EMI CONSULTING

Emera Maine Heat Pump Pilot Program

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FINAL REPORT

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Introduction

Heat Pump Pilot Program

Final Report

The Heat Pump Pilot Program provided $600 rebates and optional on-bill financing for qualifying ductless heat pumps installed in residential homes and small commercial buildings of Emera Maine customers. This report contains the results of an evaluation completed by EMI Consulting of the Emera Maine Heat Pump Pilot Program. It includes a comprehensive evaluation of the program's impacts on energy costs, peak load, and greenhouse gas reduction. It also includes findings regarding the heat pump market and the evaluation of the program's processes.

Program Participant Summary

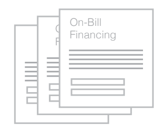
The program successfully achieved its participation goals and was fully subscribed in October 2013.

Program Overview

Program Goals

Pursuant to Public Law Chapter 637, LD 1864 of the Maine State Legislature, the program goal was to **measure the effectiveness of ductless heat pump heating systems**.

Program Activities



- Marketing and outreach to customers and installers
- Online registry for installers, provided by Efficiency Maine
- $600 rebates to customer for the installation of qualified ductless heat pumps
- On-bill financing option for the purchase and installation of qualified ductless heat pumps
- Referral credits for participants who recommend the program to other customers

Conclusions and Recommendations

Conclusions

The evaluation team has drawn four significant conclusions regarding the Emera Maine Heat Pump Pilot Program:

1 **Ductless heat pumps are a viable heating technology for cold weather climates such as Emera Maine's territory.**
Our analysis of heat pump usage and participants' experience concluded that, with a back-up heating source, heat pumps can effectively carry the heating load for residential customers throughout the Maine winter.

2 **Increased use of heat pumps results in increased savings.**
Participants that previously heated their homes with fuel oil and frequently used their heat pumps for heating were able to successfully offset fuel oil usage and significantly reduce their heating energy costs. Some participants remained skeptical and limited the use of their heat pumps. These participants did not offset as much fuel oil use, and therefore limited their savings.

3 **Customer education regarding strategic use of their heat pumps is key to maximizing cost savings**.
Customers needed to manage both the heat pumps and a pre-existing heat system (or systems) in tandem. The participants that were most effective at reducing their energy costs strategically controlled their pre-existing heating system so that their heat pumps would act as the primary heating system. Not all participants were aware of this strategy, and could have benefited from education and training.

4 **Single zone heat pumps have difficulty fully replacing a multi-zone system.**
Regardless of the strategies employed by participants, single zone heat pumps have difficulty heating every conditioned space in a residential home. Often the heat pump could effectively heat a single floor, but a single unit could not reliably heat several floors or isolated spaces. Despite these limitations, heat pumps were still able to reduce overall energy costs.

Recommendations

As a result of our research, the research team provides three recommendations for future programs that will encourage residential customers to install ductless heat pumps:

1 **Educate participants regarding heating strategies.**
Unlike other energy efficiency technologies, the installation of heat pumps into residential households requires a shift in heating behaviors on the part of customers in order for the heat pumps to achieve the desired savings.

2 **Train contractors and educate customers on effective placement of heat pumps.**
Per our research, heat pumps were most effective when placed in central locations such as living rooms or dining areas.

3 **Continue to coordinate with heat pump distributors regarding advancements in multi-zone cold weather units.**
Heat pump technology continues to advance at a rapid pace. For future program designs, Emera Maine should continue to coordinate with manufacturers and distributors.

Impact Research

In general, the impact evaluation estimated the effects the program had on participants' homes. Specifically, the results presented here aim to answer the following four key research questions:

- What is the impact of the installation of energy-efficient heat pumps on **energy use and energy costs** in participants' homes?
- What are the **CO_2 reductions** from the installation of energy-efficient heat pumps through this program?
- What is the coincident **peak demand impact** on the grid for both summer and winter peaks, resulting from the use of the heat pumps installed through the program?
- What portion of the reduced energy usage reported by the program is attributable to the **program's activities**?

Impact on Average Household Heating Costs

$$$

Participants saved on average $622 dollars in heating costs as the use of the heat pumps offset the use of expensive fuel oil (normalized for an average Maine winter).

$932	Average avoided cost of fuel oil
– $310	Average cost of heat pump use
$622	Average savings for participants

Impact on Greenhouse Gas Emissions

Normalized for the average winter, the average participant reduced their CO_2 emissions by 4,212 pounds per year, the equivalent to driving 4,549 miles fewer each year.

Change in CO_2 Emissions per Year

Electricity	+1548 lbs.
Fuel Oil	- 5760 lbs.
	- 4212 lbs.

Peak Demand Impacts

Summer Demand	Winter Demand
+0.14 kW on-peak	+0.35 kW on-peak

Our research shows an increase in summer and winter peak demand of 0.14 kW and 0.35 kW respectively as the heat pumps created an additional source of electricity demand (offsetting fuel oil as the primary heating fuel) for many participants.

Attribution

The research team assessed program attribution by examining participants' self-reported responses on program influence and what they likley would have installed absent the program

Net-to-Gross	88%
Free-Ridership	19%
Spillover	7%

These results suggest that the majority of the heat pumps would not have been installed without program assistance. Furthermore, the estimated spillover (while relatively modest) served to offest some of the observed free-ridership.

Process Research

This process research provides program administrators and implementers with insightful information and feedback on program operations and delivery in order to understand pilot program successes and optimize the design and implementation of individual program elements. As a pilot program testing various implementation approaches, this program evolved over time to streamline program operations and leverage effective strategies. This **continual improvement process is considered a best practice** for pilot programs.

Program Implementation

Program staff completed a comprehensive and **effective marketing campaign** that resulted in the program achieving its participation goals. This campaign consisted of a variety of outreach methods, including:

- Email outreach to installers, potential participants, and community groups
- Direct mailings to customers and installers
- Earned media placements in newspaper, radio, and television
- In-person presentations and trainings for installers and potential participants
- Social media presence on Facebook and Twitter

Customer Experience

Awareness

26% of participants first heard about the program from a friend or family member.

Motivation

81% of participants said they took part in the program "to save money on heating expenses."

Contractor Skills

Customers reported being very satisfied with both the installer quality of work and knowledge of heat pumps, with an average rating of **4.4 out of 5**.

Program Satisfaction

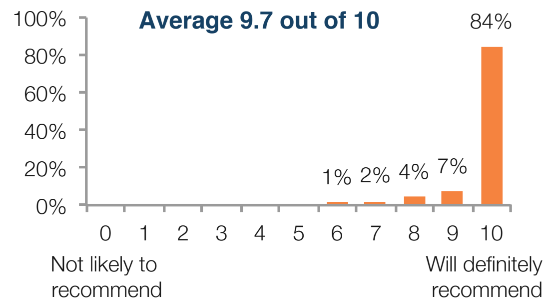
Overall, satisfaction with the program and each of its components was quite high. This indicates that customers found value in the program and that the program operated smoothly from a customer experience perspective.

85% were very satisfied with the **program**.

85% were very satisfied with the **heat pump.**

78% were very satisfied with the **savings they've seen**.

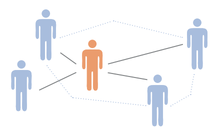
Likelihood of Recommending the Program



Market Research

Market Indicators

The program appears to have had a positive impact on the ductless heat pump market by raising awareness of heat pumps as an energy efficient technology and increasing the market share of energy efficient heat pumps. The research team developed a set of market indicators through a collaborative effort with program staff and Efficiency Maine.



Indicator	Q1 2013		Q1 2014
Awareness and knowledge of heat pumps	19%	→	35%
Energy efficiency market share	50%	→	64%

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1. INTRODUCTION

This report contains the results of an evaluation completed by EMI Consulting of the Emera Maine Heat Pump Pilot Program. It includes the results of a comprehensive evaluation of the program's impacts on energy costs, peak load, and greenhouse gas reduction. It also includes findings from the market research of the heat pump market and the evaluation of the program's processes. Emera Maine contracted EMI Consulting to complete this research in order to provide an objective assessment of program performance and to offer recommendations for how to improve future implementations of the program.

1.1 Program Overview

The Heat Pump Pilot Program (the Program) provided $600 rebates and optional on-bill financing for qualifying ductless heat pumps installed in residential homes and small commercial buildings of Emera Maine customers[1]. To qualify for the program, participants were required to have:

- Been an Emera Maine residential or small business customer,
- Used oil, propane, electric resistance heat, or kerosene as a primary heat source,
- Spent $1,400 or more on heat annually, and
- Purchase a qualifying heat pump.[2]

As part of the program, the rebates and on-bill financing were paired with a number of additional program activities - such as marketing, contractor program training, participant referrals, and contractor registration - all aimed at reducing the barriers to customers' purchasing and installing energy-efficient heat pumps to offset heating load from other fuel sources, such as fuel oil. According to the program theory, the primary objective of the Program was that customers would realize an overall reduction in energy costs by purchasing energy-efficient heat pumps. In addition, they would also benefit from non-energy impacts such as increased comfort and a reduction in CO_2 emissions.

In pursuit of these objectives, the Program undertook six main activities to help overcome four specific barriers identified in the heat pump market (including lack of heat pump awareness, lack of information regarding installers, large up-front costs, and limited access to capital). These main program activities involved Emera Maine providing:

1. Marketing and outreach to customers
2. Marketing and outreach to installers
3. An online registry provided by Efficiency Maine for heat pump installers
4. Rebates to customers that installed qualified heat pumps
5. On-bill financing for qualified heat pump purchase and installation
6. Referral credits for participants that refer other customers to the pilot program

[1] Note that Emera Maine is comprised of two service territories: Bangor Hydro and Maine Public Service. Occasionally, these two service territories are referenced when relevant to the analysis.
[2] Qualifying heat pumps must have a HSPF rating of 10 or greater.

1.2 Evaluation Objectives

The overall objectives of this research were to determine the impact of the Program on participating customers' overall energy costs, assess changes in the ductless heat pump market, and evaluate the effectiveness of the Program at achieving its desired outcomes. To address these objectives the research team explored the following three research areas:

1. The program's impact on customer energy use, energy costs, and non-energy benefits,
2. The program's impact on the ductless heat pump market, and
3. The effectiveness and efficiency of the program's processes.

This report addresses these questions and follows an interim report delivered to the Maine Public Utilities Commission in November of 2013. The research categories and detailed research questions are listed in Table 1-1 below. To avoid redundancy, this report only summarizes the findings related to the process questions, as they were discussed in detailed as part of the interim report submitted in 2013.

Table 1-1. Detailed Research Questions by Research Area

Research Area	Research Question
Impact Research	What portion of the reduced energy usage reported by the program is attributable to the program's activities?
	What is the coincident peak demand impact on the grid, for each utility, for both summer and winter peaks, resulting from the use of the heat pumps installed through the Program?
	What is the program impact upon energy use and energy costs in participants' homes?
	What are the CO_2 reductions from the installation of energy-efficient heat pumps through this program?
Market Research	What motivates customers with high-energy burdens to participate in a heat pump program?
	What are the relevant market indicators for the ductless heat pump market?
Process Research	Were the Program activities implemented as planned?
	What was the customer experience with the Program?
	What was the contractor experience with the Program?
	What barriers exist to contractor participation, customer use of rebates, and customer use of on-bill financing?
	Did the Program generate the intended outcomes?

To address these objectives, the research team collected and analyzed data from several sources, including:

- Two telephone surveys with a sample of the general customer population ("General Population Survey"). These surveys included 280 residential and commercial customers (140 for each wave) and focused on identifying trends in awareness and knowledge of heat pump technology, determining the level of customer interest in program assistance through rebates and financing, and assessing the degree to which Emera Maine and Efficiency Maine are perceived as trustworthy and valuable sources of information. The research team fielded the first wave of this survey in January 2013, and the second wave in January 2014, to assess changes in the heat pump market as a result of the program.

- Qualitative research with potential participants. This research included focus groups and in-depth interviews documenting customer perspectives on heat pumps and heat pump incentive programs, as well as message testing program collateral. The research team conducted two focus groups, one group in each of Emera Maine's service territories, with a random sample of residential and commercial customers. In addition, the research team conducted 10 in-person interviews with target customers to gauge their responses to heat pumps and potential program designs.

- In-depth interviews with heat pump distributors and installers. The research team conducted interviews with 5 distributors and 20 installers involved in the sale, installation, and distribution of heat pumps in Emera Maine's territory. During the interview, the research team queried distributors and installers as needed to better understand their perspectives on heat pumps and the market for these technologies. The purpose of the distributor interviews was to collect data to inform the market baseline for high efficiency heat pumps. The purpose of the installer interviews was to understand their perceptions of how customers interact with heat pumps (e.g., what are their motivations, concerns, and questions) and their experiences with the program.

- Two online surveys with program participants, one conducted at the time of installation and another six months after installation. The research team invited all participants in the program to complete these surveys. Of those participants invited, 301 completed the first survey while 184 completed the second. The objectives of these surveys were to establish a technical profile of participants' homes and business to inform the impact analysis, as well as to understand participants' experiences after participating in the program.

- Participants' historical electrical billing and fuel oil usage data. These data included monthly electrical consumption data for a sub-sample of the program participants (n=64) and hourly meter data for a sub-sample of Emera Maine participants. These data were used to establish a baseline pattern of electric usage prior to the installation of the heat pump. In addition, the research team collected baseline fuel oil consumption data to determine any reductions in fuel oil usage; ultimately, these latter data were too unreliable to be included in the analysis.

- In-home meters that monitored electricity usage minute-by-minute. These meters allowed the research team to isolate the usage of the installed heat pump and generate a pattern of electric usage after the installation of the heat pump. In addition, the research team used these monitors to model usage of primary heating sources (e.g., furnaces, boilers).

- In-depth interviews with 29 program participants. These interviews explored how participants used their heat pumps in relation to the data collected by the in-home meters described above. These data allowed the research team to identify behaviors among participants that contributed to the variation in heat pump performance. A critical aspect of these interviews was discussing behaviors that lead to either relatively high or relatively low heat pump usage.

1.3 Organization of Report

The remainder of this report provides detailed findings for each key research area. The first section contains conclusions and recommendations of the research, followed by sections that address program impacts, the heat pump market, and program processes. As the process evaluation results were presented as part of the Fall 2013 interim report, this report contains a summary of the findings related to that research. Finally, detailed methodologies for all research can be found in the Appendices.

2. CONCLUSIONS AND RECOMMENDATIONS

The following section provides the research team's conclusions and recommendations regarding the Heat Pump Pilot Program. This section first provides conclusions identified during our research activities, followed by actionable recommendations designed to improve programs offered by Emera Maine or Efficiency Maine in the future.

2.1 Conclusions

As a result of our research and analysis, the evaluation team has drawn four significant conclusions regarding the Emera Maine Heat Pump Pilot Program:

1. **Ductless heat pumps are a viable heating technology for cold weather climates such as Emera Maine's territory.** Our analysis of the heat pump usage and the participants' experience concluded that, with a back-up heating source, heat pumps can effectively carry the heating load for residential customers throughout the Maine winter. Given recent improvements in heat pump technology, this technology can now effectively operate at very cold temperatures.
2. **Increased use of heat pumps results in increased savings.** Participants that previously heated their homes with fuel oil and frequently used their heat pumps for heating were able to successfully offset fuel oil usage and significantly reduce their heating energy costs. However, given that previous electric heating sources tended to be inefficient, some participants remained skeptical and limited the use of their heat pumps. These participants did not offset as much fuel oil use, and therefore limited their energy savings.
3. **Customer education regarding strategic use of their heat pumps is key to maximizing cost savings.** Given that heat pumps were often an additional heating source to participants' homes (instead of replacing a heating system), customers needed to manage both the heat pumps and a pre-existing heat system (or systems) in tandem. Per the research team's analysis, the participants that were most effective at reducing their energy costs strategically controlled their pre-existing heating system so that their heat pumps would act as the primary heating system (often via coordinated thermostat settings). However, not all participants were aware of this strategy, and could have benefitted from education and training from either contractors or the pilot program (either via staff or educational materials).
4. **Single zone heat pumps have difficulty fully replacing a multi-zone system.** Regardless of the strategies employed by participants, single zone heat pumps have difficulty heating every conditioned space in a residential home. Often the heat pump could effectively heat a single floor (given conducive floor plans), but a single unit could not reliable heat several floors or isolated spaces. Please note that despite these limitations, as mentioned above, heat pumps were still able to reduce overall energy costs.

To support these overall conclusions, the following section includes our detailed results regarding:

- The impact on household energy costs
- The impact on greenhouse gas emissions
- The influence of the program on participant behavior
- Non-energy benefits
- Market effects
- Participant satisfaction

Impact on Household Energy Costs

Normalized for an average Maine winter, **participants saved on average $622 dollars in heating costs** as the use of the heat pumps offset the use of expensive fuel oil. These savings are the result of $310 worth of electricity use offsetting $932 worth of fuel oil. Table 2-1 below details the breakdown of how the reductions in fuel oil use offset the increased electricity consumption and provide net savings to individual households.

Table 2-1. Impact on Heating Costs in a Typical Season

Energy Use Parameter	Average Heat Pump Use	Avoided Fuel Oil Use	Estimated Savings
Estimated Average	2387 kWh	239 gallons	
Per Unit Rate	$0.13	$3.90	
Savings	**($310)**	**$932**	**$622**
Heating Season: October, November, December, January, February, March, April			

In addition, participants used the heat pumps to provide cooling and some supplemental heating during the summer and shoulder seasons. During these seasons the heat pumps did not offset significant fuel oil consumption, and as such did not provide energy costs savings for these specific seasons. Their use during these times reduced the overall energy cost savings seen by participants but did provide significant non-energy benefits (discussed later). Table 2-2 below summarizes the estimated impacts on energy costs during the heating season, the cooling season, and the shoulder seasons.

