Energy Efficiency Analysis for a High Rise Office Building in Indian Hot and Dry Climate by eQUEST

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Abstract— Building Simulation is widely used for understanding how a building consumes energy and before to construct the building can analyze the performance and whole building energy consumption in different space area of building also for assessing design strategies aimed at improving energy efficiency of entire building. The present research study uses eQuest, popular simulation software. eQuest is an easy to use building energy analysis tool combining a building creation wizard, an energy efficiency measure wizard and a graphical result display module with an enhanced DOE-2.1 derived building energy simulation program. This paper is based on a case study of a commercial building have a total build-up area including four floor which contains training and seminar rooms, conference rooms, open offices, server/utility spaces approximately 1,10,448 ft2. is located in MAHINDRA SEZ, JAIPUR. All Proposed HVAC systems and related parameters, such as equipment capacities, efficiencies, airflows, fans, etc. Have been modelled as designed and are consistent with energy model reflects the architectural, lighting and HVAC parameters as consistent with the relevant plans. The base-case building is simulated with actual orientation and again after rotating the entire Building by 90, 180 & 270 Degree and then averaging the results to get the Base-case Energy consumption. The energy performance has to be quantified and compared to a Base-case Building that complies with ASHRAE Standard 90.1-2010.After compare to proposed case and base case the building achieving 38.4 % of energy savings in entire one year.

Keywords: High Rise Office Building, eQUEST, USGBC (LEED)

I. INTRODUCTION

Building industry is one of the largest consumers of energy and thus has a high potential of saving the consumption as well. Presently, the residential and commercial areas have about 30% (22% residential and 8% commercial) of total electricity utilization and expenditure in these sectors is increasing about 8% yearly (Dr Satish Kumar, USAID ECO - III Project, 2011). As energy expenditure from residential buildings is portend to increase by greater than eight times up to year 2050 under the business as usual as present situation, it is of main importance for India to buildup energy-efficiency techniques highlighted on the residential sector to restrict the current fashion of unsustainable higher energy demand. The Bureau of Energy Efficiency (BEE) has carried out energy audits in buildings which show that existing buildings have 30 to 50 percent energy savings potential. This study tries to understand the energy preservation in residential sector and the ways to minimize it through the identification of suitable electrical equipment and appliances. This study tells about the energy consumption pattern in residential areas in India and tries to search the theory of energy optimization

Now a days the challenge or task for engineers and architecture to reduce the energy consumption of commercial building without compromising the building feature, envelop. [1] In a commercial building mostly of energy are utilize in electrical equipment, HVAC (heating, ventilation, and air conditioning, and by modification of these parameters we can save the energy in any building. [2] By the developing country like USA, CHINA and UK, start many study to reduce the energy consumption in building, and many technology are adopt to improve building efficiency and lightning. [3, 4] To achieving the energy efficiency in building sector need to apply energy policy and to adopt the policies, these policies may work as long term. [5] By the present day technology, and proper energy utilization, building energy efficient can be optimized. By the study of building in different climate zone conclude that to adopt the HVAC system by thermal comfort requirement in winter and hot climate we can save the energy. [6] To change building equipment and construction strategy can achieve the energy efficiency also reduce the peak load demand and adopt the peak load saving. [7] To protect and preserve the valuable resource mean to adopt the energy efficiency, energy conservation is the greatest contribution in our society and our country. [8] Existing design and technology have potential to improve energy quality in commercial building. By adopt building envelop design, improve the HVAC system, improve the lightning system technique achieve the energy efficiency in upcoming building. To modify these parameters we can save 20% of energy in building. Existing buildings also adopt these technologies and reconstruct these parameters. By the case study find that energy utilization in a commercial building in different part is around 26% in air conditioned, 19% in food preservation, 19% illumination, 13% heating. So to control the parameter we can achieve energy efficiency. [9] If construct the sustainable building than more than 30% energy can be saved. To move toward sustainable in commercial building optimize the building envelop, HVAC, and lightning. [10, 11] According to the study in South Africa around 20 percentage of all generated electricity are used in commercial building. If air conditioned is include in building than around 50 percentage of total municipal electrical energy are utilized. [12] Around 40 percentage of energy can be saved if proper orientations are done by HVAC (heating ventilation and air condition). [13] Building design is the main factor to achieve energy efficiency, building design is the complete chain in which building orientation, lightning system, HVAC system, are include by change in input of these parameter energy saving can be achieved. [14] For building designer a simple and rapid building design tool is made which is presented by Urban et al “MIT design advisor”. In the research energy predication has been explained the heat transfer model. Without any formal training building design can be modeled quickly. [15] More than 60% energy is consumed in HVAC in some country due to hot dry climate, for example in USA more than 25 percentage of energy are use in HVAC. [16, 17] Proper applying day lightning system, and artificial lightning integration system 35% of lightning load can be reduced and 13% of overall energy consumption are reduced. For the day lightning window design and its orientation, window area glazing's are matter. [18] The proper definition of thermal comfort is feeling is well being and it depends on metabolic rate. [19] The simulation tools for the building that are used early that reduced the energy demand of new constructed building. [20] Building energy simulation software is used to analysis the energy efficiency before to construct the building and also to modification of the building before to construct. Energy simulation software is very popular engineering tools that would analyze the energy behavior of any building with different input parameter. It is only one techniques by which find the non-linear behavior of any model. It is preferred to simulate with respect to input like, time varying and time invariant system, linear and non-linear system, discrete and continuous system. Modeling simulation software are used to analysis the behavior of energy before to construct the building and it also impact analysis to modified the existing building. For complex and high rise building simulation software are classified into two type (1) open source code, (2) propriety programs. [21] Environmental system performance is the one type of energy simulation tool that depend on the parameter of energy and environmental specific. Initially it is used in Europe and Asia country. ESP-r is the tools in which make the integration equation with the respect of occupancy, heating, cooling, lightning and comfort level. ESP-r tells the relationship of air flow, plant and control with different input parameter. [22] Designer simulation tool kit (DeST), this tool kit is used in china and Japan to analysis the HVAC system of entire building through calculation is annually. It has some mane part which simulation will be done, AHU system, Duct system, plant analysis, thermal process etc. [23] By suggesting strategies the building energy efficiency is analyzed and further proceed to energy saving. The energy saving to be expected by suggested strategies and modeled in eQUEST. [24]

