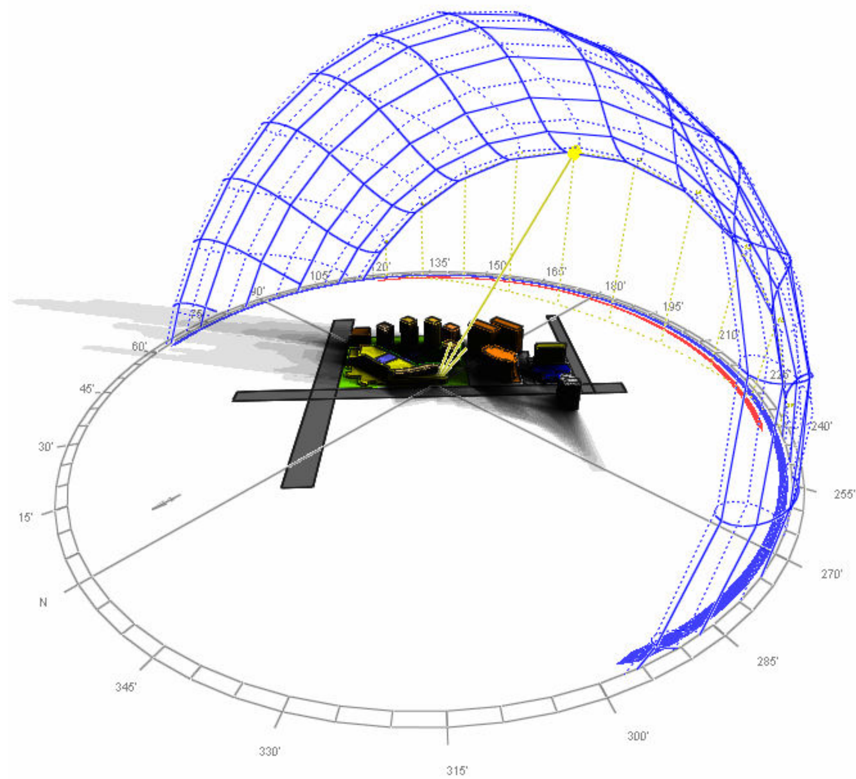
Draft ECBC 2007 Compliance Details &
Energy Efficient Design Assistance - R 1.0

F3 BUILDING AT QUARKCITYTY INDIA PVT. LTD.
Mohali Punjab



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Revision Details

Release 1: The measures are identified and savings are reported.

Preface

This report is prepared by Global Evolutionary Energy Design “GEED India” to assist in the best case energy design of F3 Building situated at QuarkCity Mohali Punjab, INDIA. The report contains results, recommendations and methodology followed in energy analysis and ECBC Compliance Details of the proposed building – Report is primarily based on information provided by Architect and HVAC consultants. The proposed building was analyzed using Dynamic Thermal Modeling and hourly energy simulation to explore opportunities for energy savings in HVAC, and to enhance the thermal comfort of the occupants. The proposed building comprises of 12+2 half floors and 2 basements and a stilt level.

We have used DOE1.2, Energy Modeling Solver as a calculation engine to explore opportunities for energy savings in envelop and orientation, Plant room equipments and to enhance the thermal comfort of the occupants. The proposed site comprises of many building i.e. office blocks, mall and residential towers etc. The envelop optimization is done only for F3 Building which is at construction stage.

The aim of the study is to analyze the passive design of the proposed site and by performing various simulations like lighting; solar isolation and sun shading etc to support the best possible selection decisions for materials. The report presents analysis of several different materials and envelops options. This Draft Report which only indicate the relative saving and the points need discussion before they are finally included.

The other objective of this study is to assess the energy and cost benefits associated with energy-efficient design features focusing on the design and envelope specifications. The study primarily asses the cost benefit of using different type of high performance glazing for efficient façade design.

1 Questions Addressed in the Report

Following question would be addressed in the current report.