Table 2-2. Impact on Overall Energy Costs for a Typical Weather Year

Season [a]	Energy Use Parameter	Average Heat Pump Use	Avoided Fuel Oil Use	Estimated Savings
Heating (n=51)	Estimated Average	2387 kWh	239 gallons	
	Per Unit Rate	$0.13	$3.90	
	Savings	($310.31)	$932.10	$621.79
Shoulder [b] (n=38)	Estimated Average	163 kWh	17 gallons	
	Per Unit Rate	$0.16	$3.90	
	Savings	($26.08)	$66.30	$40.22
Cooling (n=51)	Estimated Average	398 kWh	N/A	
	Per Unit Rate	$0.16	$3.90	
	Savings	($63.68)	-	($63.68)
Total		**($400.07)**	**$998.40**	**$598.33**

a. Heating Season: October, November, December, January, February, March, April; Shoulder Season: May, September; Cooling Season: June, July, August

b. More heat pump use was observed in the shoulder season during the reporting period; however, typical weather years have a mixture of HDD and CDD during this period, resulting in limited offset of fuel oil use.

These values represent the expected savings during an average Maine winter based on historical weather data. The research team also estimated that during the 2013-2014 heating season, on average participants saved 284 gallons of fuel oil for a net savings of $739. In addition, participants reported an average savings of $746 dollars during that same time period. Note that it is unclear how all participants calculated these self-reported savings.

In addition, our research identified a great deal of variation in heat pump and subsequent savings among participants. The usage ranged from 342 kWh to 7,372 kWh across the period from June 2013 to May 2014. Qualitative follow-up research with participants identified several factors driving this variation.

First, low usage is often driven by:

- **Using the heat pump as a "spot source" for heat (similar to a space heater) while allowing pre-existing heating sources to carry heating loads**. For example, while many participants allowed the thermostat to control the heat pump so that it ran automatically as needed, several participants controlled their heat pump manually, only turning it on when needed. This lead to drastically reduced usage of the heat pump and continued reliance on pre-existing heating sources (e.g., furnaces and boilers) and therefore a missed savings opportunity.
- **Households that require multiple zones of heating and which cannot be supplied by a single head heat pump.** For example, homes with living spaces on second floors or in basements often use the pre-existing heating source to heat these areas while simultaneously heating the living space served by the heat pump. This would drive demand and usage down for heat pumps.
- **Lower thermostat settings.** Some low heat pump users kept household thermostats set surprisingly low (between 64 and 66 degrees).

High usage was often driven by:

- **Coordinating thermostat settings between the heat pump and the pre-existing heating source** so that the thermostat for the pre-existing heating source is set significantly lower than the heat pump. This strategy ensured that the household relied on the heat pump for primary heating without constant monitoring or intervention.
- **Households with smaller, more open floor plans** in which the heat pump was centrally located. In these households, the heat pump was able to more effectively heat the living spaces as they were not required to heat multiple zones.

Impact on Greenhouse Gas Emissions

Normalized for typical weather, the average Bangor Hydro participant reduced their CO_2 emissions by 3,448 pounds per year, while the average Maine Public Service customer reduced their CO_2 emissions by 4,976 pounds per year. Overall, participants reduced their CO_2 emissions by an average of 4,212 pounds per year, the equivalent to driving 4,549 miles fewer each year. These reductions are summarized in Table 2-3 below.

Table 2-3. Normalized CO_2 Reductions per Year

Fuel Type	Change in Fuel Use	Change in CO_2 Emissions per Year (lbs. CO_2)		
		Maine Public Service	Bangor Hydro Electric	Average (by participation)
Electricity	+2.947 MWh	784	2,312	1,548
Fuel Oil	-256 Gallons	-5,760	-5,760	-5,760
Change per Customer		**-4,976**	**-3,448**	**-4,212**

Influence on Installation Decisions

The program's activities (e.g., financial assistance, awareness and education regarding heat pump technology) are having a strong influence on participants' installation decisions, and a majority of the program's impact is attributable to the program itself. Table 2-4 below summarizes the research team's net-to-gross results.

Table 2-4. Net-to-Gross Summary

Net Impact Category	Evaluation Estimate
Free-ridership	19%
Spillover	7%
Net-to-Gross Ratio *(100% - Free-ridership + Spillover)*	88%

Non-energy Benefits

Participants in the program are experiencing **significant non-energy benefits,** including increased comfort during the heating and cooling seasons and better air quality in their home.

- When asked, 55% of participants reported that their comfort level during the heating season had increased. Likewise, 88% of participants reported increased comfort during the cooling season, suggesting that many participants appreciated the cooling and dehumidification capabilities of the heat pump.

- Indoor air quality also improved for a significant portion of participants, with 47% reporting improvements (a majority – 53% – reported either the quality had stayed the same or did not notice a change).
- During in-depth interviews several participants mentioned that heat pumps reduced the manual labor required with other heat sources, such as wood stoves. While reported by a small number, this impact was significant for several older participants.

Heat Pump Market Effects

Given the 12-month timeframe included as part of the evaluation, market indicators show that **the program is having a positive impact on the heat pump market**, overcoming awareness barriers regarding the effectiveness of heat pumps as a supplemental heating source in Maine. Research indicates that:

- Among the general population, awareness and knowledge of heat pumps increased from 19% to 35% over the year.
- Per distributors, the market share of energy efficiency heat pumps sold in Maine increased from 50% to 64% over the year.

However, other data indicated **slower progress regarding the uptake of heat pumps among residential customers or provided inconclusive evidence**. Based on our sample of residential customers eligible for heat pumps responding to a survey, there was no statistically significant change in the number of homes with heat pumps installed. However, sales data from distributors indicated that heat pump installations in Maine have increased dramatically over 2013. As stated above, given the 12-month timeframe for this evaluation, these indicators are in-line with a typical initial year of a market transformation program.

Participant Satisfaction

On average, **participants are very satisfied with their experience** with the Emera Maine heat pump program. This indicates that customers found value in the program and that the program operated smoothly from a customer experience perspective.

- Participants reported that they were very satisfied with the program (85% very satisfied), with the heat pump (85% very satisfied), and the savings they have seen (78% of participants noticed savings and 83% of those who noticed savings were very satisfied with the amount of savings).
- On average, respondents rated the likelihood that they would recommend the Program a 9.7 on a 0 to 10 scale. This is indicative of high levels of satisfaction with the Program and customers' experiences with the heat pumps.
- Customer satisfaction with installers is very high – 84% of participants were satisfied with the quality of the installation of their heat pump, with 76% very satisfied. This suggests a ready pool of experienced contractors to install heat pumps.

2.2 Recommendations

As a result of our research, the research team provides three recommendations for future programs that will encourage residential customers to install ductless heat pumps:

1. **Educate participants regarding heating strategies.** Unlike other energy efficiency technologies (e.g., CFLs, high-efficiency clothes washers, insulation), the installation of heat pumps into residential households requires a shift in heating behaviors on the part of customers in order for the heat pumps to achieve the desired savings. Given the myriad of heating options available to Mainers, we suggest that in future programs, Emera Maine leverage its experience with heat pump programs and partner with participating contractors to educate customers on realistic heating strategies.

2. **Train contractors and educate customers on effective placement of heat pumps.** Per our research, heat pumps were most effective when placed in central locations such as living rooms or dining areas. While heat pumps can provide significant heating and cooling benefits when placed in other locations (e.g., bedrooms), such a placement limits their ability to serve overall conditioned spaces in the home and offsets fuel oil efficiencies.

3. **Continue to coordinate with heat pump distributors regarding advancements in multi-zone cold weather units.** Heat pump technology continues to advance at a rapid pace. For future program designs, Emera Maine should continue to coordinate with manufacturers and distributors. As highly efficient multi-zone systems become available, this technology would likely address many of the challenges detailed above.

3. IMPACT EVALUATION RESULTS

This section of the report describes the results of the impact evaluation study. In general, the impact evaluation estimated the effects the program had on participants' homes. Specifically, the results presented here aim to answer the following four key research questions:

1. What is the impact of the installation of energy-efficient heat pumps on energy use and energy costs in participants' homes?
2. What are the CO_2 reductions from the installation of energy-efficient heat pumps through this program?
3. What is the coincident peak demand impact on the grid, for each utility, for both summer and winter peaks, resulting from the use of the heat pumps installed through the Program?
4. What portion of the reduced energy usage reported by the program is attributable to the program's activities?

In addition to these questions, the evaluation research also explains the drivers behind the observed variation in heat pump usage and summarizes the reported non-energy benefits of program participation. Finally, the research team assessed program attribution and peak demand impacts in the interim report delivered to the Maine Public Utilities Commission in November 2013. For comprehensiveness, this report also summarizes these results.

3.1 Overview of Approach

In order to address the impact-specific research questions, the research team collected and analyzed data regarding participants' homes. This included collecting a year's worth of baseline and reporting period fuel use and electricity use data for a sample of heat pump program participants, cleaning the energy use data to remove any outliers or erroneous data points, and normalizing the results to create regression models that represent the typical changes in energy use one can expect from a program heat pump.

Specifically, the research team recruited 64 households from the population of participants and installed sub-meters on their circuit breakers. Once the data were collected and cleaned, the research team generated normalized results through a multistep process that included the following steps:

1) The research team reviewed correlations and covariations to identify which variables demonstrated the highest statistically significant impacts on the energy and fuel use data sets.
2) The research team then applied a regression analysis to generate two models for the electricity and fuel use of the sample sites during the baseline (pre-heat pump installation) and reporting (post-heat pump installation) periods. These models use electricity consumption data and weather data from the baseline period and reporting period to determine the relationship between variables (such as weather, house size) and electricity use and fuel use.
3) To determine the impact of the heat pump installation on electricity and fuel use, the research team then used these models to estimate normalized electricity use for the baseline and reporting periods. These normalized values represent typical or average

conditions and were input into these models to achieve electricity and fuel use values representing the typical home.

4) The difference between normalized modeled baseline and reporting period consumption captures the impact of the heat pump. This fuel use analysis assumes that use of other sources of heat, such as wood pellets, electric heat or fireplaces, are not changed between the baseline and reporting periods. The electric heating use for customers who have electric heat support this assumption. Significant changes in secondary heating sources would mean that the customer chose to offset those costs instead of fuel oil costs.

3.2 Energy Use and Cost Impacts

Using regression models, the research team was able to normalize the data and isolate the changes in electricity and fuel use due to the program heat pumps. These models showed that, normalized for an average Maine winter, participants saved $622 dollars on average in heating costs as the use of the heat pumps offset the use of fuel oil. Table 3-1 below details the breakdown of how the reductions in fuel oil use for heating offset the increased electricity consumption of the heat pump and provide net heating cost reductions to individual households.

Table 3-1. Impact on Heating Costs in a Typical Heating Season

Energy Use Parameter	Average Heat Pump Use	Avoided Fuel Oil Use	Estimated Savings
Estimated Average	2387 kWh	239 gallons	
Per Unit Rate	$0.13	$3.90	
Savings	**($310)**	**$932**	**$622**
Heating Season: October, November, December, January, February, March, April			

Overall, participants' use of the heat pump increased their annual electricity consumption across all seasons by 2,947 kWh (which includes the additional cooling load). As such, the evaluation team's model shows that participants' average annual energy costs decreased by $598.33 as the increased cost of cooling offset savings realized during the heating season. Table 3-2 details the impact of the heat pump across the various seasons. Over the estimated 20-year measure life of the heat pump, with a 7.37% discount rate, this amounts to a normalized NPV of $6,758.78 in energy cost savings.[3]

[3] Discount rate of 7.37% reported by Emera Maine on June 18, 2014, via email correspondence.

Table 3-2. Impact on Annual Energy Costs in a Typical Year

Season [a]	Energy Use Parameter for Heating Season	Average Heat Pump Use	Equivalent Fuel Oil Use	Estimated Heating Savings
Heating (n=51)	Estimated Average	2387 kWh	239 gallons	
	Per Unit Rate	$0.13	$3.90	
	Savings	($310.31)	$932.10	$621.79
Shoulder [b] (n=38)	Estimated Average	163 kWh	17 gallons	
	Per Unit Rate	$0.16	$3.90	
	Savings	($26.08)	$66.30	$40.22
Cooling (n=51)	Estimated Average	398 kWh	N/A	
	Per Unit Rate	$0.16	$3.90	
	Savings	($63.68)	-	($63.68)
Total		**($400.07)**	**$998.40**	**$598.33**

a. Heating Season: October, November, December, January, February, March, April; Shoulder Season: May, September; Cooling Season: June, July, August
b. More heat pump use was observed in the shoulder season during the reporting period; however, typical weather years have a mixture of HDD and CDD during this period, resulting in limited offset of fuel oil use.

These values represent the expected savings during an average Maine year based on historical weather data, separated by heating, cooling and shoulder seasons, and include additional load from cooling. While the heating season savings normalized to a typical year are presented as part of the table above, the research team also estimated that during the 2013-2014 heating season (a season that was colder than average), participants saved, on average, 284 gallons of fuel oil for a net savings of $739.[4] In addition, participants reported an average savings of $746 dollars.[5] To illustrate this difference, Table 3-3 below summarizes the difference in heating degree days (HDD) between the typical Maine winter and the recent 2013 and 2014 winters included as part of the impact analysis.

Table 3-3. Comparison of Recent Years to Historical Heating Degree Days (Heating Season)

Timeframe	Heating Degree Days (HDD)	
	Bangor Hydro	Maine Public Service
30 Year Average (TMY)	6,888	7,811
2013 (Baseline)	8,756	7,352
2014 (Reporting)	8,947	8,493

Source: National Climate Data Center Weather Data

[4] This estimate is based on normalization to the 2013-2014 heating season as opposed to normalizing to the typical meteorological year (TMY).
[5] While our savings estimate assumed a flat cost of fuel oil of $3.90 per gallon, participants purchase fuel throughout the year and on different payment schemes. Therefore, the actual cost of fuel to customers is not flat.

Note that our analysis assumed that the overall heating load for the household remained the same when some users may be strategically lowering their heating load (e.g., by voluntarily limiting heat to some previously conditioned spaces regardless of comfort). In addition, our analysis assumed that the heat pumps were displacing fuel oil use, while some participants may have offset other fuels (such as wood pellets). This assumption is based on observed usage via metered data and the rationale that most participants would first offset fuel oil, the most expensive commonly used heating fuel.

Variation in Usage

In addition, the research team found considerable variation in the usage of the heat pumps. The usage ranged from 342 kWh to 7,372 kWh across the period from June 2013 to May 2014. Based on in-depth interviews with 29 participants, this wide variation is often driven by differences in heat pump operation and the interactions between heat pumps and pre-existing heating sources. Table 3-4 summarizes the patterns the evaluation identified during these interviews.

Table 3-4. Reporting Period Usage and Heat Pump Operational Characteristics

Usage Pattern	Operational Characteristics	Thermostat Setting
Low (less than 300 kWh/month)	Manually operated their heat pump, turning it on or off when needed throughout much of heating season	Less than 70˚
Moderate (300 - 900 kWh/month)	Allowed thermostat to control heat pump so that it ran automatically, but relied on pre-existing heating sources to heat other living household spaces	70˚-72˚
High (over 900 kWh/month)	Allowed thermostat to control heat pump so that it ran automatically, but adjusted pre-existing heating sources	74˚ or higher

First, the lowest users (those that used less than 300kWh per month during the peak-heating season, December-March) did not operate the heat pumps effectively. These participants often set their heat pumps to “manual,” and when in use set the thermostat to a relatively low temperature. Two of the lowest users manually run and shut down their heat pumps as needed for localized heat in the house. Both explained that they do not run their heat pumps in conjunction with their home furnaces, and were frequently not sure which to use. When in use, the heat pump thermostats were set to 66˚ and 70˚. Another participant was an extremely frugal energy user who turned off all heat sources while out of the house for over twelve hours every weekday. Additionally, he reported keeping his home at 63-65˚F when home, the lowest reported in the interviews. Finally, one participant only ran the heat pump almost exclusively during the shoulder season, and shut it off completely from December through February, instead relying on a wood stove furnace. This participant also reported setting the thermostat to 66˚.

Second, moderate users (participants that used between 300kWh and 900kWh per month during the peak-heating season) differed from the lowest heat pump users as they generally leave their heat pump thermostats set throughout the vast majority of the heating season. However, these users do not fully rely on their heat pumps and use pre-existing heating sources in addition to the heat pump to heat their home. These participants described using the heat pump to heat a core area of the house and allowing the furnace to pick up the heating load in other parts of the house, often running them simultaneously. As such, low heat pump usage may be caused by the pre-existing heating source increasing the ambient air temperature near the heat pump and shutting it off. Like the lowest heat pump users, customers in this group also generally set their thermostats to a low temperature; a majority at or below 72°.

