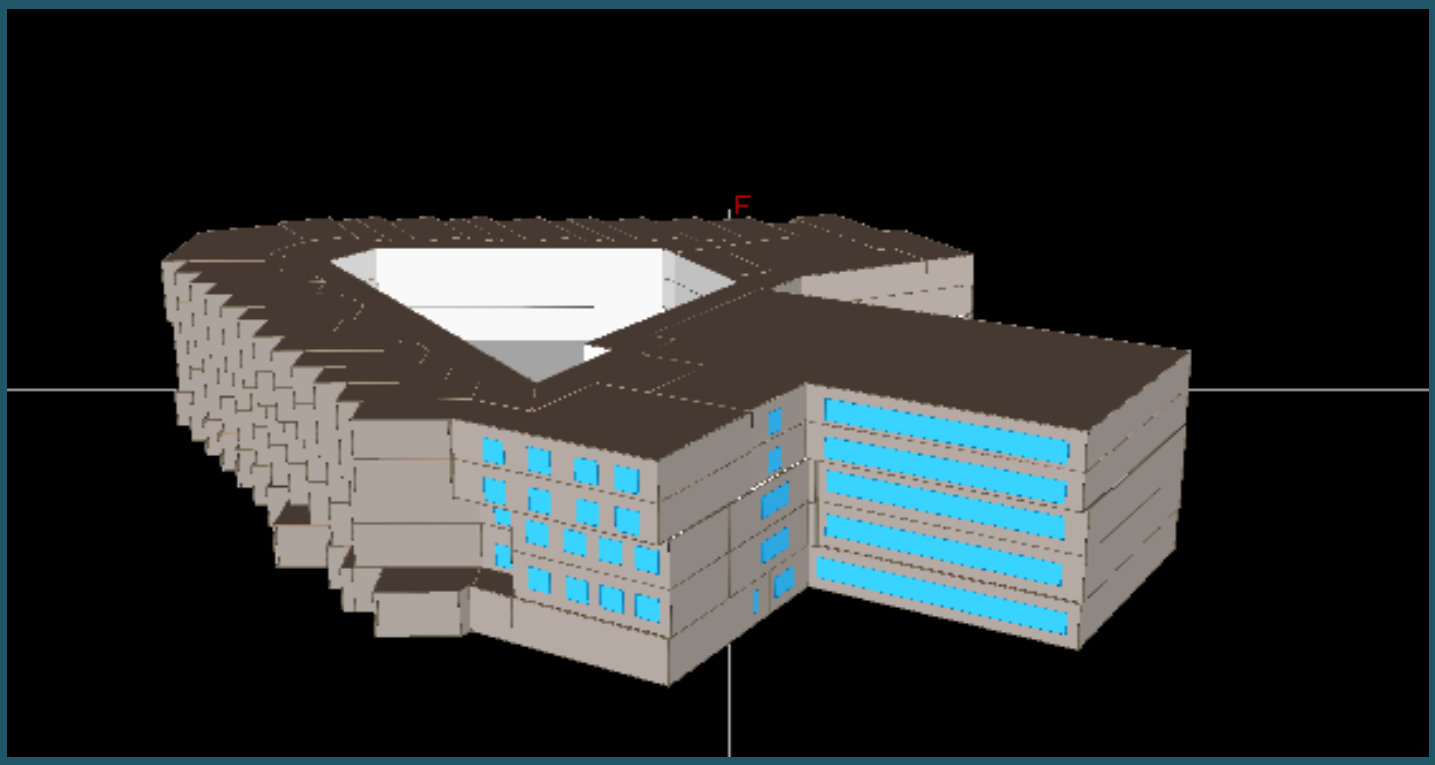
ECBC COMPLIANCE REPORT FOR NEW PWD REST HOUSE KARNAL

Towards Compliance of

Energy Conservation Building Code- 2017



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List of Abbreviations

- BEE- Bureau of Energy Efficiency
- ECBC– Energy Conservation Building Code
- EPI– Energy Performance Index
- HVAC- Heating Ventilation & Air Conditioning
- SRI- Solar Reflectance Index
- SHGC– Solar Heat Gain Coefficient
- SC– Shading Coefficient
- VLT– Visible Light Transmittance
- DGU– Double Glazing Unit
- DG– Diesel Generator
- kWh– Kilo-Watt-Hours
- kW– Kilo-Watt
- LED- Light Emitting Diodes
- LPD- Lighting Power Density
- PF– Power Factor
- UPS- Uninterruptible Power Supply
- VRF– Variable Refrigerant Flow
- AHU– Air Handling Unit
- VAV- Variable Air Volume
- WWR– Window to Wall Ratio
- COP– Coefficient of Performance

Summary

Input Parameter	Baseline	Proposed	Units
Wall material	As per ECBC	20mm External high SRI Tiles + 200mm External AAC Block + 40mm Cavity + 100 mm Internal Fly Ash Brick + 15mm Internal Plaster	
Wall U-value	0.0704	0.162	Btu/hr sqft F
Roof material	As per ECBC	20mm high SRI tiles + 125mm RCC + 50mm XPS Insulation + 5 mm Waterproofing membrane + 100 mm Green roof (optional)	
Roof U-value	0.058	0.090	Btu/hr sqft F
Glazing U Value	0.53	0.88	Btu/hr sqft F
SHGC	0.27	0.27	
Window Shading	No	As per Architectural Drawings	
Cooling Sizing Ratio	1.15	1	
Heating Sizing Ratio	1.25	1	
HVAC System	VRV with DOAS sys	VRV with DOAS sys	
HVAC System Efficiency (EER)	3.02	3.5	
Lighting Power Density calculation (As per space function method- ECBC§6.3.2)			
Internal	0.91	0.71	W/ ft^2
External	0.79	0.88	W/ ft^2
Zone Cooling set point	75	75	Deg F
Zone Heating set point	70	70	Deg F

Description	Energy Consumption/Generation
Proposed case energy consumption (kWh)	**8,91,460**
Base case energy consumption (kWh)	**9,67,500**
Savings%	**7.85%**
Base case EPI (kWh/Sq.m./Annum)	**97.9**
Proposed case EPI (kWh/Sq.m./Annum)	**90.2**
EPI ratio	**0.92**

1. Overview of ECBC

The Energy Conservation Building Code (ECBC) was introduced by the Bureau of Energy Efficiency (BEE) in 2007 to establish minimum energy performance standards for commercial buildings in India. In2017, BEE released an updated version, ECBC 2017, which introduced more stringent and comprehensive standards to meet modern energy efficiency requirements and global sustainability goals. The2017version included revised thermal performance requirements for walls, roofs, and windows; lighting system, including daylighting, and lamps and luminaire performance requirements; HVAC system, including energy performance of chillers and air distribution systems; Electrical& renewable energy system; and Water heating and pumping systems, including requirements for solar hot-water systems.

ECBC2017standards are divided into three categories: ECBC, ECBC+, and Super ECBC. ECBC compliance is mandatory for all commercial buildings, including hospitality, education, healthcare, shopping complexes, business, and assembly buildings, that exceed a specified energy consumption threshold. Buildings compliant with ECBC can save approximately 25% of annual energy consumption compared to conventional buildings in the same climate zone.

