Efficiency Maine Low-Income Multifamily Weatherization Evaluation Report

FINAL

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Submitted to:

Efficiency Maine

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Executive Summary

Efficiency Maine retained NMR Group and Energy Futures Group ("the evaluation team" or "the team") to conduct a comprehensive impact and process evaluation of the Low-Income Multifamily Weatherization (LIWx) Program. The overarching goal of this evaluation is to assess the effectiveness of the program in achieving its savings goals. The evaluation covered the 2013 fiscal year (FY2013), which encompasses the period from July 1, 2012 to June 30, 2013.

The evaluation team completed an impact and process evaluation that accomplished the following:

- **Reviewed program data –** including savings assumptions and program tracking databases.
- **Interviewed staff and partners –** completed four telephone interviews with program staff and contractors as well as 12 telephone interviews with owners and managers of participating properties to gather feedback regarding program design, implementation, participation and satisfaction.
- **Surveyed tenants –** completed 57 telephone surveys with tenants from participating properties regarding their experience, satisfaction, and demographics.
- **Collected energy usage data –** collected electricity usage data from 47 participating properties representing 837 housing units and collected natural gas usage data from one property representing 201 housing units.
- **Estimated energy savings** – conducted a billing analysis to estimate energy savings and realization rates.
- **Assessed the program results** – calculated cost-effectiveness and annual savings.

The LIWx program sought to increase the efficiency of electricity and natural gas use in Low-income Home Energy Assistance Program (LIHEAP) eligible multifamily homes in Maine, through weatherization and heating system upgrades. The program was launched in January 2012 and ended in June 2014 as nearly all multifamily buildings in Maine that met the program's eligibility criteria – i.e., primarily heated with electricity or natural gas, occupied by LIHEAP-eligible customers, and presenting cost-effective energy opportunities – had been served by the program. The program was managed by Efficiency Maine and implemented by Conservation Services Group (CSG). The following measures were installed under the program:

- Weatherization measures, including air sealing and insulation
- Ductless heat pumps (DHP)
- Domestic hot water measures, including low flow showerheads, faucet aerators, and temperature turndowns
- CFL bulbs

In FY2013, the program completed efficiency upgrades at 84 electrically heated properties and one gas-heated property. Of the 80 electrically heated properties targeted for data collection in

the evaluation study, 23 properties received weatherization measures, 26 received ductless heat pumps, and 31 received both weatherization measures and ductless heat pumps[1]. These 80 properties represented a total of 2,088 housing units. The sole gas-heated property contained 201 housing units and received attic insulation and air sealing.

Impact Evaluation

In this section we summarize the impact evaluation results, including savings, realization rates, and cost-effectiveness, first for electricity then for natural gas.

Electricity Savings

The evaluated average annual gross normalized electricity savings per multifamily housing unit was 996 kWh or 12.1% of the pre-weatherization usage (Table ES-1). Average gross annual savings per unit for properties that received only heat pumps was 1,401 kWh or 15.6% of pre-weatherization usage, which was significantly higher than that for properties that received weatherization-only upgrades that saved 299 kWh or 4.5% of pre-weatherization usage. Estimated savings for properties that received weatherization in addition to heat pumps were similar to those that received heat pumps only, which may be due to interactive effects between the measures.

Table ES-1: Average Annual Gross Electricity Savings per Housing Unit by Upgrade Type

	Average Annual Normalized kWh per Unit				Percent Savings
	Pre	Post	Savings	±90% c.i.	
Weatherization Only	6,683	6,384	299	±95	4.5%
Heat Pumps Only	8,986	7,585	1,401	±166	15.6%
Weatherization and Heat Pumps	9,282	7,844	1,438	±204	15.5%
All	8,216	7,220	996	±101	12.1%

Average gross normalized electric savings for heating per multifamily housing unit was 846 kWh or 21% of the pre-weatherization heating usage (Table ES-2). As would be expected given Maine's predominantly heating-based climate, the program achieved most of its savings through reducing electricity usage for heating.

Cooling, on average, constituted a tiny portion of total electricity usage for program participants therefore electric savings for cooling were negligible even if the savings as a percentage of pre-treatment cooling usage were relatively high. There has been some concern that heat pumps may increase electricity demand and consumption during the summer if air conditioners were not

[1] Most properties, regardless of their upgrade type, also received some domestic hot water measures and direct install of CFL bulbs.

used beforehand; however, this analysis indicates that heat pumps did not result in an increase in cooling consumption.

Multifamily properties that received only heat pumps were the sole group that had baseload savings that were significantly different from zero at a 90% confidence level. We are unclear as to why this is the case because the measures that should primarily contribute to baseload savings (domestic hot water and CFLs) were installed at most properties.

Table ES-2: Average Seasonal Gross Electricity Savings per Housing Unit by Upgrade Type

	Heating		Cooling		Baseload	
	kWh Savings	Percent Savings	kWh Savings	Percent Savings	kWh Savings	Percent Savings
Weatherization Only	287	9.0%	6	13.0%	5	0.2%
Heat Pumps Only	989	22.2%	28	41.2%	383	8.6%
Weatherization and Heat Pumps	1,345	29.3%	16	18.2%	77	1.7%
All	846	21.0%	15	23.1%	134	3.3%

Measure-level Savings

A regression analysis was performed to estimate measure-specific savings (Table ES-3). Heat pumps were the only measure that had a statistically significant coefficient in the model. The results indicate that the annual heat pump savings per unit were 1,045 kWh. In comparison, a recent evaluation of the Connecticut Home Energy Services – Income Eligible (HES-IE) program[2] found that ductless heat pumps yielded an annual savings of 803 kWh each.

Although not statistically significant, each CFL bulb reduced annual electricity usage by 28 kWh.[3] Air sealing and insulation measures yielded very low savings estimates per unit.

Table ES-3: Gross Measure-Level Savings Estimates

Measure	Estimated Annual Savings (kWh)	±90% c.i.
Heat pump savings per housing unit	1,045	±322
Air sealing and insulation savings per housing unit	24	±343
Domestic hot water savings per housing unit	72	±389
CFL savings per bulb	28	±36

[2] Final Report Impact Evaluation: Home Energy Services – Income Eligible and Home Energy Services Programs. Connecticut Energy Efficiency Fund. Cadmus Group and NMR Group. December 31, 2014. http://www.energizect.com/government-municipalities/hes-and-hes-ie-impact-evaluation-r16-final-report-12-31-14

[3] The program, on average, provided 5.3 CFLs per housing unit. This suggests that the contribution of CFLs to annual savings per unit, on average, was 28 kWh ×5.3=148 kWh.

Realization Rates

The evaluation team compared the savings estimates from the billing analysis to the program savings assumptions from the Real Home Analyzer (RHA) software as well as to the lighting and domestic hot water measures in the program tracking database in order to compute a realization rate for electricity savings. The overall savings realization rate was 40% (Table ES-4). The savings realization rate for weatherization-only upgrades was 26%, which was lower than that for the other types of upgrades: 54% for heat pumps and 38% for weatherization plus heat pumps. Weatherization-only projects led by the prime contractor yielded an average realization rate of 55% while weatherization-only projects led by a subcontractor yielded an average realization rate of just 14%. This large difference in realization rates is driven by higher savings assumptions as well as lower evaluated savings for the subcontractor-led projects.

