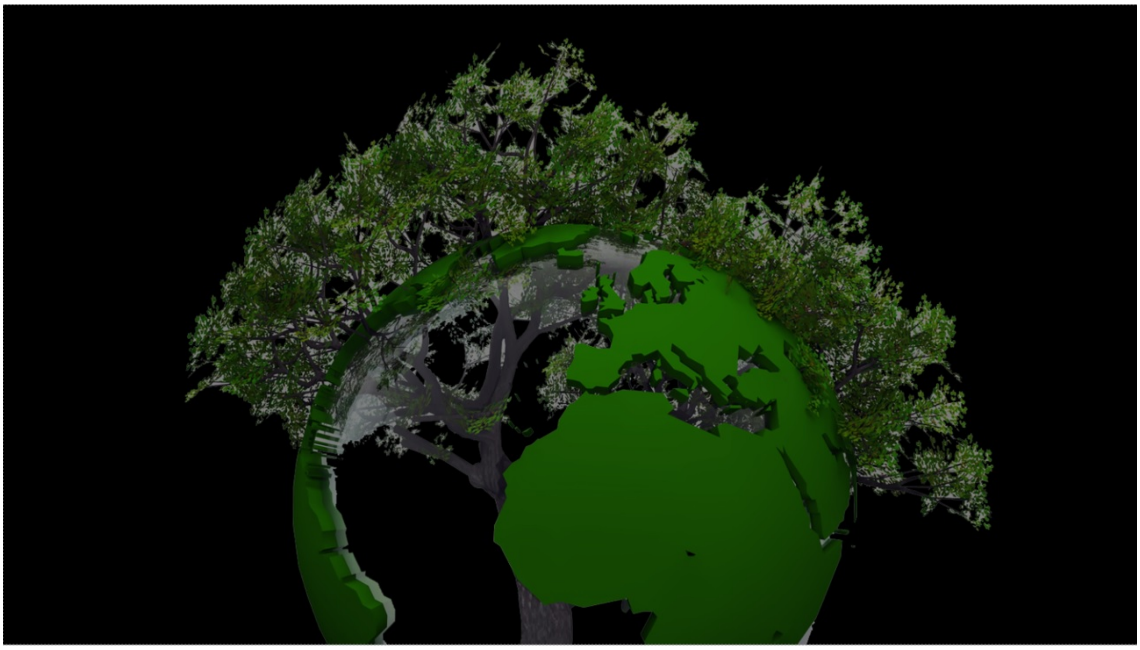

# Research to Understand the Challenges and Successes of Carbon Reduction Projects in Healthcare Facilities


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**Declaimer**

This report was produced as part of the UBC Sustainability Scholars Program, a partnership between the University of British Columbia and various local governments and organizations to provide graduate students with opportunities to do applied research on projects that advance sustainability across the region.

This project was conducted under the mentorship of Provincial Health Services Authority staff. The opinions and recommendations in this report and any errors are those of the author and do not necessarily reflect the views of the Provincial Health Services Authority or the University of British Columbia.

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**Executive Summary**

Climate change is a pressing global issue with significant implications for public health. Canada's healthcare system contributed to 33 million tonnes of carbon dioxide equivalents (CO2e), which accounts for 4.6% of the nation's overall emissions. Additionally, it was responsible for over 200,000 tonnes of other pollutants. these emissions can be connected to approximately 23,000 disability-adjusted life years (DALYs) lost each year due to both direct exposure to harmful pollutants and the environmental effects of pollution (Eckelman et al. 2018).

This research focuses on understanding challenges and success factors in carbon reduction initiatives within healthcare facilities in BC. Guided by these objectives, the research questions seek to explore the barriers faced by healthcare facilities in implementing energy-efficient and low-carbon solutions, as well as the strategies that contribute to successful energy efficiency and carbon reduction projects.

To fulfill these objectives, a mixed-methods approach was adopted. The project commenced with an in-depth literature review encompassing energy efficiency and carbon reduction projects in public sectors and healthcare facilities. Interviews followed, engaging stakeholders from health organizations and utility providers across BC. Experts from the healthcare and energy sectors shared their experiences, challenges, and strategies.

The findings reveal a comprehensive view of carbon reduction dynamics within healthcare facilities. Barriers emerged across economic, educational and behavioural, technological and implementation, and governmental dimensions. Success factors include early engagement, robust measurement and verification, continuous optimization, targeting low-hanging fruit, and promoting fuel switching and electrification. These insights culminate in actionable strategies for healthcare facilities to lead in carbon reduction.

As healthcare facilities grapple with the dual challenge of environmental sustainability and public health, this research offers a roadmap. By tackling barriers and harnessing success factors, healthcare organizations can pave the way for a greener, healthier tomorrow. Through collaborative endeavours and strategic actions, they can transform into catalysts of change, shaping a sustainable and vibrant future for all.

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# 1 Introduction

## 1.1 Provincial Health Services Authority

The Provincial Health Services Authority (PHSA) is committed to taking a leadership role in environmental stewardship, which is exemplified by its dedication to adopting sustainable practices. This commitment involves the implementation and adoption of best practices that support sustainability throughout its operations, while also fostering collaboration within the healthcare community to achieve this shared objective. Central to this commitment are efforts to address climate change and effectively manage energy usage and carbon emissions. These priorities have remained at the core of the organization's mission since 2008.

By prioritizing the effective management of energy consumption and carbon emissions, the PHSA is not only mitigating the impact of escalating energy expenses but also showcasing its dedication to environmentally conscious development. Moreover, these actions are in alignment with public sector regulations related to emission reduction, including the "Climate Change Accountability Act[1]." The primary goal is to minimize the adverse environmental effects of healthcare facilities on the well-being of the population.

The PHSA is actively involved in identifying opportunities and implementing projects aimed at reducing carbon emissions within its portfolio of buildings. These initiatives are specifically designed to meet both provincial and organizational targets for decreasing greenhouse gas (GHG) emissions.

## 1.2 Project Overview

The project's primary aim is to address the urgent global challenge of carbon emissions reduction by focusing on healthcare facilities in BC. Climate change poses a significant threat to human health and well-being, and healthcare organizations have a vital role to play in mitigating their environmental impact. This project seeks to explore the challenges and success factors in implementing carbon reduction projects within healthcare facilities. By understanding these factors, we aim to develop an informed and effective implementation process that will enable healthcare organizations to achieve their carbon reduction targets successfully.

The motivation behind this project is rooted in the commitment to promoting sustainable healthcare practices. Carbon emissions from healthcare facilities contribute to climate change, which, in turn, adversely affects public health. By identifying and understanding the barriers, success factors and achievements of past carbon reduction projects, we can provide healthcare organizations with valuable insights and guidance to implement environmentally responsible practices.

Despite the increasing focus on sustainability, there is limited research specifically targeting the implementation of carbon reduction projects in healthcare facilities, particularly within the BC region. Moreover, it is crucially important to research the barriers to implementing carbon reduction projects in BC healthcare facilities.

[1] B.C. has established legislative goals to decrease GHG to 40% below 2007 levels by 2030, 60% by 2040, and 80% by 2050. for more information, click here

By conducting a comprehensive literature review and engaging stakeholders through interviews this project will contribute to bridging the existing knowledge gap in this field.

One of the key motivations of this project is to foster collaboration and inclusivity among stakeholders within the healthcare sector. By involving various healthcare organizations, public sector stakeholders, and energy and carbon management experts, we seek to create an effort in collecting lessons learned and designing an effective carbon reduction implementation process. This inclusive approach will lead to the co-creation of strategies that address the unique challenges faced by different healthcare facilities, resulting in more robust and sustainable solutions.

The successful implementation of carbon reduction projects at healthcare facilities will have far-reaching positive impacts. Besides directly reducing GHG emissions, this endeavour will contribute to improved air quality, resource conservation, overall environmental health, as well as climate resilience and adaptation. Additionally, by aligning with low carbon resilient and environmentally sustainable practices, healthcare facilities can become role models for the community, inspiring others to adopt eco-friendly approaches and contributing to broader social awareness and change.

### 1.3 Report Outline

The structure of this report is as follows. Sections 2 and 3 present the research method we used and the finding of this study respectively. Finally, Section 4 summarizes the main findings, contributions and limitations of our research.

## 2 Research Methods

The research approach for this project will be carried out in several phases. To achieve the objectives of the study, a mixed-methods approach has been adopted, combining a literature review and interviews. Figure 1 shows the phases of the research approach used in this study.


Figure 1: Research method phases.

The first phase of the research involves conducting a comprehensive literature review focused on energy efficiency projects within the healthcare sectors. This entails gathering relevant academic papers, reports, and publications from reputable sources. The review aims to identify common barriers and success factors experienced in similar projects. The literature review lay the foundation for the subsequent research phases.

