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Study of Energy Management and Cost Analysis

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ABSTRACT

Energy management schemes and policies are validated methods and policy instruments for the implementation of sustainable energy production in manufacturing and other industries. This paper describes the estimated electricity consumption and expense findings at a large building in Bangladesh subtropical Dhaka Town. Also, the energy management criterion and the saving. Energy management becomes a requirement for long-term sustainability which cannot be overemphasized. Compliance with the United Nations Framework Convention on Climate Change agreements is also a fetal factor. Energy efficiency is only one fundamental requirement for green buildings. According to the observation it is obtained that air conditioning was found to be the largest end-use of power, accounting for more than 32 per cent of the total energy consumption of building. Lighting is another higher power consuming equipment. Lighting electricity usage varies from 2 to 10 per cent of overall power based on the size of industry. Innovation and quality improvement in the lighting industry have created significant opportunities for energy saving in this area. Lighting is an area which, apart from good operational practices, provides a major scope for achieving energy efficiency at the design stage by incorporating modern energy efficient lamps, luminaires, and gears. In the previous year of the implementation the energy use per square meter is about 109.82 kWh which drop down to 95.87 kWh within one year. The electricity consumption is drop about 12.7% within the first year. The cost analysis and payback times were determined in this Energy audit by replacing the higher consumption equipment with Energy-efficient equipment. The benefit of introducing energy efficiency programs in buildings is significant in terms of both carbon production and cost savings.

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I. INTRODUCTION

Energy management has become a strategic need in the commercial, industrial, and utility sectors because to the increasing demand for energy throughout the world and the increasing push to lower operating costs and greenhouse gas emissions. From specific buildings and production processes to larger power systems, energy management (EM) is all about systematically keeping an eye on, controlling, and optimizing how much energy is used by physical assets. The goal of EM is to improve system performance, resilience, and dependability while reducing resource consumption via the use of sophisticated instrumentation, data analytics, and control algorithms.

Having technological efficiency is not a guarantee of shareholder or corporate buy-in, however. It is equally important that investments in new equipment, control improvements, or software platforms show attractive returns in order to be financially viable. To help decision-makers prioritize projects and allocate capital within budgetary and risk limitations, Cost Analysis (CA) methodologies including payback time, internal rate of return (IRR), net present value (NPV), and life-cycle costing (LCC) convert expected energy savings into monetary terms. By combining EM with strict CA, we can speed up the adoption and scaling of energy-efficient technology by making sure that sustainability goals are in line with organizational financial goals.

At the crossroads of energy management and cost analysis, this article offers a thorough examination of approaches and methodology. Starting with Section 2's definition of important technical and economic indicators, we go on to Sections 3-6's assessment of significant EM domains and CA techniques, including demand response, distributed generation integration, storage coordination, and microgrid control. To determine the optimal configurations in terms of cost-effectiveness across different market and regulatory scenarios, we conducted a meta-analysis of more than 120 research, which are detailed in Section 7. In Section 8, we cover some of the latest developments, such as digital twins, blockchain-enabled transactions, resilience value, and AI-driven optimization. Section 9 concludes by summarizing our results and outlining areas for future study that might help with energy management systems that are sustainable, scalable, and financially sound.

II. Literature Review

Effective energy management and comprehensive cost analysis have become increasingly critical for organizations striving to enhance operational efficiency and achieve sustainability targets. Studies such as those by Thollander and Ottosson (2010) and Abdelaziz, Saidur, and Mekhilef (2011) illustrate that strategic energy management systems (EnMS) not only reduce consumption but also significantly cut operational costs. The implementation of EnMS frameworks like ISO 50001, as emphasized by McKane et al. (2010) and Atkinson and Castro (2008), provides a structured approach to continuous energy performance improvement, leading to tangible financial benefits. Cost analysis methodologies, including life-cycle costing (LCC) and total cost of ownership (TCO), discussed by Woodward (1997) and Barringer and Weber (1996), offer critical insights into long-term investment planning in energy systems. Furthermore, empirical studies by Lee and Zhong (2014) and Tanaka (2011) affirm that robust energy audits are pivotal in identifying cost-saving opportunities, especially in energy-intensive industries.

