


Business Model Innovation to Support Air Source Heat Pump Retrofits in Metro Vancouver

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Community Energy Association

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UBC

About this Report

This report was produced as part of the UBC Sustainability Scholars Program, a partnership between the University of British Columbia and various local governments and organizations in support of providing graduate students with opportunities to do applied research on projects that advance sustainability across the region. This project was conducted under the mentorship of Community Energy Association staff. The report was authored by Aaron Nelson, Sustainability Scholar.

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Disclaimer

The views expressed herein do not necessarily represent the views of the Community Energy Association or University of British Columbia. Details related to the various programs discussed in this report may also change over time. Therefore, please contact or visit the websites of the cited organizations for the most up to date information.

About Community Energy Association

The Community Energy Association is a charitable organization that supports BC local governments with climate action in their community and own corporate operations. CEA helps to accelerate building energy efficiency, renewable energy projects and sustainable transportation through community energy planning and project implementation. To download a copy of this guide or additional resources for local governments, please visit: www.communityenergy.bc.ca.

Contact Information

To provide any feedback or suggestions regarding program listings in this guide, please contact us at:

Community Energy Association
326-638 W. 7th Avenue
Vancouver, BC V5Z 1B5
Tel: 604-628-7076
info@communityenergy.bc.ca
www.communityenergy.bc.ca

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Executive Summary

The province of British Columbia and Metro Vancouver have set targets to reduce greenhouse gas (GHG) emissions 80% by 2050 below 2007 levels. Within British Columbia the residential sector is responsible for 6% of emissions. At the Metro Vancouver level, residential heating released nearly two million tonnes of CO_2e in 2015, making up 13% of total emissions. The majority of these emissions come from the dominant use of more affordable natural gas burning furnaces. Emissions from residential heating will need to drop 4.2% every year to reach the 80% reduction target by 2050.

Among several available technologies to decarbonize residential heating, electric air source heat pumps (ASHPs) are the most economic and technologically feasible. British Columbia's electricity is sourced from carbon minimal hydroelectric power generation. ASHPs use a small amount of electricity to leverage the heat that exists in outdoor air to heat indoor spaces. Additionally, ASHPs can cool indoor spaces by extracting indoor heat and expelling it outside, eliminating the need to purchase a separate air conditioner. ASHPs are currently used in just 3.0% of Metro Vancouver homes, while natural gas heating dominates with usage in 72% of homes. Reaching emission reduction targets requires converting over 10,000 homes per year from natural gas to electric ASHP heating. With an energy market of nearly $700 million, switching to electric ASHPs presents a significant economic opportunity for ASHP manufacturers and contractors. The Vancouver Economic Commission estimates the market for heat pumps in new construction to reach $121 million by 2024. The up-front value of switching all-natural gas heated single-family homes to ASHPs is $4 billion in today's dollars.

The biggest challenge to large-scale residential retrofitting to electric ASHP for heating is the much lower price of natural gas and natural gas furnaces relative to electricity and ASHP systems. Natural gas is $10.94/gigajoule (GJ)[1], nearly a third the price of equivalent electricity at $31.53/equivalent GJ[2]. The price of installing an ASHP system can range from $5,000 to over $15,000 while natural gas furnaces typically range between $5,000 to $7,000 (Frappé-Sénéclauze, Heerema, Tam Wu, & Wu, 2017; Milani Plumbing Heating and Air Conditioning, 2019; Sundberg, 2019). The higher efficiency of ASHP systems can make up much of the operating cost price differential but their cost of installation can be much higher.

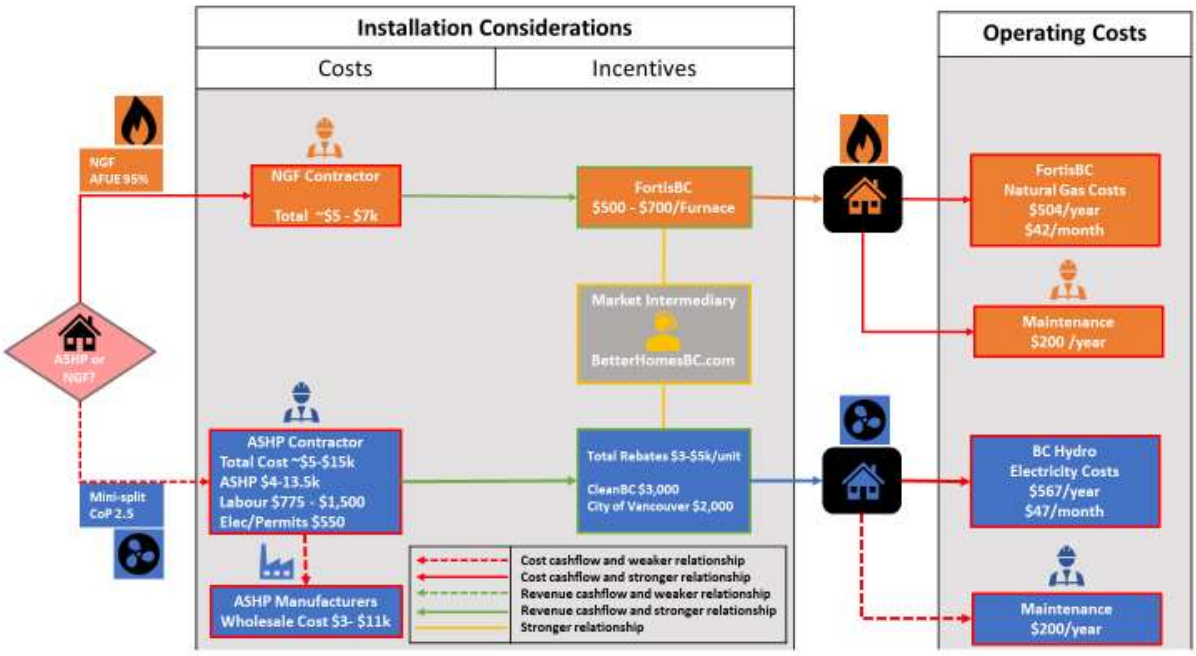
The objective of this report is to recommend fundamental elements of a new industry business model that can transform the electric ASHP market and deliver the number of electric ASHP retrofits needed for Metro Vancouver to reach its single-family home GHG emission reduction targets. Business model recommendations are based on a literature review of market transformation strategies and six existing heat pump business models, as well as dozens of interviews with government, industry, and civil society organizations. The analysis includes elements of the business model innovation process where different ideas are aggregated and evaluated to enhance the value proposition of electric ASHPs to subject market. Ultimately, the new business model will be refined and tested as a pilot program by the Community Energy Association.

[1] Based on monthly consumption of 8 gigajoules.
[2] Based on monthly consumption of 900 kWh.

Market Transformation initiatives have typically focused on individual interventions to overcome barriers to transformation rather than on business models that act as a medium for sustainable and scalable transformation. The current Metro Vancouver ASHP industry business model remains niche and underdeveloped due to several key barriers as categorized by Natural Resources Canada (Natural Resources Canada, 2017):

1. **Affordability:** Higher cost of electricity and ASHP systems relative natural gas systems.
2. **Availability:** ASHPs and ASHP systems are not fully commercialized, they do not have strong market presence.
3. **Accessibility:** The most efficient ASHPs are not accessible in Metro Vancouver or Canada.
4. **Awareness:** There is much less awareness of ASHP systems by households and the Heating, Venting and Air Conditioning (HVAC) industry.
5. **Acceptance**: Households and industry perceive ASHP systems as less tested and riskier in terms of quality of installation, ease of use, and achievement of stated performance. This is in response partly due a history of mixed quality of installations and systems, and a contractor community that lacks familiarity with ASHP systems and actively dissuades its adoption.

Current Metro Vancouver Home Heating Business Model and Cashflows



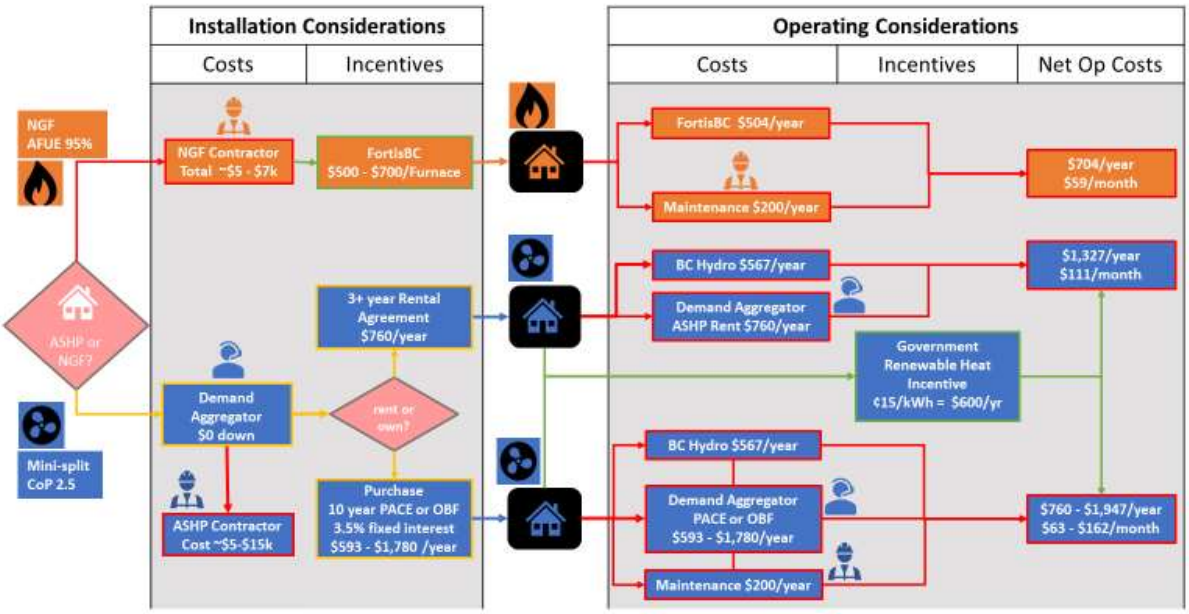
Households interested in installing an ASHP system are largely left on their own to identify a qualified installer, ensure a quality unit and system design, locate available incentives, and arrange financing. BetterHomesBC is the main intervention tool of the government of British Columbia, it provides limited assistance and is primarily focused on providing residents information about rebates and offering general energy advice. When faced with the choice of furnace replacement with limited time and resources,

households have largely selected a new furnace which is more the market norm and cost effective, and recommended by their HVAC professional.

The literature review and analysis of six existing heat pump business models revealed tools to overcome current barriers including:

1. Shifting from short-term and upfront to long-term and ongoing expenditures and incentives.
2. Well designed Property Assessed Clean Energy (PACE) (also known as Local Improvement Charges or LICs) and On-bill Financing (OBF) is convenient, obtained with few hurdles, and provides attractive financing that shifts the cost burden from one upfront payment to smaller amortized payments over many years.
3. One-Stop-Shop (OSS) type models where there is a single customer interface for sourcing quality ASHPs, contractors, and financing. OSS models reduce household time and resources needed for the retrofit process. They can be realized through close business relationships such as Saint John Energy and its contractors and certain types of Demand Aggregators.
4. Full-service rental agreements provide the benefits of ASHPs without the upfront cost of ownership and without having to manage installation, servicing, or replacement in the case of malfunction.
5. Production-based incentives and the opportunity for GHG offsets can provide long-term sustainable incentives for ASHP retrofits and continued use.
6. Developing closer partnerships with contractors and manufacturers through coordinated marketing, education, training, and certification can assist in creating industry buy-in and further commercialization of more ASHP systems.

Potential Metro Vancouver Home Heating Business Model & Cashflows



A new business model has the potential to re-align the industry to effectively and efficiently deliver the electric ASHP retrofits needed for Metro Vancouver to reach its GHG emission reduction targets. Further research is needed in the areas of ASHP lifecycle costing and performance, development of a new rental market, the ingredients for production-based incentives, and how demand aggregators may be realized in Metro Vancouver.

Introduction

The Need for Household Decarbonization

There is growing momentum at the federal, provincial, and municipal levels of government in Canada to substantially reduce GHG emissions in order to avoid the worst effects of climate change. In 2015, the federal government committed to reducing emissions 30% by 2030 (2005 baseline). Provincially, the Government of British Columbia passed the Climate Change Accountability Act which set emission reduction targets of 40% by 2030, 60% by 2040, and 80% by 2050 below 2007 levels. At the local level, municipalities have set greenhouse gas emission reduction targets that meet or exceed those set by the provincial government. Metro Vancouver matched provincial reduction targets. The City of Vancouver recently set a minimum GHG emission reduction target of 80% below 2007 levels by 2050.