The next phase involves primary data collection through interviews. A selected number of stakeholders within Lower Mainland health authorities[2], Northern Health and Vancouver Island Health authorities and utility providers[3] are invited to participate. The stakeholders targeted include experts from the healthcare and energy sectors. The data collected focuses on their experiences, challenges faced, and successful strategies employed during the implementation of carbon reduction projects in healthcare facilities.

Upon completion of data collection, the collected information is analyzed using qualitative analysis techniques. The data collected through interviews are subjected to thematic analysis to identify common themes and perspectives. The findings are cross-referenced with the literature review results to validate and strengthen the research outcomes.

Finally, the research findings from the literature review and primary data collection phases are synthesized to create a comprehensive overview of the challenges and success factors in carbon reduction projects within the healthcare sector.

# 3 Findings

This section presents the results of the literature review and interviews with important professionals in the health and energy industries of the Lower Mainland health authorities, Northern Health and Vancouver Island Health Authority. First, the studies conducted on energy efficiency and carbon reduction projects in the healthcare context are reviewed. Then, a wealth of valuable information is collected, shedding light on the perspectives, experiences, and expertise of the individuals who kindly took part in this study. The study aims to gain a comprehensive understanding of the challenges and success factors of energy efficiency and carbon reduction projects, primarily as shared by energy managers and specialists.

## 3.1 Literature Analysis

In the course of conducting this comprehensive literature review, the research's emphasis was predominantly placed on general studies pertinent to commercial buildings. It is crucial to recognize that while these studies have furnished valuable insights into potential barriers and strategies, a key consideration is their contextual relevance to healthcare facilities within the confines of BC and the wider North American domain. It should be noted that a significant portion of the reviewed literature does not exclusively target healthcare facilities. As such, the direct applicability of the findings to the BC healthcare context could be influenced by factors like geographical disparities and evolving regulatory landscapes. While conscientious efforts were made to integrate literature closely aligned with the research scope, a limitation arises from the scarcity of readily accessible BC-specific studies explicitly addressing healthcare facility challenges and strategies.

It is imperative to acknowledge that the primary goal of this literature review was to formulate an initial conceptual framework of potential barriers and strategies. Sub-

[2] Provincial Health Services Authority, Vancouver Coastal Health (VCH), Fraser Health Authority (FHA) and Providence Health Care (PHC)

[3] FortisBC and BC Hydro

sequent to this preliminary analysis, through the conduct of interviews with relevant stakeholders, it is conceivable that certain identified barriers and strategies may not seamlessly translate to the BC context. Consequently, a refined list of barriers and strategies, shaped by insights from the interview data, will be presented. This iterative approach is vital for ensuring that the finalized list accurately reflects the unique dynamics and challenges faced by healthcare facilities in BC, thus enhancing the pragmatic utility of the research outcomes.

### 3.1.1 Barriers to Energy Efficiency Carbon Reduction in Commercial Buildings

The barriers to implementing energy efficiency and carbon reduction projects for commercial buildings have been classified into four categories - economic, educational and behavioural, technological and implementation and governmental barriers - based on a comprehensive literature review (see e.g., Alabid et al. 2022; T. Cristino, Lotufo et al. 2021; T. Cristino, Neto et al. 2021; T. Wang et al. 2016). The following section provides an explanation of these barriers.

#### Economic Barriers

Utilizing energy-efficient equipment typically involves a greater upfront cost in comparison to conventional equipment (Alabid et al. 2022; T. Wang et al. 2016). Investing in energy-efficient and new technologies in Heating, ventilation, and air conditioning (HVAC) systems (e.g., heat pumps), lighting, and renewable energy technologies (e.g., solar photovoltaic panels) has been found to increase the initial investment cost according to various sources (Gliedt and Hoicka 2015; Kangas et al. 2018; Liu et al. 2015). In addition, the high soft costs and fees of specialized professionals required for installing and maintaining these technologies also contribute to the increased investment capital required (Marefat et al. 2019). While energy consumption and carbon costs can be reduced after implementation, the long period required to recover the initial investment can cause some investors to hesitate and forego investing in expensive equipment (Curtius 2018; Du et al. 2014).

Moreover, T. Wang et al. 2016 have highlighted the importance of economic incentives in promoting the adoption of energy-efficient technologies. However, despite the significance of such incentives, several studies have shown that their absence is a recurring barrier to the implementation of energy-efficient technologies (Karkanias et al. 2010; Yeatts et al. 2017). This barrier arises when local governments and utility companies fail to provide financial support and economic incentives to building owners to adopt energy-efficient technologies instead of conventional ones (Ding et al. 2018; Gupta et al. 2017; Häkkinen and Belloni 2011; Jagarajan et al. 2017).

Several authors have identified the longer payback period of energy efficiency projects compared to conventional ones as a barrier to implementation (Häkkinen and Belloni 2011; Tuominen et al. 2012). This obstacle occurs because the return on investments takes place over a medium-to-long-term period (Bertone et al. 2016; Gliedt and Hoicka 2015), making it less attractive to investors who may choose to forgo energy-efficient investments (I. Goodier and Chmutina 2014; Shukla et al. 2018; T. Wang et al. 2016).

#### Educational and Behavioural Barriers

The implementation of energy-efficient technologies faces several educational and behavioural barriers, which can take different forms. One significant obstacle is the shortage of professionals with expertise in the development of energy efficiency and carbon reduction projects that can be experienced in certain jurisdictions more than others (Häkkinen and Belloni 2011; Shukla et al. 2018). This challenge arises from the lack of institutions that offer courses for professional training in this area (Curtius 2018; Du et al. 2014. Most practitioners are not trained in energy-saving technologies and, thus, are unfamiliar with the principles needed to implement energy efficiency measures (Alabid et al. 2022; Caputo and Pasetti 2017). Unskilled professionals can lower building energy efficiency expectations (Jagarajan et al. 2017; T. Wang et al. 2016). This lack of adequate skills and education might result in missed opportunities and limitations in offering effective energy-efficient and low-carbon solutions for building systems.

Moreover, the lack of knowledge leads to inadequate engagement and participation of key stakeholders, which hinders the adoption of energy efficiency requirements during projects (Jagarajan et al. 2017; Tuominen et al. 2012).

Finally, changing lifestyles and attitudes within a society is crucial for achieving maximum energy efficiency. While many people believe that the government should take the lead in energy conservation efforts, they are often reluctant to modify their own behaviour, especially when there are no penalties for excessive energy usage (Alreshidi et al. 2018).

#### Technological and Implementation Barriers

Technological barriers encompass challenges that can be addressed through innovative solutions, which are crucial for the efficient utilization of energy in buildings.

Certain studies indicate the presence of technology-related barriers in energy efficiency and carbon reduction projects. This barrier stems from the perception that appropriate technologies for optimizing energy usage in buildings do not exist (Gupta et al. 2017). Consequently, there is concern that energy-efficient technologies may not achieve the desired level of performance (Lianying Zhang and J. Zhou 2015).

Access to information regarding the potential of suitable technologies plays a vital role in their adoption (Akadiri 2015). However, the absence of reliable information on how to effectively incorporate these technologies into energy efficiency and carbon reduction projects presents a barrier to their implementation (Ding et al. 2018).

Furthermore, the insufficient number of pilot projects that showcase innovative and energy-efficient initiatives to investors and property owners exacerbates the situation (Peterman et al. 2012). It can be inferred that these latter two obstacles are fundamental reasons for the presence of the former ones (Gupta et al. 2017).

**Governmental Barriers**

This group identifies barriers that impede the progress and development of energy-efficient technologies due to government mandates, regulations and policies.

The primary hindrance is inconsistent policies and poor governance standards that delay the adoption of energy-saving technologies (Ding et al. 2018; Tuominen et al. 2012). Inconsistent government policies on energy efficiency affect the selection of appropriate technologies for buildings (Amoruso et al. 2018; Stevenson and Baborska-Narozny 2018). Insufficient policy systems may result in inconsistencies in the application of laws and regulations, reducing market enthusiasm for energy efficiency (Durdyev et al. 2018; T. Wang et al. 2016). Additionally, the lack of consistency in government standards hinders practical guidance on energy-saving, efficient energy management, and the motivation to choose more energy-efficient technologies (Foong et al. 2017).

The lack of incentives and government commitment to the development of energy-saving projects is another significant barrier in the literature (Bertone et al. 2016; Jin et al. 2009). The government's approach to understanding and prioritizing the development of projects aimed at enhancing energy efficiency in buildings may vary across different contexts (Ding et al. 2018; Marefat et al. 2019). While some instances suggest a lack of government involvement in formulating supportive laws and regulations that guide investors and owners towards more informed decisions, potentially influencing the adoption rate of energy-efficient technologies (Curtius 2018; Karkanias et al. 2010), it's important to note that governmental actions in this regard can differ significantly.

