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# Design of Energy Efficient & Sustainable Buildings for ISRO Data Centers Using E-Quest

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***Abstract:** Saving energy is the same as producing new energy. Sustainable development has elevated the importance of energy performance and energy efficiency. Energy efficiency is a crucial part of sustainability, which includes all sectors of the economy from agriculture to manufacturing to services to infrastructure, including buildings used for business and research activities. Developing countries face unique difficulties in achieving sustainability because they must balance two phenomena that are diametrically opposed to one another: rapid economic growth and long-term prosperity. Commercial, information technology (IT), real estate development and construction are important economic drivers. Energy is, of course, a crucial consideration in these fields. In this research, we propose a design strategy for improving energy efficiency in an ISRO Data center by using sustainable green building technology [1]. This paper discusses the initiatives of ISRO in this direction. As maximum operation & maintenance cost of the buildings is due to electrical energy, this study shows how to design the most energy efficient institutional buildings for IMGEOS (Integrated Multi mission Ground Segment for Earth Observation satellites) of ISRO, Hyderabad. The research work discuses about the strategies / techniques to be considered since the planning & designing stage of the building infrastructure itself. This research gives the complete details of the materials with their detailed technical specifications and the methodology to be adopted, for achieving the required energy efficiency level in the data centers / similar IT infrastructure buildings. The research work also explains the process of finding & selecting the most energy efficient model by using different combination of green building materials, with respect to the base line model of ASHRAE using the e-Quest building simulation software and the results obtained thereof. Thus, this detailed research study investigates the process of designing the energy efficient data center buildings for ISRO in the context of emerging countries.*

***Index Terms:** Energy Efficiency, e-QUEST, Green Building, Simulation, Lighting & HVAC.*

## I. INTRODUCTION

Indian Space Programmed was commenced in 1963 in a modest way. Over the past 6 decades, it has continually advancing in its technological developments.

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With its advanced technology ISRO developed PSLV, GSLV, GSLV Mk-III rocket engines. It is building & operating the INSAT series & IRS series satellites for various technological & societal applications of India & also for the countries around the globe. ISRO needs vast ground-based building infrastructure & technical establishments at various locations in India for building the rocket engines, launch pads, satellites, telemetry, tracking, command network, satellite data acquisition & reception establishments.

Building large infrastructure facilities will have negative impact on the natural environment by consuming more electrical energy, water & other resources. While it's not possible to completely eliminate this effect, it can be mitigated by the use of sustainable development [2][17][18][19] practices including the creation of optimal energy- efficient building designs.

ISRO operates the telemetry, tracking, command network, satellite data acquisition and data reception activities on global time scale round the clock. Hence, energy efficiency should be the primary goal for developing the sustainable infrastructure. The conventional buildings consume 25-30 % more power than the energy efficient buildings. To achieve the best possible energy design solution, it is essential to implement the energy efficiency strategy from the outset of the building's design process itself. The research was conducted in the ISRO Data center at the IMGEOS complex in Hyderabad, India. IMGEOS is an Integrated Multi Mission Ground Segment Earth Observation Satellite facility. Figure 1 is a satellite view of the 310-acre location where the project is built in Hyderabad, India (Latitude 17°38' North and Longitude 78°48' East).

**Figure 1: Location Plan of the Facility buildings**

## II. THE METHODOLOGY & MATERIALS

The basic requirement of the sustainable buildings is to meet the occupant's thermal, visual & Hygienic comfort with less use of energy & other resources. In an energy efficient building the lighting, HVAC and other requirements shall be optimized by using solar passive techniques.

Sustainable green buildings will use passive solar interventions, energy efficient systems and materials with low embodied energy.

By using the solar passive system, thermal and visual comfort is provided by natural energy sources such as solar radiation, outside air, sky, wet surfaces, vegetation, internal gains etc. In hot climate primary aim would be to reduce solar gains, maximize solar ventilation and so on [3][20][21].

**Figure 2: Building Envelope**

A, B, C, and D are the four sections of the IMGEOS & NDEM building, and they house the respective data control room, processing area, office space, and cubicles, respectively. The total square footage of the building's floors is 1, 11,590. The building has a total of 68,120 net square feet of air-conditioned space. These blocks have a semicircular shape that allows them to blend into the terrain and take full use of the surrounding vistas thanks to their extensive useof glass. A central planted courtyard connects all four buildings by a connecting hallway. Eachof the four buildings surrounds a central courtyard.

