HEAT PUMP ADOPTION IN KAMLOOPS: OPPORTUNITIES, CHALLENGES AND BEST PRACTICES

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1. INTRODUCTION

1.1 Objective

Decarbonization of buildings' energy systems is necessary to address the growing climate change concerns. Canada has set ambitious objectives for its economy-wide reduction of greenhouse gases (GHG). Achieving the low-carbon transition would involve a variety of technological advances, including the electrification of fossil fuel processes.

In Canada, buildings contribute 13% of all GHG emissions, and space heating is one of the factors contributing to energy consumption and related GHG emissions in buildings (refer to Figure 1.1 below). It is Canada's second-largest source of GHG emissions and the single largest energy end-use in the nation. 60% of the energy used in the typical Canadian home is for space heating.[1] Due to the low carbon intensity of a large portion of Canada's electricity infrastructure, especially in British Columbia, using electric heat pumps for space heating is an important technique to reduce emissions. Heat pumps can increase resilience to the changing climate, as unlike traditional heating systems, they can also provide cooling for year-round comfort. Cooling during the summer is becoming a necessity in more areas of Canada due to the increasing frequency and intensity of heat waves. Heat pumps are highly efficient; greater heating and cooling can be accomplished with an identical amount of energy as opposed to electric resistance heating or fossil fuel systems.

The initial expense of purchase and installation, the need for retrofitting to boost heat pump efficiency, and concerns about performance and operating costs are some obstacles preventing the greater adoption of heat pumps.[2]

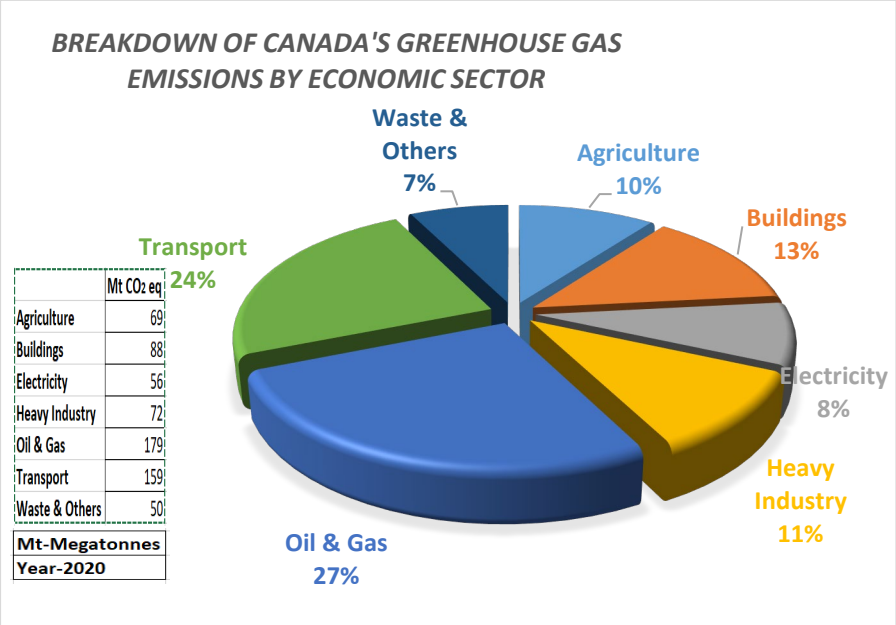


Figure 1.1: Breakdown of Canada's greenhouse gas emissions by economic sector (2020)[3]

[1] NRCan. (Aug 2022) "Energy Efficiency - Green Buildings, Government of Canada", online: https://www.nrcan.gc.ca/energy-efficiency/green-buildings/24572.

[2] NRCan. (Aug 2022) " Heating and Cooling with a Heat Pump", online: https://www.nrcan.gc.ca/energy-efficiency/energy-star-canada/about/energy-star-announcements/publications/heating-and-cooling-heat-pump/6817.

[3] Government of Canada. (2022) "Greenhouse gas sources and sinks in Canada: executive summary 2022", online: https://www.canada.ca/en/environment-climate-change/services/climate-change/greenhouse-gas-emissions/sources-sinks-executive-summary-2022.html.

This report intends to investigate and assess the challenges, advantages, driving forces and user experiences with heat pumps, drawing on case studies developed through site visits, surveys and interviews with Kamloops residents. The report's goal is to help the City of Kamloops develop best practices to increase the uptake of heat pumps and support capacity-building measures for local heat pump businesses and contractors.

1.2 Global and Canadian Emissions Reduction Goals

Since the Industrial Revolution, the increased GHGs in the atmosphere have caused the Earth's temperature to rise. Increasing energy demands, burning fossil fuels to produce electricity, using gasoline for transportation, and using fossil fuel-fired burners (i.e. natural gas furnaces) in the home are some of the primary causes of rising GHG emissions. Under the Paris Agreement of 2015, governments pledged to restrict global warming to 1.5°C above pre-industrial levels to limit temperature rise and avoid the related catastrophic effects. According to the Intergovernmental Panel on Climate Change (IPCC), 1.5°C warming would be reached or exceeded in the early 2030s under all emission scenarios save the scenario with the greatest emissions, in which case the crossover could occur even earlier.[4]

However, it is still possible to keep global warming below 1.5°C if countries reduce their emissions to net-zero as soon as possible. Due to its unique location in the northern hemisphere and vast land mass, Canada is warming twice as quickly as the global average, with the Arctic warming three times as quickly. Canada's annual land temperature has increased by approximately 1.7°C relative to pre-1948 levels, and northern Canada's temperature has increased by 2.3°C, which is higher than the national rate. Ocean ice and the habitat it provides will be significantly affected by rising temperatures.[5]

The Government of Canada is committed to the Paris Agreement and achieving net-zero emissions by 2050. The Canadian Government introduced Canada's 2030 Emissions Reduction Plan in March 2022. It provides a road map for the Canadian economy to achieve 40-45% emissions reductions below 2005 levels by 2030, building on actions outlined in previous climate plans. Canada has joined more than 120 nations in committing to net-zero emissions by 2050, including all other G7 countries. The Canadian Net-Zero Emissions Accountability Act, which became law on June 29, 2021, enshrines Canada's commitment to achieving net-zero emissions by 2050 to meet these objectives.[6]

1.3 British Columbia Context

Buildings in British Columbia (B.C.) emit approximately 6.9 million tonnes of GHG emissions annually. This represents approximately 10.7% of the province's total emissions and makes the building sector one of the highest emitters – exceeded only by road transportation (27.1%) and the oil and gas sector (17.6%). 68% of the total energy used for space heating and domestic hot water comes from burning fossil fuels, and there is a huge potential for GHG emission reduction.[7]

[4] IPCC. (2019) "Global Warming of 1.5°C", online: https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Full_Report_High_Res.pdf.
[5] United Nations Climate Change. (2016) "The Paris Agreement", online: https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement.
[6] Government of Canada. (Aug 2022) "Net-Zero Emission by 2050", online: https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/net-zero-emissions-2050.html.
[7] Zebx. (March 2021) "British Columbia's Building Electrification Road Map", online: https://www.zebx.org/wp-content/uploads/2021/04/BC-Building-Electrification-Road-Map-Final-Apr2021.pdf.

At the community scale, the GHG emissions attributed to buildings make up an even greater proportion of total GHG emissions. For communities working to reduce their overall GHG emissions, rapidly reducing GHG emissions from the building sector is a key strategy. In recognition of this important sector, jurisdictions across B.C. have included a concerted focus on decarbonizing the building sector to meet their ambitious emissions reduction goals and targets.

In British Columbia, approximately 93% of electricity comes from renewable energy sources.[8] The electrification of space heating by switching from fossil fuels (e.g., oil, natural gas) to electric heat pumps is a cost-effective and viable option in most of B.C., especially in the milder climate zones in the Lower Mainland and Vancouver Island. In these areas, where air conditioning is less common, they are also providing essential cooling during heat waves. However, cold climate heat pumps have been demonstrated to operate in temperatures as low as -30°C, making them suitable for the cooler Interior and Northern parts of the province. Heat pumps can provide cost savings, particularly compared to other electric heating options, and reductions in GHG emissions due to technological advances.[9]

1.4 The City of Kamloops – Community Climate Action Plan[10]

The City of Kamloops adopted the Community Climate Action Plan (CCAP) on June 29, 2021, in accordance with global, national, and provincial efforts to reduce GHG emissions and limit the temperature rise to 1.5°C. The Community Climate Action Plan identified eight Big Moves and twenty-four strategies with the potential to reduce GHG emissions in the community at a rate consistent with the Council's resolution. In addition, a series of short, medium, and long-term actions were identified to implement the Community Climate Action Plan's Big Moves and interim and long-term goals to help focus local commitment on measurable outcomes.

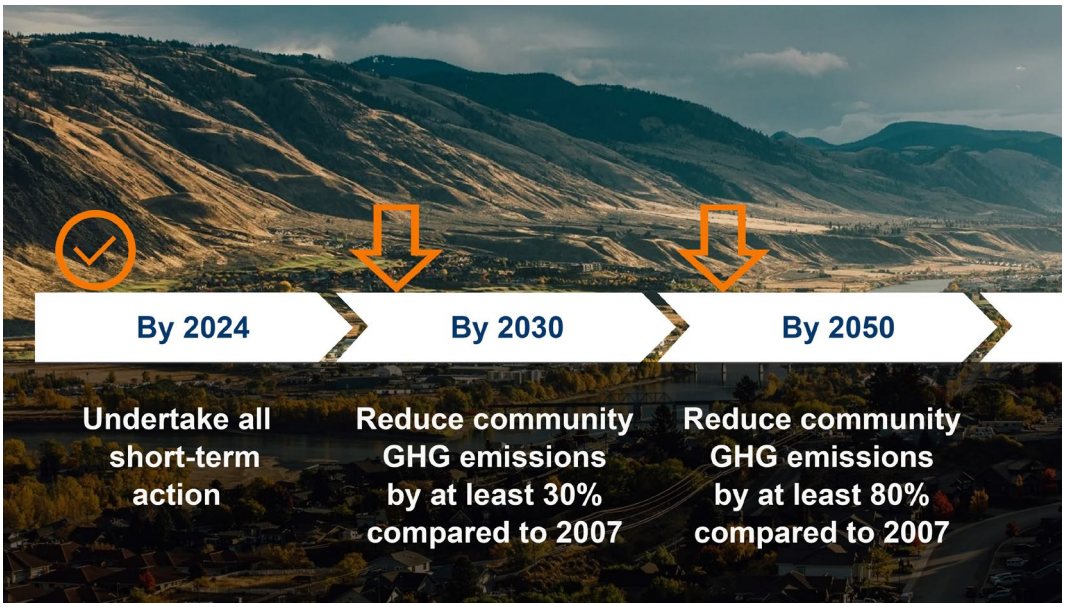


Figure 1.2: Targets of the CCAP

[8] NRCan. (Aug 2022) " Heating and Cooling with a Heat Pump", online: https://www.nrcan.gc.ca/energy-efficiency/energy-star-canada/about/energy-star-announcements/publications/heating-and-cooling-heat-pump/6817.

[9] Government of BC. (June 2022) "Heat pump demand heats up in northern B.C", online: https://news.gov.bc.ca/releases/2022FIN0022-000979.

[10] City of Kamloops. (June 2021) "Community Climate Action Plan", online: https://www.kamloops.ca/sites/default/files/docs/cityofkamloops_communityclimateactionplan_june2021_final_0.pdf.

1.5 Community Climate Action Plan: Big Move 4

One of the Big Moves, Big Move 4: Zero-Carbon Homes and Buildings, aims to reduce GHG emissions from buildings in Kamloops by up to 95,300 metric tonnes of carbon dioxide equivalent by 2050. Buildings account for 29% of GHG emissions in Kamloops, primarily due to the use of natural gas for space and water heating. In most buildings, switching heating systems from natural gas (a fossil fuel composed primarily of methane) to electricity (primarily hydropower in British Columbia) or other renewable energy sources will significantly reduce emissions.

