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Energy Performance Analysis Using eQuest Sotware

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Abstract

This project presents a comprehensive analysis of building energy performance through modeling and simulation of JECRC College B Block using eQUEST Software. The study aims to compare the energy consumption of the standard baseline building with the proposed design, focusing on evaluating the effectiveness of energy efficiency measures and assessing compliance with the Energy Conservation Building Code (ECBC) standards. Key objectives include optimizing energy usage, enhancing sustainability, and identifying opportunities for improvement in building design.

Article Status

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Keywords: ZW-CAD Interface, Building Envelope, E-Quest Interface, Commercial buildings, Energy efficiency measures

1. Introduction

In the global pursuit of sustainability, buildings play a pivotal role as both contributors to energy consumption and potential sites for significant efficiency gains. Within the context, educational institutions stand as beacons o progress, tasked not only with imparting knowledge but also with embodying principles of environmental responsibility. The JECRC B Block College Building, nestles within the sprawling campus o JECRC Foundation, embodies this ethos, serving as a focal point for academic endeavor and innovation

By addressing the objectives, the building performance simulation report aims to provide evidence-based insights into the potential energy saving and financial benefits o implementing energy conservation measures tailored to the JECRC B Block College Building. This analysis will inform decision-makers about the most effective strategies for enhancing energy efficiency while meeting regulatory requirements and contributing to the institution's sustainability goals.

2. Related Works

Article [1] "A review of validation methods for building energy modeling programs (BEMPs)" by Zhou, X. and Liu, R. This paper proposes a analyzes validation methods for BEMPs, including analytical, comparative, and empirical approaches.

Article [2] "Urban building energy modeling (UBEM): Challenges and opportunities" by Kong, D., Cheshmehzangi, and A., Zhang. This paper presents UBEM which calculates urban-scale energy use with limited resources, aiding energy policy formulation. Challenges include input uncertainty and model calibration.

Article [3] " Simulation-aided occupant-centric building design " by Azar, E., O'Brien, W., Carlucci, S. This paper proposes a : A critical review of tools, methods, and applications. Energy and Buildings, 224: 110292. This review explores tools and methods for occupant-centric building design.

Article [4] "Windows thermal resistance" by Y. Yan and W. Zhang. This paper proposes Infrared thermography aided comparative analysis among finite volumes simulations and experimental methods. This study investigates thermal resistance in windows using simulations and experimental data.

Article [5] Novel mathematical modeling, performance analysis, and design charts for the typical hybrid photovoltaic/phase-change material (PV/PCM) system " by Al-Najjar, H. M. T., and Mahdi, J. M. This research focuses on mathematical modeling and performance analysis for PV/PCM systems.

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Article [7] "Measurement of Energy, Demand, and Water Savings. Atlanta, GA, USA: American Society of Heating, Refrigerating and Air-Conditioning Engineers" by **ANSI/ASHRAE.** This guideline provides standards for measuring energy savings.

3. Problem statement

The JECRC B Block College Building aims to enhance its energy efficiency and align with the Energy Conservation

Building Code (ECBC) standards to reduce operational costs and environmental impact. This project involves conducting a building performance simulation to compare the standard energy consumption according to ECBC guidelines with the proposed consumption of a similar building type, thereby determining potential energy savings and assessing the feasibility of implementing energy conservation measures.

4. Objective of the project

The main objective of this project is to develop a the building performance simulation report aims to provide evidence-based insights into the potential energy savings and financial benefits of implementing energy conservation measures tailored to the JECRC B Block College Building.

1. Evaluate the current energy consumption patterns of the JECRC B Block College Building and assess its compliance with ECBC standards.
2. Identify energy conservation measures (ECMs) relevant to the building's infrastructure, including HVAC systems, lighting, insulation, and building envelope.
3. Develop a simulation model to predict the energy consumption of the JECRC B Block College Building based on ECBC standards.
4. Customize the simulation model to incorporate proposed energy efficiency upgrades and ECMs tailored to the building's specific requirements.
5. Conduct comparative simulations to analyze the difference in energy consumption between the standard ECBC-compliant building and the proposed energy-efficient version of the JECRC B Block College Building.
6. Quantify the potential energy savings and associated reductions in operational costs and carbon emissions resulting from the implementation of energy conservation measures.
7. Assess the financial feasibility and return on investment (ROI) of implementing the proposed ECMs compared to adhering solely to ECBC standards.
8. Provide recommendations for prioritizing and implementing cost-effective energy conservation measures based on the simulation results and economic analysis.

