Comprehensive Energy Audit and Conservation Strategies for Commercial Buildings: A Case Study of C21 Business Park, Indore

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Abstract:- This study presents a detailed energy audit of C21 Business Park, an 11-floor commercial building in Indore, India. The audit identified HVAC systems (58%), lighting (18%), and motor-driven systems (14%) as primary energy consumers. Recommendations include LED retrofitting, VFD installation, and solar integration, projecting 25-30% annual cost savings (₹1.2-1.5 crore) and 142 tonnes CO_2 reduction.

Keywords: - Energy audit, HVAC optimization, solar integration, commercial building, energy conservation

I. INTRODUCTION

- Commercial buildings consume 8-10% of India's electricity
- C21 Business Park: 11 floors + 3 basements, 5500+ kW peak load
- Audit objectives: Quantify consumption, identify savings potential, propose ECMs

II. LITERATURE REVIEW

Xin. Wang, and Chen. Huang 2016, Using a case study of a Shanghai commercial building, the paper provides a thorough analysis of building energy audit. A thorough energy audit study is then provided after diagnosing the building energy-usage system's weak points and tapping latent power using recorder data of energy consumption of each building service system. Through an examination of energy usage, the energy audit primarily concentrates on equipment usage, particularly on air conditioning systems, electronic equipment, lighting systems, lifts, etc. Wintertime field measurements of the indoor environment were conducted as part of the energy audit study. During the field measurement, the CO2 concentration, relative humidity, and inside temperature were recorded [1].

Sunita & S.Y Kamdi 2011, Present a case study of an electroplating unit located in Vidarbha region of Maharashtra state. The energy audit indicated scope areas for conservation of energy. He suggests certain recommendations such as IE3super efficiency motors in the place of low rated efficiency motors, T5 in the place of T12 tube lights and energy efficient fan in the place of conventional fan for energy saving [2].

Aakash Raj, Dr. Beemkumar Nagappan 2023, The foundation of a methodical approach to energy management decision-making is the energy audit. Through effective management, energy efficiency is crucial for the sector's overall energy supply and consumption. Energy audits and management can lower expenses by conserving energy in a variety of settings, including homes, hospitals, businesses, and institutions.
The main conclusions of the audit are presented along with the general procedure, equipment, methodology, and summary. Through efficient energy management and auditing techniques, these management and audits identify places where electricity is wasted and adopt suitable and efficient energy use. It is possible to conserve money and energy without sacrificing the natural and high-quality work that is done in each sector. The steps involved in energy audits and management are briefly described in this article [3].

Malkiat, Gurpreet & Harmandeep 2012, presents a physically based model and formulation for industrial load management. Lighting is an essential service in all the industries. He suggests certain recommendations such as electronic chokes in the place of conventional chokes, metal halide lamps in the place of halogen and mercury vapour lamps for energy saving [4].

Rajat Sharma, Vedant Shukla, Vaibhav Mudgal, Mr. R.M holmukhe 2017, Previously, there was little incentive for energy efficiency investments in the building sector due to subsidised pricing; however, rising energy tariffs now make these investments crucial for any establishment's economic growth. A significant portion of municipal budgets is allocated to energy costs for both private and public facilities, including offices, schools, hospitals, and institutions. Buildings must be renovated and energy efficiency measures must be put in place in order to lower energy expenditures and consumption and enhance the internal atmosphere. Effective project development and implementation necessitate the use of sound energy auditing and project management techniques and resources. Today, this capacity is not present at a high enough level. Therefore, in order to achieve sustainable development, capacity building on these topics is crucial [5].

Sanjay & Tarlochan 2011, provides an overview of a general energy conservation measures (ECMs) that can be commonly recommended for NIT Hamirpur. He suggests certain recommendations such as high energy efficient fans in the place of conventional fans, CFL in the place of incandescent bulb, use of motion sensor for energy saving in NIT Hamirpur [6].