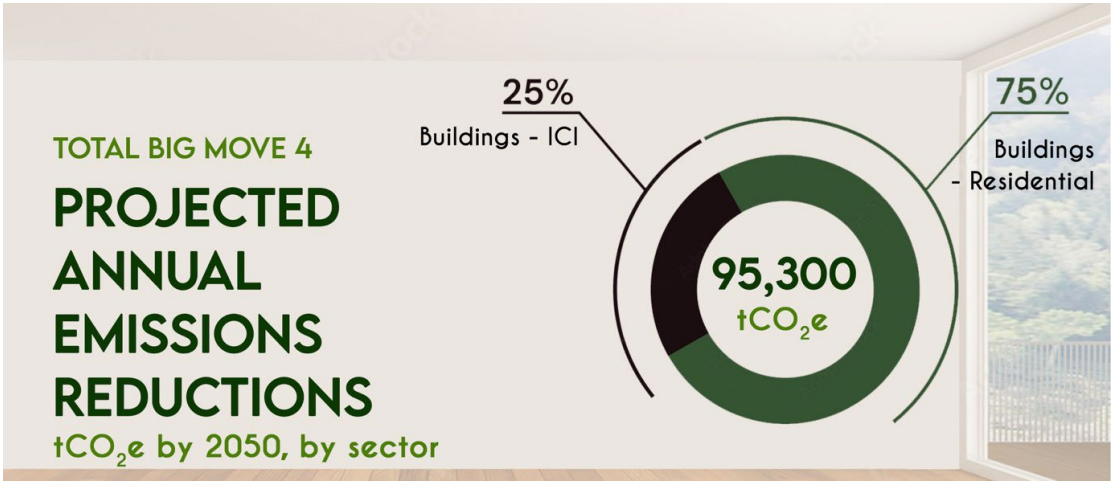


Figure 1.3: Projected Annual Emission Reductions

Emission reductions from zero-carbon homes and buildings are the most significant of the Big Moves. Emissions reductions in new buildings will require going above and beyond the B.C. Energy Step Code's energy efficiency measures (projected emissions reductions from existing policies are already accounted for), primarily by integrating low-carbon space and water-heating systems. Retrofitting existing buildings represents the largest opportunity to meet the CCAP targets. It will be a significant challenge for all buildings to be retrofitted by 2050 with low-carbon energy systems and energy efficiency measures. Therefore incentives, legislation and other measures will be necessary.

Big Move 4: Zero-Carbon Homes and Buildings is sub-divided into two categories:
4A - New Homes and Buildings. With a projected annual GHG reduction of 13,500 tCO2e by 2050, the objective is to support the transition to high-performance, energy-efficient, zero-carbon homes and buildings.

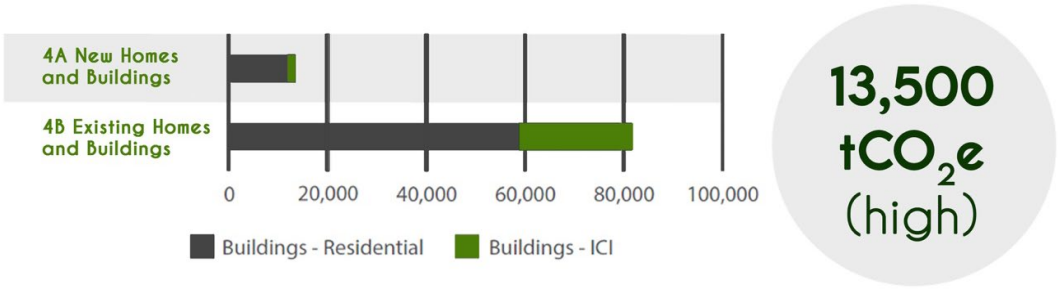


Figure 1.4: Projected Annual GHG Reduction by 2050 from Implementation of the CCAP's Big Move 4 Actions

4B - Existing Residences and Structures. The objective is to support rapid, large-scale retrofits of existing homes and buildings that result in energy efficiency improvements and the switch to low-carbon energy sources, resulting in an annual GHG reduction of 81,800 tCO2e by 2050.

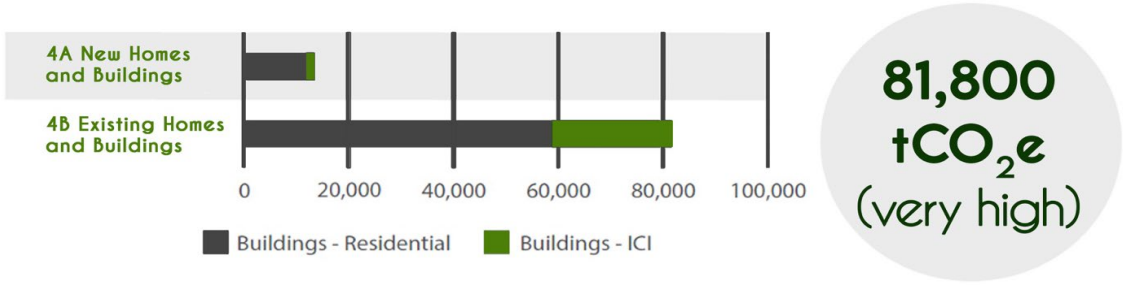


Figure 1.5: Projected Annual GHG Reduction by 2050 (Very High)

Electric heat pumps offer a low-carbon solution for space and water heating and will play a crucial role in achieving community GHG reduction targets. However, there are concerns, including the industry capacity of Kamloops is a barrier to the widespread adoption of heat pumps.[11] Despite generous rebate offers, heat pump adoption has been low in recent years. There are gaps in contractors' understanding of the eligibility requirements for rebates available to homeowners willing to install heat pumps as their primary home heating source. For greater adoption of heat pumps in Kamloops, it is necessary to dispel the myths surrounding the performance of cold-climate heat pump

[11] Barone, K. (2022) "City of Kamloops Heat Pump Capacity Building Project Report", online: https://www.kamloops.ca/sites/default/files/docs/2022%20Heat%20Pump%20Capacity%20Building%20Project%20Report_FINAL.pdf

2. ENERGY EFFICIENT LOW-CARBON HEATING & COOLING SOLUTIONS

2.1 Heat Pumps

A heat pump is a device capable of heating a building (or a portion of a building) by transferring thermal energy from the exterior using the refrigeration cycle. Heat pumps are an energy-efficient alternative to furnaces and air conditioners in most climates. Contrary to their name, heat pumps do not produce heat; they transfer heat from one location to another using different air or heat sources. A heat pump absorbs heat energy from the outside air (even at low temperatures) and transfers it to the indoor air. In contrast, a furnace generates heat that is distributed throughout a home. In cooling mode, heat pumps and air conditioners operate identically, absorbing heat from the indoor air and releasing it from the outdoor unit.

Heating Cycle

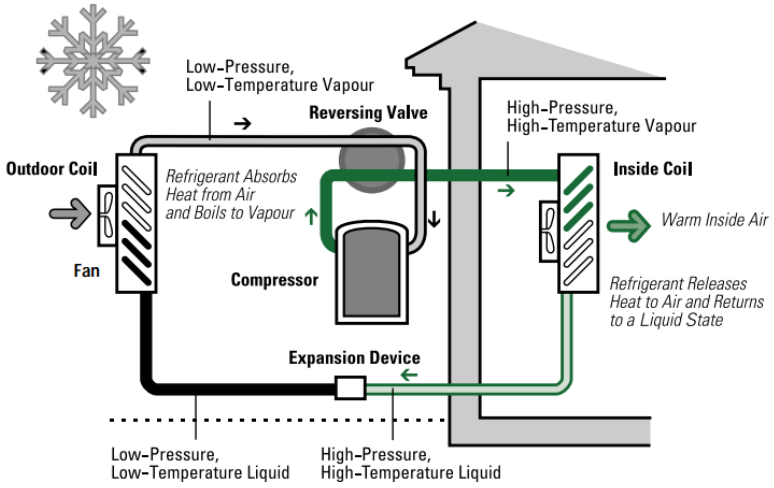


Figure 2.2: Image Credit: https://www.nrcan.gc.ca

Cooling Cycle

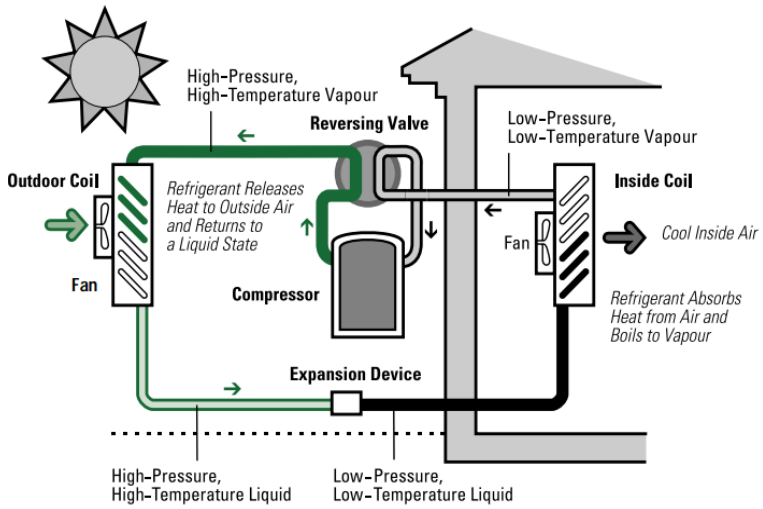


Figure 2.3: Image Credit: https://www.nrcan.gc.ca

Based on the source of thermal energy, heat pumps are most commonly divided into two categories:[12]

A. Air-Source Heat Pumps

The most common type of heat pump is an air-source heat pump, which moves heat from an indoor space to the outside air or, in summer, the other way around to cool an inside space. These appliances account for most air-source heat pump integrations in Canada and heat or cool the air within your house. The several kinds of air-source heat pumps are as follows:

- **Ducted:** Through ductwork connected to vents in each room, a ducted heat pump disperses heat and cools the air.
- **Ductless:** A compact bundle of cables, including the refrigerant line, connects an outdoor unit to wall-mounted indoor heads. These indoor units are often installed on the floor or wall of an occupied space and immediately heat or cool the air within that space. Among these units, the terms mini- and multi-split may appear:
    - **Mini-Split:** A mini-split heat pump can heat and cool a home without ducting. Mini-split heat pumps utilize an indoor head that is installed within the home.
    - **Multi-Split:** Frequently, the term multi-split is applied to heat pump systems with many interior heads serviced by a single outdoor unit.

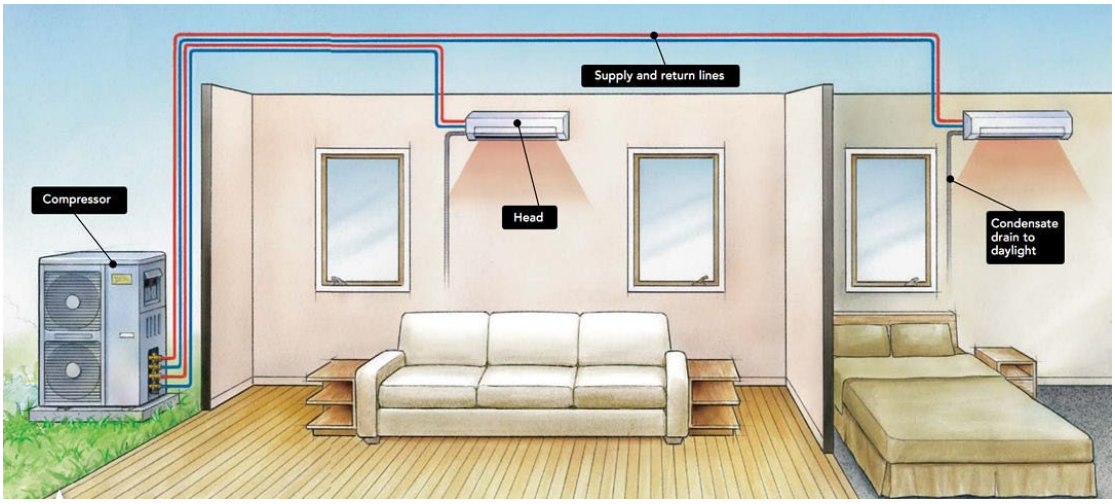


Figure 2.4: Ductless / mini-split heat pump. Image Credit: https://www.finehomebuilding.com/2019/03/07/high-performance-hvac-2

B. Ground-Source Heat Pumps

Ground source heat pumps, often known as geothermal heat pumps, are heating and cooling systems that collect heat from the Earth. Sometimes the sun (warming the surface and transporting heat underground) is the source of this heat, and sometimes it is the geothermal energy.[13]

[12] NRCan. (Aug 2022) " Heating and Cooling with a Heat Pump", online: https://www.nrcan.gc.ca/energy-efficiency/energy-star-canada/about/energy-star-announcements/publications/heating-and-cooling-heat-pump/6817.

[13] NRCan. (Aug 2022) " Heating and Cooling with a Heat Pump", online: https://www.nrcan.gc.ca/energy-efficiency/energy-star-canada/about/energy-star-announcements/publications/heating-and-cooling-heat-pump/6817.

In the winter, the subsurface temperatures provide a consistent heat source; hence, a ground source heat pump can heat a building with lesser electricity. In the summer, the home's heat can be dispersed underground, and pumps can be employed to cool the space (Figure 2.5).