The residential sector was responsible for 6% of provincial GHG emissions in 2014 (Ministry of Energy Mines and Petroleum Resources, 2017). Emissions from the residential sector decreased 11%, or 0.5 Mt, between 2007-2016 (Government of British Columbia, 2018).

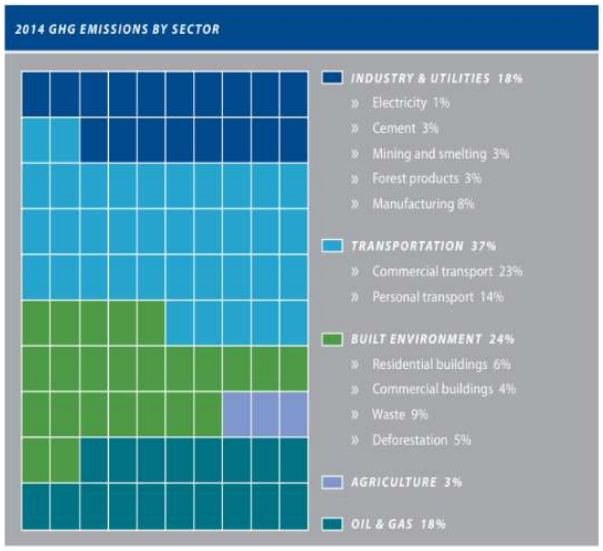


Figure 1. British Columbia greenhouse gas emissions by source (Source: Province of British Columbia)

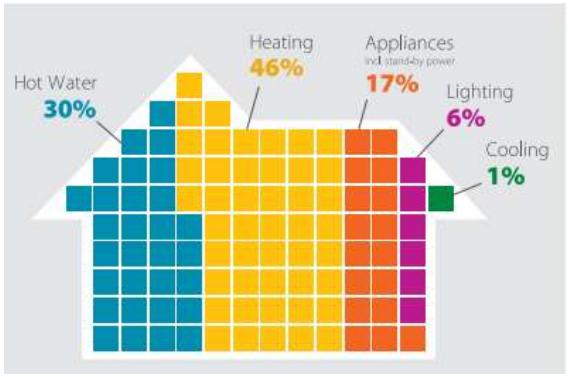


Figure 2. Household greenhouse has emissions by energy use (Source: Province of British Columbia)

Specifically, BC households consumed energy largely for space heating (46%), cooling (1.0%), and water heating (30%) in 2005 (Ministry of Energy Mines and Petroleum Resources, 2008). However, residential energy consumption does not always result in GHG emissions. The type of energy consumed determines whether there are associated GHG emissions.

In Metro Vancouver, residential heating released 1,956,496 tonnes CO_2e (2015) making up 13% of the region's total 14,754,098 tonnes CO_2e emissions (Metro Vancouver, 2015), of which natural gas is the main source. There are 554,050 single-family homes (including single-family homes, attached dwellings,

and townhouses) equating to 58% of the 960,895 residential dwelling units in the region (Statistics Canada, 2016b).

In order to achieve an 80% reduction in home heating GHG emissions by 2050 over 2007 levels, Metro Vancouver would need to reduce such emissions by an average of 4.2% per year, equivalent to eliminating 1,522,1296 tonnes CO_2ebetween 2015 and 2050. This equates to a near decarbonization of home heating, meaning a switch to home heating that does not result in GHG emissions.

Options for Household Heating and Cooling Decarbonization

Several energy sources and technologies can support decarbonization of Metro Vancouver residential household heating and cooling - including biomass, renewable natural gas, and electric ASHP. Currently, electric ASHPs have a market penetration of 3.0% of all single attached and detached households in Metro Vancouver, biomass has 1.0% of the market. Figures for renewable natural gas (RNG) were not available at the time of this report.

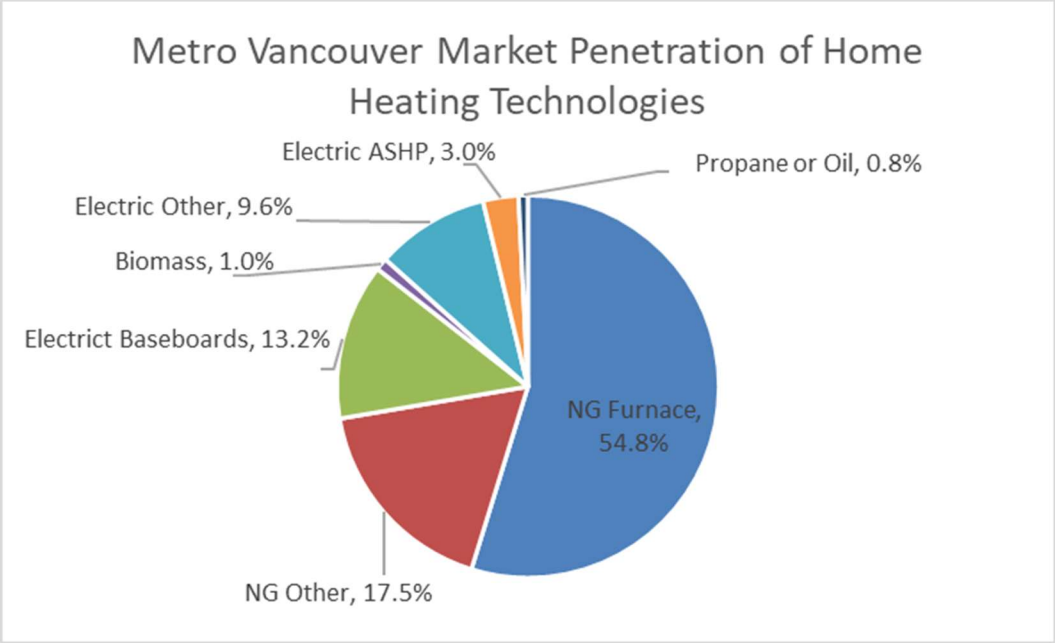


Figure 3. Metro Vancouver Market Penetration of Home Heating Technologies (Source: BC Hydro Residential End Use Survey (2017))

Biomass consists of "organic material that is plant or animal based" (Community Energy Association, 2017) and, in the Canadian context, predominantly refers to both processed and unprocessed wood and waste wood materials. Biomass can be burned through a traditional stove to create heat or through modern, efficient biomass boilers. Biomass is a sustainable resource for home heating decarbonization because the CO_2 released during decomposition or burning is roughly equal to the CO_2 absorbed by trees during their lifespan. The major challenges for scaling biomass energy include:

- High capital cost of biomass boilers relative to natural gas boilers;

- Handling of biomass materials, which can vary in size, moisture, density, and particle size, can pose a challenge during collection and processing;
- Ad-hoc and variable nature of supply chains;
- Adverse air quality effects; and
- The need to dispose of biomass ash waste. (Community Energy Association, 2017)

Renewable natural gas is methane produced from organic waste and is considered carbon neutral because it captures GHG that would have otherwise been released into the atmosphere. It is mainly produced from agricultural and agri-food sources, forestry bi-products, and municipal solid waste and wastewater. RNG is more expensive to produce than traditional natural gas (Hallbar Consulting & Research Institute of Sweden, 2017). Additional challenges include the technology needed to remove chemical and solid impurities to produce RNG and the amount of RNG that can be mixed with traditional natural gas before pipe corrosion or end-use issues become a challenge (Canadian Gas Association, 2014; Gas Technology Institute, 2009)(Canadian Gas Association, 2014).

Electric ASHPs have been in use for decades in many parts of the world because of their efficiency in providing both home heating and cooling, ensuring year-round living comfort. The technology, however, faces challenges to widespread adoption in Canada, including higher equipment costs, lack of familiarity among consumers and installers, lack of full commercialization (particularly for system design and system conversion), and perceived barriers associated with older heat pump technologies such as heightened noise levels. The majority of these challenges relate to the economic competitiveness of ASHPs relative to alternative heating methods such as natural gas and electric baseboards, which have lower capital expenditures, lower operating expenses, or in cases such as BC, both (The Government of Canada, 2018).

Overall, ASHPs will play a crucial role in decarbonizing single-family heating while biomass and RNG are likely to be applied in other building contexts (Frappé-Sénéclauze, Heerema, Tam Wu, & Wu, 2017).

Retrofit Pathways

Encouraging retrofit of the existing stock of natural gas heated single-family homes with electric ASHPs can help Metro Vancouver reach its GHG emission reduction goals with less complexity and costs than encouraging a whole home deep energy efficiency retrofit (Frappé-Sénéclauze et al., 2017). Fuel switching from home heating systems using gas to electricity alone can achieve a high degree of decarbonization due to 98% renewable energy generation of the province's electricity grid. The whole home energy efficiency retrofit process can be more complex, costly, and time consuming than solely fuel switching home heating to an ASHP for homeowners who have few outside resources to navigate this process.(Amy, 2017; Frappé-Sénéclauze et al., 2017; Integral Group, 2019a).

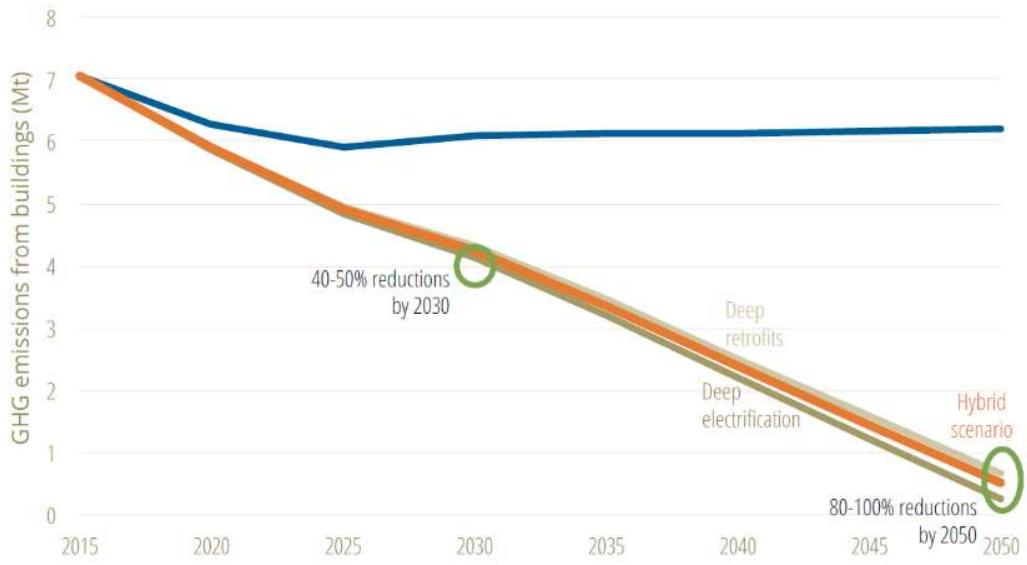


Figure 4. Deep Decarbonization Scenarios (Source: Pembina Institute)

Metro Vancouver Heat Pump Market Opportunity

While the environmental benefits of electric ASHP heating are well established, their use in Metro Vancouver and British Columbia is still marginal. The Pembina Institute estimated the typical household could reduce their emissions by 97.5% or from 1 to 0.025 tonnes of CO_2e annually by switching to electric ASHP home heating because of British Columbia's low carbon hydroelectric power generation (Heerema, 2018). However only an estimated 3% of homes across the province and Metro Vancouver use electric ASHP for home heating.

An estimated 72.3% of single-family attached and detached homes use natural gas for home heating with 54.8% heated by forced air furnaces and 17.5% by other forms of heating, such as hot water radiant or baseboard heating. This translates to 400,578 single-family homes with natural gas based home heating in Metro Vancouver (BC Hydro, 2017). Assuming the typical natural gas furnace (NGF)features, a lifespan of 15 years before needing replacement, 26,705 homes per year will need to have their furnace replaced. This equates to a potential annual replacement rate of 6.7% for natural gas heated homes. In contrast, reaching Metro Vancouver's goal of an 80% reduction in residential energy consumption by 2050 requires approximately 10,338 homes per year, or an annual switch of 2.6% of homes to electric ASHP for home heating. There is a significant opportunity to encourage households to switch to electric ASHP for home heating when their current NGF system reaches its end of life.