Table ES-4: Electricity Savings Realization Rates by Upgrade Type

	Evaluated Savings	Program Savings Assumptions	Realization Rate	±90% c.i.
Weatherization Only	299	1,140	26%	±8%
Heat Pumps Only	1,401	2,608	54%	±6%
Weatherization and Heat Pumps	1,438	3,824	38%	±5%
All	996	2,488	40%	±4%

The Connecticut HES-IE study found a realization rate of 46% for ductless heat pumps, which is slightly less than the Efficiency Maine LIWx realization rate of 54% for heat pump projects (some of which also include CFLs and domestic hot water measures).

A study conducted for the Bonneville Power Administration found that DHP heating savings in multifamily buildings were less than anticipated for two reasons.[4] Based on metering of 12 units, the study found "takeback"—significant increases in heat output after the installation of the DHP (from 39% to 78%). In addition, the DHPs were not fully utilized because electric resistance heating was estimated to account for 25% to 57% of input heating energy. The degree of conversion to DHP usage was strongly associated with the degree of savings.

The recent Emera Maine heat pump study found that customer education is essential in order to maximize savings because customers need to control both their existing heating system and their

[4] Ductless Heat Pump Retrofits in Multifamily and Small Commercial Buildings. December 7, 2012. Prepared for Bonneville Power Administration. Prepared by Ecotope, Inc. http://www.bpa.gov/EE/Sectors/Residential/Documents/DHPx_Multifamily%20_Small_Commercial_Report_02-08-13.pdf

new DHP.[5] The study found that participants who utilized their DHP as the primary heating system achieved the highest savings.

Similar results were found in this study. The eleven tenants who responded to the telephone survey and reported only using their ductless heat pump yielded an average of 16% savings, which reflects a 50% realization rate, similar to the 54% realization rate for all heat pump projects. In contrast, the five tenants who reported using both their electric baseboard system and the ductless heat pump had an average of −4% savings, which reflects a −13% realization rate. While this analysis is based on a small sample size, it indicates that the tenants who only used the ductless heat pump to heat their apartments realized more savings than those that also used their electric baseboard.

[5] Emera Maine Heat Pump Pilot Program, November 17, 2014. EMI Consulting. http://www.emiconsulting.com/assets/Emera-Maine-Heat-Pump-Final-Report-2014.09.30.pdf

Cost-Effectiveness

The Total Resource Cost (TRC) test benefit/cost ratio for electric measures was calculated to equal 1.89 with program savings assumptions and 0.76 with evaluated savings (Table ES-5). It should be noted that this benefit computation did not account for the non-energy benefits of the program, such as improved comfort, health, and safety of the participants; avoided greenhouse gas and criteria air pollutant emissions; and reduced utility collections costs associated with increases in energy affordability. The inclusion of these non-energy benefits would have resulted in a higher TRC ratio for the program.

Due to the substantial difference in realization rates for weatherization-only projects completed by the prime contractor and those completed by subcontractors, TRC ratios were calculated separately by upgrade type and implementation contractor. During the FY2013 evaluation period a higher percentage of weatherization-only projects were completed by subcontractors than either before and afterwards.

The evaluated cost-effectiveness ratios for the ductless heat pump projects (0.78) and combined ductless heat pump & weatherization projects (0.74) were similar to the overall program value of 0.76. However, the evaluated cost-effectiveness ratio for all weatherization-only projects is 0.62, ranging from 0.31 for those projects implemented by subcontractors to 1.46 for those projects implemented by the prime contractor.

Table ES-5: Cost-Effectiveness by Electric Upgrade Type, TRC Test, FY2013

Upgrade Type	Assumed TRC Ratio	Evaluated TRC Ratio
Ductless Heat Pump Only	1.44	0.78
Ductless Heat Pump & Weatherization	1.96	0.74
Weatherization Only	2.37	0.62
Weatherization Only – Prime Contractor	*2.66*	*1.46*
Weatherization Only – Subcontractors	*2.23*	*0.31*
All Electric Upgrade Projects	**1.89**	**0.76**

Benchmarking

Table ES-6 compares the evaluated annual electricity savings to two studies that estimated savings for programs that also serve low-income multifamily properties. The Connecticut HES-IE program offers ductless heat pumps, weatherization, and other measures; the evaluation found annual savings of 880 kWh per multifamily housing unit, representing 14% of pre-program usage. In addition, an evaluation of the Ohio Electric Partnership Program estimated annual savings of 1,486 kWh for high usage apartments and 728 kWh for moderate usage apartments,

representing between 11% and 13% of pre-program usage.[6] The Ohio program offered lighting retrofits, appliance replacements, DHW measures, and other miscellaneous measures.

Overall, these results indicate that the annual savings (996 kWh) and percentage savings (12%) from the Efficiency Maine LIWx program are similar to those of other low-income multifamily programs. However, the program's realization rate of 40% is substantially lower than the Connecticut HES-IE realization rate of 64%.

Table ES-6: Benchmarking Comparison of Electricity Savings for Other Low-income Multifamily Programs

	Evaluated Annual Savings per Housing Unit (kWh)	Pre-Program Annual Usage per Housing Unit (kWh)	Percent Savings	Realization Rate
Efficiency Maine LIWx Program				
Weatherization Only	*299*	*6,683*	*4.5%*	*26%*
Heat Pumps Only	*1,401*	*8,986*	*15.6%*	*54%*
Weatherization and Heat Pumps	*1,438*	*9,282*	*15.5%*	*38%*
Overall	*996*	*8,216*	*12.1%*	*40%*
Connecticut HES-IE Multifamily	880	6,143	14.3%	64%
Ohio Electric Partnership Program				
High Usage Apartments	1,486	11,721	12.7%	
Moderate Usage Apartments	728	6,308	11.5%	

Natural Gas Savings

The average gross normalized annual gas savings for the sole gas-heated property that participated in FY2013 was 3,085 ccf or 13.7% of the pre-weatherization usage (Table ES-7). About two-thirds of these savings were for heating and one-third was for baseload.

Table ES-7: Total Gross Annual Gas Savings per Property

	Average Annual Normalized Gas Usage (ccf)				Percent Savings
	Pre	Post	Savings	±90% c.i.	
Total Gas Usage	22,575	19,490	3,085	±1,745	13.7%
Gas Usage for Heating	15,748	13,822	1,926	±1,563	12.2%
Gas Usage for Baseload	6,828	5,668	1,159	±599	17.0%

[6] Ohio Electric Partnership Program Impact Evaluation Results for April 2004 – March 2005 Participants, Final Report. Prepared for the Ohio Office of Energy Efficiency. June 30, 2006. Prepared by: Michael Blasnik.

The gross savings realization rate for this property was 69%. While this gas realization rate is higher than the electric realization rates, it reflects only one property while the electric analysis reflects the average estimates found from multiple properties representing a range of individual realization rates.