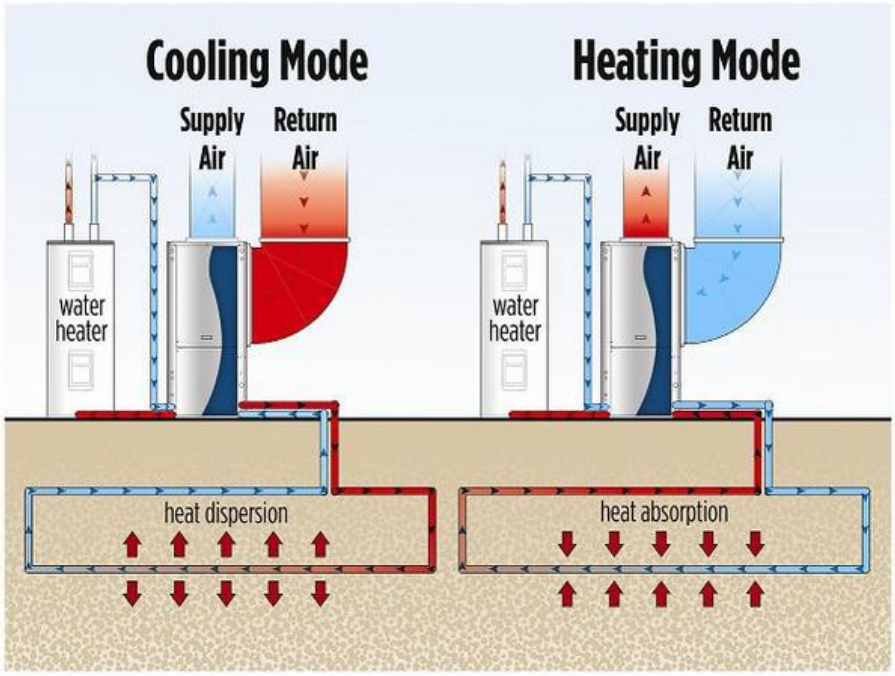


Figure 2.5: Ground Source Heat Pump Cooling and Heating Modes Image Credit: https://energyeducation.ca/encyclopedia/Ground_source_heat_pump

Two system classifications are possible depending on how the heat pump and ground heat exchanger interact:

- **Closed-Loop Systems**

Most closed-loop geothermal heat pumps circulate an antifreeze solution through an underground or submerged closed loop. Heat is transferred between the heat pump's refrigerant and the antifreeze solution via a heat exchanger. Depending on the configuration of the underground refrigerant piping, the Closed loop system can be further categorized as a Horizontal closed loop, Vertical closed loop, or Pond closed loop system.

- **Open-Loop System**

This GHP system uses groundwater or surface water as the heat exchange fluid that circulates directly. After circulating through the system, water is returned to the ground via the well, a recharge well, or surface discharge. This option is only viable when a sufficient quantity of relatively clean water is available, and all local codes and regulations regarding groundwater discharge are met.

2.2 Supplementary Heat Sources

Since air-source heat pumps transfer heat from the outside air into the home, their heating capacity is reduced at temperatures below -7°C. During cold snaps, it is essential to consider a

backup heating source for air-source heat pump operation.[14] Types of supplementary or backup heating are:

- **All Electric:** In this configuration, heat pump operations are augmented by electric resistance elements located within the ductwork or by electric baseboards. These resistance elements are less efficient than heat pumps, but their heating capacity is unaffected by the outdoor temperature.
- **Hybrid Systems:** The air-source heat pump utilizes a furnace or boiler as a supplementary system in a hybrid system. This option is suitable for new installations and adding a heat pump to an existing system, such as when a heat pump is installed to replace a central air conditioner. Hybrid systems save substantial energy and carbon emissions compared to most other systems and can provide peace of mind in colder climates. Here are some standard hybrid configurations:
    - **Electric strip:** A common feature in mild climates, a simple electric heating element can be incorporated into the heat pump or air handler. These strips consume a great deal of energy, but they are inexpensive to install and maintain, and they are a cost-effective way to endure brief cold snaps.
    - **Mini-split plus radiators:** Radiator systems that run on oil or propane, as well as "regular" electric-resistance heat, tend to be costly to operate, whereas mini-split systems are large enough to heat an entire home and are typically costly to install. A common compromise is installing a mini-split system that can handle most of your heating (and cooling) needs while retaining the old radiator system for the coldest days.
    - **Ducted heat pump plus furnace:** Similar to the mini-split and radiator combination described previously. Installing a heat pump is identical to installing a central air conditioner.

2.3 Selecting a Heat Pump[15]

The following are considerations for residents considering a heat pump:

A. Capacity

An insufficiently sized heat pump will struggle to keep your home comfortable. On the other hand, an oversized unit will be more expensive, and if it is not a variable-speed model, it will turn on and off more frequently. This reduces the home's efficiency, stresses its components, and reduces its comfort.

B. Efficiency

Some heat pumps provide the same level of comfort while consuming less energy than others. In cooling mode, energy efficiency is typically expressed as the seasonal energy efficiency ratio (SEER). More efficient systems have higher SEER ratings. In heating mode, the heating seasonal performance factor, or HSPF, is the unit of measurement. Again, the greater the number, the greater the unit's energy efficiency.

C. Climate Performance

[14] NRCan. (Aug 2022) " Heating and Cooling with a Heat Pump", online: https://www.nrcan.gc.ca/energy-efficiency/energy-star-canada/about/energy-star-announcements/publications/heating-and-cooling-heat-pump/6817.

[15] NRCan. (Aug 2022) " Heating and Cooling with a Heat Pump", online: https://www.nrcan.gc.ca/energy-efficiency/energy-star-canada/about/energy-star-announcements/publications/heating-and-cooling-heat-pump/6817.

If you live in a region with cold winters, choose a cold-climate rated heat pump that performs well in the region's coldest temperatures or have a secondary heating system as a backup for your heat pump. Compared to standard air source heat pumps, cold climate heat pumps are more efficient and can function in colder temperatures. At lower temperatures, conventional heat pumps often work at lower heating capacity. While cold climate heat pumps can still produce heat at outdoor temperatures as low as -25°C or -30°C, depending on the manufacturer's specifications.

D. Noise

In the user manual and frequently on their websites, manufacturers list the decibel levels of their products. They typically include decibel-based noise estimates for a range of outdoor temperatures and fan speeds. A lower rating is preferable, mainly if the heat pump is installed near a bedroom window.

E. Reliability

Reliability is a great concern for new heat pump customers. As heat pump technology is still in the early phase of adoption in many provinces, the perception of being an unreliable technology is there in the mind of many customers. However, if attention is paid to the purchase, installation and operation of heat pumps, it is a highly reliable and proven technology.

F. Find the Right Contractor

As with most heating and cooling systems, hiring a professional to design and install a new heat pump system is prudent. To receive heat pump rebates in B.C., a Program Registered Contractor (PRC) or Home Performance Contractor Network (HPCN) member must be used.

G. Backup Heating System

A backup heating system should not be required if the heat pump and system design are appropriate for the home and local climate. However, a backup system may be the most cost-efficient way to maintain a comfortable home in colder climates. You could even consider it a hybrid system instead of a system with a backup. You will use the backup system only on cold days when the heat pump cannot keep up. A contractor can automatically configure the system to switch at a predetermined outdoor temperature.[16]

[16] NRCan. (Aug 2022) " Heating and Cooling with a Heat Pump", online: https://www.nrcan.gc.ca/energy-efficiency/energy-star-canada/about/energy-star-announcements/publications/heating-and-cooling-heat-pump/6817.

3. OPPORTUNITY AND CHALLENGES

3.1 Opportunity

The supply of low-carbon electricity in B.C. and the mature state of high-efficiency heating and cooling technology has immense potential for decarbonizing the province's building sector.

Unlike transportation and oil and gas, the building sector is regulated entirely by provincial and local governments. It, therefore, represents one of the most straightforward opportunities for a rapid transition to a low-carbon market sector.

At the provincial scale, the Province of B.C.'s CleanBC Plan is the primary means through which the province outlines several regulations, programs and rebates to help shift the sector towards higher energy efficiency and fewer emissions. The province is also a signatory to an aspirational national target for all space heating technologies for sale in Canada to meet an energy performance of more than 100%. This means that after 2030, all new space and water heating equipment sold and installed in B.C. will be at least 100% efficient (i.e. electric resistance heating, heat pumps, and hybrid electric heat pump-gas systems).[17]

3.2 Challenges

Before identifying the potential for Heat Pumps in B.C.'s building sector, it is important to explore the associated challenges. This report focuses on heat pumps for space heating and cooling. High upfront capital cost, low level of awareness, retailers' & contractors' preference for traditional heating & cooling systems and perception of the technology are some of the challenges. The barriers are discussed in detail below:

BARRIERS	ASSESSMENT
AWARENESS	• Heat pump technologies are less promoted due to the lower level of many customers. Other market participants such as distributors, retailers, designers and contractors still have less information about heat pump technologies than conventional space heating options. • Cold climate heat pump awareness in customers, retailers and contractors. • Due to low market penetration, fewer neighbourhood references are available to increase awareness.
ACCEPTANCE	Many challenges associated with performance and reliability affect the acceptance of heat pumps. Some of these challenges are perceptual such as • cold heat from a heat pump vs hot heat from a furnace, • poor performance feedback from earlier heat pump models While others are technological constraints such as • the performance of heat pumps during cold snaps. Heat pumps tend to work at reduced efficiencies at negative ambient temperatures • higher noise levels due to moving parts such as fans and compressors compared to furnaces.
AFFORDABILITY	There are cost barriers for residential customers considering switching from natural gas heating to heat pump technologies (including capital and operating costs). • High upfront costs are a significant barrier to the increased uptake of heat pumps. Despite rebates from Federal and Provincial governments, high cost remains a barrier.

[17] Clean BC. (October 2021) "Roadmap to 2030", online: https://www2.gov.bc.ca/assets/gov/environment/climatechange/action/cleanbc/cleanbc_roadmap_2030.pdf.

	• Higher electricity bill is another cost barrier. There are no subsidies to cover the increased electricity bills • The lower cost of natural gas makes it affordable to run a furnace.
AVAILABILITY	• The low motivation of manufacturers, retailers and contractors to promote heat pumps • Poor availability of Cold Climate heat pumps and other leading heat pump technologies • Weak North American market presence
ACCESSIBILITY	Accessibility of a Heat Pump is still a challenge due to: • Retailers and contractors preference to conventional heating systems • limited presence in the North American market • Long gestation period from concept to operationalization. The lengthy process to avail incentives and long lead time for purchase and installation. • A lack of awareness of heat pumps by retailers, contractors and other building professionals (new and existing)

Table 1: Barriers to the uptake of heat pumps[18]

COST	• Significant incentives available to increase affordability • Possibility of increase in natural gas price to discourage consumption
MARKET/ INDUSTRY	• Considering the shift towards low carbon technologies, there is a huge market potential for heat pumps • Opportunity for retailers and contractors to increase sales • The requirement of tradesmen will boost jobs
ENERGY EFFICIENCY	• a heat pump uses half to a third as much energy as electric baseboards or a gas furnace. • Heat pumps last, on average, approximately 15-25 years.
CLIMATE FRIENDLY	• reduces carbon footprint • No harmful gases are released inside or outside of the home
COMFORT	• Heat pumps provide year-round comfort by heating and cooling • Heat pumps provide airflow and dehumidification options to add an enhanced filtration system to clean the air circulating through your home of indoor pollutants, dust, pollen, and other allergens.

Table 2: Main Benefits of Heat Pumps[19]

[18] Zebx. (March 2021) "British Columbia's Building Electrification Road Map", online: https://www.zebx.org/wp-content/uploads/2021/04/BC-Building-Electrification-Road-Map-Final-Apr2021.pdf.

[19] Zebx. (March 2021) "British Columbia's Building Electrification Road Map", online: https://www.zebx.org/wp-content/uploads/2021/04/BC-Building-Electrification-Road-Map-Final-Apr2021.pdf.

4. PRIMARY RESEARCH FINDINGS

Customer uptake and experiences with heat pump technologies are important to evaluate. The City of Kamloops and the UBC Sustainability Scholar conducted site visits, surveys and interviews with eight single-family homes to assess local residents' perceptions and energy consumption patterns. Customers' experiences with home heat pumps were examined using a customer satisfaction survey, as well as interview questions that explored the impact of the installer and user-related variables on measured heat pump system efficiency. According to the surveys, most users were happy with their system's comfort, warmth, hot water, and dependability. Higher system efficiencies were linked to user understanding of their heat pump system and more continuous operation, according to an analysis of user characteristics. However, larger samples are needed for solid statistical confirmation.

