ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology (IARJSET)
National Conference on Renewable Energy and Environment (NCREE-2015)
IMS Engineering College, Ghaziabad
Vol. 2, Special Issue 1, May 2015

# Simulation of Net Zero Energy Office Building in Kolkata, West Bengal, India

**Arpan Sengar, Abhishek Singh, Shubham Khandelwal, Debojyoti Sen**

Asst Prof, IMSEC Ghaziabad

**Abstract:** Energy simulation tools are increasingly used for analysis of energy performance of buildings and the thermal comfort of their occupants. Today, there are many building performance simulation programs with different user interfaces and different simulation engines that are capable of these analyses. Given the significant variety of such simulation tools, it is crucial to understand limitations of the tools and the complexity of such simulations. The reliability of data exchange and straightforward, user-friendly interfaces are major aspects of the practical usage of these tools. Due to the huge amount of data that is to be input and the availability of rich 3D geometry rendering engines, effective data exchange and software interfaces are crucial to enable faster and reliable performance of the simulation tools.. For our project we have chosen a office building of area 17000 sqft. The building was two stored and the energy consumed annually by the building is 314339 units. After applying the following various energy measures.
The energy consumption decreases to 290830 units. Further the PV generation from the rooftop solar system in nearly 610,512 kWh/year. The energy consumption of the building is 314339 kWh. It means that it is a net positive energy office and if the office is made twice its area even then also it will be a net zero building.

**Keywords:** ZEB, Equest.

## INTRODUCTION

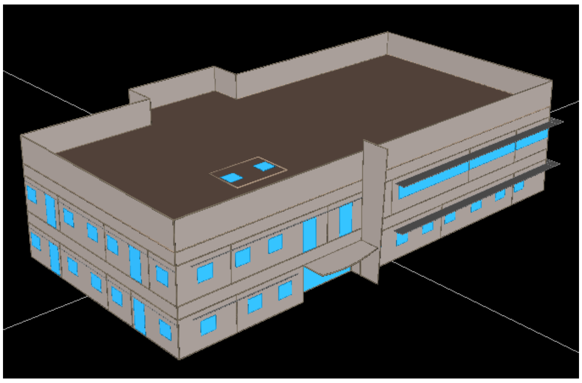
Buildings have a significant impact on energy use and the environment. Commercial and residential buildings use almost 40% of the primary energy and approximately 70% of the electricity in the United States (EIA 2005). The energy used by the building sector continues to increase, primarily because new buildings are constructed faster than old ones are retired. Electricity consumption in the commercial building sector doubled between 1980 and 2000, and is expected to increase another 50% by 2025 (EIA 2005). Energy consumption in the commercial building sector will continue to increase until buildings can be designed to produce enough energy to offset the growing energy demand of these buildings. Toward this end, the U.S. Department of Energy (DOE) has established an aggressive goal to create the technology and knowledge base for cost-effective zero-energy commercial buildings (ZEBs) by 2025.

In concept, a net ZEB is a building with greatly reduced energy needs through efficiency gains such that the balance of the energy needs can be supplied by renewable technologies. Despite our use of the phrase “zero energy,” we lack a common definition—or a common understanding—of what it means. In this paper, we use a sample of current generation low-energy buildings to explore the concept of zero energy—what it means, why a clear and measurable definition is needed, and how we have progressed toward the ZEB goal

### Overview of the Process

eQUEST calculates hour-by-hour building energy consumption over an entire year (8760 hours) using hourly weather data for the location under consideration. Input to the program consists of a detailed description of the building being analyzed, including hourly scheduling of occupants, lighting, equipment, and thermostat settings. eQUEST provides very accurate simulation of such building features as shading, fenestration, interior building mass, envelope building mass, and the dynamic response of differing heating and air conditioning system types and controls. eQUEST also contains a dynamic daylighting model to assess the effect of natural lighting on thermal and lighting demands. The simulation process begins by developing a "model" of the building based on building plans and specifications. A base line building model that assumes a minimum level of efficiency (e.g., ASHRAE 90.1) is then developed to provide the base from which energy savings are estimated. Alternative analyses are made by making changes to the model that correspond to efficiency measures that could be implemented in the building. These alternative analyses result in annual utility consumption and cost savings for the efficiency measure that can then be used to determine simple payback, life-cycle cost, etc. for the measure and, ultimately, to determine the best combination of alternatives.

OFFICE BUILDING MODEL



ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology (IARJSET)
National Conference on Renewable Energy and Environment (NCREE-2015)
IMS Engineering College, Ghaziabad
Vol. 2, Special Issue 1, May 2015

**Building Description**

The case building is located in Kolkata, West Bengal, India. It is a West facing two storied office building with a total floor area of 17,000 sft. Kolkata is in a Hot and Dry location.

