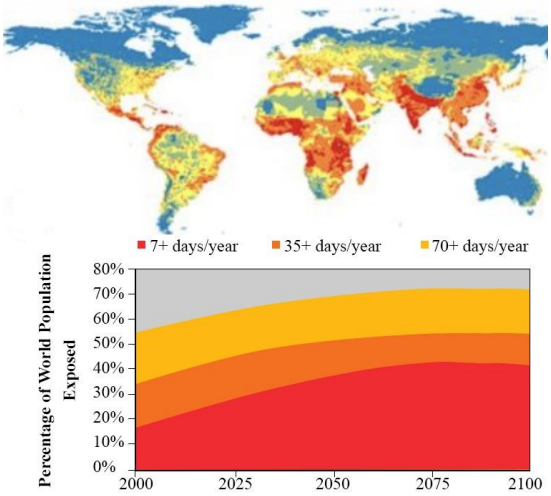
Impact of need of Thermal Comfort: Consumption and Emission



- In 2017, the estimated commercial floor was around 1.2 million sqft
- Is expected to grow about 1.5 to 2 times by 2027-2028
- 2.5 to 3 times by 2037-38, respectively

Source: Ministry of Environment, Forest & Climate Change, & Government of India. (2019, March). India Cooling Action Plan. Retrieved from http://ozonecell.nic.in/wp-content/uploads/2019/03/INDIA-COOLING-ACTION-PLAN-e-circulation-version080319.pdf

Need for Thermal Comfort



Present-day heat exposure risk

- Perceived luxury to a vital enabler of health, productivity & prosperity
- Worldwide, by 2030, extreme heat could lead to a $2 trillion loss in labour productivity. India's economy alone stands to lose $450 billion

Source: Kjellstrom, T. (2015). Impact of Climate Conditions on Occupational Health and Related Economic Losses. Asia Pacific Journal Of Public Health, 28(2_suppl), 28S-37S. https://doi.org/10.1177/1010539514568711

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Sustainable Developmental Goals (SDG)

- **SDG 3:** Health and Well Being
- **SDG 7:** Ensure access to affordable, reliable, sustainable, and modern energy for all
- **SDG 9:** Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation *(Industry-focused)*
- **SDG 11:** Make cities and human settlements inclusive, safe, resilient, and sustainable *(Building focused)*

Source: Sustainable Development Goals (SDG) Professional Certificate. Hertie School. Retrieved 12 April 2022, from https://www.hertie-school.org/en/who-we-are/global-public-policy-network/sdg-certificate

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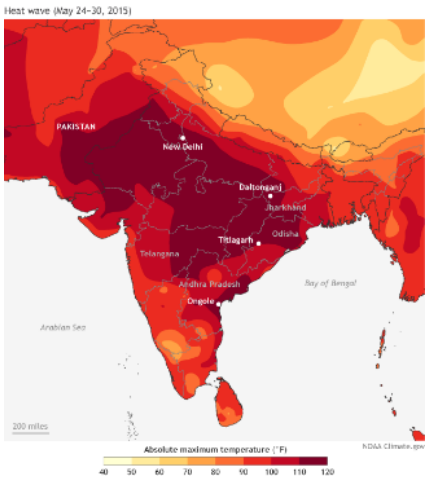
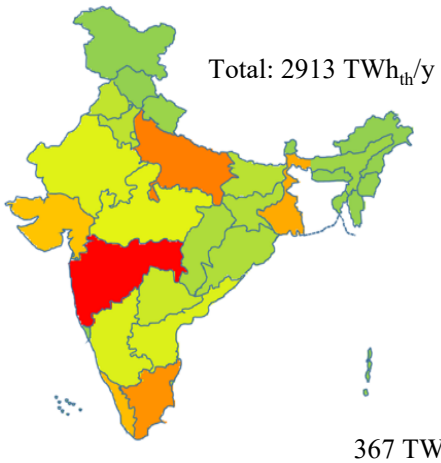
Extreme Climate Events: Heat waves



- 495,000 human deaths across the world in 1999–2020
- 12,000 extreme weather events led to losses worth USD 3.54 trillion (measured in terms of purchasing power parity or PPP)
- Housing needs to provide comfort over an extended period
- Less reliance on electro-mechanical systems
- Affordability to achieve comfort

Source: Climate.gov. (2015). India heat wave kills thousands [Image]. Retrieved 12 April 2022, from https://www.climate.gov/news-features/event-tracker/india-heat-wave-kills-thousands

Cooling Requirement Map of India 2050, Urban Residential



Source: IETP : Maithel, S., Chandiwala, S., Bhanware, P., Rawal, R., Kumar, S., Gupta, V., Jain, M. (2020, June). Developing cost-effective and low-carbon options to meet India's space cooling demand in urban residential buildings through 2050. India Energy Transformation Platform

Can we have a policy that can provide comfort and save energy?

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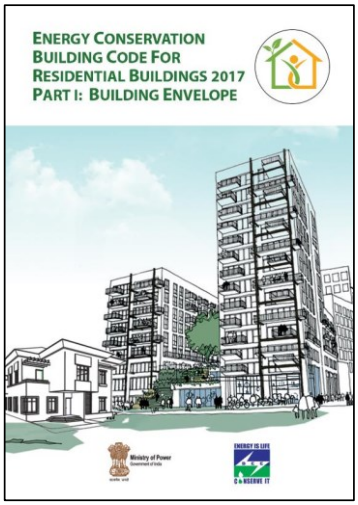
ECO NIWAS Samhita: ECBC Residential



PROVISIONS FOR BUILDING ENVELOPE

- Reduce Heat Gain/Loss
- Improve Natural Ventilation & Daylighting

Improved thermal comfort & reduced energy consumption

Source: Bureau of Energy Efficiency, Government of India, & Ministry of Power. (2018). Eco-Niwas Samhita- Part I: Building Envelope. Retrieved from https://www.beeindia.gov.in/sites/default/files/ECBC_BOOK_Web.pdf

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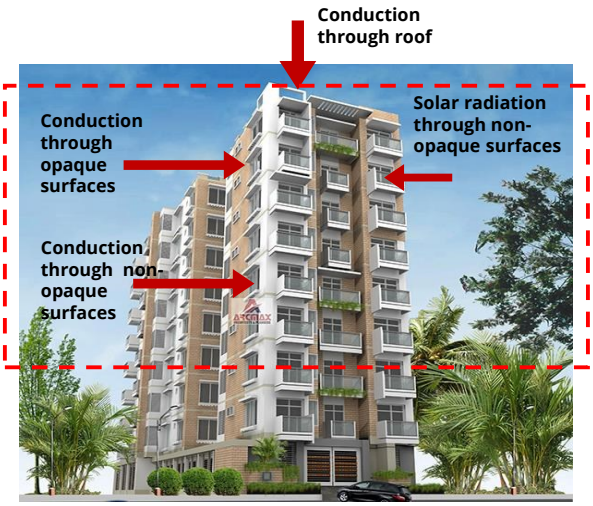
ECO NIWAS Samhita: ECBC Residential



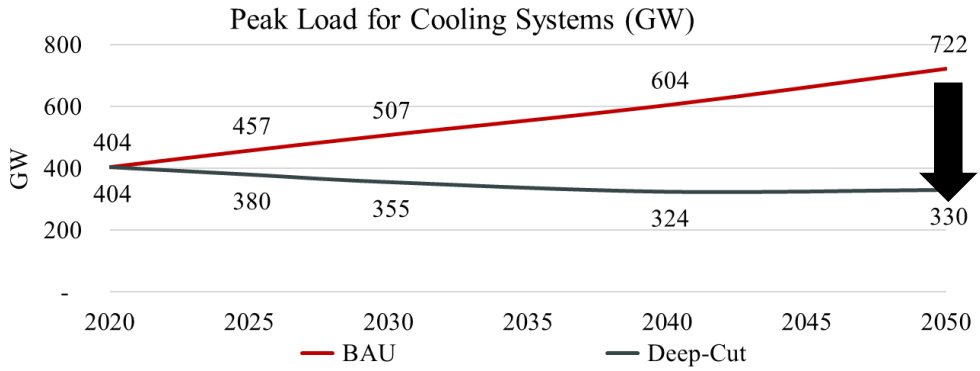
To limit the heat gain/loss from the building envelope, the code specifies:

The maximum value of thermal transmittance of roof (U_{roof}= 1.2 W/m^2.K) for all climate zones

The maximum value of Residential Envelope Transmittance Value (RETV) for the building envelope (except the roof)

Source: Bureau of Energy Efficiency, Government of India, & Ministry of Power. (2018). Eco-Niwas Samhita- Part I: Building Envelope. Retrieved from https://www.beeindia.gov.in/sites/default/files/ECBC_BOOK_Web.pdf

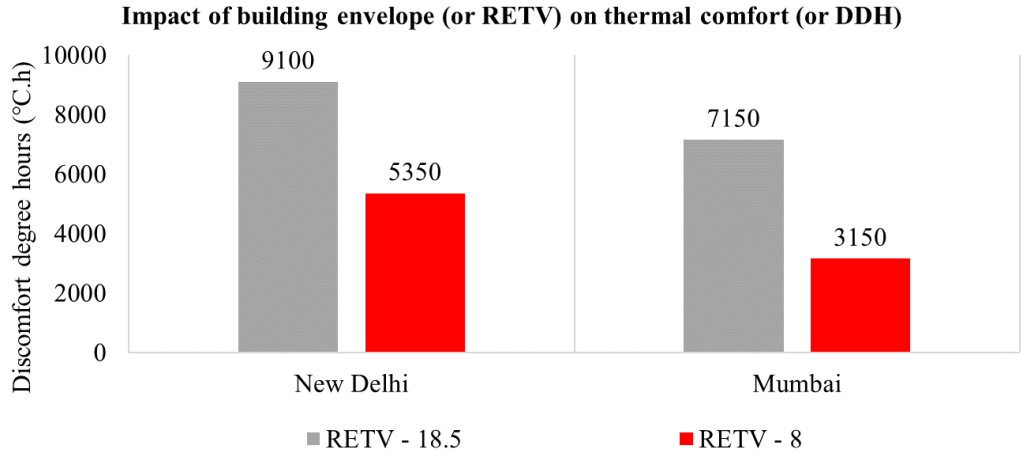
Peak Load for Cooling Systems (GW)



- 55 % Reduction.
- 391 GW of avoided power generation capacity addition or avoided investment of Rs.16,00,000 – 20,00,000 crores on power plants

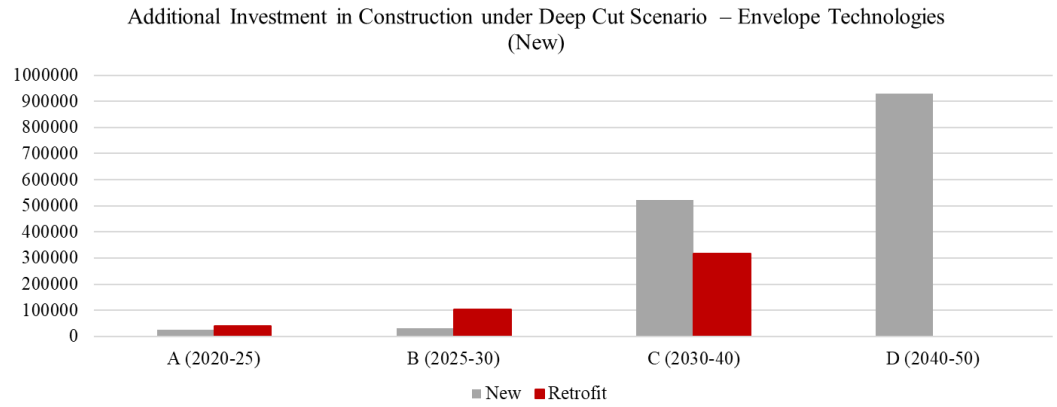
Source: Maithel, S., Chandiwala, S., Bhanware, P., Rawal, R., Kumar, S., Gupta, V., Jain, M. (2020, June). Developing cost-effective and low-carbon options to meet India's space cooling demand in urban residential buildings through 2050. India Energy Transformation Platform.

Impact of building envelope on thermal comfort



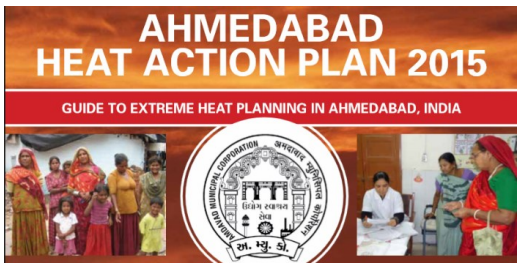
Source: Maithel, S., Chandiwala, S., Bhanware, P., Rawal, R., Kumar, S., Gupta, V., Jain, M. (2020, June). Developing cost-effective and low-carbon options to meet India's space cooling demand in urban residential buildings through 2050. India Energy Transformation Platform.

Additional Investment in Construction



The total additional investment (at current prices) for envelope improvements under the "deep cut scenario" is around Rs 20 lakh crore ≈ Rs 15-20 lakhs crore savings due to avoided power generation capacity

Extreme Climate Events: Heat Actions Plans



- Public Awareness and Community Outreach
  1. March – July
  2. Interpersonal Communication
  3. Social Media
  4. Widespread Awareness
- Early Warning System and Inter-Agency Coordination
  1. Forecasting by IMD
  2. Communication to Health Dept, Hospitals
  3. Disaster management & NGOs

Source: Ahmedabad Municipal Corporation. (2019). Ahmedabad Heat Action Plan. Retrieved from https://www.nrdc.org/sites/default/files/ahmedabad-heat-action-plan-2018.pdf

Extreme Climate Events: Heat Actions Plans

Alert Category	Alert Name	Temperature Threshold (°C)
RED ALERT	Extreme Heat Alert Day	≥ 45°C
ORANGE ALERT	Heat Alert Day	43.1°C – 44.9°C
YELLOW ALERT	Hot Day Advisory	41.1°C- 43°C
WHITE	No Alert	≤41°C

Phase 1: Pre-Heat Season (Annually from January through March)

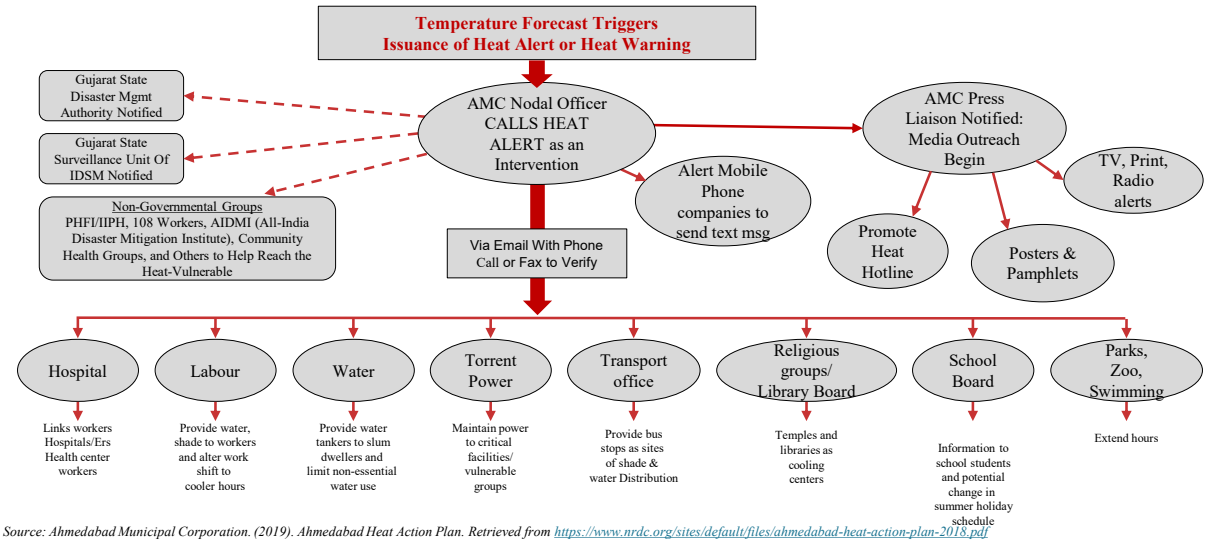
Phase 2: During the Heat Season (Annually from March through July)