Elena Lucchi 2018, The study provides a critical evaluation of the application of the infrared thermography (IRT) survey in the building energy audit based on a comprehensive bibliography (148 publications made up of books, guides, scientific articles, and other materials). The applicability of passive and active approaches has been discussed after its historical development, taking into account both existing and new methodologies, general procedures, types of IR cameras utilised, technical challenges, and limitations. The most popular method for identifying thermally significant flaws is the passive technique. As a result, this article reports a particular energy audit technique that complies with many regulations, guidelines, and expert advice. Recurring energy-related issues are also given in a severe manner, such as indoor temperature, insulation level, air leakage and moisture detection, thermal characterization of structures, and thermal bridging [7].

Ana Mickovic, Marc Wouters 2020, This study examines empirical data regarding the availability and application of energy cost information in manufacturing firms that have been published in research journals. The study intends to distinguish between the practices of small and medium-sized firms (SMEs) and large corporations, as well as to concentrate on both energy-intensive and non-energy-intensive businesses. The final sample, which consists of 51 papers for the analysis, is the result of the literature research, which comprises 23 publications in the domains of business, accounting, energy, and engineering. Large, energy-intensive businesses are the subject of the majority of the research in this sample. The most startling finding is that, with very few exceptions, virtually no studies include a detailed explanation of the process used to measure and allocate energy costs [8].

Oxana, Michael & Ali 2013, to introduce non science and engineering students to the concepts of energy, power, electricity, heat, temperature, first and second laws of thermodynamics, embedded energy and world energy consumption. The most common categories included; energy consumed in heating up water, transportation, and electricity. Additionally, on calculating energy used by electricity, we asked the students to confirm their calculations by reading labels and using Kill-a-Watt reading devices [9].

Zaved Ahmad, Naveen Asati 2024, It order to analyse the patterns of energy usage and offer specific recommendations to increase energy consumption efficiency and lower energy costs, this article offers a case study of an energy audit conducted at an academic hostel in Bhopal. The audit method involved gathering data through an on-site survey, analysing the data, and making recommendations for performance improvement. According to the energy audit, the hostel's annual electrical energy consumption was 7.2981 MWh, with a potential for energy savings of 2.6056 MWh, or 35.7%. The most successful energy-efficiency measures plan to improve the lighting and electrical efficiency in hostels is the installation of efficient equipment and control systems, which also raises awareness of the need to decrease energy waste. The benefits of implementing the energy efficiency measures in academic hostel are substantial both in terms of energy savings and cost savings [10].

Shubham Soni, Inderpreet kaur 2021, Energy efficiency is one of the best ways to address the world's energy dilemma, which is a major issue. There are two ways to meet the need for energy: first, conventional and non-conventional means of generating electricity, each of which has an impact on the environment; second, improving the efficiency of the current system. Systematic approaches are needed to enhance system performance in order to save energy. The best method for determining how much energy is used and wasted by institutions and organisations is an energy audit. In this work, we use both traditional and non-conventional methodologies to correlate the environmental impact of energy usage [11].

III. METHODOLOGY

3.1 Site Characterization

- Location: Indore (hot-dry climate)
- Operational hours: 08:00-22:00 (weekdays)
- Major systems: HVAC, lighting, pumps, IT infrastructure

3.2 Data Collection

- **Electricity Bills**: Monthly data for FY 2023–24
- **Inventory Audit**: 2,500+ devices audited across floors
- **Load Monitoring**: Clamp-on meters and client-level measurements

Data Type	Source	Period	Parameters Collected
Electrical Bills	DISCOM Portal	Nov 2023-Sep 2024	kWh, kVAh, MD, PF
Equipment Inventory	Physical Audit	Sept 2024	2,500+ devices cataloged
Load Measurements	Fluke 435 Power Analyzer	27 Sep 2024	Real-time current/power

Equipment	Quantity	Total Load (kW)	% of Total
HVAC Systems	387	2860	58%
Lighting	4200	890	18%
Motors	92	690	14%
IT Infrastructure	3500	245	5%
Miscellaneous	-	255	5%

IV. RESULTS AND ANALYSIS

4.1 Energy Consumption Profile

- Annual consumption: 5.38 million kWh
- Peak demand: 1690 kVA (June 2024)
- Seasonal variation: 31% summer increase
- Summer demand (May–July) is 31% higher due to HVAC load
- Power Factor remains stable (~0.92)