1. What is the impact of different wall and roof material on annual energy use?
2. What is the impact of different glazing on annual energy use?
3. What is the impact of shading on annual energy use?
4. What are the ECBC's limiting values of thermal properties for proposed building envelop.
5. What are different plant room efficiency options
6. What is the impact of Evaporative Cooling on Annual energy use
7. what is the impact of putting delighting sensors on annual energy use
8. what is the impact of VFD in Cooling Towers
9. what is the impact of using VFD in AHUs
10. what is the impact of high efficiency chiller

2 Introduction

This F3 building in QuarkCity situated in Mohali Punjab, India is a 50000 m^2 office consisting of 12 floors and about 5400 m^2 of façade. The report contains results, recommendations and methodology followed in energy analysis of the proposed building – Report is primarily based on information provided by Architect and consultants and glass vendors of china and India.

This analysis determine the energy use impact of several energy efficiency measures (EEM) and recommends enhancements to the proposed design budget case model. Estimates for occupancy and schedules were obtained from the standard practice, design team and incorporated into the analysis.

The aim of the study is to analyze and support the decision to select best suitable envelop and plant room product option by optimizing the initial capital with operational losses. The report presents analysis of several different types of available energy efficiency measures which range from poorest to the best available or least to very expensive options. This is a Draft Report and several points need discussion before they are finally included in the Proposed Building design.

3 Weather Data and Design Conditions

Latitude (°N) : 30° 6'

Longitude (°E) : 76° 2'