Phase 3: Post-Heat Season (Annually in July through September)

- Capacity Building Among Health Care Professionals
  - Prevent and Manage
  - Reduce mortality and morbidity
  - Active additional Urban Health centres
- Reducing Heat Exposure and Promoting Adaptive Measures
  - Mapping of high-risk areas of the city
  - Increasing access to potable drinking water and shaded space

Source: Ahmedabad Municipal Corporation. (2019). Ahmedabad Heat Action Plan. Retrieved from https://www.nrdc.org/sites/default/files/ahmedabad-heat-action-plan-2018.pdf

Extreme Climate Events: Heat Actions Plans



Source: Ahmedabad Municipal Corporation. (2019). Ahmedabad Heat Action Plan. Retrieved from https://www.nrdc.org/sites/default/files/ahmedabad-heat-action-plan-2018.pdf

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Ministry of Housing and Urban Affairs Government of India
आज़ादी का अमृत महोत्सव
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Let us understand Thermal Comfort, Briefly

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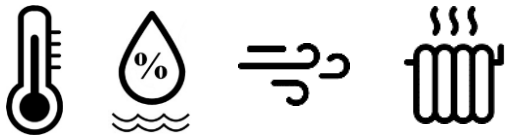
Factors Affecting Thermal Comfort



- **Environmental Factors**
- Air temperature, *°C*
- Relative Humidity, *%*
- Mean Radiant Temperature (MRT) *°C*
- Air Velocity, *meter/second*

- **Personal Factors**
- Activity (metabolic rate), *MET*
- Clothing, *Clo.*

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Factors Affecting Thermal Comfort: Others

Short term physiological adjustments | **Long term physiological adjustments**

- **Acclimatization**
- Short-term physiological adjustments
- Long-term endocrine adjustments
- **Body shape and fat**

Age | **Gender** | **Health and Wellbeing**

- **Age and gender**
- **Status of health**

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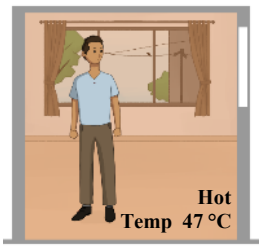
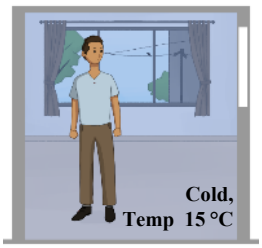
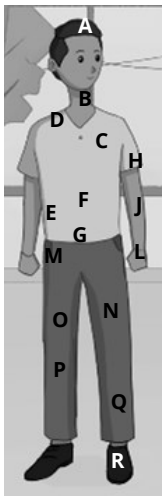
Thermal Comfort: Cold – Neutral - Warm



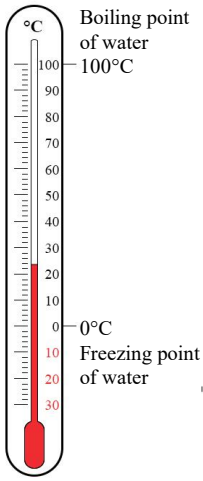


Air Temp 27 °C



Body Part	Skin Location	Cold (15 °C)	Neutral (27 °C)	Hot (47 °C)
A	Forehead	31.7	35.2	37
B	Back of Neck	31.2	35.1	36.1
C	Chest	30.1	34.4	35.8
D	Upper Back	30.7	34.4	36.3
E	Lower Back	29.2	33.7	36.6
F	Upper Abdomen	29	33.8	35.7
G	Lower Abdomen	29.2	34.8	36.2
H	Tricep	28	33.2	36.6
J	Forearm	26.9	34	37
L	Hand	23.7	33.8	36.7
M	Hip	26.5	32.2	36.8
N	Side thigh	27.3	33	36.5
O	Front thigh	29.4	33.7	36.7
P	Back thigh	25.5	32.2	36
Q	Calf	25.1	31.6	35.9
R	Foot	23.2	30.4	36.2

Factors Affecting Thermal Comfort: Air Temperature

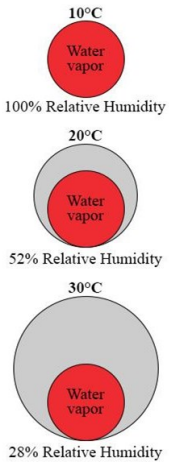


Boiling point of water 100°C

0°C Freezing point of water

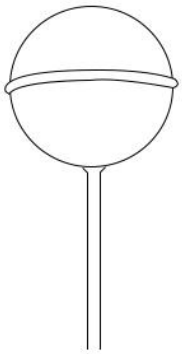
- Temperature of the air surrounding the body (Dry Bulb Temperature) – DBT)
- Temperature of air measured by a thermometer freely exposed to the air, but shielded from radiation and moisture.
- Degrees Celsius (°C)

Factors Affecting Thermal Comfort: Relative Humidity



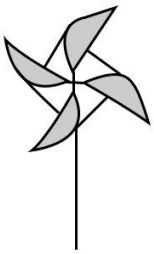
- Moisture Content of the air
- The amount of moisture in the air depends upon
- Air Pressure
- Air Temperature
- Percentage (%)

Factors Affecting Thermal Comfort: Mean Radiant Temperature



- Uniform temperature of an imaginary enclosure
- Measure of the effect of Radiant interchanges at a point in space
- Calculated using (T_g), (T_a) and air velocity

Factors Affecting Thermal Comfort: Air Speed



- Air Speed is the rate of air movement at a point, without regard to direction
- Average air speed, height and directions
- Calculated using (T_g), (T_a) and air velocity
- Meter per second (m/s)

Factors Affecting Thermal Comfort: Clothing Value

- The resistance to sensible heat transfer provided by clothing ensemble
- Clothing Insulation Value (clo - I_{cl})
- Impact of furniture such as chair and beddings

Factors Affecting Thermal Comfort: Metabolic Rates

- The rate at which metabolism occurs in a living organism.
- Rate of energy expenditure per unit time
- Average adult 1.8 square meter
- Energy per unit areas, watts per square meter (W/m^2)

Recap

- India Cooling Action Plan
- Sustainable Development Goal
- Comfort Parameters
- Envelop attributes for the comfort

Source: freepik. (2021). Digital News. Retrieved April 13, 2022, from https://www.freepik.com/photos/digital-news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GLOBAL HOUSING TECHNOLOGY CHALLENGE INDIA
Ministry of Housing and Urban Affairs
Government of India
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RACHNA
RESILIENT, AFFORDABLE AND COMFORTABLE HOUSING THROUGH NATIONAL ACTION

Session 9(Technical): Building Codes, Affordable Housing, and Thermal Comfort

10h15, April 21, 2022

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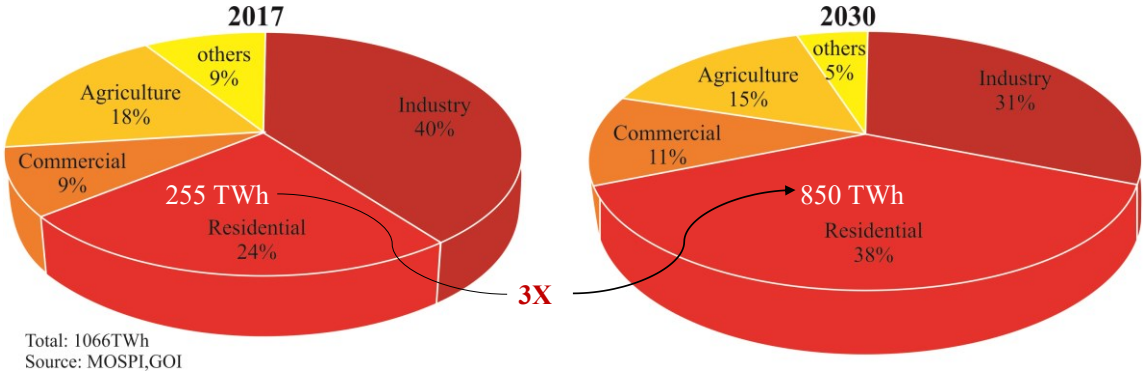
1

Energy Consumption in Residential Buildings



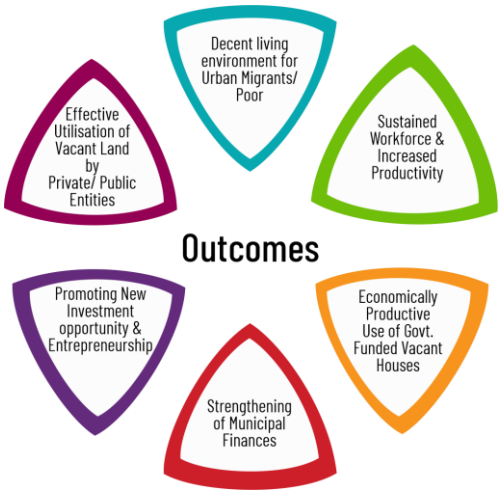
Total: 1066TWh
Source: MOSPI,GOI

Residential building stock more than doubles in the next 15-20 years.

