# OPTIMIZING THE ENERGY EFFICIENCY OF THE EXISTING STRUCTURE: A CRITICAL ANALYSIS OF INDUSTRIAL AND FORMAL BUILDINGS

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**ABSTRACT**

Over 40% of the world's energy is used by buildings, which also produce nearly a third of the world's greenhouse gas emissions (GHG). Building energy efficiency must be improved in order to counteract climate change and achieve energy independence (i.e. to become net-zero energy). Existing buildings have gotten a lot of attention lately for their energy efficiency as well as the health and comfort of the people who live there. Methods that don't rely on cutting-edge technology must be used. However, there is a dearth of studies addressing these issues in depth. The goal of this project is to conduct a thorough review of the available literature on energy-efficient building operations in commercial and institutional settings. Peer-reviewed journal articles from respectable journals published between 2000 and 2014 were the focus of our investigation. According to the findings, there are many different techniques to improving energy efficiency nowadays. The study's findings serve as a solid foundation for developing a national and organization-wide strategy to improve commercial and institutional building energy efficiency.

**Keywords:** Energy efficiency Commercial and institutional buildings Existing buildings Sustainability

## Introduction

Any nation's socio-economic progress can be measured by looking at the number of commercial and institutional buildings in the country. In spite of the many advantages buildings provide to society, they have significant environmental and social implications throughout their lifespan (Myers et al., 2002). Around the world, the building stock consumes 40, 25 and 40% of all resources, and emits a third of all GHGs (GHG). Energy use estimates forecast an increase in commercial building energy consumption, whereas residential building energy consumption is expected to decrease. The construction of commercial and institutional buildings has a significant impact on their long-term social, environmental, and economic viability. 3% of GDP was spent on operating energy by commercial and institutional buildings in Canada, according to Statistics Canada. With energy use of 1057 petajoules, commercial and institutional buildings accounted for 12% of secondary energy use in Canada (PJ). Buildings are responsible for 11% of Canada's total GHG emissions (Proulx-Bourque et al., 2019). Similar numbers can be found in other advanced countries throughout the world. A key issue in hot climates is the heat island effect, which is caused by city buildings radiating heat. Buildings have a societal impact that extends well beyond their environmental and economic consequences. Canadians, for example, spend 90% of their time inside buildings doing indoor activities.

Improving the energy efficiency of functional buildings has numerous environmental and economic benefits, two of which are reduced GHG emissions and lower running costs. The growing awareness of climate change, combined with other macroeconomic changes (such as rising energy prices and technological advancements), has increased demand for high-performance buildings that use less energy and cost resources while also utilising natural resources more efficiently and providing a higher indoor quality environment as well. The operating phase has the largest environmental influence on building material life cycle impacts and energy use. The result of this is that building laws and regulations are requiring more eco-friendly and energy-efficient building techniques and materials On the other hand, new construction makes up a small percentage of the total number of buildings in the country. As a result, reinforcing current structures offers the most potential for sustained development. (Xing et al., 2011) The purpose of this article is to assess the present status of energy efficiency approaches available for operating buildings. The poor energy efficiency of existing buildings is a global issue. As a result, rehabilitating historic structures is a key priority for improving the overall energy performance of a country's building stock. To find out which business and institutional energy saving techniques are most effective, researchers combed through existing literature. Systematically looking for relevant literature on this subject is being done. This research will also demonstrate current commercial and institutional building energy efficacy approaches and research areas. Researchers and practitioners trying to make buildings more ecologically friendly while also increasing their energy efficiency can benefit from the findings of this study (Roberts, 2008).