ECBC+ and Super ECBC go beyond the minimum standards of ECBC, allowing buildings to achieve greater energy savings. By implementing the prescribed design parameters for ECBC+ and Super ECBC, energy savings can increase from 25% to 50% compared to conventional buildings in the same climate zone.

As per ECBC 2017, the project is classified under the "Retail Building" category of Commercial buildings. Energy simulation models analysed that New Rest House Karnal building could achieve significant energy savings by meeting the desired EPI ratio in accordance with the ECBC-2017 compliance guidelines.

Integration with other ratings compliance mechanisms

Complementing the efforts of the Government of India, the ECBC has been integrated in other rating & compliance systems being followed in the country such as EIA (Environmental Impact Assessment) for large area development under MoEF (Ministry of Environment& Forest), Green Rating for Integrated Habitat Assessment (GRIHA) rating system, USGBC LEED rating system, the Indian Green Building Council (IGBC) rating systems and ASSOCHAM's GEM rating system.

Mandatory requirement

The code mandates that the criterion be followed verbatim. These criteria are mandatory, as the name suggests. The criterion has been laid down to impose minimum standards of compliance in any compliant building.

Prescriptive requirement

The prescriptive requirements are in addition to the mandatory requirements. These requirements are in the form of efficiencies for equipment, U-value for envelope parameters etc. The same may be followed as is, as per the guideline laid down by ECBC. Alternatively, a trade off method is available, as detailed below.

Whole building simulation approach

The whole building simulation software performs hourly simulation in approved software and derives the estimated energy consumption for a given building. Energy conservation measures may be applied in addition to them mandatory requirement to achieve an improved performance over ECBC baseline. This method gives the necessary flexibility to the owner over the prescriptive requirement and enables the possibility of a tradeoff in efficiency for different building elements.

Climate

As per ECBC 2017 Section 4.3, Karnal falls under the Composite Climate Zone, and the building envelope parameters for this zone are designed to minimize heat gain and enhance energy efficiency, given the region's respective temperatures and humidity. In this climate zone, the envelope should be designed with high thermal mass materials that absorb heat during the day and release it during the cooler night, thereby reducing cooling loads.

Technical software

The building was analyzed in eQUEST version 3.65.7173. It is a building energyanalysissoftwaredesignedanddevelopedbyDOE2(Copyright James J. Hirsch). eQuest uses the DOE-2.2 Building energy simulation engine. It has the ability to explicitly model all the following:

Figure 1 eQuest

- 8,760 hours per year.
- Hourly variations in occupancy, lighting power, miscellaneous equipment power, thermostat set points, and HVAC system operation, defined separately for each day of the week and holidays
- Part-load performance curves for mechanical equipment
- Capacity and efficiency correction curves for mechanical heating and cooling equipment.

Procedure for whole-building simulation

Project has decided to go through whole building performance approach for ECBC compliance. As per ECBC requirement, both mandatory and whole building performance requirement shall be necessary to comply with the code. Therefore, the project team has studied the whole ECBC requirement categorized in building envelopes, HVAC, service hot water& pumping lighting& electrical system. The model is simulated using the appropriate weather file for the project's location.

In accordance with ECBC guidelines, the baseline model is simulated for four orientations 0°, 90°, 180°, and 270° based on parametric runs. The final energy consumption is determined by taking the average of these parametric runs. After conducting the simulation, the Energy Performance Ratio (the ratio of the Proposed EPI to the Standard Case EPI, equivalent to the ECBC benchmark) was calculated to determine the minimum performance requirements as per the ECBC 2017 guidelines

Weather File

The building is to be constructed at Karnal, Haryana which comes under composite climate zone. Envelope parameters for Baseline model have been selected as per the composite climate zone. Weather file **(IND_Hisar.421310_ISHRAE.BIN)** used for simulation for the Project. The same weather file has been used for both Baseline and Proposed models.

2. Project Description

New Rest House Building to be constructed in Karnal District of Haryana spans a built-up area of 9882 m^2. The project is a G+3 storey building. The project is now at design stage and the project will implement all the measures which make the building comply with ECBC-2017. The project is going for ECBC compliance through Whole Building Simulation Approach. The project will use LED lights and high COP VRV systems for air conditioning and BEE star-rated electrical equipment in the building.

The project aims to achieve ECBC compliance through a whole-building simulation approach, comparing the proposed model with a standard benchmark.

3. Building Envelope

The building envelope refers to the exterior façade and is comprised of opaque assembly and fenestration systems. Opaque components include walls and roof etc. The fenestration system includes windows, ventilators etc. The envelope of the building protects the building interior and occupants from exterior weather conditions. So, to make the building envelope energy efficient and to comply with the mandatory requirement following energy efficient material shall be recommended in the envelope design. The envelope considered in the baseline case and proposed case is detailed in the compliance forms.

WWR Calculations

WWR is the window wall ratio. As more heat comes from the windows than compared to wall & roof. Detailed WWR calculation has been mentioned in further section of this report. The WWR is required to calculate as this is a necessary parameter to find the

baseline envelope requirement of building. Windows accounts for the maximum amount of heat in the building. The overall WWR of the building is about 4.74%. The WWR is in the acceptable range and hence by the simulation approach will be easily compliant.

The envelope requirement is divided as per the percentage WWR calculation mentioned below for building:

Total Window Area= 1630 (sq. ft), Total Window + Wall Area= 34340 (sq. ft.)

The formula to calculate WWR is: WWR= (Total Window Area/ Total window+ wall Area) ×100

WWR=(1630/34340)×100

So, the Window-to-Wall Ratio (WWR) is approximately **4.74%.**

Roof construction

OPAQUE Roof Assembly							
S. no	**LAYER**	**THICKNESS (L)**	**L/1000**	**THERMAL CONDUCTIVITY (K)**	**REFERENCE**	**RESISTANCE (L/K)**	**U- VALUE**
		mm		W/mK			W/sq mK
1	SRI Tile	20	0.02	1.500	ECBC 2017	0.00	
2	Extruded polystyrene (XPS)	50	0.05	0.035	ECBC 2017	1.43	
3	Water proofing membrane	5	0.005	0.850	ENS 2018	0.14	
4	RCC	125	0.12	1.580	ENS 2018	0.13	
5	Green Roof (optional)	100	0.10				
	Total thickness	300				1.96	0.51

Table1 Proposed Roof construction

Wall construction

OPAQUE Wall Assembly							
S. No	**LAYER**	**THICKNESS(L)**	**L/1000**	**THERMAL CONDUCTIVITY (K)**	**REFERENCE**	**RESISTANCE (L/K)**	**U-VALUE**
		mm		W/mK			W/sq m K
1	External High SRI Tiles	20	0.02	-	ECBC User Guide	0.04	
2	Internal Cement Plaster	15	0.01	0.750	ECBC User Guide	0.03	
3	External AAC Block	200	0.20	0.184	ECBC2017	0.82	
4	Air Gap/ Cavity	40	0.04	-	ECBC User Guide	0.13	
5	Internal Fly Ash Brick	100	0.100	1.05	ECBC 2017	0.95	
	Total thickness	375		-		1.09	0.92

Table2 Proposed Wall construction

Fenestration Specification

Fenestration Heat Transfer Coefficients			
S.No.	Glass Specification	Evo-Lite (ETII150)	
	Window Glass	Values	Unit
1.	U Value-Thermal Transmittance (SI)	5	W/m2-K
2.	U Value -Thermal Transmittance (IP)	0.88	Btu/hr-ft^2-F
3.	SHGC-Solar Heat gain coefficient	0.5	Unitless
4.	SC-Shading Coefficient	0.57	Unitless
5.	Visible Light Transmittance (VLT)	0.5	Unitless

Table3 Fenestration Specifications of proposed design

4. HVAC Parameters

Heating, ventilating & air conditioning system refers to the equipment, distribution systems and terminals that provide heating, ventilation or air conditioning requirement to a building or portion of the building. The HVAC systems contribute to the major energy consumption in buildings having larger conditioned areas. The ECBC contains mandatory as well as prescriptive requirements for ventilation, refrigerant piping, controls, system balancing etc.