Distorted fiscal policies related to taxes, subsidies, or other fiscal policy interventions that affect the costs of energy resources consumed by building occupants inhibit investment in energy efficiency (T. Cristino, Neto et al. 2021).

In some jurisdictions, obtaining energy-efficient certification can be complicated and require significant effort from stakeholders, creating an obstacle (Häkkinen and Belloni 2011). Complex certification systems can make providing information on the optimal use of technologies challenging and discourage investors from adopting energy-saving technologies in their projects (Du et al. 2014). Moreover, in some cases, Meeting third-party standards can add additional capital costs to construction. The certification/labelling process requires the developer to absorb additional time and financial resources.

Poorly addressed financial implications of public policies also hinder the development of energy efficiency and carbon reduction projects (Adeyeye et al. 2007). This can be attributed to challenges related to securing the necessary funding, as well as uncertainties surrounding the allocation and management of financial resources.

In other cases, policy and regulatory developers lack knowledge of energy-efficient technologies (Liu et al. 2015). The lack of knowledge of legislators and regulators is an obstacle that can result in inappropriate legislation and regulations (Chmutina et al. 2013).

Furthermore, government institutions and mechanisms may not clearly communicate their codes and regulations in some jurisdictions. This obstacle results from the lack of interest or ability of institutions to disseminate government information on energy efficiency and carbon reduction programs for buildings (I. Goodier and Chmutina 2014).

In some countries, both public service announcements and commercial advertisements have failed to highlight the advantages of efficient energy usage. As a result, consumers and developers are not fully aware of the economic benefits of efficient operation and the social benefits of environmental conservation (T. Cristino, Lotufo et al. 2021).

#### 3.1.2 Features of Healthcare Facilities

Healthcare facilities face unique obstacles to achieving energy efficiency due to differences in investment and operational methods compared to ordinary commercial buildings. While healthcare facilities are typically publicly funded and operated by the government, they still face internal challenges such as conflicting priorities between investment and property management. For instance, managers responsible for investments may not prioritize energy-saving expenditures, leading to a potential disagreement with property managers. Furthermore, the budget management system of government-owned institutions may hinder energy-saving efforts. Budgets for energy consumption in healthcare facilities are often based on previous years' average energy costs, which could lead to a reduction in government grants if renovations are made to improve building efficiency.

Healthcare facilities primarily provide medical care, which also incurs the highest daily operational costs. This is while energy costs may only account for a small fraction (approximately 1%) of total operating costs, resulting in relatively small expected savings through increased energy efficiency (T. Wang et al. 2016). Generally, healthcare facilities managers are appointed by the government and are primarily evaluated based on their ability to provide consistent, high-quality medical services. As a result, these managers, who also serve as investment decision-makers, do not prioritize energy efficiency in their buildings. They may be hesitant to adopt energy-efficient measures, such as implementing new technologies or altering the environment, due to concerns about potential accidents during the operation of healthcare facilities. Rather than risking emergencies with patients, managers may choose to keep lights and computers on 24/7.

Infrastructure construction and facility management departments are often overlooked in healthcare facilities, as they are not considered part of the core business. Consequently, staff development in these departments is typically neglected. Generally, in government-operated institutions, staff mobility is generally low, and the situation in the construction and facility management departments is even worse. Due to budget constraints, only a small number of new staff members are typically added to these departments, and they are often not highly educated. Additionally, the personnel management system often results in department heads without relevant professional backgrounds. Furthermore, there are few in-service programs[4] available to train employees on the value and benefits of energy efficiency, which is a common issue in government-operated institutions in many countries. This lack of knowledge and awareness poses a significant challenge to promoting energy efficiency

[4] A professional training or staff development effort programs

in healthcare facilities.

In contrast to commercial buildings, constructing energy-efficient healthcare facilities generally does not come with any financial incentives or subsidies, and the government's budget does not support such economic incentives. Therefore, even if there were requirements for renovating buildings or implementing specific technology to increase energy efficiency, funds would have to be allocated as an additional item in the total budget. There are no benefits or rewards for healthcare facilities and their managers, providing no motivation to improve efficiency. Additionally, hospital buildings are among the most complex civic buildings, and different standards are required for the various departments of the hospitals, such as outpatient clinics, inpatient wings, medical diagnostic sections, and operating rooms, regarding the use of thermal insulation, ventilation, air conditioning, and lighting. Furthermore, determining the Key performance indicators for monitoring energy consumption, such as floor area, outpatient quantity, or number of beds, has yet to be established in many hospitals around the world. This lack of clear standards makes it difficult for investors and developers to distinguish between the most effective products and inferior or counterfeit ones, making investing in new technologies quite risky.

Taking into account these features, the list of barriers can be specifically revised for healthcare facilities, as shown in Table 1.

Table 1: List of barriers to energy efficiency and carbon reduction projects in commercial buildings.

| Category | Barrier |
|---|---|
| Economic | High capital investment and upfront costs |
| | Lack of sufficient financial incentives |
| | Long payback periods |
| Educational and Behavioral | Limited and/or out-of-date education/knowledge regarding available low carbon and energy-efficient equipment and design approaches |
| | Inadequate collaboration and participation of key stakeholders |
| Technological and Implementation | Inadequate energy-efficient technologies |
| | Lack of information about the role of suitable energy-efficient technologies |
| | Insufficient number of pilot projects |
| Governmental | Inefficient energy-efficient buildings codes/ regulations/standards |
| | Lack of support from the government |
| | Distorted fiscal policies |
| | Complex certification procedures |
| | Policies do not address the financial implications |
| | A lack of publicity regarding the benefits of energy-efficient buildings |
| | A lack of awareness of the individual's role in saving energy |

### 3.1.3 Strategies to Overcome the Barriers

#### Strategies to Overcome the Economic Barriers

Referring to Bertone et al. 2016, a highly effective strategy for addressing the challenges posed by energy efficiency and carbon reduction projects, which often involve significant initial capital investment and upfront expenses, is to prioritize educational initiatives that revolve around comprehensive financial analysis. These efforts are designed not only to underscore the link between substantial upfront expenditures and sustained financial advantages but also to recognize that the outcomes can vary depending on contextual factors such as regulatory environments, electricity and fossil fuel rates, carbon taxes, and other relevant considerations (Zadeh et al. 2016). Consequently, stakeholders, including investors and project proprietors, can develop a nuanced understanding that their substantial investments can yield both future financial benefits and non-financial gains.

An alternative solution for addressing the lack of sufficient financial incentives is to establish a framework of economic incentives that lead to tax reductions and financial rewards (T. Wang et al. 2016). Nevertheless, it is crucial that this framework is explicit and specific, rather than vague or open to interpretation (Häkkinen and Belloni 2011), and accessible to the investors engaged in energy efficiency and carbon reduction projects (Lianying Zhang and J. Zhou 2015).

The decrease in costs associated with energy-saving technologies leads to a shorter payback period for invested capital (Wilson et al. 2015). To overcome the obstacle of "long payback periods," one approach is to employ a combination of financing mechanisms tailored to varying levels of investment capital, thereby resulting in different durations for financial returns (Paiho and Ahvenniemi 2017). Consequently, investors have the flexibility to select the financing option that aligns with the specific needs of their projects (Cattano et al. 2013).

#### Strategies to Overcome the Educational and Behavioural Barriers

The key strategy for overcoming these obstacles is to enhance professionals' awareness and knowledge through specialized training (Ding et al. 2018; Gupta et al. 2017; Lin Zhang et al. 2018), facilitated by organizations that advocate for the necessities and advantages of energy efficiency and carbon reduction practices.

Additionally, it is crucial to elevate the level of professional engagement in energy efficiency and carbon reduction projects (Mahmoud et al. 2017) by recognizing and rewarding outstanding projects (Greenough and Tosoratti 2014; Hosseini et al. 2016). This approach serves as an incentive for professionals to embrace energy-saving technologies (Du et al. 2014; T. Wang et al. 2016).

#### Strategies to Overcome the Technological and Implementation Barriers

An effective strategy for overcoming this barrier involves providing assistance for research endeavours focused on the advancement of energy-saving technologies (Kojok et al. 2016). The governments can actively promote the establishment of research centers by universities and local institutions as hubs for innovation, education, and research, with the aim of creating affordable technological alternatives to enhance energy efficiency (Lin Zhang et al. 2018).