## 2. Methodology

The keywords "energy efficiency" and "commercial and institutional buildings" were used to search the "Compendex engineering village" database. Only articles published between the years 2000 and 2014 were considered for the study because it only looked at recent studies on energy efficiency. High-impact journals were heavily scrutinised during the course of this investigation. In terms of impact factor, this refers to how many times a journal's published articles have been cited in other publications. Although it has certain limitations, it's nevertheless a useful tool for determining the value of a diary. This research was conducted. (Hendee et al., 2012)

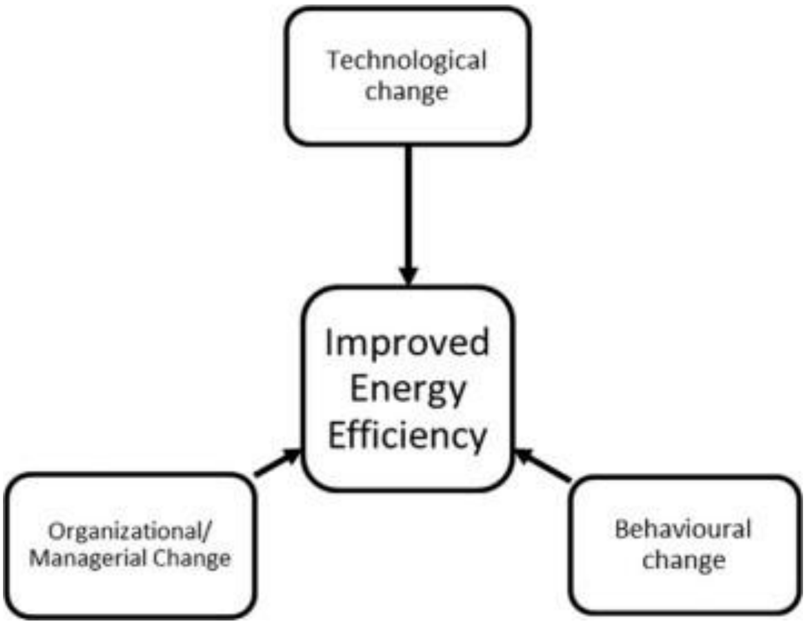


**Fig. 1** Paradigms for energy performance improvement in existing buildings (Hendee et al., 2012).

Published articles with five-year impact factors of 1.08 to 5.6 were found using keyword searches on energy management and engineering. In our study, the effect factors were on average 2.7. Only journals with an impact factor greater than 2.7 were considered for calculating a journal's impact factor. Peer-reviewed journals with at least a 2.7 impact factor are listed below. There are two parts to energy use: energy policy and building. A high impact factor is found in journals like Review of Energy Conversion & Management, Solar Energy, and Renewable Energy Sources. Consequently, only those books listed above were considered for inclusion in this study. The study's search criteria tallied up to 122 results in the form of journal articles. The articles collected were divided into three building energy efficiency paradigms based on the study's goals (Fig. 1). Table 1 summarises commercial and institutional energy efficiency research over the preceding 15 years and indicates the main focus areas.

## 3. Technologies assemblies

There has been a lot of effort put into making existing buildings more energy efficient. Commercial and institutional building energy efficiency has increased dramatically since the mid-1990s when compared to patents for residential structures. Various approaches, technologies, and assemblies detailed in published literature have been shown to minimise building energy use while improving environmental performance. By putting these ideas into practise, building projects will be able to set more accurate energy efficiency targets.

### Mechanical components

These are the most important factors to consider. Aside from the above-mentioned factors, the type of building and environment has an impact. Ensuring that the HVAC system is as energy-efficient as possible helps the building save money on its utility bills. HVAC systems that are properly selected and operated can save up to 25% on energy costs while still delivering a comfortable interior atmosphere, according to study. There are two approaches to reduce HVAC energy demand: passively or actively. Passive HVAC energy efficiency techniques include things like window replacement and optimum air tightness with enough ventilation. Improved boilers and micro-generation using renewable energy sources are only two examples of practical active solutions for reducing energy demand. Other common active energy-saving methods reported in the literature include variable refrigerant flow systems, programmable thermostats, and water heaters with inline heat pumps. These are just a few examples. Taking these steps is vital, but they must not ignore the needs of residents in terms of temperature and humidity regulation or the quality of the indoor environment (Cavique & Gonçalves-Coelho, 2009).