II. COMMERCIAL BUILDING IN INDIA

The bottom-up approach was used to estimate appliance energy usage and made the simplified assumption that residential energy usage is solely dependent on household income (The World Bank, 2008). The Climate Works Foundation study on "Reducing GHG Emissions in the Building Sector in India" (Climate Works Foundation, 2010) indicates that the residential sector calculated for 21% of overall electricity consumption. The energy preservation distribution in the residential areas is shown in Figure 1.1 where ceiling fans and lighting comprise the mostly of energy utilization at 62% (Climate Works Foundation, 2010). Within this, the Indian residential sector has been seeing the maximum growth which may be attributed to the higher GDP, population increase, urbanization and improving economy and higher income levels.

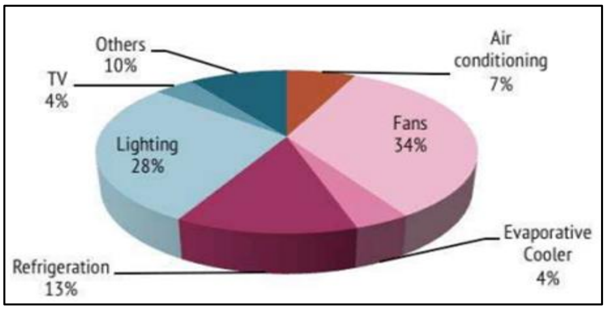


Fig. 1: Electrical energy consumption in different area of building

From Figure-1.1 above, we can conclude that lighting and space cooling are the biggest consumers of electricity in India in buildings in India. Same time the growth of building sector in India is phenomenal as given in figure 1.2. The Climate Works Foundation study (Climate Works Foundation, 2010) also predicted that the major growth in the building industry will be seen in the residential and commercial areas and will be as high as four to five times when compared to its condition in 2005 (Planning Commission, 2011). If our buildings achieve better energy efficiency, it will resultantly come down the energy consumption of these sectors.

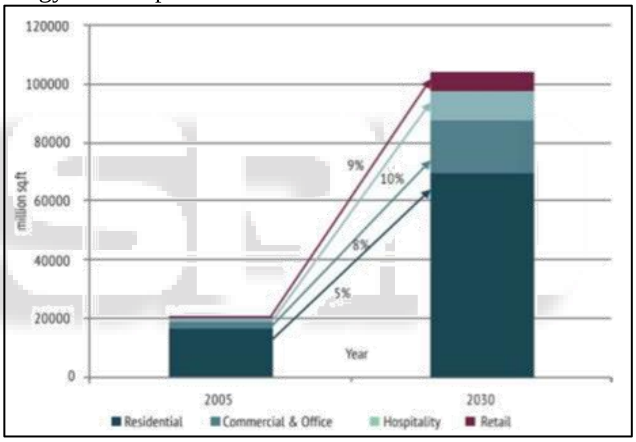


Fig. 2: Growth of Building Sector, Source (Source: Planning Commission, 2011)

III. GOVERNMENT EFFORTS TOWARDS ENERGY EDEQUATE BUILDINGS

The increasing demand for buildings and rising energy consumption have alerted the government for taking up energy efficient measures in buildings. Encouraging the purpose of building automation systems in buildings will help in down to the energy consumption. Appliances with energy rating given by BEE (Bureau of Energy Efficiency) may down the energy consumption considerably.

A. ECBC code

The main aim of the Energy Conservation Building Code is to supply minimal requisites for the energy-efficient design and structure of buildings. The Code also gives two more sets of incremental demand for buildings to perform increased points of energy capability that go beyond the minimal requisites. The Code is relevant to buildings or complexes that have a load of 100 kW or greater or a contract demand of 120 kVA or more and are intended to be used for commercial purposes. Buildings intended for private residential purposes only are not covered by the Code.