Between 2010 and 2017, the estimated percentage of homes using electric ASHP for heating only increased from 1.7% to 3.0%, or just 0.19% per year (BC Hydro, 2017). At a minimum, Metro Vancouver needs to convert 10,338 homes per year, or the same number of homes that currently use electric ASHPs every year and a half.

Metro Vancouver Heat Pump Market Potential

While Vancouver's current heat pump market is currently small, the market is expected to expand significantly going forward. British Columbian households spent an average of $1,746 per annum on household energy in 2017 (Statistics Canada, 2018). This equates to an energy market of nearly $700 million among single-family attached and detached households.[3]

The Vancouver Economic Commission forecasts that the demand for heat pumps (including air-to-air, air-to-water, and ductless mini-splits) in new residential construction will increase three-fold after 2024, equating to 15,510 units and a total market value of $121 million (Veltkamp, 2019). In comparison, using a HP installation cost of $10,000/retrofit results in a potential single-family retrofit market size of $4 billion.[4]

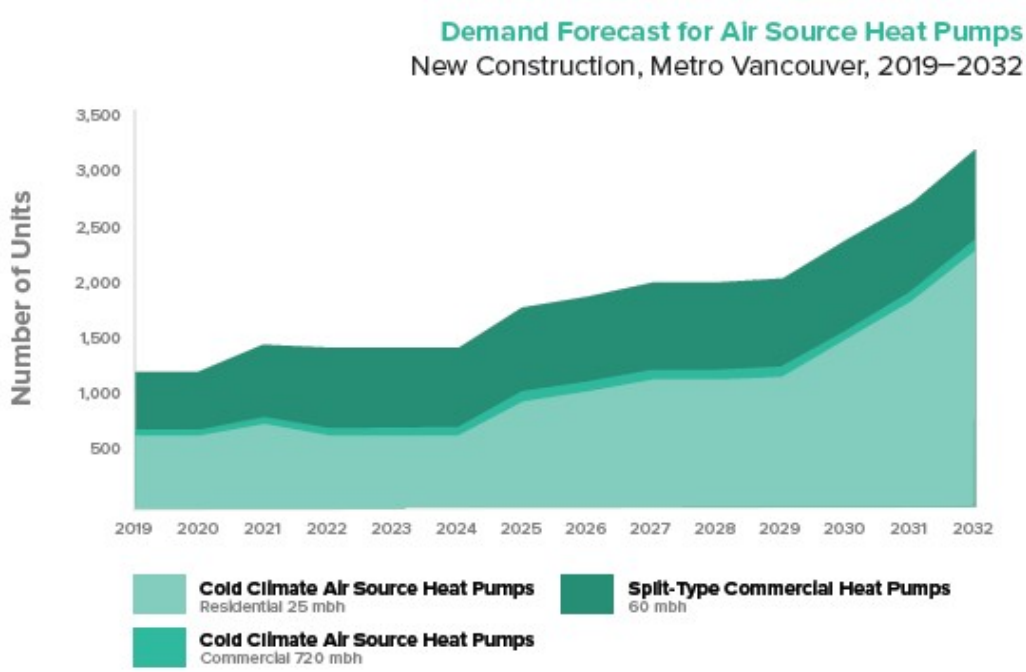


Figure 5. Demand Forecast for Air Source Heat Pumps (Source: Vancouver Economic Commission)

Climate change is likely to lead to more opportunity for the electric ASHP market to expand as there is greater demand for home cooling. There were 21 more cooling degree days in 2013 than 1900 in the Lower Mainland (British Columbia Ministry of Environment, 2016). The use of portable air conditioning (A/C) units increased 23% since 2001 in the Lower Mainland. During the summer, a window mounted A/C unit can cost nearly $30 per day, or over $900 per month (BC Hydro, 2018). These trends and costs add

[3] $1,746/year household energy spending x 400,578 single-family attached and detached households using natural gas furnace heat

[4] 400,578 homes * $10,000/retrofit

economic weight to retrofitting a home with a mini-split electric ASHP, as they can seamlessly provide both heating and cooling throughout the year within a single system.

Figure 6. Average Cost to Operate an Air Conditioner in British Columbia (Source: BC Hydro)

Air Source Heat Pumps Vs Natural Gas Furnaces

The most significant challenge to fuel switching for home heating is the price competitiveness of NGFs. This is due to the large price differential between the energy sources, natural gas and electricity, and the infrastructure, NGFs and ASHPs.

Table 1. Historical Electricity and Natural Gas Prices

Fuel Type	2011	2012	2013	2014	2015	2016	2017	2018	2019
Electricity ($/GJ)*	$21.96	$22.68	$23.02	$25.09	$26.59	$27.66	$28.63	$29.50	$31.53
Natural Gas ($/GJ)**	$11.86	$10.84	$10.66	$12.58	$10.37	$9.08	$10.17	$9.91	$10.94
Ratio Electricity to NG	1.85	2.09	2.16	1.99	2.56	3.05	2.82	2.98	2.88

Rates are based on submissions to the British Columbia Securities Commission
**Electricity rates are based on monthly consumption of 900 kWh (BC Hydro average monthly consumption rate)*
***Natural Gas rates are based on monthly consumption of 8 gigajoules (FortisBC average consumption rate) and includes carbon taxes and the Innovation Clean Energy Fund levy.*

Table 1 displays historical energy pricing in common gigajoule terms and the indicated electricity to natural gas price ratio. Heat pumps would need to be roughly three times more efficient than natural gas furnaces in order to be economically competitive on an operating basis. ASHPs have previously shown to be competitive with NGFs, an analysis of a sample of 900 participants in the LiveSmart program, where the only change was the retrofit of their NGF to a ASHP system, resulted in an average annual energy bill reduction of $16/year (BC Hydro, 2012). NGFs are required to obtain a minimum Annual Fuel Utilization Efficiency (AFUE) of 90%, and must achieve 95% to be considered high efficiency. Ultimately, there is still some heat loss during NGF combustion (Natural Resources Canada, 2012). This is a result to the venting required to expel carbon monoxide and carbon dioxide produced from combusting natural gas. In

contrast, ASHPs in Canada typically achieve a Coefficient of Performance (COP) of 2.0-3.5 depending on the quality of the heat pump and the region in which operates. While most of Canada requires more expensive cold climate ASHPs which have more variable performance, Metro Vancouver's relatively temperate climate results in field tests which suggest that a COP of 2.5 is achievable (Integral Group, 2019b).

Energy price divergence between natural gas and electricity has made this more challenging since the LiveSmart program. Going forward, however, natural gas prices are forecast to increase from $1.38 (current) to nearly $5.75/GJ in 2028, equating to an annual increase of 7.56% (FortisBC, 2017). In addition, the provincial carbon tax, which is currently $1.99/GJ, is scheduled to increase to $2.23/GJ in 2020, and to $2.48/GJ in 2021. This equates to a 4.6% increase to the price of natural gas on its own. In comparison, British Columbia Utilities Commission recently approved a BC Hydro electricity price increase of 8.1% over the next 5 years (The Canadian Press, 2019). Consequently, electric ASHP are anticipated to become more competitive with NGFs as natural gas prices increase more quickly than electricity prices.

The other major challenge is the cost differential between these two heating systems. Cost estimates for a ductless mini-split ASHP system range from $5,000 to $12,000 and average $10,000 depending on a home's size and layout complexity. Installations over $15,000 while the minority, are not uncommon (Frappé-Sénéclauze et al., 2017; Milani Plumbing Heating and Air Conditioning, 2019; Sundberg, 2019). Rebates of up to $6,000 are available in the City of Vancouver for heat pump retrofits thus bringing the net cost to approximately $4,000. In contrast, replacement of a NGF ranges between $5,000 - $7,000 with significantly less cost variance and rebates of $700 available for older inefficient furnaces bring the cost to $4,300 - $6,300 (Milani Plumbing Heating and Air Conditioning, 2019).

Purpose, Methodology, Outline, and Limitations

The Community Energy Association received grant funding from the Real Estate Foundation of British Columbia (REFBC) and the Bullitt Foundation to pilot a new renewable energy retrofit business model that will substantially increase uptake of air source heat pumps uptake in single-family homes that is scalable, does not require new municipal powers to be created at the provincial level, is not heavily reliant on upfront government funding, and is isolated to home heating fuel switching. CEA has partnered with five municipalities: The Cities of New Westminster, Richmond, Surrey, Vancouver, the District of West Vancouver, as well as Metro Vancouver to develop and implement a pilot of the new business model. This report aims to recommend fundamental elements of a new business model that the Community Energy Association can use to develop a pilot project which can deliver the number of single-family residential electric ASHP retrofits required to meet Metro Vancouver's GHG emission reduction targets in the residential sector.

A three-step methodology was applied to achieve this purpose:

1. Completion of a literature review of North American academic, government, and professional sources.

2. Interviews with government, industry, and civil society organizations during the spring and summer of 2019. The interviews were held to understand recent and current research initiatives, existing successful and innovative heat pump initiatives, and developments on the issue.
3. An analysis of six existing heat pump business models in North America, as identified during the literature review and interviews.

Outline

1. The first section of the report introduces the need for decarbonization of household heating to meet Metro Vancouver GHG emission reduction targets, how ASHP retrofits are best suited to meet these targets, the Metro Vancouver market potential for heat pumps, and the challenge current energy prices pose to mass retrofits.
2. The concept of market transformation business models is introduced and used to describe the current Metro Vancouver heat pump model, and analyzed on six heat pump market transformation programs. Additional market transformation strategies and business models are reviewed based on a literature review.
3. The Metro Vancouver context is evaluated for its suitability in applying a heat pump rental program or individual transformation strategies identified in the case study and literature review. A new heat pump business model is proposed. Report conclusions and recommendations are given on a new potential business model to be applied in an upcoming pilot project.

Limiting Conditions

Due to limited time and resources, the majority of the information used in this analysis comes from publicly available online sources or through contacts made during the course of research. Limited primary data was collected through interviews with contractors, manufacturers, utilities, and program administrators.

Business Model Innovation for Heat Pump Market Transformation

Dramatically increasing the number of heat pump retrofits in Metro Vancouver requires a market transformation. A strategic process of intervening to overcome identified barriers to heat pump mass adoption so that their use becomes standard practice, as compared to the current business as usual which supports NGF heating (American Council for an Energy-Efficient Economy, 2019). Market transformation initiatives have typically focused on individual intervention tools to overcome barriers to transformation rather than on alternative business models that act as a medium for sustainable and scalable transformation. For example, heat pump rebates and regulation are often used to overcome barriers of affordability and awareness without consideration to the current or potential types of business models that these initiatives would operate within. Viewing market transformation through a business model innovation lens deliberately considers what type of industry or business structure could best deliver public policy goals within which individual tools, such as rebates or regulation, are part of a holistic business model strategic approach.

A *business model is* "the value proposition, organization of supply chain and customer interface, and financial model" of a business or industry from Boons and Lüdeke-Freund (2013). The following table adds context:

Table 2. Business Model Components

Business Model Elements	Heat Pump Context
Value proposition what value is embedded in the product/service offered by the firm;	What value is communicated to individual households on the utilization of an air source heat pump?
Supply chain how are upstream relationships with suppliers structured and managed;	What are the linkages between installers, manufactures, and utilities?
Customer interface how are downstream relationships with customers structured and managed;	What are the customer's interactions with other business model stakeholders throughout the heat pump's use?
Financial costs and benefits from 1), 2) and 3) and their distribution across business model stakeholders	What are the net financial flows between the model stakeholders at the time of installation and throughout the heat pump's lifecycle.