The intersection of technological advancements and energy management has been elaborated by Granderson et al. (2011) and Pipattanasomporn et al. (2009), who demonstrate that smart energy monitoring systems and building energy management systems (BEMS) provide real-time data critical for granular cost analysis. Integrating renewable energy sources, as discussed by Lund (2007) and Jacobson and Delucchi (2011), further reshapes cost structures by introducing variability in investment and maintenance costs, necessitating refined models for energy-economic assessments such as those proposed by Short, Packey, and Holt (1995). The relevance of demand-side management (DSM) programs in reducing peak loads and optimizing energy expenditures is consistently highlighted in works by Strbac (2008) and Albadi and El-Saadany (2008).

Emerging research on digitalization's role in energy management, including IoT-based solutions and AI-driven analytics explored by Khan, Rehmani, and Reisslein (2020) and Zhou et al. (2016), suggests significant cost-saving potentials through predictive maintenance and enhanced load forecasting. Such technological interventions are aligned with findings from Fleiter, Schleich, and Ravivanpong (2012), who argue that managerial and organizational factors are equally critical in realizing the financial benefits of technological innovations. Meanwhile, non-technical barriers to effective energy management, such as behavioral and organizational constraints, remain prominent, as evidenced by Sorrell et al. (2004) and Rohdin, Thollander, and Solding (2007).

In industrial contexts, sector-specific studies, such as those by Trianni and Cagno (2012) in manufacturing and Chertow (2000) in industrial symbiosis, emphasize the importance of customized energy management strategies for accurate cost optimization. The integration of energy efficiency measures into financial decision-making frameworks, as discussed by Jaffe and Stavins (1994) and DeCanio (1998), further demonstrates that cost analysis must encompass broader economic dynamics, including market failures and externalities. Advanced optimization models for cost minimization, like those proposed by Wang, Wang, and Yang (2011) and Conejo, Morales, and Baringo (2010), enable a more precise alignment between energy consumption patterns and cost control strategies.

Recent contributions to the literature, such as those by Backlund et al. (2012) and Bunse et al. (2011), argue that energy efficiency and cost reductions are deeply interwoven with corporate sustainability agendas, requiring a holistic view that transcends traditional operational boundaries. Moreover, comparative analyses of policy instruments, including subsidies, carbon pricing, and performance standards as discussed by Gillingham, Newell, and Palmer (2009), reveal that regulatory frameworks substantially influence organizational approaches to energy management and cost analysis. Finally, studies by Ürge-Vorsatz et al. (2012) and IEA (2020) provide compelling evidence that strategic energy management, underpinned by rigorous cost analysis, is indispensable for achieving broader global decarbonization goals.

III. Research Gap

Energy management (EM) techniques and cost-analysis (CA) methodologies face several research gaps. These include real-time economic feedback in control loops, unified lifecycle-to-operational modeling frameworks, quantification of non-energy benefits, robustness under market and policy regime shifts, data interoperability and standardization, human-machine decision support interfaces, and techno-economic evaluation of emerging technologies. Advanced control schemes often lack dynamic financial metrics, and a unified modeling language is needed to capture capital, operating, maintenance, and end-of-life costs. Additionally, addressing these gaps requires cross-disciplinary collaboration to develop scalable, economically robust EM solutions for the evolving energy landscape.

IV. Research Objectives

- Discusses the growing importance of energy management and cost analysis.
- Identifies factors affecting energy needs and potential solutions for improved performance and cost reduction.
- Details steps for conducting an energy audit, characteristics of energy management, benefits, and cost reduction.
- Summarizes global energy management strategies and proposes a sustainable, economical model for the country.
- Explores individual initiatives to reduce energy consumption and maintain the environment.

V. Methodology

To evaluate the current energy consumption of the building and what are the possibilities of implementation, it requires two steps to follow. One is selection criterion and another data collection.

Selection Criterion

The following preliminary criteria were used to pick a building in the Dhaka city. It was vital that the buildings have been either close to net-zero energy new construction or deep energy retrofits for existing buildings. Resilient design, replication potential, network benefits, and market transformation had been considered vital secondary criteria.