**Lighting systems**

Lighting accounts for about 15% of a building's total energy use. The energy efficiency of lighting systems can be improved in several ways, according to past studies. The use of occupancy sensors in work spaces, task-based lighting design, daylight-linked lighting systems, and more energy-efficient bulbs are just a few of the methods that can be implemented. It is important to take numerous factors into account when choosing a lighting source, including power factor, output luminous flux, system power requirements, and harmonic distortions caused by excessive current. There should also be more programmes created to inform building managers about the various approaches to building lighting systems and the selection of appropriate technology (Khan & Abas, 2011)

**Structure's protective layer**

It is feasible to save up to 14% of energy in hot regions by modifying fenestration geometry factors, but this is not possible in cooler and temperate areas. Due to their importance, numerous studies have focused on boosting building fenestration to increase energy efficiency. Windows with vacuum or triple glazing or those made of aerogels are considered to be cutting-edge technology. Paint, for example, can be used to improve a building's energy efficiency. For more information, please see Roberts.(Roberts, 2008) Buildings with high-reflectivity external coatings, for example, have better energy efficiency in locations with large day-night temperature variations (Susorova et al., 2013)

**Retrofitting and performance assessment**

To incorporate energy-saving measures into existing structures is very challenging task. Barriers to renovate projects have been mentioned in the literature lack of money, interoperability, and a lack of organisation in decision-making process. The rate of innovation is often judged insufficient, despite several governmental tools aiming at boosting building energy efficiency. Moreover, Insufficient information, disconnected decision-making, principal-agent difficulties, and a lack of learning from different initiatives are among the contributing factors to the aforementioned problem, according to (Altwies & Nemet, 2013)

**Micro generation using renewable energy sources**

Energy and environmental performance can be improved at the building level by using hybrid technologies. For the money, hybrid technologies are a great way to cut down on the carbon footprint of construction projects. For commercial and institutional buildings, ground-coupled heat pumps (GCHP) have been shown in tests to be an efficient heating/cooling solution using solar thermal energy. GCHPs can be used in both cold and hot climates. It is possible to improve the efficiency of the building heating system by using solar-assisted GCHP systems with a latent heat storage tank, for example. (Sarbu & Sebarchievici, 2014)

## 5. Occupancy and operational requirements

Reduce your building's energy use by following these simple steps.

i. For this reason, facilities should be scheduled to meet user needs while also adhering to the terms of the energy utility contract.
ii. A building management can utilise this feature to repair or fix issues if their power consumption rises without their knowledge or permission.
iii. Making the building energy system simple for building users to comprehend and control is step number two in the training process. Widespread awareness efforts would help motivate staff to save electricity.
iv. Engagement and information exchange, as well as advocating the most effective use of resources are all part of this strategy.(Pitts, 2008)