IV. INTRODUCTION OF PROJECT

The project is located in Mahindra SEZ, Jaipur. This is a residential office building. The building has four floors which contain training and seminar rooms, conference rooms, open offices, server/utility spaces. The first floor comprises of common areas such as reception, kitchen, cafeteria, party hall, training and seminar rooms. The four floors total an overall area of approximately 1, 10,448 ft2.

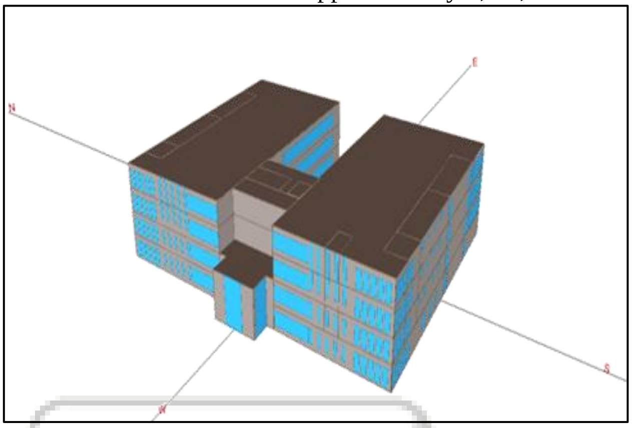


Fig. 3: 3D Simulation data input model

A. *USGBC (LEED) Certified office building*

USGBC New-Construction Rating System is a voluntary and consensus based program started by the United States Green Building Council to promote the growth of green buildings in United States. The rating system has been perfected based on the modern day materials technologies and is disclose so as to be comprehensive and at the same time user-friendly.

B. *Energy Simulation for EA Prerequisite 2, and Credit 1*

Each LEED project building or LEED project space must demonstrate individual compliance. This specific analysis shall form part of the documentation that will be submitted for points under USGBC New Construction Building, Energy and Atmosphere, Mandatory Requirement 2 and credit 1 – Minimum Energy Performance and Optimize Energy Performance respectively. In order to evaluate optimized energy performance of the Building a computer simulation model is used to assess and identify the most cost effective energy measures. The energy performance has to be quantified and compared to a Base-case Building that complies with ASHRAE Standard 90.1-2010. As of April 8, 2016, an additional 4 points are necessary to meet the minimum energy performance requirements of LEED.

C. *Energy Model Parameter Summary*

1) *Building Envelope Summary*

The project building envelope has a "double glazed glass assembly". The U-values of building envelope assemblies are less efficient compared to the baseline requirements. This has a sort of impact on the building's energy efficiency'

Envelope Parameter	Proposed Case	Baseline Case
Roof Assembly	Proposed Construction consists in order from exterior to interior as high SRI tiles 10mm, concrete screed 25mm, Brickbat Coba75 mm, Cement plaster 20mm, RCC Slab 200mm, Rubber Insulation 19mm, with a U-factor of 0.190Btu/h.ft2.degF	R-15 insulation entirely above deck with a U-factor of 0.063Btu/h.ft2.degF.
Wall Assembly	Proposed Construction Consists of in order from exterior to interior as Stone Cladding 45mm,Plaster of 20mm"Air Gap , brick wall 230 mm and a plaster of 20mm with a U-factor of 0.245 Btu/h.ft2.degF	Steel framed with R-13 Cavity insulation with a U-factor of 0.124 Btu/h.ft2.degF.
Glass Construction (SHGC)	"Double Glazed glass with a SHGC of 0.20 and U- factor0.28 Btu/h.ft2.degF- South ,East, West Glazing, Single Glazed Glass with SHGC of 0.46&U- factor0.95 Btu/h.ft2.degF- North Glazing	Metal framing (curtain wall/storefront) with a SHGC of 0.25and U- factor 1.2Btu/h.ft2.degF [Table 5.5 per Table G3.1#5(b)]
Window Wall Ratio	34.88%	34.88%

Table 1: Envelop Parameter

D. *Energy Conservation Measures*

1) *VRF Systems*

Initially as being an office building the project building was looking for a water cooled chiller but looking at the cooling load of the building installing a water cooled chiller was not feasible. Thereby the project team suggested going for VRF systems to maximize the energy efficiency of the building. The project building now is using VRF systems.

2) *LED Lightings*

The lighting for the project building was designed to keep the LPD around 0.80 w/ft2, but now a day's LED lighting systems are used which a far efficient. The Lighting designing of the building had been revised thereby the revised LPD of the building is around 0.49 w/ft2 which is making the building to be efficient in lighting.

3) *Heat Recovery Units*

The project building is using heat recovery units for maximizing the energy efficiency, the heat recovery units recover the energy from the exhaust air and use it to cool the fresh air which is to be supplied in the building. The heat recovery unit has been modeled with their specified fan power and efficiencies.

4) Roof Insulation

The project building is using an under deck rubber insulation for roof. The roof U- value would have been 0.372 Btu/hr.ft2. deg.F without the insulation, but after a healthy discussion with the consultant the project team agrees to go with the under deck rubber insulation which made the roof U- value to be 0.190 Btu/hr.ft2. deg.F.