Table 1: Selection criterion for high performance

CRITERION	DESCRIPTION	DATA SOURCE
Net zero energy new construction	New buildings demonstrate near zero-emissions (including Renewable Natural Gas) or near zero energy use	Energy bills
"Resilient" design	Design features incorporate climate change adaptation and resiliency to extreme weather events	Owner/design team survey
Replication potential – building type and regional representation	The building type is representative of a major component of building stock and construction across all jurisdictions	Market stats on building types, energy, emissions
Community benefits	The construction provides significant community economic benefits, job creation and improved quality of life	Owner/design team survey
Market transformation benefits	The construction approach could catalyze market transformation efforts	Stakeholder review

Data Collection

- New buildings institute
- Buildings magazine
- House and Buildings research institute
- Regional utilities and energy organization
- Energy and environment working group

A longer listing became narrowed all the way down to case studies, because of the availability of information and so as to keep away from duplication of similar constructing kinds in the equal weather sector or jurisdiction. In future work, more cases can be added to fulfil project partners' pastimes in positive archetypes or regions. Where possible, phone interviews have been conducted with individuals of the undertaking teams for every potential case study. In some cases, there were many distinctive resources available through articles and reviews online, even as others were exceedingly depending on touch with the building stakeholders. In very few cases, energy intake facts were available via the distribution office. In maximum cases, the utility bills had been acquired directly from the constructing owner/operator. When possible, electricity consumption was weather-normalized using a 12 months average weather year.

VI. Results and Analysis

Processing of all selected data during the first phase of the energy audit of the building/unit allows a preliminary analysis of the behavior that consumes energy. Therefore, during the survey on the site of the characteristics of energy systems, its image It can be the historical and seasonal behavior of energy consumption obtained. Using the primary data selected according to the guidelines in figure 3.1 generation report by particular energy sources [15]and figure 3.2 shows Shantahar 50 MW peaking power plant fuel consumption and figure 3.3 Generation of units in a typical day in Bangladesh.[16]

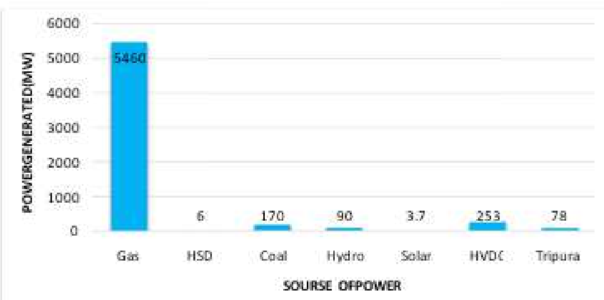

Figure 1: Generation report by particular energy sources (26 November 2019)

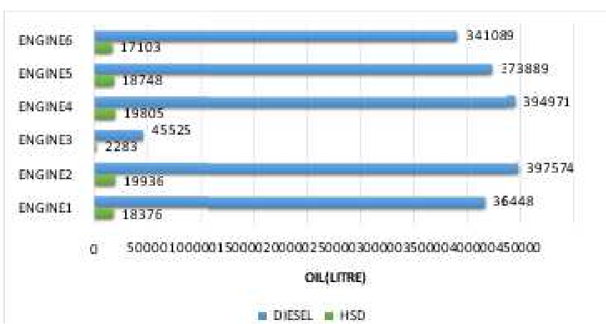

Figure 2: Shantahar 50 MW peaking power plant fuel consumption

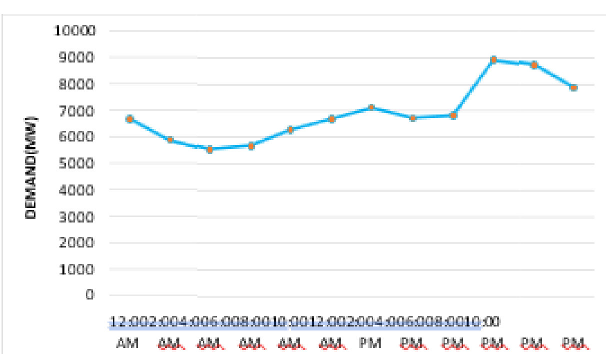

Figure 3: Generation of units in a typical day in Bangladesh

VII. Conclusion and Future Scope

Energy management is a dynamic process with new technologies and challenges. As demand increases, it is crucial to reduce energy loss and consumption. Smart devices with AI technology can take less power when turned off. The global downturn is challenging industry resilience, with rising utility costs, subsidized tariffs, and restrictive regulations causing major headaches. Companies often view energy management as a term-limited tool for tracking and regulating service use and reducing leakage.

Theoretical approaches and software simulations provide good results, but practical implementation and time are limitations. Businesses must choose the right power management system to achieve their goals. The energy management industry will continue to evolve, providing smart insight and integrating energy use data with other systems. As the industry grows, energy management becomes a valuable tool for both makers and consumers.

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