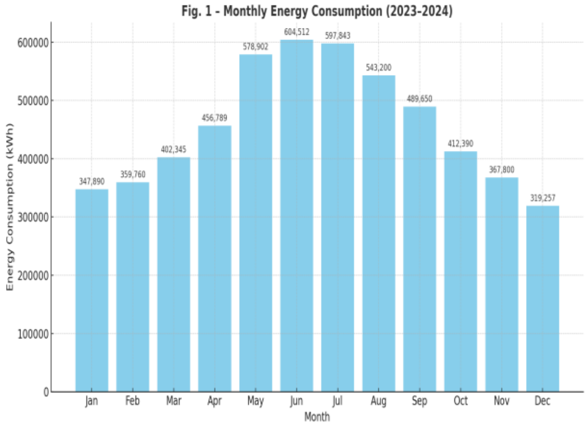

Fig. 1 - Monthly Energy Consumption (2023-2024)

4.2 System-wise Energy Consumption

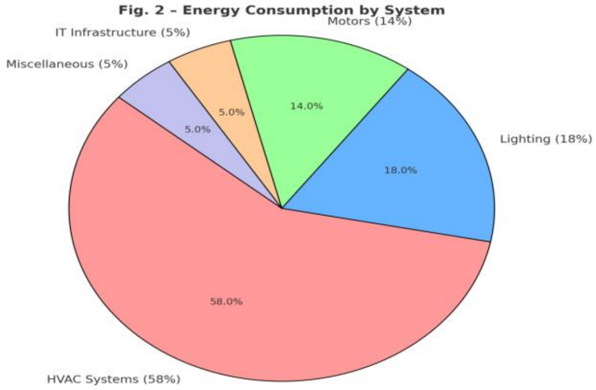

Fig. 2 - Energy Consumption by System

4.3 Key Inefficiencies Identified

- Lighting: 40% T12 tubes (18W) vs. LED alternatives (7W)
- HVAC: Chillers operating at 60% efficiency (best practice: 85%)
- Motors: 70% without VFDs
- Standby losses: 15% of IT energy consumption

Company	Floor	Load (A)	Equivalent kW
TaskUs	7F	373	155 kW
Rakuten	3F	207	86 kW
ICICI Bank	5F	251	104 kW

V. RECOMMENDATIONS

5.1. Immediate Low-Cost Measures

- **LED Lighting**: Replace T12s (₹18.7 lakh/year saved)
- **VFDs**: Install on pumps/fans (₹22 lakh/year saved)
- **Smart Plug Use**: For IT equipment standby cut (₹8.5 lakh/year)

5.2. Medium-Term Investments

- **HVAC Optimization**: Chiller tuning + IoT-based occupancy zoning
- **Solar Integration**: 500 kW rooftop PV (Saves ₹45 lakh/year; 4-year ROI)

5.3. Behavioral and Operational Changes

- Tenant workshops on energy efficiency
- Install occupancy sensors in corridors and restrooms

5.4. Energy Conservation Measures (ECMs)

Measure	Scope	Investment (₹ lakh)	Annual Savings (₹ lakh)
LED Retrofitting	4,200 fixtures	22.5	18.7
VFD Installation	64 motors	33.0	22.0
Solar PV (500 kW)	Rooftop installation	180.0	45.0
Standby Power Control	Smart plugs for IT	4.2	8.5

VI. ECONOMIC AND ENVIRONMENTAL IMPACT

6.1 Cost-Benefit Analysis

Measure	Annual Savings	CO_2 Reduction	Payback Period
LED Retrofitting	₹18.7 lakh	42 tonnes	1.2 years
VFDs for Motors	₹22 lakh	50 tonnes	1.5 years
Solar PV (500 kW)	₹45 lakh	50 tonnes	4 years
Total	₹85.7 lakh	142 tonnes	—

6.2. Carbon Reduction Potential

- Total CO_2 reduction: 142 tonnes/year
- Equivalent to 3,900 tree-years sequestration

VII. CONCLUSION

C21 Business Park's energy audit reveals a 25–30% savings potential via:

- Technical Upgrades: LEDs, VFDs, rooftop solar
- Operational Changes: IT standby cuts, HVAC improvements
- Behavioral Shifts: Workshops and awareness

This supports India's climate goals and offers a template for similar commercial buildings. Future work can integrate real-time BMS and AI-driven demand forecasts.

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