The design elements that directly (or) indirectly affects thermal comfort conditions and there by the energy consumption in a building are

Orientation: Building orientation is a significant design consideration, mainly with regard to solar radiation and wind. In hot regions building should be oriented to minimize solar gain.

Building envelope: The building envelop and its components are key determinates of the amount of heat gain and loss and wind that enters inside.

Materials & Construction techniques: Choice of building materials is very important in reducing the energy contents of the building. Reducing the strain on conventional energy can be achieved by low energy buildings with low energy materials. The choice of materials also helps to maximize indoor comfort. The following innovative materials are used in the subject building [4].

**Figure 3: External Wall**

External walls are of cavity walls with air gap in between to minimize the heat ingress into the building.8inch Aerocon wall + Airgap + 8inch Aerocon in double wall areas with U value of 0.061 Btu / hr.ft 2.0F as shown in figure 3 above.

Aero con Blocks: Heat conduction property of walls are key to meeting desired thermal comfort conditions Aero con blocks are an innovative product [8] in green building revolution [5].

**Figure 4: View of Building with Insulated Glass**

Insulated Glass: Nearly 15-20% of all building energy is lost via windows and doors, having energy efficient windows in building should be a priority. These double glass windows are with low heat transmission value of 35% and high light transmission value of 65% in hot areas [6] as shown in below figure 4.

Under deck Thermal Insulation: Insulation is of great value when a building requires cooling and helps reduce the space conditioning loads. Laying under deck thermal insulation with 75 mm thick and U-value of 0.072 Btu/hr.ft2/°F.

**Figure 5: Day Light Pipe**

Day Light Pipe*:* Light pipes to bring daylight to deep interiors. The Light pipe is an innovative technology for daylight transportation and Energy efficiency in buildings [7]. It has a Sunlight capture system (Light collector), light transfer pipe and double glazed light diffuser as shown in figure 5 above.

Roofs: Roof receives significant solar radiation and should be provided with suitable insulating properties to minimize heat gains. 100% cool roof is provided with all roof having high reflective. Albedo paint with 45% reflectivity of solar radiation [8].

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**Figure 6: View of Corridors**

## III. DESIGN OF ENERGY EFFICIENT LIGHTING & HVAC SYSTEMS

By incorporating passive solar architectural concepts, the load on conventional systems (HVAC & lighting) is reduced. Further energy conservation is possible by judicious design of the artificial lighting and HVAC systems using energy efficient equipment's, controls and operation strategies.

The Indian Bureau of Energy efficiency specifies a maximum light power density (LPD) of 11.50 W / Sq. Mtr for the purpose of energy efficiency. The lighting fixtures used were 8.6 W / sq.m LPD in the office areas and 1.6 W/sq. LPD in the parking garages, a savings of 20%.Integration of day lighting with artificial lighting brings about considerable savings in energy consumption. A good day lighting system has a number of elements, most of which must be incorporated into the building design at an early stage. This can be achieved by considering the following in relation to the incidence of daylight on the building. Energy efficient light fittings LEDs, T8 tubes, task lights, occupancy sensors, day light controllers [9], Dimming system, solar daylight pipes etc.

Variable frequency Drives (VFDs) are used for AC systems and AHU units for energy efficiency. Energy efficient pumps, motors & Water chillers are used for air condition equipment. Techniques such as natural ventilation, thermal-mass storage, radiant cooling and passive solar control are applications of basic thermodynamic principles [10].

## IV. MODELLING PROCESS

The e-QUEST energy analysis software is used to model the energy use for this study. The e-QUEST energy analysis software, operates on the DOE 2.1 simulation engine [11].

The Energy modelling software was used to analyze all of the possible outcomes. The entire campus and all of its materials and energy systems are simulated using this software- based approach. The model displays the maximum efficiency that may be attained by the structure. It also aids in determining what may be done to increase the building's energy efficiency and boost its performance to its highest possible levels [12].