5. Flowchart

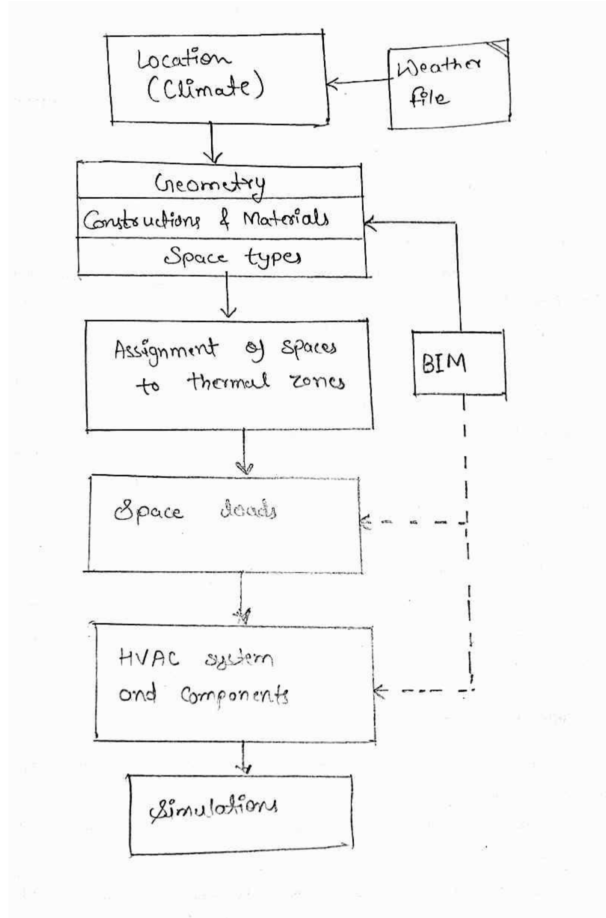


Fig 1:Flowchart

6. ALGORITHM:

eQuest and ZW-CAD eQUEST is a widely-used building energy modeling software developed by the U.S. Department of Energy (DOE). It stands for "Quick Energy Simulation Tool" and is designed to perform detailed energy analysis for buildings. eQUEST is primarily used for energy modeling and simulation of buildings to evaluate energy performance, identify energy-saving opportunities, and comply with energy codes and standards. eQUEST allows users to input detailed building geometry, including floor plans, walls, windows, roofs, and shading devices. Users can define various HVAC systems such as packaged rooftop units, chillers, boilers, VAV systems, radiant systems, etc. The software calculates energy consumption for heating, cooling, lighting, equipment, and other end-uses based on building characteristics and user-defined parameters. eQUEST supports the integration of renewable energy systems such as photovoltaic panels, wind turbines, and solar water heaters into the building model. Users can

conduct parametric analyses to evaluate the impact of design alternatives, system configurations, and energy-saving measures on building energy performance.
Here we are using ZW-CAD for modelling of JECRC Building B Block. ZW CAD likely refers to ZWCAD, which is a professional CAD (Computer-Aided Design) software developed by ZWSOFT. It's a popular alternative to other CAD software like AutoCAD, offering similar functionalities for designing and drafting in various industries like architecture, engineering, and manufacturing. ZWCAD provides 2D drafting, 3D modeling, rendering, and other features tailored to meet the needs of professionals in these fields.