The program's natural gas TRC benefit/cost ratio in FY2013 was 1.18 with program savings assumptions and 0.82 with evaluated savings (Table ES-8). As noted above, this benefit computation for the TRC test did not account for the non-energy benefits of the program.

Table ES-8: Cost-Effectiveness of Gas Measures, FY2013

Benefits & Costs	Assumed	Evaluated
TRC Ratio	1.18	0.82

Net-to-Gross

The interviews with property owners and managers indicate that participants exhibit relatively modest free ridership and spillover, the effects of which likely counteract one other. The experience of the evaluation team with other low-income programs indicates that these programs typically have very limited free ridership and spillover, implying a net-to-gross (NTG) ratio of 100%. In addition, the recent Emera Maine heat pump pilot program study found an 88% NTG ratio for market-rate heat pump projects. Based on these results, the evaluation team believes that a NTG ratio of 100% is a reasonable assumption for the LIWx program.

Process Evaluation

In this section, we present key findings from the process evaluation.

Program Design and Implementation

- **Program staff worked well together and effectively communicated with owners/managers.** There was a strong common understanding of roles and responsibilities among the program staff members and communications between Efficiency Maine and CSG were regular and effective. In addition, outreach by the program accounted for the majority of participants, and eleven of the twelve participating owners/managers indicated that it was clear to them at all times who their primary point of contact with the program was.
- **Program staff made timely and appropriate adjustments to program criteria in order to achieve program goals.** The program shifted its focus from weatherization to heat pumps after initial field experience revealed that the weatherization opportunities were less than anticipated. Given the higher realization rate for DHP projects, this decision appears to be justified. Another example is the weighting process used in selecting a winning bid for heat pump installations. The initial focus was on quality over

price, but was later adjusted to prioritize price over capability as the pool of bidding contractors self-selected to become more reliably capable of meeting the program's requirements.

- **Program staff report that heat pump installation costs were effectively reduced to well below industry norms due to a streamlined bidding process**. One staff member indicated that most of the vendors provided bids for the jobs sight unseen, based only on a detailed scope of work and the programs work standards manual. In addition, after the winning bid was selected, the program shared the pricing for each bid with all of the bidding contractors, which the staff believes drove costs down to a common, low level. Vendors who were not competitive simply stopped bidding.

- **Program staff perceived quality control to be sufficient, which was generally supported by the owners/managers.** Staff reported that the program instituted rigorously detailed operating procedures, and maintained close communications with owners/managers and contractors. Staff also reported that quality assurance was approached as a collaborative endeavor rather than as an enforcement issue, with a common desire on all parts to improve the quality of the work. Where this collaborative approach was not successful, contractors were asked to leave the program or simply were not given any more work. For the most part, participating owners and managers agreed that quality control was sufficient, however two owners/managers identified significant frustration with the lack of information provided regarding heat pump operation, and one of these respondents also experienced noteworthy problems related to inadequate quality assurance.

- **Program staff held different perspectives as to whether more savings opportunities exist in Maine's low-income multifamily market.** Two of the four staff believed there are opportunities at smaller buildings, however these opportunities may not currently be cost-effective. If further opportunities do exist in the Maine low-income multifamily market, it lies in smaller and possibly privately held housing that may be under the radar of the affordable housing community, where cost-effective solutions will be challenging to develop.
- **It is unclear whether participating owners/managers would have moved forward with the projects if the program had not paid the entire cost.** A few owners/managers indicated they would have considered moving forward if they had to pay 25% or maybe even 50% of the installation cost. However, it is likely that the program would not have been able to achieve its participation goals as quickly as it did if it required cost sharing.

- **Nearly all tenants appear to be low-income.** Eighty-nine percent of tenants were classified as low-income, which is much greater than the Maine multifamily population where only 45% are classified as low-income. This indicates that the program properly targeted and served properties with LIHEAP-eligible tenants.

- **About one-third of the tenants knew that their building had participated in an Efficiency Maine Program.** Because the program works directly with building owners and managers rather than tenants, relatively few tenants were aware of their property's participation.

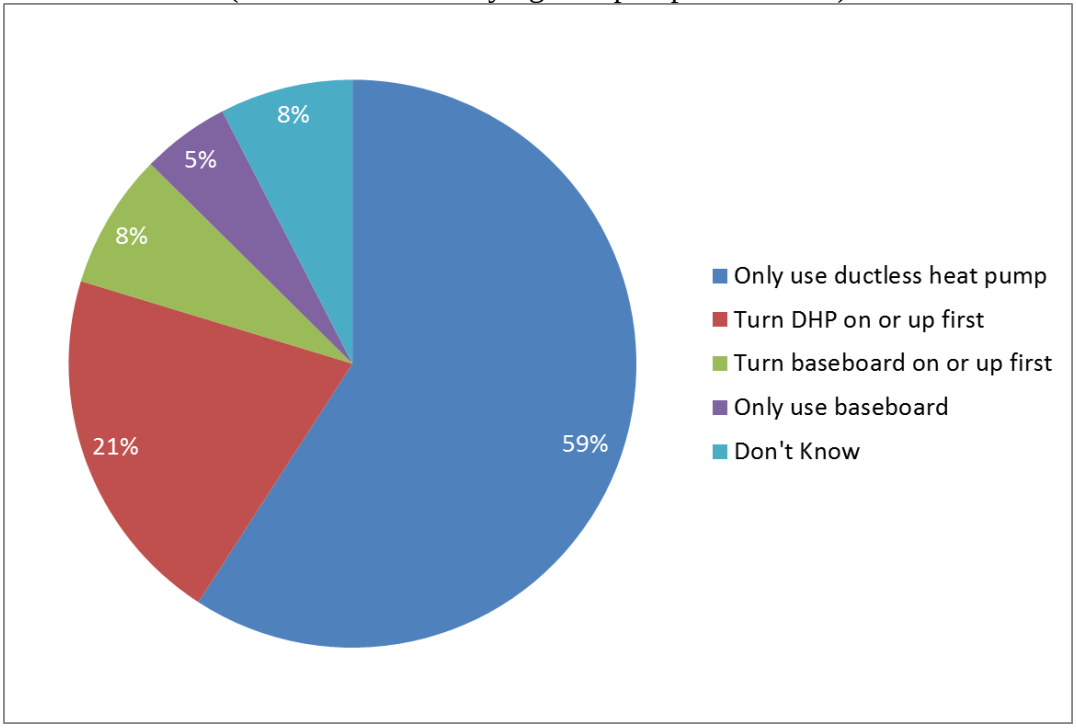
Ductless Heat Pump Knowledge and Usage

- **Almost three-quarters of tenants knew that the ductless heat pump cost less to operate.** Seventy-three percent of the 40 tenants who received DHPs thought that DHPs cost less to operate than the electric baseboard, although 23% did not know and 5% thought the electric baseboard cost less to operate.
- **Program staff, owners/managers, and tenants indicate that training regarding the operation of ductless heat pumps was not effective.** Two program staff referenced challenges in determining the appropriate level of training, the appropriate trainer, and the most useful people to receive training regarding heat pump operation. The program initially relied on the installation contractors to ensure that the tenants understood how to operate their new heat pump systems. However, the emphasis on minimizing installation costs may have led to less-than-optimal education from some contractors. In addition, interviews with owners/managers confirmed that, in some cases, insufficient training on heat pump operation was viewed as a shortcoming of the program. Five of the twelve owners/managers indicated that at least some of their tenants had experienced some level of confusion about the heat pumps, ranging from concerns about the systems blowing cold air to not understanding how to use the remote controls. In addition, nearly one-third of the 40 tenants who received ductless heat pumps did not receive any training or materials to help them learn how to operate the new DHP system. Toward the end of the program, an effort was made to systematically train building operations staff on the effective operation of the heat pumps with the understanding that the staff would then be best positioned to educate the tenants.