Largest end-user of electricity , 38% of the total electricity consumption.

2

Affordable Housing Programme in India



- 115.44 Units sanctioned
- 56.35 Units Completed
- Carpet Area 30-45 Sq.mt
- Multi Family Buildings

Pradhan Mantri Awas Yojana - Urban (PMAY-U)
Affordable Rental Housing Complexes (ARHCs)

Affordable Housing Programme in India

GLOBAL HOUSING TECHNOLOGY CHALLENGE INDIA

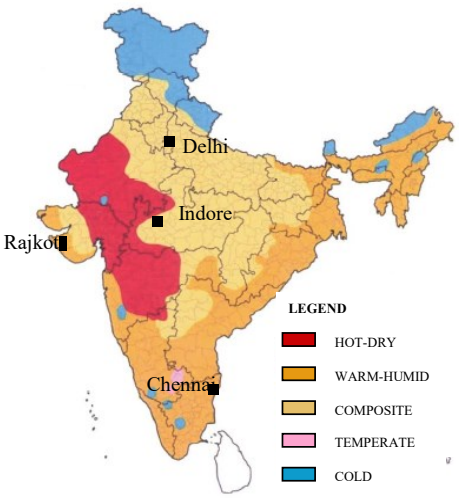
Global Housing Technology Challenge - India (GHTC-India)

- Construction Technology India Biennial Expo-cum-Conference
- Iidentifying and Mainstreaming Proven Demonstrable Technologies for the Construction of **Light House Projects**, Rajkot, Lucknow, Indore, Ranchi, Agartala, Chennai
- Identifying Potential Future Technologies for Incubation and Acceleration Support through **ASHA - India** (Affordable Sustainable Housing Accelerators)

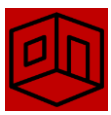
The context for the code

5

Context: Affordable Housing



During Peak Summer Period:



36.5 - 42°C.

Peak inside room temperature (operative temperature/ air temperature) can reach anywhere between **36.5 °C and 42 °C**

30 - 35 °C

Peak indoor temperatures can be reduced to ~ **30 - 35 °C** by design strategies:

- Reducing heat ingress
- Utilizing natural ventilation,

Source: Bansal, N. K., & Minke, G. (1995). Climatic Zones and rural housing in India: German-Indian-cooperation in scientific research and Technological Development. Forschungszentrum Jülich GmbH, Zentralbibliothek. K

6

Standards, Guidelines, Codes, Laws, Rules.

Technical Specifications, Conditions, and Performance defined	**Standards**
Voluntary in nature based on standards, best practices, or empirical evidence	**Guidelines**
Set of guidelines referring to standards - aspirational	**Codes**
The successor of Codes, Under an act of law, codes become law	**Laws**
A subset of Laws with penalty and enforcement mechanisms defined	**Rules**

Types of Building Energy Codes

A set of rules to regulate the activities across the region

- **Prescriptive codes**
- **Trade-off codes**
- **Performance codes**
- **Outcome-based codes**

Source: freepik. (n.d.). Pencil Ruler. freepik. Retrieved from https://www.freepik.com/free-photos-vectors/pencil-ruler

Types of Building Energy Codes

Specify requirements for key elements such as wall and ceiling insulation, windows and doors, roofs, etc.

Prescriptive codes

Trade-off codes

Performance codes

Outcome-based codes

Source: Patients rising now. (2020). Insurance companies are forcing patients to get prescriptions by mail. Patients rising now. Retrieved from https://patientsrisingnow.org/mail-order-prescriptions-risk-insurance/

9

Types of Building Energy Codes

Typically allow for trade-offs between similar building components – exchange between performance values.

Prescriptive codes

Trade-off codes

Performance codes

Outcome-based codes

Source: PNG Mart. (2018). Balance Transparent Background. PNG Mart. Retrieved from https://www.pngmart.com/image/117277

10

Types of Building Energy Codes

Specify a minimum required level of energy consumption or intensity for the whole building, high flexibility of design, - to be equated against the baseline

Prescriptive codes

Trade-off codes

Performance codes

Outcome-based codes

Source: Nice PNG. (n.d.). Performance Indicator. Nice PNG. Retrieved from https://www.nicepng.com/ourpic/u2w7e6y3e6r5o0e6_computer-icons-performance-indicator-drawing-benchmarking-performance-png/

Types of Building Energy Codes

Requires demonstration of buildings achieving code required performance, in operation

Prescriptive codes

Trade-off codes

Performance codes

Outcome-based codes

Source: freepik. (n.d.). Progress Vectors. freepik. Retrieved from https://www.freepik.com/vectors/progress

Types of Building Energy Codes

- **Prescriptive codes**
- **Trade-off codes**
- **Performance codes**
- **Outcome-based codes**

ECBC – R
Eco Niwas Samhita – 1

Eco Niwas Samhita - 2

ECBC 2017
ECBC
ECBC+
Super ECBC

13

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Eco Niwas Samhita

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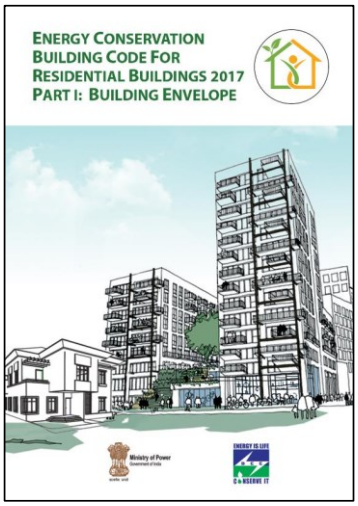
Eco Niwas Samhita (ENS, ECBC – Residential) (Part 1 Building Envelope)



PROVISIONS FOR BUILDING ENVELOPE

Reduce Heat Gain/Loss
Improve Natural Ventilation & Daylighting

Improved thermal comfort & reduced energy consumption

Source: Bureau of Energy Efficiency, Government of India, & Ministry of Power. (2018). Eco-Niwas Samhita- Part I: Building Envelope. Retrieved from https://www.beeindia.gov.in/sites/default/files/ECBC_BOOK_Web.pdf

Overview of Code Provisions

- Code Provisions
  - I. Heat gain
    - Maximum Residential Envelope Transmittance Value (RETV) for Envelope (excluding roof)*
    - Maximum U-value for Roof
  - II. Natural Ventilation
    - Minimum openable Window-to-Floor area Ratio
  - III. Daylight
    - Minimum Visible Light Transmittance w.r.t. Window-to-Wall Ratio

*** The RETV provisions are for all climate zones except Cold.**

Code Provision: Heat Gain

Reducing Heat Gain:

Maximum RETV for building envelope (except roof)

$RETV \leq 15\ W/m^2$

For all climate zones except Cold

Roofing material's maximum thermal transmittance value (for all climate zones)

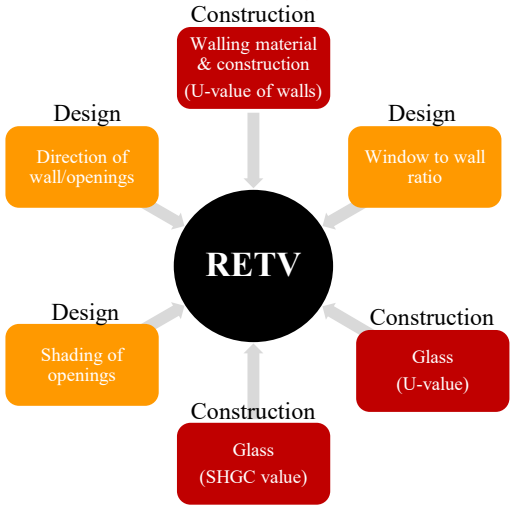
$U_{roof} \leq 1.2\ W/m^2K$

Source: Bureau of Energy Efficiency, Government of India, & Ministry of Power. (2018). Eco-Niwas Samhita- Part I: Building Envelope. Retrieved from https://www.beeindia.gov.in/sites/default/files/ECBC_BOOK_Web.pdf

Residential Envelope Transmittance Value (RETV)

The net heat gain rate (over the cooling period) through the building envelope, walls, and windows (excluding the roof) divided by the area of the building envelope (excluding the roof), is measured in W/m^2.

