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A Review of the After-Effects of Energy Audits in the Residential, Commercial, and Industrial Sectors

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Abstract

Energy audits are essential for spotting the trends in energy usage and suggesting ways to increase energy efficiency in all sectors. The rising need for sustainable energy practices has amplified the importance of systematic energy assessment methods, allowing organizations to synchronize operational performance with environmental objectives. The consequences of energy audits in the commercial, industrial, and residential sectors are examined in this review. The study emphasizes how energy audits provide cost savings, increased operational effectiveness, environmental sustainability, and energy conservation. The integration of sophisticated monitoring technologies, data analytics, and intelligent energy management systems has enhanced the accuracy and dependability of audit results, facilitating informed decision-making. The implementation difficulties and long-term effects of audit suggestions, such as equipment improvements, behavioral modifications, and the integration of renewable energy sources, are also covered in the assessment. The results show that energy audits improve system dependability and economic performance while drastically lowering energy usage and carbon emissions. The research highlights the crucial role of supportive policies, regulatory structures, and the involvement of stakeholders for successful adoption. It also points out opportunities tailored to specific sectors that could improve the overall efficiency of energy audit strategies. In summary, energy audits are crucial for sustainable development and advancing the shift to a low-carbon future.

Keywords: Energy, audit, payback, carbon emissions, energy conservation

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INTRODUCTION

Urbanization, population growth, and industrial expansion have contributed to a sharp increase in energy demand. Sustainable development depends on efficient energy use. An energy audit is a methodical analysis of a facility's energy use with the goal of finding ways to lower energy use without compromising the comfort or productivity of the facility.

Energy audits aid in comprehending a system's energy flow, identifying energy losses, recommending energy-saving measures (ECMs), and enhancing energy management techniques. Energy audits have a noticeable effect on the commercial, industrial, and residential sectors, where energy-saving measures

result in long-term advantages, such as lower greenhouse gas emissions, better equipment performance, and cheaper energy bills.

RESEARCH REPORTS: A SURVEY

Owolabi et al. focused on improving energy efficiency in residential buildings as part of a Korean government retrofitting program. The study analyzed electricity bills and collected data from household occupants to identify energy-saving opportunities. Energy conservation measures were implemented to improve the building's performance. The results showed significant energy savings in heating and cooling systems with a short payback period. The study also reduced CO_2 emissions and confirmed that the simulated and actual energy consumption data were similar [1].

Abdul Halim et al. conducted an energy audit in two buildings at the State Polytechnic of Samarinda, namely, the Electrical Engineering Office and the Mechanical Engineering Office. The analysis considered factors such as temperature, relative humidity, OTTV, RTTV, and energy consumption intensity. The results showed that both buildings maintained temperatures of approximately 28°C with relative humidity of approximately 70%. Energy consumption slightly increased from 2022 to 2023 but remained within the efficient limits. This study highlights the need for additional energy efficiency measures to reduce energy waste and improve sustainability on campuses [2].

Kluczek et al. focused on examining the results of energy efficiency enhancements and evaluating the advantages attained under different energy efficiency strategies from energy audits based on case studies. To achieve a reduction in energy consumption and carbon emissions in industrial processes, new insights into non-energy advantages are outlined through a discussion of the energy audit framework. The findings indicate that for the targeted processes utilized by energy efficiency investments, the cost-effective and energy conservation potential represent reductions in energy consumption of 30%, 13%, 70%, 14%, 10%, and 5%, respectively. With a reasonable and acceptable return period of fewer than two years, energy efficiency investment plans were carefully developed based on local facts.

Diego A. Larrahondo et al. discussed the importance of improving energy efficiency in industries to reduce the effects of global warming. An energy audit was conducted at a bakery company in the Valle del Cauca region. The audit followed the guidelines of ISO 50002 to analyze the energy consumption of the company. The study identified equipment with high energy usage and suggested opportunities for improvement. These recommendations help companies make better decisions to improve energy performance and reduce energy waste [3].

Morais et al. focused on improving competitiveness in the agri-food industry through better productivity and efficient processes. This highlights the importance of technology, quality, and proper management in industrial operations. This study mainly analyzed the energy consumption and technologies used in the bakery and pastry sectors. This sector is an important part of the Portuguese agri-food industry. This research helps in understanding energy usage and improving efficiency in the bakery production process [4].

Luiz Vieira et al. focused on the importance of energy management in small and medium-sized enterprises. A model is proposed to support energy management implementation through energy audits. The model analyzes electricity consumption, ranks improvement suggestions, and provides performance indicators. A case study was conducted in a plastic injection company to evaluate the model. The results showed that the model helps organizations make better decisions and improve energy efficiency based on the ISO 50001 principles [5].

Akhtar et al. conducted an energy audit to identify how energy is consumed and to find ways to reduce unnecessary usage. This study uses a fuzzy logic-based auditing method to improve energy efficiency in residential buildings in Kasganj, Uttar Pradesh. Different factors, such as appliance usage time, temperature, humidity, and energy consumption, were analyzed. The system combines solar power and grid electricity with intelligent control to effectively manage the load. The results show that the proposed method can reduce electricity costs by approximately 69% and improve energy efficiency [6].