E. Definitions:

1) Solar Heat Gain Coefficient (SHGC)

It is the ratio of solar radiation that passes through fenestration to that falls on the fenestration. Perfectly transmitting fenestration would have an SHGC of 1.0, but this is a physical impossibility, since even the clearest glass blocks some solar radiation. It is also a whole product rating and accounts for the glazing material as such as the frame and sash. The SHGC is a property of the fenestration product and does not account for interior shading from Venetian blinds, vertical blinds, or draperies.

2) Shading Coefficient (SC)

It is a number between zero and one that indicates the amount of solar heat gain that will pass through fenestration. By definition, the shading coefficient of ⅛ in. thick, clear, double-strength window glass is 1.0. All other fenestration is rated relative to this. If a window has a shading coefficient of 0.5, it means that it will allow into the building only half the solar heat gain as the same size window with ⅛ in. clear glass. The shading coefficient of glass and other materials depends on the thickness of the material, the number of panes; any tinting that is mixed with the glass when it is manufactured, and any special coatings that are applied to the surface of the glass. Shading coefficient is being replaced by SHGC, so its use is limited.

3) Visible Light Transmittance (VLT)

It is the fraction of solar radiation in the visible spectrum that passes through fenestration. VLT is important for day lighted buildings. It is also important in order to enjoy views from windows. The quality of the view is directly proportional to the VLT. Higher the VLT, better the view. There is a strong relationship between the visible light transmittance and the solar heat gain coefficient. The lower the solar heat gain coefficient, generally the lower the visible light transmittance. For instance, bronze, gray, and green tinted glass all have about the same shading coefficient for a given glass thickness, but green glass has a significantly higher visible light transmittance. Likewise, some coatings applied to the surface of glazing reduce the shading coefficient more than they do the VLT. For these reasons, manufacturer's literature should be carefully consulted in the selection of glazing products. For good day lighting without excessive solar gain, look for a product whose VLT is at least 1.2 times the SHGC

4) U-Factor

When it is colder on one side of an envelope element, such as a wall, roof, floor, or window, heat will conduct from the warmer side to the cooler side. Heat conduction is impelled by temperature differences and represents a main component of heating and cooling loads in buildings. The U-factor is the rate of steady-state heat flow. In inch-pound units, it is the amount of heat in Btu (British thermal units) that flows each hour per square foot.

5) R-Value

It is used to describe steady state heat flow but in a little different way. The R-value is the thermal resistance to heat flow. A larger R-value has greater thermal resistance, or more insulating ability, compared a smaller R-value. R-value is highly known in the building industry and is used to identify insulation effectiveness. Therefore, the normative criteria tables comprise a compliance option that is based on the R value of the insulation alone. The insulation R-value does not identify the overall performance of the complete assembly, however. It only identifies the thermal resistance of the insulation material. The performance of the entire wall assembly can be significantly lower when metal framing penetrates the insulation. Most construction meeting place includes more than one material in the same layer.

6) Window-Wall Ratio

It is the ratio of vertical fenestration area to gross exterior wall area. The fenestration area is the rough opening, i.e., it includes the frame, sash, and other non-glazed window components. The gross exterior wall is measured horizontally from the exterior surface; it is measured vertically from the top of the floor to the bottom of the roof. The gross exterior wall area includes below-grade as well as above-grade walls.

V. LIGHTING LOAD SUMMARY

The project lighting is designed with the “Building Area” method of lighting. The high efficiency interior LED lighting specified has a significant impact on the overall energy savings of the project. Baseline Lighting Power Density (LPD) is taken Per ASHRAE Standards 90.1-2010. The Lighting power density for the whole building is 0.49 w/ft2whereas the “lighting power density” for baseline case is being taken as 0.9 W/ft2.The building is installed with occupancy sensor and daylight sensor as per the mandatory requirements of ASHRAE 90.1-2010 Section 8.4. Savings for occupancy sensor is claimed by running zones with OS on a different schedule.

A. Different Schedule

In detailed data mode make all schedules like HVAC, occupancy, lighting, infiltration, heating and cooling as weekly, monthly and annually. These data are referring from ASHRAE 90.1.2010 Appendix G.