Altitude (m) : 300

WMO Station : 421820

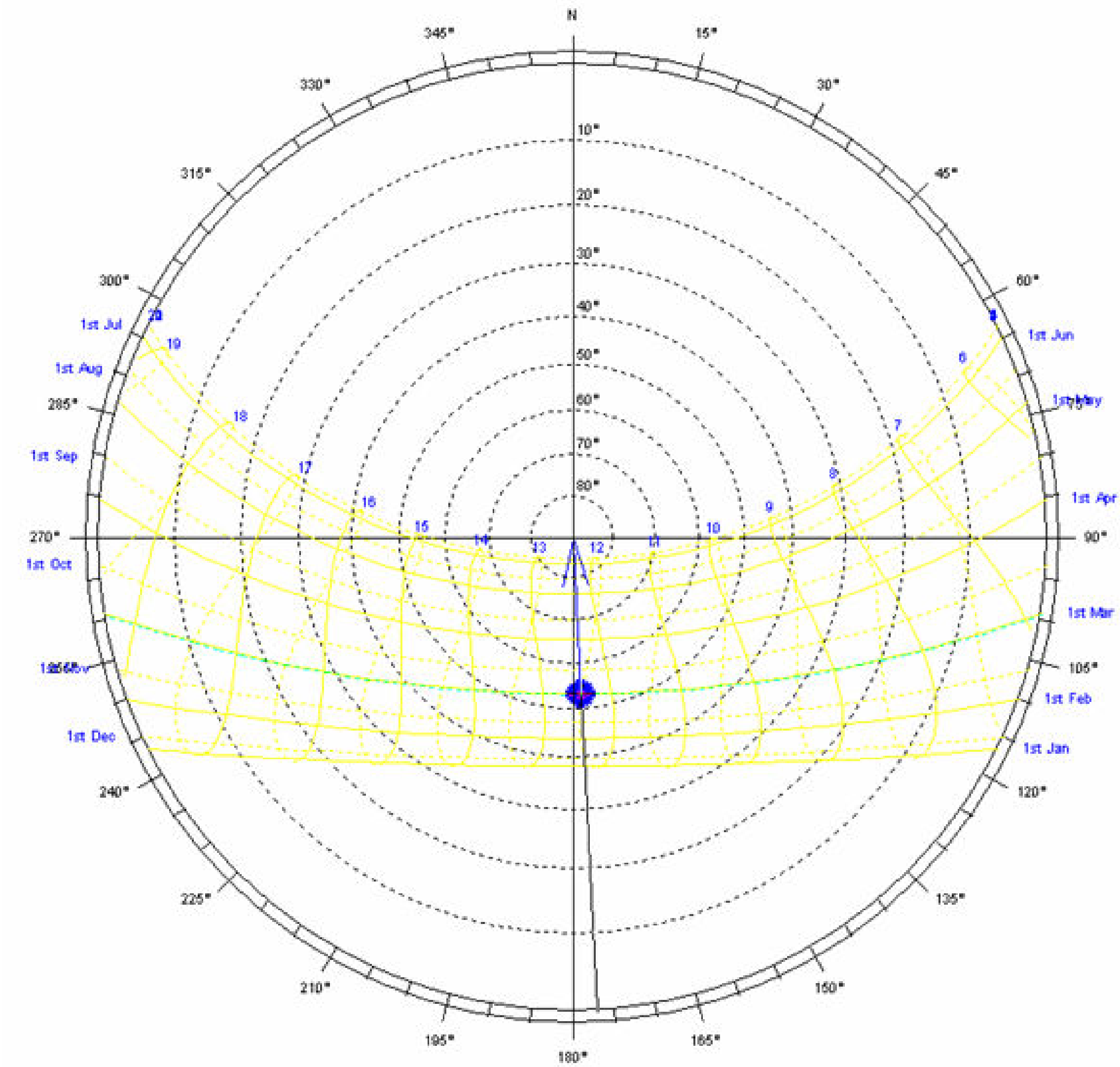

Chart 1. Sun Path Diagram for Delhi

Recorded at Indra Gandhi International Airport weather file in the TMY2 format was used in simulation model. Following table shows the ISHRAE design dry bulb and wet bulb conditions for Delhi.

Table 1 ISHRAE Design Temperatures for Delhi

I	Design Temperatures	
	Dry Bulb	Mean Coincident Wet Bulb
0.4%	42	22.1
1%	40.6	22.6
2%	39.3	22.8

The climate type for the location of subject house is "4B" (ASHRAE Standards 90.1-2004 and 90.2-2004 Climate Zone) Mixed Dry, Probable Köppen classification=BSk/BWh/H, Semiarid Mid Latitude/Arid Subtropical/Highlands with 2721 annual cooling degree-days (18°C baseline) and 278 annual heating degree-days (18°C baseline). This kind of climate has to be designed for efficient cooling.

4 Building Energy Modeling

An energy model is created by creating a thermal and operational model of the proposed building. By changing some parameter the annual energy consumption is compared and reported. This model is not very good for exactly calculating the annual energy use but it can accurately depict the relative changes in terms of percentages etc.

4.1 The Process

The geometry replicating the thermal behavior of the proposed building is created using CAD environment, and the material assignment is done for the different envelop components, then schedule are assigned for occupancy, lighting, cooling system and fans etc. The set point and the environmental parameter are set in the energy model.

Now for each energy efficiency measure the simulations were performed and annual energy consumption is calculated. This annual energy consumption is then compared with the budget case consumption and percentage saving were established.

4.2 The Budget Building

The Budget Building was developed on the basis of the following parameters. The building is simulated with its actual orientation and again after rotating the entire building 90,180,270 degrees, then averaging the results. The Budget Building model input parameters are as follows

Building Envelope

- Exterior Wall Construction: Steel-frame construction, R-13 insulation, U-factor=0.124 Btu/hr.ft^2.ºF
- Roof construction: Insulation entirely above deck, R=15,u-factor=0.063,Roof reflectivity=0.30
- Window to gross wall ratio: 30.6 % , uniformly distributed on all sides
- Fenestration Type:
  - North:
    - U-Value : 6 W/ m^2.ºC
    - SHGC : 0.8
    - VLT : 70%
  - Non North:
    - U-Value : 6 W/ m^2.ºc
    - SHGC : 0.8
    - VLT : 70%
- Shading Device: None

Lighting & Equipment

- An average lighting power density of 11.0 W/m^2 (Whole building area method) and LPD of 4 W/m^2 in parking
- No day lighting controls

System

- A Variable Air Volume (VAV) system with 2 inches of static fan and reset by warmest zone
- No economizer
- No heat recovery
- No Evaporative Cooling

Central Plant

- Water cooled centrifugal chiller with a full load efficiency of 0.576 Kw/T (a COP of 6.0 at ARI conditions)

5 Energy Conservation Measures

A total of 31 energy conservation measures were evaluated. All the ECMs were broadly divided into following three categories

- Envelope: Increasing the envelope's thermal resistance reduces the unwanted heat loss and gain from the outside, thus reducing the energy required for heating and cooling. Insulation also improves thermal comfort in addition to reducing heating and cooling equipment sizes
- Lighting: Lights are a significant part of the total energy use and demand in a building. Good electrical lighting design is one of the most cost effective ways to save energy.
- Central Plant: Use of efficient chillers-types, sizing and selection contributes in reducing the energy use.