Business Model Innovation consists of three phases including: Concept Design; Detail Design; and Implementation (Geissdoerfer, Savaget, & Evans, 2017)

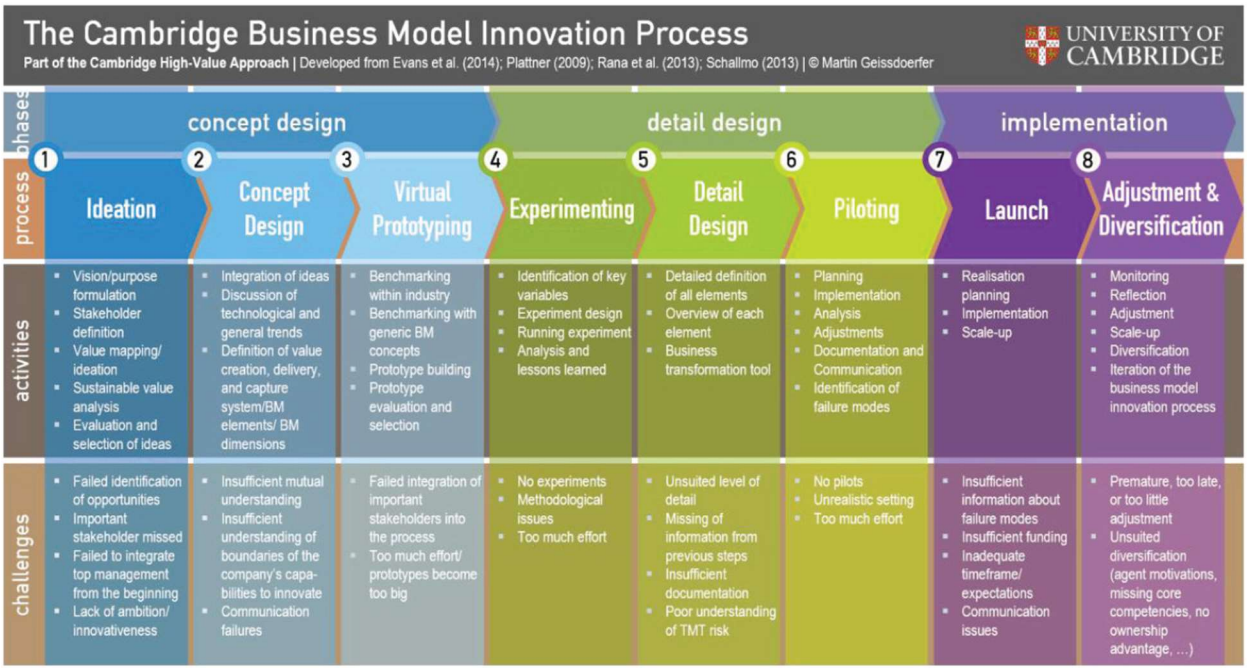


Figure 7. The Cambridge Business Model Innovation Process (Source Geissdoerfer, Savaget, & Evans, 2017)

This report focuses on the first two processes of the Concept Design phase, Ideation and Concept Design, wherein different ideas and concepts are agglomerated through a literature review, analyzed, and applied to create a new theoretical business model. This analysis can then lead to prototyping and experimenting,

detailed design, and piloting of a new business model for heat pump delivery. The first step in our analysis is to describe and contextualize the existing Metro Vancouver Business Model.

The Existing Metro Vancouver Business Model

Figure 8 illustrates the current business model and estimated cashflows that households are likely to consider when deciding to replace a natural gas home heating system with a NGF or electric ASHP. It contextualizes some of the key stakeholders involved in the decision-making process, single-family residents and industry contractors, the capital and operating costs of each system, and the sources and amounts of financial incentives.

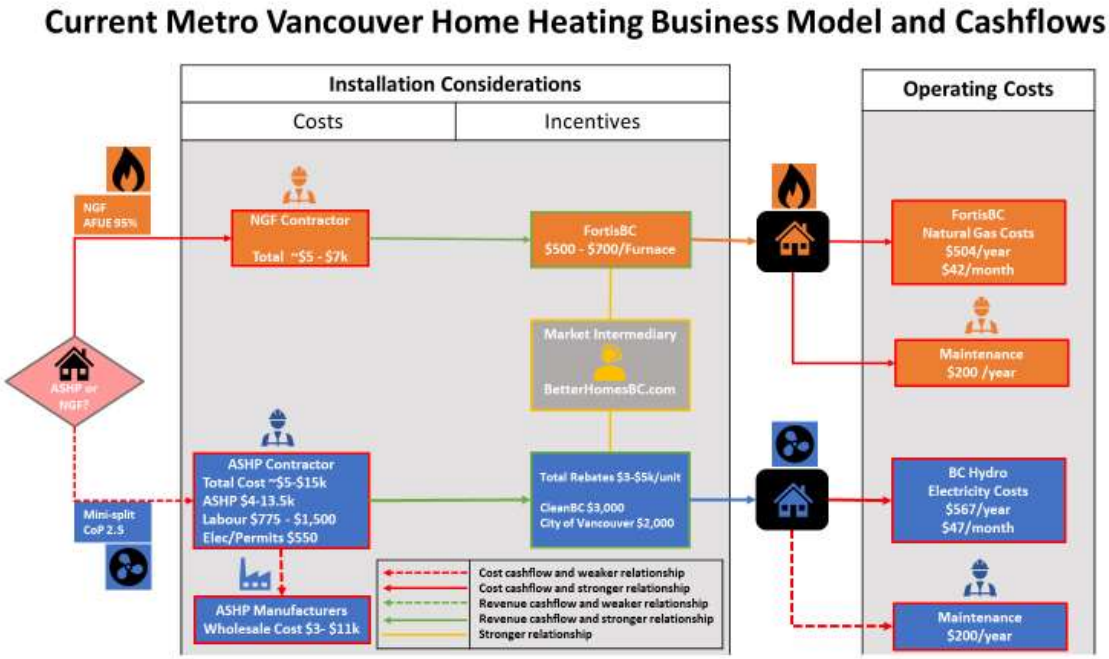


Figure 8. Current Metro Vancouver Home Heating Business Model and Cashflows [5][6][7]

[5] System replacement costs are based on information provided by City Green, Integral Group, The Pembina Institute, Coastal Heat Pumps, Milani Plumbing, and Heating & Air Conditioner.
[6] Rebates are based on information from BetterHomesBC.com
[7] Operating costs are based on an annual heating energy consumption baseline of 10,000 kWh, current FortisBC natural gas prices, and tier 2 BC Hydro electricity prices.

Table 3. Metro Vancouver Heat Pump Business Model

Element	Description
Model	▪ Market Intermediation
Value Proposition	▪ There is a lack of clear financial value proposition due to higher net installation costs of ASHPs compared to NGFs after available rebates. ▪ Secondary value propositions include year-round comfort through heating and cooling (rather than separate AC unit) and positive benefits to the environment.
Customer Interface	▪ BetterHomesBC.com website provides streamlined information on available rebates, access to basic information on ASHPs, and an energy advisor available by phone and email for basic questions. ▪ The customer must determine if they require a specialized system designer and/or installer, and if potential equipment is appropriate for their home on their own.
Supply Chain	▪ There is little coordination between BetterHomesBC, installers, and manufacturers. ▪ Minimum ASHP performance standards. ▪ There are no relationships with contractors, little marketing, and active ASHP discouragement by some contractors (Milani Plumbing Heating and Air Conditioning, 2019).
Financial	▪ No financing tools are offered. Financing is left to the customer to manage.

The current Vancouver model most closely resembles what Donal Brown describes as 'market intermediation' (Brown, 2018) where the Province of British Columbia and some municipal governments attempt to act as an intermediary between potential ASHP customers, installers, manufacturers, and government incentives to promote the value of retrofits, simplify transaction costs, and ease some elements of the customer journey. The current ASHP program is operated as BetterHomesBC.ca, a website connecting households to rebates and providing limited home energy efficiency information.

Table 4. Current Business Model Barriers and State

STAKEHOLDER	BARRIER	CURRENT STATE
Homeowner	**Higher ASHP Installation Costs** (affordability)	▪ With current government rebates of $3,000 - $5,000 per unit, ASHP systems are still significantly more expensive than NGFs which also receive rebates from FortisBC. ▪ Historically, inconsistent rebates led to swings in demand.
	Ongoing Costs (affordability)	▪ The price gap between natural gas and electricity has widened in recent years and is susceptible to future price volatility. ▪ There are no incentives to induce long-term ASHP use.
	Acceptance	▪ There is a lack of consumer confidence in ASHP due to historical performance, active discouragement from contractors, low awareness of its capabilities (year-round comfort, environmental benefits, efficiency), low visibility, and perception of technological risk.
	Project Management (awareness)	▪ BetterHomesBC.com, as a Market Intermediary, provides limited information to assist in the customer journey of heat pump retrofit, mainly rebate information and some retrofit guidance. Potential customers are largely left on their own to navigate an unfamiliar process with a greater level of perceived risk of improper system retrofit selection, installation, and performance, resulting in high transaction costs.
	Principal-Agent Problem (affordability, acceptance)	▪ Landlords are less motivated to invest in energy efficient ASHPs when their tenants benefit from lower utility costs rather than themselves
Industry	**Acceptance**	▪ Mixed performance from earlier ASHP models has created a degree of skepticism in the building industry.
	Awareness	▪ Variance in the degree to which contractors are familiar and comfortable with the technology.
	Value Proposition (availability, accessibility, affordability, acceptance, awareness)	▪ ASHP systems have higher upfront costs after rebates than NGFs. Operating costs can be similar if system is correctly designed and installed but there is greater uncertainty relative traditional NGFs which have more market history and acceptance.
	Administrative Overhead (affordability, acceptance)	▪ Higher overhead associated with innovative financial incentive programs
	Long-term Market Potential (all 5 As)	▪ History of inconsistent government market transformation programs and incentives have left uncertainty about the long-term prospects of the ASHP market.

Table 4 summarizes specific barriers to market transformation found throughout the Metro Vancouver business model.

These barriers can be organized by the five key types of market transformation barriers as described by Natural Resources Canada: affordability, accessibility, availability, awareness, and acceptance (The Government of Canada, 2018). A brief summary of these barriers is provided below:

Affordability: ASHPs are more expensive to install and can be more expensive to operate.

Accessibility: There are relatively few ASHP products to choose from and there is a lack of performance testing and quality measurement standardization.

Availability: There is a lack of ASHP product commercialization resulting in less technologically advanced products being available for purchase.

Awareness: Contractors and homeowners are unfamiliar with the technology and lack the expertise needed for home heating system design and installation.

Acceptance: Contractors and homeowners perceive a higher degree of risk with adapting ASHP technology.

Affordability is an especially acute barrier of the Metro Vancouver market because of the relatively low price of natural gas compared to electricity. An alternative business model will require a specific strategy to overcome this barrier.

Review of Six Existing Heat Pump Business Models

There are numerous market transformation business models in operation across North America with the objective of encouraging ASHP retrofits in existing residential homes. Six programs are summarized below. In the subsequent section the business models and tools used to transform respective markets are summarized. The review focused on heat pump specific initiatives rather than comprehensive home energy efficiency retrofits.

Program Summaries

Saint John Energy

Saint John Energy (SJE) is a public utility owned and operated by the City of Saint John. SJE introduced an ASHP rental program in 2016 and has acquired 4,639 new customers in three and a half years (Coughlan, 2019). Customers can rent a heat pump for $48.99 - $62.87/month on a minimum three-year term which includes a home assessment, installation, maintenance, and if needed, replacement. There is a declining termination and removal fee depending on the length of rental beyond the initial three-year term (Energy, 2019).

Efficiency Nova Scotia

Efficiency Nova Scotia (ENS) is the first energy efficiency utility in Canada, being established through provincial legislation. The utility operates two main programs which promote heat pump adoption: 1) The

Green Heat, providing rebates on cold climate mini-split ASHPs as well as biomass and solar heating and heat pump water heaters; and 2) The Home Energy Assessment, providing rebates for whole home energy efficiency initiatives such as insulation, heating, water heating, and building envelope improvements based on a subsidized home energy assessment. ENS estimated that 7,277 mini-split heat pumps have been installed as a result of these two programs over 39 months between October 2015 and December 2018. Overall, the market share of households with heat pumps has grown from 11% in 2011 to 27% in 2017 (Econoler, 2019).

Northwest Energy Efficiency Alliance

The Northwest Energy Efficiency Alliance (NEEA) is a not-for-profit agency funded by government, utilities, and other stakeholders with a mandate of promoting energy efficiency in the Pacific Northwest of the United States. In 2017, 83,700 ductless heat pumps had been installed since the launch of NEEA's ductless heat pump initiative in 2008, resulting in a target market penetration of 8.3%. The initiative offers rebates on ductless heat pumps in partnership with utilities, education programs for installers, market development with manufacturers and retailers, and information for consumers (Northwest Energy Efficiency Alliance, 2018).