- **Most tenants use their ductless heat pump as the primary heating system.** Of the 40 DHP tenants who responded to the telephone survey, 59% report using only their DHP, 21% turn their DHP on or up first but also use the electric baseboard, 8% turn their electric baseboard on or up first but also use the DHP, 5% only use their electric baseboard, and 8% don't know (Figure ES-1).

Figure ES-1: Use of Ductless Heat Pump

(Base: Tenants verifying heat pump installation)

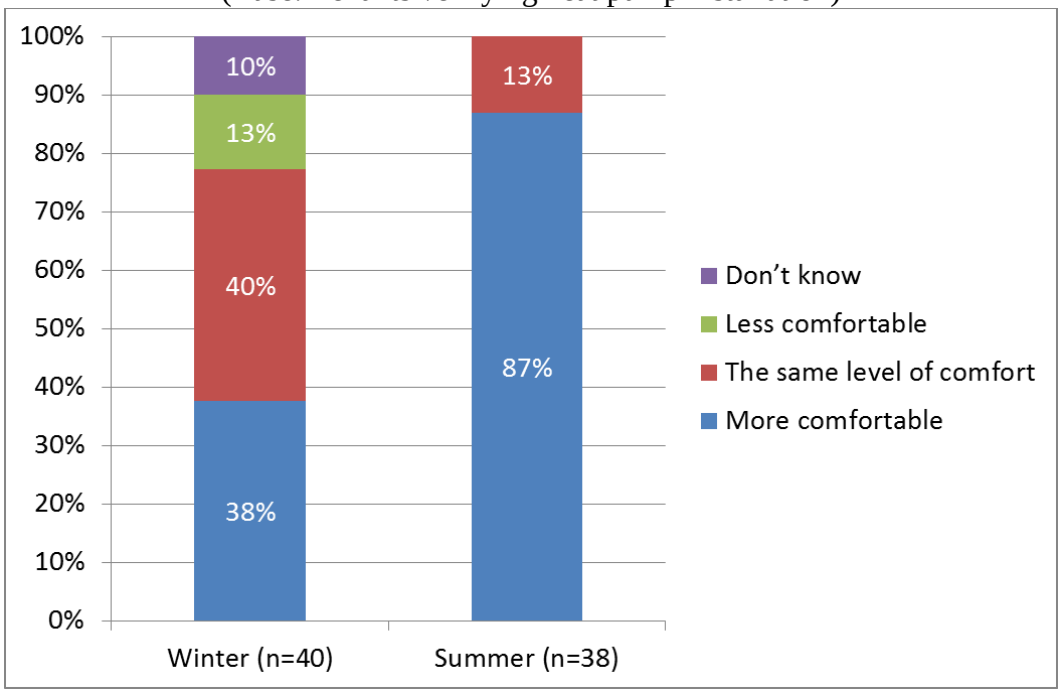


- **Most of the tenants experienced the same level of comfort or better during the winter, and all experienced the same level of comfort or better during the summer.** Thirty-eight percent of DHP tenants were more comfortable with the temperature in their apartments during the winter and 40% had the same level of comfort. Tenants who experienced discomfort during the winter mentioned issues such as cold air blowing from the ductless heat pump.

  Nearly all tenants with a heat pump have used it for cooling as well as for heating. Most of these 38 tenants (87%) said the temperature in their apartments in the summer was more comfortable since the ductless heat pump was installed, and the remainder experienced the same level of comfort (13%).

Figure ES-2: Comfort Level with Ductless Heat Pump

(Base: Tenants verifying heat pump installation)



- **About three-fourths of tenants had not encountered any problems with their heat pumps**. The remaining tenants said that the ductless heat pump did not effectively heat their homes or encountered other problems such as blowing cold air, odors, noise, leaking water, or dust.

In-Unit Direct Install Measure Persistence

- **Nearly all tenants still had all of the in-unit measures installed in their home at the time of the survey.**
  - Ninety-three percent of the 28 tenants that received CFLs reported that all of the CFL bulbs were still installed at the time of the survey. The sole tenant that removed CFLs did not think they were bright enough.
  - Eighty-eight percent of the 25 tenants who had low-flow showerheads installed reported that they were still installed at the time of the survey. In addition, 92% of the 26 tenants who had low-flow aerators installed reported that they were still installed as well. The few tenants who had removed their showerheads or aerators did so because they either broke or they preferred a different brand.

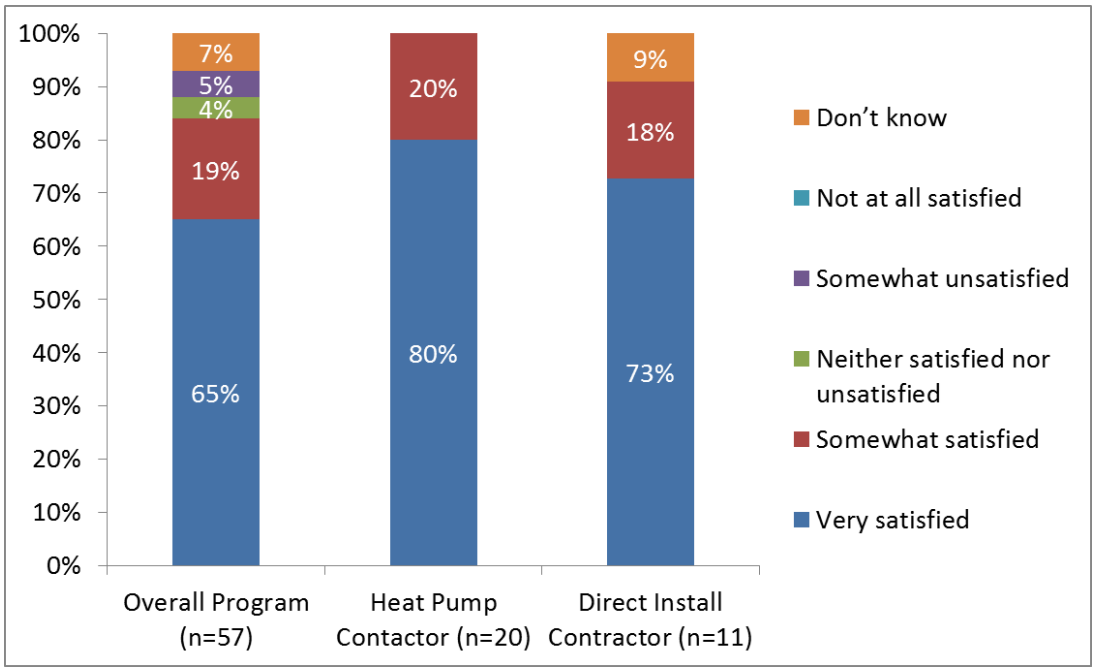
Program Satisfaction

- **Participating owners/managers are generally satisfied with the program.** Seven respondents reported that they were very satisfied, and three reported that they were between very satisfied and somewhat satisfied. One owner/manager was somewhat satisfied, and one owner/manager was between somewhat satisfied and neither satisfied nor dissatisfied.