Finally, high users (participants that consumed over 900 kWh per month during the peak-heating season) took advantage of the heat pump thermostat and relied on the heat pump as the sole source of heat, except in periods of extremely low outside temperature. To accomplish this, the participants coordinated thermostat settings between the heat pump and the pre-existing heating source so that the thermostat for the pre-existing heating source is set 10 degrees lower than the heat pump. This strategy ensured that the household relied on the heat pump for primary heating without constant monitoring or intervention. In addition, high users kept their homes warmer than other participants; a majority reported keeping their heat pump thermostats set at 74° or higher. Note that participants often set their heat pump thermostats at temperatures higher than the desired ambient temperature to remain comfortable depending on the placement of the heat pump and the corresponding thermostat.

To demonstrate the potential savings, the evaluation team also summarized how heat pump usage related to these groups. While it appears that the more a heat pump is used, the more energy is potentially saved, most users in the sample fell into the low and moderate groups, and the following analysis is for explanatory purposes only. Table 3-5 shows comparative energy use and cost tables between the three groups.

Table 3-5. Normalized Heating Season Energy Use and Cost, by Usage Group

Cost Reduction Tier	Energy Use Parameter	Average Heat Pump Use	Equivalent Fuel Oil Use	Estimated Savings
High Cost Reductions	Estimated Average	6102 kWh	701 gal	
(n=3)	Per Unit Rate	$0.13	$3.90	
	Savings	($793)	$2,732	$1,939
Moderate Cost Reductions	Estimated Average	2992 kWh	304 gal	
(n=27)	Per Unit Rate	$0.13	$3.90	
	Savings	($389)	$1,185	$796
Low Cost Reductions	Estimated Average	1078 kWh	112 gal	
(n=21)	Per Unit Rate	$0.13	$3.90	
	Savings	($140)	$436	$296
Heating Season: October, November, December, January, February, March, April				

3.3 CO_2 Emissions Impacts

Overall, although the program heat pumps resulted in increased electricity use, the offsetting of fuel oil use led to a net decrease in carbon emissions for program participants. Using the CO_2

intensity factors for electricity generation and heating fuel use shown in Table 3-6, the research team was able to convert the normalized change in electricity consumption and fuel oil use due to the program heat pumps into CO_2 emissions reductions. As shown in Table 3-6, the average change per heat pump participant site is a decrease of 4,976 lbs. of CO_2 and 3,448 lbs. of CO_2 for customers in the Maine Public Service and Bangor Hydro regions, respectively.

The CO_2 intensity factors used in this analysis were provided by Emera Maine staff on November 16, 2014 and values for fuel oil CO_2 intensity were calculated based on EPA resources.[6] The research team used the most recently disclosed labels for customers in the Bangor and Presque Isle regions (see Appendix A).

Table 3-6. Normalized Changes in CO_2 per Customer

Factor	Maine Public Service	Bangor Hydro
Electricity CO_2 Intensity (lbs. CO_2/MWh)	265.93	784.37
#2 Fuel Oil $C0_2$ Intensity (lbs. CO_2/Gallon)	22.5	22.5
Increase in Electricity Consumption (MWh)	2.947	2.947
Decrease in Fuel Oil Consumption (gallons)	256	256
Increased CO_2 from Electricity (lbs.)	783.7	2,311.5
Decreased CO_2 from Fuel Oil (lbs.)	5,760.0	5,760.0
Net Reduction per Participant (lbs.)	**4,976.3**	**3,448.5**

[6] http://www.epa.gov/cleanenergy/energy-resources/refs.html

3.4 Peak Demand Analysis

Our research shows an increase in summer and winter peak demand of 0.14 kW and 0.35 kW respectively as the heat pumps created an additional source of electricity demand (offsetting fuel oil as the primary heating fuel) for many participants. Using hourly interval regression models, the research team was able to normalize the heat pump usage data and isolate the change in electricity demand due to the program heat pumps for both summer and winter peak periods. For this analysis, the research team used demand resource on-peak hours for the ISO-NE Forward Capacity Market as the peak hour definitions. The ISO-NE Forward Capacity Market hours are defined as non-holiday weekday hours between 5:00 PM and 7:00 PM during December and January (winter), and between 1:00 PM and 5:00 PM during June, July, and August (summer). The results of this analysis are shown in Table 3-7 below.

Table 3-7. Predicted Summer and Winter Peak Impacts, Normalized (n = 35)

	Summer Predicted Mean Value	**Winter** Predicted Mean Value
Baseline Period	0.85 kW	1.32 kW
Reporting Period	0.99 kW	1.67 kW
Absolute Increase	**+0.14 kW**	**+0.35 kW**
Relative Increase	**16%**	**27%**

Summer Resource On-Peak Analysis

As mentioned in the previous section, the overall trend for participants was an increase in demand of 0.14 kW during peak summer hours. Looking more granularly at the data, the results can be broken out by households with previous A/C and household without previous A/C. For participants without previous air conditioning equipment, demand increased by 0.20 kW during peak hours and 0.19 kW during off-peak hours. For participants with previous air conditioning equipment, demand increased less due to customers already having a cooling load, only increasing by 0.07 kW during peak hours and 0.03 kW during off-peak hours. Among all participants, demand in the Reporting Period was higher than in the Baseline Period by 0.14 kW during peak hours and 0.11 kW during off-peak hours. For all of the estimates presented in Table 3-8, the confidence intervals of the estimated Baseline and Reporting period consumption do not overlap, meaning the differences are significant at the 90% level.

Table 3-8. Modeled Cooling Demand Impacts: Average Normalized kW

Status	Baseline			Reporting			Change in Demand
	Mean	90% CI Interval		Mean	90% CI Interval		
	(kW)	(kW)	(kW)	(kW)	(kW)	(kW)	
No previous AC	0.80	0.78	0.83	1.00	0.99	1.02	0.20
Previous AC	0.90	0.88	0.91	0.97	0.96	0.99	0.07
All	**0.85**	**0.83**	**0.87**	**0.99**	**0.98**	**1.01**	**0.14**

Winter Resource On-Peak Analysis

Similar to the summer demand analysis, the heat pumps contributed to an increase in the peak winter demand. For the seasonal winter peak hours, program participants increased their electricity demand by .35 kW, a relative increase of 25% over the baseline demand. The research team determined an average hourly demand during the baseline period of 1.32 kW and an average hourly demand during the reporting period of 1.67 kW. This is based on the normalized models at the mean HDD for the peak period and for the mean value of size. Based on our modeling, the difference between these two values is attributable to the installation and operation of the program heat pumps. For all of the estimates presented in Table 3-9, the confidence intervals of the estimated Baseline and Reporting period demand do not overlap, showing the differences are significant at the 90% level.

Table 3-9. Modeled Heating Demand Impacts: Average Normalized kW

Model	Baseline			Reporting			Change in Demand
	Mean	90% CI Interval		Mean	90% CI Interval		
	(kW)	(kW)	(kW)	(kW)	(kW)	(kW)	
Peak	1.32	1.31	1.33	1.67	1.65	1.68	0.35

For our analysis, the research team used the ISO-NE nominal peak is between 5 and 7 PM in December and January. However, for participants in the program, the Maine winter peak appears to be after the New England winter seasonal peak as the highest use for these participating customers is in February. As such, these estimates may slightly understate the actual peak winter impact.

3.5 Program Attribution

Overall, in terms of influencing customers to install high efficiency ductless heat pumps, the Program is operated very effectively. While some level of free-ridership is expected in any program design, our research indicates that without the interventions offered by the Program, only 1 in 5 of the customers would have purchased an equivalent heat pump for their home or business. In addition, the Program is also influencing the larger heat pump market, as 1 in 14 of the Program participants purchased additional heat pumps outside of the Program due to their experience with the Program and the equipment it incented.

Using self-reported responses, the research team's estimation of net savings attempts to assess the Program's influence on participants' decision to install a heat pump and what would have occurred absent the Program's intervention. Sources of influence include the Program's educational campaigns designed to raise awareness of heat pumps, the rebates offered by the Program that reduce up-front installation costs, and the availability of on-bill financing. This estimation includes an examination of the Program's influence on two key characteristics of the project: timing and the type of heat pump installed. This estimate represents the amount of savings attributed to the Program that would have occurred without its intervention and is often referred to as "*free-ridership*." A large percentage of "free-riders" in an energy efficiency program indicate that credit for the program's results cannot be attributed back to the program's actions.

The team's measurement of net savings also estimates program influence on the installation of additional heat pumps as a result of the indirect effects of the program's activities. This estimate, often referred to as "*spillover,*" represents the impact of the program that occurred because of the program's intervention and influence but that is not currently attributed to the program. In order to capture a comprehensive picture of a program's impacts, credit for spillover impacts must be attributed back to the program's actions.

The Program's gross impacts are adjusted by both free-ridership and spillover at the project-level to determine net impact. The net impact of the Program, summarized in Table 3-10 below, is frequently expressed as a "net-to-gross ratio" and can be calculated as:

Net-to-Gross Rate = 100% – Free-ridership Rate + Spillover Rate

Table 3-10. Net-to-Gross Summary

Net Impact Category	Evaluation Estimate
Free-ridership	19%
Spillover	7%
Net-to-Gross Ratio *(100% - Free-ridership + Spillover)*	88%

Free-Ridership

The research team estimated that approximately 19% of the Program's impact is the result of free-ridership. That is, approximately 19% of the heat pumps installed through the Program would have been installed absent any program intervention. This estimate includes both "full" free-riders and "partial" free-riders. "Full" free-riders are those that reported that would have purchased the exact heat pump at the same time without any assistance from the program. "Partial" free-riders are participants that would have installed the heat pump, but whose decision to do so was impacted in some manner by the Program. To account for both the "full" and "partial" free-riders, we have weighted the "partial" free-riders by 50%.

To classify participants' free-ridership level, the research team relied on self-reported responses to survey questions regarding the impact of the Program on their decision to install the heat pump. To minimize recall error, the research team administered this survey shortly after the heat pump was installed. Table 3-11 below summarizes our classification of the participants, while

Figure 3-1 illustrates how the research team used question responses to determine free-ridership status.

Table 3-11. Free-ridership Classification Summary

Classification	Number of Participants	Percentage of Total
Non-Free-Rider	216	72%
Partial Free-Rider	48	16%
Free-Rider	35	12%
Total	**299**	**100%**

Figure 3-1. Free-Ridership Analysis Flowchart

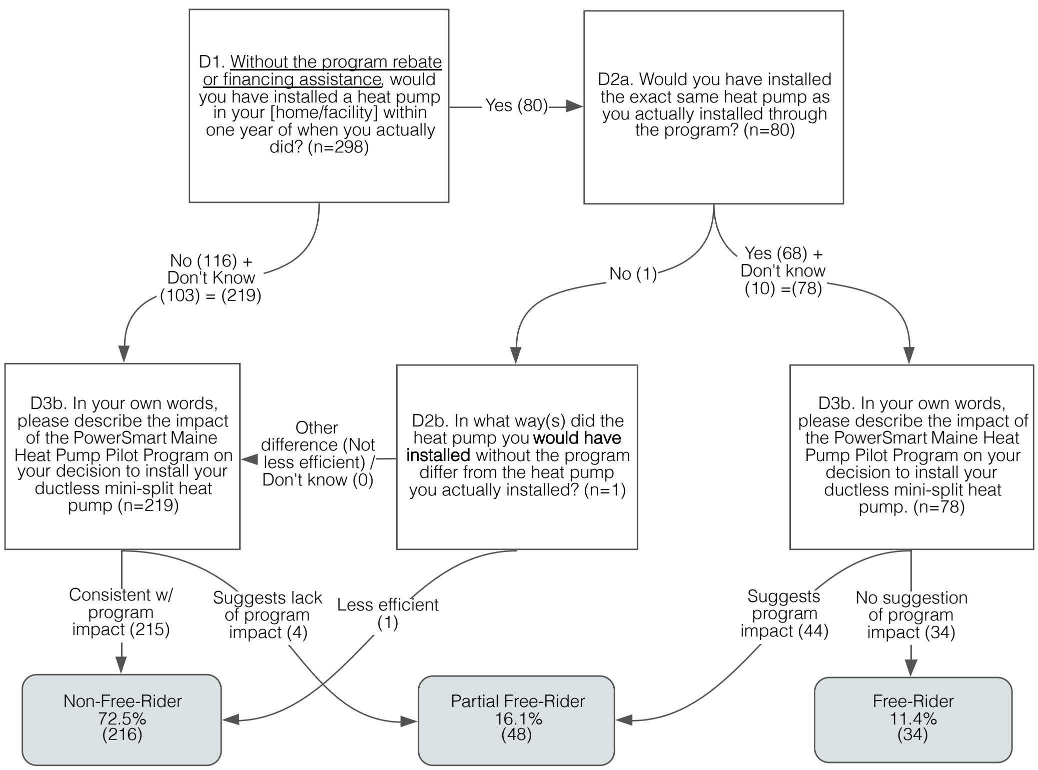


Table 3-12 below details how the research team classified free-ridership based on self-reported responses. Participants were often categorized as "partial" free-riders if they said they would have installed a heat pump within one year without the program, but when asked to describe the program's impact on their installation, provided an explanation that indicated some level of program influence. These explanations included suggestions that the program:

- Made it possible for them to install a heat pump earlier in the year than they otherwise would have.
- Provided useful information about heat pumps and/or increased their confidence in the claims made about heat pump savings.

- Encouraged them to move forward with the installation they were already considering.

Table 3-12. Free-ridership Classification by Reported Action

Participants' Reported Action Without Program Intervention	Non-Free-Rider	Partial Free-Rider	Free-Rider	Total
Would have installed the exact same heat pump.	0	40	29	69 (23%)
Would have installed a heat pump but don't know if it would have been the same.	0	4	6	10 (3%)
Would have installed a different heat pump.	1	0	0	1 (<1%)
Don't know whether or not they would have installed a heat pump.	101	2	0	103 (34%)
Would not have installed a heat pump within one year.	114	2	0	116 (39%)
Total	**216 (72%)**	**48 (16%)**	**35 (11%)**	**299**

Spillover

In addition to free-ridership, the research team also estimated that approximately seven percent of program participants installed an additional heat pump as an indirect result of their participation with the Program. These "spillover" heat pumps increase the Program's cost effectiveness by providing benefits to participating customers while creating no additional costs to the Program administrators.

To estimate spillover, the research team relied on a similar approach to estimating free-ridership. Using responses to a survey completed approximately six months after the installation of the heat pump (this lag allowed adequate time for participants to complete the installation of additional heat pumps), the research team determined the number of additional heat pumps installed and measured the self-report impact of the Program on participants' decision to complete other actions aimed at increasing their home or business's energy efficiency.

In order to be considered spillover heat pumps, participants had to report installations that met three criteria:

1. The heat pump must have been installed either at the same time or after the Program heat pump
2. The heat pump must meet program criteria
3. The participant must report that his or her participation with the Program impacted their actions

Table 3-13 below details the number of heat pumps reported by participants for each of the criteria described above. Assuming that each heat pump has similar impact, the spillover estimate is the number of qualifying heat pumps per program participant. As such, the research team estimates that seven percent of the participants' installed an additional energy efficient heat pump as a result of their program participation.

Table 3-13. Spillover Criteria and the Number of Qualifying Heat Pumps (n=180)

Heat Pump Spillover Criteria	Number of Qualified Heat Pumps
Heat pump installed after program participation	31
Installed heat pump qualified for program	16
Program participation influenced installation	13

4. MARKET RESEARCH RESULTS

This section of the report provides an overview of the current ductless heat pump market in Maine. Specifically, this section addresses the following research questions:

1. What are the relevant market indicators for the ductless heat pump market?
2. What motivates customers with high-energy burdens to participate in a heat pump program?

These results document the impact the Program activities have had on the larger heat pump market, by providing information on several different facets of this market. Given that cold weather energy efficient heat pumps are an emerging technology in the Maine HVAC market, tracking the market effects of the program acknowledges the impact of the program outside of participants. The market effects indicators selected by the research team include:

- Awareness and knowledge of heat pumps
- Utilities as first source of information regarding energy savings
- Market saturation
- Market share

In addition to updating the baseline market indicators, this section also describes customer interest in financial support for purchasing heat pumps. This information provides insight into the types of incentives and program structures that customers find most valuable with the intent of informing future program design.

4.1 Market Transformation Indicators

Given the timeframe of our evaluation (a 12-month period), the Program appears to have had a positive impact on the ductless heat pump market by raising awareness of heat pumps as an energy efficient technology and increasing the market share of energy efficient heat pumps. To accurately measure the effect of the Program on the heat pump market in Maine, the research team developed a set of market indicators through a collaborative effort with program staff and Efficiency Maine. The team calculated market indicators by analyzing data collected from the general population telephone survey along with in-depth interviews with installers and distributors.

In January 2013 and January 2014, the research team, working with a telephone survey firm, conducted two telephone surveys with the general population in an effort to measure the Program's success in impacting the heat pump market. The 2013 research measured "baseline" conditions (i.e., the conditions prior to the program's implementation) while the 2014 research measured "post" conditions (i.e., conditions after the program's implementation).

Table 4-1 below and the following sections summarize and describe these indicators and their relation to the heat pump program.

