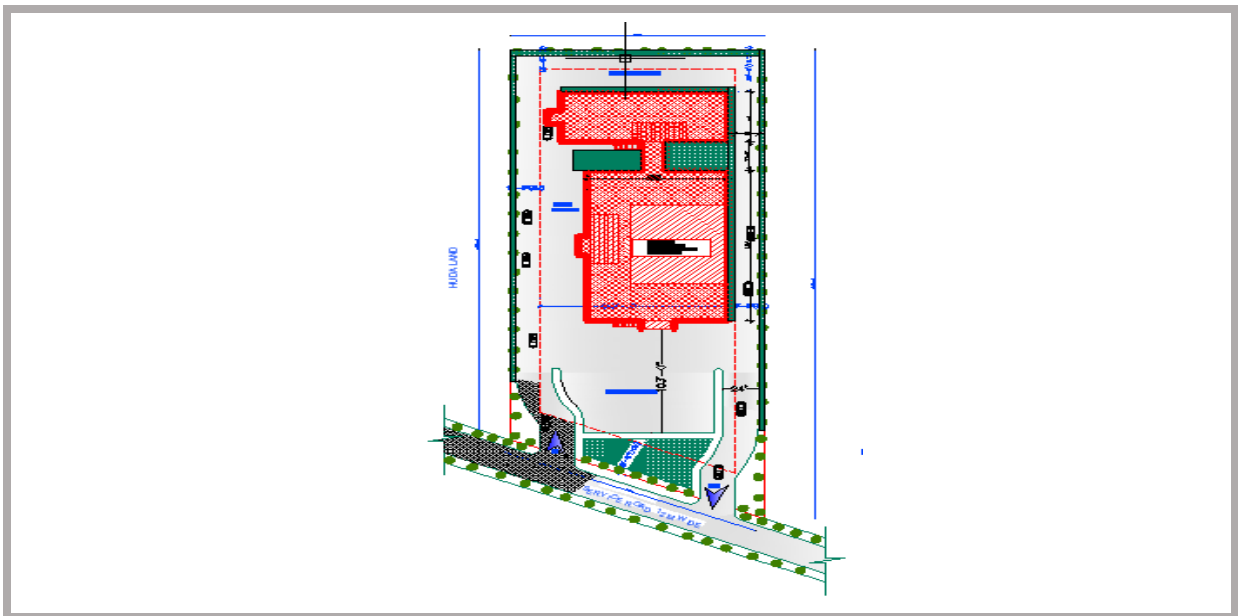




ENERGY EFFICIENT IMPROVEMENTS IN COMMERCIAL BUILDINGS

ECBC COMPLIANCE REPORT



RTA Office, Panchkula
(Business Building, Composite Climate)



©United Nations Development Programme, 2017

Project Team

HAREDA ECBC Cell,
Institutional Plot 1,
Sector -17, Panchkula

Published by

United Nations Development Programme
55, Lodhi Road, New Delhi-110003

Disclaimer

This report has been compiled based on the recommendations and implementation of interventions adopted in the demonstration building to achieve ECBC compliance. The views expressed in this publication, however, do not necessarily reflect those of the United Nations Development Programme and the Bureau of Energy Efficiency, Ministry of Power, Government of India.