RETV: Influencing Factors, Design and Construction



The net heat gain rate (over the cooling period)

through the building envelope (excluding the roof)

divided by the area of the building envelope (excluding the roof), measured in W/m^2.

Source: Bureau of Energy Efficiency, Government of India, & Ministry of Power. (2018). Eco-Niwas Samhita- Part I: Building Envelope. Retrieved from https://www.beeindia.gov.in/sites/default/files/ECBC_BOOK_Web.pdf

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Observations and Calculations

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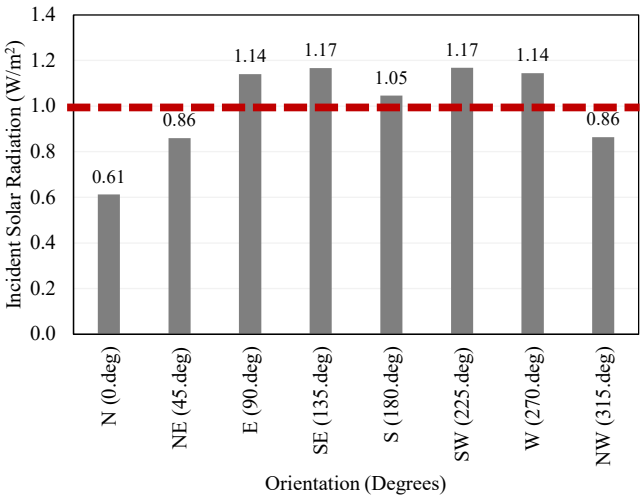
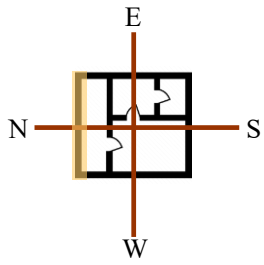
Design Decision : Orientation Factor

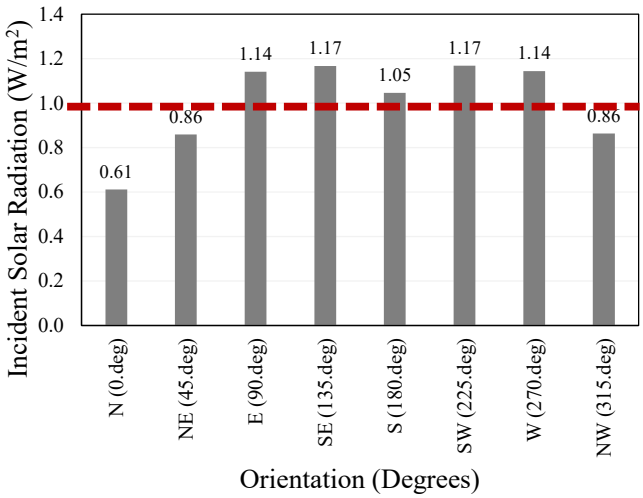


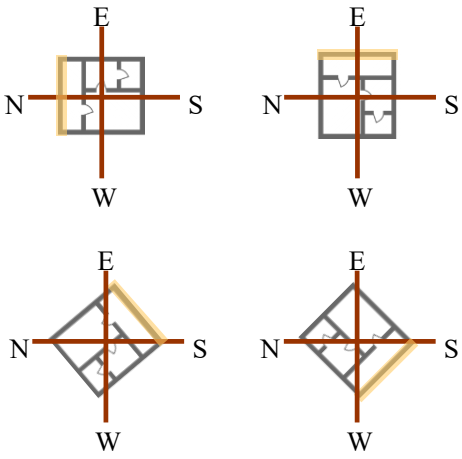
Accounts for variation in incident solar radiation falling on walls with different orientations.



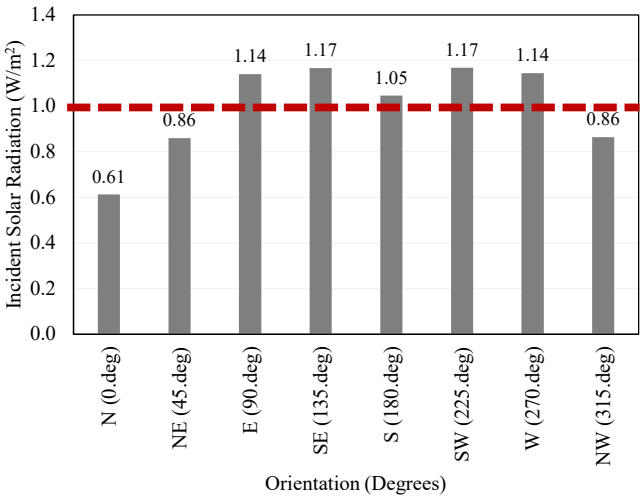
Highlighted wall is facing the North ⇒ Highlighted wall is oriented towards North

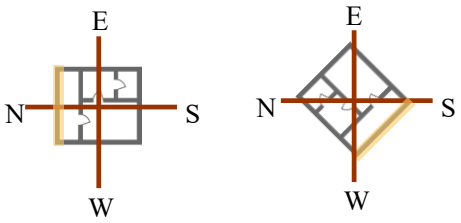
Design Decision : Orientation Factor





Design Decision : Orientation Factor





Solar radiation falling on 'South-West' orientation is almost Double as compared to 'North' orientation.

Worst orientations must be treated first.

RETV: Formula and Calculations

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

a, b, c: coefficients, based on climatic zone

$A_{envelope}$: envelope area (excluding roof) of dwelling units (m²)

A_{opaque_i}: areas of wall / opaque part (m²)

U_{opaque_i}: thermal transmittance values of wall / opaque part (W/m².K)

$A_{non-opaque_i}$: areas of glass / non-opaque part (m²)

$U_{non-opaque_i}$: thermal transmittance values of glass / non-opaque part (W/m².K)

$SHGC_{eq_i}$: equivalent solar heat gain coefficient values of glass / non-opaque part

ω_i: orientation factor

RETV: Formula and Calculations

$$RETV = \frac{1}{A_{envelope}}$$ *Area of Envelop*

a, b, c: coefficients, based on climatic zone

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ω_i: orientation factor

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RETV: Formula and Calculations

$$RETV = \frac{1}{A_{envelope}} \times \left[\left\{a \times \sum_{i=1}^{n}\left(A_{opaque_i} \times U_{opaque_i} \times \omega_i\right)\right\}\right]$$

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RETV: Formula and Calculations

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ω_i: orientation factor

RETV: Climate-specific Coefficients

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

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	-	-	-

RETV: Climate-specific Coefficients

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

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Warm-Humid	5.15	1.31	65.21
Temperate	3.38	0.37	63.69
Cold	-	-	-

Code Provisions: Natural Ventilation

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

$$WFR_{op} = \frac{A_{openable}}{A_{built-up}}$$

Climate Zone	**Minimum WFR_{op} %**
Composite	12.5
Hot-Dry	10.0
Warm-Humid	16.6
Temperate	12.5
Cold	8.3