- **Most tenants were satisfied with the Efficiency Maine program and their interactions with the installation contractors.** Eighty-four percent of the 57 tenants were satisfied with the program (Figure ES-3). The few tenants who were dissatisfied mentioned issues with the ductless heat pump as well a general dissatisfaction with the program. All 20 tenants who had interacted with their ductless heat pump installation contractor were satisfied. In addition, ten of the eleven tenants who had interacted with their direct install contractor were also satisfied.

Figure ES-3: Satisfaction with Program and Installation Contractors

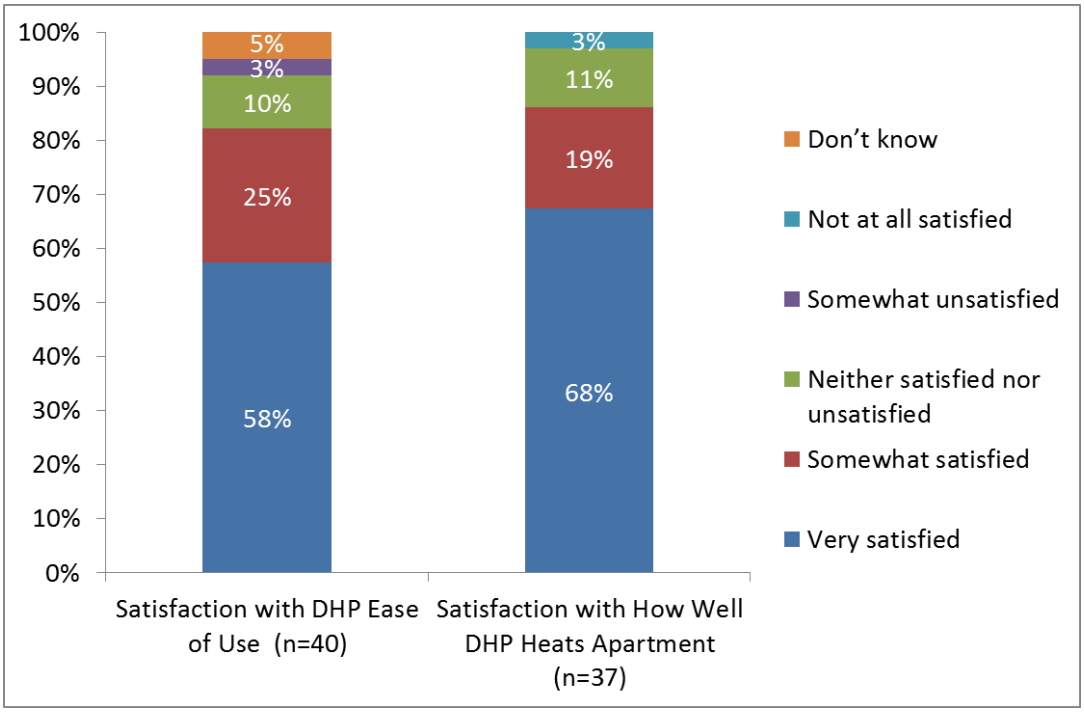
(Base: All tenants; Tenants who interacted with installation contractor)



- **Most tenants were satisfied with the ductless heat pumps ease of use and how well it heated their apartment.** Eighty-three percent of the DHP tenants were satisfied with how easy the ductless heat pump was to use and 87% were satisfied with how well the ductless heat pump heated their apartments (Figure ES-4).

Figure ES-4: Ductless Heat Pump Satisfaction

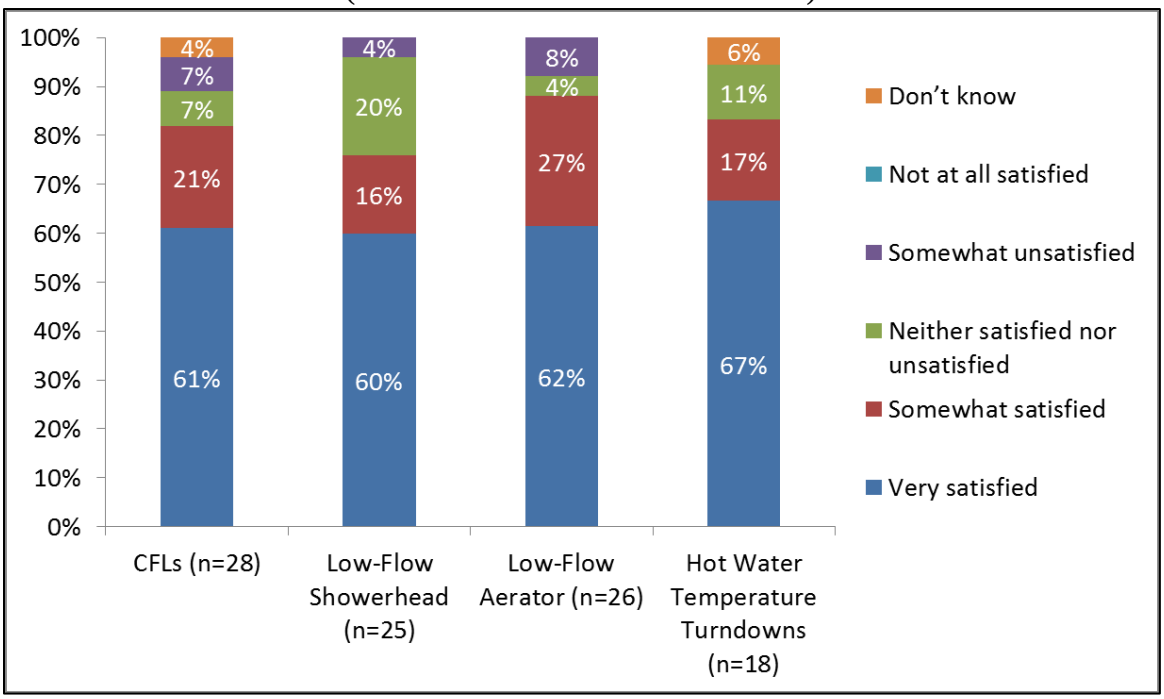
(Base: Tenants verifying heat pump installation; Tenants using DHP for all/some of heating)



- **Most tenants were satisfied with the in-unit direct install measures provided by the program.** Eighty-two percent of the tenants were satisfied with CFLs, 76% were satisfied with the low-flow showerheads, 89% were satisfied with low-flow aerators, and 84% were satisfied with their hot water temperature adjustment (Figure ES-5). The few tenants who were dissatisfied with the products mentioned the following issues: lack of brightness for CFLs, low water flow rate for aerators and showerheads, and a preference for the prior hot water temperature.