Efficiency Maine

Efficiency Maine is a quasi-governmental agency that implements state energy efficiency programs. The agency offers rebates on heat pumps, providing information about products and contractors, setting standards for ASHP units, and connecting customers with contractors who have undergone some degree of certification. 42,458 heat pumps have been incentivized by Efficiency Maine since 2011, or 7.7% of the state's 550,000 single-family homes (Efficiency Maine Trust, 2017; Lis, 2019).

Tennessee Valley Authority

The Tennessee Valley Authority (TVA) is a federal agency that produces electricity for 154 local utilities. TVA promotes ASHP retrofits through its Escore program, which connects customers to a free home energy assessment, energy efficiency incentives, and pre-approved contactors. The program has resulted in the installation of 35,900 heat pumps since its introduction in 2015 (Wagner, 2019).

Sacramento Municipal Utility District

Sacramento Municipal Utility District (SMUD) is a utility owned by the City of Sacramento, California that generates electricity primarily through a mix of energy sources including natural gas (44%), hydroelectric (35%), and other renewable (19%). SMUD's heat pump adoption program is unique in that it is designed to actively promote fuel switching from NGFs to electric ASHPs. In operation since May 2018, SMUD anticipates a total of 634 installations through to the end of 2019[8] (Blunk, 2019).

Program Business Models and Analysis

Table 5 summarizes the types of business models elicited by each of the programs

[8] Includes anticipated installations through to end of 2019.

Table 5. Heat Pump Programs Business Models

Market	Model	Value Proposition	Customer Interface	Supply Chain	Financial	Results
Metro Vancouver	MI	rebates comfort environment	**Betterhomesbc.ca** info and advisor Customer self manages	No coordination	None.	7,637 installations 1,273 per year 3.0% Accumulated MP
Saint John Energy	OSS	$0 down low monthly fee utility bill savings all included	One-stop-shop	High coordination	Monthly fee $48.99 +	4,639 installations 1,325 per year 11.8% MP
Efficiency Nova Scotia	MI	Rebates utility bill savings	**Efficiencyns.ca** info and advisor Customer self manages	Some coordination Min HP standards	On-bill PACE	7,277 installations 2,239 per year 2.4% MP
Efficiency Maine	MI	Rebates utility bill savings comfort	**Efficiencymaine.com** basic Info Customer self manages	Min HP & contractor performance standards	On-bill PACE	42,458 installations 5,661 per year 7.9% MP
TVA	MI	Rebates utility bill savings Energy advisor	**2eScore.com** Extensive info & support Dedicated energy advisor	Greater coordination Online reviews Performance guarantee	On-bill Bank partner	35,900 installations 10,257 per year 1.1% MP
SMUD	MI	Rebates utility bill savings	Basic website, email, and phone	Low coordination	on-bill	634 installations 396 per year 0.2% MP
NEEA	MI	Rebates utility bill savings comfort education/tools	Goingductlenss.com website with info for customers and contractors	Greater coordination Installer development Manuf. development	Utility dependent	83,700 installations 8,370 per year 8.3% MP

Note
MI = Market Intermediary
OSS = One-Stop-Shop
MP = Market Penetration

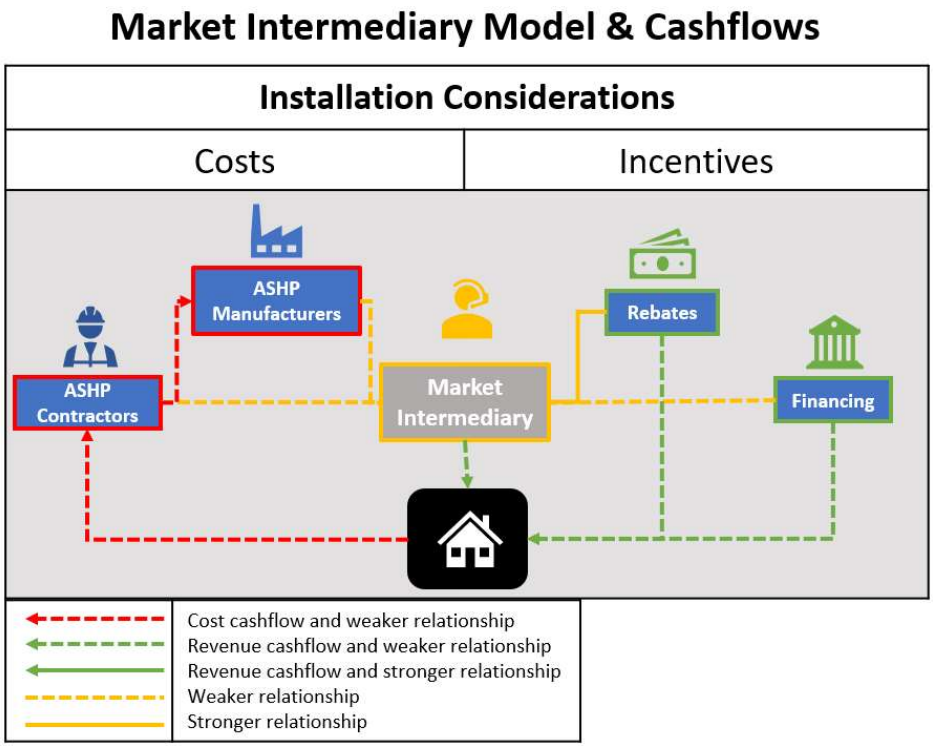


Figure 9. Typical Market Intermediary Business Model and Cashflows

Nearly all of the summarized programs and Metro Vancouver follow some form of "market intermediation" (MI) model where an intermediary organization, typically led by a government agency or utility, provides information about heat pumps, rebates, energy advisors and assessors, and potential contractors (Brown, 2018). Saint John Energy follows a One-Stop-Shop rental model with "an integrated customer interface and supply chain" (Brown, 2018) based on a competitive monthly fee heat pump rental arrangement.

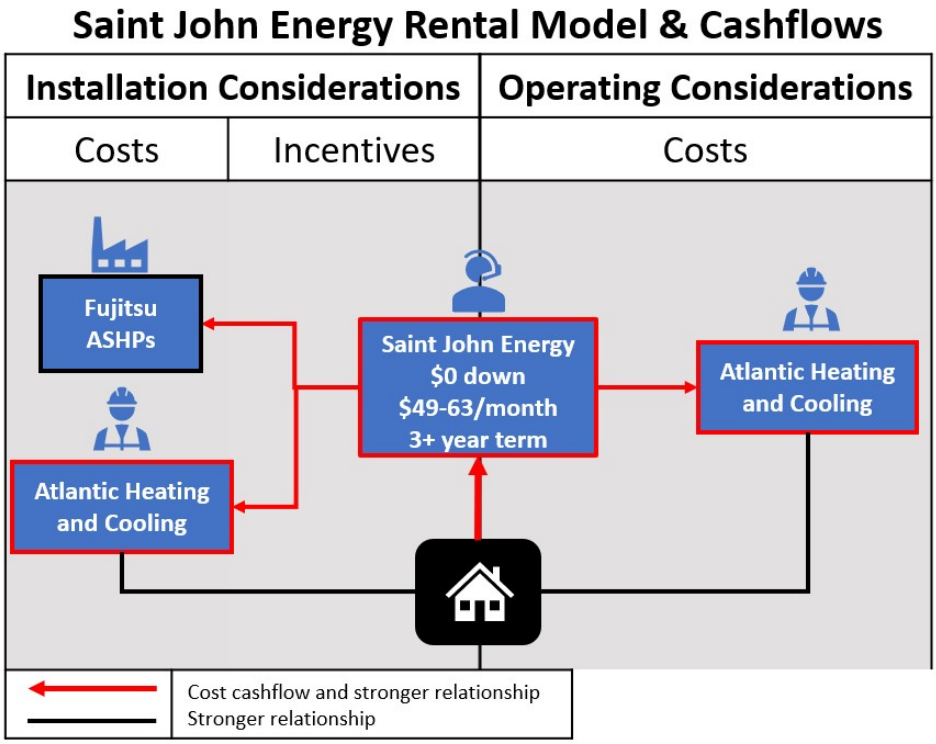


Figure 10. Saint John Energy Rental Business Model and Cashflows

For most programs, the value proposition is access to rebates and reduced utility costs. Some also market increased comfort of year-round heating and cooling. TVA highlights the eScore program and access to a free energy advisor.

Table 6. Financial Incentives

TARGET	TYPE	CASE STUDY EXAMPLE
Household	Fixed Amount Rebate	**BetterHomesBC** $3,000 - $5,000 **SMUD** US $1,500 – US $4,500 **NEEA** Up to US $1,500 (provided by partner utilities) **Efficiency Maine** US $500 (1st unit) and US $250 (2nd)
	Rebate per Ton	**Efficiency Nova Scotia** $300/ton **TVA** US $200/ton
	Energy Assessment	**Efficiency Nova Scotia** $99 per assessment **TVA** Free assessment **Saint John Energy** Free assessment
Contractor	Bonuses	**SMUD** US $25 - $100 PER QUALIFYING REFERRAL AND EE UPGRADE

All programs provide financial incentives to customers to induce heat pump adoption, primarily through rebates. Rebates range from $216 (ENS) to US $4,500 (SMUD).

Many of the programs offer free or low-cost home energy assessments to inform consumers of which retrofits could be completed and would be most effective. ENS provides an assessment at a reduced cost of $99 while SJE and TVA provide assessments at no cost.

All programs include a website of varying quality which connects customers with information on rebates, HPs, and potential customers. In all market intermediation models presented above, with the exception of TVA, customers must independently contact and contract with installers. TVA provides a dedicated energy advisor who can assist a customer along the retrofit process and suggest contractors to work with. Additionally, customers can track the progress of the heat pump installation and rebate processing through their online account. Many websites have a FAQ section and a contact number /email to submit questions.

NEEA is distinctive in that it actively works with HP manufacturers and distributors to bring lower cost products to market, produce targeted marketing material, and provide specific training to installers. In fact, NEEA developed a certification program, Master Installer, which has worked to increase the quality of installations and the marketing of HPs. NEEA also works with utilities to develop their HP marketing and incentive programs based on best practices (Northwest Energy Efficiency Alliance, 2018; York, Bastian, Relf, & Amann, 2017).

TVA has three unique features to its contractor relationships. First, TVA has a complaint resolution mechanism wherein TVA guarantees the work of its contractors at no cost to customers. This has been effective in ensuring the program only partners with high quality contractors. Secondly, its website, 2eScore.com, allows registered program participants to post reviews of contractors. This provides customers with confidence in any potential work a contractor might perform. Third, it offers installers incentives of $25 – 100 per qualifying referral or improvement to encourage more energy efficient upgrades including ASHPs.

Table 7. Financing Incentives

TYPE	CASE STUDY EXAMPLE
PACE	**Efficiency Nova Scotia** up to $10,000, interest rate of prime + 1% (currently 3.95%), term of up to 10 years, and an admin fee of $199 **Efficiency Maine** up to $15,000, interest rate of 4.99%, and a term up to 10 years
On-Bill	**Efficiency Nova Scotia** up to $10,000, interest rate of 4.49% - 9.99%, and a term up to 12 years **Efficiency Maine** up to $15,000, interest rate of 4.99%, and a term up to 10 years **TVA** up to $15,000, interest rate of 6-8%, and a term up to 10 years **SMUD** up to $30,000, interest rate of 6.99%, and a term up to 15 years
Off-Bill	**TVA** up to $2,500 - $20,000, interest rate of 10.99-19.99%, and a term of 3-10 years

Efficiency Maine and Efficiency Nova Scotia offer on-bill financing (OBF) and Property Assessed Clean Energy (PACE), also known as Local Improvement Charge (LIC) financing while TVA and SMUD offer on-bill financing. TVA also offers off-bill financing through partner financial institutions.

Property Assessed Clean Energy (PACE) is energy efficient financing that is typically attached to the property and repaid through annual property tax levies (Khanal, 2019). PACE financing is limited to individual municipalities who operate PACE programs. In Nova Scotia, customers can borrow up to $10,000 for a term length of up to ten years with an administration fee of $199 and an interest rate of prime + 1% (currently 3.95%). Heat pump and energy efficiency retrofit financing of up to US$15,000 is available through Efficiency Maine at an annual percentage rate of 4.99% on a term of up to 10 years.