CONTENTS

1. EXECUTIVE SUMMARY.....	6
1.1. PROJECT BRIEF:.....	6
2. SUMMARY OF ECBC COMPLIANCE	7
2.1. MANDATORY PROVISIONS UNDER ECBC	7
2.2. ENVELOPE	7
2.2.1 Fenestration U-Factor.....	7
2.2.2 Fenestration Solar Heat Gain Coefficient	7
2.2.3 Fenestration Visual Light Transmittance	7
2.2.4 Opaque Construction.....	9
2.2.5 Building Envelope Sealing	7
2.2.6. Building Orientation and Massing.....	7
2.2.7. Window Wall Ratio	9
2.2.8 Solar shading analysis.....	10
2.2.9 Daylight Analysis	10
2.2.11 Glazing Recommendation.....	11
2.2.10 Summary of recommendations for envelope	13
2.3. COMFORT SYSTEMS AND CONTROLS.....	13
2.3.1. Mandatory ECBC requirements	13
2.3.1.1 Natural Ventilation.....	13
2.3.2. Building HVAC design and systems	14
2.3.3. Equipment and total system efficiency	14
2.3.4. Piping and ductwork	14
2.3.6. Condensers	14
2.3.7. Summary of recommendations for HVAC	14
2.3. LIGHTING.....	15
2.3.1. Mandatory requirement	15
2.3.2. Lighting power density	15
2.3.3. Lighting control	15
2.3.4. Exterior lighting detail.....	15
2.3.5. Summary of recommendations for lighting:	15



2.4. SERVICE WATER HEATING	15
2.5. RENEWABLE ENERGY.....	15
2.6. ELECTRICAL.....	16
2.6.1. Transformer	16
2.6.2. Motors (type, efficiency).....	16
2.6.3. Diesel generator sets.....	16
2.6.4. Check metering and monitoring.....	16
2.6.5. Power factor correction	16
2.6.6. Power distribution system.....	16
3. Cost Analysis:	17
4. ECBC COMPLIANCE FORMS	20



LIST OF TABLES:

Table 1 Wall and Roof Assembly	9
Table 2: Window wall ratio	9
Table 3 SHGC.....	10
Table 4 Above Grade area Calculation.....	11
Table 5 Glazing Recommendation	11
Table 6 Equipment Efficiency	14
Table 7: Piping and ductwork insulation.....	14
Table 8: Cost Analysis Table	17

LIST OF FIGURES:

Figure 1: First Floor	11
Figure 2: Ground Floor	11

1. EXECUTIVE SUMMARY

BUILDING NAME	Regional Transport Agency Office
BUILDING TYPE	Business
LOCATION	Panchkula
CLIMATIC ZONE	Composite
AREA, m2	3511.7
CONDITIONED AREA, m2	2610
OCCUPANCY TYPE	Day time use building
Total Connected Load/ Contract Demand	To be estimated by PWD Department
ECBC compliance achieved	ECBC 2017 through prescriptive method
EPI (Baseline Case), KWh/m2/year	-
EPI (Proposed Case), KWh/m2/year	-
ENERGY CONSUMPTION BUSINESS AS USUAL, kWh/YEAR	-
ENERGY CONSUMPTION WITH ENERGY EFFICIENCY INTERVENTIONS, kWh/ YEAR	-
ENERGY SAVING ACHIEVED, kWh/ YEAR	-
Expected reduction in annual energy bills, INR % over BAU	-
Estimated GHG reduction, tCO2 per year	-
Cost of project, total, incremental cost of interventions, INR	3,29,89,505 (compared to conventional case)
PAYBACK PERIOD (in years)	-
DETAILS OF CONTACT PERSON	B. B. Mehta, Senior Architect Deptt. Of Architecture, Haryana M. - 9814145461

1.1. PROJECT BRIEF:

- The project Regional Transport Agency office is an upcoming building designed by Department of Architecture with G+2 with a total built-up area of 3511.7 sqm.
- The project is located in Panchkula, Haryana which lies under Composite region.
- The project is designed by the Department of Architecture, Haryana and the construction work will be executed by PWD (B&R), Haryana.

2. SUMMARY OF ECBC COMPLIANCE

2.1. ENVELOPE

2.1.1. MANDATORY PROVISIONS UNDER ECBC

2.1.1.1. Fenestration U-Factor

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

2.1.1.2. Fenestration Solar Heat Gain Coefficient

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

2.1.1.3. Fenestration Visual Light Transmittance

Visual light transmittance (VLT) shall be determined for the fenestration product in accordance with ISO-15099 by an accredited independent laboratory, and labeled or certified by the manufacturer.