4.1 Heat Pump Surveys

The research included two components: a) surveys plus interviews to learn more about participants' experiences, perceptions, and behaviour; and b) collecting and analysing energy bills to determine how installing a heat pump affected participants' energy use for the development of four case studies. This part focuses on the resident's experience and the results of the energy consumption analysis.

4.1.1 Resident's experiences, behaviour and satisfaction

A resident survey to supplement the energy consumption analysis was conducted. The objectives of the survey were:

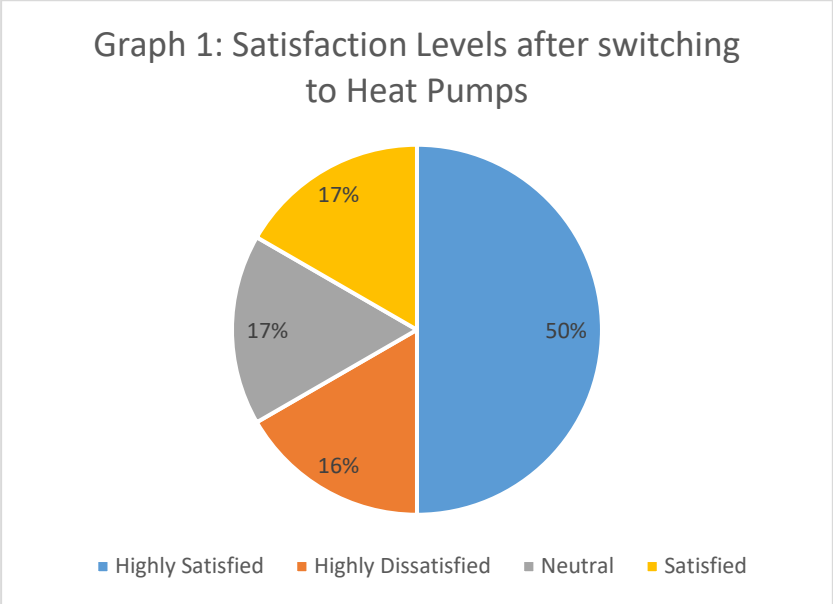
- Obtain feedback from heat pump users on their characteristics, behaviour, experiences, and satisfaction with using a heat pump system;
- Understand the motivation for switching to a heat pump;
- Obtain feedback on financial assistance/incentives/rebates programs, how easy it is to access these programs, and if assistance/incentives/rebates programs are sufficient.

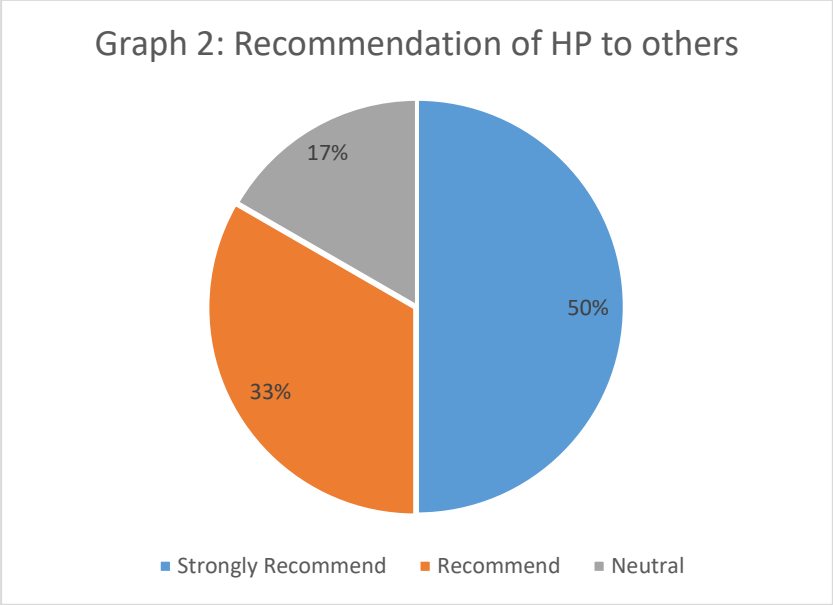
4.1.2 Survey: Method and Sample

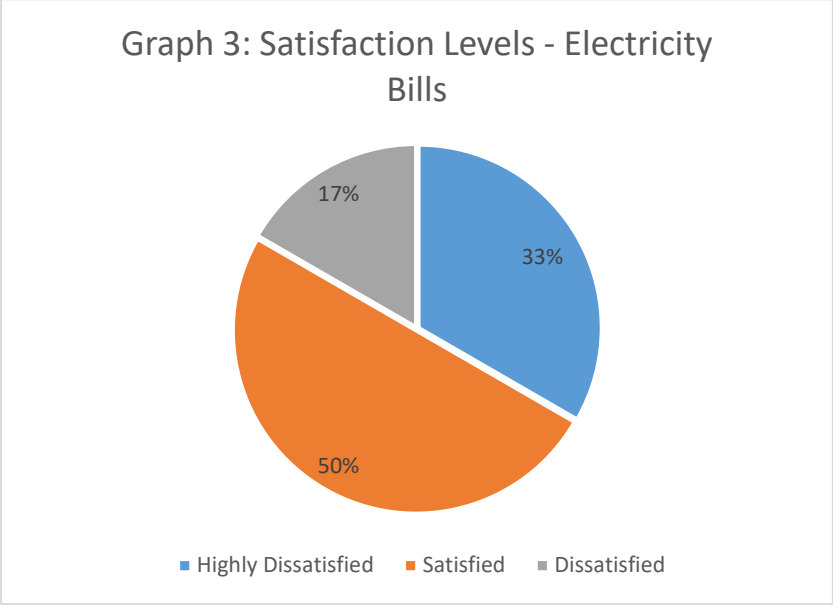
Residents chosen for the survey were sent an initial questionnaire and billing information to get their consent to participate in the user study. The City of Kamloops Sustainability Office and the University of British Columbia Sustainability Scholar created these questionnaires.
All of the surveys included questions with multiple choices and/or open-ended responses about the benefits of owning or using a heat pump, its drawbacks, any operational issues, advice and support offered, financial incentives and rebates, support from the retailer and contractor, how satisfactorily it provided heating and/or cooling, use of supplemental heating, how it compared to the user's prior heating, and reasons for switching to a heat pump.

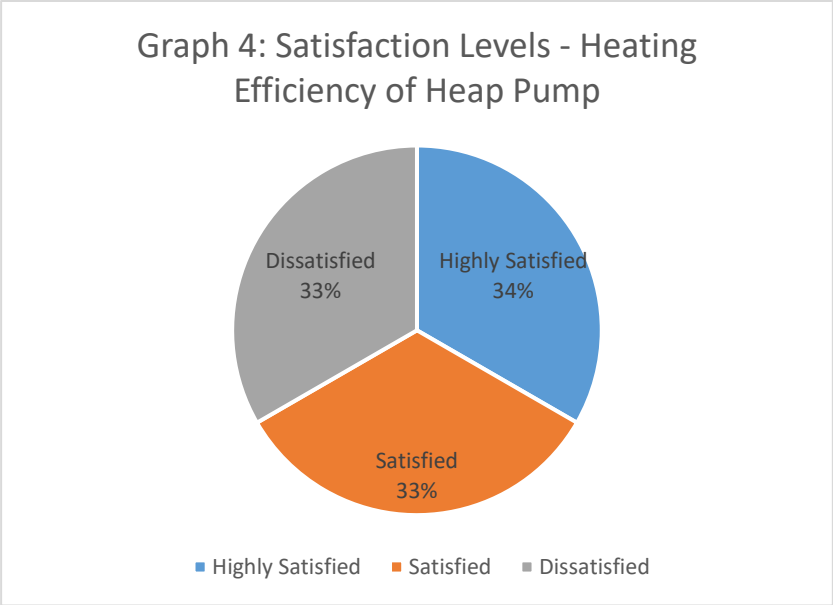
4.1.3 Survey Analysis: Experiences, Behaviour, And Satisfaction

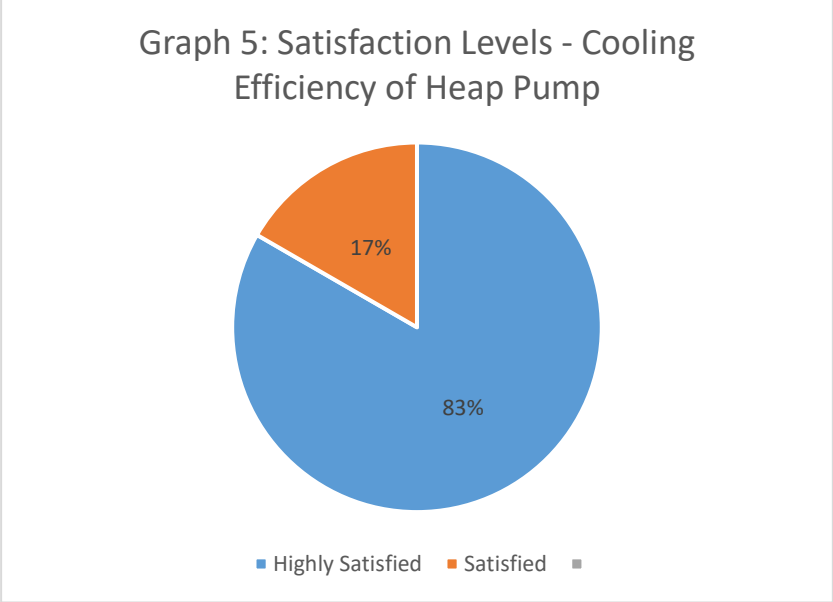
The survey assessed overall satisfaction levels with switching to a heat pump, as well as for particular aspects such as electricity bills, and heating and cooling performance. With the increasing frequency of heat waves, performance during summers is also important to improve climate resilience. One of the survey questions was to assess the overall satisfaction level of the residents after switching to a heat pump.


Graph 1: Satisfaction Levels after switching to Heat Pumps
17%
50%
17%
16%
Highly Satisfied
Highly Dissatisfied
Neutral
Satisfied


Graph 2: Recommendation of HP to others
17%
50%
33%
Strongly Recommend
Recommend
Neutral


Graph 3: Satisfaction Levels - Electricity Bills
17%
33%
50%
Highly Dissatisfied
Satisfied
Dissatisfied





Survey highlights:

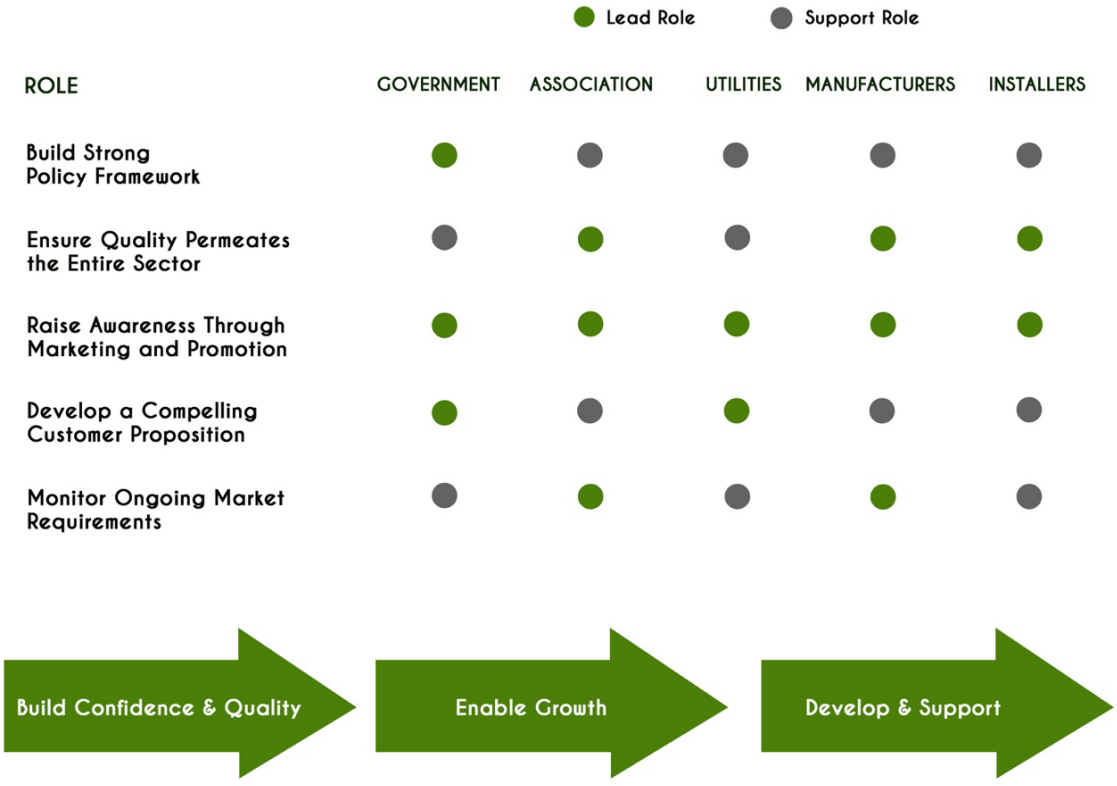
- 67% of the survey respondents claimed to be highly satisfied or satisfied, and only 16% claimed to be highly dissatisfied after switching to the heat pump (Graph 1).
- 83% of the respondents said they would recommend others to adopt heat pumps, based on their overall experience (Graph 2).
- Only 50% of the respondents are satisfied with their electricity bills after adopting a heat pump. In general, higher electricity bills were a common concern for the respondents (Graph 3). However, some have installed solar photovoltaic panels to offset their electricity bills.