Table 4-1. Market Indicators

Market Indicator	Definition	Source of Information	Numerator	Denominator	Base-line	Post-period
Awareness and knowledge of heat pumps	Percentage of customers that report at least some familiarity with ductless heat pumps	General population survey (n=141)	Number of customers who reported "Somewhat familiar" or "Very familiar" to question D4a	Total number of customers in General Population Survey	**19%**	**35%**
Utilities as first source of information regarding energy savings	Percentage of customers who report BH or MPS as their first source of information on saving energy	General population survey (n=141)	Number of customers who first turn to BH or MPS as a source of information on saving energy	Total number of customers in General Population Survey	**13%**	**11%**
Market saturation	Percentage of customers who report that they have a heat pump installed at their home or business	General population survey (n=141)	Number of customers who report that they have a heat pump installed at their home	Total number of customers who are eligible for the program	**3%**	**3%**
Energy efficient market share	Percentage of heat pumps sold in 2013 that distributors reported as program-eligible (i.e., energy-efficient), weighted by 2013 sales data.	Sales data and eligibility estimates from distributors (n=3)	Number of program-eligible heat pumps sold in 2013	Total number of heat pumps sold in 2013	**50%**	**64%**

Awareness and Knowledge of Heat Pumps

The program was successful in increasing awareness of heat pumps among this population. Using the data collected from the second wave of the General Population Survey, the research team describes in the following section the progress the Program has made since baseline awareness and knowledge of heat pump technology among customers was measured (i.e., before program action). In the year since the market indicators were established, the amount of customers who describe themselves as "very familiar" or "somewhat familiar" with ductless mini-split heat pumps has increased to 35% of the general customer population, a sizable increase over the 19% of customers who described themselves similarly in 2013. As shown in Table 4-2 below, the increased awareness of heat pumps is equally represented in the Bangor Hydro and Maine Public Service territories.

Table 4-2. Familiarity with Ductless Heat Pumps, by Year

Year	Bangor Hydro	Maine Public Service	All Residential	90% CI
2013	20%	14%	19%	± 5.89
2014	34%	38%	35%	± 6.63

Utilities As a Source of Information Regarding Energy Savings

The research team could not identify any change in the percentage of Emera Maine customers that use Emera Maine as a source of information regarding energy savings. In the 2014 survey, the research team found that 11% of the respondents looked to their utility first as a source of information regarding energy savings, compared to the baseline value of 13%. However, given the margin of error due to the sampling, this difference is not statistically significant. Note that nearly half (48%) of respondents reported utilizing an internet search as their first resource for information on energy savings—a resource that may have led respondents to information distributed by utilities or to utility web sites.

Market Saturation

During the 12-month time period the research team could not identify any change in the market saturation of heat pumps among Emera Maine customers. The research team defined market saturation as the percentage of customers who reported that they have a heat pump installed in their home compared to the total number of homes that would be eligible for the program. Since the research team last surveyed this population, residential market saturation has stayed at 3%. Results of this analysis are presented in Table 4-3 below.

Table 4-3. Percent of Customers Who Have Installed a Heat Pump in Their Home[7]

Year	Bangor Hydro	Maine Public Service	All Residential	90% CI
2013	3%	6%	3%	± 2.54
2014	3%	1%	3%	± 2.37

Energy Efficient Market Share

The Program appears to have had a significant impact on the market share of energy efficient heat pumps sold to Emera Maine customers. The energy efficiency market share represents the distributors' estimate of the percentage of heat pumps sold in 2013 that were program-eligible

[7] This is based on the question D10a from the General Population Survey: *Do you have a heat pump installed in your home?* Results in the "All customers" row and column are weighted by the utility company of the overall population.

(this qualification serving as a proxy for energy efficiency). As established in our earlier reporting, three of the five distributors provided detailed sales data and estimates of the percent sold that were program-eligible, and two of the distributors were "not authorized" to release any sales data and therefore were not included in the market share calculation (shown in Figure 4-1 and Table 4-4)[8]. Based on these estimates, the research team calculated a market share of 64%, a sizable 14% increase over the baseline of 50%.

Figure 4-1. Number of Heat Pumps Sold by Distributor

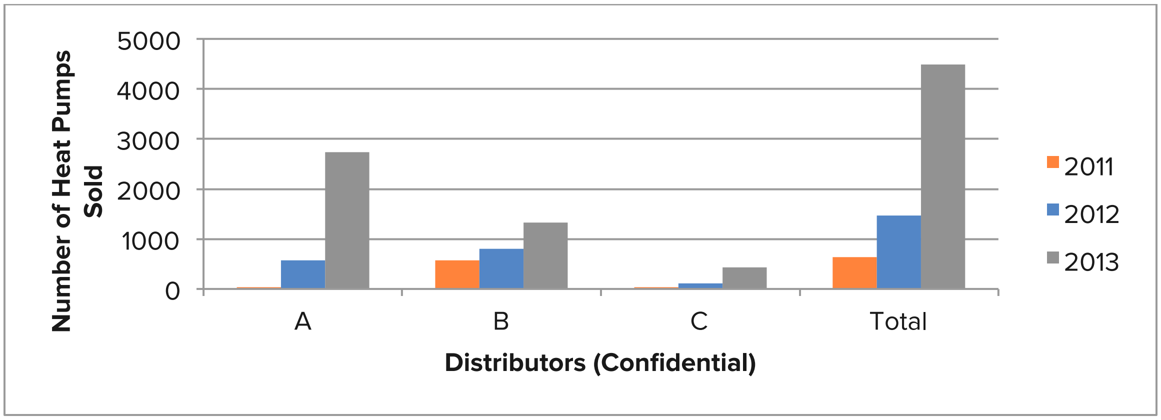


Table 4-4. Heat Pump Sales Reported by Distributors

Distributor (Confidential)	Total Heat Pumps Sold 2011	Total Heat Pumps Sold 2012	Total Heat Pumps Sold 2013	Estimate of Eligible Heat Pumps in 2012	Estimate of Eligible Heat Pumps in 2013
A	34	569	2,733	70%	70%
B	575	800	1,324	35%	50%
C	31	106	430	50%	93%
Total	640	1,475	4,487	50%	64%

[8] Based on conversations with all distributors, the two not represented in our analysis account for a small portion of the overall heat pump sales in the Bangor Hydro and Maine Public Service territories.

5. PROCESS EVALUATION RESULTS

The overall goal of the process evaluation was to provide program administrators and implementers with insightful information and feedback on program operations and delivery in order to understand pilot program success and optimize the design and implementation of individual program elements. The process evaluation identified whether organizational structures can support program implementation and whether the program design effectively overcomes the identified barriers to lead to the increased purchase and installation of ductless heat pumps to achieve the intended program outcomes. Specifically, this evaluation was designed to answer the following questions:

1. Were the Program activities implemented as planned?
2. What was the customer experience with the Program?
3. What was the contractor experience with the Program?
4. What barriers exist to contractor participation, customer use of rebates, and customer use of on-bill financing?
5. Did the Program generate the intended outcomes?

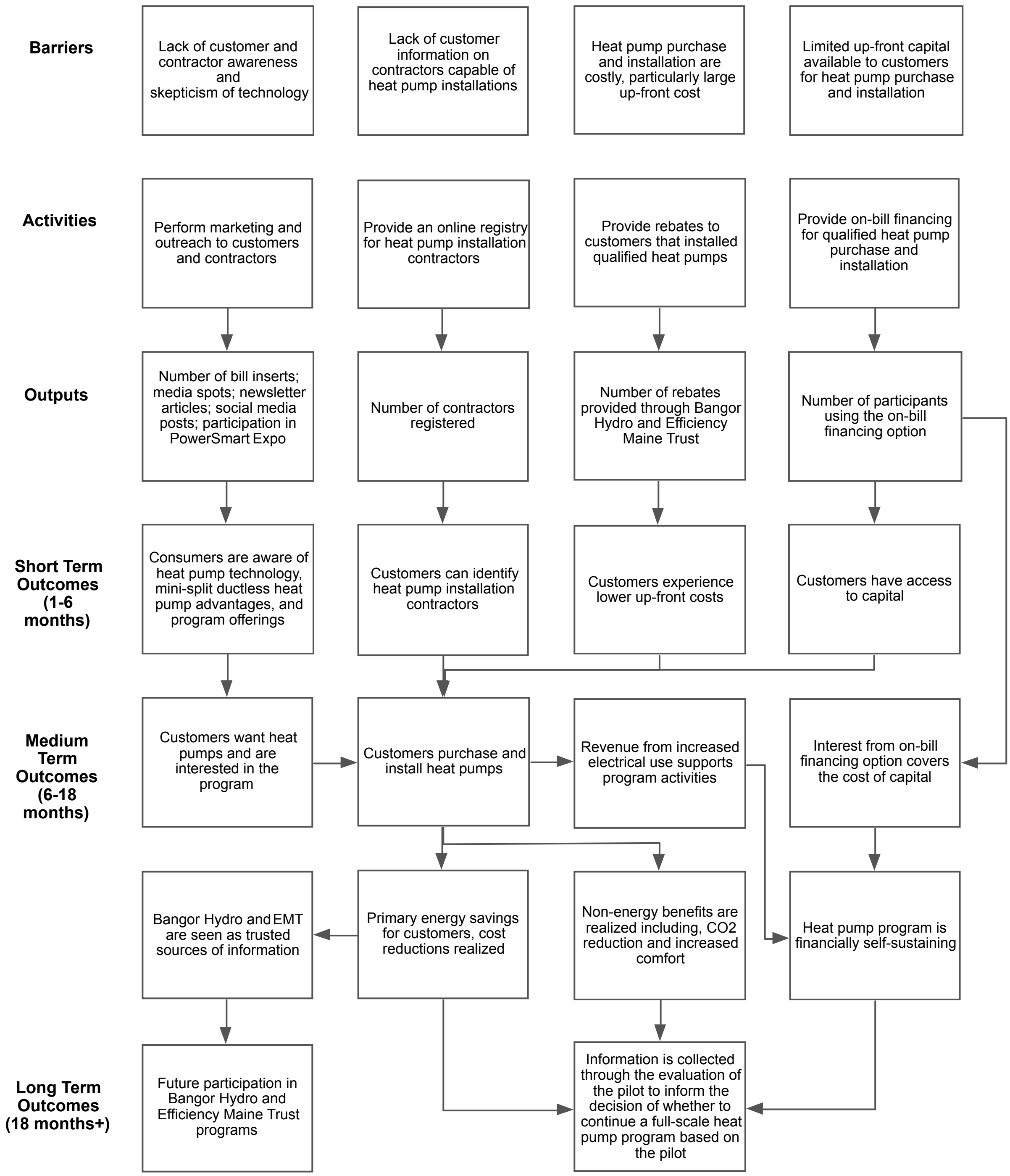
5.1 Program Implementation

Per program data, the Program was fully subscribed as of October 2013, exceeding its participation targets. Additionally, 15% of participants (n=142) participated in the on-bill financing portion of the Program. A large majority of participants were residential customers (n=908 or 96%) and generally applied for the Program online (58% of all applications).

Figure 5-1 below illustrates the Program's logic model. Identified barriers are shown in the first row of boxes in the model. The second row of the diagram shows program activities, followed by outputs from each of these activities. This is followed by expected short-term (1 to 6 months), medium-term (6 to 18 months), and long-term (18 months and greater) outcomes. To create this model, the research team interviewed utility program staff, researched other programs and program evaluations regarding heat pumps and on-bill financing, and moderated collaborative discussions with program implementation staff to revise and finalize the model prior to program implementation. This model serves as a visual tool to document the program rationale, planned activities, and expected outcomes. It also serves as a framework for the evaluation by highlighting key linkages between program activities and expected outcomes.

As the Program was intended as a pilot program to test various implementation approaches, it evolved over time to streamline program operations and leverage effective strategies. For pilot programs, the research team considers this continual improvement process a best practice. As such, the research team highlighted these changes **in bold** to the program theory in the model below. The key change was the addition of a referral program for program participants to encourage "word-of-mouth" marketing.

Figure 5-1. Heat Pump Program Logic Model



As a new program offered to the Utilities' customers, the Program faced an initial challenge of raising awareness regarding its existence. Per the team's review of the Program's marketing efforts, program staff completed a comprehensive marketing campaign supplemented by persistent in-person communication that resulted in the Program achieving its participation goals. This marketing campaign included:

- **Email communication with heat pump installers, potential participants, and local interested organizations (e.g., chambers of commerce, news outlets).** The Program sent 4,563 emails in the first seven months after launch.
- **Earned media with local news outlets including newspapers, radio programs, television news programs.** The Program earned 25 different placements throughout the year, including the Bangor Daily News (readership of 135,000) and the Portland Press Herald (readership of 74,000).
- **Direct mailings to customers and installers.** The Program included information about heat pumps and the application process in over 1 million direct mailings to customers. The Program also sent 155 direct mailings to installers participating in the Program.
- **In-person installer trainings on Program offerings and processes.** The Program conducted five trainings attended by 186 installers.
- **In-person presentation of the Program offerings at local community groups (e.g., Rotary clubs).** Program staff presented at 15 different gatherings, communicating the benefits of heat pumps and providing assistance with the application process.
- **Presence at applicable trade and home shows.** The Program had a presence at 9 different trades shows with over 11,000 attendees.
- **Paid web, print, radio, and television advertising spots.** The Program purchased three web spots (with a total impressions of 179,000 readers), 11 print advertisements (with a total impressions of 708,000 readers), 8 radio spots, and 4 television spots (total weekly viewership of 587,000).
- **Social media presence on Facebook and Twitter.**

As the program successfully met its enrollment targets and was over-subscribed in just 8 months, the research team determined that these methods were effective at encouraging customers to enroll in the Program. In addition, the team observed close cooperation and coordination between program staff and utility staff to respond quickly to new marketing opportunities. The research team believes that because program staff were able to quickly adapt marketing efforts to communicate with potential participants, the Program was able to maximize its marketing resources. Finally, analysis by Emera Maine and Efficiency Maine indicates that marketing activities were correlated with increases in applications, suggesting that marketing effectively encouraged customers to apply to the program.

5.2 Customer Experiences

In general, participants reported very positive experiences with the Program, indicating that "behind the scenes" processes did not present a barrier for participation. In order to better understand how the Program may improve engagement with future participants, the research team examined several aspects of the customers' experience, including:

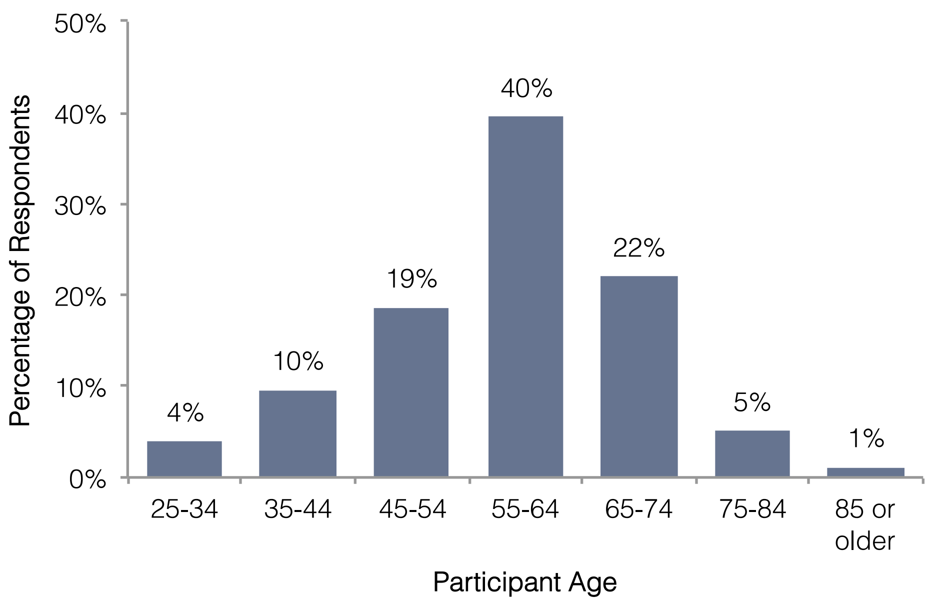
- Participant characteristics
- Awareness of the program and heat pump technology
- Motivations for participating
- Participant satisfaction with the Program
- Experience with program financing

Participant Characteristics

In general, participants in the Program tended to be between the ages of 55 to 64 with a secondary education and relatively high household incomes. In addition, while their homes tended to be of an older vintage (pre-1977), a majority had been weatherized. To better understand whom the Program is serving, the research team collected demographic data on participants through the Customer Satisfaction survey for 177 program participants to date (the survey is still in progress as of this report). These data include information on participants' age, household income, education, and home vintage.

First, the Program is generally serving older customers. The largest portion of respondents (40%) fell into the 55 to 64 age group. An additional 23% of respondents reported that they were between the ages of 65 and 74. The US Census Bureau estimates that only 15% of Maine's population falls into the 55 to 64 age group and only 9%in the 65 to 74 age group.[9] While the age difference between survey respondents and the general population might be partly explained by self-selection bias in the survey, these differences suggest that program participants tend to be older than the general population of customers. The age distribution of respondents is shown in Figure 5-2 below.

Figure 5-2. Ages of Program Participants (n=177)



In addition, respondents tended to be relatively highly educated with mid-level to high household incomes. More than half of respondents (53%) had achieved a bachelor's degree or higher, while 11% had a high school or lower level of education. In contrast, the US Census Bureau estimates that only 27% of Maine's population (age 25 or older) has a bachelor's or higher degree, while 43% has a high school or lower level of education[10]. While 67% of respondents reported a household income of $50,000 or more, only 47% of Maine households overall fall into this category[11]. The distribution of respondents' household incomes is shown in Figure 5-3 below.

