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Comparison of EPI Ratio/Energy Savings of an Office Building by Energy Simulation – Using Design Builder & Energy Plus

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ABSTRACT: With the rapid growth in urban and suburban communities across the world, Energy consumptions has become the most important aspect in the day to day life. The terms Sustainability, Energy Efficiency, Energy Savings are showing a high significance in Construction Activities. In India, the construction rate has been rapidly increasing through which the requirement of energy demand is also increasing significantly. To achieve sustainable and green design, performance simulations are often used to verify these criteria and modify the design. In India, the Office building sector is growing rapidly at over 9% per year mostly because to the robust expansion in the services sector. According to estimates, the country still has over 50% of its building stock that will exist in 2030 unfinished, which sets it apart from industrialized nations. This paper demonstrates a model of a G+1 Office Building for Energy Simulation. Building energy simulation is carried out by Design Builder software to accomplish the goal by doing Building Geometry, Construction Activities and identification of Zones, Energy Simulations and calculations, EPI Ratio Comparisons for baseline Case and Proposed Case. The Energy simulation is carried out with the codal provisions of ECBC Code Book. The Final Output analyses on a range of design factors in an effort to create a building that is both pleasant and energy-efficient. Analysis was done on building-related parameters that affect how differently the construction systems behave in terms of energy efficiency. Further simulations were conducted utilizing the selected building's shape, material and user behaviour. When base case building models and ECBC building models are compared to evaluate energy consumption, it is discovered that by designing ECBC buildings, annual energy consumption can be lowered by about 28%, according to the final output of the Energy Simulation. The results show that installing thermal insulation in the walls and roof can reduce overall energy consumption in walls by around 15%. When paired with other energy-saving measures, this decrease can reach a significant 8.22%.

KEYWORDS: ECBC, Energy Plus, Design Builder

I. INTRODUCTION

Natural Resources have become more prone to the developmental activities. The Growth of the Building Industry is experiencing a lot of up gradations in terms of thermal comfort thus making an exploitation to the Natural Resources. Lot of Energy is being consumed in the construction development activities due to the significant extraction of Raw Materials. So, reduction of Energy consumption has become a key and important factor in achieving the sustainability of a building or a neighbourhood. The More use of Energy leads to the More use of Electrical Consumption thus making the natural exploitation for the Increased comfort and interest in the sustainability of the building. This is being addressed largely in the developing countries where they will be a huge demand for Energy consumption. It is anticipated that India's energy needs would increase significantly faster than the 2% global growth rate. Given that buildings use more than one-third of all energy, they present one of the biggest opportunities to promote energy conservation. India will need to improve its energy efficiency in addition to reassessing its current building stock because it has finite energy supplies. India is aiming to provide more and more energy-efficient buildings for the next decade. In terms of Urbanization, It is anticipated that over 215 million people would move from rural to congested metropolitan areas. This increase in standard of living, building construction leads to drastic increment of energy use overall. Building efficiency is crucial to ensuring sustainable urban settings. Secondly, by 2035 Energy Security in India's energy consumption is expected to increase or triple. India now imports 59% of its oil, 24% of its natural gas, and 17% of its coal needs, as per the Energy Information Administration. India's need on expensive fuel imports will be lessened as a result of increased building efficiency, which will allow the country to satisfy its growing energy needs with the same or even less energy than it already uses. The next parameter in consideration is Reducing Power outages



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and taking Climate Change Seriously. The Central Electricity Authority of India reports that there is now a 14.25 percent nationwide shortfall of electricity and a 19.75 percent shortage during peak demand. This disparity causes frequent power outages, particularly in buildings, and in certain regions, shortages of over 24 percent of peak demand. According to the Indian government, implementing efficiency measures across the sector would avert a rise in demand equal to 24,258 megawatts. From an energy-saving perspective, a Office building is taken into consideration where building energy simulation is used to analyse energy usage and energy savings. With the energy modelling application, we can reduce our energy costs by five to twenty percent. The export of electricity has increased from 153.53 GWh in 2012-13 to 9231.63 GWh in 2021-22(P) with a CAGR of 57.64%.