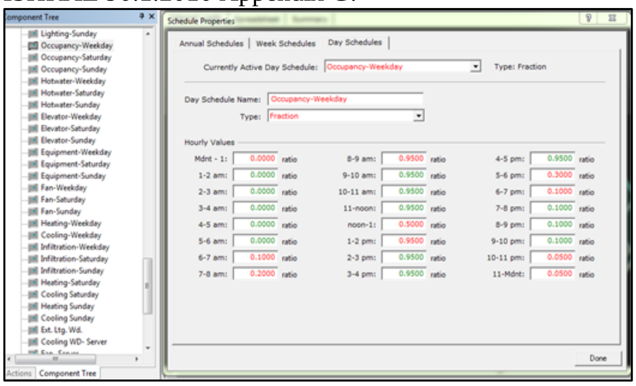


Fig. 4: Occupancy Schedule for day, weekday, monthly and yearly

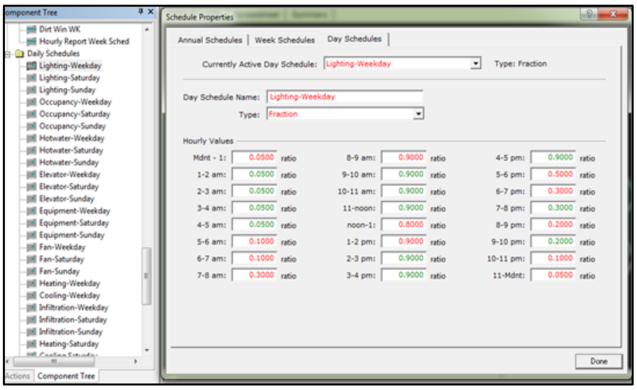


Fig. 5: Lighting Schedule for day, weekday, monthly and yearly

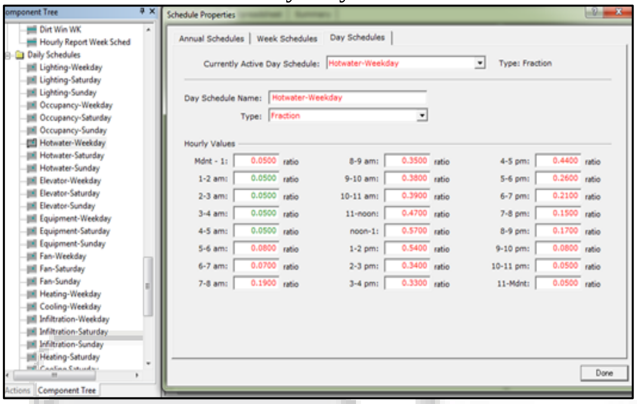


Fig. 6: Hot water Schedule for day, weekday, monthly and yearly

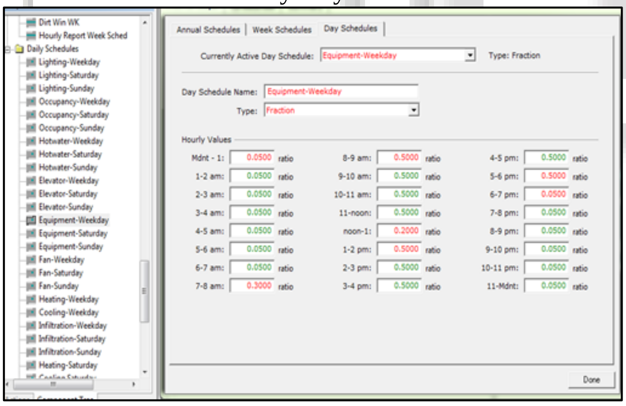


Fig. 7: Equipment Schedule for day, weekday, monthly and yearly

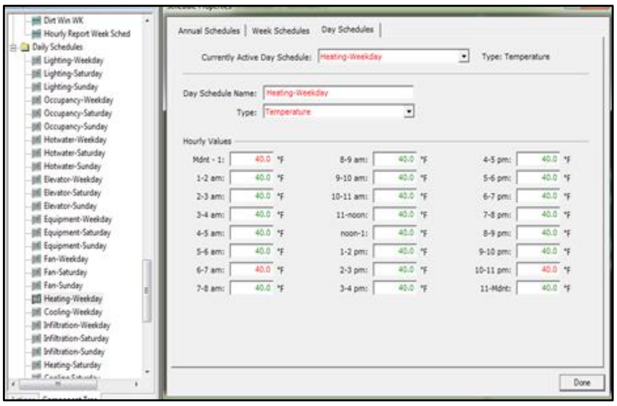


Fig. 8: Heating Schedule for day, weekday, monthly and yearly

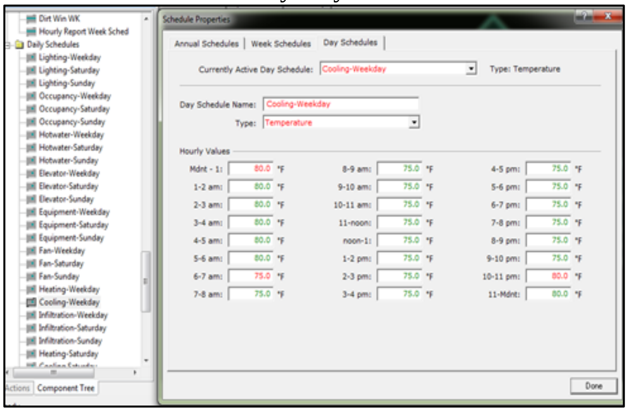


Fig. 9: Cooling Schedule for day, weekday, monthly and yearly

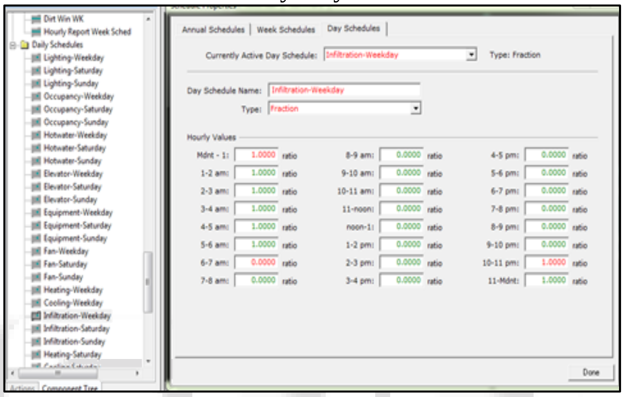


Fig. 10: Infiltration Schedule for day, weekday, monthly and yearly

B. Equipment Load Summary

The Equipment Power density of the Proposed and the Baseline Model is considered same. The actual equipment load has been considered which is as shown