Both a baseline analysis and energy efficiency simulations are available with e QUEST. For the baseline analysis, e QUEST generates a second model of the structure that is compliant with the regulations in effect at the time of the baseline (as per ASHRAE standard). The comparability of these two models allows us to verify if the model used to construct the actual design case complies with the baseline case. Alternate designs (scenarios)can be compared in terms of their energy efficiency using the Energy Efficiency Simulation.

This report's objective is to show how the Design case building fares against a baseline budget building designed to meet the mandatory standards outlined in Appendix G of ASHRAE / IESNA 90.1-2004. "(ASHRAE, 1989)" [13].

One conventional model , one ASHRAE base line model & four alternate models with different green features are developed to find out the best possible energy efficient model. The below figures 7 & 8 shows the e-QUEST software analysis process for design case inputs & lighting load profiles.

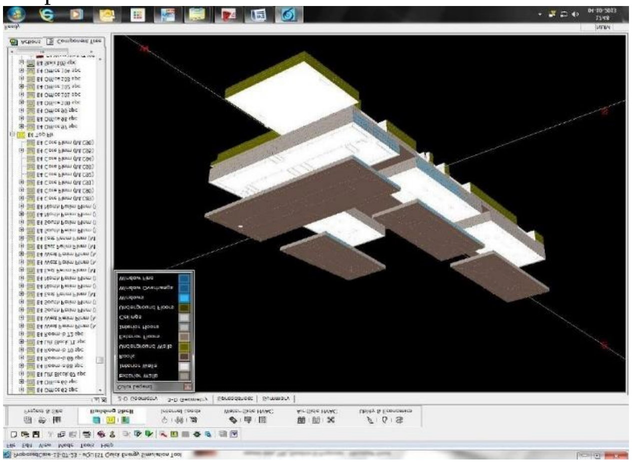

**Figure 7: Design Case Inputs**

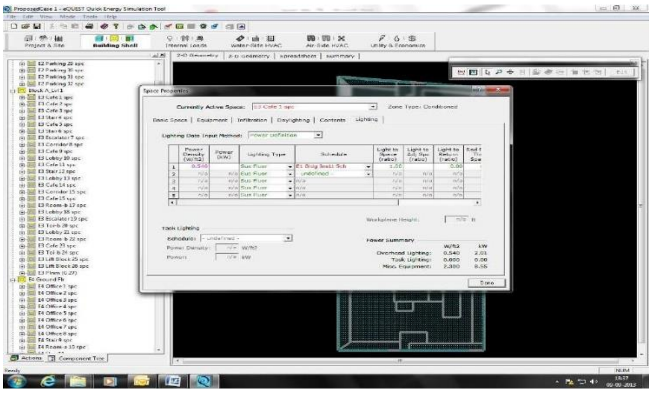

**Figure 8: Lighting Load Profiles**

Scenario 1 is based on current building practices, allowing for an accurate comparison of potential energy savings. Alternate design scenarios 2 , 3 ,4 & 5 with numerous permutations and combinations of physical and system factors are considered as there are many design parameters being evaluated for attaining energy efficient design. In addition to the standard and ASHRAE baseline designs, a total of four alternative setups have been developed.

Hourly energy simulation was used to examine the buildings for ways to reduce energy consumption and improve occupants' thermal comfort. Several methods for gauging the thermal performance and energy efficiency of the building are analyzed in the study.

Energy consumption in kilowatt hours was calculated by simulating the ASHRAE 90.1-2018 Minimally Compliant Baseline model (Scenario - 6 in this simulation model).

## V. RESULTS & DISCUSSION

The simulation study breaks down the overall energy usage in detail over all six scenarios with respect to different design characteristics and their permutations and combinations. It was determined how much electricity would be needed in each of the other five scenarios by using Scenario 6 as a reference case. By comparing the afore mentioned baseline data with the actual design case (scenario - 5), the percentage of energy savings can be saving of 18.25% of the electrical energy requirement.