Figure ES-5: Satisfaction with In-Unit Direct Install Measures

(Base: Verified measure installation)



Best Practices Review

The review of low-income multifamily energy efficiency programs provided the following key findings about best practices.

- Relationships are built with housing providers and property owners/managers in order to encourage sustained participation over time as new properties are developed and existing properties are renovated and refinanced.
- Programs collaborate with other stakeholders in this market and provide a single point of contact with properties for multiple services. In other words, a building owner can access all of the programs that are available from various organizations through a single lead program.

- Energy efficiency services for all end-uses, all fuel types, and both common areas and dwelling units are available through a single customer-facing program, even if this requires program administrators to manage tracking and reporting behind the scenes to comply with regulatory requirements.
- Funding is leveraged to stretch program dollars as far as possible. Programs understand funding options and financial requirements of affordable housing markets and offer incentives to fill the gap so that projects move forward.
- Programs provide education—both to tenants and to facilities staff—to ensure that savings are achieved.
- Results are tracked over time to foster continuous learning for program staff.

Recommendations

Based on the findings of the evaluation, the team suggests that Efficiency Maine consider the following recommendations for future programs that serve the low-income multifamily sector.

- **Assess methods to maximize the usage of and therefore savings from ductless heat pumps in low-income multifamily buildings.** Because ductless heat pumps typically serve in conjunction with existing heating systems (with which occupants are already familiar) changes in occupant behavior are necessary to ensure effective operation of the new heat pump. While most requests for quotes issued to ductless heat pump contractors specified the training requirements for property managers, the interviews indicate that the training delivered to property managers and tenants varied between adequate and deficient. The results of other studies indicate that occupant education may improve the usage of and therefore the savings from ductless heat pumps. However, in low-income multifamily properties where there may be high turnover of both property managers and tenants and where tenants often do not pay their own electric bills, the effectiveness and persistence of such training is unclear. Therefore, alternatives that do not rely upon occupant behavior may be more effective, such as disabling the pre-existing electric baseboard. However, it is important to thoroughly assess and, if possible, pilot test any new efforts in order to ensure that the savings outweigh the costs.
- **Re-assess the assumptions that feed into the projection of energy savings for low-income multifamily programs.** Given the low realization rates, we recommend that the program staff re-examine the energy savings assumptions in order to develop more conservative savings estimates for future low-income multifamily programs. In particular, given the low realization rates and cost-effectiveness for weatherization-only projects led by subcontractors, additional oversight may be warranted in the future particularly regarding energy modeling assumptions and resulting savings. For ductless heat pumps, this re-assessment may necessitate assigning a smaller percent of the heating load to the DHPs due to occupant's greater reliance on their existing heating system.

- **Continue to assess the costs of and opportunities for low-income multifamily measures**. As the technology of and market for ductless heat pumps continues to evolve, efficiency should improve and costs should decline leading to a greater likelihood that DHPs can meet cost-effectiveness requirements at low-income multifamily properties with lower electric usage or with fewer housing units. In addition, the costs of other measures may also decline or new technologies may yet develop which could provide further opportunities for cost-effective savings.
- **Investigate smaller properties for future low-income multifamily programs.** If further savings opportunities exist in the low-income multifamily sector in Maine, it likely lies in smaller and possibly privately held housing with income-eligible tenants that may be under the radar of the affordable housing community. Due to the proportionately higher administrative costs associated with projects that yield smaller savings, cost-effective solutions will be challenging to develop and therefore may require innovative program design.
- **Determine incentive levels for future low-income multifamily programs based on overall objectives.** Due to the significant barriers to owner investment, the LIWx program opted to pay the full cost for eligible measures. There is often debate in the design of energy efficiency programs (including low-income programs) regarding how large incentives must be in order to motivate action. However, the best practices review suggests that some successful low-income multifamily programs do require cost-sharing on the part of property owners in order to stretch program dollars as far as possible. In designing future low-income multifamily programs, one key question to consider is: Should the program pay a greater portion of the costs in order to achieve savings at a fast pace, or is it more appropriate to require a partial co-payment that will extend participation and savings? However, because the TRC test includes both program and participant costs, this decision will not impact cost-effectiveness.
- **Develop programs with a sustained, comprehensive commitment to the low-income multifamily sector.** The best practices review found that the most successful multifamily programs that maximize energy savings build relationships with housing providers and property owners/managers in order to encourage sustained participation over time as new properties are developed and existing properties are renovated and refinanced. In addition, programs should collaborate with other stakeholders to provide a single point of contact that offers energy efficiency services for all end-uses, all fuel types, and both common areas and dwelling units. However, providing continuous comprehensive program services may increase administrative costs and therefore decrease cost-effectiveness.

1 Introduction

In this section, we discuss the research objectives and data collection plan.

1.1 Study Objectives

Efficiency Maine retained NMR Group and Energy Futures Group to conduct a comprehensive impact and process evaluation of the Low-Income Multifamily Weatherization (LIWx) Program. The overarching goal of this evaluation is to assess the effectiveness of the program in achieving its savings goals. The evaluation covers the 2013 fiscal year (FY2013), which encompasses the period from July 1, 2012, to June 30, 2013.

The two main objectives for this project, as indicated by Efficiency Maine, were to conduct process and impact evaluations as outlined below:

- Process Evaluation – To examine the design, delivery, and implementation of the program, assess participant experience and satisfaction, and identify emerging issues and trends, including lessons learned from comparable programs in other states
- Impact Evaluation – To measure and verify the gross and net energy savings achieved through the program and the cost-effectiveness of those savings

1.2 Program Description

The LIWx program sought to increase the efficiency of electricity and natural gas use in LIHEAP-eligible multifamily homes in Maine through weatherization and heating system upgrades. For buildings containing two or more housing units, the program weatherized electrically heated residential units throughout the state and natural gas units in Unitil's service territory. The program was launched in January 2012 and ended in June 2014 after nearly all multifamily buildings in Maine that met the program's eligibility criteria—i.e., primarily heated with electricity or natural gas, occupied by LIHEAP-eligible customers, and presenting cost-effective energy weatherization opportunities—had been served by the program.

The following measures were installed under the program:

- Weatherization measures, including air sealing and insulation
- Domestic hot water measures, including low-flow showerheads, faucet aerators, and temperature turndowns
- Ductless heat pumps
- CFL bulbs

The LIWx program was overseen by an Efficiency Maine program manager and managed on a day-to-day basis by Conservation Services Group, which contributed a program manager and several technical field representatives. Numerous HVAC and weatherization contractors installed

measures at the qualifying properties. In addition, several subcontractors served as the lead implementer for some of the weatherization-only projects during the evaluation period.

In FY2013, the program completed weatherization at 84 electrically heated properties and one gas-heated property. Of the 80 electrically heated properties included in the data collection for the evaluation study, 23 properties received weatherization measures, 26 received ductless heat pumps, and 31 received both weatherization measures and ductless heat pumps. These 80 properties represented a total of 2,088 housing units. The sole gas-heated property contained 201 housing units and received attic insulation and air sealing.