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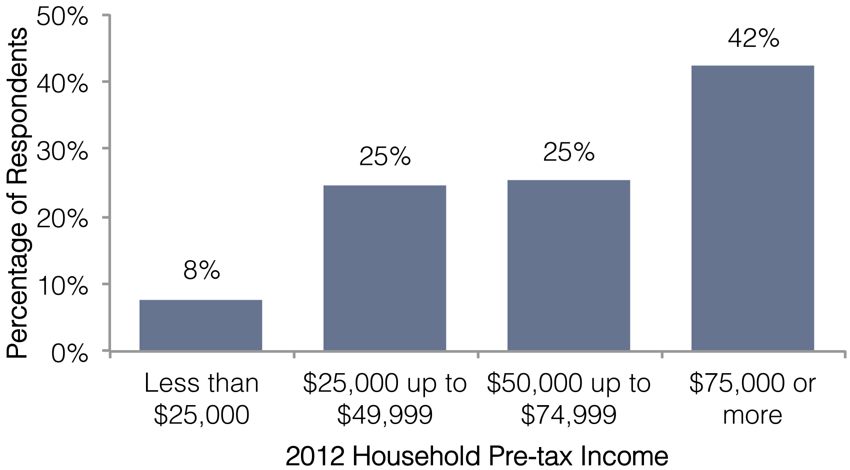
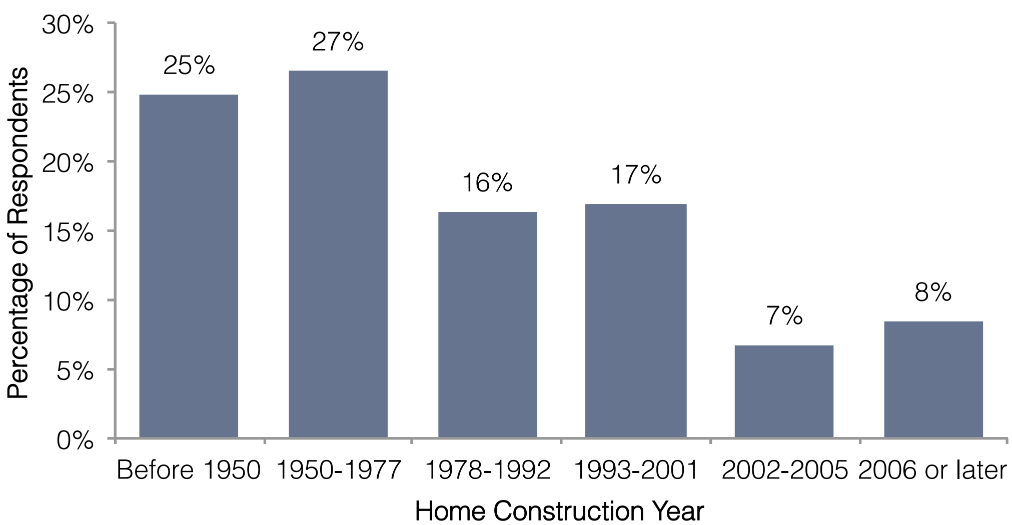
[9] U.S. Census Bureau, 2012 American Community Survey
[10] U.S. Census Bureau, 2012 American Community Survey
[11] U.S. Census Bureau, 2012 American Community Survey

Figure 5-3. Respondent Incomes (n=154)



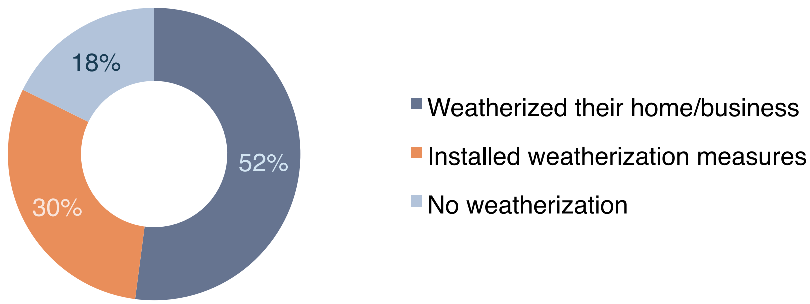
Most respondents' homes were of an older vintage, with a majority of homes having been constructed prior to 1978. Few homes could be considered "new," with only 8% of respondent homes constructed since 2006. The distribution of home construction years is show in Figure 5-4 below.

Figure 5-4. Construction Year of Participant Homes (n=177)



Interestingly, despite being older homes, the research team found that participants are installing the Program heat pumps in homes and businesses that have been weatherized. When asked, 52% of respondents reported that they had weatherized their home or business, and an additional 30% of respondents indicated that they had installed some weatherization measures (e.g., insulation, weather-stripping, new windows or doors). These results are shown in Figure 5-5 below.

Figure 5-5. Weatherization Status of Program Participants (n=169)



Finally, many of the participating homes had a secondary heating source aside from heating oil (making the heat pump the third heating source in their household). Mostly, households heated their home with wood (or wood pellets), propane, and electric resistance heat. Table 5-1 below summarizes the additional heating sources as reported by participants.

Table 5-1. Additional Heating Source (Aside From Fuel Oil And Heat Pumps)

Heating Source	Percentage of Participants (n=174)
Wood	19%
Wood Pellets	18%
Propane	18%
Electric Resistance	7%
Kerosene	5%

Program Awareness

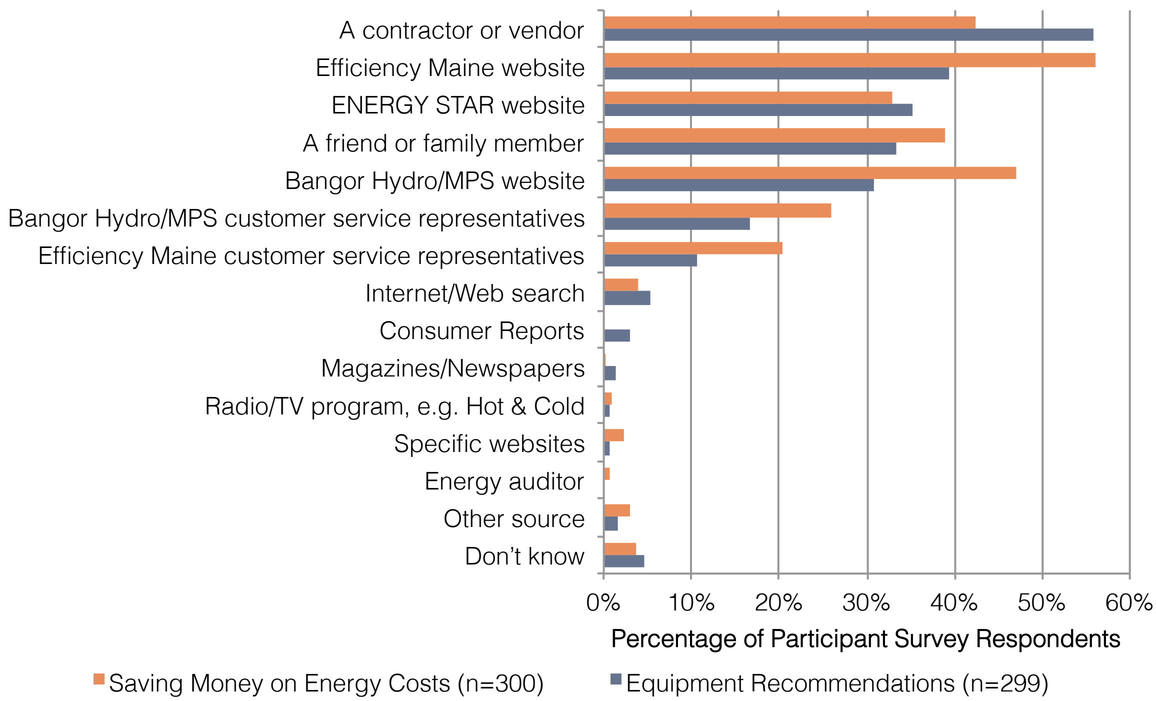
As noted above, because the Program was a new offering for Emera Maine, it initially faced a challenge in educating potential participants about its offerings. Respondents first learned about the program through a friend or family member (26%), a flyer with a bill (19%), or through a HVAC vendor or contractor (12%).

Sources of Information about Energy Efficiency

Overall, customers trust the Utilities and Efficiency Maine for information about energy efficiency, but they also use other sources of information. The general customer population tends to rely less on these organizations for their information than do program participants.
Program participants indicated that they see their utility and Efficiency Maine as trusted sources of information about energy efficiency. When asked what specific sources they turn to for information about saving money on energy costs, the most frequent responses were the Efficiency Maine website (56%), followed by utility websites (47%), vendors/contractors (42%), and friends or family (39%). For information about different types of equipment they might install, responses were slightly different, but Efficiency Maine and the Utilities still figured prominently in

the responses. Contractors/vendors and Energy Star were also common sources of equipment information. Figure 5-6 shows all reported sources for each type of information.

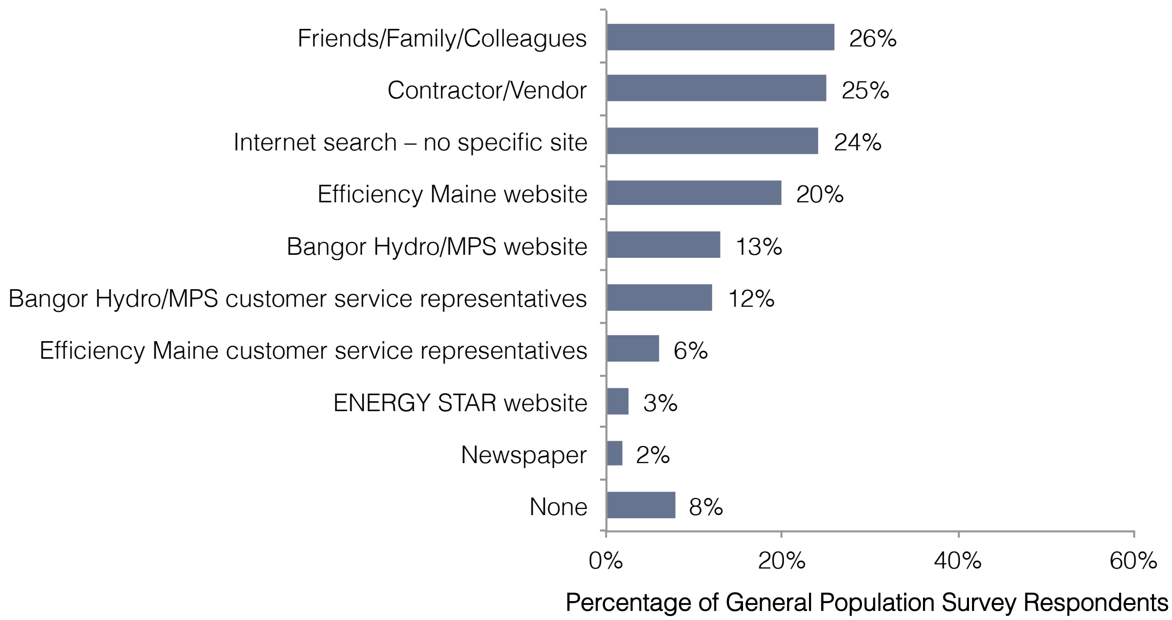
Figure 5-6. Sources of Information about Energy Efficiency – Program Participants (n=300)



The General Population Survey also collected data regarding sources of information about energy efficiency with somewhat different results[12]. In contrast with program participants, the general population had a more even distribution of energy efficiency information sources. The Efficiency Maine website and utility websites were much less prominent sources of information among the general population than among program participants. For example, while 56% of program participants turn to the Efficiency Maine website for information on how to save energy, only 20% of the general customer population reported going to the site for information about energy efficiency. Among the general population, the most prominent sources of energy efficiency information, as summarized in Figure 5-7 below, were family, friends, or colleagues, contractors/vendors, and web searches.

[12] Note that question wording was slightly different between the two surveys. For the Participant survey, we asked, "When you are looking for ways to save money on your heating, electricity, or other energy costs, to which of these sources would you go for information?" and, " When considering different types of appliances or heating and cooling equipment to install, to which of the following sources would you be likely to go for specific appliance/equipment recommendations?" For the General Population survey we asked: "When you have questions about how to save energy at your home or business, where do you first look for answers? What other sources do you use when you have questions about energy efficiency or energy efficiency upgrades for your home or business?"

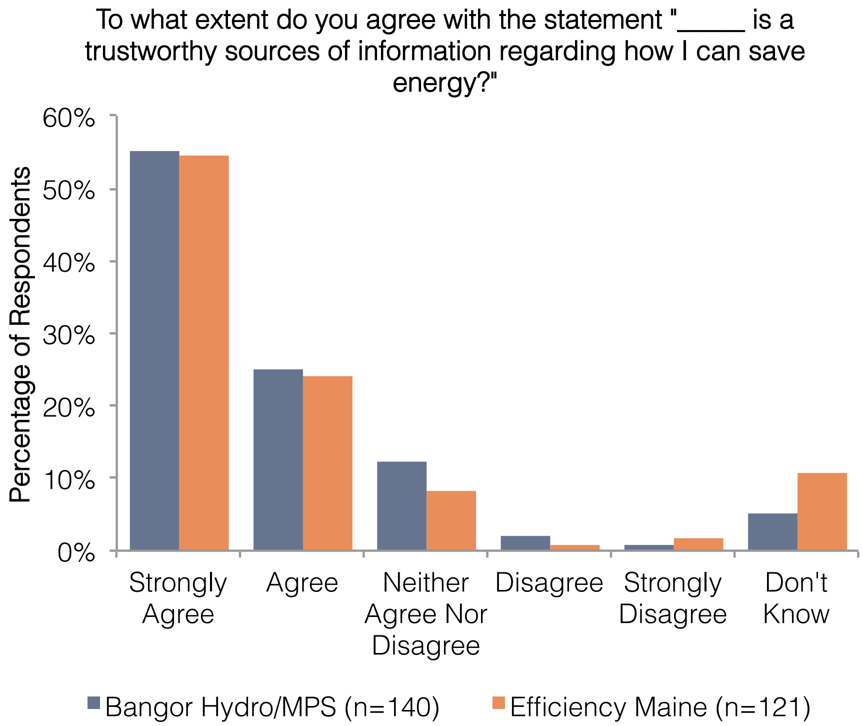
Figure 5-7. Sources of Information about Energy Efficiency – General Population (n=116)



While the difference in information sources between the participant and general population groups may reflect program influence on perceptions of Efficiency Maine and the Utilities, it may also simply indicate that those customers who already rely on these organizations for information have a greater tendency to participate in programs. While available data do not allow us to distinguish between the two factors, the research team hypothesizes that both influences are at work to some degree.

We also asked the general population to rate the degree to which they agree that their utility and Efficiency Maine are trustworthy sources of information about saving energy. Agreement was typically high, with nearly 80% of respondents saying they strongly or somewhat agree for each organization. The distribution of responses is displayed in Figure 5-8.

Figure 5-8. Perceived Trustworthiness of Utilities and Efficiency Maine



Participation in Additional Energy Efficiency Programs

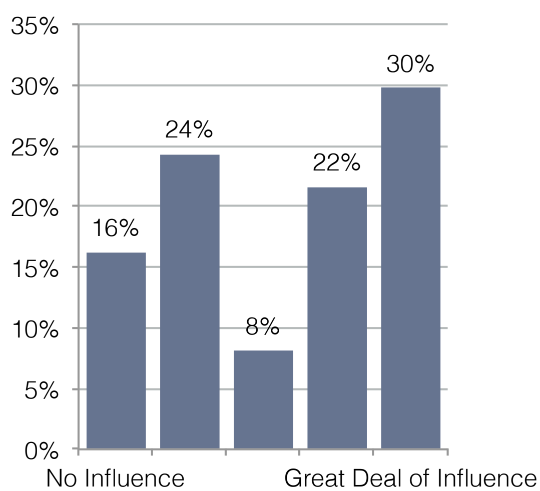
The Program effectively encouraged participants to participate in additional energy efficiency programs offered by Efficiency Maine. Approximately six months following heat pump installation, 135 of the 173 pilot participants (78%) reported that they had not participated in other energy efficient programs since their involvement in the Program. Table 5-2 below highlights the specific programs mentioned by the 38 customers who have participated in additional programs; these respondents represent only residential customers. For comparison, this table also provides the percentage of overall Maine households enrolled in the programs. From this data we conclude that Program participants enrolled in programs more frequently than the average household.

Table 5-2. Residential Customers' Participation in Additional Energy Efficiency Programs

Program Name	Number of Participating Respondents	Percentage of Residential Respondents	Percentage of Maine Households Enrolled (N=550,000)
Efficiency Maine Appliance Rebate Program	22	13%	4%
Efficiency Maine Residential Air Sealing Program	9	5%	1%
Efficiency Maine Refrigerator Recycling Program	7	4%	1%
Efficiency Maine Renewable Energy Programs	6	4%	0%
Efficiency Maine Multifamily Efficiency Program	1	1%	< 0%
Efficiency Maine PACE Loan Program	1	1%	< 0%
Other program	5	3%	-

Respondents were fairly split in how influential the pilot program was on their decision to participate in additional programs. As shown in Figure 5-9, 41% of respondents indicated little to no influence (rating a 1 or 2), and 51% indicated a fair amount of influence (rating a 4 or 5). Across all respondents, the average level of influence was 3.2, indicating moderate influence of the program. However, there were some differences in levels of influence based on the additional programs. Specifically, customers who participated in the Efficiency Maine Residential Air Sealing Program (n=9) and the Efficiency Maine Refrigerator Recycling Program (n=6) reported a higher average influence of the pilot program on their decision, with scores of 3.9 and 3.7 respectively. However, less influence was attributed to customers' experience with the pilot program for those respondents who also participated in the Appliance Rebate Program (n=21; score of 3.1) and Efficiency Maine Renewable Energy Programs (n=6; score of 2.5).