5.1 Base Case

The base case was created using the values listed in section 4, energy model and given a saving of 4.3 % over the budget case annual energy consumption value

5.2 Base Case-90

The same case was modeled with the entire building rotated at 90 degree from the proposed design, and depicting a saving of (Negative) 3.55 % over the budget case value

5.3 Base Case-180

The same case listed in section 5.1 was modeled with the entire building rotated at 180 degree from the proposed design, and this depict a saving of (Negative) 2.88 % over the budget case value

5.4 Base Case-270

The same case listed in 5.1 was modeled with the entire building rotated at 270 degree from the proposed design; the above section i.e. from 5.1 to 5.4 proves that the proposed building orientation is the best possible orientation for the building. This case is given a saving of 2 % over the budget case value.

5.5 AAC Wall

Description

This ECM evaluated the impact of using AAC blocks to the base case building. The specification of AAC blocks are as follows

- Conductivity : 0.7 w/ m^2.ºc
- Specific Heat : 214 KJ/ m^2.ºC

The AAC block gives an R-value of 6.85

Results and Recommendations

The result showed 3.99% energy savings over the budget case.

5.6 High Albedo Roof

Description

A typical roof reaches higher temperature in sunlight than a white and reflective roof. With a lower temperature roof, less air conditioning is needed. This ECM models the impact of replacing a typical roof surface with a white reflective surface.

- Conductivity : 3.07 W/ m^2.ºC
- Specific Heat : 395 KJ/ m^2.ºC

Results and Recommendations:

The result showed small energy saving of about 4.5% over the budget case.

5.7 Roof Top Garden

Description

A roof top garden save the roof form reaching higher temperature due to continuous evaporation from the roof filing this assist in reducing the air conditioning load on the building.

- Conductivity : 0.2 W/ m^2.ºC
- Specific Heat : 217 KJ/ m^2.ºC

Results and Recommendations:

The result showed small energy saving of about 3.53% over the budget case.

5.8 9 inch Brick Wall

Description

The energy use impact of using the simple brick with 9 inches thickness is used..

- Conductivity : 2.32 W/ m^2.ºC
- Specific Heat : 109 KJ/ m^2.ºC
- Thickness : 10 inch

Results and Recommendations

The result showed 2.6% energy savings over the budget case.

5.9 HPGI-6CEB12-60S+12A+6C-Ar-SglLowE

Description

For this high performance glazing option following specifications are modeled

- U-factor of 1.44 W/ m^2.ºC,
- SC of 0.46, and
- Visual light transmittance of 55% for all facades

Results and Recommendations:

This ECM also resulted in small energy savings. The result showed 7.3% energy savings over the budget case.

5.10 HPG-II-6CEF15-40S-12A+6C-Ar-SglLowE

Description

For this high performance glazing option following specifications are modeled

- U-factor of 1.499 W/ m2.ºC,
- SC of 0.32, and
- Visual light transmittance of 36% for all facades

Results and Recommendations:

This ECM also resulted in small energy savings. The result showed 8.69% energy savings over the budget case.

5.11 HPG-III-6CEF16-50S+12A+6C-Ar-SglLowE

Description

For this high performance glazing option following specifications are modeled

- U-factor of 1.45 W/ m2.ºC,
- SC of 0.37, and
- Visual light transmittance of 44% for all facades

Results and Recommendations:

This ECM also resulted in small energy savings. The result showed 8.36% energy savings over the budget case.

5.12 HPG-IV-6CED12-78S+12A+6C-Ar-DblLowE

Description

For this high performance glazing option following specifications are modeled

- U-factor of 1.45 W/ m2.ºC,
- SC of 0.37, and
- Visual light transmittance of 44% for all facades

Results and Recommendations:

This ECM also resulted in small energy savings. The result showed 7.77% energy savings over the budget case.