Additionally, it is crucial for the government and research centers to disseminate accurate information to the public regarding reliable technologies and practices that optimize the utilization of energy-efficient technologies (Akadiri 2015).

Demonstration projects present another avenue for enhancing the adoption of energy-efficient technologies (Lianying Zhang and J. Zhou 2015). These projects serve as practical showcases that educate stakeholders on the successful implementation of these technologies, offering an effective alternative to disseminating information about energy-efficiency initiatives (Yeatts et al. 2017). As a result, investors and owners can gain increased confidence in the advantages and progress associated with energy efficiency and carbon reduction projects (Castleberry et al. 2016).

#### Strategies to Overcome the Governmental Barriers

The establishment of practical norms, regulations, and laws is crucial for promoting the adoption of technologies and clearly outlining energy-saving objectives to be attained (Greenough and Tosoratti 2014; Liu et al. 2015). These laws, regulations, and standards should reflect a forward-looking government policy perspective, indicating the actions that can be implemented to ensure the achievement of governmental goals (Talita Mariane Cristino et al. 2018; Y. Zhang and Y. Wang 2013). Furthermore, it is essential to establish a government support mechanism that offers guidance and assistance to both designers and occupants (Lin Zhang et al. 2018). This government support should foster a culture of energy efficiency and carbon reduction, promoting the widespread adoption of technological measures (Adeyeye et al. 2007).

It is advisable for the government to develop various economic incentive packages tailored to the characteristics of implemented energy-efficient technologies, aiming to enhance the financial returns of building projects (Karkanias et al. 2010; Lianying Zhang and J. Zhou 2015). These packages should include augmenting subsidies and implementing interest-free policies (Lin Zhang et al. 2018).

The government ought to offer resources and tools to streamline and facilitate energy efficiency certification procedures for designers (Adeyeye et al. 2007). Additionally, it is crucial for the government to establish a comprehensive plan for building inspections that ensure the attainment of energy efficiency levels during the certification process (Karkanias et al. 2010). Moreover, the government should extend support through economic incentives, enabling investors to explore alternative options for managing the financial implications associated with energy efficiency and carbon reduction projects (Teng et al. 2016; L. Zhou et al. 2013).

Providing training for regulators and legislators (Huang et al. 2016) involved in energy efficiency and carbon reduction regulations and laws is crucial. The availability of comprehensive information will result in more informed decision-making regarding the most suitable legislation to promote the widespread adoption of energy-efficient technologies (Gupta et al. 2017; Persson and Grönkvist 2015).

The government should establish a robust policy framework to effectively communicate the advantages of adopting energy-efficient technologies, particularly because occupants still exhibit limited awareness in this regard (Gupta et al. 2017; Lianying Zhang and J. Zhou 2015). Regulations and standards should be formulated with a clear emphasis on the significance of energy efficiency and carbon reduction measures in buildings, and this information can be disseminated through public hearings and workshops targeting financial institutions, professionals, and potential occupants (Bruce et al. 2015; Yeatts et al. 2017).

## 3.2 Interviews Analysis

This study involved 14 experts from the healthcare and energy sectors in the Lower Mainland, Northern Health and Vancouver Island Health authorities. Both group and individual interviews are conducted to gather diverse perspectives and gain a comprehensive view of the industry. These interviewees are key professionals leading change and innovation in their respective organizations. Table 2 is a table detailing the distribution of interviewees among the different roles and their associated organizations:

Table 2: List of interviewee's roles and organizations.

| Interviewee Role | # of Interviewees | Organizations |
|---|---|---|
| Director | 1 | Energy and Environmental Sustainability (EES) |
| Energy Managers | 7 | EES team (PHSA, VCH, FHA, PHC, Northern Health and Vancouver Island Health Authority |
| Energy Coordinator | 2 | EES team (VCH and FHA |
| Energy Specialist | 2 | EES team (PHSA and VCH) and Northern Health |
| Key Account Manager | 2 | FortisBC and BC Hydro |

Throughout the interviews, the participants offered valuable insights, sharing their experiences, challenges faced, and success factors of energy efficiency and carbon reduction projects they were involved. The collective knowledge shared by these professionals forms the basis of the findings presented in the subsequent sections of this report, which aim to contribute to a more efficient implementation process.

### 3.2.1 Barriers

During the interviews conducted for this research project, several barriers to implementing energy efficiency and carbon reduction projects at healthcare facilities were identified. The barriers have been classified into four groups, mirroring the categorization present in the existing literature. These groups are: economic, educational and behavioural; technological and implementation; governmental, as illustrated in Figure 2. Below is a summary of the categories and their respective definitions:

- Economic: Barriers falling under this category are associated with financial limitations, budget management and cost estimation. Interviewees discussed the challenges of securing adequate funding for projects, effectively managing limited budgets to complete them, and accurately estimating project costs.

- Educational and Behavioural: This category encompasses barriers related to the educational and behavioural aspects of implementing energy efficiency and carbon reduction projects. Interviewees highlighted challenges in obtaining approvals from the Facilities Maintenance & Operations (FMO) team for certain technologies, technical issues caused by performance measurements, and the need for better training and support for FMO personnel.
- Technological and Implementation: Barriers in this category are related to accessing and implementing new technologies. Interviewees voiced apprehensions regarding technology availability, control systems in aging structures, and the electrification of facilities. The smooth project execution was impeded by staffing constraints and a shortage of skilled personnel, particularly project managers. Additionally, challenges with effective timeline management were cited as obstacles to the implementation of energy projects.
- Governmental: This category combines barriers related to the government's mandates, regulations and policies. Interviewees highlighted issues with incentives provided by the government and utility providers, obtaining approvals from multiple layers of authorities, and engaging building occupants to accept and support energy projects.

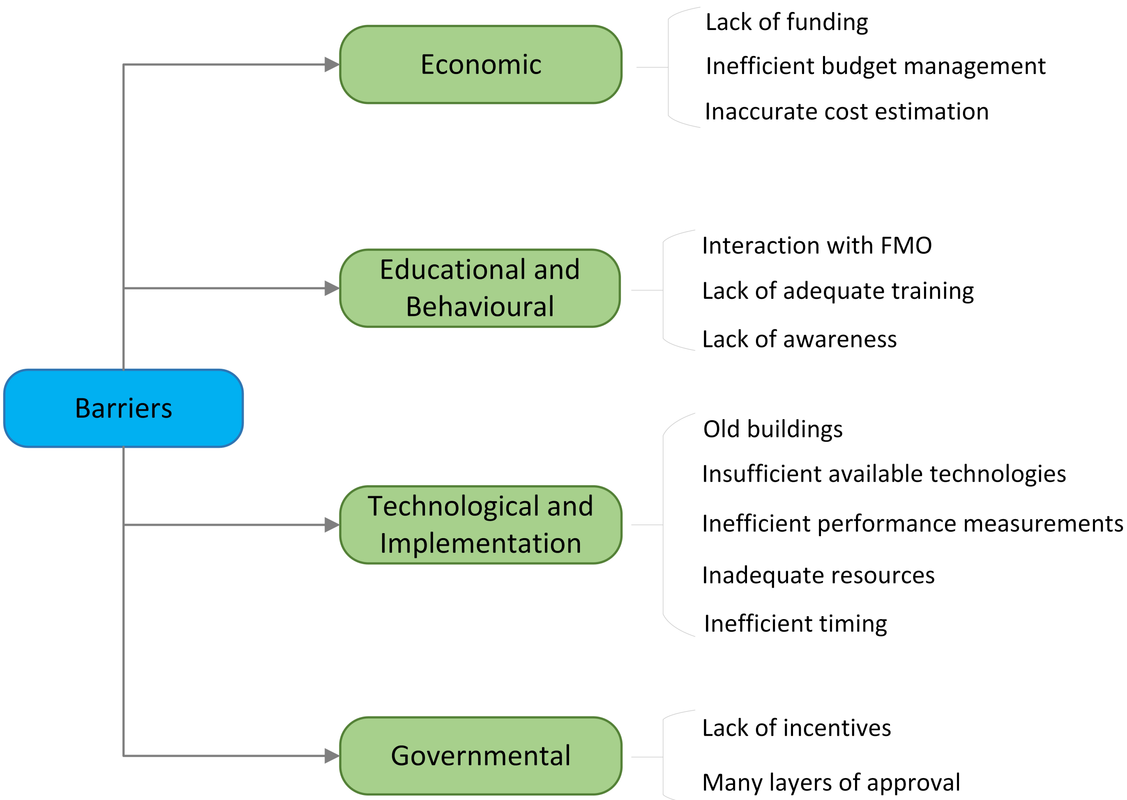


Figure 2: Barriers to energy efficiency and carbon reduction projects in Lower Mainland's, Northern Health's and Vancouver Island Health's healthcare facilities.