**Materials and Construction**

The walls are R-19 batt 2 x 6 metal frame spaced on 24-inch centers 1 ½" polystyrene 1" stucco construction and roof is R-30 3/8" built up roof and 5/8" plywood. The floor height is 12' with a floor to ceiling clear space of 9', 3' for the plenum that comprises air conditioning ducts and false ceiling.

**Building schedules and operations**

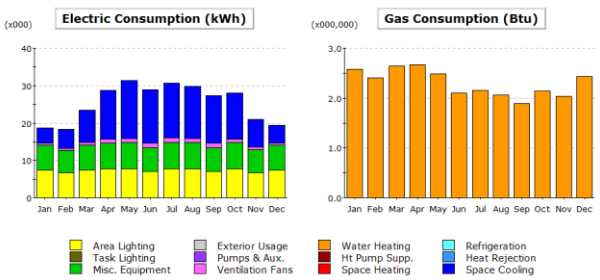
The schedules and operating hours for the models are very comprehensive. The building has different schedules for Monday to Thursday and one for Friday and different schedule for weekends and holidays

**Zoning and HVAC**

This office building basically has conference rooms, staff offices, management offices, electrical and mechanical rooms. The building has 60 small zones including the Plenum spaces. The building is conditioned with a rooftop packaged VAV system.

## RESULTS

Before taking any ECM measure




Electric Consumption (kWh x000)

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Space Cool | 4.18 | 5.10 | 8.56 | 13.03 | 15.37 | 14.24 | 14.66 | 13.85 | 12.82 | 12.19 | 7.46 | 4.81 | 126.28 |
| Heat Reject. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Refrigeration | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Space Heat | - | - | - | - | - | - | - | - | - | - | - | - | - |
| HP Supp. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hot Water | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Vent. Fans | 0.45 | 0.52 | 0.75 | 1.04 | 1.22 | 1.15 | 1.23 | 1.18 | 1.07 | 1.02 | 0.67 | 0.49 | 10.79 |
| Pumps & Aux. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Ext. Usage | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Misc. Equip. | 6.71 | 6.07 | 6.71 | 6.94 | 6.97 | 6.41 | 6.98 | 6.97 | 6.41 | 6.98 | 6.13 | 6.71 | 80.00 |
| Task Lights | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Area Lights | 7.41 | 6.71 | 7.41 | 7.73 | 7.74 | 7.07 | 7.75 | 7.74 | 7.07 | 7.75 | 6.73 | 7.41 | 88.52 |
| **Total** | 18.75 | 18.39 | 23.43 | 28.74 | 31.31 | 28.86 | 30.62 | 29.75 | 27.36 | 27.94 | 21.00 | 19.42 | 314.57 |

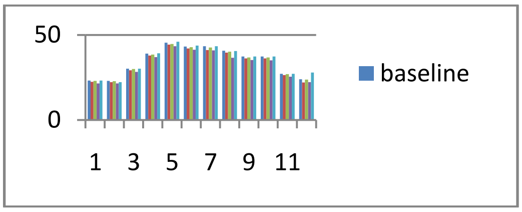
Gas Consumption (Btu x000,000)

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Space Cool | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Heat Reject. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Refrigeration | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Space Heat | - | - | - | - | - | - | - | - | - | - | - | - | - |
| HP Supp. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Hot Water | 2.58 | 2.41 | 2.65 | 2.67 | 2.48 | 2.11 | 2.15 | 2.07 | 1.89 | 2.15 | 2.04 | 2.43 | 27.62 |
| Vent. Fans | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Pumps & Aux. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Ext. Usage | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Misc. Equip. | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Task Lights | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Area Lights | - | - | - | - | - | - | - | - | - | - | - | - | - |
| **Total** | 2.58 | 2.41 | 2.65 | 2.67 | 2.48 | 2.11 | 2.15 | 2.07 | 1.89 | 2.15 | 2.04 | 2.43 | 27.62 |

The energy consumption of the office building before ECM measures is 314339 units

Result and Discussion

The analysis show the monthly energy consumption (KWh*1000) for the baseline and the different ECM measures taken. After taking the ECM measures the annual energy consumption of the house come down to units from 290830 units.




The different ECM measures taken in the office building are as follows:

DAYLIGHT CONTROL: These provide additional *daylight* and can be either fixed or operable for square and rectangular shaped skylights, and in static or mechanically ventilated configurations for tubular shaped skylights.

FAN POWER CONTROL: Ventilation provides fresh, outside air to a conditioned space; while exhaust removes unwanted air from a space to the outside. Strategically open *operable windows and skylights* to optimize natural cross ventilation. Bathroom fans should use *timer-switches* for automatic shut-off after occupants leave the room for ideal odour and moisture control and energy savings.