7. System Architecture

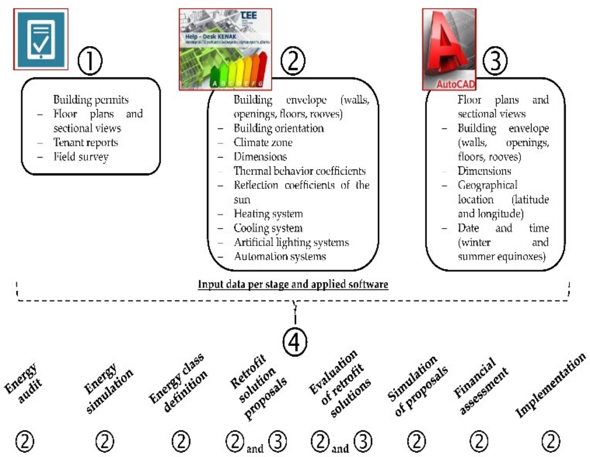


Fig 2:SYSTEM ARCHITECTURE

Figure 2 shows the block diagram of smart voting system.
The proposed system is designed to improve the accuracy and reliability of the Energy consumption in a building largely depends upon the type of materials and design of the buildings. This paper analyses the energy consumption pattern of an academic building located in Karachi using eQUEST. Some common and easy to adopt energy efficiency measures (EEMs) are proposed and applied to the baseline building to evaluate their energy savings potential. Of all the discussed, appropriate selection of air conditioning system has highest energy savings potential. When all the EEMs are applied together, the baseline building shows an energy saving potential of 30.5%.
The energy building modelling energy performance analysis of a baseline building is performed using eQUEST. Some common and easy to adopt energy efficiency measures (EEMs) are then applied using control variables method to calculate the energy savings.

8. Methodology

In the first place, energy performance analysis of a baseline building is performed using eQUEST. Some common and easy to adopt energy efficiency measures (EEMs) are then applied using control variables method to calculate the energy savings. Some of the possible EEMs may include: the addition of insulations to exterior walls and roof surfaces, replacing one type of window with another, reduction in lighting density, installation of daylight controls and appropriate selection of air conditioning systems. Moreover, the variation in window-to-wall ratio (WWR) of a building may have a positive impact on energy savings The methodology employed for performing building performance simulation using software like ZW CAD and eQUEST for the JECRC B Block College Building involves a structured approach encompassing research methodology, tools, techniques, and materials. Quantitative analysis involves the use of building performance simulation software like ZW CAD and eQUEST to model the energy consumption of the JECRC B Block College Building.

9. Performance of Research Work

The present study conducted building energy modeling and simulation of JECRC College B Block using eQUEST Software, with a focus on comparing the energy performance of the standard baseline building against the proposed building design. The project objectives included assessing the energy consumption of the proposed design and its compliance with energy efficiency standards. The analysis yielded insightful findings pertinent to the project's objectives and existing literature. The present study conducted building energy modeling and simulation of JECRC College B Block using eQUEST Software, with a focus on comparing the energy performance of the standard baseline building against the proposed building design. The project objectives included assessing the energy consumption of the proposed design and its compliance with energy efficiency standards. The analysis yielded insightful findings pertinent to the project's objectives and existing literature. The simulation revealed that the standard baseline building consumed approximately 773,060 kWh, while the proposed building's energy consumption reduced significantly to 517,810 kWh. This reduction indicates the effectiveness of the proposed design in mitigating energy demand, likely attributed to optimized lighting systems and other energy-efficient measures. The calculated EPI for the proposed building was found to be 0.67. This metric serves as a comprehensive indicator of a building's energy efficiency, considering various factors such as energy use intensity, occupancy, and climate conditions. The obtained EPI value of 0.67 signifies a notable improvement in energy performance compared to conventional building designs.