The frequency of responses resulted in the distribution shown in Figure 3. From this figure, one can observe that economic barriers are the most frequently mentioned by interviewees.

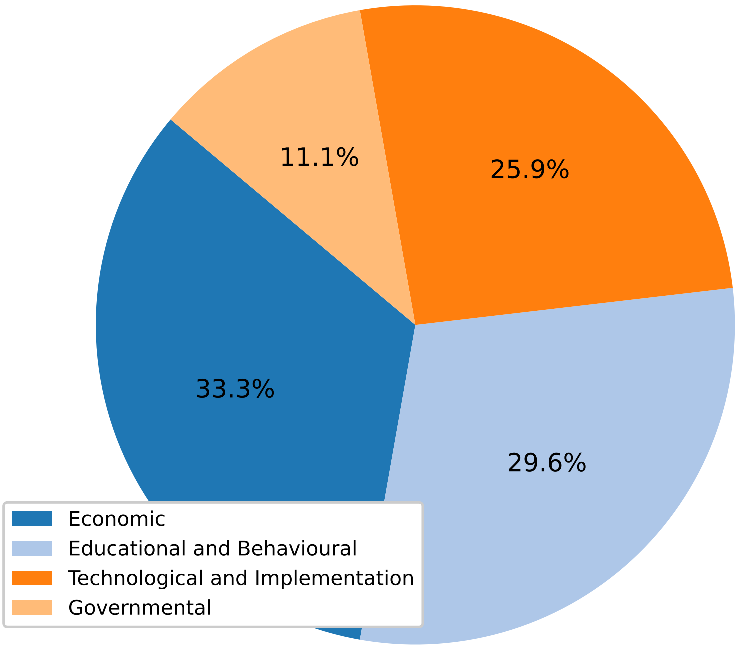


Figure 3: Percentage of total responses for each barrier category.

**Economic**

The Economic category encompasses barriers associated with financial limitations, budget constraints, and challenges in obtaining funding for carbon reduction projects. The primary economic challenge identified by the interviewees was funding limitations. Healthcare facilities often struggle to secure adequate financial resources to invest in energy efficiency and carbon reduction projects. This barrier can hinder the implementation of energy-saving technologies and infrastructure upgrades.

Two interviewees mentioned that financial constraints can limit the ability to invest in energy-efficient technologies and upgrades. They specifically pointed out that the lack of a sufficient budget may prevent the implementation of new and more environmentally friendly equipment, leading to missed opportunities for emissions reduction.

An energy manager highlighted the broader financial challenge of reaching climate targets through energy efficiency and carbon reduction projects in healthcare facilities. They emphasized that achieving ambitious emission reduction targets requires substantial funding for capital projects, which are complex, time-consuming, and involve a significant number of staff members. Most meaningful energy projects cost more than $2 million, making it essential to secure sufficient funding to come closer to the targets.

An energy coordinator provided a specific example of the lack of funding provided by FortisBC and BC Hydro in some cases, which necessitated the exploration of alternative funding sources for a solar panel installation in a hospital.

An interviewee also expressed concern over the lack of available funding hindering the implementation of numerous innovative and promising project ideas. Despite efforts to provide incentives and support, without sufficient capital investment, many impactful projects cannot be brought to fruition.

However, it is also pointed out that while funding has been a common challenge for energy efficiency and carbon reduction projects, there have been positive developments that to some extent eased this constraint. The expansion of the Carbon Neutral Capital Program (CNCP) in 2014-15 significantly increased the available capital funding, providing a larger pool of resources to support sustainability initiatives to health authorities and post-secondary institutions (Nunez and McClellan 2014). This program was instrumental in providing financial support for healthcare authorities, equivalent to the carbon offset payments they were making. in addition to the CNCP funding, internal operating fundings (such as green revolving fund) have been available to the energy and carbon management teams of the health authorities. These funding mechanisms helped alleviate some of the financial challenges that were faced previously.

Another economic challenge mentioned was budget planning and dealing with funding limitations imposed by government agencies, utility providers, and other funding organizations. Due to constrained resources, there might be difficulties in allocating sufficient funds for all the energy-saving initiatives that align with the organization's sustainability policies. Decision-making becomes crucial to prioritize various potential projects, even though not all ideas can be implemented immediately.

Furthermore, proper cost estimations can pose significant economic barriers as there is always uncertainty surrounding large projects. One of the energy managers highlighted the disconnect between the government's funding programs and the actual market conditions. They believe that the analysis of achieving targets and funding requirements may not have caught up with the reality of inflationary pressures and increased costs in the market. As inflation drives up prices, budgets may need to be adjusted, potentially leading to the inability to undertake as many projects and achieve the desired energy savings targets. One interviewee shared a specific example of a decoupling project at the University Hospital of Northern British Columbia (UHNBC), where they initially had ten bidders show interest during the site walkthrough. However, only two of them submitted bids, and the prices came to 30% higher than what was initially budgeted. This situation reflects the market's current state, where availability and costs are influencing bid submissions and overall project expenses.

#### Educational and Behavioural

The educational and behavioural category comprises barriers related to staff education and behaviour issues when they are implementing energy efficiency and carbon reduction projects. The main challenges highlighted by the interviewees are difficulties in interacting with the FMO team during the implementation of energy efficiency and carbon reduction projects and engaging building occupants in supporting the projects.

An interviewee considered the lack of comprehensive training and ongoing support for FMO people a big challenge. While they may receive a brief one-day training session, it is often insufficient when dealing with complex systems like heat pumps or TGH. The absence of internal support and expertise to troubleshoot and maintain the system properly can lead to wasted resources and ineffective problem-solving.

An energy manager highlighted a challenge revolving around maintenance and the reluctance of some FMO people to invest time and effort in understanding and adopting new equipment and technologies. Many facility operators have extensive experience working with traditional systems like boilers and chillers, but they may lack familiarity with newer technologies like heat pumps. This lack of expertise and exposure to newer technologies can lead to resistance to incorporating them into their buildings' operations.

An energy manager mentioned several challenges they encountered while implementing energy-efficient upgrades in healthcare facilities, particularly related to the FMO. These challenges included:

- Lack of understanding about how modifications to the systems during the project could lead to operational difficulties later on. FMO faced problems with operating and maintaining the building due to unexpected issues arising from the project's modifications.
- Dealing with varying levels of expertise and competence among designers and consultants. Some designers made errors in calculations or specifications, causing headaches for everyone involved.
- Changes in FMO's preferences during the project implementation phase led to last-minute decisions that were difficult to accommodate and potentially caused delays and extra costs.

Another behavioural challenge lies in the lack of occupants' awareness and acceptance of energy projects. For example, an energy manager shared their experience of challenges related to engaging building occupants during energy efficiency and carbon reduction projects. One of the hurdles they faced was the potential resistance or discomfort from occupants due to disruptions caused by the project, indicating the importance of effectively communicating the benefits of the initiatives to gain support from building occupants due to disruptions caused by the project.

One of the interviewees also highlighted change management as a significant challenge in implementing energy efficiency and carbon reduction projects. When introducing different systems, it can be challenging to gain support from facility teams responsible for maintaining those systems, especially if they are not familiar with the new technologies. This lack of familiarity can lead to resistance and roadblocks in the implementation process.

#### Technological and Implementation

During the interview, the interviewees highlighted two main technological and implementation barriers that present challenges in implementing energy efficiency and carbon reduction projects. The first significant challenge arises from the age of the buildings. Older buildings often lack suitable control systems, with many not having an integrated control system. As a result, managing different technologies becomes complex, as various companies and individuals handle them individually. The lack of integration and central control hinders their ability to effectively monitor and optimize energy usage, leading to inefficiencies in energy management.

Another prominent issue is the outdated infrastructure, which not only lacks a suitable control system but also, in some cases, essential components are missing. This deficiency in the infrastructure makes it challenging to integrate various technologies into a unified control system. Consequently, different companies and individuals are responsible for maintaining separate technologies within the buildings, leading to fragmented control and inefficiencies.

The second technological barrier is the challenge of technology availability and the relative novelty of electrification. Since these technologies are relatively new to the organization, there might be limited options and suppliers to choose from, impacting the availability of suitable equipment. Furthermore, the efficiency of the available equipment may not always match the specifications provided by the suppliers. This discrepancy can lead to unexpected challenges during project implementation, as the equipment may not perform as expected. Relying on supplier specifications to calculate project feasibility and energy savings can lead to potential issues if the equipment underperforms.

The main barrier related to the implementation was the lack of suitable measurements for evaluating the performance of buildings after implementing energy efficiency and carbon reduction projects. This makes evaluating the success level of the projects more difficult. Moreover, using sustainable measurements can help monitor the performance of a building over time and utilize historical data to make more intelligent decisions.