5.13 HPG-V-6CED13-39S+12A+6C-Ar-DblLowE

Description

For this high performance glazing option following specifications are modeled

- U-factor of 1.31 W/ m^2.ºC,
- SC of 0.25, and
- Visual light transmittance of 36% for all facades

Results and Recommendations:

This ECM also resulted in small energy savings. The result showed 9.11% energy savings over the budget case.

5.14 HPG-VI-6CED23-39F+12A+6C-Ar-DblLowE

Description

For this high performance glazing option, following specifications are modeled

- U-factor of 1.31 W/ m^2.ºC,
- SC of 0.22, and
- Visual light transmittance of 30% for all facades

Results and Recommendations:

This ECM also resulted in small energy savings. The result showed 9.34% energy savings over the budget case.

5.15 Heat Recovery

Description

A heat recovery ventilator (HRV) can help make mechanical ventilation more cost effective by reclaiming energy from exhaust airflows. HRVs use heat exchangers to heat or cool incoming fresh air, recapturing 60 to 80 percent of the conditioned temperatures that would otherwise be lost. Models that exchange moisture between the two air streams are referred to as Energy Recovery Ventilators (ERVs). ERVs are especially recommended in climates where cooling loads place strong demands on HVAC systems.

Results and Recommendations:

This ECM also resulted in significant energy savings. The result showed 5.19% energy savings over the budget case.

5.16 Economizer

Description

This ECM evaluated the impact of adding an economizer to AHUs.

Results and Recommendations:

This ECM also resulted in small energy savings. The result showed 3.81% energy savings over the budget case.

5.17 High Efficiency Chiller Water-Cooled

Description

The high efficiency water cooled chillers are modeled and they are showing a considerable saving of 12 %

5.18 Med Efficiency Chiller Air-Cooled

Description

The medium efficiency air cooled chillers are modeled and they are showing a small saving of about 4 %

5.19 Variable Speed Drive Screw Chiller

Description

The VFD Screw chillers are modeled and they are showing a small saving of about negative 2.1 %

5.20 Thermal Energy Storage

Description

The thermal energy storage would be modeled properly in the next release of this document, this would only work better in terms of operation economics. If the tariff differential exist.

5.21 Day Lighting Control

Description

The parameter zone would be receiving the natural lighting from the glazing so day light control sensor and instrumentation would be used for eliminating unnecessary use of electric lighting, the energy model is depicting a saving of 7.17%

5.22 No Secondary Pumping

The energy consequence of no secondary pumping in the chilled water supply is 4.84%

5.23 Cooling Tower VFD

Description

Adding variable frequency drives for cooling tower. This reduces the energy consumption and in some periods may reduce billed demand.

Results and Recommendations:

This ECM also resulted in small energy savings. The result showed 4.45% energy savings over the budget case.

5.24 DHW-Supply VFD

The domestic hot water supply from the basement tanks can be worked out with VFD. This gives a saving of 4.38%

5.25 Evaporative Pre-Cooling

The fresh air would be first cooled by evaporative cooling system to reduce the load on chillers. This system is showing a saving of 2.42%

5.26 Supply-Return Fan

This case would show the consequences of using Supply and return. The annual energy use would be increased by 7%

5.27 Minimum outside Air

The fresh air supply would be regulated based on the occupancy and demand control, sensor like CO_2 etc. the system can be translated into a saving of 5.5%

5.28 High Efficiency Lighting System

Description

The average lighting power density in the base case was 1.0W/ft2. In this ECM, the lighting power density was reduced to 0.8 W/ft2 in service areas such as stairs and toilets.

Results and Recommendations:

Reducing the LPD resulted in further 11.25% reduction in lighting energy usage.

5.29 WWR-10

The window to wall ratio of 10 % overall this show a saving of 8 % over the budget case

5.30 WWR-20

The window to wall ratio of 20 % overall, this shows a saving of 5% over the budget case

5.31 Final - Proposed Option

Selected option recommended in appendix 1, are worked out simultaneously then the combined effect would give a saving of **25 %** over the actual budget case.