Figure 5-9. Influence of Pilot Program on Participation in Other Energy Efficiency Program



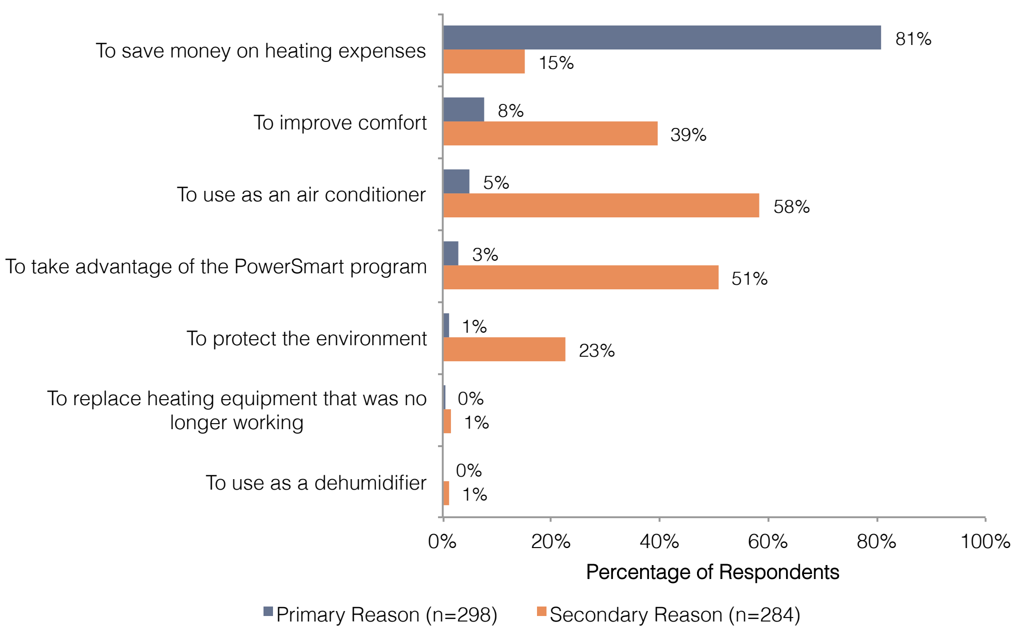
Interestingly, 12 of the 38 customers (32%) who participated in additional programs participated in more than one, indicating that there is a small subset of pilot program participants who are very active in Efficiency Maine programs. These respondents reported that the pilot program had a larger influence on their decision to participate in additional programs (average score of 3.7), compared to the scores provided by the entire group of 38 customers (score of 3.2).

Program Motivations

Program participants primarily installed their heat pumps to save money on their heating expenses, but for some respondents the ability to use the unit for air conditioning also seems to have factored into the installation decision. The vast majority of survey respondents (81%) said saving on heating expenses was their primary reason for installing a heat pump.

A common secondary reason for installing a heat pump, cited by 51% of respondents, was "to take advantage of the program." These responses indicate that the Program provided a meaningful rebate amount that encouraged participants to purchase the heat pump; a conclusion that is corroborated by the attribution analysis presented earlier. While only 5% of respondents said they installed a heat pump *primarily* for air conditioning, more than half (60%) indicated that this feature was among their reasons for choosing a heat pump. Among the 15 respondents who installed a heat pump mainly for air conditioning, 8 (53%) had some kind of air conditioning equipment prior to installing the heat pump. This proportion is not significantly different from the overall portion of respondents who had air conditioners before installing a heat pump (51%). Figure 5-10 summarizes the primary and secondary reasons respondents chose to install a heat pump.

Figure 5-10. Reasons for Installing a Heat Pump



Interestingly, participants who already had air conditioning equipment prior to installing the heat pump were significantly more likely to cite the air conditioning component as a primary or secondary reason they installed a heat pump[13]. While 68% of respondents who already had air conditioning equipment named air conditioning as a reason for installing their heat pump, only 51% of those without air conditioners mentioned this reason.

Furthermore, while the General Population Survey indicated that about 41% of residential customers had air conditioning equipment in place, 51% of program participants surveyed reported having air conditioning before installing a heat pump. These findings suggest that obtaining air conditioning equipment where none had been present is not a significant factor impacting program participation. Instead, participants may be purchasing heat pumps to replace or supplement less efficient existing air conditioners.

Program Satisfaction

Overall, satisfaction with the Program and each of its components is quite high (e.g., participating contractors, response from program staff). This indicates that customers found value in the program and that the program operated smoothly from a customer experience perspective. Based on responses to an online survey with 184 participants, participants reported that they were very satisfied with the program (85% very satisfied), the heat pump (85% very satisfied), and the savings they have seen (78% of participants noticed savings and 83% of those who noticed savings were very satisfied with the amount of savings). In addition, on average, respondents rated the likelihood that they would recommend the Program a 9.7 on a 0 to 10 scale. This is indicative of high levels of satisfaction with the Program and participants' experiences with the heat pumps.

Contributing to this satisfaction, participants in the program are experiencing significant non-energy benefits, including increased comfort during the heating and cooling season and better air quality in their homes. When asked, 55% of participants reported that their comfort level during the heating season had increased. Likewise, 88% of participants reported increased comfort during the cooling season, suggesting that many participants appreciated the cooling and dehumidification capabilities of the heat pump.

Indoor air quality also improved for a significant portion of participants, with 47% reporting improvements (a majority reported either the quality had stayed the same or did not notice a change). In addition, during in-depth interviews several participants mentioned that heat pumps reduced the manual labor required with other heat sources such as wood stoves. While reported by a small number, this impact was significant for several older participants.

Finally, on average respondents rated the likelihood that they would recommend the Program a 9.7 on a 0 to 10 scale. This rating is roughly equivalent to a Net Promoter Score (NPS) of 90%, indicating that the Program's promoters (i.e., those rating their likelihood of recommending the program 9 or 10) substantially outnumber its detractors (i.e. those rating their likelihood of recommending the program 6 or less)[14]. According to the Net Promoter System website, successful, growing companies like Amazon, Costco, Zappos, and others tend to have NPS scores of about 50% to 80%[15]. As such, the Program is considered very successful based on this

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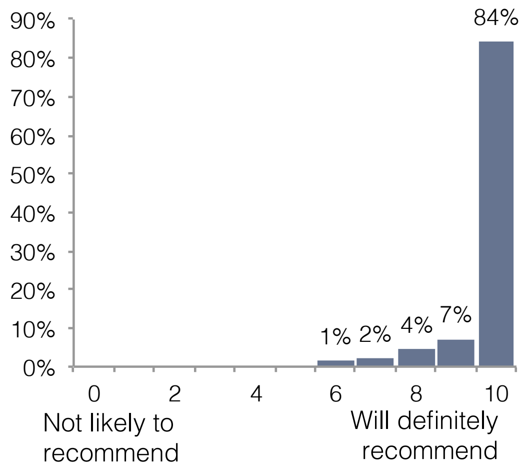
[13] This difference was statistically significant, with a p-value of less than .01.
[14] *Net Promoter Score = %Promoters - %Detractors*
[15] http://www.netpromotersystem.com/about/measuring-your-net-promoter-score.aspx

rating. Figure 5-11 below illustrates the distribution of how participants reported their likelihood to recommend the Program.

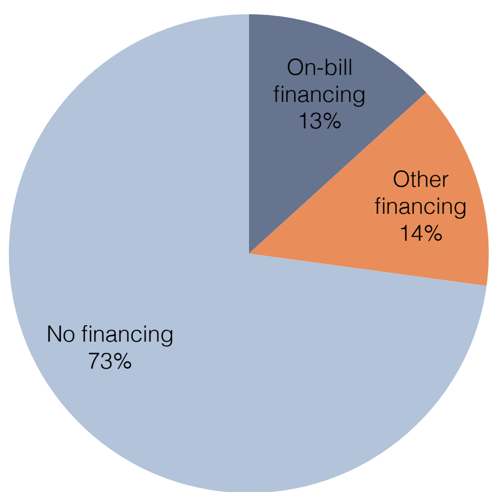
Figure 5-11. Likelihood of Recommending Program (n=297)



Program Financing

While financing is not a major driver of program participation, it does play some role in allowing potential participants access to the capital needed to purchase and install a ductless heat pump. Overall, 27% of respondents reported using some kind of financing to make their heat pump purchase. As shown in Figure 5-12, about half of these participants took advantage of the on-bill option offered through the Program.

Figure 5-12. Self-reported Financing of Program Heat Pump Purchases (n=301)



The appeal of the on-bill financing option was mostly due to its ease of use. Of those that used the on-bill financing option, most (24 of 40, or 60%) reported that they chose to take advantage of that option as they perceived that the utility's application process was easier than other options. Many also indicated they preferred to make their loan payment with their electricity bill (43%) or that on-bill financing was the best option available in terms of interest rates and fees (40%). Roughly a third of these respondents (31%) said they had also considered other financing options before choosing the on-bill option. The most frequently mentioned other financing options considered included (non-specific) bank or credit union loans, credit cards, and home equity loans.

About three-quarters (76%) of the 261 respondents not receiving on-bill financing didn't require a loan to proceed with the heat pump purchase, while some (15%) had access to a loan at a better rate. A small portion of respondents (8%) reported they were unaware that such financing had been available to them[16], and only 6 respondents (2.5%) said they did not qualify for on-bill financing. Of those not receiving on-bill financing, 42 respondents (16%) did finance their heat pump purchase through another source. The most common type of financing was a home equity loan, a (non-specific) bank or credit union loan, a credit card, or a loan from a contractor.

Overall, participants in the on-bill financing portion of the Program were satisfied with the assistance and did not indicate any difficulties making the monthly bill payments. Respondents to the follow-up Customer Satisfaction survey who had taken advantage of on-bill financing (n=26) were mostly satisfied with that aspect of the program. Specifically, 20 (77%) reported that they were somewhat satisfied with on-bill financing; interestingly, no customers reported being very satisfied with on-bill financing. There was only one customer who was dissatisfied with the financing assistance, citing the high interest rate as his reason for dissatisfaction. In total, 21 customers (81%) said they would not make any changes. However, four customers provided recommendations for improving the financing portion of the program, including:

- Improve the billing process so that customers can repay more than what is due (n=2)
- Increase the number of units that can be financed (n=1)
- Lower the interest rate on the loan (n=1)

In addition, communication with program staff indicated that the addition of the on-bill financing payment to customers' monthly bills has not resulted in any missed bill payments. This pattern corroborates the above finding that participants that take advantage of the on-bill financing are largely satisfied with the experience.

5.3 Installer Experiences

As the interests of the Program and installers were often aligned (both want to install more heat pumps), installers often acted as the de facto "sales force" of the Program. For the Heat Pump Program, installers are largely and effectively operating as this sales force, working with and educating customers regarding Program opportunities. To explore this interaction, the research team examined the following aspects of the installers' experience with the Program, including:

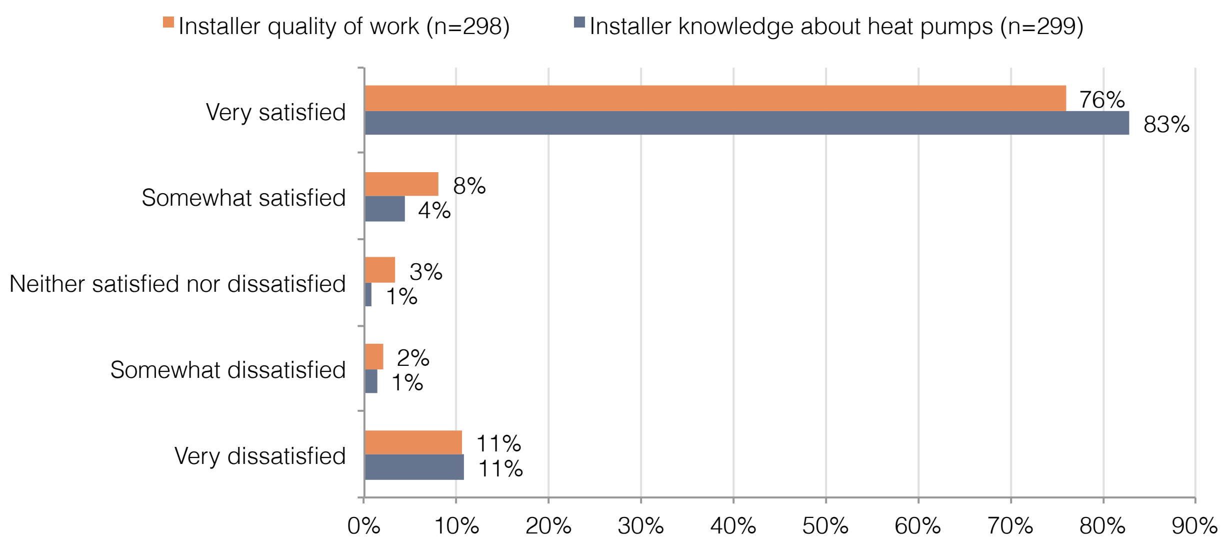
- Installation quality
- Knowledge of the program
- Program marketing
- Heat pump installation trends

[16] Of these 21 respondents, only 1 said they would have been interested in such financing had they known of it.

Installation Quality

Immediately following heat pump installation, customers reported on the work of their installers. On average, customers were satisfied with both their installers' quality of work and their installers' knowledge specific to heat pumps, as shown in Figure 5-13. Satisfaction with installers averaged 4.4 on a 1 to 5 scale, but respondents were slightly (but significantly) more satisfied with contractors' knowledge of heat pumps and the quality of their work than with their knowledge of the program[17].

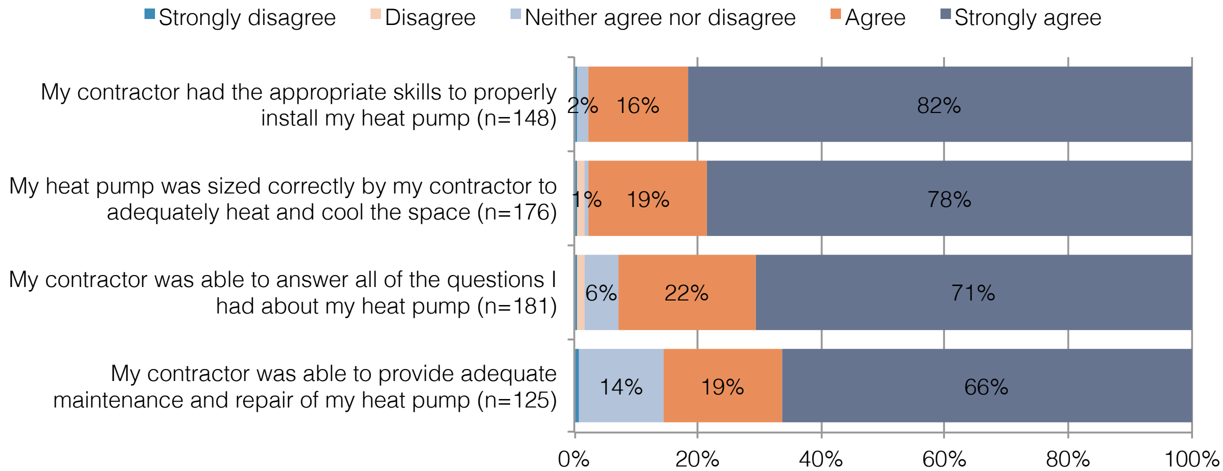
Figure 5-13. Customer Satisfaction with Installer Quality of Work and Knowledge Directly Following Installation



The team followed-up with customers approximately six months after installation. In this second round of questions, customers were again asked to report on the skills and knowledge of the contractors who had installed their heat pumps. Figure 5-14 below highlights customers' overwhelmingly high opinion of installers' capabilities in regards to installing and servicing heat pumps.

[17] p=.001, .005, respectively.

Figure 5-14. Customer Opinion of Installer Skill and Knowledge Six Months Following Installation



It is important to acknowledge that only one customer reported strong disagreement across these questions, and should thus be considered an outlier case. The four customers who reported disagreement with their installers' ability to properly size the equipment (n=2) and answer questions about the equipment (n=2) were otherwise satisfied with their installers' level of knowledge and skills.

In total, nine customers who had issues with their heat pumps contacted their original installers. Their level of satisfaction in these interactions was varied: two were very dissatisfied with their responses, one was neither dissatisfied nor satisfied, two were somewhat satisfied, and 4 were very satisfied. Unfortunately, only one respondent specified the reason for their dissatisfaction, which was related to scheduling and following through with the customer's repair needs.

Knowledge of Program

Overall, customers reported that installers have adequate knowledge of the Program, including what assistance it offers to participants and how to complete the necessary program paperwork. Directly following heat pump installation, customers reported on their satisfaction of their installer's knowledge about the Program. Of the customers that provided a response (n=295), 76 percent reported being very satisfied, and 8 percent satisfied; dissatisfied customers represented 13 percent of the responses. In addition, six months following installation during the Customer Satisfaction survey, 91 percent of the 180 customers who answered the question said they agreed that their contractor was knowledgeable about the rebate process. This finding indicates that the Program's application process was simple and easy to understand and that the Program did an effective job communicating program requirements to the participating installers.