Figure1 Trends of Imports of coal, Crude Oil and in India

Figure2 Trends of Imports of Natural Gas and Electricity

Petroleum products in India as per Energy Statistics 2023¹

per Energy Statistics 2023¹

II. CODAL PROVISIONS AND TERMINOLOGIES

ENERGY CONSERVATION BUILDING CODE:

ECBC defines norms of energy performance for various building components, and takes into consideration the climatic region. The application of these norms lowers the building's energy requirement without affecting the function, comfort, health or productivity of the occupants. BEE has launched a new version of code ECBC 2017 on 19th June 2017. The newly developed code is futuristic, pragmatic and easy to implement. The new version of Code is geared to encourage public and private sectors to not only meet the basic ECBC criteria, but to exceed them as well. Long-term success of the ECBC will depend heavily on the collaborative roles that various stakeholders would play towards the development, adoption and implementation of building code.

Having regard to the fact that the rate of growth in the Office building sector is amongst the highest and this sector needs to be moderated in its energy consumption, BEE introduced the Energy Conservation Building Code (ECBC) as a voluntary policy measure in 2007 to reduce the adverse impact of buildings on the environment².

- AHU Air Handling Unit- It is the main component that is responsible for removal of air and dust particles and Supplying the fresh air and comfortable air into the rooms through ducts.
- ACH Air Change per Hour It is a measure that will defines how many times air can be replaced and supplied within a specified time and in specified area.
- COP Coefficient of Performance It is the ratio of useful heating or cooling provided to Energy Required³
- HVAC Heating Ventilating and Air Conditioning
- SHGC Solar Heat Gain Coefficient Solar heat gain coefficient (SHGC) is the fraction of solar radiation admitted through a window, door, or skylight -- either transmitted directly and/or absorbed and subsequently released as heat inside a home. The lower the SHGC, the less solar heat it transmits and the greater it's shading

ability⁴

- U Value- It is the thermal transmittance of a Material It is a measure of how a material can prevent or obstruct heat between the inner face and outer face of the buildings.
- R Value- It is the capacity or resistance of an insulating material to hold the heat flow generated.

WWR- Window Wall Ratio



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VT – Visible Transmittance – It is the ratio of the visible sunlight spectrum to the amount of light passed through the Eye of a person.

BASE CASE: It is the Simulation carried in the Energy consumption of the Building which is carried out as per the specifications and prescribed values given in ECBC Case or any other relevant Codes.

PROPOSED CASE: It is the Simulation carried in the Energy consumption of the building which is carried out to meet or reduce the overall performance of the building when compared to Base Case of the Simulation.

III. PROJECT DESCRIPTION

The Building is a G+1 Office Building located in core area of the Nellore City. The Building area is 512 m². The Latitude and Longitude Co-ordinates of the city are 14.45° , 79.98° . It is located at elevation of 20.0 Mts from Sea Level. It is having a Core zone and Perimeter Zone.



Figure3 Building Geometry



Figure4 Zonal Classification

The building is having a wall area of 1344.00 m2, window area is 576.00 m2 which is approximate 30% of wall area. The windows used in this model are single glazing window type, and ceiling height of both Ground and First floor is 3.00 m. The Working Schedule is 8:00 A.M. to 8:00 PM. building working hours.

Description	Units	Base Case	Proposed Case
Site			
Location		Nellore	Nellore
Weather File		India- Nellore-ISHRAE	India- Nellore-ISHRAE
Usage of the		G+1 Office	G+1 Office
Building			
Floor Area	Sq. Mt	512.00	512.00
Floor Height	Mt	3.00	3.00
WWR		40%	65%
Shading		No Shading	0.90 Mt Overhang Projection
Wall U-Value	W/ Sq.m.K	0.40	0.27
Roof U-Value	W/ Sq.m.K	0.33	0.25
Floor U-Value	W/ Sq.m.K	2.729	1.80
Fenestrations			
SHGC		0.635	0.37
VLT		0.721	0.69
U Value	W/ Sq.m.K	1.934	1.50
Lighting		No	Yes
Controls			
Power Density	W/ Sq.m	10.76 for 100 LUX	7.25 for 100 LUX
HVAC System		Air Cooled Chiller	VRF
Building Floor Area Floor Height WWR Shading Wall U-Value Roof U-Value Floor U-Value Floor U-Value Fenestrations SHGC VLT U Value Lighting Controls Power Density HVAC System	Sq. Mt Mt W/ Sq.m.K W/ Sq.m.K W/ Sq.m.K W/ Sq.m.K W/ Sq.m.K	512.00 3.00 40% No Shading 0.40 0.33 2.729 0.635 0.721 1.934 No 10.76 for 100 LUX Air Cooled Chiller	512.00 3.00 65% 0.90 Mt Overhang Projection 0.27 0.25 1.80 0.37 0.69 1.50 Yes 7.25 for 100 LUX VRF