RETV: Calculation Methodology Case study

Sample Project: Overview

Block Information

- Total blocks: 32
- E-W oriented: 12
- N-S oriented 8
- NE-SW oriented:12

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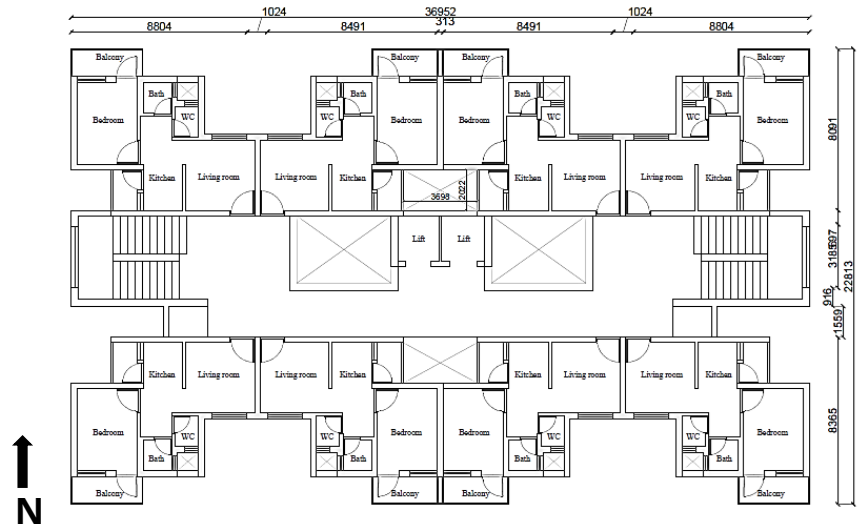
Sample Project: Block Layout