- 67% of the respondents were highly satisfied or satisfied with heating performance. However, 33% of respondents submitted that they are not satisfied, especially during cold snaps (Graph 4).
- 83% of the respondents claimed to be highly satisfied with the heat pump's cooling performance, and the remaining 17% claimed to be satisfied (Graph 5). Some mentioned that heat pumps performed well during the heat dome of 2021.

5. BEST PRACTICES

The Five Guiding Principles outlined here are the fundamental building blocks for a sustainable heat pump market. The first two are crucial in the early phases of market development: establishing a solid policy framework and ensuring quality. The following principles, marketing, awareness-raising, and creating compelling customer propositions, will facilitate and amplify market expansion. Lastly, market monitoring can provide feedback to all market participants, guiding the development and maintenance of the market over time.[20]

Government (Federal and Provincial), Municipalities, policymakers, industry associations, utilities, manufacturers, and installers are the key stakeholders in the development of the heat pump industry. These market participants play a crucial role in implementing the five guiding principles. Stakeholders may play either a leading or supporting role depending on the market's characteristics or its stage of development. Throughout the stages of market development, stakeholders should collaborate to achieve the shared goals of fostering quality, and confidence, facilitating growth and developing and supporting the sector.



5.1 The Heat Pump Market Ecosystem

The market ecosystem for heat pumps connects the Five Guiding Principles and Stakeholders. Five guiding principles comprise the core of the ecosystem: policy, quality, marketing, customer proposition, and monitoring. These elements constitute the basis of a sustainable heat pump market. They will ultimately facilitate the transition from niche to the mass market. Government (federal and provincial), municipalities and policymakers, industry associations, utilities, manufacturers, and installers drive the implementation of the five guiding principles. They are

[20] Epha and Delta. (August 2018) "Unleashing the Opportunity", online: https://www.ehpa.org/fileadmin/red/03._Media/03.02_Studies_and_reports/EHPA_BestPractice_FINAL_3.pdf.

the key market players who can act as catalysts to enable the heat pump sector to emerge and eventually develop along the path to sustainable and stable growth. Underpinning this activity are the fundamental goals of fostering confidence and quality, facilitating expansion, and developing and sustaining the market. This report will present each of the five guiding principles separately and investigate the role of the stakeholders in implementing these principles.[21]

5.2 Build a Strong Policy Framework

By building a robust policy framework, heat pumps can reach their full value potential as tools for reducing emissions and saving energy. Such a policy framework should include heat pumps in its rules and policies to be used to their full potential. If this policy framework is part of a long-term strategy, stakeholders in the market can be sure they can support and grow the market. To put together a set of policies, the following things should be part of a robust policy framework for heat pumps:

Heat pumps should be incorporated into policy and regulation within a long-term vision that establishes a framework for developing markets for low-carbon technologies and takes a market-wide approach to understand and analyzing each technology's demands. Heat pumps should be given a long-term guarantee of support which gives the industry and other stakeholders the confidence to invest in heat pump technology and market development.

A strong policy framework gives stakeholders the confidence to develop the market.

- It allows the heat pump and heating industry the confidence to invest in R&D to develop the most market-optimal products and grow production capacities.
- It enables other stakeholders (such as financial firms, utilities, and large installers) the confidence to create appealing consumer offers (e.g., financing).
- It encourages utilities to pursue heat pumps as an appealing business and income source.

[21] Epha and Delta. (August 2018) “Unleashing the Opportunity”, online: https://www.ehpa.org/fileadmin/red/03._Media/03.02_Studies_and_reports/EHPA_BestPractice_FINAL_3.pdf.

- It gives consumers assurance and trust in heat pumps as a viable alternative to conventional systems.

5.2.1 Policies, Regulations and Incentives in British Columbia

The British Columbia government has set a number of ambitious goals to lower the province's rising energy consumption and GHG emissions. The goals include policy, programmes and tools development for advancing energy efficiency and administering them to increase the adoption of energy-efficient technologies by households, businesses, institutions, and local governments. It is also recommended to mandate the use of minimum energy efficiency rated appliances and equipment and promote energy-efficient practices through the Innovative Clean Energy (ICE) Fund. The efforts to reduce energy consumption and GHG emissions will include engagement with partners and stakeholders to pursue a coordinated energy efficiency strategy.

5.2.2 Regulations

British Columbia Building Electrification Road Map

British Columbia's Building Electrification Road Map was announced in March 2021. The Road Map's overarching objective is to considerably reduce the GHG emissions due to British Columbia's building sector and to realize the following vision:

In pursuit of a province-wide transition to low-carbon buildings, by 2030, nearly all new and most replacement space heating and domestic hot water systems in British Columbia's homes and buildings will be high-efficiency electric.

Building electrification replaces fossil fuel-driven building operating systems, such as those used for cooking, space heating, and domestic hot water, with low-carbon electric-powered ones. British Columbia has easy access to hydroelectric electricity, a clean, renewable energy source that accomplishes carbon reduction goals. The contributions and teamwork of numerous stakeholders from the British Columbia building sector went into developing the B.C. Building Electrification Road Map. It is a crucial starting point for stakeholders discussing meeting GHG reduction objectives.[22]

Five core strategies of British Columbia's Building Electrification Road Map are:

STRATEGY	OBJECTIVE
CREATE MARKET DEMAND	• Demonstrate provincial leadership through messaging and market signals • Raise the level of consumer awareness about the benefits of electrification • Require building GHG performance data reporting and disclosure • Set a minimum energy performance standard of coefficient of performance (COP) >1 by 2035 for space and water heating equipment
	• Reduce equipment and whole building capital costs

[22] Zebx. (March 2021) "British Columbia's Building Electrification Road Map", online: https://www.zebx.org/wp-content/uploads/2021/04/BC-Building-Electrification-Road-Map-Final-Apr2021.pdf.

IMPROVE COST COMPETITIVENESS	• Level the playing field between natural gas and electric operational costs • Reduce electricity connection and system upgrade fees • Address housing affordability and building electrification • Reduce transactional costs for consumers
ADDRESS SYSTEMIC BARRIERS	• Reflect high efficiency features more accurately in property appraisals • Reduce landlords' legal barriers to undertaking electrification retrofits • Ensure buildings connected to district energy systems can decarbonize • Improve access to capital • Reduce permitting complexity and time for new heat pump systems
EXPAND INDUSTRY CAPACITY	• Expand electrification sales force • Improve building electrification awareness, coordination, and advocacy • Build industry knowledge, experience, and competence • Expand the use of trade certifications and energy performance guidelines • Support growth in the number of people in the building electrification trades sector
INCREASE AVAILABLE TECHNOLOGIES	• Support the development of building and equipment standards • Accelerate the certification of promising new technologies • Support the introduction of certified technologies • Expand the market in North America for building electrification

B.C. Energy Step Code

Local governments may choose to employ the B.C. Energy Step Code, an optional compliance pathway in B.C. Building Code, to encourage or mandate an energy efficiency level in a new construction that exceeds the standards of the B.C. Building Code. Builders can voluntarily follow the B.C. Energy Step Code as a new road to compliance to satisfy the B.C. Building Code's criteria for energy efficiency.

In 2008, the Province of British Columbia first made energy efficiency a goal of B.C. Building Code. Since then, designers and contractors have had the choice to adhere to the code's efficiency standards using either **"prescriptive" or "performance" methodologies.**[23] Until now, most builders in British Columbia have employed the **prescriptive approach.** Strict regulations must be followed while installing windows, furnaces, water heaters, lights, and other systems. It focuses on individual components rather than ensuring that the structure functions effectively as a whole. A structure that doesn't work as well as it should be the end outcome.

[23] British Columbia building code. (2021) "How the BC energy step code works", online: https://energystepcode.ca/.

The **performance method** is a different way for builders to adhere to the B.C. Building Code's standards for energy efficiency. An example of this strategy in a particular form is the B.C. Energy Step Code. The design and building team must select how to achieve the performance approaches to establish the desired outcome. Builders must employ energy software modelling and on-site testing to show that their design and the built building satisfy the standards to comply with the B.C. Energy Step Code. To do this, they are free to employ any materials or building techniques. This strategy is similar to that of many green-building certification programmes, such as the Canadian Home Building Association's Net Zero Home™ and Net Zero Ready Home™ programmes, the Energy Star for New Homes™ and R-2000™ programmes from Natural Resources Canada, and the certification offered by the Passive House Institute (in Darmstadt).[24]

5.2.3 Programs

Programs dedicated to energy efficiency and conservation are integral to meeting British Columbia's future energy needs.

CleanBC Better Homes and Better Buildings – Renovation and New Construction Programs[25]

By switching to high-efficiency heating equipment and making building-envelope improvements, BetterHomesBC and BetterBuildingsBC are provincial programmes that provide financial incentives, information, and support to help individuals and organizations save energy and cut GHG emissions. The Low Carbon Economy Leadership Fund, which has a $24 million budget, co-funds the programme with the Federal Government.[26]

British Columbians can get subsidies from Better Homes to reduce their energy use and GHG emissions.

About CleanBC Better Homes

The CleanBC Better Homes Program is offering heat pump rebates for fuel switching from fossil fuel to a heat pump. This program aims to promote a shift from fossil fuel heating systems to electric heat pumps by providing rebates to offset the upfront cost.

About CleanBC Better Buildings

To lower energy consumption and GHG emissions in both new and existing homes and buildings, CleanBC Better Buildings is British Columbia's online gateway for residents and companies to access information, incentives, and support. The available incentives include energy study funding and capital funding incentive to install heat pumps.

The Low Carbon Economy Leadership Fund, administered by the Government of Canada and the Province of British Columbia, provides funding for CleanBC Better Buildings. B.C.

[24] Province of British Columbia. (July 2019) "BC Energy Step Code", online: http://energystepcode.ca/app/uploads/sites/257/2019/08/BCEnergyStepCode_GuideDigital_v02July2019.pdf.
[25] Clean BC Better homes, https://betterhomesbc.ca/
[26] Province of British Columbia. (July 2019) "Energy Efficiency Programs", online: https://www2.gov.bc.ca/gov/content/industry/electricity-alternative-energy/energy-efficiency-conservation/programs.

Hydro, FortisBC, and B.C. Housing are in charge of managing the CleanBC Better Buildings incentives.[27]

5.3 Ensure Quality

The foundation of successful, long-lasting heat pump markets is ensuring quality; without it, markets would fail.

This entails laying the groundwork for quality early in the industry and value chain. Strong programmes prioritizing quality have been the foundation of thriving heat pump markets. Since technology is more complicated than traditional systems, quality must be maintained at every stage of the value chain, from production to installation to continuous maintenance.

Quality can be ensured through:

- Giving installer support and instruction.
- Programs for installer accreditation and certification.
- Ongoing performance evaluations using field tests.

Training – HPCN[28]

In British Columbia, the Home Performance Stakeholder Council (HPSC) is a non-profit organization that promotes the development of the home performance sector. Its goal is to support market expansion, capacity building, and high standards of craftsmanship to boost both the supply and demand for competent home performance service providers.

The Home Performance Contractor Network (HPCN) is a network of retrofit contractors in British Columbia (B.C.) that have passed continuing quality assurance audits and have the required trade certifications and training.

Joining the network has various advantages for the contractors, including reimbursement for training expenses, a wage contribution, and inclusion in the unique homeowner search tool. Additionally, contractors receive public acclaim for their professional excellence and the Home Performance Contractor Network emblem usage. A qualified contractor provides homeowners with the assurance of standard services.

