HVAC system performance and operational strategies in Green buildings - A Simulation approach

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Abstract - *Heating, ventilation and air conditioning (HVAC) systems in buildings will plays a crucial role to address the thermal comfort of the buildings. Most of the buildings are consuming unnecessary energy usage to a tune of 30 to 40 % with bad practices of HVAC maintenance. With a good practice of technologies in HVAC; will save enormous energy savings and also without compromising the comforts of the consumer. Buildings HVAC design with basic operational strategies like control of indoor climatic conditions, day lighting optimization, natural air cross flow ventilation will minimizes the burden on Air- conditioners.*

In this paper, an approach has given to minimize the energy consumption of HVAC system by considering the thermal comfort of the building with a certain levels of occupancy levels. A thermal model for one building has been analyzed in an Engineering college campus by using RETSCREEN software with saving reports on energy conservation.

***Key Words*: HVAC, Simulation, Thermal Comfort, RETSCREEN, Green buildings**

1. INTRODUCTION

Energy efficient buildings also known as green construction or sustainable building refers to a building which can maintain sustainable technologies and environmentally supporting clean technologies in all aspects throughout the life span of the building. By maintaining sustainability with good financial viability is also one of the major criteria in Green buildings.

Many new technologies are coming and emerging with best practices to upgrade the existing technologies into green technologies to reduce the overall energy consumption of the building keeping in view of the environmental and carbon neutral technologies.

HVAC technologies has to adopt the local climatic conditions and also by using natural materials that are available in local premises.

Hence in an overall concept, energy efficient buildings which will leads to green buildings has to adopt HVAC technologies to its full potential with all modern best practices clubbed with technical advancemans will gives an optimal solution for HVAC parameters.

2. Indoor environmental quality enhancement

While designing best system of HVAC in a building; indoor air quality is one of the important parameter to get better results. Sometimes HVAC system design may lead to bad design and causes to poor indoor air quality

Integrating natural day lighting with artificial day lighting also are features in HVAC system design. Hence, a careful monitoring and adopting these technologies leads to lighting quality of the building and less energy consumption.

2.1 Energy conservation Building Code

Energy conservation building code (ECBC) means the rules and regulations to set some benchmark parameters to decrease the energy consumption of the building depending upon climatic condition of the area. A unit will be derived as EPI (energy performance index) in kwh/m^2 will decides the performance of the building in period of yearly analysis.

A building consumes different EPI values in different locations with same HVAC benchmark parameters. Hence, validating HVAC design features in different locations is an uphill task for the designer to design HVAC system integration with a building.

The various factors which will influence ECBC with HVAC are detail of the following:

Building orientation: Building direction, insulation materials, air leakage levels, local weather conditions, coordinating the solar heat gain values with building, active and passive technologies.

HVAC design: Equipment sizes, their capacity to suit the room size, location, height of the installation, equipment efficiencies, meeting the standards of regulations of governing bodies.

Passive technologies: Solar hot water system, solar cooking, Earth air tunnel system, solar chimney.

Lighting: energy efficient lighting, sensor based lighting, scheduled lighting, natural day lighting, DC power based lighting

While planning a energy conservation building with HVAC as main feature for energy conservation a range should be planned between 30 to 40% reduction in EPI. Hence, in practical implementation

Standard regulations are framed to test the technical feasibility of a HVAC design. Some of the regulations are ECBC, GRIHA and LEED.

These regulations have been prepared to make sure that :

The fulfillment process are user friendly, easy to adopt, easy to implement, accessibility

The techniques and best practices are practically implantable to suit the various climatic conditions.

2.2 HVAC role in Building energy analysis

A building with proper sizing of facades, walls, roofs, wall to window ratio, with proper cross ventilation without and air leakages are some of the parameters in HVAC role in building energy analysis.

The main objective is to identify the exact matching of all these constraints which is not only a technical solution which leads to economical solution.

3. SIMULATION RESULTS

RETScreen 4 is a free Excel-based clean energy project analysis software tool that helps decision makers quickly and inexpensively determine the technical and financial viability of potential renewable energy, energy efficiency and cogeneration projects. The energy performance of a building envelope is influenced by a number of factors.

Case study with simulation results

An analysis has been carried out for GIET campus to analyze the Energy efficient buildings with HVAC parameters and the procedure is as follows:

Step 1: Starting worksheet

The project type is of Energy efficient Measures, this is of institutional facility type and the analysis method is considered as method 1. The Heating value reference is considered as LHV (lower heating values).