OBF is a tool wherein a loan for a heat pump retrofit is provided by the utility and paid back as an additional line item on the customers' monthly utility bill. This type of financing can be attractive as the loan qualification process is typically less onerous than traditional bank financing and the loan amount can be transferred to a new customer in the event that the property is sold because the loan is tied to the utility connection rather than as a lien on the property (Seref Efe, Inam ur Raheem, 2015).

TVA offers OBF of up to $15,000 at a fixed rate 6-8% on a maximum 10-year term, subject to a credit check (Rapley, Authority, Moore, Authority, & Ewing, 2016). Pre-approval can happen in approximately 30 minutes over the phone. Users of OBF tend to be customers with less access to traditional bank financing or are attracted to the convenience of the approval and repayment process (Wagner, 2019).

SMUD is an example of a recently started program which offers large rebate incentives for fuel switching from natural gas to electricity ASHPs in a market with little contractor or distributor buy-in. Several other program administrators recommended contacting SMUD as a program more aggressively promoting HPs. The administrator admitted that there was a lack of interest and support from contractors and distributors, with the former often actively convincing customers to instead install traditional NGFs (Blunk, 2019). Regardless of this lack of support the program has still seen some retrofit uptake.

Saint John Energy has a distinctive one-stop-shop business model which promotes a value proposition of no up-front capital expenditures, a low monthly all-included fee, and utility bill savings. SJE has not had to actively market the program because of customer referrals (Coughlan, 2019). The customer interface is nearly seamless as the main point of contact is SJE who then communicates with its sole contractor, Atlantic Plumbing and Heating, and its network of subcontractors. There is a high degree of coordination between SJE, its service contractor Atlantic Plumbing and Heating, and its heat pump supplier Fujitsu because SJE works solely with each as part of a RFP selection process SJE undertook prior to launching the program. This arrangement has resulted in SJE having more control over the quality and cost of the HPs used as well as HP installations, and ongoing servicing needs. The rental rate follows a schedule depending on the size of the HP needed. It should be noted SJE requires a backup source of heating is maintained along with the heat pump.

Table 8. Saint John Energy Rental Schedule

Heat Pump Size	Rental Rate/Month
9,000 BTU	$49.48
12,000 BTU	$49.98
15,000 BTU	$50.49
24,000 BTU	$62.87

Table 9. Energy Prices per Unit by Location

TYPE	BC	NB	NS	Maine	TVA	SMUD	NEEA
Natural Gas (GJ)	$10.94	$20.97	$21.88	$15.41	$11.51	$18.14	$10.85
Electricity (GJ)	$31.53	$41.44	$47.89	$50.39	$30.56	$42.22	$27.25
Heating Oil (GJ)	N/A	$30.30	$27.43	$25.94	N/A	N/A	N/A
Ratio of Electricity to NG	2.88	1.98	2.19	3.27	2.65	2.33	2.51
Incentives		N/A	$200/ton	$500	$200/ton	max $4,500	max $1,500

$ in domestic currencies
Sources: (BC Hydro, 2019; Enbridge Gas New Brunswick, 2019; Energie NB Power, 2019; FortisBC, 2019; Governor of Maine's Energy Office, 2019; Natural Resources Canada, 2019; Sacramento Municipal Utility District, 2019; US Energy Information Administration, 2019a, 2019b)

Table 9 shows the price differential between the three main heating fuels in each market. It is important to note that ASHPs are approximately 2.6 to 3.3 times more energy efficient than natural gas furnaces, depending on the quality of system used. Thus, there is a strong economic case for fuel switching in regions with price ratios of electricity to natural gas per gigajoule below 2.6, such as New Brunswick, Nova Scotia, Sacramento, and the US Pacific Northwest. In Saint John, Nova Scotia and Maine, the majority of households use expensive heating oil or less efficient electric baseboard heating. NEEA's programs are focused on increasing customer's energy efficiency by retrofitting electric baseboard heating with ductless mini-split heat pumps rather than fuel switching.

Table 9 also suggests an unfriendly economic environment for fuel switching in Maine due to relatively low natural gas prices. Fuel switching to electric ASHPs in Maine has not, however, been hampered by lower natural gas prices because there is a lack of access to natural gas pipelines in many of its markets. The state is actively promoting pipeline construction to improve access, but this will take time. Consequently, the program, along with other government policies, has been successful in promoting fuel switching from the heating oil which is the largest share of home heating fuel at 65% (Vermont Energy Investment Corporation & Natural Resources Defence Council, 2018).

Table 10. Program Results

TYPE	Installations	Years of Operation	Market Size	Market Penetration	MP Year
SJE	4,639	3.5	39,375	11.8%	3.4%
Efficiency NS	7,277	3.25	307,365	2.4%	0.7%
Maine	42,458	7.5	534,398	7.9%	1.1%
TVA	35,900	3.5	3,202,413*	1.1%	0.0%
SMUD	634	1.6	411,564	0.2%	0.1%
NEEA	83,700	10	1,008,632	8.3%	0.8%

*Estimated based on the TVA's population of ~10 million and Tennessee's ratio of single-family attached and detached housing
Sources: (Statistics Canada, 2016d, 2016c; United States Census Bureau, 2017a, 2017c, 2017b)

Half of the summarized programs experienced yearly market penetration of nearly 1.0% per annum while SJE achieved the highest penetration at over three times the annual installation rate of the next highest program (Maine). The TVA figure suggests low market penetration, however, accurate figures in regard to specific market size were not available. It should also be noted NEEA stratifies its target markets into three categories, single-family zonal (14%), single-family electric forced air furnace (4%), and manufactured homes electric forced air furnace (1%) and their indicated penetration rates. This suggests more success with certain markets than others.

Additional Strategies to Address Upfront and Operating Cost Barriers

The literature review revealed additional strategies to overcome the HP adoption barrier of higher upfront installation costs and operating costs due to relatively low price for natural gas as compared to electricity. These three additional strategies are discussed below, tax incentives, production-based incentives and greenhouse gas offsets.

Tax Incentives

In the United States, federal, state, and local governments provide various forms of tax incentives to induce heat pump installations including sales tax exemptions and credits. For example, the federal government provides a 30% tax credit for geothermal heat pump systems operational by the end of 2019, the program concludes at the end of 2021 (Energy Star, 2019).

Production-Based Incentives

With PBIs, governments can incentivize the production of renewable heat such as biomass, heat pumps, and solar thermal. One such program is the Renewable Heat Incentive (RHI) in the United Kingdom. Originally available for commercial and industrial users, the program was extended to residential users in 2014, and provides a tariff per kilowatt hour generated (International Energy Agency, 2017). The current tariff rate for ASHPs is $0.1733/kWh (£0.1071/kWh) for the first seven years of equipment use (Ground Source Heat Pump Association, 2019).

Greenhouse Gas Offsets

The Government of British Columbia began purchasing carbon offsets in 2010 as part of the Climate Change Accountability Act and Carbon Neutral Government Regulation which requires all public sector organizations to offset GHG emissions produced from buildings, vehicles, and paper use (Government of British Columbia, 2019b). The Government of British Columbia purchased $16.1 million of carbon offsets in 2018 to neutralize 644,633 tonnes of CO_2e emitted (Government of British Columbia, 2019a). Offset prices ranged from $7.23 per tonne for fuel switching at an ARC Resources low emissions facility in Dawson Creek to $15 per tonne for fuel switching at a Kruger Products Clean Tech Biomass Gasification project in New Westminster (Government of British Columbia, 2017). The government selects offset projects based on a competitive with preference for community-based projects that improve building energy efficiency using advanced clean technology (Government of British Columbia, 2019c).

Other Business Models

There is an emerging group of innovative pay-for-performance (P4P) models where companies are paid based on the actual utility bill savings resulting from energy efficiency upgrades. This is in contrast to the two business models discussed in the previous section, market intermediation and one-stop-shop, where payments are set upfront, either for the market cost of product (heat pump) and labour, or for the service agreement in the case of the heat pump rental. While P4P models were not analyzed in great detail because they involve whole home retrofits, a process which can take considerably more time and expense than a single heat pump retrofit, they can provide some additional tools for consideration. A brief description of two models focused on whole home energy efficiency, the Pacific Gas & Electric (PGE) Residential Pay for Performance Pilot Program and Energiesprong, are included to recognize additional innovative business models occurring in the field of single-family energy efficiency. The PGE model faces specific challenges in the British Columbia context because PGE is an integrated electricity and natural gas utility in contrast to BC where BC Hydro supplies electricity and Fortis BC supplies natural gas. PGE can offer a P4P program with internal fuel switching without compromising its customer base whereas fuel switching in British Columbia inherently involves competition.

PGE Residential Pay for Performance Pilot Program

In this model, the state utility, Pacific Gas & Electric, will pay $0.80/kWh or $1.80/therm (depending on whether energy comes from electricity or natural gas) for confirmed energy savings. While currently not part of the program, PGE may include bonuses for specific geographic and time of day savings. Payments are made to third-party aggregators for confirmed energy savings across a portfolio of residential homes so as to account for the significant variable that can occur at the individual home level. It is anticipated that PACE providers will be among key demand aggregators. It is up to demand aggregators to determine what kind of energy efficiency programs to operate and what incentives to provide customers. Savings are confirmed using smart meter technology and CalTrack, a “data analysis process for estimating energy savings focused on transparency, standardization, and broad stakeholder input” (Szinai, Julia; Borgeson, Merrian; Levin, 2017). The program will run for two years while monitoring will occur for three years in order to measure the robustness of energy efficiency savings. The program anticipates 4,200 program participants, whom cannot benefit from other energy efficiency offers (Szinai, Julia; Borgeson, Merrian; Levin, 2017).

The key advantages of this model are the reward for realized energy savings that occur over longer periods of time, and the leeway it provides the private sector to experiment with different business models to effectively induce customers and achieve savings. The model also leverages a growing business model actor, demand aggregators, to connect small individual households with profitable energy efficient initiatives which may not have been possible otherwise due to high overhead and administrative costs for smaller contractors. The payment model would need to be adopted for British Columbia, to account for alignment of achieved GHG emission reductions with reduction targets (Integral Group, 2019a).

Energiesprong

Energiesprong is a form of managed energy services agreement (MESA) where a single energy services company (ESCO) offers a whole-home guaranteed net-zero retrofit that is financed through the differential between pre- and post-retrofit energy costs. The entire retrofit process is targeted for completion within a short period of time, typically one week. Energiesprong's business model relies heavily on economies of scale, an integrated supply chain, and off-site pre-fabrication. This has reportedly cut the cost of basic retrofits from €130,000/unit in 2016 to €65,000/unit in 2018 with the goal of lowering costs further to €40,000/unit. As the current iteration of initiatives are focused on social housing projects with dozens or hundreds of highly similar residential units, there are certain economies of scale that have not yet been realized for single-family homes.

Program & Literature Review Findings

The literature review and case study analysis identified several transformation approaches that can be used to overcome market barriers. The table below summarizes and organizes the transformation approaches by the type of barrier it addresses and the stakeholder targeted.