Space for Equipment	Energy Source	Energy Demand (kW)	Remark
Training and Seminar Rooms	Electrical	32.30	Process Equipment Load has been modeled same in both models as proposed and baseline
Utility Power panel	Electrical	3.00	
Conference/Party Hall	Electrical	21.40	
Server Room/UPS Panel	Electrical	22.20	
Conference/Open offices	Electrical	252.90	

Table 2: Space wise equipment load (baseline HVAC system type)

C. Heating, Ventilation, Air Conditioning (HVAC)

1) Types of Air Conditioning System

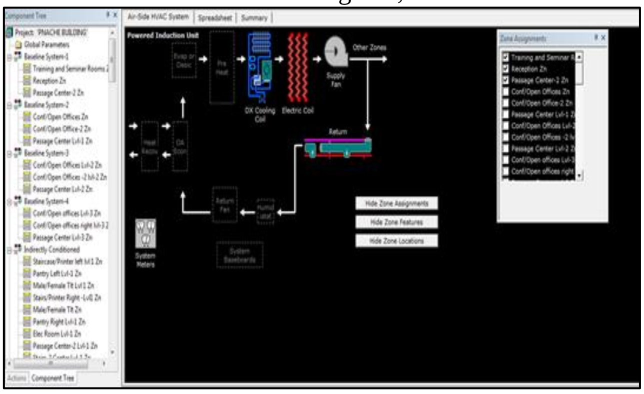
The proposed case has been modeled with HVAC systems in consistence with the provided HVAC plans. There are VRF units of different range depending upon zone's HVAC requirements. The Baseline Model has been designed per the guidelines of ASHRAE so the Baseline System is modeled as System per floor with fulfilling all requirements of ASHRAE standards 90.1-2010

System Type	Supply CFM	Fan Motor (kW)	Cooling Capacity (Btu/h)	Cooling EER
GF-ODU-01	23,372	3.62	778,500	11.25
GF-ODU-02	12,216	3.23	443,600	12.96
GF-ODU-03	17,146	1.124	594,300	10.57
FF-ODU-01	20,107	1.714	632,500	10.57
FF-ODU-02-1	20,319	1.714	626,600	11.942
FF-ODU-02-02	3,372	0.81	126,200	11.942
SF-ODU-01	20,054	1.714	622,900	10.57
SF-ODU-02-1	20319	1.714	626,600	12.624
SF-ODU-02-2	2,047	0.76	76,400	12.624
TF-ODU-01	21,273	1.714	750,600	11.259
TF-ODU-02-1	21,432	1.714	765,900	11.942
TF-ODU-02-2	2,542	0.76	95,500	11.259

Table 3: Air conditioning system type

2) *HVAC for Baseline System*

For the baseline case HVAC are designed. And for HVAC Powered Induction Unit System types are used because follow the ASHRAE 90.1.2010 guide,



HVAC Powered Induction Unit System

VI. Simulation Results

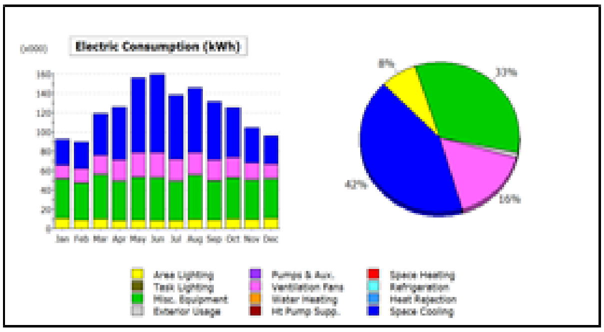
A. *Baseline Case Energy Consumption*

The Baseline case model is strictly in accordance with the ASHRAE Standards 90.1-2010Appendix G "Performance Rating Method". Based on the energy simulation results, it is observed that the average annual electric consumption from the minimum energy performance calculators 1489.706* 103kWh. The Baseline Case consumption of all the four degrees is as given below:

Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	26.7	27.6	42.6	54.7	77.0	80.9	66.5	66.9	59.6	51.4	36.6	28.8	619.3
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.0	0.0	0.0	0.1	0.5
HP Supp.	0.0	-	-	-	-	-	-	-	-	-	-	-	0.0
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	13.8	14.1	19.3	21.2	25.2	25.2	21.8	22.5	21.2	20.5	17.0	14.7	236.4
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	1.4	1.3	1.4	1.3	1.4	1.3	1.4	1.4	1.3	1.4	1.3	1.4	16.3
Misc. Equip.	40.0	37.9	45.3	40.1	43.5	43.4	40.3	45.2	40.1	41.8	39.9	40.3	497.7
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	10.6	8.9	10.3	8.7	8.9	8.9	8.4	9.7	9.0	10.2	10.0	10.7	114.2
Total	92.6	89.7	118.8	126.0	156.0	159.8	138.3	145.9	131.3	125.2	104.8	96.0	1,484.5