10. Experimental Results

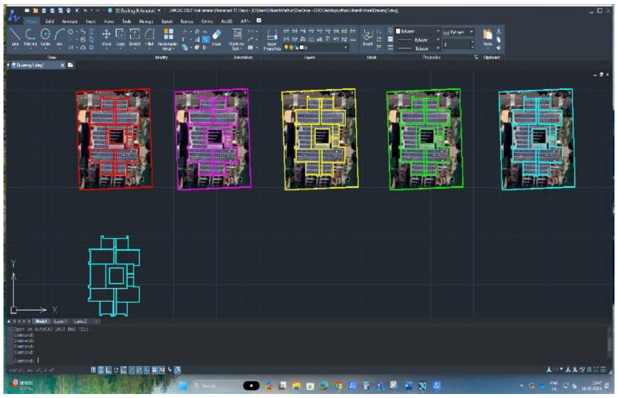


Fig 3:ZW-CAD Interface

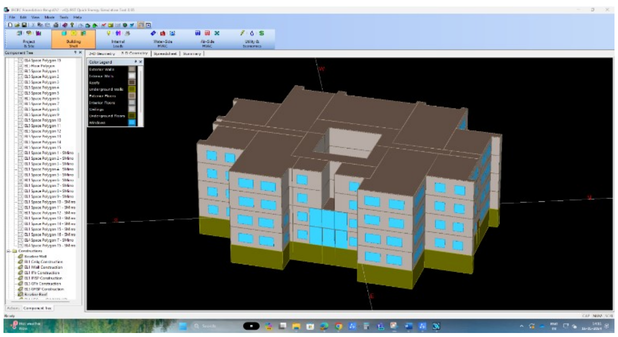


Fig 4:eQuest Interface

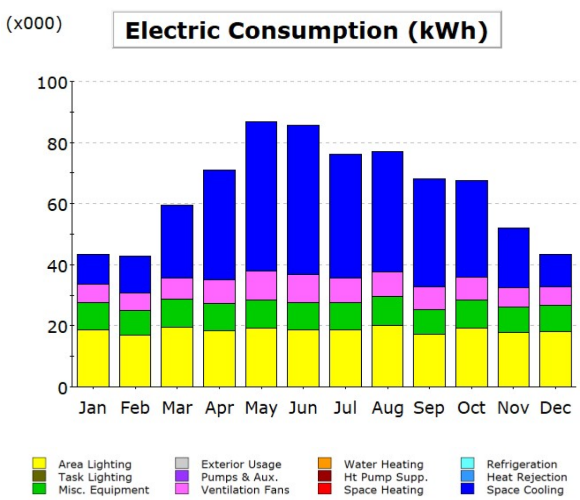
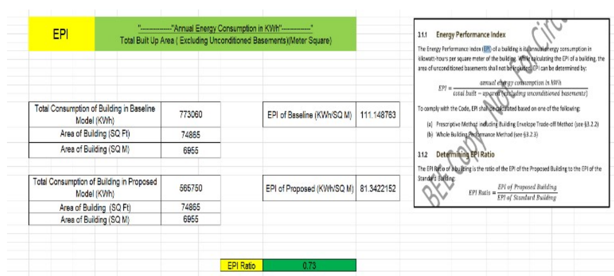


Fig 5:Consumption Graph



EPI	"-------------"Annual Energy Consumption in KWh"-------------" Total Built Up Area (Excluding Unconditioned Basements)(Meter Square)

Total Consumption of Building in Baseline Model (KWh)	773060
Area of Building (SQ Ft)	74865
Area of Building (SQ M)	6955

EPI of Baseline (KWh/SQ M)	111.148763

Total Consumption of Building in Proposed Model (KWh)	565750
Area of Building (SQ Ft)	74865
Area of Building (SQ M)	6955

EPI of Proposed (KWh/SQ M)	81.3422152

EPI Ratio	0.73

3.1.1 Energy Performance Index

The Energy Performance Index (EPI) of a building is its annual energy consumption in kilowatt-hours per square meter of the building. While calculating the EPI of a building, the area of unconditioned basements shall not be included. EPI can be determined by:

$$EPI = \frac{annual\ energy\ consumption\ in\ kWh}{total\ built-up\ area\ (excluding\ unconditioned\ basements)}$$

To comply with the Code, EPI shall be calculated based on one of the following:

(a) Prescriptive Method including Building Envelope Trade-off Method (see §3.2.2)

(b) Whole Building Performance Method (see §3.2.3)

3.1.2 Determining EPI Ratio

The EPI Ratio of a building is the ratio of the EPI of the Proposed Building to the EPI of the Standard Building:

$$EPI\ Ratio = \frac{EPI\ of\ Proposed\ Building}{EPI\ of\ Standard\ Building}$$

Fig 6: Comparision b/w Baseline & Proposed Model

CONCLUSIONS

 The implementation of building energy consumption modelling and simulation is a complex yet rewarding process. It provides a comprehensive understanding of the energy performance of buildings, enabling stakeholders to make informed decisions about energy efficiency measures. The process involves defining the scope and objectives, collecting and analyzing data, developing and calibrating the model, running simulations, evaluating and optimizing, and finally implementing and monitoring the recommended measures. The proposed building design, incorporating a lighting power density (LPD) of 0.8, demonstrated a significant reduction in energy consumption compared to the standard baseline building. The simulation revealed a notable decrease in energy usage, with the proposed building consuming 517,810 kWh compared to 773,060 kWh in the standard baseline scenario.

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