	HVAC Parameters	
S.No.	Standard Design (As per ECBC)	Proposed Design
	VRV	Same as ECBC
1.	COP	COP
2.	3.28	3.6

Table4 HVAC Parameters

Mandatory ECBC requirements

- **Ventilation (5.2.1-ECBC 2017):**
  - The project buildings hall follow all the necessary provisions of NBC 2016 including the design guidelines for Natural /mechanical/Mixed mode ventilation.
- **Space Conditioning Equipment Efficiencies (5.2.2-ECBC 2017):**
  - Variable Refrigerant Flow with Direct expansion with air cooled condenser 3.6 cop shall be provided.
- **Temperature Controls (5.2.3.2-ECBC 2017):**
  - Mechanical cooling equipment in all buildings shall be installed with controls to manage the temperature inside the conditioned zones. Each floor or a building block shall be installed with at least one control to manage the temperature.

- A separate thermostat control shall be installed in each room less than 30m2 in Business.

➢ **Centralized Demand Shed Controls (5.2.4.1-ECBC 2017):**

- The building shall have a building management system. All mechanical cooling shall be equipped with any programmable logic controller (PLC) to the zone level shall have the following control capabilities to manage centralized demand shed in noncritical zones.
- Automatic demand shed controls that can implement a centralized demand shed in non-critical zones during the demand response period on a demand response signal. Controls thatcanremotelydecreaseorincreasetheoperatingtemperaturesetpointsbyfourdegrees or more in all noncritical zones on signal from a centralized control point. Controls that can provide an adjustable rate of change for the temperature setup and reset

➢ **Supply Air Temperature Reset (5.2.4.2-ECBC 2017):**

- Buildings should have a building management system. All mechanical cooling and heating systems in the building shall be equipped with any programmable logic controller (PLC) to the zone level shall have the following control capabilities to manage centralized demand shed in noncritical zones.

➢ **Piping Insulation (5.2.6.1-ECBC 2017):**

- Piping for space conditioning shall meet the insulation requirements listed in Table 5-8 (ECBC2017). Insulation exposed to weather shall be protected by aluminum sheet metal, painted canvas, or plastic cover. Cellular foam insulation shall be protected as above or be painted with water retardant paint.

Table 5-8 Insulation Requirements for Pipes in ECBC Building

Operating Temperature (ºC)	Pipe size (mm)	
	<25	>=40
	Insulation R value (m^2.K/W)	
Heating System		
94°C to 121°C	0.9	1.2
60°C to 94°C	0.7	0.7
40°C to 60°C	0.4	0.7
Cooling System		
4.5°C to 15°C	0.4	0.7
< 4.5°C	0.9	1.2
Refrigerant Piping (Split systems)		
4.5°C to 15°C	0.4	0.7
< 4.5°C	0.9	1.2

Table5InsulationforPipes(SourceTable-5.8-ECBC-2017)

- **Condenser Locations (5.2.8.1-ECBC 2017):**
  - Condensers shall be located such that the heat sink is free of interference from heat discharge by devices located in adjoining spaces, and do not interfere with other such systems installed nearby.

5. Lighting System

Project is a Hospitality type. Project understands the requirement of ECBC in selection of Lighting & it shall ensure the use of a lighting with a LPD of 0.88 W/sq.ft. or equivalent system.

Lighting Specifications (Building Area Method)		
Space Name	**Standard Design** (As per ECBC)	**Proposed Design**
	Lighting Power Density (in W/sq. ft.)	Lighting Power Density (in W/sq. ft.)
Hospitality Building	0.79	0.88

Table6 Lighting Specifications

Mandatory Requirement

- **Lighting Control (6.2.1-ECBC 2017):**

  90% of interior lighting fittings in buildings or space larger than 300m^2shall be equipped with automatic control devices.

  Occupancy Sensors is recommended for below mentioned cases:

  - All habitable spaces are less than 30m^2, enclosed by walls or ceiling height partitions.
  - In all Business and all conference or meeting rooms.
  - Public toilets more than 25 m^2, controlling at least 80 % of lighting fitted in the toilet. The lighting fixtures, not controlled by automatic lighting shut off, shall be uniformly spread in the area.

- **Automatic Controls (6.2.1.1-ECBC 2017):**

  - On a scheduled basis at specific programmed times. An independent program schedule is recommended to provide for areas of no more than 2,500 m2 and not more than one floor.

- Occupancy sensors that shall turn off the lighting fixtures within 15 minutes of an occupant leaving the space. Light fixtures controlled by occupancy sensors shall have a wall-mounted, manual switch capable of turning off lights when the space is occupied.

➢ **Exterior lighting Control (6.2.1.5-ECBC 2017):**

- Lighting for all exterior applications shall be controlled by a photo sensor or astronomical time switch that is capable of automatically turning off the exterior lighting when daylight is available, or the lighting is not required.

Table 6-7 Exterior Building Lighting Power for ECBC Buildings

Exterior lighting application	*Power limits*
Building entrance (with canopy)	10 W/m² of canopied area
Building entrance (w/o canopy)	90 W/ linear m of door width
Building exit	60 W/lin m of door width
Building façade	5.0 W/m² of vertical façade area
Emergency signs, ATM kiosks, Security areas façade	1.0 W/m²
Driveways and parking (open/ external)	1.6 W/m²
Pedestrian walkways	2.0 W/m²
Stairways	10.0 W/m²
Landscaping	0.5 W/m²
Outdoor sales area	9.0 W/m²

Table7 Exterior lighting details (source: ECBC 2017)

➢ **Control in Daylight Are as (6.2.1.3-ECBC 2017):**

- Lighting Power Density adjustment factor of 20% is recommended as per ECBC to all spaces with more than 70% of their area under daylight controls.
- Luminaires, installed within daylighting extent from the windows hall be
- equipped with either a manual control device to shut off luminaires, installed within day lit area, during potential day lit time of a day or automatic control device that:

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

- **Centralized Controls (6.2.1.4-ECBC 2017):**
  - Building shall have centralized control system for schedule based automatic lighting shutoff switches.
- **Exit signs (6.2.2- ECBC 2017):**
  - The lighting power for energy exit signs shall not exceed a maximum of 5watts.