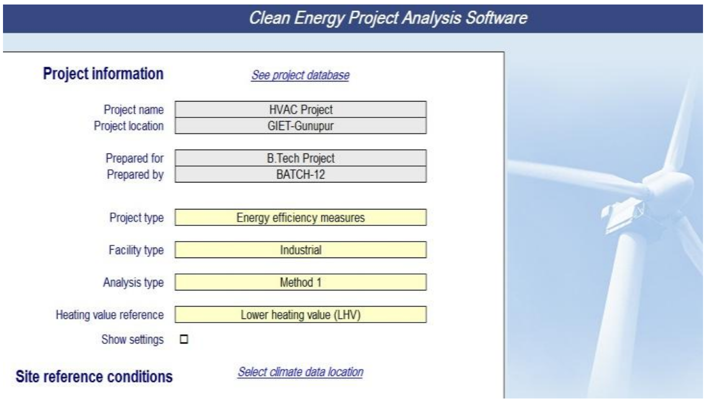


Fig.3.1 starting worksheet of Software

For selecting climate location:

To access the RETScreen Climate Database click on the "Select climate data location" hyperlink or use the RETScreen menu or toolbar.

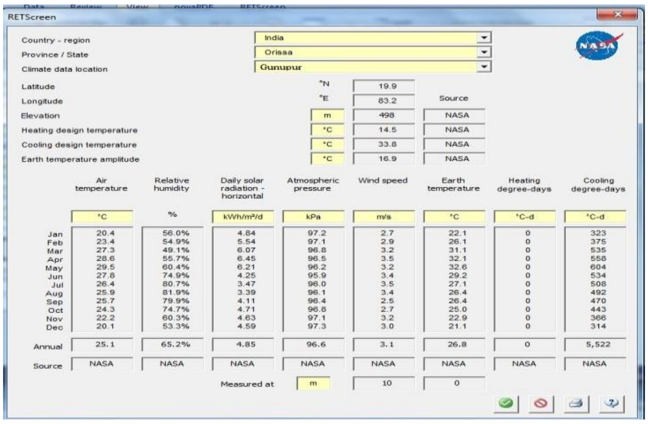
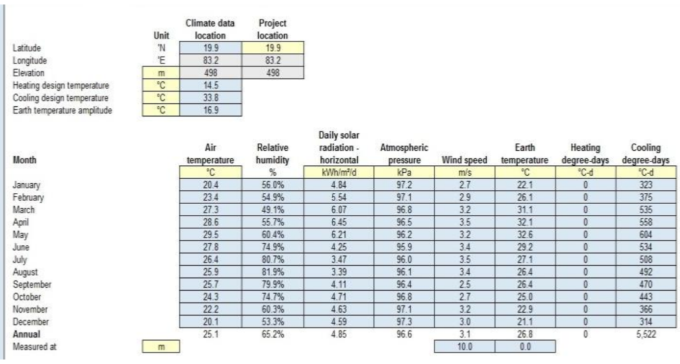


Fig.3.2: Gunupur climate data sheet



	Unit	Climate data location	Project location
Latitude	°N	19.9	19.9
Longitude	°E	83.2	83.2
Elevation	m	498	498
Heating design temperature	°C	14.5	
Cooling design temperature	°C	33.8	
Earth temperature amplitude	°C	16.9	

Month		Air temperature	Relative humidity	Daily solar radiation - horizontal	Atmospheric pressure	Wind speed	Earth temperature	Heating degree-days	Cooling degree-days
		°C	%	kWh/m²/d	kPa	m/s	°C	°C-d	°C-d
January		20.4	56.0%	4.84	97.2	2.7	22.1	0	323
February		23.4	54.9%	5.54	97.1	2.9	26.1	0	375
March		27.3	49.1%	6.07	96.8	3.2	31.1	0	535
April		28.6	55.7%	6.45	96.5	3.5	32.1	0	558
May		29.5	60.4%	6.21	96.2	3.2	32.6	0	604
June		27.8	74.9%	4.25	95.9	3.4	29.2	0	534
July		26.4	80.7%	3.47	96.0	3.5	27.1	0	508
August		25.9	81.9%	3.39	96.1	3.4	26.4	0	492
September		25.7	79.9%	4.11	96.4	2.5	26.4	0	470
October		24.3	74.7%	4.71	96.8	2.7	25.0	0	443
November		22.2	60.3%	4.63	97.1	3.2	22.9	0	366
December		20.1	53.3%	4.59	97.3	3.0	21.1	0	314
Annual		25.1	65.2%	4.85	96.6	3.1	26.8	0	5,522
Measured at	m					10.0	0.0		

Fig. 3.2(A): Online Data of Gunupur Climatic conditions

This is the extension of fig 3.2 and 3.2(A) window which show the data of climatic conditions of the considered location. While the latitude and longitude values are entered, the values of Air temperature, Relative humidity, Daily radiation-horizontal, Atmospheric, wind speed, Earth temperature, Heating Degree days, Cooling degree days are obtained for monthly basis. The data obtained is only for reference purpose not to run the model

Step 2: Energy Model:

The fuel type is of Electricity at a unit rate of 6.0 Rs/Kwh. The scheduled working days are of 24 days on an average for a month. The base case and proposed cases have working hours of 8 per a day. Therefore, out of 100%, 33% occupancy is utilized. The climatic conditions are always hotter as described in the previous worksheet; hence the cooling temperatures are required for 365 days.