Table 11. Summary of Market Transformation Barriers and Tools

STAKEHOLDER	BARRIER	TRANSFORMATION APPROACHES
Homeowner	**Higher ASHP Installation Costs** (affordability)	▪ Rebates ▪ $0 down financing (PACE, OBF) ▪ Non-ownership installations (rental model) ▪ Tax Incentives
	Ongoing Costs (affordability)	▪ GHG emissions offsets ▪ Production-Based Incentives ▪ Improved design/installation quality and equipment selection to raise performance
	Acceptance	▪ Establishment of QA standards for ASHP performance, installation, and servicing. ▪ Buy-in from contractors through marketing, training, certification and targeted incentives. ▪ Coordinated and targeted marketing by public sector, utilities, manufacturers, demand aggregators, and contractors ▪ Full-service contracts wherein customers pay for usage of equipment, maintenance, and replacement in case of malfunction.
	Project Management (awareness)	▪ One-Stop-Shop where customers engage with a single interface for accessing information, incentives, quality contractors and systems, and financing.
	Principal-Agent Problem (affordability, acceptance)	▪ Financing that is assigned to tenants and transferable to new tenants.
Industry	**Acceptance**	▪ Development of ASHP performance standards.
	Awareness	▪ Buy-in creation through marketing, training, certification and targeted incentives.
	Value Proposition	▪ Integration of revenue streams, marketing, and QA programs which could include:

	(availability, accessibility, affordability, acceptance, awareness)	○ $0 down financing (PACE, OBF) ○ Term based full-service rental contracts ○ GHG emissions offsets, Production-Based Incentives, & tax incentives ○ Focus on year-round comfort from heating and cooling ○ Work warrantees.
	Administrative Overhead (affordability, acceptance)	▪ Use of market intermediaries or demand aggregators
	Long-term Market Potential (all 5 As)	▪ Long-term GHG Production-Based Incentives

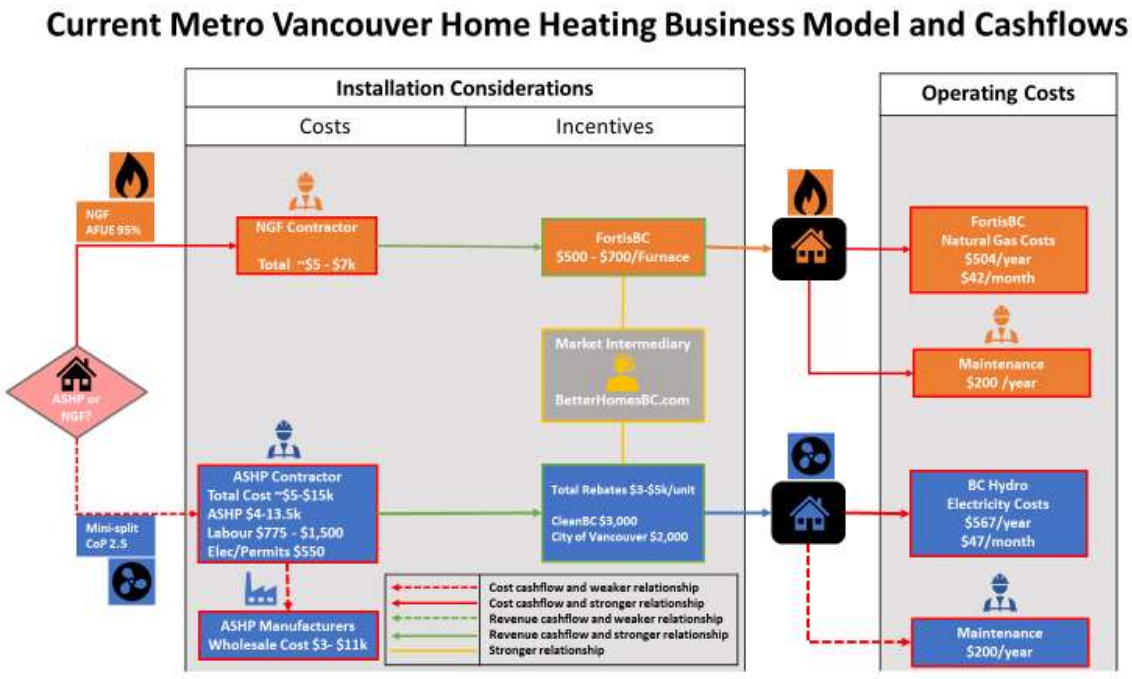


Figure 11 Current Metro Vancouver Home Heating Business Model and Cashflows [9][10][11]

Table 11 summarizes market transformation strategies to address barriers identified within the current Metro Vancouver cashflow and business model chart. A discussion of some of the key tools and strategies follows.

Financial costs and incentives are the main value proposition for heat pump programs to their customers. Affordability is a key barrier to, and metric for evaluating, heat pump adoption. Most programs operate in markets where heat pump adoption would result in utility bill savings because of differences in energy prices and heat technology efficiencies. This is most clear in the Maritimes where many homes rely on heating oil. Programs most often respond to affordability challenges by providing rebates and innovative financing. Saint John Energy's rental program circumvents the need for any upfront cost and instead charges a competitive monthly fee for an all-inclusive service.

Innovative strategies such as Production-Based Incentives and Greenhouse Gas Offsets provide additional *long-term* incentives that can help mitigate potential energy price differentials between natural gas and electricity. These tools also provide assurance to residents and industry that market transformation efforts are stable and long-term.

[9] System replacement costs are based on information provided by City Green, Integral Group, The Pembina Institute, Coastal Heat Pumps, Milani Plumbing, and Heating & Air Conditioner.
[10] Rebates are based on information from BetterHomesBC.com
[11] Operating costs are based on an annual heating energy consumption baseline of 10,000 kWh, current FortisBC natural gas prices, and tier 2 BC Hydro electricity prices.

A seamless customer interface enables customers to follow through with a HP retrofit that matches their needs and objectives. In the SJE model, customers had one primary point of contact for any part of the process including information on products and services, installation, maintenance, servicing, and replacement, making the overall process convenient and simple. TVA's eScore program website provides a single point of reference for customers to move through the retrofit process, even when installation is provided by an outside contractor.

Effective programs work to develop close relationships with suppliers and contractors. SJE developed close relationships with its sole supplier and contractor through a request-for-proposal (RFP) process. Working with only one supplier and contractor allows SJE to better ensure that heat pumps meet in-field needs and that installation and servicing work is performed at high standards. NEEA has spent years cultivating greater supplier and contractor buy-in through coordinated training, certification, and marketing programs resulting in more products coming to market, higher quality installations, and increased heat pump sales. TVA's incentives and work guarantee ensure high quality service partners and buy-in from contractors

Convenient and competitive financial tools help make heat pump investments more affordable and effortless. Efficiency Nova Scotia and Efficiency Maine both utilize PACE and on-bill financing so that customers must not have thousands of dollars available to purchase a heat pump. Pre-approval via phone, such as by available by TVA, or mobile app, streamlines the process.

Demand aggregators play a pivotal role in scaling demand for energy efficiency services so that a sustainable business model can be created that may not otherwise exist because of the small economic value and profitability of individual single-family households. Aggregators aggregate customers and energy efficiency services such as PACE financing and retrofits. Examples include Renovate America which provides PACE financing and connects customers with qualified contractors and Franklin Energy, a provider of energy efficiency and grid optimization programs. Demand aggregation firms are forecast to play a growing role in energy efficiency because of the advanced data analytics and demand side management services they provide (Tweed, 2015) .

Business Model Evaluation for Metro Vancouver Context

The previous section of this report identified several market transformation strategies that have been used in other jurisdictions to overcome barriers to ASHP retrofits. The following section considers several contextual factors unique to Metro Vancouver that could impact the application of a heat pump rental program or individual market transformation strategies. The factors considered include: the results of previous energy efficiency programs; Metro Vancouver's appliance rental history; contractor and supplier communities; potential regulatory impediments; experience with on-bill and PACE financing; and the presence of demand aggregators.

History of Energy Efficiency Programs

A heat pump rental model could deliver heat pump retrofits without relying on changing government energy efficiency initiatives. Previous market transformation programs include:

1) Federal ecoENERGY (tax credits; 2007-2010, 2011-2012);
2) Provincial LiveSmart BC program (rebates; 2008 – 2014);
3) Federal Home Renovation Tax Credit (tax credits; 2009); and
4) Provincial Home Energy Retrofit Offer (rebates; 2014-2015)

These programs relied on government funding for rebates, or tax credits, and marketing but had limited success. The LiveSmart BC program, for example, ran for six years from 2008 to 2014and cost $35 million. These programs together reached just over 6% of the housing stock over seven years. LiveSmart BC experienced market penetration rates of 3% per month at its highest. In contrast, Saint John Energy is reaching an average of 3.4% annual market penetration at no cost to government or taxpayers.

Alternatively, long-term incentive strategies that provide guaranteed tariffs for renewable heat generation such as the UK Renewable Heat Initiative can provide confidence to both industry and residents that an investment in ASHPs will have sustainable environmental, comfort, and financial benefits. The Government of British Columbia GHG offset program could be enhanced to incentivize more renewable heating and cooling through ASHPs by providing a $/kWh equivalent of energy incentive to those that have retrofitted their homes.

Rental History

Saint John, New Brunswick, like much of Eastern Canada, has a long history of rental markets for appliances similar to heat pumps, such as hot water heaters, whereas Metro Vancouver does not. A carefully crafted approach to developing a new rental market would be needed, which can draw learnings from the mistakes of other rental markets such as Ontario.

Approximately 60% of hot water tanks are rented in Ontario. In 2002 the government of Ontario introduced changes to increase competition in the rental market which had theretofore been dominated by two companies. There had been no issues for several years until 2010 when water heater rental complaints became the third most complained issue in the province for consumer services. The complaints focused on four main issues: 1) deceitful sales tactics; 2) complicated and esoteric rental contracts; 3) barriers to switching service providers; and 4) protections against improper installation and resulting home damage (Allen, Ceara; Lio, 2013). The government of Ontario has since passed changes to The Consumer Protection Act which, including among others, prohibit door-to-door sales of hot water heaters (Consumer Protection Ontario, 2019). In the Metro Vancouver context, ensuring consumer protection and fair business practices can help ensure that an ASHP rental model experiences sustainable success.

Contractor Community

Saint John Energy's sole contractor relationship may not be possible in the much larger Metro Vancouver market nor would it likely be supported by the local business community. There was indeed local business community opposition from those contractors that were not selected by SJE's RFP process (Coughlan, 2019). In another example, Emera Maine, a private utility in Maine, attempted to begin leasing ASHPs in 2015 but faced opposition from the business community which cited unfair competition. The state regulator rejected Emera's request on the grounds that it fell outside the core utility service (Vermont Energy Investment Corporation & Natural Resources Defence Council, 2018). An adapted multi-contractor model is more likely to succeed in Metro Vancouver.

Supplier Community

A sole supplier relationship may be beneficial if it results in bulk purchase cost reductions and is able to spur greater interest from the manufacturing community. Manufacturers have focused less on developing the Metro Vancouver market because they perceive local interest in heat pumps to be low (Hamer, 2019).The Metro Vancouver market, which is much larger and would likely require several different types of heat pumps to fit the needs of a diverse building stock and the local business community, would likely object to a sole contract arrangement.

Regulatory Restrictions

Utilities in British Columbia face regulatory limitations on what business operations they have beyond energy delivery, as per the Retail Meters Downstream of the Utility Meter Guidelines (British Columbia Utilities Commission, 1997). This may pose challenges to a utility contemplating whether to operate a heat pump rental program.

On-Bill Financing

OBF is an effective tool already being used by the EcoSave program in Nelson, British Columbia. Half of the participants in the initial pilot program used OBF, resulting in an average loan of $8,100 at a 3.5% fixed interest rate on a ten-year term with a $100 processing fee (Duffy & Beresford, 2016).

OBF financing could prove particularly useful for rental properties as it helps to overcome the Principal-Agent problem where landlords are resistant to retrofit because tenants pay utility bills. 36.3% of Metro Vancouver households rent their dwelling (Statistics Canada, 2016b), however, this figure varies greatly

amongst the communities as the City of Vancouver features a renter rate of 53.1% (Statistics Canada, 2016a). It is thus important to include tools that incentivize the uptake of heat pump retrofits where this conflicting cost-benefit relationship exists. Manitoba Hydro's Pay as You Save (PAYS) program (Manitoba Hydro, 2019), where on bill financing facilitates energy efficiency loan repayment by the tenant and is transferable to future tenants, is an example of one such tool that can be used to overcome this potential conflict.

PACE Financing

Since 2013, several Nova Scotia municipalities have operated PACE programs. The most active of these programs is the City of Halifax's program called Solar City, which was introduced in 2013 as a pilot project and then as a full commercialized in 2016. The program provides PACE financing for solar power related improvements such as solar electric, solar hot air, and solar hot water. Participation in the program requires good standing in terms of property taxes, local improvement charges, and other municipal charges. Financing is provided at a rate of 4.75% over 10 years with no penalty for early repayment. 176 homeowners have participated in the program since May 2016 with a total loan value of $3.6 million, resulting in a reduction of 895,000 tonnes of CO_{2e} (Halifax, 2018).

BC municipalities have had a difficult time attempting to implement PACE programs largely due to the lack of explicit authority to do so in the legislation governing municipalities. The City of Vancouver attempted to implement PACE style financing in 2010 as part the Home Energy Loan Program but eventually altered its structure to a more traditional loan due to the perceived risk that a legal challenge might surface in regard to its legislative authority (Duffy & Beresford, 2016; Ramslie, 2019). The program was not successful and ended a year later.