Hassan et al. reviewed that an energy audit is an evaluation that determines how much energy is used by various services and makes recommendations for energy-saving measures. Few people were informed about cost analysis and energy-saving techniques, and even fewer were informed about how appliances waste energy. This study aims to develop a mechanism for determining the energy efficiency of new high-rise buildings. People spend approximately 90% of their time indoors at the same time. Therefore, it is essential to have comfortable and healthy conditions in buildings, including air quality and thermal comfort. [7].

Clairand et al. evaluated energy efficiency in the bakery industry through energy audits conducted in six bakeries in Quito, Ecuador. Data such as electricity bills, equipment usage time, and monthly energy consumption were analyzed. The study identified the baking process and production activities as the major energy-consuming areas. Energy indicators were used to calculate the consumption per unit of product. The results showed that these bakeries used electrical energy more efficiently than other bakeries [8].

Esteves et al. studied the impact of energy audits on a Wastewater Treatment Plant (WWTP). The audit was conducted based on ISO 50001:2018 using the Plan-Do-Check-Act (PDCA) method. The aim was to identify energy inefficiencies and improve the electrical energy performance. The results showed that the energy audit reduced electricity consumption by approximately 10.8%. However, factors such as old equipment, complex systems, and a lack of real-time data affect efficient energy management [9].

Lalith Pankaj Raj Nadimuthu et al. focused on reducing harmonics in the textile industry using a harmonic-mitigating filter. The analysis was carried out through different stages of the energy audit, such as preliminary, detailed, and post-audit. The study found that third, fifth, and seventh-order harmonics were mainly present in the system. A passive harmonic filter was installed to reduce the harmonics and improve the power quality. The results showed approximately 66.45% reduction in current harmonics along with energy savings and reduced carbon emissions [10].

Challa et al. proposed a method for analyzing building energy efficiency using drone thermal images and indoor thermal monitoring. Deep learning techniques have been used to detect heat loss areas in buildings. This study used outdoor drone images along with indoor thermal camera data for better analysis. A dataset was collected and trained to identify the heat envelopes and energy inefficiencies. The results help improve building energy management and reduce energy consumption and costs [11].

Dongellini et al. conducted an initial energy audit on eight sizable industrial buildings owned by a well-known Italian automaker. The structures on the property have heating energy demands ranging from six to slightly over 74 y. The energy audit made it possible to create a particular industrial energy model, which was used to examine how different energy-saving measures affect the primary energy use at the site. It has been shown that in this particular instance, improving the building envelopes and optimizing the performance of the current heating, ventilation, and air conditioning (HVAC) systems can result in a reduction of gas consumption of up to 15% annually, with an estimated annual economic savings of the order of 100,000 euros; the proposed thermal retrofitting's total simple payback time is estimated to be less than six years [12].

Khoshkhoo et al. studied energy consumption in the bread manufacturing industry, which is an energy-intensive sector. An energy audit was conducted in a large bread factory in Iran to analyze the exhaust gases from baking chimneys. Parameters such as gas composition, temperature, and flow rate were measured. This study focused on recovering heat energy from exhaust gases to improve furnace efficiency. The results showed that the factory could save approximately 200,000 m^3 of gas per year through heat recovery [13].

Pongiannan et al. conducted an energy audit of a medium-sized textile mill in western Tamil Nadu, India. The energy consumption patterns were analyzed using instruments such as a power quality analyzer, thermal leak detector, and luminance meter. Based on the collected data, several energy conservation methods and improvements were suggested. The implementation included better use of existing machines and a reduction in energy wastage. As a result, the industry achieved approximately 21% reduction in daily energy consumption and around 13.59% energy savings [14].

Kannan et al. discussed the importance of energy management in industries, especially in small- and medium-scale enterprises. Many small and medium-sized enterprises (SMEs) face challenges such as a lack of knowledge, expertise, and financial support for implementing energy management. This study reviews an energy management method applied in a German bakery. It explains the tools, methodology, and difficulties faced during the implementation process. This study also provides guidelines to help entrepreneurs improve energy efficiency in their businesses [15].

SUMMARIZED REVIEW

The energy audit process involves data collection and analysis, energy consumption assessment, identification of inefficiencies, recommendation of energy conservation measures, implementation, and monitoring. Energy audits in residential buildings mainly focus on electricity consumption related to lighting, HVAC systems, appliances, and insulation. The key outcomes are a reduction in electricity consumption (10–30%), lower household energy bills, improved energy-efficient appliances, and the adoption of renewable energy systems such as rooftop solar. Major energy-saving measures include the replacement of conventional lamps with LED lighting, energy-efficient air conditioners and refrigerators, smart home energy monitoring systems, and improved building insulation. The impact includes reduced peak demand, improved energy awareness among residents, and a reduction in carbon footprint.

CONCLUSION

Energy audits are useful tools for increasing energy efficiency in the commercial, industrial, and residential sectors. Energy audits result in reduced energy usage, lower operating costs, increased system efficiency, and environmental sustainability. To reap long-term benefits, energy-saving measures must be properly implemented and continuously monitored. The achievement of global energy sustainability targets will be greatly aided by the promotion of energy-auditing methods. The environmental benefits include reduced CO_2 emissions, lower energy demand, promotion of renewable energy adoption, economic benefits, reduced electricity bills, short payback period for energy-efficient technologies, and improved competitiveness for industries.

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