1.2.1 Internal Program Checkup

In late 2013, the prime contractor conducted an internal program review in order to assess savings realization rates and identify possible program improvements. The review included a billing analysis that entailed the collection of energy usage data from nine participating properties (representing 233 housing units) and two non-participating properties (representing 58 housing units) that served as a control group. The review found a realization rate of 107% for weatherization-only upgrades and 59% for ductless heat pump upgrades. Based on tenant surveys and other observations, the primary drivers of the low realization rate for ductless heat pumps was due to some tenant's reliance on the pre-existing electric baseboard for heating as well as ineffective training for tenants and property managers. After the checkup was completed, the program instituted several changes including (1) increasing the minimum annual electricity usage for ductless heat pump projects (2) offering training to property managers on ductless heat pump operation and maintenance and (3) providing stickers for tenant's electric baseboard thermostats that read "Expensive Heat – Use Heat Pump First".

1.3 Methodology

The overall evaluation work plan can be divided into two components: the impact evaluation and the process evaluation. The following sections present the methodology for each component.

1.3.1 Impact Evaluation

The central component of the impact evaluation was an analysis of electric and gas billing data in order to estimate first-year and lifetime energy savings at the program and measure level.[7] Another important component of the impact evaluation was the cost-effectiveness analysis.

[7] In the work plan, the evaluation team proposed to apply the realization rate derived from the billing analysis to the demand savings algorithm in the Efficiency Maine program tracking database in order to estimate the verified electric demand savings. However, because the program tracking database did not include projected electric demand savings, estimates of verified demand savings could not be developed.

1.3.1.1 Target Population

The target population for the billing analysis included the electrically heated and gas-heated multifamily buildings and units for which weatherization was completed in FY2013. Projects that were completed in FY2014 were not included in the billing analysis because there were insufficient post-weatherization billing data available at the time the billing data was collected for the evaluation.

1.3.1.2 Sample Frame

The sample frame was developed from the LIWx program tracking database, dated March 7, 2014.[8] The database included 84 electrically heated properties for which weatherization was completed in FY2013. Four properties were excluded from the sample frame because they were revisited in FY2014 for installation of additional measures. As a result, the sample frame for the electrically heated buildings included 80 FY2013 multifamily properties, with a total of 2,088 housing units. Table 1-1 shows the distribution of these properties and projected lifetime savings by upgrade type.[9]

Table 1-1: Electrically Heated Properties by Upgrade Type, FY2013

Upgrade Type	Number of Properties	Number of Units	Projected Lifetime Electric Savings (MWh)
Weatherization Only	23	791	25%
Heat Pumps Only	26	576	22%
Weatherization and Heat Pumps	31	721	53%
All	80	2,088	98,915

The program tracking database included only one gas-heated property with 201 housing units for which weatherization was completed in FY2013. These units were individually metered for electricity but master metered for gas. While this property received attic insulation and air sealing targeted to reduce gas usage, it did not receive any measures targeted to reduce electricity usage.

[8] The database file was named "LIWxMF Tracker 2014-03-07.xlsx"
[9] Most properties, regardless of their upgrade type, also received some domestic hot water measures and CFLs.

1.3.1.3 Sample Selection

Efficiency Maine conducted a preliminary electric billing data analysis as part of an internal program checkup in early 2014. Table 1-2 presents information on the properties included in this checkup.[10]

Table 1-2: FY2013 Properties and Units Included in the Internal Checkup

Upgrade Type	Number of Properties	Number of Units
Weatherization Only	2	74
Heat Pumps Only	3	89
Weatherization and Heat Pumps	3	70
All	8	233

In order to leverage the data collected for the preliminary analysis, the sample frame (80 properties; 2,088 units) was divided into two initial strata for the purposes of sample selection.

- Stratum 1 consisted of the FY2013 properties (8) and units (233) that were included in this internal program checkup. All properties and units in Stratum 1 were sampled with certainty.
- Stratum 2 consisted of the remaining FY2013 properties (72) and units (1,855). An initial sample from this stratum was drawn using a two-stage probability-proportional-to-size (PPS) sampling design. The subsequent challenges associated with collecting billing data from the property owners and managers required the release of the remaining FY2013 properties in Stratum 2 for data collection.

The sample for the gas billing analysis included the sole gas-heated property for which weatherization was completed in FY2013. Given that there were no unit-level gas meters in this property and that no electric upgrades were done, no electric billing data was collected for this property.

[10] Efficiency Maine shared the data and results of this interim billing analysis with the evaluation team. The shared files were named "Efficiency Maine LIWx Program Checkup_2014-02-25.docx" and "Maine Results mb-bh3 2013-11-15.xlsx."

1.3.1.4 Collection of Energy Usage Data

The evaluation team collected the energy usage data from May through October of 2014 via outreach to building owners and managers from sampled properties. The evaluation team offered a $100 incentive check per property in exchange for monthly energy usage data for all housing units for 12 months prior to and 12 months after measure installation. However, not all building owners or managers were willing or able to share their usage data. Some owners and managers reported not having the time to participate, others were unable to provide all of the data for the entire 24-month period, and some were simply unresponsive.

The evaluation team encouraged the owners and managers who did not have any or all of the usage data available to reach out to their utilities to request the data. Some owners and managers were able to successfully retrieve the data through this method, while others either were unwilling to submit the request or only received partial data from their utility. In some instances, owners or managers were willing to make second or third data requests of their utilities in order to receive all the missing data. However, in other instances, owners or managers did not have access to the usage data because their tenants were responsible for the electric bills.

As an alternative tactic, the evaluation team also offered to submit utility requests on behalf of the owners, managers, or tenants through their completion of a utility bill release form. Typically, the owners or managers signed the form and then returned it to the evaluation team. However, for a few properties where tenants were responsible for paying the electric bills, the evaluation team requested tenant contact information. If the owner or manager was willing to provide this tenant contact information (some would not share it due to privacy concerns), the evaluation team mailed the utility release form along with an explanatory letter to the tenant. Tenants were then asked to sign and mail the release back to the evaluation team using the enclosed pre-paid return envelope; the team placed follow-up telephone calls to remind tenants to return the forms. After the evaluation team received the signed release forms, Efficiency Maine submitted the forms to the appropriate utility. In some instances there was a significant delay between the time a utility request was made and when the data was provided to either the evaluation team or to the owner or manager.

One final method that the evaluation team used to obtain usage data was submitting account numbers to the utilities for properties where at least some data had been provided. The evaluation team developed a spreadsheet with account numbers, utility names, property names, addresses, owners, and tenant names (where available) and submitted it to Efficiency Maine, who in turn made requests of the respective utilities. The evaluation team received some usage data from Central Maine Power through this method.