2.1.1.4. Building Envelope Sealing

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

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

2.1.1.5. Building Orientation and Massing

The longer axis of the building is in East – West direction. The building site plan showing the true north is shown below.

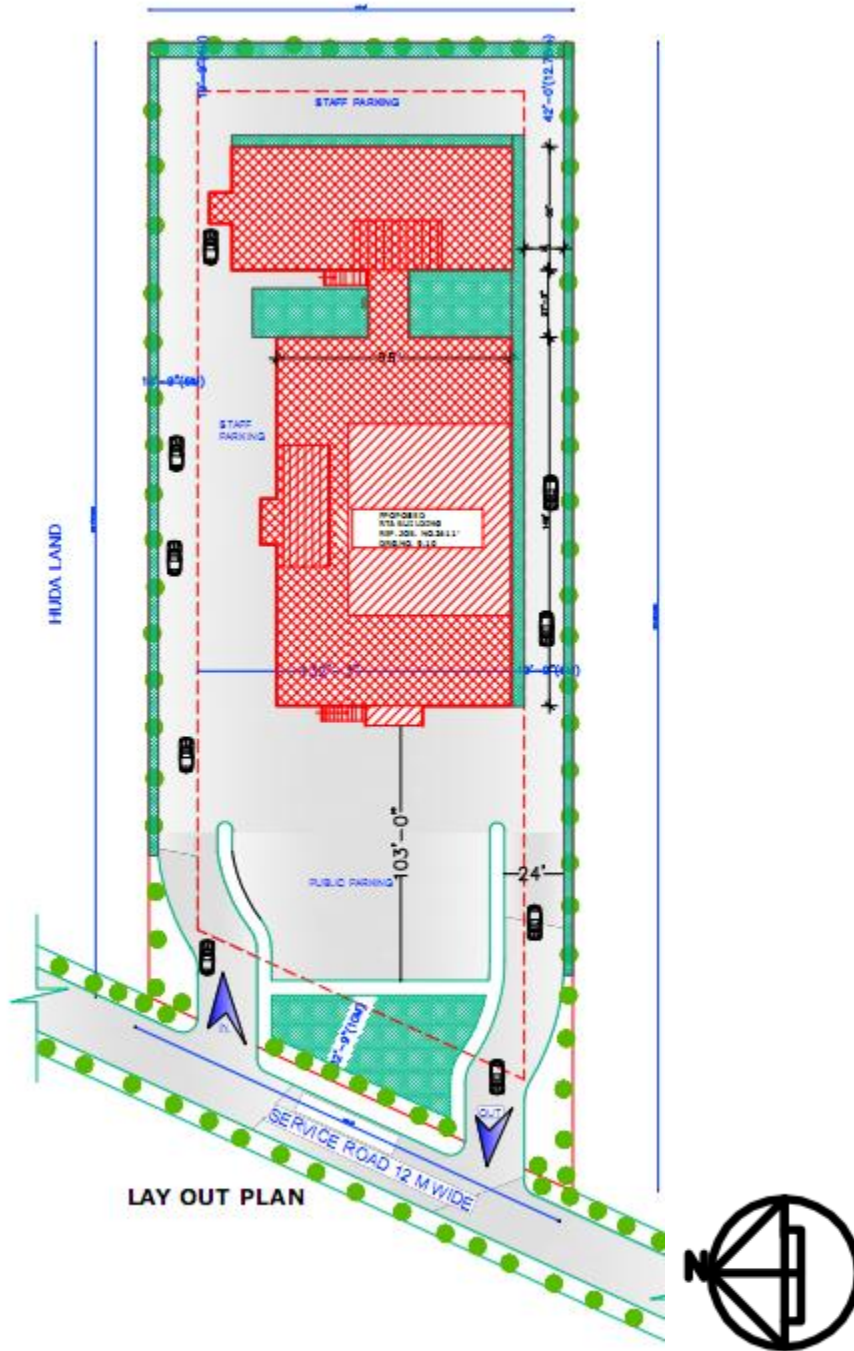


Figure 1: Site Plan

2.1.2. Opaque Construction

U-factors shall be calculated for the opaque construction in accordance with ISO-6946. Testing shall be done in accordance with approved ISO Standard for respective insulation type by an accredited independent laboratory, and labeled or certified by the manufacturer.