**Table 1: Scenario Analysis in MWH Calculated**

| Input Parameters | Scenario 1: Conv. Design | Scenario 2 ( Green parameters modified) | Scenario 3 (parameters modified) | Scenario 4 parameters modified) | Scenario 5: As built Design | Scenario 6: ASHRAE Baseline |
|---|---|---|---|---|---|---|
| Interior Lights | 880 | 711 | 711 | 711 | 710 | 845 |
| % increase | - | 15.11 | 15.11 | 15.11 | 15.11 | - |
| Equipment | 1032 | 1032 | 1033 | 1035 | 1032 | 1047 |
| Space Cooling | 3446 | 2866 | 4398 | 2606 | 2159 | 2931 |
| % increase | -20.25% | 0 | -53.32% | 9.09% | 24.68% | - |
| Heat Rejection | 50 | 28 | 39 | 26 | 26 | 27 |
| % increase | -106.50% | 0 | -39.35% | 8.30% | 5.42% | - |
| Pumps and Aux | 305 | 250 | 190 | 199 | 223 | 253 |
| % increase | -23.51% | 0 | 23.55% | 19.79% | 9.71% | - |
| Fans | 1616 | 510 | 509 | 497 | 507 | 515 |
| % increase | -217.13% | 0 | 0 | 2.53% | 0.49% | - |
| Elevators | 265 | 264 | 265 | 150 | 150 | 265 |
| % increase | 0 | 0 | 0 | 43.40% | 43.40% | - |
| Exterior Lights | 15 | 16 | 15 | 16 | 15 | 16 |
| **Total** | **7609** | **5677** | **7160** | **5240** | **4822** | **5899** |
| **Savings** | **-28.98%** | **3.76%** | **-21.37%** | **11.17%** | **18.25%** | **-** |

According to the LEED rules, the necessary percentage of savings is determined by comparing the design case scenario with the baseline scenario in order to earn the necessary energy related credits. In order to achieve LEED certification, a building must reduce its energy consumption by at least 10% compared to baseline levels established by the LEED rating system [14].

All other possible outcomes, measured in total building MWh consumption, are likewise provided by the modelling software. Table 1.0 outlines the investigation in full. Energy consumption is calculated for each scenario, and the results are compared to the ASHRAE baseline case (Scenario- 6). Below each metric is a percentage increase vs scenario 6 that can be used as a comparison scale. This is done to assess how well each parameter performs, with an eye towards selecting the optimal option for the final design scenario.

Above Table 1.0 shows that compared to the ASHRAE baseline (Scenario 6), the as-built design (Scenario 5) results in an 18.25% decrease in energy usage. Scenario 5 was found tobe the most energy-efficient when compared to the other four and the baseline reference (Scenario 6), after incorporating the Solar passive techniques, Energy efficient lighting & HVAC systems as explained above for Integrated Multi mission Ground segment Earth Observation Satellite (IMGEOS), ISRO campus at Hyderabad with 1, 00,000 sft area. Hence, it is found with the help of e-QUEST design software that, the energy requirement of the campus has been decreased to 4822 MWH units against 5899 MWH units of electricity as shown in the below table 1, which results a saving of 18.25% of the electrical energy requirement.

The energy simulation findings show that a campus that is 1, 00,000 square feet and has a LEED Platinum rating can save money on its utility bills by installing energy-efficient lighting, HVAC systems with minimum energy savings of 18.25 percent.

The LEED India Core and Shell rating version 1.0 Platinum level qualification was achieved due to the service design's compliance with IGBC and ASHRAE standards for this project.

## VI. CONCLUSION

The investigation revealed a minimum potential energy savings of 18.25% LEED-PLATINUM rated "IMGEOS Campus," which was also realized and validated in actual operational conditions. The measured energy consumption is consistent with both the baseline and the final design case energy consumption scenarios. Establishing the renewable energy solar PV power plants also contributes much to the development of sustainable green building infrastructure [15].

Economic and environmental considerations have combined to elevate the priority of maximizing building energy efficiency.

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This study reaffirms the importance of including sustainability concepts into the design of all future data center facilities of ISRO. The energy usage of the IT industry is the greatest of any industry. A helpful standard for all future buildings is the creation of energy modelling to achieve energy efficiency in Data centers and the strategies employed to achieve it. The findings of this study will aid policymakers in designing more resource- and energy-efficient buildings [16].

## DECALARION STATEMENT

| | |
|---|---|
| Funding | No, I did not receive. |
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| Ethical Approval and Consent to Participate | No, the article does not require ethical approval and consent to participate with evidence. |
| Availability of Data and Material/ Data Access Statement | Not relevant. |
| Authors Contributions | All authors have equal participation in this article. |

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