The District of Saanich is in the process of implementing PACE financing as part of its proposed Home Energy Retrofit Municipal Financing Pilot. The pilot would provide up to $12,000 on a ten-year term and 0% financing for up to 50 homes to accelerate the switch from heating oil to ASHPs. In a report to District Council, the Directors of Planning and Finance specifically referenced the lack of explicit support from the Province for authorizing municipalities from using local improvement charges for improvements on private rather than public property as a historical barrier to municipalities attempting to utilize PACE type financing. District of Saanich staff indicated that the pilot will require the creation of individual financing bylaws for each property in order to overcome any potential uncertainty with municipal financing powers from the Province. The pilot program is expected to receive Council approval in early fall 2019 and is contingent on receiving $430,000 grant funding in addition to $220,000 to be provided by Council (Hvozdanski & Tinney, 2019).

Demand Aggregators

Energy efficiency demand aggregation for residential customers is a new and developing segment of demand aggregation in North America. And while demand aggregator firms such as Rodan Energy Solutions, Enbala, and PowerStream operate in Ontario, there have yet to be any firms of significant size to the British Columbia market. Currently, BC Hydro, FortisBC, and other regulated utilities provide their own demand side management and energy efficiency programs. While demand aggregator firms have begun to provide energy efficiency services in Ontario, there have yet to be any firms of significant size

to enter the British Columbia market. Currently, BC Hydro and other regulated utilities have provided their own demand side management and energy efficiency programs. Thoughtful consideration of appropriate objectives, resources, incentives, and risks to allocate to these types of firms is needed.

A New Heat Pump Business Model for Metro Vancouver

Synthesizing the aforementioned transformation tools together could result in a new effective business model to dramatically increase uptake of ASHPs among single-family homes in Metro Vancouver. Success can be achieved by eliminating upfront retrofit costs and focusing on continued use affordability. This is possible through the use of demand aggregators, innovative financial tools like rental agreements, PACE financing, on-bill financing, and targeted ASHP usage incentives like renewable heat PBIs or GHG offsets. While ongoing costs would be similar or higher than NGFs in this model, this synthesized model incorporates no upfront installation cost. A household could forgo spending thousands of dollars on a new NGF and instead have a new ASHP system installed at no cost and then pay a small incremental extra amount per month as compared to the cost of a NGF system.

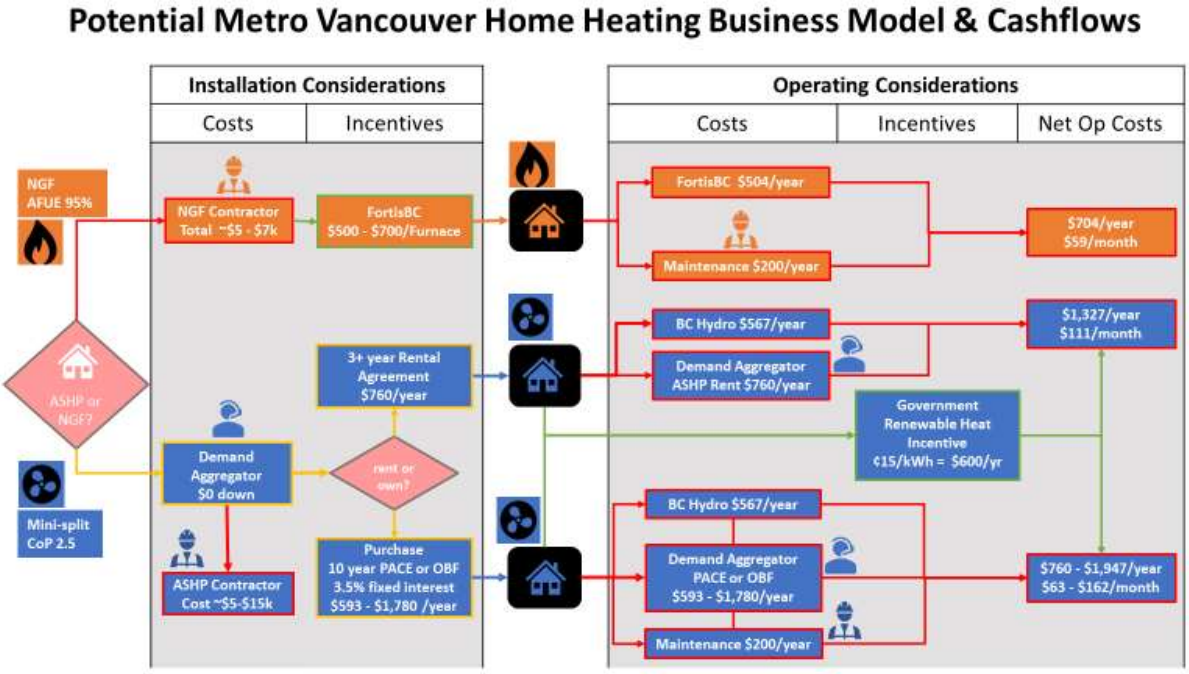


Figure 12. Potential Metro Vancouver Home Heating Business Model and Cashflows

This new ongoing affordability focused business model features several key characteristics:

Table 12. Potential Metro Vancouver Business Model Tools

TOOL	CHARACTERISTICS
Demand Aggregators	• Focus marketing and sales of ASHPs to market of single-family homes. • A single point of contact customer experience.

	• Expertise in providing, or seamlessly connecting customers with, full-service rental agreements, purchase financing, incentives, and quality contractors.
ASHP Contractors	• Strong business relationships with demand aggregators. • Well trained and certified in designing, installing, and servicing ASHPs.
Rental Agreements	• $0 down with affordable monthly rental rate ($63/month (Figure 12)). • Includes use of ASHP; installation, maintenance, and replacement. • Reasonable termination fees, strong, and consumer protection.
PACE / LIC / OBF	• Competitive and easily obtained $0 financing from PACE/LIC or OBF. (Figure 12 above uses Nelson, BC's EcoSave - 3.5% fixed interest rate on a ten-year period). • Transferable to tenants or new purchasers.
RHI or GHG Offsets	• Focus incentives on continued renewable heating and cooling production. • Model above uses: ASHP - 2.5 CoP; 4,000 kWh/year; and ¢14.17/kWh NGF - 95% AFUE; 37.9 GJ/year; basic charge - $149/year; and variable - $9.35/GJ RHI of ¢15/kWh or $600/year

Conclusion and Recommendations

Metro Vancouver's greenhouse gas emissions reduction targets require decarbonizing household heating and cooling, as they currently rely predominantly on NGF heating. Electric air source heat pumps are an effective tool for decarbonizing home heating and increasing energy efficiency, thanks to electricity generation in British Columbia predominantly from hydroelectric dams. However, the low price of natural gas acts as a strong financial disincentive for retrofits. The current Metro Vancouver heat pump business model places a heavy burden on households to research rebates, identify an appropriate heat pump system, seek out installers, ensure quality of installation, and handle financing on their own.

This paper reviewed several heat pump market transformation models and strategies across North America and the United Kingdom. Components from each could lead to business model innovation for Metro Vancouver to overcome barriers to transforming the ASHP market. A one-stop-shop heat pump rental model has been very successful in Saint John, New Brunswick without any government subsidies. The rental model uses a low rental fee, single point of contact, and an integrated supply chain to make renting easy, worry-free, and affordable rather than incentivizing heat pump purchases. Further, the model attempts to reduce information asymmetry between consumers, installers, and manufacturers. Other strategies should also be pursued to incentivize short and long-term ASHP adoption such as property assessed clean energy and on-bill financing, production-based incentives, and GHG offsets.

The following recommendations are provided for consideration by Metro Vancouver while pursuing a heat pump rental model pilot project to enhance the current market intermediary business model;

1. Partner with potential third-party model leaders (ESCOs and regulated and non-regulated utilities) to further research the potential of demand aggregators and a heat pump rental model and conduct in-depth feasibility analysis.
2. Identify legislative restrictions which may limit participation by regulated utilities to operate heat pump rental programs or other roles in a new business model which involve household heating equipment.
3. Engage with industry partners such as the High-Performance Stakeholder Council, the Vancouver Economic Commission, ZEBx and ASHP manufacturers to increase the availability, accessibility, training, and marketing of high performance ASHPs with a focus on local production and servicing by small and medium sized enterprises.
4. Advocate for customer centred on-bill financing with regulated and non-regulated utilities as an effective means of encouraging retrofit uptake.
5. Engage with provincial partners for long-term incentive strategies such as GHG offset purchases and production-based incentives.

Areas of further Research

There are several areas of incomplete knowledge where additional research would be beneficial;

1. Key inputs for determining the viability of a rental program are the heat pump lifecycle costs. Lifecycle costs depend on a number of variables such as the type of heat pump chosen, home

configuration, heat pump and system cost, installation costs, in field performance, regular maintenance costs, and refurbishment, if needed.

2. Since it is generally not the norm to rent home heating and cooling appliances in the Metro Vancouver or Western Canadian markets, any rental program would benefit from research into best practices to further define this concept with households.
3. A detailed economic and feasibility analysis of a production-based incentive scheme.
4. Determine what role local governments, not-for-profit organizations, or the private sector can play in aggregating customer demand to accelerate the scaling of innovative ASHP business models.

Glossary of Terms

Air source heat pump (ASHP): A device that absorbs natural warmth from the air outside and distributes it throughout the building. It provides heating in the winter and cooling and dehumidifying in the summer. It is the most common type of heat pump.

Annual Fuel Utilization Efficiency (AFUE): a measure of the percentage of fuel that is converted into heating energy and therefore maximum performance is 100%.

Coefficient of Performance (COP): The COP is the energy output of the heat pump divided by the amount of electricity needed to run the unit. The higher the COP, the more efficient the heat pump.

CO_2e: Carbon dioxide equivalent: CO2 is the most prevalent greenhouse gas after water vapour and has therefore become the proxy by which we measure greenhouse gas emissions. However, carbon dioxide is only one of many greenhouse gases that are emitted. Other greenhouse gases are methane, nitrous oxide and ozone – all of which occur naturally in our atmosphere. To take into account the emission of other greenhouse gases when calculating the level of greenhouse gas emissions, scientists have devised an equivalent measure – CO2e – allowing other greenhouse gas emissions to be expressed in terms of CO2 based on their relative global warming potential (GWP).

Cooling Degree Days (CDD): A measurement designed to quantify the demand for energy needed to cool buildings. It is the number of degrees that a day's average temperature is above 18C.

Demand Aggregator: Firms that implement energy efficiency measures to a large group of customers applying a business model consisting of product, regulatory, financing, and/or installation expertise. The majority of aggregators operate in markets where they sell the energy savings to a program administrator such as a utility or government.

Ductless mini-split heat pumps (mini-splits): Devices that are wall-mounted, free-air delivery units that can be installed in individual rooms of a house. They make good retrofit add-ons to buildings with "non-ducted" heating systems, such as hydronic (hot water heat), radiant panels, and space heaters (wood, kerosene, propane).

Energy services company (ESCO): A commercial or non-profit business providing a broad range of energy solutions including design and implementation of energy savings projects, retrofitting, energy conservation, energy supply, and risk management.

Greenhouse Gas (GHG): a gas that contributes to the greenhouse effect by absorbing infrared radiation

Heat pump (HP): A device that transfers heat energy from a heat source (air, ground, water) to a destination called a "heat sink" (a building). Heat pumps are designed to move thermal energy in the opposite direction of spontaneous heat transfer by absorbing heat from a cold space and releasing it to a warmer one. They can draw heat from air external to a building ('air source') or from geothermal energy ('ground source').

Natural Gas Furnace (**NGF)**: a household heating system based on natural gas combustion to create heat and subsequently distribute the heat through a series of ducts.

Natural Resources Canada (NRCan): The government of Canada ministry responsible for policy involving natural resources, energy, minerals and metals, forests, earth sciences, mapping, and remote sensing.

One-Stop-Shop (OSS): A business model where an organization acts as a single point of contact for part or all of the energy efficiency retrofit process. The OSS creates a single consumer interface for the design, procurement, financing, installation, and maintenance of retrofits.

Production Based Incentives (PBI): Incentives paid to the energy generator owner based on the energy that is generated by the system.

Property Assessed Clean Energy (PACE): energy efficient financing that is typically attached to the property and repaid through annual property tax levies.

Principal Agent Problem: a cost benefit problem that arises when the agent (landlord) is responsible for energy efficiency investment costs whereas it is the principal (tenant) who benefits from the associated reduction in energy consumption costs.

Renewable Natural Gas (RNG): methane produced from organic waste.

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