Table 1 Wall and Roof Assembly

OPAQUE ASSEMBLY	Construction Layers	Specification
Ext. WALL assembly	Assembly layers: a. Cement Plaster (20mm) b. AAC Block (115mm) c. Air Cavity (20mm) d. AAC Block (230mm) e. Cement Plaster (20mm)	U-value, W/m ² K: 0.39 Assembly thickness, mm: 405
Wall insulation	Type: -	R-value, K m ² /W: - Thickness, mm: -
Roof Assembly	Assembly layers: a. White Tile (10 mm) b. Cement Screed (20 mm) c. XPS Insulation (75 mm) d. Cement Screed (20 mm) e. Mother Slab (RCC) (150 mm)	U-value, W/m ² K: 0.33 Assembly thickness, mm: 275
Roof insulation	Type: XPS (Slab/Foam)	R-value, W/m ² K: .025 Thickness, mm: 75 mm

2.1.3. Window Wall Ratio

In Prescriptive Method, maximum allowable Window Wall Ratio (WWR) is 40%.

Following is the WWR calculation which confirms that the Overall Window to Wall Ratio is around 34%.

Table 2: Window wall ratio

	Window+ Wall, ft ²	Glazed area, ft ²	WWR
East	6228.8	1893.3	30%
West	6228.8	2394.7	38%
North	5143.5	1841.5	36%
South	5143.5	1553.4	30%
Total	22744.6	7682.9	34%

2.1.4. Solar shading analysis

In Prescriptive Method, maximum allowable Solar Heat Gain Co-efficient (SHGC) for Vertical Fenestration is:

- 0.27: For Non-North Façade
- 0.50: For North Façade

In this project, there are overhangs which is the permanent shade for fenestration. As most of the windows have not big overhangs, the effect of shading is less. The maximum allowable SHGC value shall be increased due to shading effect. Here, the maximum allowable SHGC is calculated by multiplying the prescriptive SHGC requirement with the SEF.

Table 3 SHGC

Façade Orientation	Window Type	ECBC Recommended SHGC	Projection Factor (PF)	Shading Equivalent Factor (SEF)	Equivalent SHGC
NORTH	G1	.50	0.99	1.3	0.53
NON-NORTH	G2	.28	0.69	1.66	0.28

2.1.5. Daylight Analysis

Above grade floor areas shall meet or exceed the useful daylight illuminance (UDI) area requirements listed in Table 4.1 for 90% of the potential daylight time in a year. For the ECBC Building compliance as per ECBC 2017, minimum 40% of above grade floor area shall meet the UDI requirement for this project. The Glass with the VLT of more than 30% shall be proposed to be used in this project. Accordingly, the detailed calculation has been performed and placed at Annexure-2.

The Above Grade Floor area has been calculated excluding toilet area. According to the calculation the total % of Daylight Area Meeting the UDI Requirement for 90% of the Time in a Year come up to be around 54%, which meets the ECBC Building Mandatory requirement. Following are couple of screenshots of architectural plans with marked daylight area:

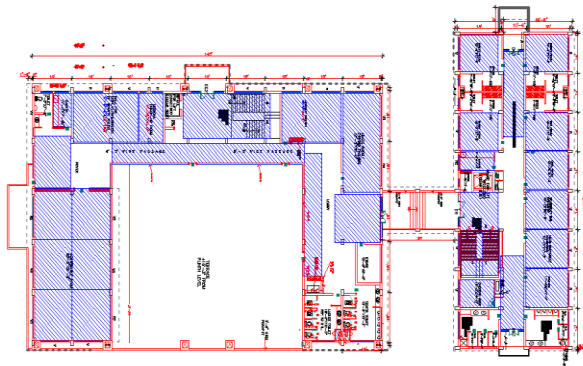


Figure 3: First Floor

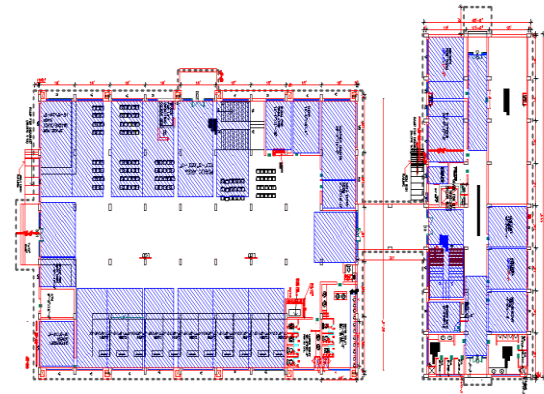


Figure 2: Ground Floor

Table 4 Above Grade area UDI Calculation

Total above grade floor area, m ²		2783.9
Total daylight area per floor meeting UDI requirement during 90% of the year, m ²	TOTAL	1506.0
% of above grade floor area meeting UDI requirements		54%

2.1.6. Glazing Recommendation

Table 5 Glazing Recommendation

GLAZING ASSEMBLY	Specification	Incremental cost (compared to BAU)
Non-North	Assembly layers: a. Toughened Glass (6mm) b. Air Cavity (12mm) c. Toughened Glass (6mm) U-value, W/m ² K: 1.87	Rs 62,19,4.80 (Glass Similar to ECBC Standard Glass)

	SHGC: 0.28 VLT: 23%	
North	Assembly layers: a. Single Glaze Glass U-value, W/m ² K: 5.4 SHGC: 0.53 VLT: 43%	Rs 36,19,480 (Glass Similar to ECBC Standard Glass)

Ecosense Enhance - 6 mm (Solar Control Glass) - 12 mm (airgap) - 6 mm (Clear Low-E Glass/Clear Essence)								
Product Name	Shade	Code	Visible Light			SF	SC	U-Value
			Transmission	Reflection				
				%	External			Internal
Dawn	Clear	SC 26/33	25	21	33	30	0.34	1.88
Spring	Clear	SC 59/52	55	29	27	51	0.59	1.88
Aura	Clear	SC 48/46	45	27	24	43	0.49	1.88
Snow	Clear	SC 21/28	20	26	34	26	0.3	1.88
Nectar	Clear	SC 32/35	31	23	20	32	0.37	1.87
Ivory	Clear	SC 20/25	19	34	22	21	0.24	1.86
Cove	Blue	SH 18/25	17	12	33	22	0.25	1.88
Marine	Blue	SH 38/37	36	19	29	33	0.38	1.88
Bay	Blue	SH 31/34	30	13	34	29	0.34	1.9
Orchid Blue	Blue	SH 13/23	13	14	34	19	0.22	1.88
Indigo	Blue	SH 22/26	20	12	20	23	0.26	1.87
Bluebell	Blue	SH 13/21	12	17	23	17	0.20	1.86
Pine	Green	SN 22/24	21	16	33	21	0.24	1.66
Meadow	Green	SN 49/38	47	25	28	34	0.39	1.88
Coral	Green	SN 39/35	37	20	24	30	0.34	1.88
Jade	Green	SN 18/24	18	20	34	21	0.24	1.88
Lime	Green	SN 27/26	26	18	20	23	0.26	1.87
Citrus	Green	SN 16/21	15	25	24	17	0.20	1.86