6. Electrical and Renewable Energy

Mandatory Requirement

➢ **Transformer (7.2.1- ECBC 2017):**

- Power transformers of the proper ratings and design must be selected to satisfy the minimum acceptable efficiency at 50% and full load rating.
  Permissible to t all values shall not exceed

(a) 5% of the maximum total loss values mentioned in IS1180 for oil type transformers in voltage class above 11 kV but not more than 22 kV

(b) 7.5% of the maximum total loss values mentioned above IS1180 for oil type transformers in voltage class above 22 kV and up to and including 33 kV

(c) values listed in the following Table7.2 (ECBC-2017) for oil type transformers

Table 7-2 Permissible Losses for Oil Type Transformers. Total losses for oil type transformers shall confirm with Indian Standard IS 1180.

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

Total loss values given in above table are applicable for thermal classes E, B and F and have component of load loss at reference temperature according to Clause 17 of IS 1180 i.e., average winding temperature rise as given in Column 2 of Table 8.2 plus 300C. An increase of 7% on total for thermal class H is allowed.

Figure3PermissibleLossesforOilTypeTransformers

- All transformers of capacity of 500kVA and above would be recommended to equipped with additional metering class current transformers (CTs) and potential transformers (PTs) additional to requirements of Utilities so that periodic loss monitoring study may be carried out.

➢ **Voltage Drop (7.2.1.3- ECBC 2017):**

- Voltage drop for feeders shall notexceed2%atdesignload.Voltage drop for branch circuits shall not exceed 3% at design load.

➢ **Diesel Generator (DG) Sets (7.2.3- ECBC 2017):**

- BEE star rated DG sets shall be used in all compliant buildings. DG sets in buildings shall have a minimum 3 stars rating or equivalent.

➢ **Energy Efficient Motors (7.2.2- ECBC 2017):**

- Three phase induction motors shall conform to Indian Standard (IS) 12615 and shall Have minimum IE 2.

➢ **Check Metering and monitoring (7.2.4- ECBC 2017):**

- Services exceeding 1000 kVA shall have permanently installed electrical metering to record demand (kVA), energy (kWh), and total power factor. The metering shall also display current (in each phase and the neutral), voltage (between phases and between each phase and neutral), and total harmonic distortion (THD) as a percentage of total current.

➢ **Power factor correction (7.2.5- ECBC 2017):**

- The transformer shall maintain the minimum power factor 0.97.

➢ **Power distribution system (7.2.6- ECBC 2017):**

- The power cabling shall be sized so that the distribution losses shall not exceed 3% of total power usage.

➢ **Uninterruptible Power Supply (UPS) (7.2.7- ECBC 2017):**

- UPS shall meet or exceed the energy efficiency requirements listed in Table 7-4 (ECBC 2017).Any Standards and Labeling program by BEE shall take precedence over requirements listed in this section:

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

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

Table8 Uninterruptible Power Supply (UPS)

- **Renewable Energy Systems (7.2.7-ECBC 2017):**
  - A dedicated Renewable Energy Generating Zone(REGZ) equivalent to at least 25% of roof area or area required for generation of energy equivalent to 1% of total peak demand or connected load of the building, whichever is less, shall be provided in all buildings.
  - Minimum Electricity 1% of total electrical load shall be Generated in REGZ.