Baseline Consumption at 0 Degree Rotation

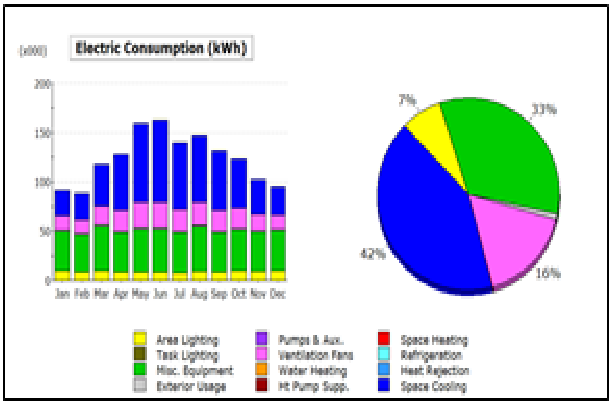


Baseline Consumption at 0 Degree Rotation in Chat from

Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	26.0	26.8	42.0	56.0	79.5	83.2	67.9	67.7	59.9	50.6	34.8	28.1	622.5
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.0	0.0	0.0	0.1	0.5
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	14.0	14.2	19.5	21.9	26.1	26.0	22.4	22.9	21.6	20.4	16.8	14.8	240.5
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	1.4	1.3	1.4	1.3	1.4	1.3	1.4	1.4	1.3	1.4	1.3	1.4	16.3
Misc. Equip.	40.0	37.9	45.3	40.1	43.5	43.4	40.3	45.2	40.1	41.8	39.9	40.3	497.7
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	10.2	8.4	9.8	8.2	8.6	8.6	8.1	9.4	8.7	9.8	9.5	10.3	109.5
Total	91.7	88.5	117.9	127.6	159.1	162.6	140.1	146.9	131.6	123.9	102.3	94.8	1,487.1

Baseline Consumption at 90 Degree Rotation

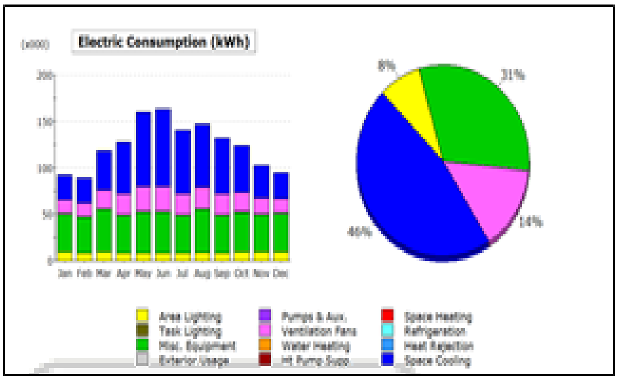


Baseline Consumption at 90 Degree Rotation in Chat from

Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	26.2	26.9	42.1	56.1	79.8	83.5	68.2	67.9	60.1	50.8	34.9	28.2	624.8
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.0	0.0	0.0	0.1	0.5
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	14.1	14.2	19.5	22.0	26.3	26.2	22.5	23.0	21.7	20.6	16.8	14.8	241.8
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	1.4	1.3	1.4	1.3	1.4	1.3	1.4	1.4	1.3	1.4	1.3	1.4	16.3
Misc. Equip.	40.0	37.9	45.3	40.1	43.5	43.4	40.3	45.2	40.1	41.8	39.9	40.3	497.7
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	10.2	8.7	10.1	8.3	8.7	8.7	8.2	9.5	8.8	10.0	9.7	10.3	111.2
Total	92.0	88.9	118.3	127.9	159.8	163.2	140.7	147.3	132.1	124.6	102.5	95.0	1,492.3