INPUT DATA FOR BOTH BASE CASE AND PROPOSED CASE⁵:



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СОР	W/W	0.85	2.25
Cooling COP	W/W	1.80	3.60

PROCESS OF DOING SIMULATION

The methodology adopted in this case study is made up in two steps. In step 1, the base line considerations are adopted i.e., Wall, Roof and Glass U Values are defined based upon ECBC codal provisions. The Glazing Fenestration details, lighting, Computer equipment's load, Office loads are taken. The Templates considered in Base case and ECBC Case should not change, however material specifications considered in base case will be altered as per ECBC Mandatory Compliance during simulation. The Template Considered in this paper is Office- Open Plan. The Occupancy considered is 18.58 People/Sq. Mt. The Schedules considered here are 8:00 A.M. to 8:00 PM. Computer and Office Equipment loads (W/M²) are considered as per the requirements. The Wall Considered in Base case is ACC Block with Cement Plaster in between the ACC Block.

BASE CASE PARAMETERS:

Component	Materials Used
Wall	ACC Block, Cement Plaster, ACC Block
Roof	Concrete Dense
Floors	Tiles, Cement Plaster, Concrete slab, Insulation Material
Openings- Fenestration	Glazed, 1.50 Meters, Window to Wall Ratio as per Case.
Shading	No Shading is considered.
HVAC	Air Cooled Chiller









Figure7 Roof Construction- Base Case

Figure6 Wall Construction- Base Case



Figure8 Visualization of the Model- Base Case

Base Case Simulation Results:

In Base case, Simulation is carried out annually. The simulation results are also checked for monthly, daily & Hourly analysis.

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Results Obtained from Base Case Model Analysis:

ENVELOPE

Window-Wall Ratio					
	Total	North (315 to 45 deg)	East (45 to 135 deg)	South (135 to 225 deg)	West (225 to 315 deg)
Gross Wall Area [m2]	576.00	192.00	96.00	192.00	96.00
Above Ground Wall Area [m2]	576.00	192.00	96.00	192.00	96.00
Window Opening Area [m2]	166.54	55.80	27.48	55.80	27.48
Gross Window-Wall Ratio [%]	28.91	29.06	28.62	29.06	28.62
Above Ground Window-Wall Ratio [%]	28.91	29.06	28.62	29.06	28.62
Conditioned Window-Wall Ratio					
	Total	North (315 to 45 deg)	East (45 to 135 deg)	South (135 to 225 deg)	West (225 to 315 deg)
Gross Wall Area [m2]	576.00	192.00	96.00	192.00	96.00
Above Ground Wall Area [m2]	576.00	192.00	96.00	192.00	96.00
Window Opening Area [m2]	166.54	55.80	27.48	55.80	27.48
Gross Window-Wall Ratio [%]	28.91	29.06	28.62	29.06	28.62
Above Ground Window-Wall Ratio [%]	28,91	29.06	28.62	29.06	28.62

Table1: Window to Wall Ratio





Table2: Site and Source Energy



Graph1: Peak Heating Sensible Heat Gain



Graph3: Zone Summary

Table3:	Annual	Heat	Gain	Components
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Graph2: Zone Sensible Cooling