7. Energy Simulation Results Calculations

Schedules and Inputs

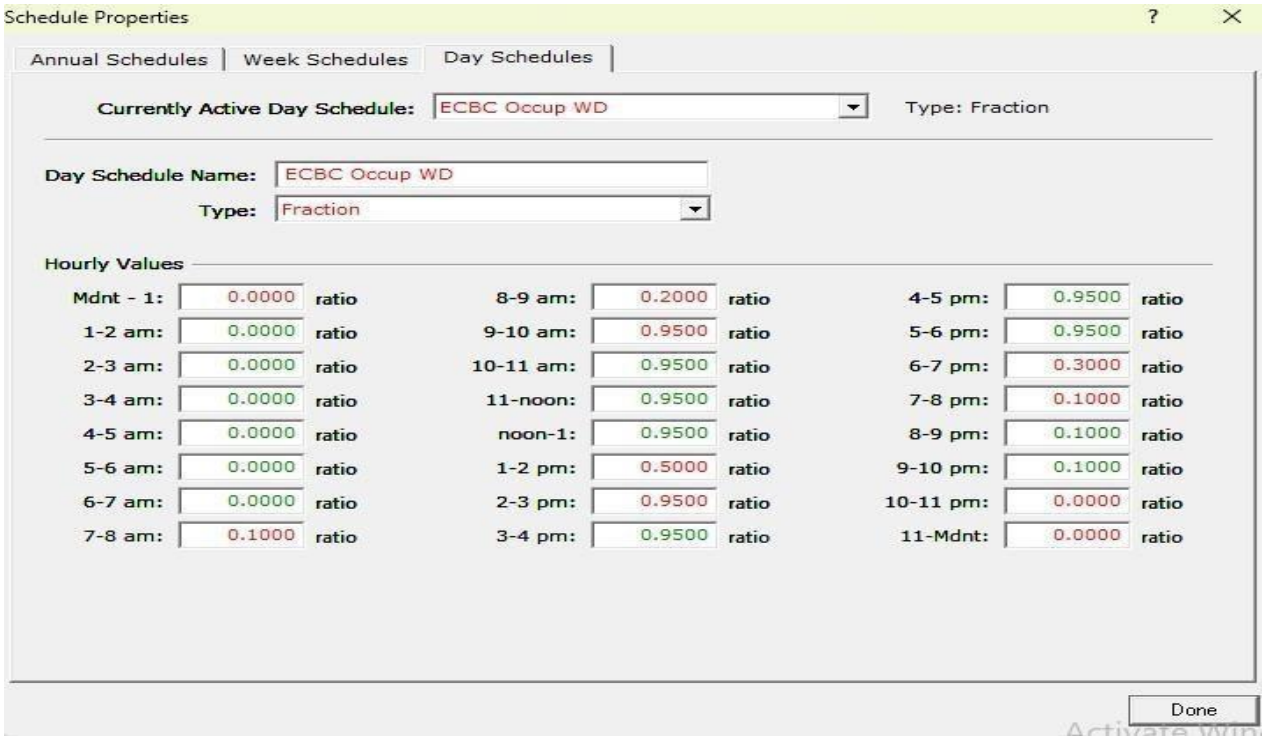

Figure4-OccupancySchedule

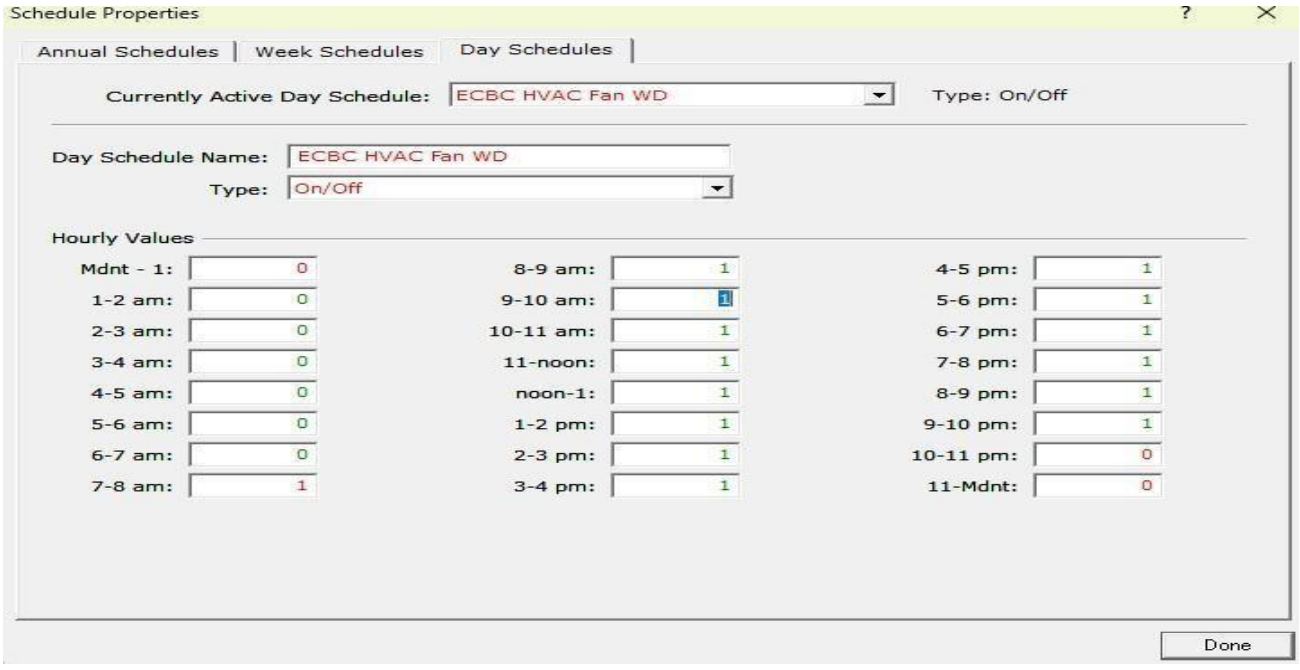

Figure5- HVAC Fan Schedule

Schedules for the building show the building's operational hours, which is how much time the building parameters like HVAC, equipment, fans, water heater etc. will run in the year. The operational hours for the building have been taken similarly for both the proposed and standard case.