6 ECBC Compliance,

Following are the limiting value of the thermal properties for the different envelops components. These values are taken from ECBC 2007 Manual.

6.1 ECBC Limiting Values for the Envelop

The limiting envelop values for the proposed F3 building.

Mass Walls

Description	Net Area (m²)	U-factor (W/m²-°C)
north	2031	0.440
east	2156	0.440
west	2122	0.440
south	5061	0.440

Roofs

Description	Net Area (m²)	U-factor (W/m²-°C)
Steel floor Roofs	2033	0.261
Roof Top Garden	2137	0.261

Windows

Description	Area (m²)	U-factor (W/m²-°C)	SHGC	Orientation	Exterior Shades
north	4428	1.5	0.24	North	None
east	233	1.5	0.24	East	None
west	169	1.5	0.24	West	None
south	1689	1.5	0.24	South	None

7 Results and Conclusion

The results are shown in Appendix 1, table of energy efficiency measures, and there corresponding relative savings. The breakup of different consumption heads is also listed. Appendix 2 contains the general floor plans of the building.

8 Appendix-1- Saving From Individual Energy Conservation Measure

Energy Efficiency Measures and there Corresponding Annual Cost/ Saving Impacts

Alternative	Lights	Equip.	Cooling	Tower	Pumps	Fans	Hot Water	Total	% Saving From Proposed	Saving in KWh / yr	Cost / yr	Comments	Selected(Yes / No)
Base Case-Proposed	1,739,735	3,671,910	2,572,840	131,206	33,815	584,712	11,125	8,745,343	**4.38**	400,438	INR 2,002,190	recommended Case	Yes
Base Case-90	1,739,735	3,671,910	3,093,746	156,981	40,690	755,898	11,125	9,470,085	**-3.55**	-324,304	(INR 1,621,520)	Loss	No
Base Case-180	1,739,735	3,671,910	3,099,058	151,854	39,524	695,746	11,125	9,408,952	**-2.88**	-263,171	(INR 1,315,855)	Loss	No
Base Case-270	1,739,735	3,671,910	2,768,973	138,776	35,638	592,586	11,125	8,958,743	**2.05**	187,038	INR 935,190	recommended Case	No
AAC Wall	1,739,735	3,671,910	2,593,644	133,181	34,467	597,130	11,125	8,781,192	**3.99**	364,589	INR 1,822,945	recommended Case	No
High Albedo Roof	1,739,735	3,671,910	2,559,259	130,744	33,712	581,582	11,125	8,728,067	**4.57**	417,714	INR 2,088,570	recommended Case	Yes
Roof Top Garden	1,739,735	3,671,910	2,621,584	134,159	34,723	607,570	11,125	8,820,806	**3.55**	324,975	INR 1,624,875	recommended Case	Yes
9 inch Brick Wall	1,739,735	3,671,910	2,679,613	138,183	35,768	631,905	11,125	8,908,239	**2.60**	237,542	INR 1,187,710	recommended Case	Yes
HPGI-6CEB12-60S+12A+6C-Ar-SglLowE	1,739,735	3,671,910	2,369,954	120,058	30,966	495,114	11,125	8,438,862	**7.73**	706,919	INR 3,534,595	recommended Case	No
HPG-II-6CEF15-40S-12A+6C-Ar-SglLowE	1,739,735	3,671,910	2,302,719	117,106	30,225	477,990	11,125	8,350,810	**8.69**	794,971	INR 3,974,855	recommended Case	No
HPG-III-6CEF16-50S+12A+6C-Ar-SglLowE	1,739,735	3,671,910	2,325,879	118,050	30,470	483,941	11,125	8,381,110	**8.36**	764,671	INR 3,823,355	recommended Case	No
HPG-IV-6CED12-78S+12A+6C-Ar-DblLowE	1,739,735	3,671,910	2,367,002	119,849	30,900	494,727	11,125	8,435,248	**7.77**	710,533	INR 3,552,665	recommended Case	No
HPG-V-6CED13-39S+12A+6C-Ar-DblLowE	1,739,735	3,671,910	2,275,758	115,922	29,921	468,680	11,125	8,313,051	**9.11**	832,730	INR 4,163,650	recommended Case	Yes
HPG-VI-6CED23-39F+12A+6C-Ar-DblLowE	1,739,735	3,671,910	2,259,590	115,188	29,744	464,014	11,125	8,291,306	**9.34**	854,475	INR 4,272,375	recommended Case	Yes