Program Marketing

Overall, installers are accurately marketing the Program to their customers and have avoided "overpromising" either what the Program can offer and what a ductless heat pump can deliver. Specifically, 94% of the 176 respondents in the Customer Satisfaction survey agreed with the following statement: *The information provided to me about the PowerSmart Maine Heat Pump Pilot Program by my contractor was accurate and reflected the experience I have had with my* *heat pump thus far.* No customers disagreed with this statement, and 72% indicated that they strongly agreed. Additionally, 88% of the 177 customers who reported an opinion said that their heat pump has been operating as well as had been advertised by contractors and program material. These two data points illustrate that customer experiences with their heat pumps and the Program align with what was advertised by contractors.

Likewise, installers are actively marketing the Program to potential customers. Of the 14 installers who were asked the question during in-depth interviews, all reported discussing the Program with their customers. Two additional installers who were aware of the Program said they had not had the opportunity to discuss the program with their customers yet. However, installers also highlighted the fact that customers are frequently the ones pushing for the installation of ductless heat pumps (12 of 12 asked the question), so for some customers promotion of the technology is unnecessary. This finding suggests that the Program marketing is effective at encouraging heat pump installations as customers become more aware of the technology.

In addition, installers are frequently recommending heat pumps. Of those installers that were asked the question (n = 19), all recommend ductless heat pumps to their customers. When asked if they promote ductless heat pumps over other types of heating or cooling equipment, four of the seven installers said that they do, while the remaining three said that they promote ductless heat pumps to the same degree as other equipment. Eight installers were asked to report on how often they recommend heat pumps to customers when they are a good fit; responses ranged from 25% to 100% of the time, with a mean response of 89% of the time.

Heat Pump Installation Trends

Per program documentation, a majority of the heat pumps installed as part of the program are Fujitsu heat pumps. Table 5-3 below details the number of heat pumps installed as part of the Program as of September 25, 2013.

Table 5-3. Heat Pump Installation by Brand

Brand	Number Installed	Percent of Total
Fujitsu	820	88%
Mitsubishi	86	9%
Daikin	22	2%
LG	1	0%
Total	**929**	**100%**

When asked why they choose to install or recommend one brand over another, installers expressed their higher opinion and trust of the quality of a particular manufacturer's product over another's. However, several felt that Fujitsu, Mitsubishi, and Daikin all had products of similarly exceptional quality. Others said that they mostly work with the heat pumps that their distributor provides and recommends to them. For the most part, installers expressed loyalty to the distributor and trust in their product choices over any loyalty to a particular brand. In this way, the distributors' product preferences have a large impact on the types of heat pumps that are installed within the Utilities' service territories.

For installers, the availability of heat pumps was not a significant issue in terms of determining which models to install, though there have been supply interruptions in the past. These interruptions were primarily due to increasing demand, pricing specials from manufacturers' rebates, and overseas shipping delays. However, all installers reported that supply is not a consistent issue for their projects.

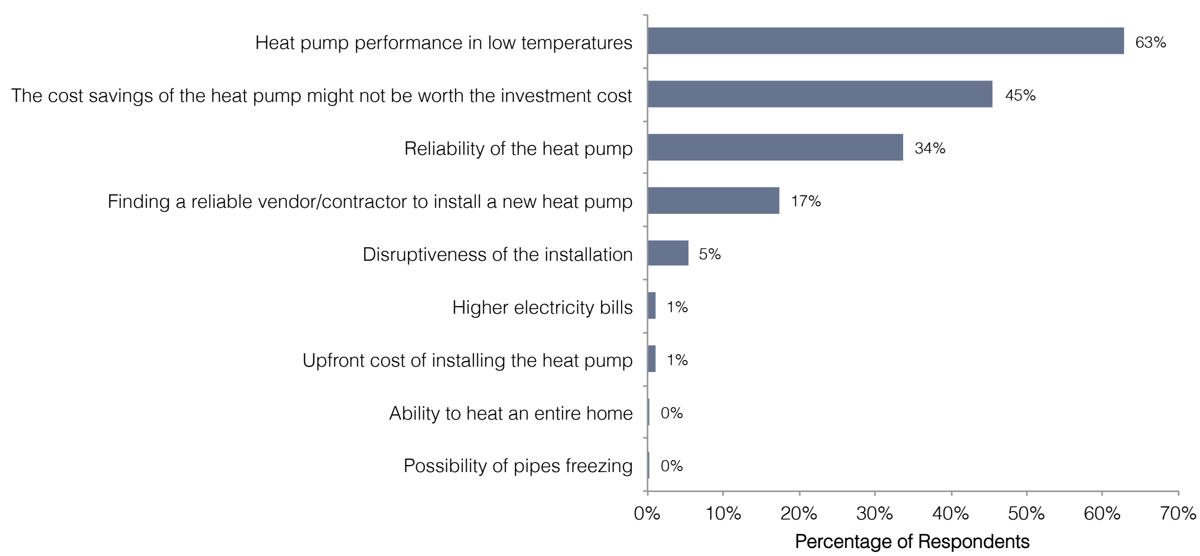
5.4 Program Barriers

The Heat Pump Pilot Program was designed around mitigating four major barriers: (1) lack of awareness regarding heat pumps, (2) difficulty identifying qualified contractors, (3) high first costs of installation, and (4) lack of available capital to make home improvements. The research team discussed these barriers and others with customers and installers to determine their impact on the Program's performance.

Customer Barriers to Participation

The research team identified several barriers experienced by customers when making the decision to purchase and install a heat pump and participate in the Program. When asked to describe the concerns they may have had when they were trying to decide whether to install a heat pump, a majority of customers reported concerns regarding the pumps' performance in cold weather, their overall cost-effectiveness, and their reliability. These concerns all stem from possible knowledge gaps among potential customers, and indicate that effective customer education was needed to close these gaps. Responses relating to heat pumps are shown in Figure 5-15.

Figure 5-15. Concerns about Heat Pumps (n=277)



Participants also recalled concerns they had about the Program prior to participation. Relative to concerns about the heat pumps, respondents reported that worries about the Program prior to participation were infrequent (<10% of respondents). Reported concerns included potential application difficulties and the amount of time it might take to receive the rebate check.

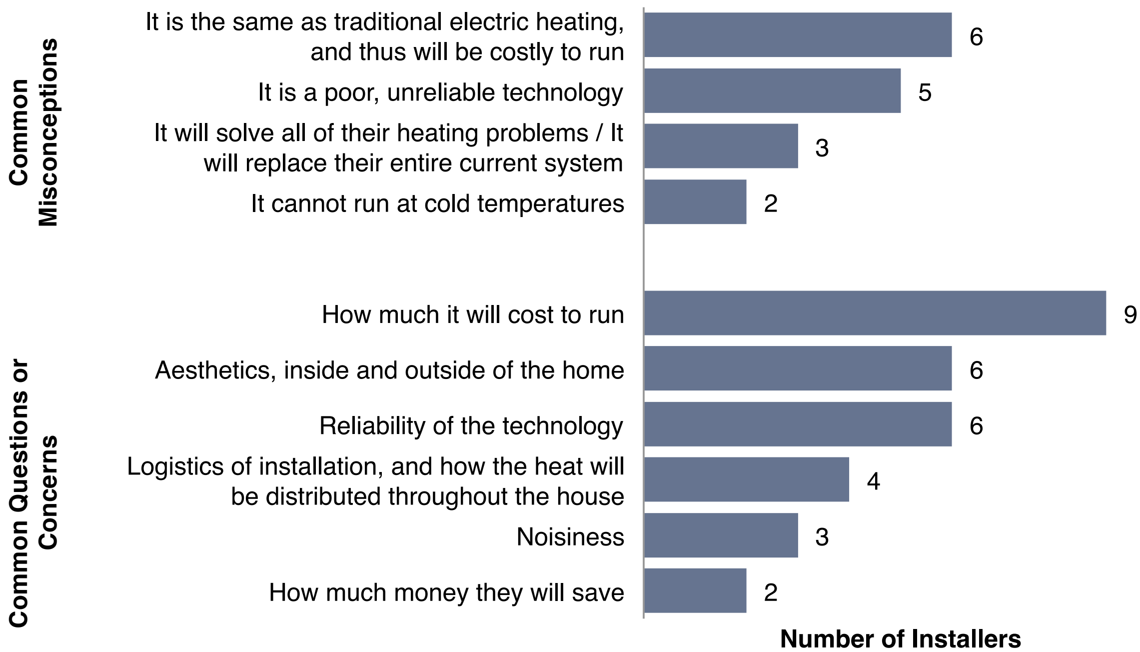
In addition, the research team asked installers for their perspective on barriers to selling and installing ductless heat pumps to their customers. The most frequent response, cited by half of the installers, was that they perceived the first cost of the equipment was prohibitive for many customers, regardless of sales technique. In fact, two installers had difficulty justifying the cost of the equipment to customers. As ductless heat pumps are a supplemental technology, they can be a harder sell to customers compared to other primary heating and cooling systems or other secondary systems that cost less. However, as customers were driving demand for heat pumps and did not require to be “sold” on the equipment, this barrier had little impact on the Program’s performance.

The second most frequently mentioned barrier installers noted was customers’ lack of awareness of the ductless heat pump technology (e.g., its efficiency, its heating and cooling capabilities). When asked what type of customer typically installs ductless heat pumps, installers mostly agreed that they tend to be those who are already aware of and educated on heat pump capabilities and uses. Specifically, installers said that these customers tend to be more affluent, educated, and have a good grasp on their existing energy usage. These customers not only have more time to devote to researching the best heating and cooling options, but also have the ability to decipher publically available technical reports and to make informed decisions on equipment installation. This finding mirrors the identified characteristics of typical program participants.

Another key demographic of ductless heat pump installers are those who have existing knowledge of heat pumps through their profession in building or energy services. These responses indicate that adopters of ductless heat pump technology are mostly those that are aware of and educated on heat pump capabilities and uses. This finding suggests that a lack of a wider awareness of and education on ductless heat pumps—especially among customers who might not educate themselves on heating and cooling technologies—is a barrier toward additional installations.

Likewise, installers reported that customers often have misconceptions about ductless heat pumps and the effectiveness of the equipment. Typical misconceptions and questions arise in regard to heat pumps’ cost-effectiveness and overall reliability. These findings suggest specific areas in which the customer base is unfamiliar with heat pump technology. Other concerns and questions include concerns about what would happen during power outages, the likelihood of pipes freezing, the quality of the heat, the noise level of units, and the aesthetics of the indoor and outdoor units. Figure 5-16 summarizes customer misconceptions and the types of questions and concerns they voiced to installers.

Figure 5-16. Number of Installer Mentions of Customers' Common Misconceptions, Questions, and Concerns Regarding Ductless Heat Pumps



Installer Barriers to Selling Heat Pumps

Of the 18 installers queried, 16 reported facing challenges when trying to sell ductless heat pumps to customers. Beyond the issues associated with selling a relatively new technology to a large customer base, there are issues that are currently preventing installers from selling as many heat pumps as they would like. For installers, barriers to installing ductless heat pumps are primarily a lack of resources and tools that would help in sales and installation, as well as misinformation about the technology being spread by word of mouth. Specifically, installers highlighted the following challenges:

- Poor quality installations being performed by inexperienced or unlicensed installers has created a negative image for heat pumps (*n* = 4)
- The lack of available tools to predict cost savings makes it difficult for installers to educate customers regarding heat pump payback (*n* = 3)
- Customers' negative attitude toward zonal heating (*n* = 2)
- False information and negative opinions being spread in the market about the technology (*n* = 2)
- The logistics of installation, including how to properly zone the house and the proper placement of piping (*n* = 2)

Efforts to Overcome Barriers for Installers

While the Program has worked to address many of the barriers faced by customers, installers reported that additional assistance from the Program and its partners, specifically ongoing trainings and educational materials, may encourage additional heat pump installations.

Most of the installers (15 of 17 asked) reported being aware of ductless heat pump trainings and technical assistance available to them; most of these reported that they have used these resources (13 of 14). Specifically, installers mentioned having attended trainings hosted by distributors (*n* = 9); of these, the majority were sponsored by Fujitsu (*n* = 9), followed by Mitsubishi (*n* = 5), the EPA (*n* = 1) and Efficiency Maine (*n* = 1). However, of the 14 installers asked, nine reported that their company would benefit from having additional training or technical assistance when attempting to sell heat pumps. Specifically, the types of technical assistance and trainings needed included:

- **Tools for calculating energy savings**. A number of installers spoke about the need for a tool that would help estimate energy savings for customers based on their current energy usage. Many installers expressed frustration with their current inability to estimate savings for customers, especially when comparing across fuel types.

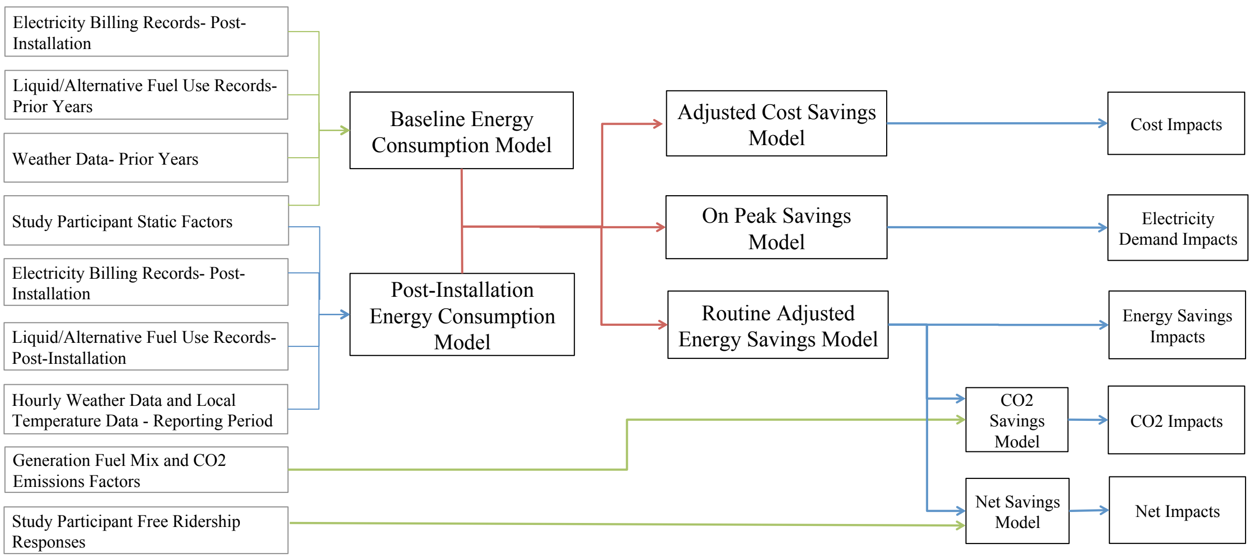
- **More literature available on the systems.** One installer said that local manufacturer reps run out of detailed literature on the ductless heat pump systems quickly since the demand is high. Having glossy literature to provide to customers is an important selling tool, so having enough for all installers to distribute is important.

- **In-depth trainings available locally.** Many installers mentioned that the trainings currently being run through distributors provide only a cursory look at the heat pump technology. Four installers said that their company would benefit from a hands-on training that would offer more background for ductless heat pump assembly, maintenance, and repair. As it is now, most installers are learning about the technology on the job, and they call manufacturers' support lines with specific questions on an as-needed basis. If there were trainings that addressed this education gap up-front and helped installers troubleshoot and diagnose problems themselves, the heat pump market could be better served. Since the only trainings that provided this information occur out-of-state, many firms could not afford to send their installers to such trainings. As one installer articulated, "We are the installers, but we are also the service people… It would be good to understand how everything works 100%, so that if a customer has a problem, we already know what that is, so it can be easily fixed. It would put more confidence in the business as well."

APPENDIX A: EVALUATION DETAILS

This appendix presents an overview of the analysis structure of the impact evaluation, which centers on the development of a baseline consumption and a post installation (reporting period) consumption model. These two models are used to normalize the change in overall energy consumption due to the heat pumps and overall cost change due to changes in the fuel and electricity use.