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Steady-state Summ	107										Analysis	Sumay	1																
Block	Zone	Comfort Te	nperature (*C) Steady-State Heat Loss	Design Capacity (KHI)	Design Capacity (Win2)	Diazing Gains	- Wall Gains (KW)	Floor Gains (WV) Root and	celle. Verblation Ge	. Infibration Gain.	Zone	Block	Design Ca	Design Filter	Total Casi	Sensible (k	Labort (R	Ak Tenpera	at. Runiday (%) Time of Hax Co	ool. Nax Op 1	Fibor Area I	in. Volume (in	FONFD.	Design Con	Outside 1	a Gazing Gal	na Wat Gai	Floor Gains (KW)
Building 1 Total Des	ign Heating Capacity × 917.7.	20 (KW)									-Building 1					-	-					_							-
- OF 1 Total Desig	# Heating Capacity = 230.26	0.009									Zone 1	OF 1	90.44	4.313	78.65	54.39	24.25	24.00	79.2	Jun 15:00	32.41	10.363	31,069	416,241	8727 654	41.30	0.00	0.72	-1.22
GF 1	Zone 1	21.27	3.96	4.95	477.3035	0.000	-0.029	-0.106 0.013	-3.823	-0.012	Receptor	14	91.12	4.129	79.74	54.58	24.65	24.00	78.9	Jun 15:00	2272	10.563	31.059	417 697	\$783 090	41.30	2.00	0.84	.1.19
GF 1	Zone 3	20.99	98.53	20.41	478.1216	-4.085	-0.048	-0.385 0.053	-15.814	-0.048	Then 1	1011	95.73	4.472	83.25	55.00	27.95	24.00	78.6	Jun 15-00	16.00	10.363	30.053	477 721	6738 834	41.00	8.00	1.03	4.50
OF 1	Zone 4	20.99	16.52	20.45	476.0154	-1.083	-0.046	-0.387 0.054	-15.814	-0.048	Danie I	er.	AL AP	4.070	17.44	10.00	17.40	21.00	79.4	100 10 10	36.10	10.000	58.065	100 000	1010 100	44.00	1.00	100	4.00
G# 1	Zone 5	20.95	27.25	34.05	474,4375	-0.105	-0.056	-0.621 0.094	-26.458	-0.081	Treed	001	23.29	17.407	22.44	30.50	21.90	24.00	12.8	100 12 22	20.10	10.000	418 554	420.220	8338.800	41.00	1.00	1.02	-9.23
GF 1	Zone 6	20.97	27.24	54.06	474.3345	-0.101	-0.052	-0.624 0.095	-28.488	-0.001	aure -	or i	100.00	17,007	248.14	269.01	00.00	24.00	012	200 12.00	22.44	42.000	140.004	401.000	4444 544	41.00	1.00	-141	1.01
GF 1	Zone 2	20.95	93.11	116.38	470.0722	0.000	0.029	-1,824 0.310	-91.341	-0.280	Zone 3	er.	351.A/	17.4/6	210.04	220.51	90.47	24.00	81.5	100 12:00	33.10	42.065	125.584	407.050	\$339.509	41.30	1/4	-1.02	-0.42
HOF Total Design	Heating Capacity = 230,200	(WV)			12						Zone 3	GF 1	358.95	17,491	311.44	220.56	90.88	24.00	81.2	Jun 15:00	33.92	42,865	128.594	408.048	\$355.968	41.30	2.09	-1.14	-7.14
QF	Reception	21.27	3.96	4.95	477.2964	0.000	-6.029	-0.108 0.013	-3.823	-0.012	Zone 2	G,	390.57	17.543	313.54	221.23	92.31	24.00	68.9	Jun 15:00	34,44	42.865	128.584	409.276	8411,788	41.30	2.58	-1.35	-4.52
GF	Zone 2	20.99	16.33	20.41	476.1216	-1.005	-0.048	-0.365 0.053	-15.814	-0.048	Zone 4	FF 1	376.09	17.886	327.04	225.55	101.49	24.00	79.0	Jun 15:00	37.34	42,865	124.388	417,270	8773.990	41.30	1,65	-1,40	-2.22
GF	Zone 3	20.99	18.52	20.43	476.0154	-4.083	-0.048	-0.387 0.054	-15.814	-0.048	Zone 3	11	377.36	17.914	328.14	225.90	102.24	24.00	75.5	Jun 15:00	37.53	42.885	124.308	417.929	8803.518	41.30	1.54	-1.18	-1.55
GF	Zone 4	20.96	27.25	34.06	474.4375	-0.105	-0.056	-0.621 0.094	-26.488	-0.081	Zone 3	FF 1	378.46	17.939	329.09	226.21	102.88	24.00	78.7	Jun 15:00	37,79	42,865	124 308	418,499	8829.968	41.30	1,57	-1.33	-2.32