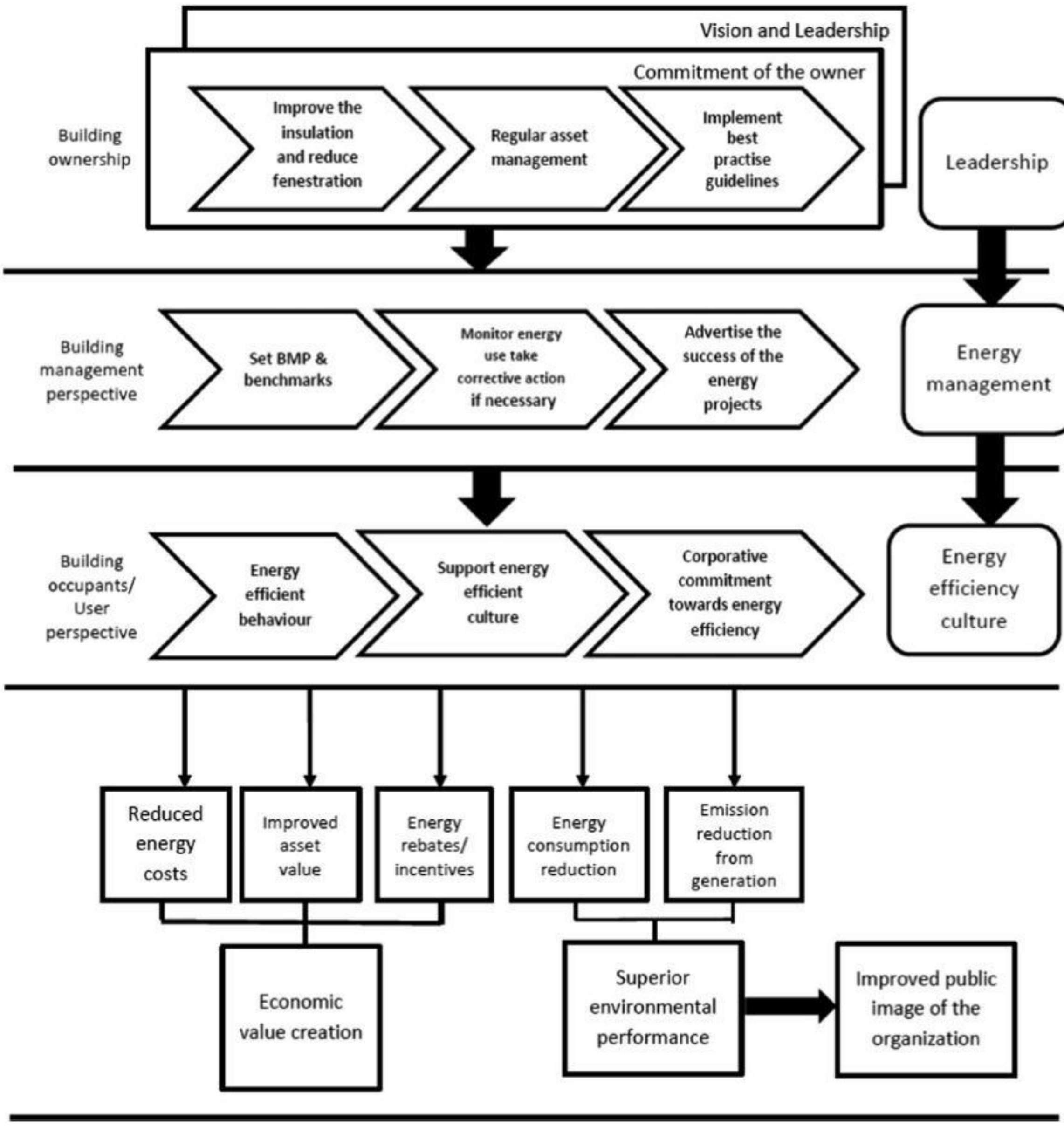


**Fig. 2** A road map for improving building energy operations(Sarbu & Sebarchievici, 2014)

## 7. Discussion

Research was conducted on energy efficiency enhancement techniques in running buildings, and important conclusions were drawn from the findings. There will be an emphasis on building energy management, as well as occupant and operation-specific requirements in this study.

When attempting to boost a building's energy efficiency, take an organised strategy. Aside from that, it's vital to look for innovative ideas instead of just following the herd. Smart facades (climate- and environment-adaptive facades), intelligent buildings, innovative, cost-effective, and aesthetically acceptable insulating materials, high-performance windows, and micro generation are some examples of the future vision for commercial and institutional buildings, respectively. One of the most important steps in managing a building's energy consumption is conducting regular energy audits. A comprehensive energy audit should consider environmental factors, occupant habits, and the use of energy-efficient building components (Kamilaris et al., 2014).

**Conclusions**

This research looked at a wide range of current ways to enhancing the energy efficiency of commercial and academic buildings in use. The review was based on papers published in prestigious energy engineering and management publications during the previous 15 years. As a result, behavioural techniques to enhancing a building's energy efficiency can be the focus of future research. Further study is needed to understand how firms establish and apply energy management best practices. It's also important to research the safety hazards, design, installation, and regulatory restrictions associated with new technology before putting them to use in the real world. As a result, a framework for asset management should be put in place to help buildings become more energy efficient. There are no thorough studies on building asset management that the authors are aware of.

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