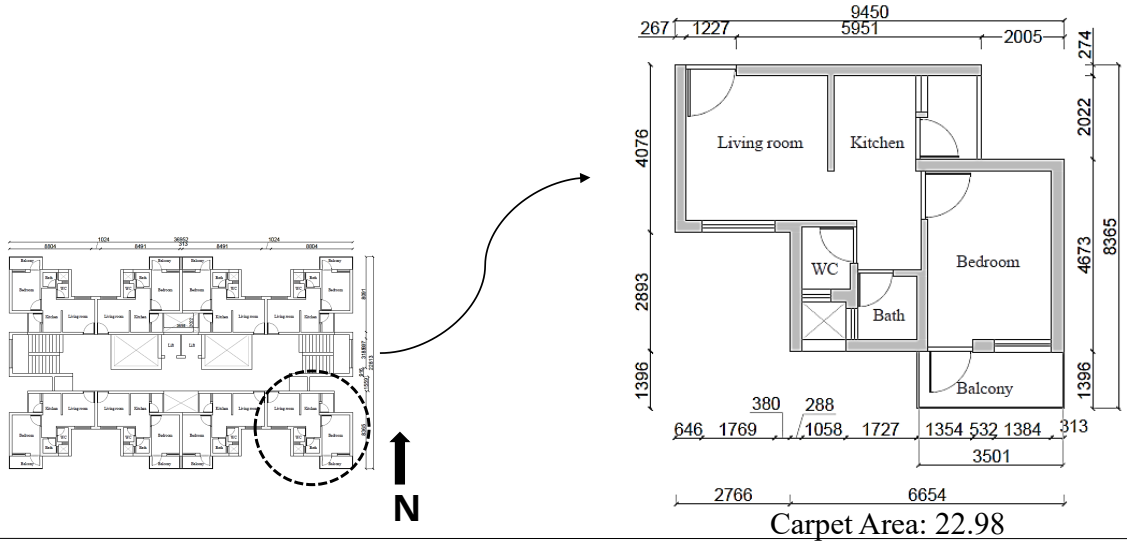


P+G+14

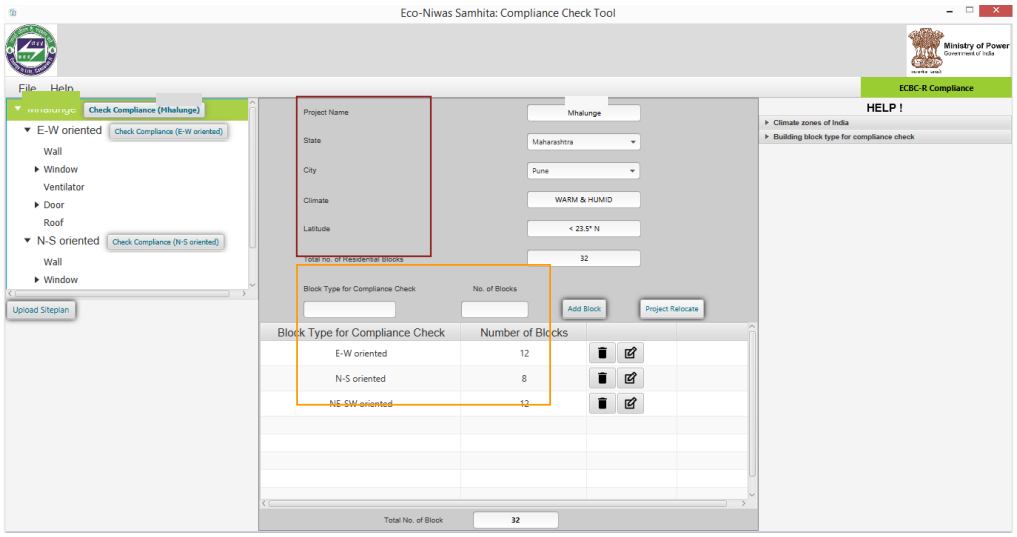
Parking
+
Ground
+
14 Floors

34

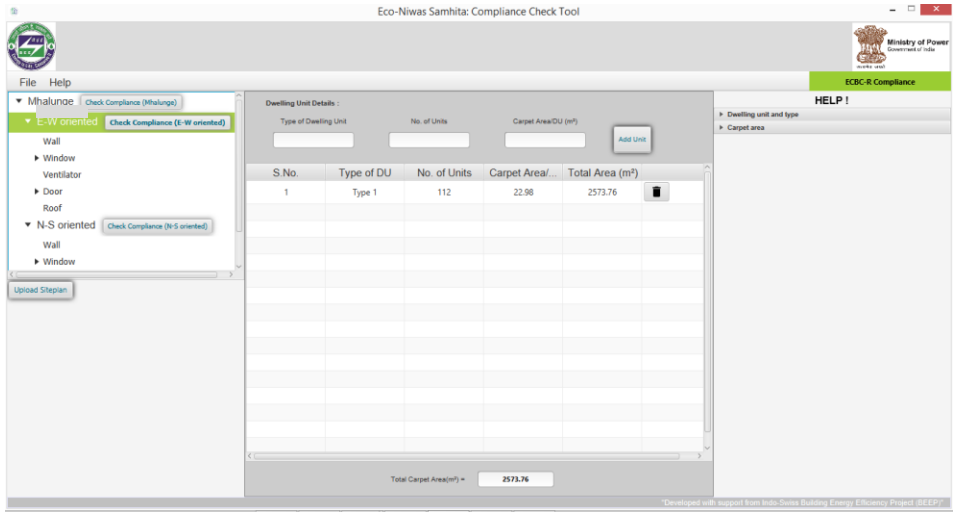
Sample Project: Unit Plan



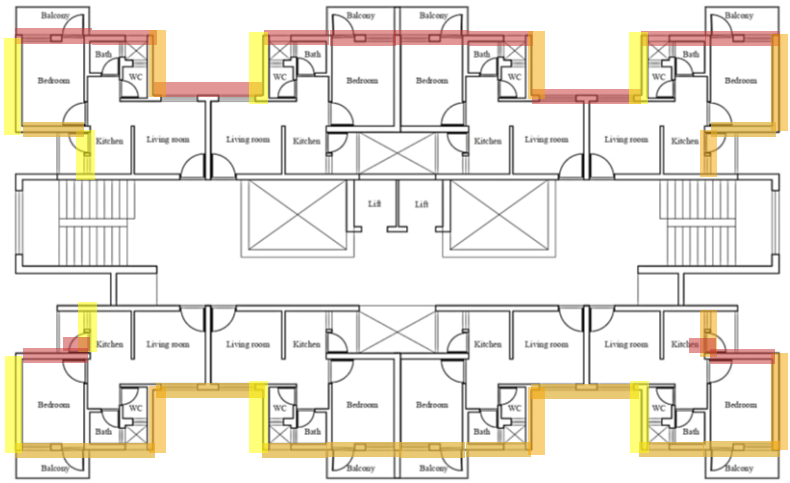
ENS Tool: Entering details



Dwelling Unit Details



Wall Construction details



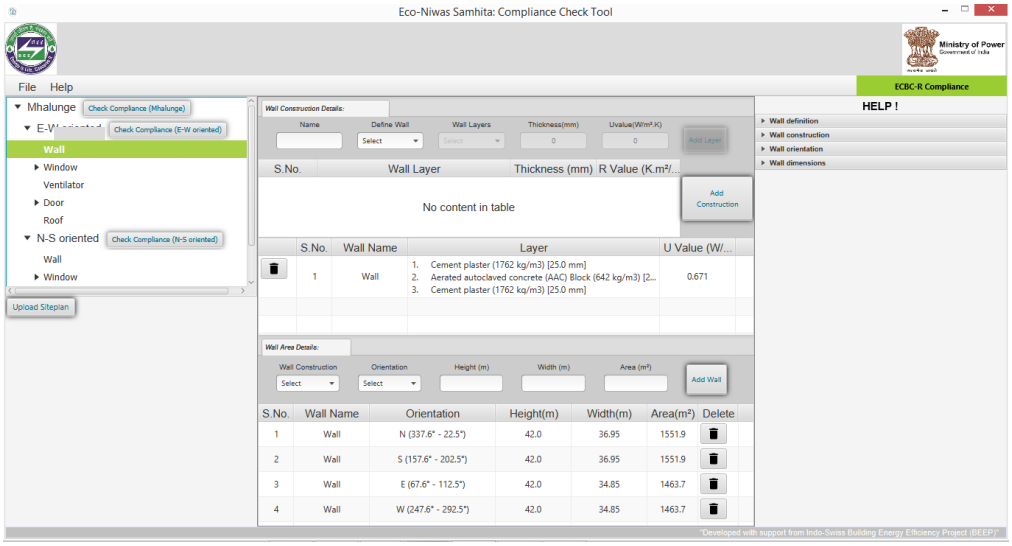
Legend

- E
- W
- S
- N

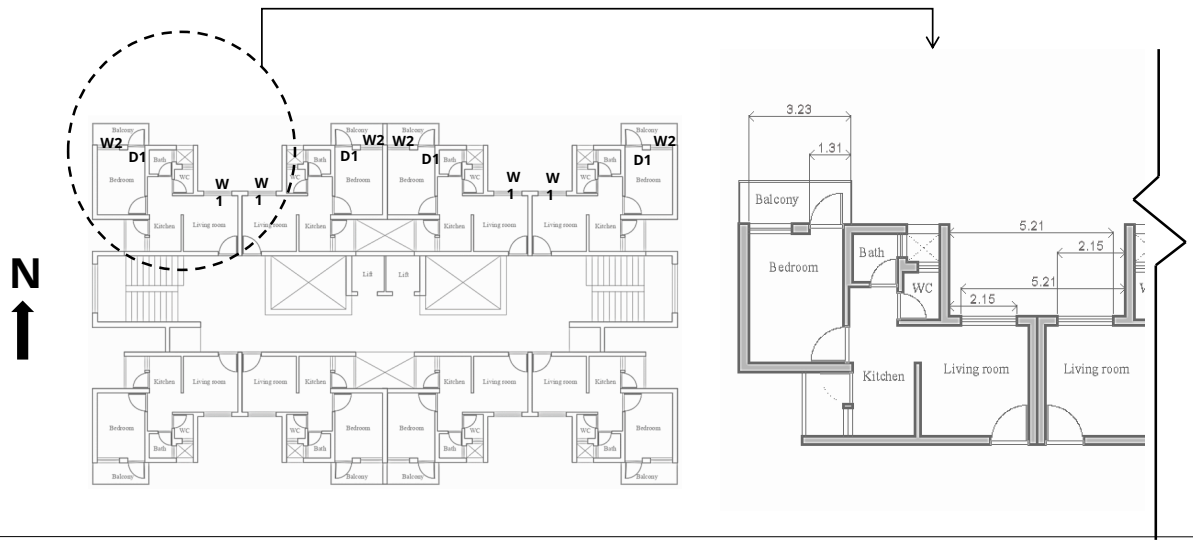
Construction:

- Outer: 25mm Cement plaster
- Layer 1: 200mm AAC block
- Inner: 25mm Cement plaster