LIGHTING AREA CONTROL: Interior *automated lighting controls* typically save 20-40% through the use of *occupancy sensors* to turn off the lights when spaces are unoccupied. Exterior lights should be controlled by *motion sensors*, *photocells or time clocks* to reduce unnecessary hours of lighting electricity use

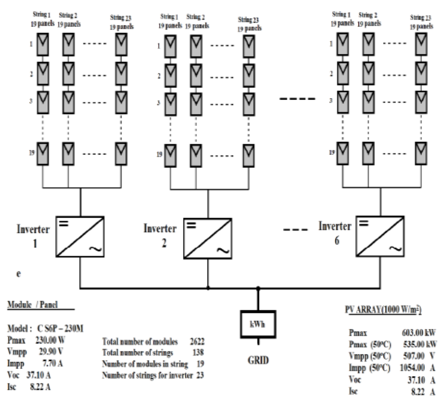
WINDOW GLAZING CONTROL: *High performance* windows, glazed doors and skylights reduce heating and cooling energy costs; *Spectrally-selective glazings* use a low-emissivity coating to minimize ultraviolet transmission, maximize the visible light admitted, and reduce solar heat gain in the summer and heat loss in the winter. This type of glazing typically lowers solar gain and heat loss by 25-45% with only a 10-15% reduction in visible light transmission – while tinted glass or reflective coatings can also be used for additional solar control

EQUIPMENT POWER CONTROL

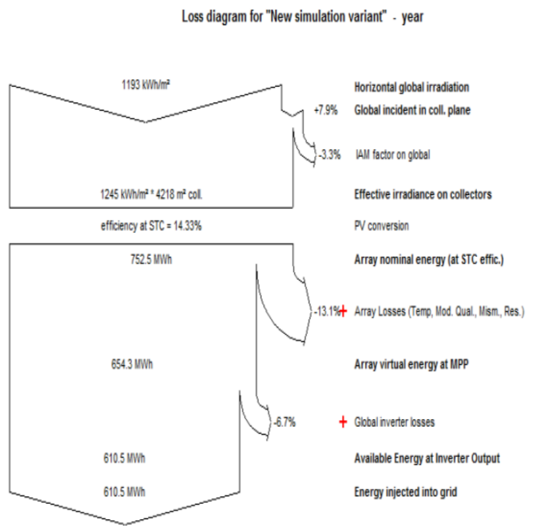
ROOF AND WALL INSULATION ACCORDING TO ECBC GUIDELINES

The last two ECM measure is not shown in the graph as they were showing negligible improvement with the baseline condition.

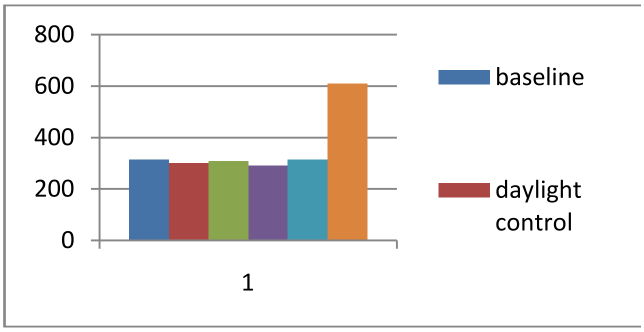
The block diagram of the PV system installed are as follows:



PV OUTPUT




ANALYSIS




The PV generation from the rooftop solar system in nearly 610,512 kWh/year. The energy consumption of the building is 314339 kWh. It means that it is a net positive energy office and if the office is made twice its area even then also it will be a net zero building.

The design, the optimization and the simulation ofthe PV systems for use have been analyzed and discussed, and the following conclusions are drawn: average annual PV system energy output is 1012 kWh/kWp and average annual performance ratio of the PV system is 78.7 %.The performance ratio shows the quality of a PV system and the value of 78.7% is indicative of good quality. Usually the value of performance ratio ranges from 60-80%. This shows that about 21.3% of solar energy falling in the analysed period is not converted in to usable energy due to factors such as losses in conduction, contact losses, thermal losses, the module and inverter efficiency factor, defects in components, etc.

## REFERENCES

[1] Pooja Joshi et al "Power System Solution provided by FACTS and HVDC" in IJRET eISSN:2319-1163/pISSN:2321-7308

[2] ABB official site www.abb.com

[3] P. Kundur, Power System Stability and Control. McGraw-Hill, 1994.

[4] D. Ernst and M. Pavella, "Closed-loop transient stability emergency control," in Proc. IEEE Power Engineering Society Winter Meeting, vol. 1, 2000, pp. 58–62.

[5] M. Glavic, D. Ernst, D. Ruiz-Vega, L. Wehenkel, and M. Pavella, "ESIME - a method for transient stability closed-loop emergency control: achievements and prospects," in Proc. iREP Symposium-Bulk Power System Dynamics and Control - VII,Revitalizing Operational Reliability, Aug 2007, pp. 1–10.

[6] Ruihua Song et al, " VSCs based HVDC and its control strategy " in 2005 IEEE/PES Transmission and Distribution Conference & Exhibition: Asia and Pacific Dalian, China