Figure 3 Glass Recommendation – Non North

Ecosense Enhance (Solar Control Glass) - 6 mm								
Product Name	Shade	Code	Visible Light			SF	SC	U-Value
			Transmission	Reflection				
				%	External			Internal
Dawn	Clear	SC 26/33	29	18	26	43	0.49	5.4
Spring	Clear	SC 59/52	65	26	26	64	0.73	5.4
Aura	Clear	SC 48/46	53	25	21	58	0.67	5.4
Snow	Clear	SC 21/28	23	26	36	38	0.44	5.4
Nectar	Clear	SC 32/35	37	22	16	45	0.52	4.8
Ivory	Clear	SC 20/25	23	34	19	34	0.39	4.5
Cove	Blue	SH 18/25	20	12	26	36	0.41	5.4
Marine	Blue	SH 38/37	43	17	28	48	0.55	5.4
Bay	Blue	SH 31/34	35	12	22	46	0.53	5.4
Orchid Blue	Blue	SH 13/23	15	14	35	35	0.4	5.4
Indigo	Blue	SH 22/26	24	12	16	38	0.43	4.9
Bluebell	Blue	SH 13/21	14	17	20	32	0.37	4.5
Fine	Green	SN 22/24	25	14	26	35	0.4	5.4
Meadow	Green	SN 49/38	56	22	26	48	0.56	5.4
Coral	Green	SN 39/35	44	19	22	46	0.53	5.4
Jade	Green	SN 18/24	21	20	35	36	0.41	5.4
Lime	Green	SN 27/26	31	17	16	37	0.43	4.8
Citrus	Green	SN 16/21	18	25	21	31	0.36	4.5

Figure 4 Glass Recommendation – North

2.1.7. Summary of recommendations for envelope

- The prescriptive requirement for maximum U-factor (W/m².K) for Opaque External Wall Assembly for this project is 0.425 W/m².K.
- The prescriptive requirement for maximum U-factor (W/m².K) for roof Assembly for this project is 0.33 W/m².K.
- The Overall Effective SHGC for North façade is 0.53 and Non- North façade is .28
- Total daylight area per floor meeting UDI requirement during 90% of the year is 2783.9 m² (54%) which satisfies the ECBC 2017 requirements.

2.3. COMFORT SYSTEMS AND CONTROLS

2.3.1. Mandatory ECBC requirements

2.3.1.1 Natural Ventilation

The project team has designed the building following all the necessary provisions of NBC 2005 including the design guidelines for Natural Ventilation. Since the building type is a business, the natural ventilation is provided such that the building is comfortable without Air-Conditioning.

2.3.1.2 Minimum equipment efficiencies

The project will meet all the minimum equipment efficiency norms under ECBC 2017 for Chillers, unitary AC systems, ceiling fans etc. The project is under design stage; the project will take the necessary measures to meet with ECBC 2017 while designing HVAC Systems.

2.3.1.3 Controls

The project has given all the necessary controls required for heating and cooling equipment's. The dead band between the heating and cooling temperature shall be maintained at 3⁰ C.

2.3.2. Building HVAC design and systems

The project is installing Split AC (Packaged terminal AC) Systems.

2.3.3. Equipment and total system efficiency

Table 6 Equipment Efficiency

Equipment type	ECBC recommended efficiency	System efficiency
Equipment 1 (Split AC)	BEE 3 star rated	BEE 5 star rated

2.3.4. Piping and ductwork

The piping for pipes carrying refrigerants at less than 15⁰ C temperature will have insulation of R value 0.35 Sq. m. K/W or higher.

Table 7: Piping and ductwork insulation

System Description (with operating temperature, °C)	Pipe size (mm)	ECBC recommended R value (m ² .K/W)	R value of insulation used (m ² .K/W)	Thickness of insulation used (mm)
Nitrile Rubber	20mm	1.4	0.35	13 mm

2.3.6. Condensers

The Project team does not utilize any condenser equipment.