In an interview, it is mentioned that the traditional method of relying solely on utility bills from companies like FortisBC and BC Hydro proves inadequate in providing a comprehensive picture of system performance. Fluctuations in utility bills may not accurately reflect the actual performance of installed systems, as other external factors could influence consumption levels.

An energy manager discussed the complexity of evaluating building performance, mentioning the use of various capital-building metrics and performance indicators. These indicators typically rate buildings on a scale, such as from one to ten or zero to one hundred percent, to assess their overall performance. Buildings with scores falling below a designated threshold, such as 0.6 for instance, on a scale from zero to one, are identified for potential demolition or renovation. This evaluation process poses analytical challenges, as it requires considering multiple metrics and not just the building's physical characteristics. The interviewee acknowledged the difficulty in analyzing and interpreting these metrics accurately.

The interviewees also expressed their opinion on a crucial challenge related to identifying the most effective carbon or energy reduction measures for buildings. They emphasized that when multiple consultants are involved, each might propose different ideas for achieving energy efficiency. The difficulty lies in ensuring that the selected measures are truly optimal or at least fall within the top-performing 80% ideas. They mentioned that some consultants tend to adopt a generic or "cookie-cutter" approach, which may not thoroughly explore site-specific and condition-specific opportunities for energy reduction. Therefore, the challenge is to strike a balance between broad, general strategies and in-depth, nuanced analysis to identify the most effective measures tailored to each building's unique characteristics.

The interviews also highlighted several key challenges related to resources and staffing that pose significant obstacles to the successful implementation of energy efficiency and carbon reduction projects in healthcare facilities.

One primary concern was the availability of adequate resources, such as project managers, to effectively execute projects. One interviewee emphasized the importance of having the right individuals in the appropriate positions to ensure the smooth implementation of initiatives. However, some health authorities are facing difficulties in hiring qualified personnel for various roles within their facilities team or capital planning team, creating a shortage of suitable resources that hampers project success.

The problem of internal staffing exacerbated the difficulties. The team's limited size, tasked with project implementation and management, led to a predominant emphasis on project completion, sometimes at the expense of certain quality standards. This shortage of personnel made it challenging to allocate resources for conducting post-retrofit analysis, particularly related to the measurement and verification (M&V) process.

Another significant challenge raised in the interview is staff retention and capacity within the organization. Experienced and dedicated staff are crucial for the successful implementation of energy projects in healthcare facilities. However, staff turnover can lead to a loss of knowledge and expertise gained from previous projects. With limited resources and multiple projects, managing the workload effectively becomes challenging, potentially impacting the continuity of knowledge transfer and hindering learning opportunities from one project to the next.

The timing was also identified as a crucial challenge. Some energy projects had strict fiscal year requirements, and the complexity of certain initiatives made it challenging to complete them within a year. Proper planning and creating a project funnel well in advance were emphasized as crucial strategies to mitigate timing issues. With multiple projects happening simultaneously, it became difficult to deliver all projects with limited resources. Enlisting support from FMO helped address this limitation, leveraging additional resources to implement projects successfully.

#### Governmental

The Governmental and Behavioral category encompasses barriers related to the government's mandates, regulations and policies barriers that impact the implementation of energy efficiency and carbon reduction projects. Interviewees discussed issues with a lack of incentives and obtaining multiple layers of approvals as the main barriers in this category.

An energy manager highlighted the challenge of funding limitations from various sources, including the government, BC Hydro, and FortisBC. While these sources provide funding support, there may be restrictions or constraints on the available funds, creating obstacles in securing adequate financial resources for energy projects.

Two of the interviewees emphasized how the multi-layered approval process can pose challenges in terms of time, resources, and coordination. The complex and time-consuming nature of obtaining approvals at each level, with scrutiny of project details against required standards and guidelines set by the government, can lead to delays in project implementation and add administrative overhead to energy-efficient initiatives within healthcare organizations.

An interviewee pointed out that public sectors usually have to navigate through various parties and stakeholders involved in approving capital projects. This complexity can become a significant barrier to efficiently accomplishing projects. The process of obtaining approvals from different levels of authority and various parties can be time-consuming and require extensive coordination and documentation, hindering project timelines and increasing administrative overhead.

#### 3.2.2 Suggestions to Overcome Barriers

To successfully address these obstacles and foster a sustainable energy-efficient environment, some suggestions, listed in Table 3 were provided by the interviewees for each barrier.

Table 3: Suggestions to overcome barriers.

| Barrier | Suggestions |
|---|---|
| Economic | Actively seek available incentives and grants from government and other entities.<br>Advocate for increased funding and explore alternative financial sources like grants and private partnerships.<br>Engage in policy advocacy efforts and establish funding support programs.<br>Align funding programs with current market realities and consider potential inflationary impacts in budget planning.<br>Be creative in utilizing funding, strategic planning, and prioritize budget allocation for energy efficiency and carbon reduction projects. |
| Educational and Behavioural | Engage the FMO team from the outset of energy efficiency and carbon reduction projects.<br>Provide comprehensive training and support for FMO personnel to empower them with the necessary knowledge and skills.<br>Demonstrate the benefits of energy efficiency and carbon reduction projects, including long-term cost savings and positive environmental impacts. |
| Technological and Implementation | Improve the monitoring and evaluation process by implementing individual submeters for each part of the Energy Conservation Measures (ECMs).<br>Increase the size of the energy team by hiring additional staff members.<br>Use strategic planning to address resource constraints and timing challenges by evaluating and prioritizing projects effectively. |
| Governmental | Streamline the approval process and improve communication between all involved parties. |

#### Suggestions to Overcome the Economic Barriers

One of the most significant steps to overcome financial barriers is actively seeking available incentives and grants. Organizations can offset project costs and make energy-efficient initiatives more financially feasible by utilizing funding programs from the government or other entities aimed at supporting sustainability in hospitals and universities. Advocating for increased funding and exploring alternative financial sources, such as collaborating with government agencies, seeking grants, and leveraging partnerships with private organizations, are potential avenues to secure the necessary funding for these projects.

Moreover, health authorities should engage in policy advocacy efforts. By advocating for the reinvestment of carbon offsets and pursuing initiatives like the establishment of funding support programs, such as the CNCP, healthcare facilities can secure the financial support needed to implement energy efficiency and carbon reduction projects. Additionally, aligning funding programs with current market realities and considering potential inflationary impacts in budget planning can aid in effectively managing project costs.

To tackle budget management challenges, healthcare organizations must be creative in utilizing funding to complete the project budget and make the best use of available resources. Strategic planning, considering life-cycle costs, and exploring available financial incentives or programs that support the adoption of sustainable technologies can help prioritize budget allocation for energy efficiency and carbon reduction projects. Intentionally creating projects that span multiple fiscal years can aid in effective cost management and allow for adequate planning, design, and procurement of resources.

#### Suggestions to Overcome the Educational and Behavioural Barriers

To overcome technical challenges, it is essential to engage the FMO team from the outset of energy efficiency and carbon reduction projects. Collaborating with FMO teams and involving them in the decision-making process can lead to better approvals for certain technologies, address technical issues, and facilitate effective training and support for FMO personnel. Regular communication and coordination among all involved parties are vital to promptly address any issues with installed systems and ensure energy savings targets are met.

Moreover, demonstrating the benefits of energy efficiency and carbon reduction projects, including long-term cost savings and positive environmental impacts, is crucial to overcoming resistance and gaining buy-in from key decision-makers and staff. Education and awareness campaigns about sustainability and the benefits of adopting modern technologies can play a significant role in changing mindsets and attitudes toward energy efficiency and carbon reduction projects.

Finally, providing comprehensive training and support for FMO people is essential. Empowering them with the necessary knowledge and skills can lead to more efficient building operations, reduced downtime, and decreased reliance on external assistance. Mandatory training and education can bridge knowledge gaps and ensure that FMO personnel are up-to-date with the latest advancements in the HVAC industry.

#### Suggestions to Overcome the Technological and Implementation Barriers

To address capacity challenges, it is crucial to increase the size of the energy team by hiring additional staff members. Having more human resources will enable active involvement in various projects, initiatives, and funding opportunities, resulting in smoother implementations and improved outcomes.

Strategic planning is also necessary to address resource constraints and timing challenges. Healthcare organizations must carefully evaluate and prioritize projects based on their potential return on investment, energy savings, and environmental impact to make the most effective use of available budgets.

Furthermore, improving the monitoring and evaluation process is crucial to better assess a project's performance. Implementing individual submeters for each part of the Energy Conservation Measures (ECMs) can lead to a more precise comparison between project performance and utility bills, enabling a more informed decision-making process for future projects.