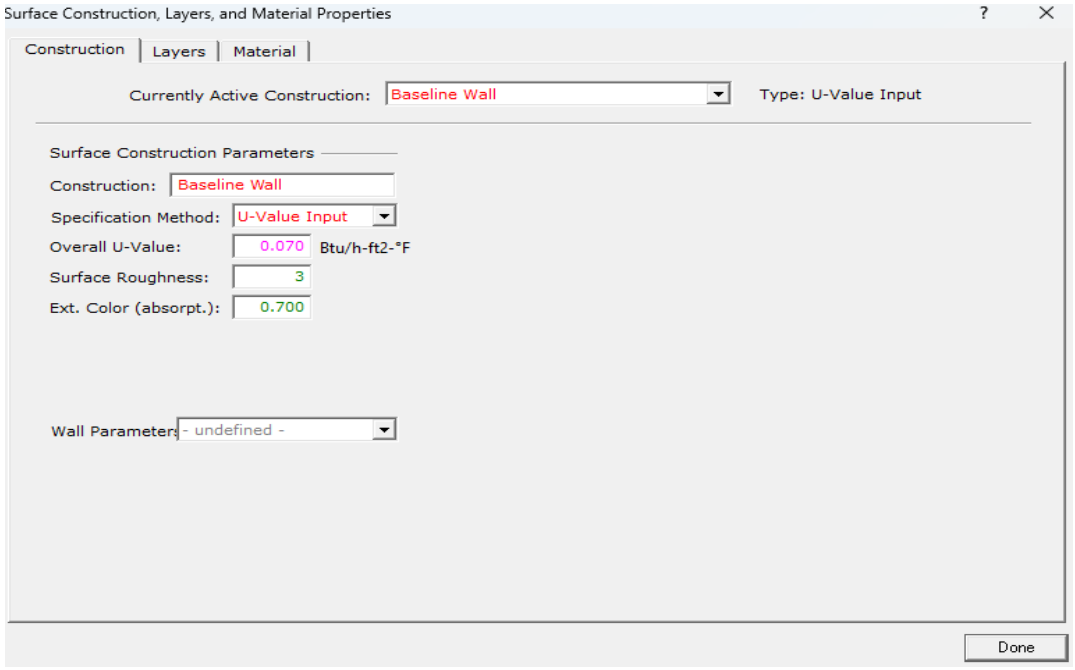

Figure6 Baseline Exterior Wall Properties

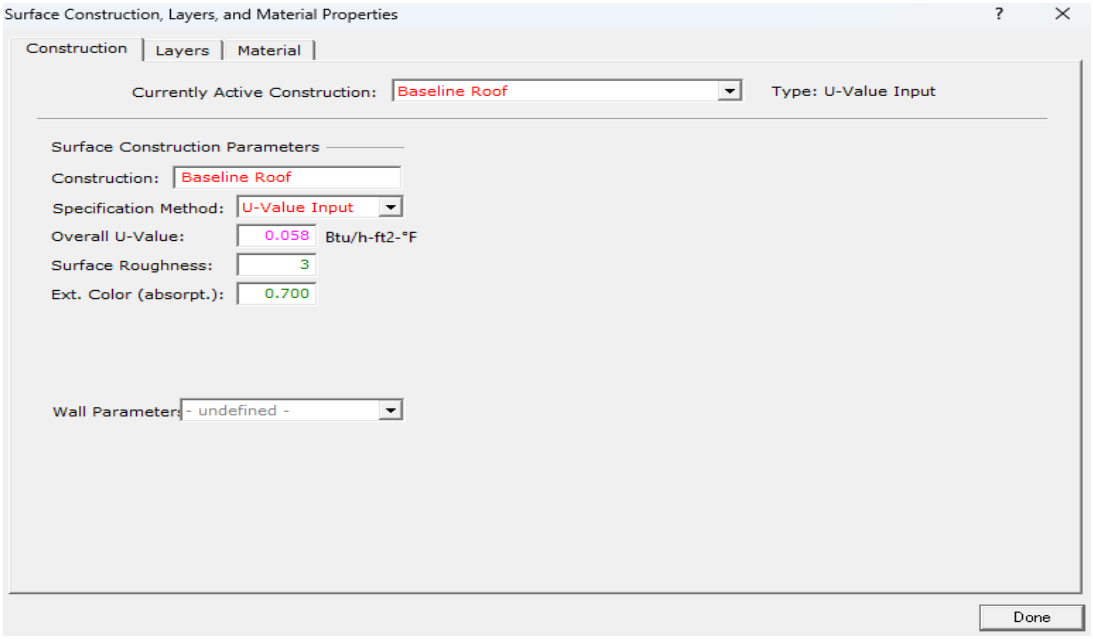

Figure7 Baseline Exterior Roof Properties

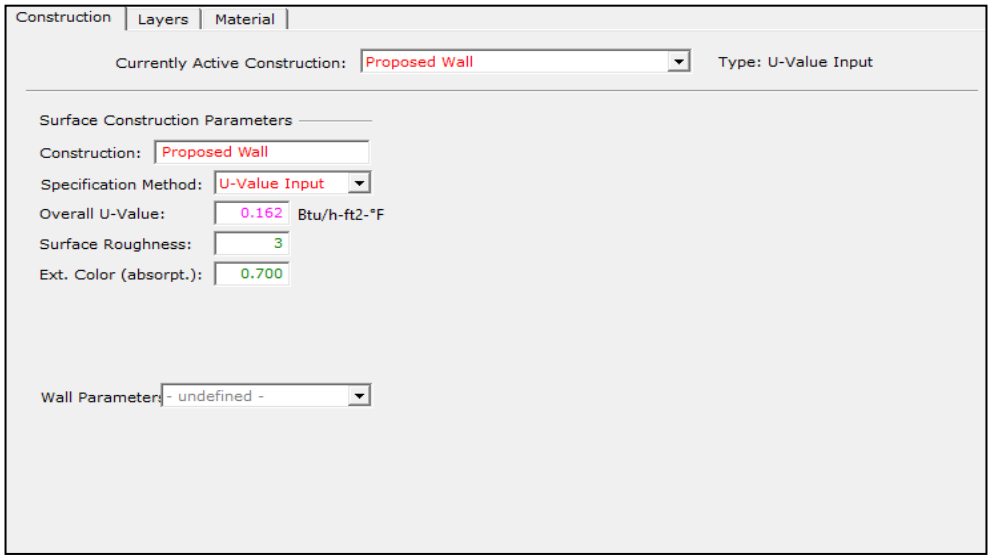

Figure8 Proposed Exterior Wall

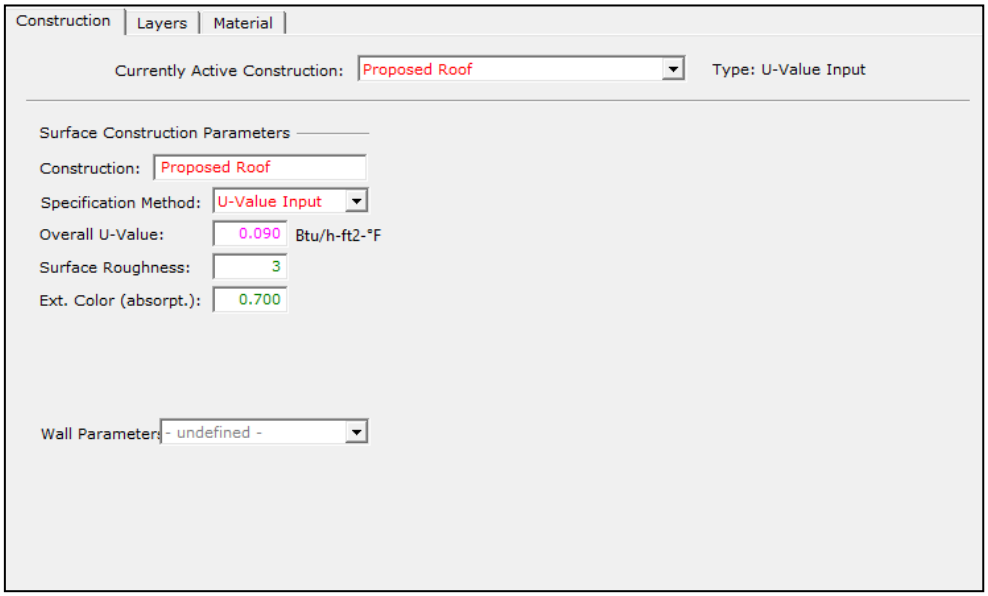

Figure9 Proposed Exterior Roof

Simulation Results

Baseline Case consumption

Baseline model stands for a standard benchmark with which we compare our actual proposed model. The baseline model has inputs as per ECBC against of actual as in the proposed case. The model is then simulated by using an appropriate weather file for the project location.

Figure10 Baseline Consumption

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	4.3	7.5	18.2	22.8	39.3	32	31.4	31.4	24.2	20.5	11.9	7.8	251.3
Heat Reject.	0	0	0	0	0	0	0	0	0	0	0	0	0
Vent. Fans	11.3	12.4	13.5	14.6	16	15.2	15.5	16.3	14	14.2	12.7	14.5	170.2
Pumps G Aux.	0	0	0	0	0	0	0	0	0	0	0	0	0
Ext. Usage	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. Equip.	10.2	8.6	10.8	10.7	10.8	8.7	11.2	10.8	8.7	11.2	8.4	10.2	120.3
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Area Lights	36.4	30.7	35.7	34.5	35.7	34.5	37.4	37.7	36.5	37.4	32.8	36.4	425.7
Total	62.2	59.2	78.2	82.6	101.8	90.4	95.5	96.2	87	83.3	65.8	68.9	967.5

Analysis of Baseline Energy Consumption:

The simulation results for baseline case consumption revealed that the primary energy usage is attributed to area lighting and space cooling. Miscellaneous equipment consumption remains consistent across both the proposed and baseline cases. The remaining energy consumption is allocated to ventilation fans.

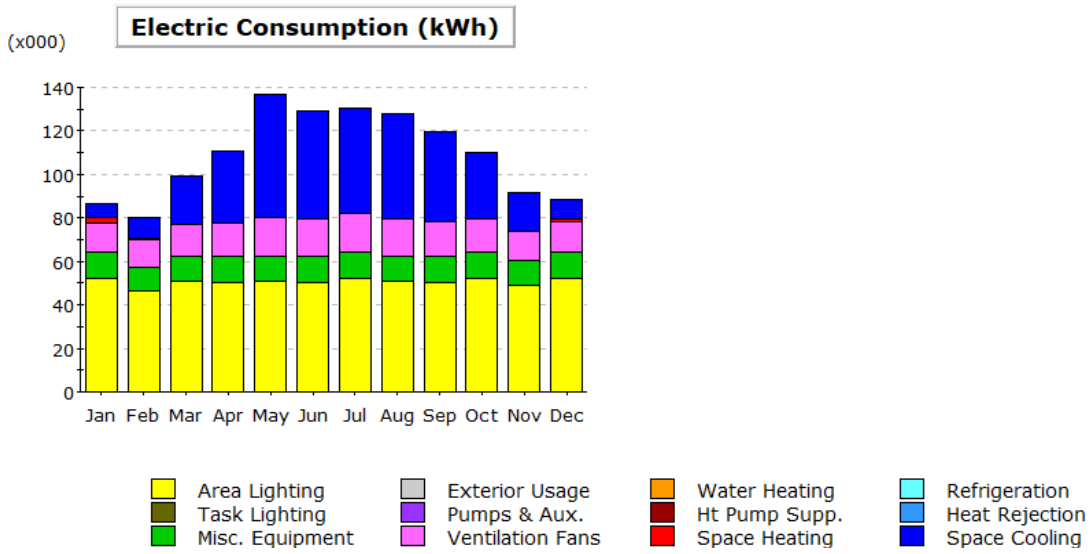

Figure11 Baseline Consumption Graph

Proposed Case Consumption

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	4.3	7.5	18.2	22.8	39.3	32	31.4	31.4	24.2	20.5	11.9	7.8	230.3
Heat Reject.	0	0	0	0	0	0	0	0	0	0	0	0	0
Vent. Fans	11.3	12.4	13.5	14.6	16	15.2	15.5	16.3	14	14.2	12.7	14.5	150.2
Pumps G Aux.	0	0	0	0	0	0	0	0	0	0	0	0	0
Ext. Usage	0	0	0	0	0	0	0	0	0	0	0	0	0
Misc. Equip.	10.2	8.6	10.8	10.7	10.8	8.7	11.2	10.8	8.7	11.2	8.4	10.2	100.3
Task Lights	0	0	0	0	0	0	0	0	0	0	0	0	0
Area Lights	36.4	30.7	35.7	34.5	35.7	34.5	37.4	37.7	36.5	37.4	32.8	36.4	410.66
Total	56.2	53.2	71.2	76.6	87.8	87.4	89.5	90.2	79.3	75.3	60.8	63.9	891.46