All stakeholders in the industry have a place in these operations. Assuring quality fosters consumer confidence and promotes market expansion:

- It gives policymakers proof that heat pumps can play a significant role in helping them reach their goals.
- It gives installers more assurance that the system will work for their clients.
- It increases end customers' trust in heat pumps as a reliable and affordable heating and cooling option.

[27] Province of British Columbia. (July 2019) “Energy Efficiency Programs”, online: https://www2.gov.bc.ca/gov/content/industry/electricity-alternative-energy/energy-efficiency-conservation/programs.
[28] Home Performance Stakeholder Council (HPSC). (2021) "Home performance contractor network", online: http://homeperformance.ca/home-performance-contractor-network/.

5.4 Raise Awareness Through Marketing and Promotion

Increasing consumer confidence by demystifying heat pump technology can be accomplished through awareness-raising, promotion, and effective marketing.

This entails conveying to customers a straightforward, clear, and appealing message. Giving consumers the assurance to adopt new technology and build market momentum is essential to transforming heat pumps from specialty items to ones with broad appeal. This means presenting and disseminating a simple, easily understood and compelling message to consumers. Central to this is giving consumers the confidence to embrace the technology and create a pull in the marketplace to assist in transitioning heat pumps from a niche product to one having mass market appeal.

Ways to raise awareness:

- Programs and product marketing.
- The sharing of information.
- Roadshows, info sessions, press events, and P.R. initiatives.
- The participation of reliable actors and companies.
- Ongoing field tests and trials with results that have been published.

There is a role for all industry stakeholders in these activities.

Heat Pump Adoption Curve[29]

The product adoption curve is a model that depicts different client types at various product lifecycle stages. This section is a hypothetical application of the adoption curve for heat pumps. Recognizing these consumer types to tailor your marketing strategy to them and maintain sustainable growth is critical. Early adopters have a different marketing strategy than innovators and vice versa. The following categories make up the heat pump adoption curve, depending on the product lifecycle:

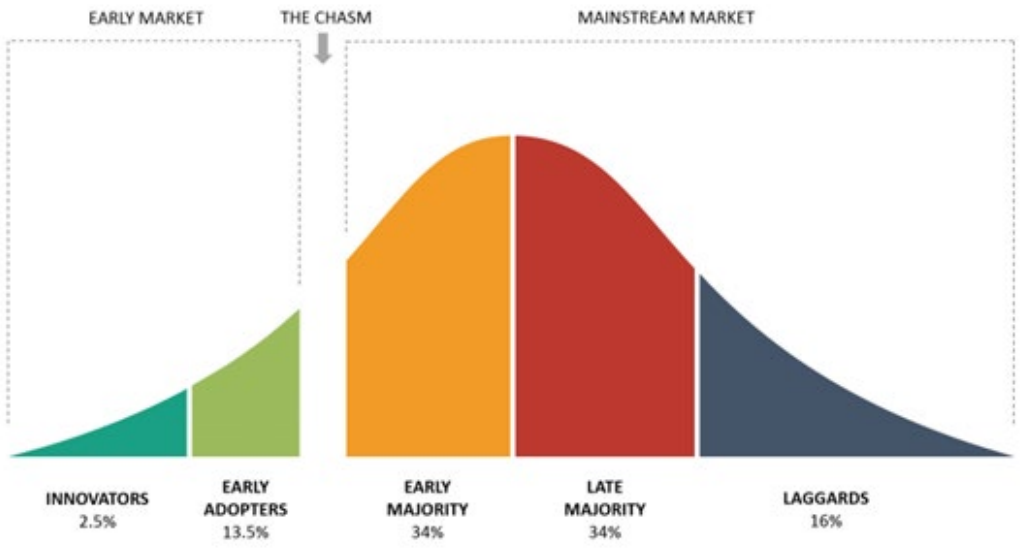


Figure 2.6: Image Credit: https://www.crazyegg.com/blog/product-adoption-to-transform-marketing/

[29] Rogers, Everett – Adoption curve, 1960

Innovators (2.5%)

Since they eagerly explore new technology goods, innovators are the first ones likely to invest in heat pumps. Regardless of its purpose, technology is a major interest in their lives. The disadvantage is the shortage of innovators. Nevertheless, gaining their support is crucial since it assures the other market customers that heat pumps are a success. These Tech Enthusiasts can also be used as a test group to make the required adjustments before aiming for the general public. The Innovators tend to have higher incomes and education levels.[30] This category of heat pump owners also tend to be older than early adopters and early majority.[31]

Early Adopters (13.5%)

Like innovators, early adopters invest in the heat pump early in its development. They are not, however, avid users of technology like Innovators are. They are constantly searching the market for cutting-edge technologies. As a result, they are the least price-sensitive adopter groups, extremely demanding, and willing to take significant risks to try something new. Early Adopters, who make up about 13.5% of the population, don't base their purchasing decisions on trusted sources. They would instead rely on their instincts and eyesight. They also accept to act as very conspicuous references for other adopter groups in public. Visionaries are crucial to influencing since they are adept at warning the general populace. This category of consumers are socio-demographically similar to Innovators.

Early Majority (34%)

Early adopters and innovators are included in the original buyer's group. Heat pumps must win over the early majority to expand their market penetration. Although they will be motivated mainly by a keen sense of realism, this group of people will be able to relate to heat pump technology. Before making a purchase, they will hold off till heat pump technology is well-established and has enough references. Gaining the favour of this segment's sizable (approximately 34%) population is essential for expanding the heat pump market. Previous research generally finds that in terms of socio-demographics, consumers who are younger, wealthier, more educated, and from larger households are more likely to adopt heat pumps and other pro-environmental technologies.[32]

Late Majority (34%)

With 34% of the population, the Late Majority group is roughly equal in size to the Early Majority. They have all the same issues as the Early Majority, plus one: they place a much greater value on tradition than on progress. This segment will continue to favour traditional heating methods like

[30] Tal, G., and Nicholas, M. A. (2013). "Studying the PEV market in California: Comparing the PEV, PHEV and hybrid markets," in *2013 World Electric Vehicle Symposium and Exhibition (EVS27)*, 1–10. doi: 10.1109/EVS.2013.6914965
Plötz, P., Schneider, U., Globisch, J., and Dütschke, E. (2014). Who will buy electric vehicles? Identifying early adopters in Germany. *Transp. Res. A Policy Pract.* 67, 96–109. doi: 10.1016/j.tra.2014.06.006

[31] Axsen, J., Goldberg, S., and Bailey, J. (2016). How might potential future plug-in electric vehicle buyers differ from current "Pioneer" owners? *Transp. Res. Part D: Transp. Environ.* 47, 357–370. doi: 10.1016/j.trd.2016.05.015

[32] Willis, K., Scarpa, R., Gilroy, R., and Hamza, N. (2011). Renewable energy adoption in an ageing population: Heterogeneity in preferences for micro-generation technology adoption. *Energy Policy* 39, 6021–6029. doi: 10.1016/j.enpol.2011.06.066
Michelsen, C. C., and Madlener, R. (2012). Homeowners' preferences for adopting innovative residential heating systems: A discrete choice analysis for Germany. *Energy Econ.* 34, 1271–1283. doi: 10.1016/j.eneco.2012.06.009
Lillemo, S. C., Alfnes, F., Halvorsen, B., and Wik, M. (2013). Households' heating investments: The effect of motives and attitudes on choice of equipment. *Biomass Bioenergy* 57, 4–12. doi: 10.1016/j.biombioe.2013.01.027

gas fireplaces. Members of the Late Majority may find it challenging to run a heat pump during the first few days of operation, in contrast to those in the Early Majority who will feel confident in their abilities to handle a heat pump. As a result, this market would hold off on making investments until heat pumps established themselves as industry norms. This category of consumers is socio-demographically similar to the early majority.

Laggards (16%)

Laggards are the last 16% of the client base. This market sector is skeptical of emerging technology, such as heat pumps, and will only purchase one after it has gained significant market traction. To pursue the laggards, no special marketing initiatives are needed. In British Columbia, the heat pump market is in the early adopters' stage. To expand the adoption of heat pumps and foster sustainable growth, all stakeholders must take action to bridge the gap and win over an early majority. These might only adopt heat pumps after legislation is introduced that mandates low carbon space and water heating.
After comprehending the various client types, it is important to comprehend the values of heat pumps and how to convey those values to customers. A key instrument for capturing values and promoting heat pumps on their distinctive selling characteristics that set them apart from natural gas furnaces is the 4Ps of Marketing Mix.

Marketing Mix – The 4Ps[33]

Several aspects need to be considered when marketing heat pumps to increase uptake. Included are the needs of consumers, how a heat pump may satisfy those needs, how customers view the heat pump, how it differentiates itself from the competitors, and how stakeholders share these values with consumers.

The idea is classified into four elements called The 4Ps:

- Product
- Price
- Place
- Promotion

[33] McCarthy, E. Jerome. (1960) “4Ps of marketing”

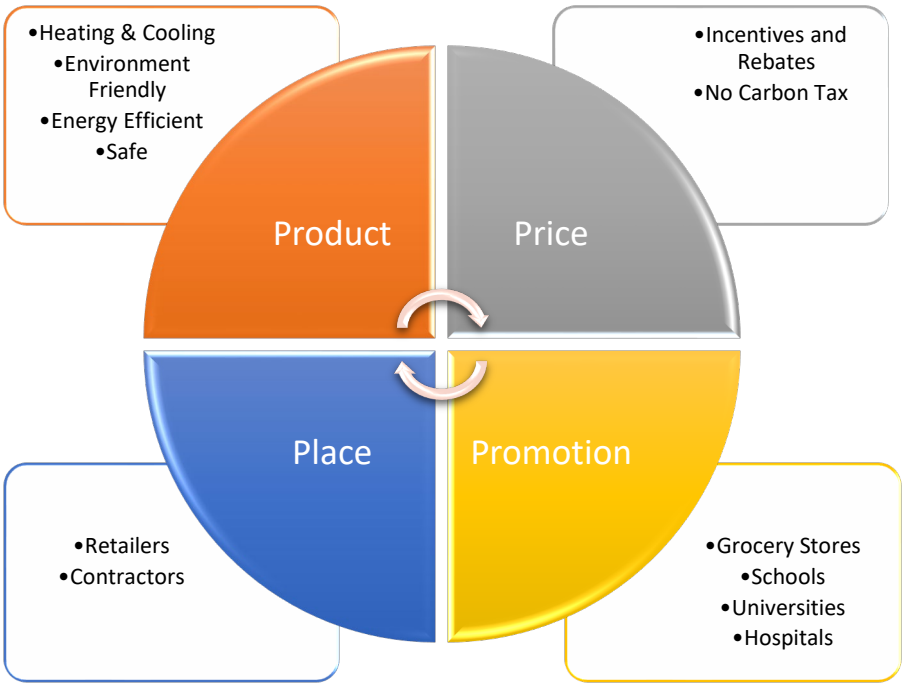


Figure: Adapted from the 4P's of marketing

Product

A product is a tangible or intangible item satisfying a customer's need. For this study, the tangible product is a heat pump, and the intangibles are the services such as heating & cooling, environment friendliness, energy efficiency and safety provided by the heat pump. The heat pump does not only differ from a natural gas furnace in WHAT it does, i.e., providing cooling in addition to heating, but also in HOW it does it. Heat pumps provide a low-carbon, energy-efficient and safe heating & cooling solution for homes compared to a natural gas furnace.

Price

A heat pump's pricing directly influences sales volume and market penetration. Prices are influenced by demand, cost, natural gas furnace pricing patterns, electricity and natural gas costs, and government incentives. A heat pump costs more upfront than a natural gas furnace with a comparable rating. However, proper government taxation and refunds on high-carbon goods may achieve an equal playing field.

Place

The place is where a customer can get access to the product. The distribution channels and physical or digital locations connect a heat pump and a consumer. According to the Industry & Product Lifecycles analysis, the heat pump market penetration is still in its early stages. The product currently has interest from early adopters and innovators. Further, the age range of these potential innovators and early adopters is between 30-45 years and 55-65 years, based on the demographic study and the age group of the survey respondents. Young couples in single-family homes with young children or people who are just starting their retirement are among the survey's respondents.

Based on these variables, the following physical channels are recommended for raising more awareness in these categories:

- Schools
- Universities
- Medical, Dental Clinics and Hospitals
- Grocery Stores

Promotion

The main goal of promotion is to convey to consumers the worth of the product. The marketing effort can emphasize the advantages of a heat pump versus a natural gas furnace.

Heat pumps have the following advantages that could be promoted via marketing campaigns:

Efficiency: When built correctly, a heat pump uses between 50 and 30 percent less energy than electric baseboard heating or a gas furnace.

Year-round comfort: To keep you warm in the winter and cool in the summer, a heat pump replaces both a heating system and an air conditioner.