Figure A-1. Analysis Structure for Impact Evaluation



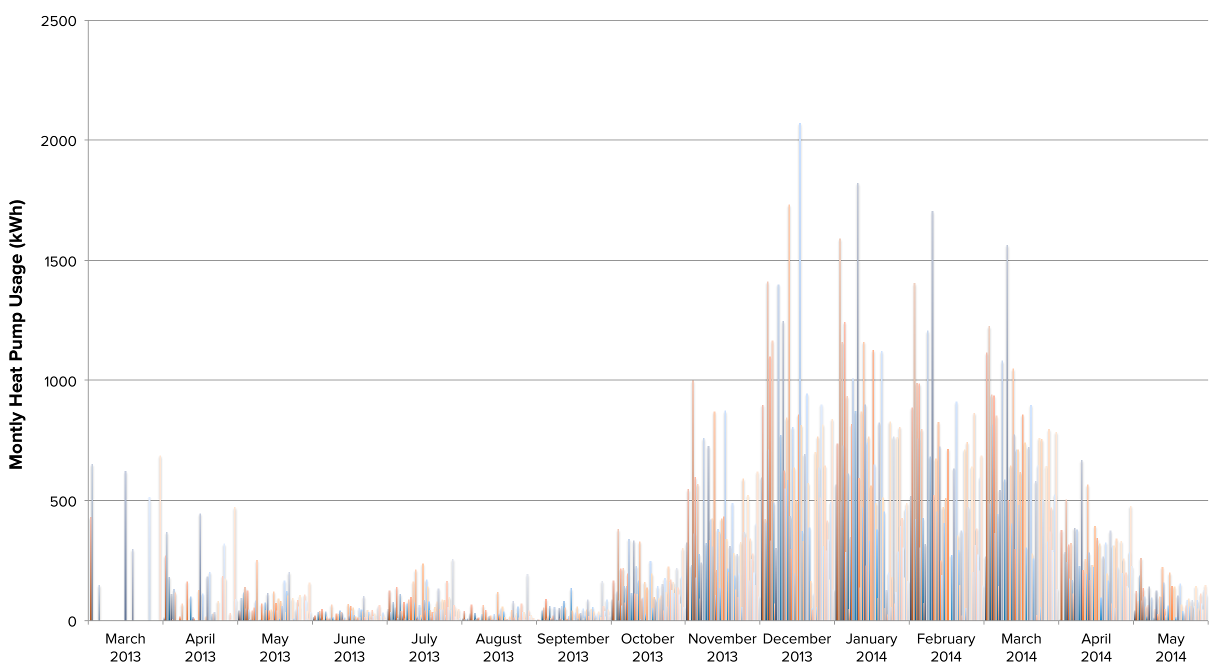
Definition and limitations of normalized and non-normalized data:

- Non-normalized energy use data can only be used to draw conclusions about the given period in which the data was collected. For example, the simple subtraction of baseline and reporting period results, if taken in different time periods, could result in skewed findings because the differences in weather between the periods were not controlled for. Also when averaging non-normalized results between different homes, differences in home features such as size are not being controlled for and can also lead to skewed findings. However, if the differences between the conditions, such as home features and weather, are known to be small, then the use of non-normalized data can be useful and help lead to significant findings.

- Normalized energy is more helpful because it can be used to compare data from different homes, taken in different weather conditions due to different time periods or locations, or homes of differing sizes, features, etc. as long as those variables are incorporated into the normalization process. Normalization is the process of controlling for other variables so that the change in energy use can be confidently attributed to the intervention under study, heat pump installation in this case, and not other condition based factors.

Using the raw meter data, the following are the average **non-normalized** household electricity use and heat pump electricity use values from the reporting period. These values are broken out by month and mirror the monthly raw reported values provided to Emera Maine during the data recording period.

Figure A-2. Monthly Heat Pump Usage, kWh (March 2013-May 2014)



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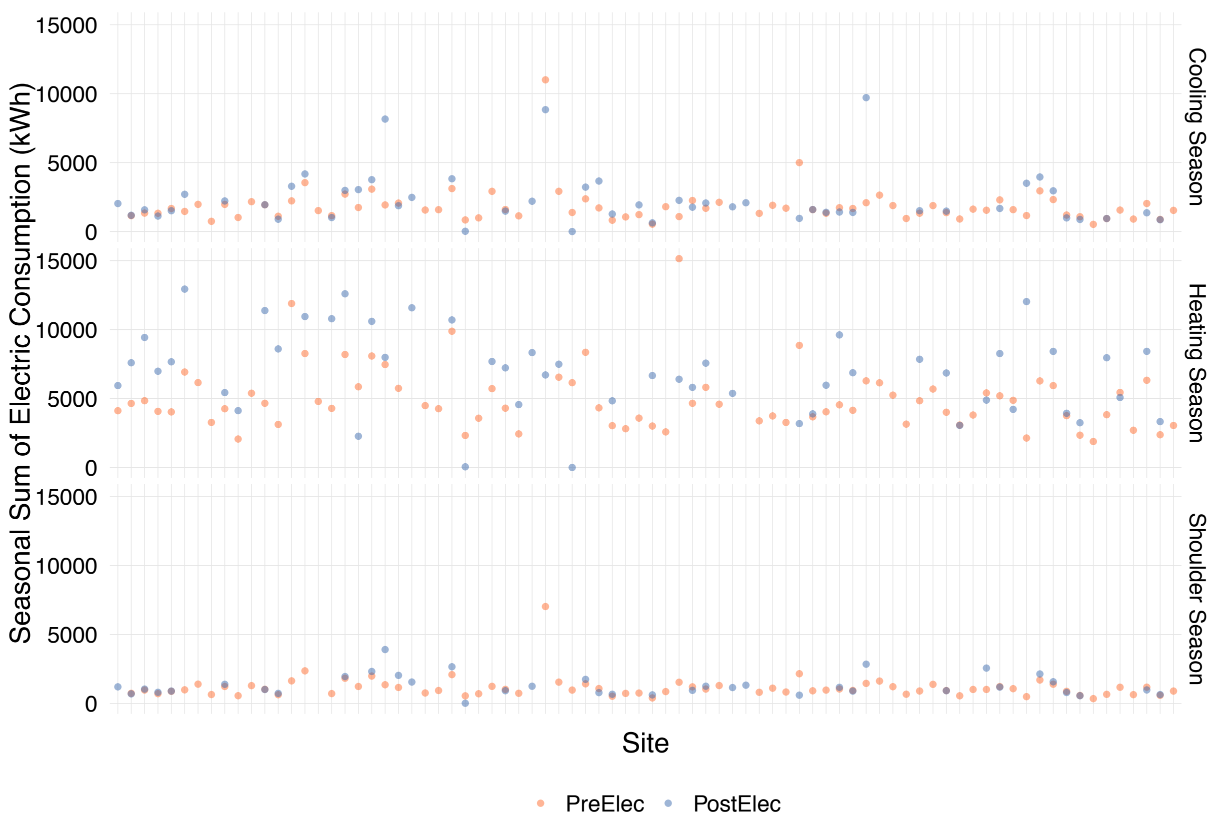
Note this graph presents the raw collected data, which includes data gaps. These gaps are the result of the staggered start dates of eMonitor installation as well as missing data during the March 2013 to May 2014 period. For instance, the eMonitors were installed over several months beginning in March 2013, which is reflected in the blank data of the graph.

Observed **non-normalized** change in electricity consumption is presented in Figure A-3, by showing both Pre and Post actual values[1]. Note that sites with higher consumption in the Pre condition previously had electric resistance heating as the primary heating source; this result is congruent with the expected change in consumption. In general there is a net increase in main power from the baseline to the reporting period. However, this change is not normalized, so does not account for differences in weather or other factors between the two periods.

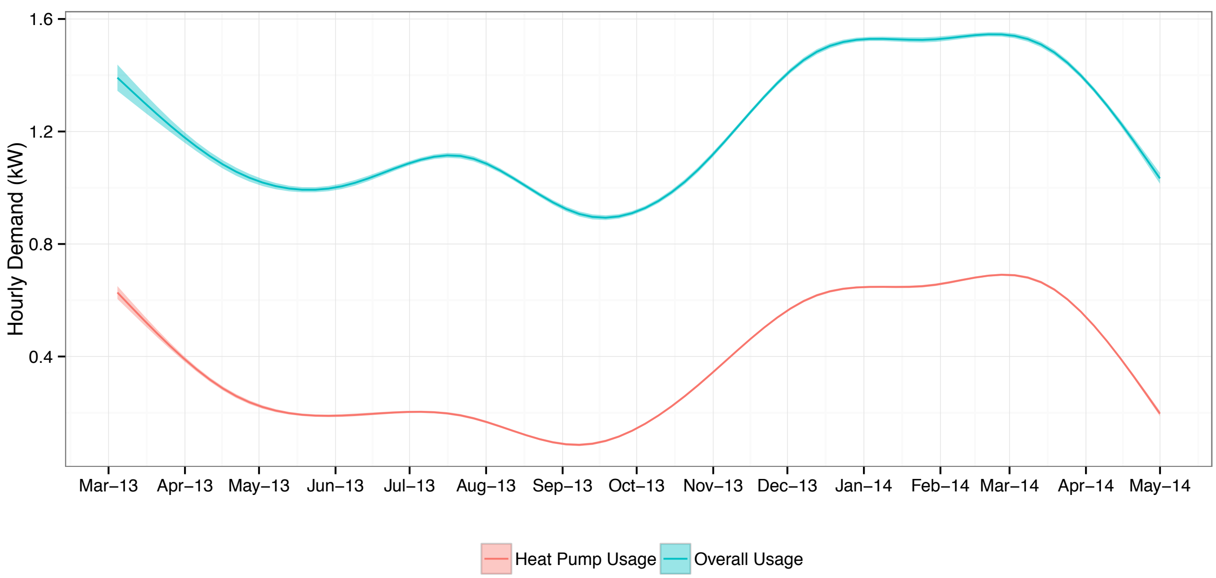
Figure A-3. Observed Pre and Post Overall Electricity Consumption by Season



[1] One site with significantly higher consumption is omitted from this plot.

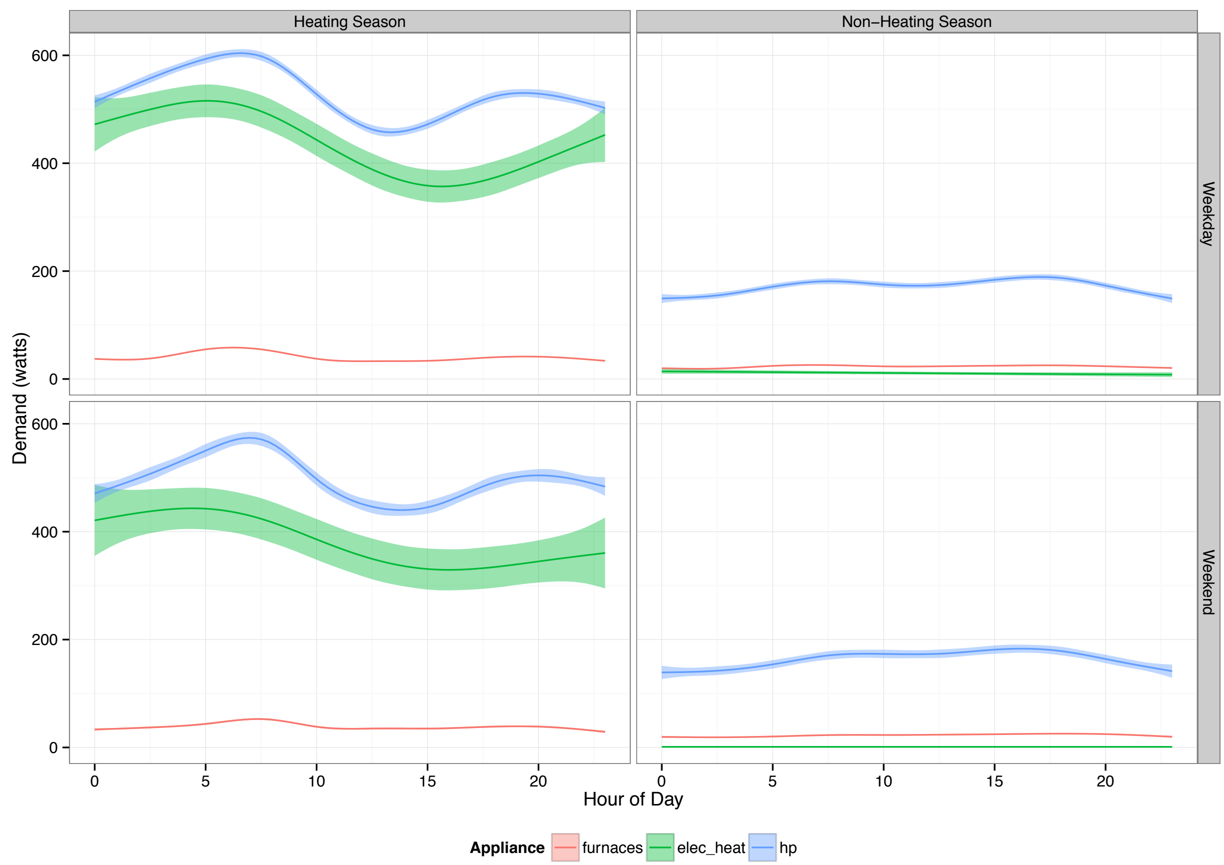
Figure A-4 presents the **non-normalized** average kWh per day of all sample sites observed during a 15-month reporting period from March 2013 to May 2014. The error bands represent the 90% confidence interval around the mean value shown by the line. The observed values show that the heat pumps represent a noticeable portion of the total electricity consumption for these sites. The only time when the heat pump curve load shape does not drive the main load shape is during July, when additional electric power may be used to run fans, other cooling units, or other services, such as pool pumps.

Figure A-4. Observed Main Power and Heat Pump Circuits, average kWh/day



Non-normalized hourly demand curves show how three different heating appliances contribute to total demand in the sites throughout typical days during the heating season, from October to April, and the rest of the year. The heating appliances demand more electricity during the heating season, as illustrated in Figure A-5. The heat pump and electric resistance heat appliances have higher demand because furnaces only use electricity to power fans and timers; the furnace curves mainly represent where furnaces continued to be used alongside the heat pump. These curves also show that those sites with electric resistance heat continued to use these electric heat sources; however, only three sites had electric resistance heat, so there is more uncertainty around the average demand value. Because there were only three sites with electric heat, no strict conclusions can be drawn, but sites with electric heat may warrant further consideration because their change in electric demand is different during the heating season.

Figure A-5. Heating Appliance Use during the Reporting Period, Heating Season and Non-Heating Season (watts)



To calculate non-normalized heating oil reductions, the research team applied values for heat pump efficiency and the heating value of heating oil (BTU/gallon) to the heat pump energy use to estimate the equivalent number of gallons represented by this heat pump use.

Table A-1 presents the Maine Electricity Suppliers Mix used as the source for the CO_2 intensity of the electricity use. These impact calculations use the most recent values, 265.93 for the Maine Public Service and 784.37 for the Bangor Hydro regions.

Table A-1. Maine Electricity Suppliers Mix of Air Emissions

Post date	Utility	Period of Time	Carbon Dioxide, (lbs/MWh)	Nitrogen Oxide, (lbs/MWh)	Sulfur Dioxide, (lbs/MWh)
Sep-14	Maine Public Service Utility	January 2013 - December 2013	265.93	0.21	0.27
Sep-14	Bangor Hydro-Electric Company	January 2013 - December 2013	784.37	0.74	0.62

The research team developed regression models using electricity usage data and 2012-2014 weather data to determine the normalized change in energy use from the pre and post periods due to the program heat pumps.

The following model was applied separately to heating, cooling and shoulder season data for the pre- and post- installation periods; the seasonal models captured differences in parameter coefficients across seasons of use.

Equation 1. General Linear Regression Model

$$lm(formula = usage \sim size + season.dd.act + electric\_heat + cool\_have, data = x)$$

A definition of the regression variables is found in Table A-2.

Table A-2. Definition of Linear Regression Variables

Variable	Definition
size	Home size, expressed in square feet
season.dd.act	Degree days in the observed season (HDD+CDD)
electric_heat	Binary expressing whether a home had an electric resistance heating system (no = 0; yes = 1)
cool_have	Binary expressing whether a home had a previous cooling system (no = 0; yes = 1)

Table A-3 presents the resulting coefficients for the separate cooling, heating and shoulder season models.

Table A-3. Resulting Model Coefficients for Cooling, Heating and Shoulder Seasons

	Pre						Post					
Seasons	Cooling		Heating		Shoulder		Cooling		Heating		Shoulder	
Intercept	A.1	1413	A.2	3522	A.3	1082	A.4	1518	A.5	7430	A.6	150
size	A.7	0.29	A.8	0.77	A.9	0.20	A.10	0.33	A.11	0.49	A.12	0.07
season.dd.act	A.13	-0.86	A.14	0.95	A.15	-0.53	A.16	1.27	A.17	0.10	A.18	1.59
electric_heat	A.19	61.5	A.20	1018	A.21	96	A.22	-677	A.23	611	A.24	21
cool_have	A.25	292	A.26	-438	A.27	25	A.28	-605	A.29	-1280	A.30	-520

These models were used to estimate the change in electricity consumption due to the installation of the heat pump for each of these three seasons. In order to estimate a normalized change in electricity use, the evaluation team used the program data for **size**, **electric_heat** and **cool_have** variable values, as well as TMY (typical meteorological year) weather data for the **season.dd.act** variable value. The evaluation team was also able to compare consumption in other time periods, using the observed weather data; for instance, by inputting 2013 weather data to the model, the evaluation team could estimate a value for the difference in consumption in two scenarios (one with and one without) the heat pump in 2013.

The evaluation team reported estimated use and savings to the TMY weather data. The weather during baseline and reporting periods were both more extreme than TMY HDD and CDD values. If weather in future program years reflects the weather in the baseline and reporting period instead of typical values, estimated use and savings should be re-calculated. Table A-4 and Table A-5 show the comparative values.

Table A-4. HDD Normals and Actuals, by Utility and Season

Utility	Season	Baseline	Reporting	TMY
BHE	Cooling	313	342	213
BHE	Heating	8,756	8,947	6,888
BHE	Shoulder	716	787	628
MPS	Cooling	301	363	486
MPS	Heating	7,352	8,493	7,811
MPS	Shoulder	681	663	928

Table A-5. CDD Normals and Actuals, by Utility and Season

Utility	Season	Baseline	Reporting	TMY
BHE	Cooling	480	451	542
BHE	Heating	3	10	6
BHE	Shoulder	68	76	41
MPS	Cooling	292	266	318
MPS	Heating	5	3	2
MPS	Shoulder	55	55	20