Figure12 Proposed Consumption

Analysis of Proposed Energy Consumption

The simulation results highlight the Proposed Case Consumption, with miscellaneous equipment consumption remaining the same as the baseline. The primary energy consumption is attributed to space cooling, where the proposed system incorporates VRF systems. To enhance efficiency, the project should adopt LED lighting, as lighting power density (LPD) represents the second-highest energy consumption in the building.

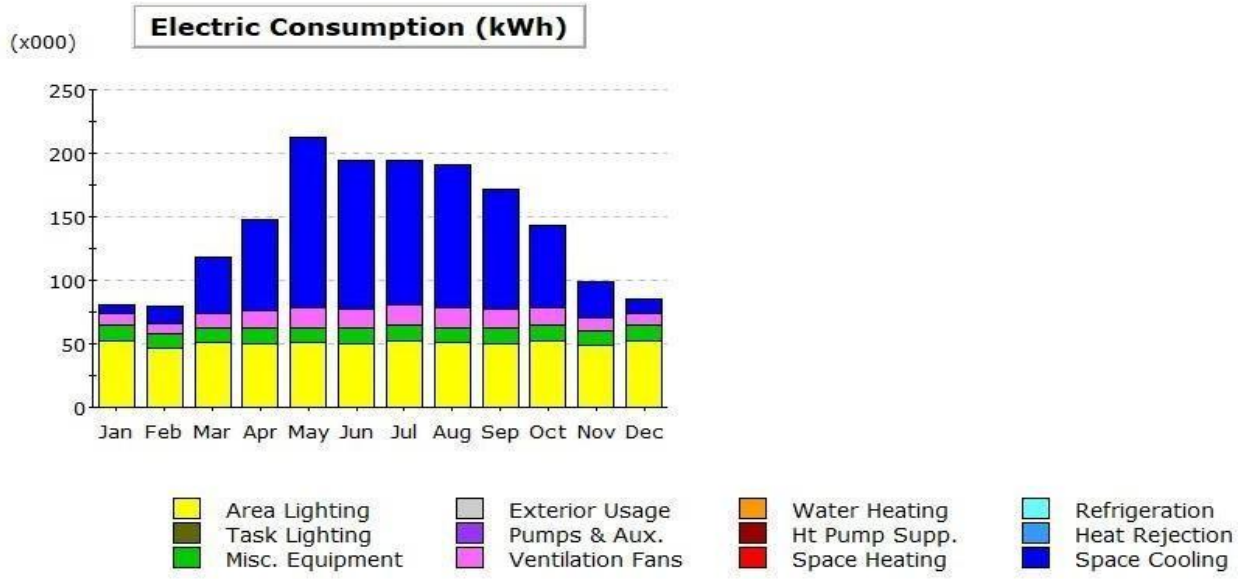

Figure13 Proposed Consumption Graph

Summary and Results of the Simulation

The whole building simulation approach has been used for the project for the ECBC compliance. The models have been prepared for both the cases – Baseline and proposed. The proposed case annual consumption after simulation is around 8,91,460 kWh and for baseline case is 9,67,500 kWh. The results are summarized in the table below:

S. No	Case Description	Unit	Values
1.	**Proposed Consumption**	**(kWh)**	8,91,460
2.	**Baseline Consumption**	**(kWh)**	9,67,500
3.	**Built-up Area**	**(Sq.m.)**	9882
4.	**Proposed EPI**	**(kWh/Sq.m./year)**	90.2
5.	**Baseline EPI**	**(kWh/Sq.m./year)**	97.9
6.	**EPI Ratio**	**Unitless**	**0.92**

Table9 Calculation and Results

It can be observed that the EPI ratio for the project is **0.92** i.e. less than **1** (minimum requirement of EPI ratio as per ECBC for composite climate) hence, the project fulfils the ECBC compliance requirement.

Therefore, the project achieves energy saving of **7.85%** when compared with ECBC baseline case. Thereby, project is meeting the ECBC compliance by 'Whole Building Performance' approach.

8. Conclusion-

1. New Rest House Karnal Building in Karnal District, Haryana spans a built-up area of 9882 m^2. The project consists of Ground, First, Second and Third Floor (G+3).
2. The project aims to achieve ECBC compliance by utilizing a whole-building simulation approach to attain an Energy Performance Index (EPI) ratio of less than 1, as required for compliance within the relevant building category.
3. The energy performance analysis of the building was conducted using eQUEST version 3.65. This software, aligned with ECBC requirements, operates on the DOE-2.2 simulation engine.
4. The project considers Karnal, Haryana Composite climate conditions as per ECBC guidelines Consequently, the weather file "IND_ Hisar.421310_ISHRAE.BIN" was used in the simulation software for both the baseline and proposed cases.
5. The Window-to-Wall Ratio (WWR) of the building is approximately 4.74%, which is significantly below the maximum prescriptive value of 40% set by ECBC standards.
6. For the proposed design, envelope specifications (external wall, roof, windows, skylights & doors) are derived from the actual case, while the baseline case follows ECBC standards.
7. The project's proposed lighting power density (LPD) was considered to 0.88W/ft^2across different space types, which are very efficient from the standard ECBC design which is 0.79 W/ft^2.
8. The proposed case incorporates efficient VRV systems with a COP of 3.6 and VRV system with COP of 3.28 used of standard ECBC case.
9. The calculated annual energy consumption for the proposed case is 8,91,460 kWh, which is less than the baseline case consumption of 9,67,500kWh.
10. Based on the proposed and baseline annual energy consumption, the building achieves an Energy Performance Index (EPI) ratio of0.92, hence meeting the ECBC compliance requirement of less than 1.
11. It is recommended that the proposed building meets the minimum fresh air requirements as specified in the NBC. Furthermore, transformers, DG sets, UPS, motors, and renewable energy systems should have at least the minimum BEE star rating or comply with the efficiency and capacity requirements outlined in the ECBC.
12. It is also recommended that the project building utilize high-SRI (Solar Reflectance Index) paint or tiles on the roof to minimize unwanted heat generation, thereby reducing the energy required for space cooling.