#### Suggestions to Overcome the Governmental Barriers

To address governmental barriers, streamlining the approval process and improving communication between all involved parties is essential. Establishing clear guidelines and communication channels can help expedite the approval process and reduce unnecessary delays.

### 3.2.3 Success Factors

Throughout the interviews with various experts involved in energy efficiency and carbon reduction projects at healthcare facilities, several key success factors emerged. These factors contribute to the effectiveness and positive outcomes of these initiatives. The success factors include:

#### Early Engagement and Collaboration

The success of energy efficiency and carbon reduction projects often hinges on early engagement and collaboration among relevant stakeholders. This includes energy managers, consultants, health authorities, and funding organizations like FortisBC and BC Hydro. Early involvement ensures that all parties have a clear understanding of project requirements, objectives, and timelines. Collaborative efforts foster effective planning, resource allocation, and decision-making, which ultimately leads to optimized project outcomes and successful implementation.

#### Measurement and Verification (M&V)

Robust measurement and verification processes are critical for validating the actual energy savings achieved by a project. Although some interviewees faced challenges with post-project M&V due to staffing limitations, successful projects incorporated rigorous data collection and analysis. Accurate M&V allows healthcare facilities to assess the project's impact, identify areas for improvement, and demonstrate the project's success in terms of energy efficiency and carbon reduction. Reliable M&V data also inform future decision-making for similar initiatives.

#### Continuous Optimization

Continuous optimization projects focus on enhancing energy efficiency through systematic and ongoing improvements in control systems, lighting, HVAC, and other aspects. By regularly monitoring building occupancy, usage patterns, and system performance, healthcare facilities can make real-time adjustments to maximize energy efficiency and operational effectiveness. Continuous optimization ensures that energy-saving measures remain effective over the long term, contributing to sustained energy savings and operational cost reduction.

#### Targeting Low-Hanging Fruit

The concept of "low-hanging fruit" refers to energy-saving opportunities that offer significant returns with relatively little effort. Interviewees stressed the importance of targeting these areas or equipment with high energy-saving potential. By prioritizing such projects, healthcare facilities can quickly realize substantial energy and cost savings. Tackling low-hanging fruit early in the project not only delivers quick results but also frees up resources for more complex or long-term initiatives.

#### Focus on Fuel Switching and Electrification

To align with sustainability goals, several healthcare facilities opted for fuel-switching projects, transitioning from fossil fuel-based systems to electric alternatives. Emphasizing electrification in new construction projects and upgrades reduces greenhouse gas emissions and supports environmental objectives. This strategic focus on fuel switching and electrification enables healthcare facilities to actively contribute to carbon reduction efforts while promoting a greener and more sustainable approach to energy consumption.

The frequency of responses about the success factors resulted in the distribution shown in Figure 4. From this figure, it can be concluded that emphasizing early engagement and collaboration of the FMO team could significantly contribute to the success of a project. However, it is important to incorporate all success factors into energy efficiency and carbon reduction projects to enable healthcare facilities to achieve their energy and sustainability goals efficiently.

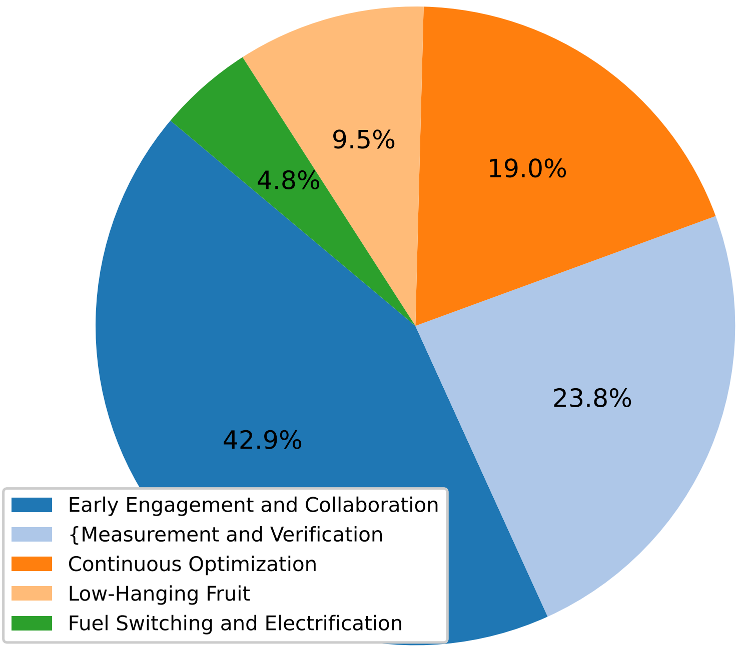


Figure 4: Percentage of total responses for each success factor.

### 3.2.4 Potential Benefits of Implementing Energy Efficiency and Carbon Reduction Projects in Healthcare Facilities

In conducting interviews with individuals regarding the potential benefits of implementing energy efficiency and carbon reduction projects in healthcare facilities, several key advantages were consistently mentioned. These benefits extend beyond cost savings and encompass a diverse range of positive outcomes that contribute to the overall success of such projects.

#### Environmental Sustainability and Emissions Reduction

The reduction of greenhouse gas emissions emerged as a primary and prominent benefit highlighted by multiple interviewees. Energy efficiency and carbon reduction projects play a pivotal role in aligning healthcare facilities with aggressive climate action targets and broader environmental sustainability goals. By implementing these projects, healthcare facilities can significantly contribute to combating climate change and protecting the environment.

#### Enhanced Comfort and Improved Patient Care

Upgrading to energy-efficient systems can create a more comfortable and conducive environment for patients, residents, and staff. Improved ventilation, cooling, lighting, and heating systems positively impact occupant comfort and overall patient care, promoting faster recovery and well-being.

#### Financial Savings and Operational Efficiency

Cost savings were frequently mentioned, encompassing both reduced utility bills and lower maintenance and operational expenses. Energy efficiency and carbon reduction projects lead to lower energy consumption, resulting in financial savings for healthcare facilities. Additionally, by adopting efficient technologies, maintenance costs are minimized, further optimizing operational efficiency. While some energy efficiency and carbon reduction projects may not yield immediate cost savings, they provide long-term financial benefits. As carbon taxes and environmental regulations intensify in the future, these projects will prove more economically advantageous and contribute to the organization's environmental stewardship.

#### Building Resiliency and Climate Risk Management

Upgrading infrastructure and embracing energy efficiency measures enhance a healthcare facility's resiliency to climate-related risks. By preparing for extreme weather events and reducing vulnerabilities, healthcare facilities can ensure continuous operations and patient care even in adverse conditions.

#### Enhanced Staff Safety

Implementing energy efficiency measures, such as proper insulation of steam pipes, can significantly improve staff safety. Reducing the risk of burns or accidents from hot surfaces contributes to a safer working environment for maintenance personnel.

#### Public Sector Leadership and Reputation

As public sector organizations, healthcare facilities can lead by example in adopting energy efficiency and carbon reduction projects. Demonstrating proactive environmental stewardship enhances its reputation and inspires others to follow suit, contributing to a broader culture of sustainability.

#### Avoiding Expensive Electrical Infrastructure Investments

For utilities, encouraging energy efficiency and carbon reduction projects among customers benefits both parties. Reduced electrical demand from energy efficiency and carbon reduction projects allows utilities to avoid costly investments in electrical infrastructure, optimizing the energy ecosystem for both ratepayers and the utility.

In conclusion, the potential benefits of energy efficiency and carbon reduction projects in healthcare facilities are multi-faceted and extend beyond immediate cost savings. With a consistent focus on environmental sustainability, enhanced comfort, operational efficiency, and staff satisfaction, these projects can create a greener and more resilient healthcare environment while delivering lasting positive impacts on patient care and organizational reputation. By acknowledging and prioritizing these benefits, healthcare facilities can play a crucial role in driving progress toward a sustainable and energy-efficient future.