OP .	Zone 5	20.97	27.24	34.05	474.3545	-0.101	-0.052	-0.624 0.095	-26.488	-0.001	Zone 2	FF	381.68	18.011	331.90	227.12	104.77	24.00	78.3	Jun 15:00	38.46	42.865	124.305	420.181	6804.257	41.30	2.55	-1.57	-3.78
QF	Zone 8	20.95	93.10	116.38	470.0596	0.000	6.029	-1.818 0.386	-91.341	-0.260	Zone 5	QF	591.40	25.111	514,26	367.10	147.16	24.00	81.9	Jun 15:00	34.00	71.796	215.388	405.473	8237,229	41.30	2.36	-1.61	-11.72
HFF 1 Total Desig	Heating Capacity = 228 600	1.0007									Zone 4	OF	594.72	25.183	517.54	368.01	149.14	24.00	81.6	Jun 15:00	34.45	71.796	215,388	406.475	\$253.374	41.30	2.76	-1.49	-12.21
FF 1	Zone 2	21.32	92.55	115.68	467.2439	000.0	0.023	-0.310 -0.644	-91.341	-0.274	Zone 6	OF 1	595.39	25.158	517.73	368.19	149.54	24.00	81.6	Jun 15:00	34.56	71,796	215 388	406.680	8292 790	41.30	2.33	-1.34	-11.51
FF 1	Zone 6	21.28	27.03	33.79	470 5752	-0.111	-0.061	-0.095 -0.201	-28.488	-0.079	Zore 5	CE 1	600.29	25.325	521.99	360 54	152.45	24.00	812	Jun 15:00	35.29	71.794	215 389	435 168	8381 809	41.30	3.77	.175	15.04
FF 1	Zone 5	21.27	27.03	33.79	473.6846	-0.115	-0.065	-0.094 -0.299	-26.488	-2.079	71005	-	626.64	25.868	543.92	375 54	167.18	24.00	79.3	lun 15:00	38.45	71 754	204 215	415 898	8212 344	41.90	2.06	-155	-1.14
FF 1	Zone 4	21.29	\$6.18	20.23	471.8398	-4.089	-0.053	-0.054 -0.124	-15.814	-0.047	Zread	FF	620.40	20.545	547.30	377.66	165.73	24.00	79.0	Jun 15-65	2.00	71754	268.215	417 110	\$287 779	41.90	2.44	178	4.82
FF 1	Zone 3	21.28	96.10	20.23	471.9521	-1.092	-0.055	-0.053 -0.123	-15.814	-0.047	Treat	-	430.73	10.004	647.60	277 12	100.07	34.05	75.0	Ine 12 M	36.65	71.754	104 148	417 300	6774 BBC	41.00	1.01	1.00	147
FF 1	Zone 1	21.58	3.90	4.55	470.5801	0.000	-0.023	-0.013 -0.031	-3.823	-0.011	20101		444.44	40.004	200.00	317.74	100.00	01.00	18.0	201112.00	30.83	24.244	699.619	411.200	0111.000	41.00	2.00	-1.04	
-FF Total Design	Hosting Capacity - 228.600 (WV)									Zone S	re 1	93630	30.775	353.65	31812	124.10	24.00	785	201 12:00	38.39	11/90	206,210	415.443	00/1.339	41.30	2.41	-2.11	-0.00
17	Zone 6	21.32	92.54	115.68	457.2274	000.0	0.023	-0.306 -0.645	-91.341	-0.274	2014 2	ur1	101223	995.00	1049.77	1256.50	491.27	24.00	64.5	201 15:00	2644	287.584	/42.752	433.097	8127,470	41.30	100	-171	-40.85
FF	Zone 5	21.28	27.03	33.79	470.5752	-0.111	-0.061	-0.201	-28.488	-0.079	Zore 6	8	2012.56	99,008	1750.05	1256.59	491.47	24.00	82.5	Jun 15:00	36.46	247.584	742.752	403.128	5128.812	41.30	0.00	-1.59	-45.80
FF	Zone 4	21.27	27.00	33.79	472.6046	-0.115	-0.005	-0.290	-26.488	-0.079	Zone 2	FF 1	2148.52	102,781	1968.28	1296.09	572.19	24.00	79.5	Jun 15:00	43.56	247 584	717.993	415.137	8677.951	41.30	0.00	-2.21	-17.01
ft.	Zone 3	21.29	16.18	20.23	471.8396	-1.009	-0.053	-0.054 -0.124	-15.814	-0.047	Zone 6	ff	2145.12	182,795	1868.80	1298.25	572.55	24.00	79.5	Jun 15:00	43.60	247.584	717.993	415.191	8680.372	41.30	0.00	-2.21	-18.84
FF	Zone 2	21.28	16.18	20.23	471.9521	-0.092	-0.055	-0.053 -0.123	-15.814	-0.047	Totals		16545.10	801.078	14387.05	10101.72	4285.32	24.90	88.6	Jun 15:00	43.90	1543.076	5749.774	411,864	8488.691	0.99	36.85	-27.90	-235.53
11	Reception	21.56	3.50	4.88	470.5652	0.000	-0.023	-0.013 -0.031	-3.623	-0.011																			