Heat Recovery	1,739,735	3,671,910	2,503,120	127,758	33,060	584,712	11,125	8,671,420	**5.19**	474,361	INR 2,371,805	recommended Case	Yes
Economizer	1,739,735	3,671,910	2,612,960	139,978	36,610	584,712	11,125	8,797,030	**3.81**	348,751	INR 1,743,755	recommended Case	Yes
High Efficiency Chiller Water Cooled	1,739,735	3,671,910	1,835,779	131,027	33,815	584,712	11,125	8,008,103	**12.44**	1,137,678	INR 5,688,390	recommended Case	Yes
Med Efficiency Chiller Air Cooled	1,739,735	3,671,910	2,659,405	0	33,815	584,712	11,125	8,700,702	**4.87**	445,079	INR 2,225,395	recommended Case	No
Variable Speed Drive Screw Chiller	1,739,735	3,671,910	3,188,143	111,019	33,815	584,712	11,125	9,340,459	**-2.13**	-194,678	(INR 973,390)	Loss	No
Thermal Energy Storage	1,739,735	3,671,910	3,996,530	484,953	136,454	584,712	11,125	10,625,420	**-16.18**	-1479639	(INR 7,398,195)	Loss	No Comment
Day Lighting Control	1,556,380	3,671,910	2,519,272	128,793	33,206	569,270	11,125	8,489,956	**7.17**	655,825	INR 3,279,125	recommended Case	Yes
No Secondary Pumping	1,739,735	3,671,910	2,564,919	130,971	0	584,712	11,125	8,703,372	**4.84**	442,409	INR 2,212,045	recommended Case	No
Cooling Tower VFD	1739735	3671910	2572840	124296	33815	584712	11125	8738433	**4.45**	407,348	INR 2,036,740	recommended Case	Yes
DHW-Supply VFD	1,739,735	3671910	2572840	131206	33,815	584,712	11,125	8,745,343	**4.38**	400,438	INR 2,002,190	recommended Case	No
Evaporative Pre-Cooling	1,739,735	3,671,910	2,737,388	142,238	37,291	584,712	11,125	8,924,399	**2.42**	221,382	INR 1,106,910	recommended Case	Yes
Supply-Return Fan	1,739,735	3,671,910	2,807,550	141,169	36,345	1,420,042	11,125	9,827,876	**-7.46**	-682,095	(INR 3,410,475)	Loss	No
Minimum Outside Air	1,739,735	3,671,910	2,473,689	123,778	31,832	584,712	11,125	8,636,781	**5.57**	509,000	INR 2,545,000	recommended Case	Yes
High Efficiency Lighting System	1,270,323	3,671,910	2,452,716	126,158	32,563	552,119	11,125	8,116,914	**11.25**	1,028,867	INR 5,144,335	recommended Case	Yes
WWR-10	1,739,735	3,671,910	2,342,500	119,220	30,705	495,434	11,125	8,410,629	**8.04**	735,152	INR 3,675,760	recommended Case	No
WWR-20	1,739,735	3,671,910	2,511,178	127,286	32,760	567,091	11,125	8,661,085	**5.30**	484,696	INR 2,423,480	recommended Case	No
Final - Proposed Option	**1,156,359**	**3,671,910**	**1,447,472**	**104,333**	**12,931**	**470,783**	**11,125**	**6,874,913**	**24.83**	**2,270,868**	**INR 11,354,340**	**recommended Case**	**Yes**

Note: The KWh values are derived from the simulation; it is recommended that they should not be understood as it is they are an out come of an un-calibrated energy model, they are derived from ratio or relative saving.

9 Appendix-2- Model Geometry-(Plans)