Potential Retrofit of Heat Pumps in Multi-Use Residential buildings in Alberta

Authored by Mercy Jenifer Gunasekaran| Supervised by: Dr. Simon Li & Dr. Eduard Cubi | University of Calgary & Introba

Research Question

How and **when** is the right time to retrofit a natural gas boiler with heat pumps in a multiuse residential buildings?

Abstract

Canada has committed to attaining net zero emissions by 2050 with an interim goal of 40% to 45% emission reduction by 2030. The building sector is Canada's third largest producer of greenhouse gas emissions. Around 70% of buildings' emissions come from space and water heating equipment. Therefore, this research is focuses on finding the most suitable time and approach for retrofitting heat pumps in multiuse residential buildings. This research assesses the various retrofit options considering the specific characteristics of the building. Subsequently, it establishes a set of decision criteria to evaluate these alternatives. This set of decision criteria pertains to both the building and its specific location. It enables homeowners to make informed choices that diverge from the conventional approach of retrofitting. After a detailed analysis, the research concludes that the hybrid system aligns best with the building's characteristics and is well-suited to adapt to the changes in the electricity grid.

Purpose of the Study

- Canada has about 16 million dwellings and 482,000 commercial and public buildings in use, accounting for 18% (including electricity) of the total emissions in Canada.
- 78% of these emissions come from space and water heating equipment, since most of these buildings are already constructed, it is essential to explore retrofitting to make them more energy efficient and reduce emissions.
- Heat pumps are an exceptional energy-efficient alternative to natural gas furnaces or boilers to heat a building.

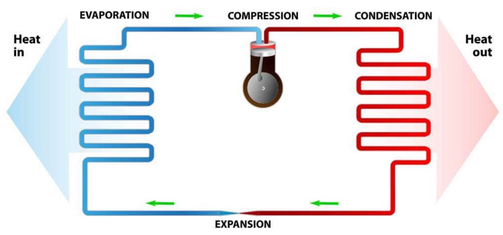


Figure 1: How a Heat Pump Works

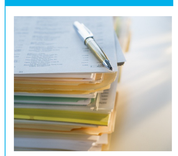
- This research will explore the electrification of an existing building using heat pumps in the residential sector of Alberta.
- The primary goal of this study will focus on when is the right time to electrify an existing building.
- Since there are numerous barriers and factors to consider, ranging from the type of mechanical system already in place to the decision of homeowners to change the system, it is critical to determine the conditions under which electrification in an existing building will allow for the long-term sustainable performance of heat pumps.

This research project's goal & objective align with UN Sustainable Development Goals #7, #9, & #11.

Methods

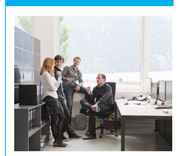
The chosen building has an estimated age of 30 to 40 years, which makes it suitable for this case study. It is in excellent condition, having undergone renovations a few years ago. Currently, the building relies on a natural gas boiler for both space heating and water heating purposes. To assess the potential benefits of heat pumps, the study will consider the same building for both the base case and the project case. In the base case scenario, the building will continue to utilize the natural gas boiler for heating, while in the project case scenario, the installation of heat pumps will be examined as an alternative heating system. This study is divided into three phases:

Phase 1



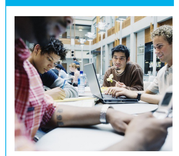
Options available for retrofitting

Phase 2



Identifying the decision criteria

Phase 3



Result of the case study

Figure 2: Case study building

Literature Review

- Government Actions:
  - Canada's green building strategy
  - Government Incentives (Provincial + Federal)
- Alberta Grid
  - AESO Long Term Outlook (LTO)
  - National inventory report
  - Alberta electricity grids emission intensity

References

- United Nations. (n.d.). *THE 17 GOALS | Sustainable Development*. https://sdgs.un.org/goals
- Natural Resources Canada. (n.d.). *Why use a cold climate air source heat pump?* https://natural-resources.canada.ca/energy-efficiency/homes/canada-greener-homes-initiative/oil-heat-pump-affordability-program-part-the-canada-greener-homes/why-use-cold-climate-air-source-heat-pump/24914

Case Study

Phase 1:

Options	Name
Option 1	**Upgrade Heating for Decarbonization**
Option 1a	Cold Climate Air Source Heat Pumps (ccASHP)
Option 1b	Ground Source Heat Pumps
Option 1c	Hybrid System (Existing Boiler + ccASHP)
Option 2	**Maintaining or Retaining the Existing Heating System**
Option 3	**Minor Retrofits**

Phase 2:

Seven Different Criteria was developed based on the building and the available options

- Decarbonization Potential
- Environmental Impacts
- Economic Feasibility
- Suitability for Building's Age and Construction Type
- Space and Resource Limitations
- Remaining Lifespan of the Building
- Integration with Existing Heating Systems

Results

Criteria	Option 1a	Option 1b	Option 1c	Option 2	Option 3
Decarbonization Potential	✓	✓	✓	⊖	✓
Environmental Impacts	✓	✓	✓	⊖	✓
Economic Feasibility	⊖	⊖	✓	✓	✓
Suitability – Age & Type	✓	✓	✓	⊖	⊖
Space and Resource Limitations	✓	⊖	✓	✓	✓
Remaining Lifespan	✓	✓	✓	⊖	⊖
Existing Heating System	⊖	⊖	✓	✓	✓

Future Research

- Energy and Environmental Impact – Calculations
- Assessment Tool