13. It is recommended that the proposed building meets the minimum fresh air requirements as specified in the NBC. Furthermore, transformers, DG sets, UPS, motors, and renewable energy systems should have at least the minimum BEE star rating or comply with the efficiency and capacity requirements outlined in the ECBC.
14. It is also recommended that the project building utilize high-SRI (Solar Reflectance Index) paint or tiles on the roof to minimize unwanted heat generation, thereby reducing the energy required for space cooling.

9. Checklist as per ECBC compliance requirements

S. No.	Parameter	ECBC case	Proposed Case	Remarks
Building Envelope				
1.	4.2.1	Fenestration Rating		
2.	Specify whether per 4.2.1.1 or default in Appendix C	U-factor	Complied	**Using Whole Building Performance Approach**
3.	Specify whether per 4.2.1.2 or default in Appendix C	SHGC	Complied	**Using Whole Building Performance Approach**
4.	Specify whether per default in Appendix C or ASHRAE	Opaque U-factors	Complied	**Using Whole Building Performance Approach**
5.	Indicate sealing, caulking, gasketing and weather stripping	Bldg. envelope sealing	Recommended	
HVAC Parameters				
1	Ventilation (5.2.1-ECBC2017):	Necessary provisions of NBC 2016 including the design guidelines for Natural /mechanical/Mixed mode ventilation	Recommended	
2	Demand Control Ventilation (5.2.1.3- ECBC 2017):	Mechanical ventilation systems shall have demand control ventilation if they provide outdoorairgreaterthan1,500 litres per second	NA	
3	Ductwork Insulation (5.2.6.1-ECBC2017):	Duct work and plenum shall be insulated in accordance with Table 5-11(ECBC-2017)	NA	
4	Piping Insulation (5.2.6.1-ECBC 2017):	Piping for space conditioning shall meet the insulation requirementslistedinTable5-10 (ECBC 2017).	Recommended	

5	Fan Controls (5.2.3.4-ECBC 2017):	two speed motors, pony motors, or variable speed drives to control the fans	NA	
6	Centralized Demand Shed Controls(5.2.4.1-ECBC2017):	Building Management System (BMS)/SCADA to control HVAC Demand	NA	
7	Variable Air Volume Fan Control (5.2.5.1-ECBC 2017):	Fans in Variable Air Volume (VAV)systems in Buildings shall have controls or devices that will result in fan motor demand of no more than 30% of their Design wattage at 50% of design airflow.	NA	
8	Air-Handling Units (5.3-ECBC 2017):	60%	NA	
		IE2	NA	
9	Variable Speed Drives (5.3.4.3-ECBC 2017)	Pump motors greater than or equal to 3.7 kW shall be Controlled by variable speed drives	NA	
Lighting Parameters				
1	Lighting Control (6.2.1-ECBC 2017):	90% of interior lighting fittings in buildings or space larger than300m^2shall be equipped with automatic control devices	Recommended	
2	Exterior lighting Control (6.2.1.5-ECBC 2017):	Photo sensor or astronomical time switch	Recommended	
3	Exit signs (6.2.2-ECBC 2017):	The lighting power for energy exit signs shall not exceed a maximum of 5 watts.	Recommended	

Electrical Parameters				
1	Transformer (7.2.1-ECBC 2017):	Transformer shall be used with maximum losses of at 50% and full load rating as per ECBC	Recommended	
2	Power factor correction (7.2.5-ECBC2017):	The Building Shall maintain the minimum power factor 0.97	Recommended	
3	Uninterruptible Power Supply (UPS) (7.2.7-ECBC2017):	UPS shall meet or exceed the minimum energy efficiency requirements of ECBC	Recommended	
4	Renewable Energy Systems (7.2.7-ECBC 2017):	Minimum Electricity to be Generated as 1% of Total Electrical Load	Recommended	
5	Diesel Generator (DG) Sets (7.2.3 -ECBC 2017):	BEE 3Star Rated DG sets shall be used in all compliant buildings	Recommended	
6	Voltage Drop (7.2.1.3 -ECBC 2017):	Voltage drop for feeders shall not exceed the minimum prescribed as Per ECBC	Recommended	
7	Check Metering and monitoring (7.2.4-ECBC2017):	Services exceeding 1000kVA shall have permanently installed electrical metering to record demand (kVA), Energy (kWh), and total power factor.	Recommended	
8	Energy Efficient Motors (7.2.2-ECBC 2017):	Buildings shall have IE2 (high efficiency) class motors	Recommended	

Note:- This checklist is proposed as ECBC compliance.

10. Appendix

Floor Plans

Figure14- Ground Floor plan

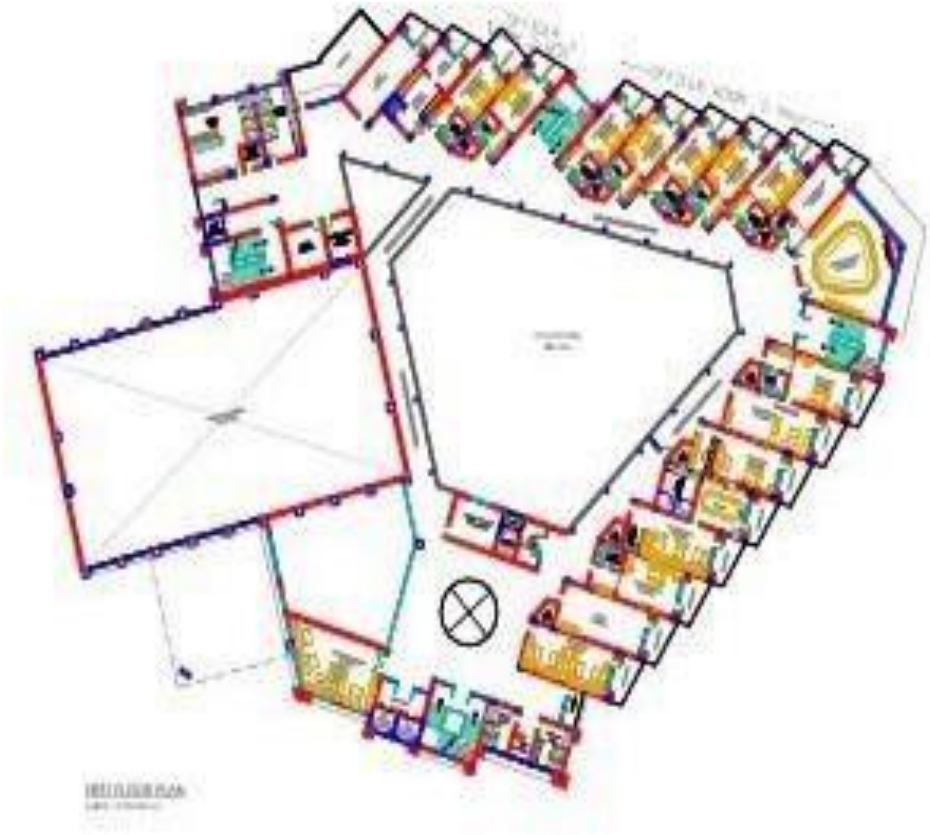

Figure15- First Floor plan

Figure16- Second Floor plan

Figure17- Third Floor plan

THANK YOU