Table4: Heat Gains in all Zones

Table5: Cooling Gains in all Zones

It is evident from the simulation results obtained in the base case of the Building, that the Energy consumed is 258 MWh. So to reduce the Energy consumption in the building, specification changes in the material are carried out to reduce the Overall Energy Consumption of the Building.

ANALYSIS DATA:

For analyzing the energy consumption in Base case, the building is oriented in all directions i.e., $0^0 90^0 180^0 270^0$. So, the Energy Consumption generated in all the cases will be taken as average for Base Case Energy Consumption. The Proposed case will be compared with the Base case for Energy Consumptions and check whether the Proposed case.

						Cite and Course Eng	NO1				
Window-Wall Ratio						SILE dilu Source che	agy				
	Total	North (315 to 45 deg)	East (45 to 135 deg)	South (135 to 225 deg)	West (225 to 315 deg)						
Gross Wall Area [m2]	576.00	192.00	96.00	192.00	96.00		T. I. Ruda	r a ruladh a fluit a	r a a hu ladh a fluit al		
Above Ground Wall Area [m2]	576.00	192.00	96.00	192.00	96.00		lotal Energy [kWh]	Energy Per Total Building Area (kWh/m2)	Energy Per Conditioned Building Area [kWh/m2]		
Window Opening Area [m2]	325.21	107.74	54.86	107.74	54.86						
Gross Window-Wall Ratio [%]	56.46	56.12	57.15	56.12	57.15	Total Cita Enarmy	010000710	0/02 22	0/02 22		
Above Ground Window-Wal Ratio [%]	56.46	56.12	57.15	56.12	57.15	Total site Lifelyy	013077113	0103.22	0103.22		
Conditioned Window-Wall Ratio						Net Site Energy	8198227.13	8483.22	8483.22		
	Total	North (315 to 45 deg)	East (45 to 135 deg)	South (135 to 225 deg)	West (225 to 315 deg)	3					
Gross Wall Area [m2]	576.00	192,00	96.00	192.00	96.00	Total Source Energy	8767620.85	Q072 41	9072 41		
Above Ground Wal Area [m2]	576.00	192.00	96.00	192.00	96.00	Total boardo citory	0/0/020/05	2016.11	2072412		
Window Opening Area [m2]	325.21	107.74	54.86	107.74	54.86	202 2					
Gross Window-Wal Ratio [%]	56.46	56.12	57.15	56.12	57.15	Net Source Energy	8767620.85	9072.41	9072,41		
Above Ground Window-Wal Ratio [%]	56.46	56.12	57.15	56.12	57.15	01	0.000	2003			

Results Obtained from PROPOSED CASE Model Analysis:

Table6: Window to Wall Ratio





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	HVAC Zone Eq & Other Sensible Air Heating [ldth]	HVAC Zone Eq & Other Sensble Air Cooling [k0h]	HVAC Terninal Unit Sensible AirHeating [idth]	HVAC Terninal Unit Sensible Air Goolog [idsh]	HUAC Input Heated Surface Heating [Wh]	HUAC Input Cooled Surface Cooling [kth]	People Sensible Host Addition [kth5]	Lights Sensible Heat Addition [kth]	Equipment Sensible Heat Addition [idth]	Window Heat Addition [kWh]	Intensone Air Transfer Heat Addition [kWh]	Infitution Heat Addition [Mith]	Opaque Surface Conduction and Other Heat Addition [kWb]	Equipment Sensible Heat Removal [eth]	Wedow Heat Renoval [kth]	laterzone Ar TransferHeat Removal [kith]	Infibration Heat Removal [KMb]	Opaque Surface Conduction and Other Heat Removal (Jdth)
GEARECERTION	0.00	-76.8	1.00	0.000	0.000	1.011	751.00	4.574	7,720	0.00	1.00	6.115	1.518	0.00	0.000	0.000	4,41	64
(F20)65	110	1208.55	0.000	0.000	0.000	1.001	14172,836	1834	174,685	0.00	1.00	147.229	1074	0.000	0.00	0.000	41.67	-2547.36
GR201EI	630	-2115.15	1.00	0.000	0.000	130	263247	4,99	30.052	201.546	1.00	23.060	1834	0.000	-725	0.000	-1.8	571.28
(F20162	130	-2115-25	5.000	0.000	0.000	1.001	2438247	3.952	30.052	202.012	0.000	23.87	1932	0.00	-7,6	0.000	-3.95	-570,74
9720164	6300	-312.77	1.000	0.000	0.000	1.001	4090.755	7.25	50.420	23,66	0.000	38.987	1.822	0.890	-12.85	0.000	4.63	423.30
(F20)E	6.000	-512.3	6.000	0.000	0.000	1.000	4290.755	8.216	52.420	24.93	0.00	40.06	1.749	0.000	-12.8	2.000	6.60	431.62
FREEPTION	1300	-797.85	1.000	0.000	0.000	1.000	758.000	4374	7.312	1.00	0.000	4578	28,993	0.000	0.00	0.000	-7.18	6300
FF20165	1.00	4383	1400	0.00	0.000	100	14172.836	18.84	174,685	0.00	1.00	119.542	11.094	0.00	0.000	0.00	421.34	-645.21
FF20NEI	1.00	-38.5	0.000	0.000	0.000	1.000	268.247	4,635	30.052	174,399	0.000	18.478	2.052	0.000	-21.02	0.000	-11.36	-34.0
FR201E2	130	08.0	1.00	0.000	0.000	1.001	268267	3.901	30.052	175,681	0.000	18.555	2,160	0.00	-21.27	0.000	-11.48	-3457
FF20164	130	-951.92	0.00	0.000	0.000	130	4090.755	6367	50.420	237.415	3.890	31.810	3.801	0.000	-3154	0.000	-21,49	41132
#20165	130	-3950.60	1.000	0.000	0.000	100	4090.755	7.583	51,430	135.504	0.00	31,887	1.755	0.00	-11.8	0.000	-11.39	49.3
Tetal Roby	1,000	51222.94	1.000	0.000	0.000	1,001	55977.701	24.747	665,290	1774-67	0.00	504,813	55,704	1.00	-142.83	0.000	18.3	765.74

Graph6: Zone Summary- for selected zones

Table8: Annual Heat Gain Components

Comparison of Energy Consumption- Energy per Total Building Area- Base Case and Proposed Case [kWh/m2]

S.No	Description	AVERAGE BASE CASE	PROPOSED CASE	% of Energy Saving
1	Net Site Energy	9200.68	8483.22	7.78%
2	Net Source Energy	9885.39	9072.41	8.22%

OBSERVATIONS:

- 1. The Utility usage of the building is reduced by 26 [kWh/m2] upon comparison with the Base Case.
- 2. The Energy usage by Electricity is lower than the base case.
- 3. As U-Value of the material is lower than the base case, the Energy consumption has reduced.
- 4. With the addition of Insulation Materials, Rockwool (Standard Board) in the walls has significantly reduced the overall energy consumption for the walls.





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RECOMMENDATIONS:

The U- value of a Material is having a significant impact in the Energy Consumption of the Building. Lower the U-Value, higher will be the performance of the building. The Double Glazing or triple glazing will show most impact in the Energy Performance of the glass. The Site location has the highest impact on Energy usage consumption on Cooling and Heating Gains for the entire annual usage simulation. Based upon the COP requirements for Heating and Cooling, HVAC System is to be selected for Higher Performance of the building.

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