Environment friendly: The eco-friendliness of a heat pump is one of its main advantages. No harmful gases are emitted into the air because the heat pump doesn't use fossil fuels.

Better indoor air quality: Most heat pumps offer ventilation and dehumidification with the option to add an improved filtration system to remove indoor pollutants, dust, pollen, and other allergens from the air circulating through your home.

Safety: Heat pumps are more secure than heating systems that rely on combustion. Since they rely on electricity and do not require burning fuel to produce heat, they are safe to use. As a result, there is a lower chance that dangerous gases will escape from the house.

Rewards: The federal and provincial governments offer subsidies to encourage the use of heat pumps, this aids in bringing down the initial expense and making it cheaper.

Effective marketing and promotion instill confidence and position heat pumps favourably relative to competing technologies.

- It puts heat pumps in the forefront of policymakers' minds for all the right reasons as a solution of choice for accomplishing their energy savings and emission reduction goals.
- It encourages the participation and active engagement of recognized market participants.
- It inspires client trust and promotes heat pumps as a dependable, cost-effective, energy-efficient, and environmentally responsible heating option.

5.5 Develop a Compelling Customer Proposition

A compelling customer proposition that can accelerate heat pump market growth is built on the solid foundations of long-term policy support and quality products and installation.

For heat pumps to break out of their niche status in many markets, their initial investment and operating expenses must decrease. Numerous factors can contribute to the development of a

compelling customer proposition for heat pumps, putting them on par with other competing technologies:

- Technology and installation cost reductions reduce the up-front expense of heat pumps.
- The provision of grants, subsidies, and incentives by the Government

5.5.1 Incentives

SCHEME	AMOUNT	ELIGIBILITY
Natural Resources Canada Greener Homes Grant[34]	$2,500 - $5,000	For first-time installation of a heat pump system or a replacement of an existing heat pump system
B.C Hydro Home Renovation Rebates[35]	Up to $6,000	When switching from fossil fuel (oil, propane, or natural gas) B.C. Hydroelectric territory.
	up to $2,000	The heat pump must replace an electric heating system as the primary heating source. Existing electric heating systems, such as electric baseboards, radiant ceilings, floors, or forced-air furnaces, can be utilized.
FortisBC Rebates[36]	$2,0000	To qualify for this rebate, one must have an electric space heating system.
Municipal Top-Ups -City of Kamloops[37]*	$350 top-up	For residents who switch from a fossil fuel (oil, natural gas, or propane) water heating system to an electric heat pump water heater.

*The City of Kamloops promotes heat pumps through the Renovate Smart program Kamloops.ca/renovatesmart[38] and online at Kamloops.ca/heatpumps[39]. The City offers a heat pump group purchase rebate and municipal top-ups for heat pump rebates.

Developing a compelling customer proposition accelerates the transition of heat pumps to mass market appeal

- It reduces the cost of the technology for end-users.
- Guaranteed government support facilitates incentives availability.
- It may level the playing field for competing technologies.

[34] NRCan. (Aug 2022) "Helping you save energy and make your home more comfortable", online: https://www.nrcan.gc.ca/energy-efficiency/homes/canada-greener-homes-grant/start-your-energy-efficient-retrofits/plan-document-and-complete-your-home-retrofits/eligible-grants-for-my-home-retrofit/23504#s5.
[35] BC Hydro. (July 2022) "Rebates for home renovations", online: https://www.bchydro.com/powersmart/residential/rebates-programs/home-renovation/renovating-heating-system.html.
[36] Fortis BC. (2022) "Rebates and offers", online: https://www.fortisbc.com/rebates/home/air-source-heat-pump-rebate.
[37] Clean BC Better Homes. (2022) "Kamloops Heat Pump Water Heater Top-up", online: https://betterhomesbc.ca/rebates/kamloops-heat-pump-water-heater-top-up/
[38] City of Kamloops. (2022) "Renovate smart Kamloops", online: https://www.kamloops.ca/business-development/building-permits/home-energy-efficiency/renovate-smart-kamloops.
[39] City of Kamloops. (2022) "Electric heat pumps", online: https://www.kamloops.ca/our-community/environment-sustainability/go-electric-kamloops/electric-heat-pumps

- If heat pumps are supported favourably, they can catalyze significant market growth.

5.6 Monitor: Tracking the Progress and Ongoing Market Requirements

Monitoring the evolving market trends and demands for heat pumps enables better positioning of the sector for future expansion.
This means profiling the heat pump market to understand customer preferences, technology responses and product requirements. This understanding facilitates more focused R&D, contractor training, marketing approaches and policy adjustments to maximize the future opportunities for heat pumps.

Dynamic market requirements can be tracked through:

- Field surveys.
- Feedback from existing installations.
- Gathering end-user feedback.
- Sector profiling, e.g., customer segments, applications, growth rates, and comparison to other heating technologies.

The impact of best practices on the uptake of heat pumps can be monitored through the following framework:

	GOAL	CORE TECHNIQUES	KEY INDICATORS
AWARENESS	Increase the visibility of heat pumps and improve access to information on heat pumps	• Improved, focused channels for client education and activation • Expanding the network used to distribute information	• Changed perceptions • Increased customer engagement with awareness channels
ACCEPTANCE	Create demand pull from fossil fuel heating technologies to heat pump	• Improved knowledge of current perception • Coordination of statewide initiatives to shift perceptions where necessary	• Changed perceptions • Increased uptake of heat pumps
AFFORDABILITY	Bridging the Capex gap between fossil-fuel-based heating technologies and heat pumps; and rebates on electricity bills for initial years	• Incentives and rebates by the Government for • Capex and Opex • Consistent and long-term rebates and incentives	• Eligible heat pump installation with and without rebates and incentives • Customer satisfaction with ease of availing rebates and incentives
AVAILABILITY	Improving the Supply chain and certified contractors for installation	• Improve market penetration • Ease of training and certifications	• Number of certified or trained retailers and contractors • Growth in retailers and contractor networks • Increase in recommendations for • Heat pumps by retailers and contractors
ACCESSIBILITY	Increasing certified or trained retailers and contractors	• Improve market penetration • Ease of training and	• Number of certified or trained retailers and contractors

		certifications	• Growth in retailers and contractor networks • Increase in recommendations for heat pumps by retailers and contractors

Continuously monitoring ensures the development of appropriate products and regulatory frameworks.

It monitors market demands, which include:

- Industry feedback ensures that products that meet customer requirements, such as heat pumps for cold climates and heat pumps with additional heating mechanisms, are created and delivered and that the industry learns from and builds on prior experiences.
- Recommendations to policymakers to help them develop future incentives and regulatory frameworks to support heat pumps and level the playing field for rival technologies.

6. RECOMMENDATIONS

With a clear understanding of the market conditions, roles of stakeholders, opportunities, and key barriers, a roadmap for increasing the uptake of heat pumps can be prepared. Widespread adoption of heat pumps will require a concerted effort from multiple stakeholders to effectively address the barriers to market transformation. It will also require coordination between Governments and Municipalities to formulate and implement policies to encourage the use of low carbon technologies, continuous engagement of customers to ensure sustained interest in heat pumps, adequate financial support to offset the upfront cost and running expenses, and ensure the benefits of decarbonization are communicated across B.C.'s communities.

This section describes seven key market transformation strategies. Earnest deployment of the recommended market strategies outlined here should produce the necessary market conditions for accelerated and sustained uptake of heat pumps.

6.1 Enhance consumer education and awareness to increase acceptance of heat pumps

Many consumers still do not have enough information on heat pumps to make an informed decision. For market growth, consumer awareness of and confidence in heat pumps as a year-round space heating and cooling technology must be solidified. There must be a greater understanding of the existence, availability, and potential benefits of heat pumps that operate efficiently, including at negative temperatures. These messages must come from various stakeholders, including independent, trusted sources such as federal and provincial governments, utilities, peers and industry experts.

Understanding when and where consumers look for information is important for determining methods for disseminating information on efficient heat pump options. Suppose a homeowner is looking to replace an old or failed heating system. In that case, they may search the internet for replacement options, such as a utility website, to find information on heating systems and available incentives. Information on efficient heat pump technology should include more traditional heating systems on the website. A detailed customer segmentation based on various life cycle stages of heat pumps is covered under Section 6: best practices of this report.

Regional stakeholders should implement several strategies to improve the broader industry message's effectiveness.

a) Customer-oriented educational messages promoting heat pump technology. Messaging should solidify the reputation of heat pumps as a year-round heating and cooling solution. Messages should be disseminated by utilities, state agencies, manufacturers/retailers and contractors through various channels (i.e., efficiency program websites, POP materials, T.V., radio, etc.). A regional heat pump informational website should communicate important educational heat pump messages.

b) Municipality should develop and disseminate case studies and testimonials for different heat pump applications, including cold climate heat pumps. Customers often consider these more credible when provided by residents.

c) Municipality to develop educational presentations or workshops for residential architects, mechanical designers, and single and multifamily housing market actors.

6.2 Increase retailers' and contractors' awareness of and confidence in heat pumps through expanded training and education to improve availability and accessibility

Retailers and contractors represent the frontline in consumer education for heating and cooling technologies in existing homes. Builders represent that same frontline when it comes to new construction. Contractors and builders with knowledge and experience installing heat pumps will likely effectively communicate the value proposition presented by heat pumps. To further develop the infrastructure of enthusiastic heat pump contractors and builders, education and training are needed.

In general, contractors are much more aware of new technologies than consumers, but outreach and education are still important to broaden awareness and assure the quality of installations. As was the case for consumers, there are also different types of contractors to target:

Traditional HVAC contractors – should see the heat pump technology as an attractive option for space heating and cooling solutions.

Home performance contractors – who may or may not be equipment installers, are often the initial contact with a homeowner considering an energy retrofit of an older home. These home energy retrofits represent a key target market for efficient heat pumps. The energy audit is an opportune time for the homeowner to become aware of the technology and seek more information. The home performance contractor provides better service by being up-to-date on the latest technologies and providing customers with options.

Many retailers and contractors do not recommend heat pumps over conventional central systems for the following reasons:

- Retailers and contractors are not familiar or experienced with heat pump systems;
- Retailers and contractors lack confidence in heat pumps as the sole heating source in cold climates. Many HVAC retailers and contractors feel that Heat pumps do not or cannot provide adequate heat under extreme conditions or at low temperatures. Contractors need to be aware of the capabilities and limitations of specific equipment and have guidance that suggests how to design heat pump systems that may or may not include backup heating strategies, taking into account customer needs, costs, etc.

To increase retailers' and contractors' confidence, the following strategies may be adopted:

a) Stakeholders should develop educational contractor training materials on efficient heat pump technology to increase contractor confidence. Training, via presentations, workshops, and webinars, should include information on:

- How the technology works;
- Important differences from traditional heating sources;
- Importance of year-round heating and cooling for climate resilience;
- Leverage installer best practice resources in development (focus on appropriate heat pump sizing, selection and installation practices);
- Highlight ease of installation;

Compelling messages to encourage contractors' participation in training programs:

Traditional HVAC contractors – Heat pumps offer cooling solutions, especially well-suited for homes that heat with hydronic systems, as well as a highly efficient heating solution for customers

Home performance contractors – Heat pumps enable them to offer customers more options and demonstrate their knowledge and expertise, i.e. value.

Fossil-fuel heating system installers –Heat pumps provide an attractive additional product offering that is relatively easy to install, offers cost savings opportunities to their customers and can keep the workforce busy year-round.

b) Programs offering financial incentives for installing heat pumps should require the contractor to either participate in some form of heat pumps specific training or complete some quality installation protocol.

c) Develop case studies for retailers and contractors to highlight the benefits of installing efficient heat pumps versus traditional heating systems. This should highlight comfort, convenience, first costs, operating costs, energy use, carbon footprint, maintenance requirements, aesthetics, space requirements, and air quality.

6.3 Reduce upfront and operational costs of heat Pumps through consistent incentive schemes to increase affordability

Several cost-related barriers will need to be reduced to enable heat pump technology to compete more directly on economic terms with natural gas space heating and domestic hot water systems. As more energy-efficient and cost-competitive technologies are introduced to the B.C. market, the cost differential between fossil fuel and high-efficiency electric options will become more competitive. In the interim, it is recommended that steps be taken to level the economic playing field between these competing systems.

Upfront cost - The capital cost of heat Pumps is generally higher than natural gas furnaces. Unless the additional costs can be captured through energy savings, it is difficult for many consumers to justify the added cost of using a heat pump. Incentives to help offset the incremental capital cost of heat pumps are critical to the success of decarbonization efforts in the near term. However, as the cost differential between natural gas and electrification systems narrows, the need for incentives will diminish. Details on incentives and rebates are available in section 6: best practices.