#### 3.2.5 Technological Advancements or Innovations

Several interviewees highlighted various technological advancements and innovations aimed at improving energy efficiency in healthcare facilities. Some of the key advancements mentioned include:

- Heat Recovery and Thermal Energy Recovery: Heat recovery systems, such as Thermal Gradient Header (TGH), $CO_2$ heat pumps, and heat recovery through different design concepts, were emphasized as essential methods to capture and reuse wasted heat within buildings. These systems allow for efficient energy utilization and can lead to significant reductions in emissions.
- Building Automation and Controls: Advanced building controls and automation were recognized as critical tools to optimize energy consumption. Implementing sophisticated building management systems can improve the efficiency of HVAC, lighting, and other energy-consuming systems, reducing operational costs and enhancing occupant comfort.
- Ozone Laundry Systems: Ozone laundry systems were praised for their ability to clean clothes using ozone gas and oxidizing gases, which are effective in cold or lukewarm water. These systems can significantly reduce the energy required for laundry operations, making them a promising technology for healthcare facilities.
- Dynamic Glazing: Dynamic glazing, which adjusts its transparency based on sunlight intensity, was mentioned as a valuable option for new construction projects. By controlling solar gain and optimizing daylighting, dynamic glazing can contribute to energy savings and occupant comfort.
- Combined Heat and Power (CHP) and Renewable Energy: CHP units and renewable energy sources, such as solar photovoltaics (PV) and potentially renewable natural gas, were recognized as effective ways to generate on-site energy with high efficiency and reduced emissions.
- Displacement Ventilation: Displacement ventilation systems, which move air in patient rooms without using forced air, were highlighted for their potential benefits in improving energy efficiency while maintaining indoor air quality and infection control.

Each of these technological advancements and approaches offers unique benefits and challenges. Some of these benefits are listed as follows:

- Reduced Emissions: The primary advantage of adopting these innovations is a significant reduction in greenhouse gas emissions, supporting healthcare facilities' sustainability goals and contributing to broader climate change mitigation efforts.
- Energy Savings: By utilizing energy more efficiently and integrating renewable energy sources, healthcare facilities can achieve substantial cost savings in their energy consumption and operational expenses.
- Improved Occupant Comfort: Some technologies, like dynamic glazing and displacement ventilation, also enhance indoor environmental quality and occupant comfort, leading to better patient outcomes and staff well-being.
- Resilience and Reliability: CHP systems and on-site renewable energy solutions can enhance energy resiliency and provide backup power during grid outages or emergencies.

However, implementing these technologies could also have some challenges including:

- Complex Implementation: Some technologies, like TGH or other heat recovery systems, may require advanced engineering and skilled personnel to design and operate effectively. Complex implementations can pose challenges to facilities management teams and may require ongoing support and training.
- Initial Investment Costs: The upfront costs of implementing these innovations can be a barrier, and healthcare facilities may need to carefully assess the financial viability and potential return on investment before adopting these technologies.
- Operational Complexity: Integrating advanced building controls and automation systems may require adjustments to operations and maintenance procedures, and staff training to ensure optimal performance and efficiency.
- Balancing Priorities: Healthcare facilities must strike a balance between achieving maximum emission reductions and considering other factors like cost, operational efficiency, and the impact on existing facility management practices.

In conclusion, embracing technological advancements and innovations in healthcare facilities can pave the way for significant energy efficiency improvements, emission reductions, and enhanced sustainability. However, it's crucial for healthcare organizations to carefully evaluate the benefits and challenges associated with each technology to make informed decisions aligned with their long-term goals and available resources. Table 4 summarizes the highlighted technologies and their benefits mentioned by interviewees.

Table 4: Technological advancements for energy efficiency and carbon reduction projects.

| **Advancement** | **Description** | **Benefits** |
|---|---|---|
| Heat Recovery Systems | TGH, $CO_2$ heat pumps, and other concepts to capture and reuse wasted heat | • Efficient energy utilization<br>• Significant emissions reduction |
| Building Automation | Advanced controls and automation for optimized energy consumption | • Reduced operational costs<br>• Enhanced occupant comfort |
| Ozone Laundry Systems | Uses ozone gas and oxidizing gases for energy-efficient laundry operations | • Significant reduction in laundry energy requirements |
| Dynamic Glazing | Adjusts transparency based on sunlight intensity | • Energy savings through optimized daylighting<br>• Improved occupant comfort |
| Combined Heat and Power | On-site energy generation with high efficiency | • Reduced emissions<br>• Enhanced energy resiliency |
| Displacement Ventilation | Energy-efficient air movement for improved indoor air quality and infection control | • Improved energy efficiency<br>• Better indoor air quality |

### 3.3 Comparing Literature Review and Interview Findings

This section compares the results from both the comprehensive literature review and the insightful interviews with experts in the healthcare and energy fields. By looking at the insights from these two different sources together, our goal is to get a better overall understanding of the success factors and barriers associated with energy efficiency and carbon reduction projects within healthcare facilities in BC. The synthesis of these sources not only broadens the range of what we're exploring but also makes the research findings more practical for dealing with the ever-changing world of managing energy in healthcare.

### 3.3.1 Similarities and Overlapping Themes

Both the literature review and interview analysis highlight several common themes and barriers related to energy efficiency and carbon reduction projects in healthcare facilities.

#### Economic Barriers

Both sources emphasize economic barriers as a significant challenge. The upfront costs of energy-efficient equipment, particularly in comparison to conventional options, are acknowledged. The concept of longer payback periods for energy efficiency projects is also recognized as a potential obstacle. Moreover, the importance of economic incentives to encourage the adoption of energy-efficient technologies is discussed, and the absence of such incentives is noted as a recurring challenge in both sources.

#### Technological Challenges

The challenges associated with technology are identified in both the literature review and interview analysis. The age of buildings and infrastructure poses difficulties, especially when integrating new technologies into existing systems. The availability of suitable technologies is recognized as a concern, and the need for proper measurements and evaluation tools to assess project performance is highlighted.

#### Governmental Influence

Both sources underline the impact of government mandates, regulations, and policies on energy efficiency projects. Inconsistencies in policies and challenges related to understanding and adhering to government standards are mentioned. The need for incentives and the complexities of multi-layered approval processes involving various government authorities are acknowledged.

### 3.3.2 Differences and Additional Insights

#### Educational and Behavioral Barriers

The interview analysis delves deeper into educational and behavioural barriers. It highlights issues with the engagement of FMO teams, the need for staff training, and the challenges of change management. These insights provide a nuanced understanding of how organizational dynamics and behaviour can influence project implementation.

#### Stakeholder Perspectives

The interview analysis benefits from direct engagement with experts from the healthcare and energy sectors. These experts provide real-world experiences and insights from professionals actively involved in project implementation. This practical perspective complements the findings from the literature review, offering a contextualized understanding of challenges and potential solutions.

#### Resource and Staffing Challenges

The interview analysis emphasizes challenges related to resources, staffing, and personnel turnover. These practical difficulties, such as shortages of qualified personnel and managing workload effectively, provide insights into the operational aspects that may impact project success and sustainability.

#### Project Evaluation

The interview analysis provides insights into the challenges of evaluating project success and building performance after implementation. The complexities of measuring energy savings, assessing building performance, and selecting optimal energy reduction measures are discussed in more detail.

#### Funding and Governmental Approvals

The interview analysis offers more detailed insights into challenges with funding limitations and the multi-layered approval process involving various government authorities. These insights provide a clearer picture of the administrative and bureaucratic challenges healthcare facilities face in implementing energy efficiency projects.

## 4 Conclusions

Addressing climate change's impact on health is vital, especially in Canada's healthcare system which produces a lot of pollution. This research dives into how healthcare facilities in BC can become more eco-friendly, leading to better health. The primary goal was to learn about the challenges and success factors of implementing energy efficiency and carbon reduction in healthcare facilities.

By employing a comprehensive mixed-methods approach, this research embarked on a two-step journey. The first phase involved an in-depth review of existing literature, delving into projects focused on energy efficiency and carbon reduction in healthcare facilities and public sectors. The subsequent phase consisted of interviews with stakeholders from health authorities and utility providers across BC. These discussions with experts in the healthcare and energy sectors provided valuable insights into their experiences, challenges, and strategies.

The research findings reveal that various challenges related to finances, education, technology, and regulations have been identified. Simultaneously, the study highlights success factors that include getting started early, ensuring accurate measurement and verification, making continuous improvements, targeting low-hanging fruits first, and adopting cleaner energy sources.

While this research enriches our understanding, it is not without limitations. The lack of studies on past research on challenges and success factors of implementing energy projects in the healthcare sector of BC restricted our review. Furthermore, time constraints precluded interviews with stakeholders from the other key stakeholders (such as the FMO team, project managers, etc.) involved in the process of energy project implementation. These limitations emphasize the scope for future research and the continued refinement of insights.

Healthcare facilities are responsible for both taking care of the environment and public health. This situation creates an opportunity where they can make positive changes. This research acts as a guide to help healthcare facilities overcome challenges and improve energy efficiency while reducing pollution. By working together and making thoughtful plans, healthcare organizations can drive change, creating a future where health and the environment coexist harmoniously for the benefit of everyone.

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# Appendix

## A Examples of Energy Efficiency Projects Implemented at Healthcare Facilities

The information in this section is only available to health organizations for internal use.