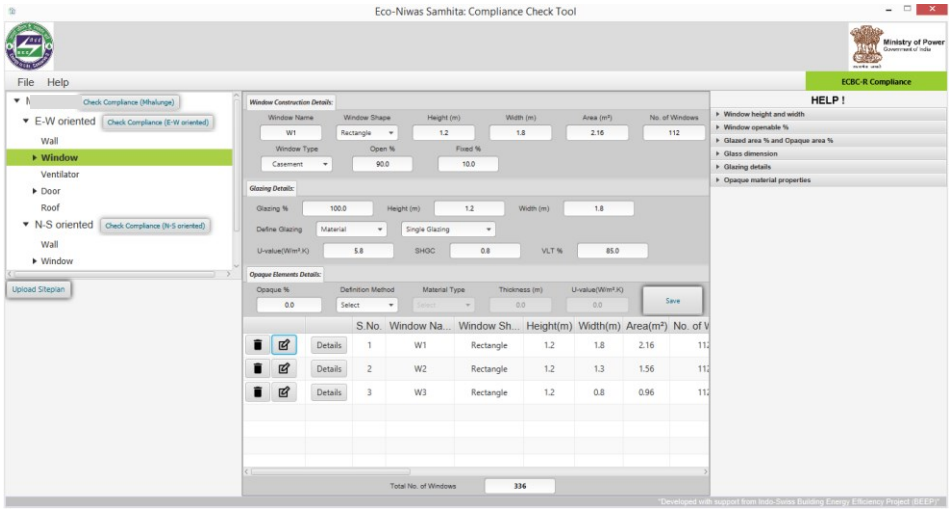
Wall Construction details



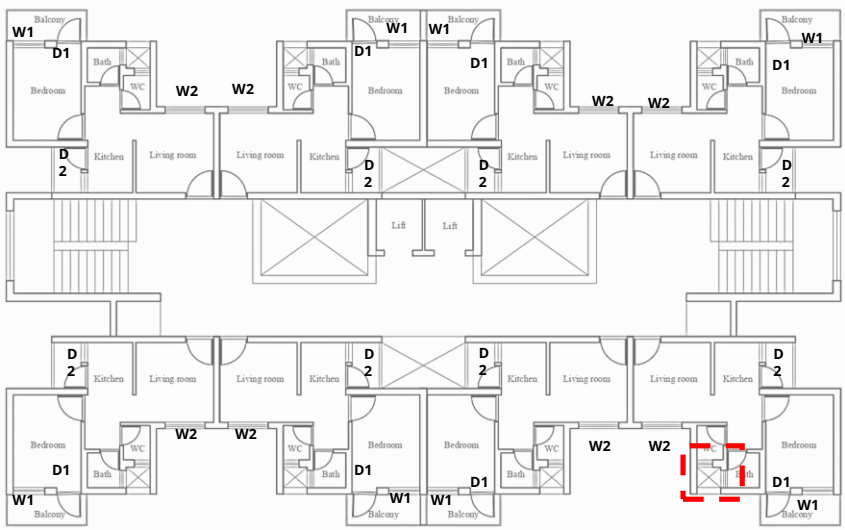
Window Construction details



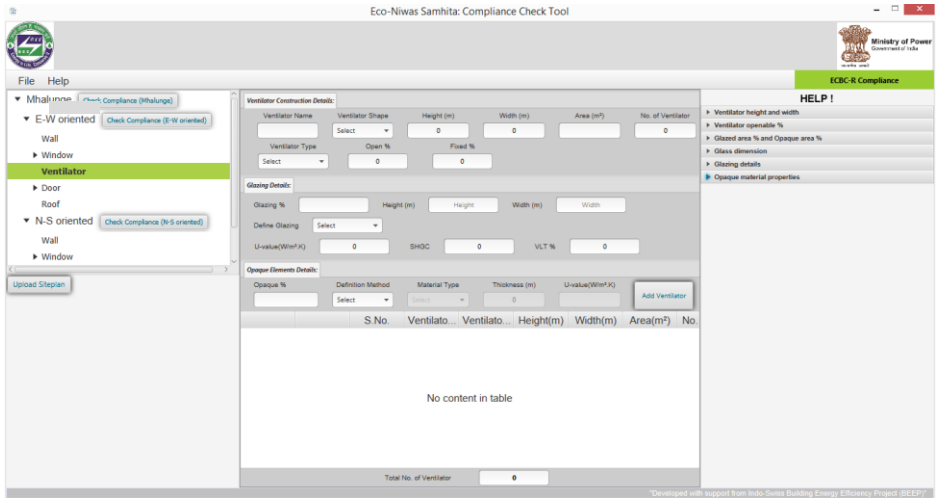
Window Construction details



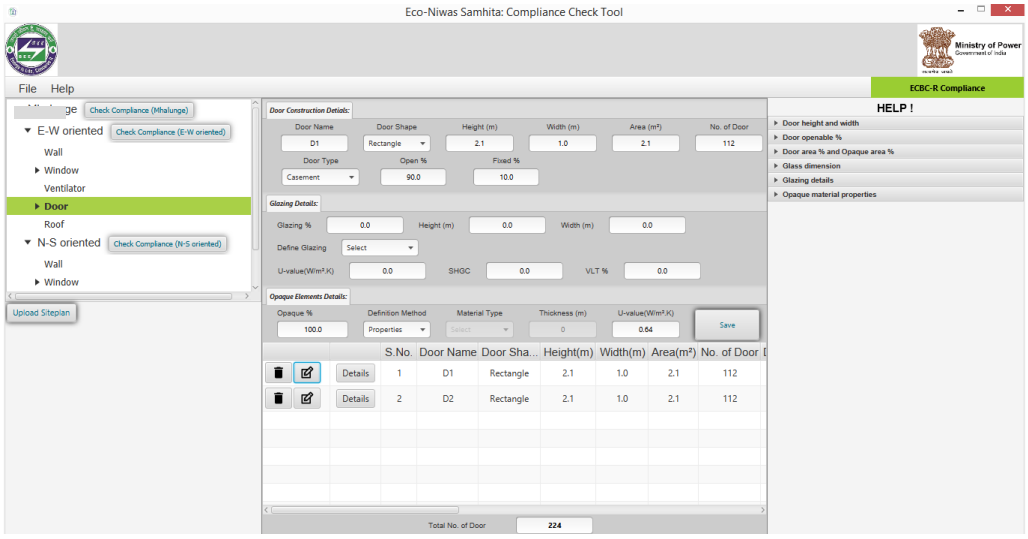
Ventilator details



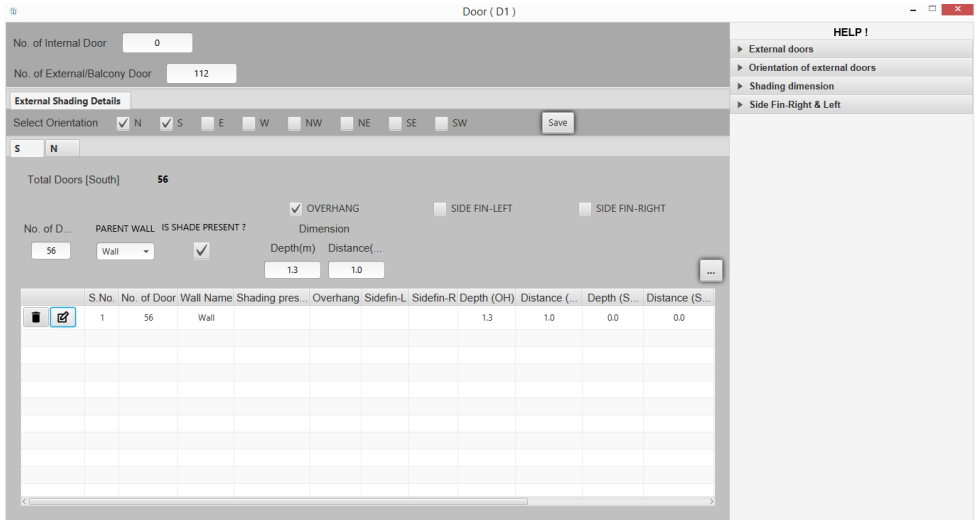
Ventilator details



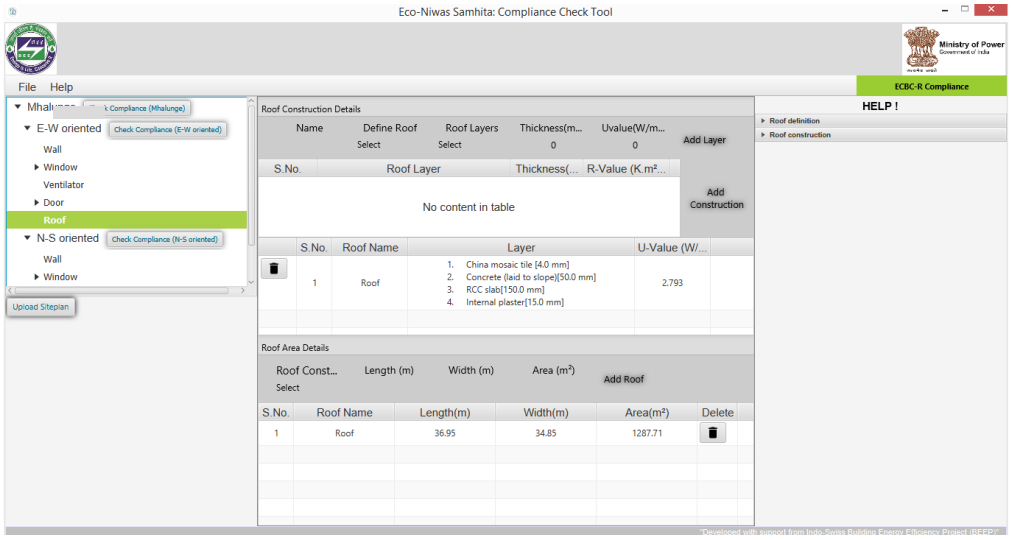
Door details



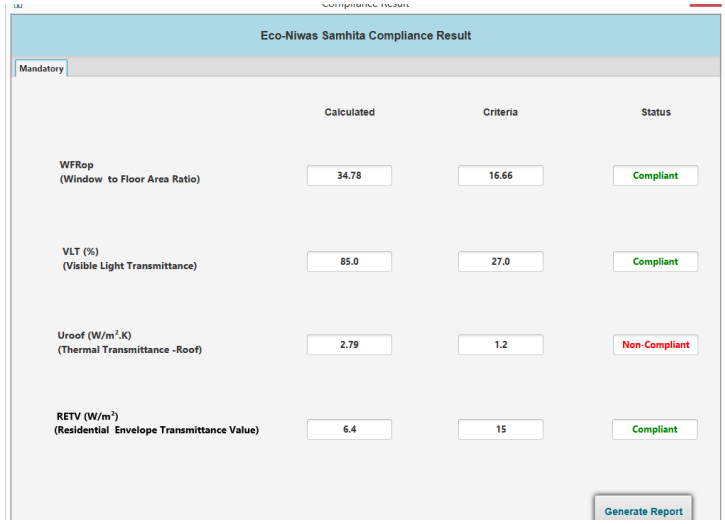
Door details



Roof construction details



Compliance result



Eco-Niwas Samhita Compliance Result

Mandatory

	Calculated	Criteria	Status
WFRop (Window to Floor Area Ratio)	34.78	16.66	Compliant
VLT (%) (Visible Light Transmittance)	85.0	27.0	Compliant
Uroof (W/m².K) (Thermal Transmittance -Roof)	2.79	1.2	Non-Compliant
RETV (W/m²) (Residential Envelope Transmittance Value)	6.4	15	Compliant

Generate Report

प्रधान मंत्री आवास योजना-शहरी Pradhan Mantri Awas Yojana-Urban | GLOBAL HOUSING TECHNOLOGY CHALLENGE INDIA | Ministry of Housing and Urban Affairs Government of India | आज़ादी का अमृत महोत्सव | bmtpc | giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

Thank You

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