Fuel	Fuel type 1	Fuel type 2	Fuel type 3
Fuel type	Electricity	Electricity	
Fuel consumption - unit	MWh	MWh	
Fuel rate - unit	Rs/kWh	Rs/kWh	
Fuel rate	6.000	6.000	

Schedule	Unit		Schedule 1	Schedule 2	Schedule 3
Description			24/7	12/7 - Base case	12/7 - Proposed case
				Occupied	Occupied
Temperature - space heating	°C				
Temperature - space cooling	°C		20.0	18.0	22.0
				Unoccupied	Unoccupied
Temperature - unoccupied	+/-°C			0.0	2.0
				Occupied	Occupied
Occupancy rate - daily			h/d	h/d	h/d
Monday			24	12.0	12.0
Tuesday			24	12.0	12.0
Wednesday			24	12.0	12.0
Thursday			24	12.0	12.0
Friday			24	12.0	12.0
Saturday			24	18.0	18.0
Sunday			24	18.0	18.0
Occupancy rate - annual	h/yr		8,760	5,006	5,006
	%		100%	57%	57%
Heating/cooling changeover temperature	°C	16.0			
Length of heating season	d	0			
Length of cooling season	d	365			

Fig.3.3: Energy model worksheet

The fuel type is of Electricity at a unit rate of 6.00 Rs/Kwh. The scheduled working days are of 24 days on an average for a month. The base case and proposed cases have working hours of 12 per a day. Therefore, out of 100%, 57 % occupancy is utilized. The climatic conditions are always hotter as described in the previous worksheet; hence the cooling temperatures are required for 365 days.

Step 3: Facility characteristics

In this section, enter the information about the facility characteristics, for the base case and the proposed case facilities. The user clicks on the blue hyperlinks (e.g. Heating system, Cooling system, Building envelope, ventilation, lighting etc.) to access the data entry forms used to describe the facility.

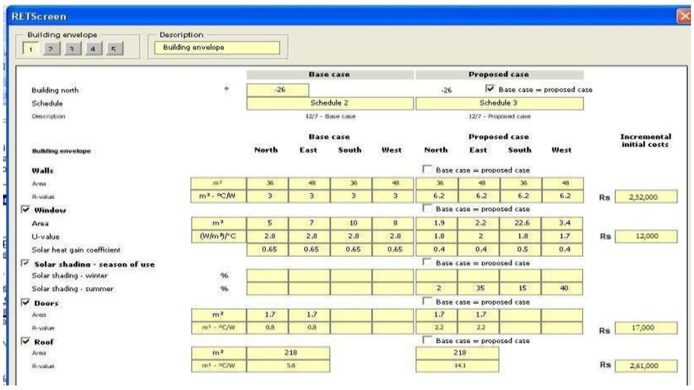


Fig.3.4: Facility Characteristics of Building

In this analysis the electrical equipments like fans, tube lights and computer are taken. For these equipments the base case and proposed case are considered.

Windows properties are considered as tools and there total number of windows in a building are consider in all directions with the measurements in both base case and proposed case and U-value is calculated for all direction as per area of each window.

Show:	Heating	Cooling	Electricity	initial costs	savings	O&M savings	simple payback
Energy - proposed case	GJ	GJ	kwh	Rs	Rs	Rs	Yr
Heating system							
Water heater - Domestic hot water			37200	312593	405696		1.2
Cooling system							
Air Conditiones			63984	2520000	639840		3.9
Building envelope							
Building envelope			5200	121600	31200		3.8
Ventilation							
Ventilation - Natural							
Lights							
Lighting			18585	495600	111510		4.4
Electrical equipment							
Indoor - Electricity loads							
Outdoor - Electricity loads							
Hot water							
Hot water use - Heat recovery							
Heat recovery							
Other							
Total			124969	3449793	1188246		2.9
Solar PV			152712	12003944	916272		13

Fig. 3.5: Result analysis

The results obtained by using RETSCREEN software can be very realistic and gives very promising results for Energy Efficient Buildings.

The building simulation results, found that how various parameters in energy dependence can be decreased by step by step and finally gives the reduction in energy needs. However, as the consideration of equipments was done optimistically for the desired building load and net profits will be higher than the results in simulation by considering carbon credits and subsidies from government organizations.

5 Conclusion

In most of the countries, buildings represent 30-40% of the countries primary energy use, including fuel input for production. Furthermore, buildings today are almost exclusively dependent on energy supplied from outside, even though they have significant potential for self-support using renewable energy. Buildings have the physical potential to harness diluted and sometimes unpredictable renewable energy. The building envelope and the ground constitute the basic resources for energy autonomous buildings.

The key objective of this project is to produce new, innovative and non conventional scientific knowledge in sustained, clean and efficient energy technologies to give a better solution for rooftop PV assisted buildings and achieving energy efficient buildings. The present work will be analyzed through simulation by using RETSCEEN software and compared with measured values and to arrive at certain general design rules for such systems.

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