Operational costs - In BC, one unit of electricity is approximately three times more expensive than one equivalent unit of natural gas. This means that heat pumps need to operate, on average, three times more efficiently than equivalent natural gas systems for the operating costs of both systems to be equivalent. Although this efficiency level is possible, it is difficult to maintain throughout the year. The option of splitting the upfront incentives into upfront and operational incentives/ rebates may be explored to address this issue. The operational incentive/rebate scheme may be run for a few years, and later on, as heat pump technology gains popularity and presence, the dependency on incentives/rebates will reduce.

Carbon tax - The use of fossil-fuel-based heating systems should be discouraged by increasing the carbon tax. The monetary cost of fossil fuels should include the social cost of higher Global Warming Potential (GWP). However, this should only be done for higher and middle-income groups, which can afford to switch to lower carbon intensity heating and cooling solutions. The

federal government implemented a coordinated nationwide carbon price, beginning at $20 per tonne of carbon dioxide equivalent emissions (tCO2e) in 2019 and rising to $50 per tonne as of April 1, 2022. On April 1, 2022, B.C. provincial government increased the carbon tax rate from $45 to $50 per tCO2e.[40] The minimum price on carbon pollution (for direct pricing systems) will increase by $15 per tonne per year starting in 2023 through to 2030.[41]

Fossil-fuel incentives – The incentives on fossil fuel for space and water heating equipment are to be gradually phased out. These incentives support fossil-fuel-based heating solutions such as natural gas furnaces and increase the upfront cost gap between heat pumps and natural gas furnaces. However, this should only be done for higher and middle-income groups, which can afford to switch to lower carbon intensity heating and cooling solutions.

6.4 Prepare a data bank of upfront and operational costs and GHG emission reduction for analysis

Due to the lack of large-scale real-world data from residents operating heating systems under various scenarios, accurately measuring the savings and benefits of a heat pump is not easy. There is inadequate data to support one-size-fits-all deemed savings estimates.

To recommend heat pump usage to a broader population, such data and analysis would help policymakers make an informed decision. It will give a near accurate expected benefits representation to the potential customers. Also, the contractors can make reliable recommendations to their potential customers. This will help match the expectation and benefits of operating a heat pump.

On a broader level, three main types of studies and evaluations can be undertaken for heat pumps:

- Pre/post utility bill analyses where electricity and fuel bills are compared before and after heat pumps are installed;
- Field metering studies that involve installing equipment to monitor the detailed performance of heat pumps;
- They are conducting controlled monitoring of heat pump systems within test houses that have adequate instrumentation built into the home. These homes have greater capabilities for measuring actual heat delivery, which is highly difficult in the field.

Utility bill analyses can generally be done on a much larger scale. But due to various factors such as type of heat pump, auxiliaries, number and age of occupants, age of home, insulation level, renewable energy generation by solar photovoltaic panels etc., there will be a significant variation in energy consumption and savings pattern of each home. Future studies should include other evaluation parameters such as home size, age, occupancy, demographics, etc., possibly explaining the broad range in savings.

[40] Government of British Columbia. (2022) "British Columbia's Carbon Tax", online: https://www2.gov.bc.ca/gov/content/environment/climate-change/clean-economy/carbon-tax.
[41] Government of Canada. (2021) "An increasing carbon price from 2023 to 2030", online: https://www.canada.ca/en/environment-climate-change/services/climate-change/pricing-pollution-how-it-will-work/carbon-pollution-pricing-federal-benchmark-information.html.

a) Large-scale utility bill analysis studies to evaluate changes in heating energy consumption after efficient heat pumps are installed. Include documenting reduced consumption of various fossil fuels. Analysis should document how heating energy consumption patterns vary with:

- Energy or fuels displaced (especially elec. resistance, oil, propane, and natural gas)
- System types displaced (hydronic, central furnace, etc.)
- Home characteristics (size, year of construction, single-family/multifamily, etc.)
- Demographics (no. of occupants, age, schedules, etc.)

The analysis should also include a similar examination during the cooling season to inform cooling savings assumptions under various scenarios.

b) Focused monitoring studies on heat pumps in different weather conditions. Monitor thermal energy and electric consumption in detail to assess performance under varying weather conditions, loads, legacy heating systems, various control strategies, etc. Year-round monitoring would provide valuable information about energy usage during the cooling season of units with cooling capabilities.

While very useful, pre/post evaluations record differences in overall energy use. These differences are subject to weather variations, occupant behaviour, and system interactions. Field monitoring studies typically require instruments to monitor heat pump temperature, humidity, airflow rates, and electrical energy consumption and record data at short intervals. These studies can help stakeholders understand the performance of specific pieces of equipment in varying conditions and applications much better.

6.5 Developing a marketing campaign to increase awareness

A significant challenge in the increased uptake of heat pumps is a general lack of public, consumer and industry awareness about the opportunities and benefits of high-efficiency electric systems over fossil-fuel-based systems.

Significant efforts to raise awareness about the benefits of high-efficiency electric solutions over fossil-fuel-based space heating are necessary. It is recommended that the level of promotion required by governments and electric utilities should at least match that used by natural gas utilities to promote the benefits of their product. Included in this message should be informed about the environmental benefits and resilience of heat pumps over fossil fuel furnaces.

It is recommended that the Provincial Government, municipalities, utilities, and key industry associations work together to develop a comprehensive general communications plan to raise awareness about the province's and cities' low-carbon plans and targets and their implications for the building sector. To increase awareness following strategies may be adopted:

a) Setting up the promotional and information dissemination framework for driving the heat pump market growth.
b) An awareness-building campaign that targets consumers and home and building owners about the benefits of decarbonization and the heat pump's role in achieving it.
c) Communication with key industry groups about the province's commitment to building electrification, how this may impact their businesses and the plan for ensuring a smooth transition

7. CONCLUSION

The transition to a net-zero scenario is difficult but not impossible. It requires cleaner energy sources and efficient use of energy. Heat pumps offer a low carbon or even carbon-neutral solution in the case of a 100% renewable energy grid. As per the City of Kamloops Community Climate Action Plan, buildings account for 29% of the total GHG emissions in Kamloops. Switching to heat pumps is one of the critical steps in decarbonizing Kamloops' building sector and achieving Community Climate Action Plan Big Move 4: Zero-Carbon Homes and Buildings targets. By addressing the challenges, overcoming the barriers, using best marketing and awareness practices and continuous monitoring, Kamloops will achieve its Big Move 4 targets.

8. REFERENCES

Axsen, J., Goldberg, S., and Bailey, J. (2016). How might potential future plug-in electric vehicle buyers differ from current "Pioneer" owners? Transp. Res. Part D: Transp. Environ. 47, 357–370. doi: 10.1016/j.trd.2016.05.015

Barone, K. (2022) "City of Kamloops Heat Pump Capacity Building Project Report", online: https://www.kamloops.ca/sites/default/files/docs/2022%20Heat%20Pump%20Capacity%20Building%20Project%20Report_FINAL.pdf.

BC Hydro. (July 2022) "Rebates for home renovations", online: https://www.bchydro.com/powersmart/residential/rebates-programs/home-renovation/renovating-heating-system.html.

British Columbia. (July 2019) "BC Energy Step Code", online: http://energystepcode.ca/app/uploads/sites/257/2019/08/BCEnergyStepCode_GuideDigital_v02July2019.pdf.

British Columbia. (July 2019) "Energy Efficiency Programs", online: https://www2.gov.bc.ca/gov/content/industry/electricity-alternative-energy/energy-efficiency-conservation/programs.

British Columbia. (2021) "How the BC energy step code works", online: https://energystepcode.ca/.

City of Kamloops. (June 29, 2021) "Community Climate Action Plan", online: https://www.kamloops.ca/sites/default/files/docs/cityofkamloops_communityclimateactionplan_june2021_final_0.pdf.

City of Kamloops. (2022) “Electric heat pumps”, online: https://www.kamloops.ca/our-community/environment-sustainability/go-electric-kamloops/electric-heat-pumps

City of Kamloops. (2022) “Renovate smart Kamloops”, online: https://www.kamloops.ca/business-development/building-permits/home-energy-efficiency/renovate-smart-kamloops.

Clean BC Better homes. (2022) "find rebates for renovating a home", online: https://betterhomesbc.ca/.

Clean BC Better Homes. (2022) "Kamloops Heat Pump Water Heater Top-up", online: https://betterhomesbc.ca/rebates/kamloops-heat-pump-water-heater-top-up/.

Clean BC. (October 2021) "Roadmap to 2030", online: https://www2.gov.bc.ca/assets/gov/environment/climatechange/action/cleanbc/cleanbc_roadmap_2030.pdf.

Epha and Delta. (August 2018) "Unleashing the Opportunity", online: https://www.ehpa.org/fileadmin/red/03._Media/03.02_Studies_and_reports/EHPA_BestPractice_FINAL_3.pdf.

Fortis BC. (2022) "Rebates and offers", online: https://www.fortisbc.com/rebates/home/air-source-heat-pump-rebate.

Government of British Columbia. (June 2022) "Heat pump demand heats up in northern B.C.", online: https://news.gov.bc.ca/releases/2022FIN0022-000979.

Government of British Columbia. (2022) "British Columbia's Carbon Tax", online: https://www2.gov.bc.ca/gov/content/environment/climate-change/clean-economy/carbon-tax.

Government of Canada. (2021) "An increasing carbon price from 2023 to 2030", online: https://www.canada.ca/en/environment-climate-change/services/climate-change/pricing-pollution-how-it-will-work/carbon-pollution-pricing-federal-benchmark-information.html.

Government of Canada. (2022) "Greenhouse gas sources and sinks in Canada: executive summary 2022", online: https://www.canada.ca/en/environment-climate-

change/services/climate-change/greenhouse-gas-emissions/sources-sinks-executive-summary-2022.html.
Government of Canada. (Aug 2022) "Net-Zero Emission by 2050", online: https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/net-zero-emissions-2050.html.
Home Performance Stakeholder Council (HPSC). (2021) "Home performance contractor network", online: http://homeperformance.ca/home-performance-contractor-network/.
IPCC. (2019) "Global Warming of 1.5°C", online: https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Full_Report_High_Res.pdf.
Lillemo, S. C., Alfnes, F., Halvorsen, B., and Wik, M. (2013). Households' heating investments: The effect of motives and attitudes on choice of equipment. *Biomass Bioenergy* 57, 4–12. doi: 10.1016/j.biombioe.2013.01.027
McCarthy, E. Jerome. (1960) "4Ps of marketing"
Michelsen, C. C., and Madlener, R. (2012). Homeowners' preferences for adopting innovative residential heating systems: A discrete choice analysis for Germany. *Energy Econ.* 34, 1271–1283. doi: 10.1016/j.eneco.2012.06.009
NRCan. (Aug 2022) "Energy Efficiency - Green Buildings, Government of Canada", online: https://www.nrcan.gc.ca/energy-efficiency/green-buildings/24572.
NRCan. (Aug 2022) "Heating and Cooling with a Heat Pump", online: https://www.nrcan.gc.ca/energy-efficiency/energy-star-canada/about/energy-star-announcements/publications/heating-and-cooling-heat-pump/6817.
NRCan. (Aug 2022) "Helping you save energy and make your home more comfortable", online: https://www.nrcan.gc.ca/energy-efficiency/homes/canada-greener-homes-grant/start-your-energy-efficient-retrofits/plan-document-and-complete-your-home-retrofits/eligible-grants-for-my-home-retrofit/23504#s5.
Plötz, P., Schneider, U., Globisch, J., and Dütschke, E. (2014). Who will buy electric vehicles? Identifying early adopters in Germany. *Transp. Res. A Policy Pract.* 67, 96–109. doi: 10.1016/j.tra.2014.06.006
Rogers, Everett – Adoption curve, 1960
Tal, G., and Nicholas, M. A. (2013). "Studying the PEV market in California: Comparing the PEV, PHEV and hybrid markets," in *2013 World Electric Vehicle Symposium and Exhibition (EVS27s)*, 1–10. doi: 10.1109/EVS.2013.6914965
United Nations Climate Change. (2016) "The Paris Agreement", online: https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement.
Willis, K., Scarpa, R., Gilroy, R., and Hamza, N. (2011). Renewable energy adoption in an ageing population: Heterogeneity in preferences for micro-generation technology adoption. *Energy Policy* 39, 6021–6029. doi: 10.1016/j.enpol.2011.06.066
Zebx. (March 2021) "British Columbia's Building Electrification Road Map", online: https://www.zebx.org/wp-content/uploads/2021/04/BC-Building-Electrification-Road-Map-Final-Apr2021.pdf.