2.3.7. Summary of recommendations for HVAC

- The project team has been recommended to install BEE 5 Star rated split ACs.
- The project team was also recommended to Nitrile Rubber for insulation of ducting with a size of 13 mm thickness.

2.3. LIGHTING

2.3.1. Mandatory requirement

The project will install Occupancy Sensors in common areas like corridors, toilets, treatment rooms, and conference rooms and Astronomical time switch will be provided for exterior lighting.

2.3.2. Lighting Power Density

The project has adopted Building Area method. The required LPD for the project is 9.50 W/m² and the project team has proposed to provide 7 W/m² LPD throughout the building interior.

2.3.3. Lighting Control

The project will be using occupancy sensors in the Conference rooms and Common Areas. The occupancy/motion sensors will be installed in the building which specify the accessibility of the occupant in the specific areas mentioned.

Astronomical time switch will be provided for automatic control of exterior lighting. The astronomical time switch will provide maximum energy efficiency which will operate according to the time already defined.

2.3.4. Exterior lighting detail

LED lights will be used in the exterior of the building. All the fixtures used in the exterior part of the building are having minimum efficacy of 80 lumens/watt.

2.3.5. Summary of recommendations for lighting:

- LPD of the proposed case is 7 W/m² as per Building Area method.
- Occupancy sensors will be installed in common areas like Toilets and Conference rooms.
- LED lights with min 80 lm/W shall be used in exterior lighting.
- Astronomical time switch will be used in exterior lighting.

2.4. SERVICE WATER HEATING

The project is a Business type building as the hot water is not required and not mandatory for such type of buildings. Hence, project is not installing any hot water systems in the building.

2.5. RENEWABLE ENERGY

The project has not installed any renewable energy systems, however the project has provided vacant space in the terrace for any future installation of Renewable Energy systems.

2.6. ELECTRICAL

2.6.1. Transformer

11 KV / 433 - 250V 25 KVA Oil core Conventional type Aluminum conductor Distribution Transformers with BEE 5 Star Rating shall be installed in the project to maintain maximum power losses at 50% and full loading capacity. The cut sheet of Transformer is placed at Annexure - 5.

2.6.2. Motors (type, efficiency)

The motors better than IS 12615 rated motors will be installed for plumbing purposes. IS Certified recommended motors improves better energy efficiency and consuming less energy as compared to conventional case.

2.6.3. Diesel generator sets

The project shall install two 320 kVA, 415 V, 50Hz 3 phase water cooled silent type Diesel Generators with 4 Star BEE rating. The cut sheet of DG Set is placed at Annexure - 5.

2.6.4. Check metering and monitoring

A HT side Incomer Panel, Main LT panel load manager to be provided and at the outgoing feeder MFM to be provided. The meters with MFM shall be done for all common loads like HVAC, plumbing, lighting, lifts, etc. All meters with RS 485 port total data from meters will be transferred to computer with the help of software for energy monitoring. The meters can display V, A, kVA, kWh, PF, current, voltage, THD.

2.6.5. Power factor correction

Automatic Power Factor Corrector with capacitor banks shall be provided for maintaining minimum power factor 0.95 to 1. The capacitor shall be of MPP/APP/MDXL type.

2.6.6. Power distribution system

Project will install cables of adequate size to maintain the internal power distribution losses at max 1%.

3. Cost Analysis:

For the increased energy performance of the building, energy efficient materials were used in the building which are not conventionally used. Cost comparison analysis was done for the building systems coming under the scope of ECBC for both the conventional and proposed ECBC complied building. The total investment in the conventional building is Rs. 9,09,29,366 for the building systems coming under the scope of ECBC. As for the proposed building it is Rs. 12,35,92,242. The incremental cost of investment in energy efficient systems is Rs. 3,26,62,876 which is 36% of the BAU.

Since the building is in designing stage, cost reference is taken from the most accepted market price that was taken from market research.

The quantity of tonnage refrigeration required in the building is calculated from the thumb rule accepted in the HVAC industry of 1 TR for 150 ft². This gives a requirement of approximately 233 ton refrigeration for the air conditioned area in the building.