Baseline Consumption at 180 Degree Rotation

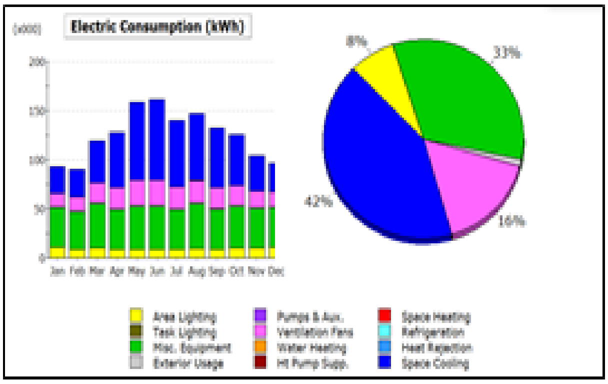


Baseline Consumption at 180 Degree Rotation in Chat from

Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	26.8	27.8	43.0	56.5	79.1	82.6	67.7	67.8	60.3	51.7	36.6	29.0	629.0
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.0	0.0	0.0	0.1	0.5
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	13.8	14.1	19.4	21.8	25.8	25.7	22.1	22.7	21.4	20.5	16.9	14.7	238.9
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	1.4	1.3	1.4	1.3	1.4	1.3	1.4	1.4	1.3	1.4	1.3	1.4	16.3
Misc. Equip.	40.0	37.9	45.3	40.1	43.5	43.4	40.3	45.2	40.1	41.8	39.9	40.3	497.7
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	10.5	8.8	10.0	8.5	8.7	8.7	8.3	9.5	8.8	10.1	9.9	10.7	112.5
Total	92.7	89.8	119.1	128.2	158.6	161.7	139.8	146.9	132.1	125.5	104.6	96.1	1,495.0

Baseline Consumption at 270 Degree Rotation



Baseline Consumption at 270 Degree Rotation in Chat from

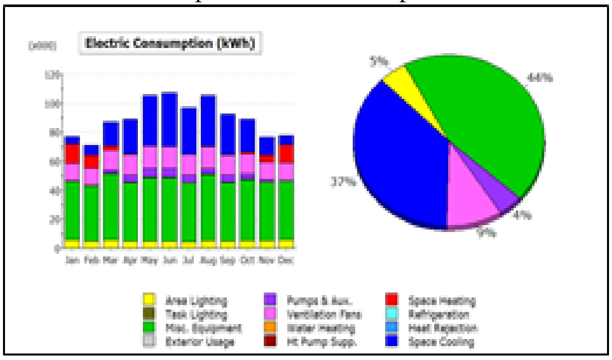
B. Proposed Case Energy Consumption:

The Proposed model is designed in eQUEST 3.65 with its various parameters like Occupancy, lighting, HVAC. HVAC is modeled per mechanical floor plans. The total annual Electric Energy Consumption for the proposed case was 1075.1*1000 kWh.

Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	5.2	7.0	16.1	23.8	34.7	36.6	32.0	34.7	28.0	22.6	12.6	6.2	259.5
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	13.2	9.1	3.1	0.5	0.1	0.1	0.1	0.3	0.2	1.2	4.4	12.4	44.8
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	11.8	11.3	13.9	14.0	15.1	15.1	14.1	14.8	13.9	13.7	12.3	12.2	162.3
Pumps & Aux.	0.0	0.3	1.9	4.8	5.9	6.0	4.7	4.0	4.4	3.4	1.2	0.0	36.7
Ext. Usage	0.7	0.6	0.7	0.6	0.7	0.6	0.7	0.7	0.6	0.7	0.6	0.7	7.7
Misc. Equip.	40.0	37.9	45.3	40.1	43.5	43.4	40.3	45.2	40.1	41.8	39.9	40.3	497.7
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	6.1	5.1	6.0	5.2	5.3	5.3	4.9	5.6	5.2	5.8	5.7	6.2	66.3
Total	77.0	71.3	87.0	89.0	105.4	107.0	96.7	105.3	92.5	89.1	76.7	77.9	1,075.1

Proposed case consumption



proposed case consumption chart form

VII. RESULT ANALYSIS AND DISCUSSION

The Project building "Pinnacle InfoTech Solutions", is achieving 38.4 % of savings. And is able to achieve 15 points in LEED V4 NCEA credit Optimize energy Performance.

Case	Energy	Cost
Proposed consumption	1075085	158027
Baseline consumption	1489706.5	218976
Solar Capacity Installed	100 kW	
Energy Generation from Renewable Energy	156963	23072.0
Proposed consumption excluding renewable	918122	134955
Savings	38.36%	38.36%
No. of Points Achieved	15	

VIII. CONCLUSIONS AND FUTURE SCOPE

This chapter summarizes the major contributions of the work and suggests directions for future investigations.

A. Conclusion

Base on the work represented in this thesis, the following conclusions are drawn:

Energy Saving is the major task in every sector to move toward sustainability, Building sector is the biggest sector where energy are utilize and in this sector we can save more energy and adopt the sustainability. By this case study, conclude that before to construct the building we can analysis the whole building energy consumption in every part. By the use of this simulation software calculate the monthly energy consumption of any type of building and also calculate the running and installation cost of project/ building. And we find the solution to reduce the energy consumption in term of different aspects. By the change of building parameter like lightning, HVAC, building envelop, roof U- value, wall U- value, glass property etc. calculate energy saving and energy costing. And by the energy saving calculator find that total 38.4% energy saving. We can also rotate the entire building in different direction or angle and calculate in which direction energy saving is achieved.

B. Future Scope

Some possible future scopes are identified as follows:

- For the future prospective this type of study are very useful to calculate the energy consumption of building before to construct the building.
- To calculate the daylight analysis of a building that why this simulation study are useful.
- To calculate the running and installation coasting of building before to construct.
- To reduced the lightning load and equipment load and calculate the electrical consumption lightning and equipment in a building before to construct and find the solution to reduced the energy consumption.
- To check the property of any material and impact on the entire building energy performance.

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