The number of fixtures required in the building were estimated based on LPD. Conventional building has CFL fixtures which amount to an LPD of 12 W/m². For 12 W/m² LPD, 1053 40 watt CFL fixtures will be required. As for proposed case, for an LPD of 7 W/m², 1225 20 W LED fixtures will be required. The detailed cost analysis is shown in the following table.

Table 8: Cost Analysis Table

S.No	Catagorey	Conventional Case	Proposed Case	Cost
1	Wall	230mm thick brick wall	20mm Plaster + 115 mm AAC Block + 20 mm air cavity + 230 mm AAC Block + 20 mm Plaster	
	Wall Area	22744.6	22744.6	
	Cost Per Sqm	1220	1920	
	Total Cost	27748412	43669632	15921220

2	Roof	Heat reflective paint + 35mm Screed + 85mm EPS board Insulation +150mm BBC +150mm R.C.C + 15mm Plaster	20 mm Cement Screed + 150 mm R.C.C Slab + 75 mm XPS insulation + 20 mm Cement Screed + 12 mm Tiles	
	Roof Area	1124	1124	
	Cost Per Sqm	3346	4500	
	Total Cost	3760904	5058000	1297096
3	Fenestration	Single Clear 6 mm thick glass	Double Glazed Unit(6 mm Glass + 12 mm Airgap + 6 mm Glass)	
	Window Area	7682.9	7682.9	
	Cost Per Sqm	6700	7900	
	Total Cost	51475430	60694910	9219480
5	HVAC	Split AC (3 Star)	Split AC (5 Star)	
	Quantity Tonnes (TR)	233	233	
	Cost Per Tonne (TR)	32990	45000	
	Total Cost	7686670	10485000	2798330
	Envelope Sealing (Weather Sealing, Gasketing and Caulking)			
	Quantity (Running Metre)	-	24886	0
	Cost Per Running Metre	-	100	0
	Total Cost	-	2488600	0
	HVAC			

	Timer Based Control	-	150000	
	Variable Speed Drive for Fans	-	150000	
	System/Air Balancing and Commissioning	-		300000
	Solar Water Heating			
	Solar Water Heating system as per ECBC (20% of Hot Water Requirement)	-	-	0
	Lightings	CFL Lights (LPD 12 W/m²)	LED Fixtures (LPD 7 W/m²)	
	No. of Fixtures	1053	1225	
	Cost Per Fixture	150	450	
	Light Fixtures	157950	551250	393300
	Lighting Controls			
	Passive Infrared (PIR) based occupancy sensor with daylight control			
	Quantity (Pcs)	-	45	
	Cost	-	4500	
	Total Cost	-	202500	202500
	Exterior Lighting Controls			
	Astronomical time switch for street light			
	Total Cost	-	12000	12000
	Electrical Systems			
	Energy Metering	40000	40000	40000
	Service Water Pump and Motors	60000	80000	20000
	Low Loss Transformers	Needs to be computed based on actual design after		

		finalizing detailed electrical consumption		
	Power Factor Control	Needs to be computed based on actual design after finalizing detailed electrical consumption		
	Total Cost	90929366	123592242	32662876

Capital Investment	3,26,62,876
Maintenance cost (@1%)	3,26,629
Total Incremental Cost	3,29,89,505

*Note - The above cost details has been referred from market research assessment with various vendor's (manufacturers/suppliers) as per availability & selection of material/product in the state of Haryana.

4. ECBC COMPLIANCE FORMS

ECBC Compliance Forms are placed at Annexure - 4.

5. APPENDIX:

- Annexure I : Architectural Drawings
- Annexure II : Calculations (SEF, DEF & Wall and Roof Sections)
- Annexure III : Cost analysis report
- Annexure IV : Compliance forms
- Annexure V : Cut Sheets

** End of Report**