1.3.1.5 Billing Analysis

Because the LIWx program often included the installation of multiple measures at each property, estimation of the total energy savings required a comprehensive method for estimating the

combined impact of multiple installed measures. The evaluation team's impact evaluation method was an analysis of electricity and gas consumption data, which is the recommended approach in the Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol from the Uniform Methods Project.[11] The evaluation team used a house-by-house degree-day adjustment method, which is similar to the Princeton Scorekeeping Method (PRISM), to weather-normalize the energy consumption data. The method applies the following weather normalization procedures.[12]

1. Calculate the number of heating and cooling degree-days that are included in each usage period, which is usually about a month, for each account from the closest weather station.[13]
2. Determine whether periods should be classified as baseload periods, heating periods, or cooling periods based on the number of heating and cooling degree-days in the period.
3. Calculate the total baseload period usage, heating period usage, and cooling period usage.
4. Calculate the relationship between heating period usage minus baseload usage and degree-days (i.e., heating usage per heating degree-day). Calculate normalized annual heating usage using this value and the average long-term heating degree-days.
5. Follow the same method to calculate normalized annual cooling usage.
6. Sum the baseload usage, heating usage, and cooling usage to obtain the normalized annual usage for pre- and post-treatment periods.

The evaluation team calculated verified gross savings for each account as the difference between pre- and post-treatment normalized annual usage.

Multifamily properties that received program services in FY2013 were treated as the analysis group for this evaluation. Energy usage was analyzed both for the year prior to and the year after service delivery was completed, excluding the measure installation period. The analysis included as close to a full year of pre- and post-treatment data as possible. Table 1-3 displays the attrition statistics for the electric usage analysis. The evaluation team was able to collect electric billing data for accounts serving 1,110 units in 53 properties. Accounts were included in the analysis if their pre- and post-treatment usage data each had at least 183 days and at least 50% of an average year's heating degree days. Eight additional accounts were removed from the analysis because their pre- or post-treatment annual usage was below 1,200 kWh or if their change in usage was

[11] Chapter 8: Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol. http://www1.eere.energy.gov/wip/pdfs/53827-8.pdf

[12] PRISM software has not been updated since 1995, and it does not run on modern operating systems or allow batch processing for multiple weather stations. This method provides very similar results to PRISM and allows for a greater number of housing units to be included in the estimation.

[13] The analysis used weather data from six airport locations in Maine: Augusta, Bangor, Caribou, Houlton, Millinocket, and Portland.

greater than 65%.[14] After these exclusions, the evaluation team included 59% of the 80 properties and 40% of the 2,088 units in the analysis.

Table 1-3: Electric Billing Analysis Data Attrition

	Number of Properties	Number of Units
Original Population	80	2,088
Billing Data Collected[15]	53	1,110
Insufficient Pre-Treatment Data	4	150
Insufficient Post-Treatment Data	2	113
Pre or Post Usage Below 1,200 kWh	0	2
Change in Total Usage > 65%	0	6
Final Sample	47	837
% Included in Analysis	59%	40%

Table 1-4 shows the distribution of the final electric analysis sample by upgrade type. The analysis sample included a sufficient number of cases in each upgrade group.

Table 1-4: Final Electric Analysis Sample by Upgrade Type

	Number of Properties	Number of Units
Weatherization Only	14	336
Heat Pumps Only	13	222
Weatherization and Heat Pumps	20	279
All	47	837

Finally, analysis weights were developed for each unit included in the sample so that the analysis sample properly represents the total treated population of 2,088 electrically heated units in FY2013 by upgrade type. The case weights for each unit were developed as the product of unit-, property-, and implementer-weights. Unit weights were computed by dividing the total number of units in the property by the number of units included in the analysis from that property. Unit weights ensure that the units included in the analysis from a property also represent all other units in that property. Property weights were computed as the total number of units in the population for each upgrade type divided by the total number of units in the properties included in the analysis for that upgrade type.[16] Property weights ensure that the properties included in the

[14] Annual usage amounts below 1,200 kWh usually indicate periods of vacancy. A change in usage that is greater than 65% is usually related to factors unrelated to the program treatment or indicates issues with usage data.

[15] Four properties for which billing data were available were master-metered for electricity. The number of units associated with each master meter is included in the unit counts.

[16] The property weight for properties included in the interim billing analysis was 1.0 because these properties were included in the analysis with certainty.

analysis also represent all other properties that received the same type of upgrade but were not included in the analysis. Because different contractors implemented the weatherization-only projects, implementer weights were also applied to all weatherization-only projects. Implementer weights were calculated as the fraction of units completed by the prime contractor (as opposed to a subcontractor) in the population divided by the fraction of units completed by the prime contractor in the sample during the evaluation period. Implementer weights ensure that the fraction of units that were implemented by the prime contractor in the sample accurately represent the fraction that were implemented by the prime contractor in the population during the evaluation period[17].

The sole gas-heated property that was included in the analysis had three master-metered gas accounts. The data from all three accounts passed the attrition screening and were included in the gas billing analysis.

1.3.2 Process Evaluation

The evaluation team conducted a comprehensive process evaluation, including telephone interviews with program staff and participating property owners/managers, telephone surveys with tenants from participating properties, and a best practices review.

1.3.2.1 Review of Program Materials, Data, and Best Practices

The evaluation team reviewed program manuals and other documents to develop a comprehensive understanding of program design and delivery. The evaluation team also reviewed program tracking databases to develop a comprehensive understanding of the data available and to develop the sample frames. In addition, the team reviewed reports on other low-income multifamily programs to identify innovative and "best practice" approaches utilized elsewhere.

1.3.2.2 Interviews with Program Staff

The evaluation team conducted three interviews with Efficiency Maine and CSG staff and one interview with a participating installation contractor. The interviewees included those staff with the greatest level of responsibility for designing and implementing the program as well as a Senior Technical Field Representative who had significant personal interactions with building owners/managers and installation contractors over an extended period. Because the budget only allowed for one interview of a participating contractor, we selected an active contractor suggested by program staff who had installed measures for a significant number of projects. Interview questions focused on eliciting information on the following:

- The key goals of the program and input about the success to date in meeting them

[17] The participation of subcontractors during the evaluation period (July 1, 2012 – June 30, 2013) was somewhat higher than their participation either prior to or after that period.

- Program management structure, responsibilities, lines of communication, and authority; relationship between management and contractors; and any opportunities for improvement
- Clarification of any program design issues arising from the review of program design documents, discussion of any changes made to the initial program design during implementation, and investigation into why the changes were made
- Whether there were implementation challenges, and, if so, how they were addressed
- How the eligible low-income properties and participants were identified for the program
- How well the program tracking databases met the various needs for program monitoring and assessment
- What program management reports were generated from the databases and how they meet information needs
- What additional program data, if any, would be useful to have in the tracking databases
- Ideas and recommendations for any program enhancements and modifications

1.3.2.3 Interviews with Participating Property Managers

The evaluation team interviewed a total of 12 program participants representing at least 36[18] separate properties and a total of over 900 housing units. Interviews with this diverse group of building owners and managers focused on the following issues:

- How the property owners/managers became aware of the program
- The ease of getting information and enrolling in the program
- Clarity of program requirements and offerings
- Perceived value of the benefits
- Accessibility and responsiveness of the program and contractor staff to answer questions and address issues
- Ease of scheduling the installation
- Actual experience of the installation: how well the contractor staff and installation process met expectations, whether work was completed in a timely and tidy fashion, whether the installation process caused any tenant issues that the property owners/managers had to resolve, whether there were any unanticipated challenges and how they were resolved
- The experience of the project close-out: how communication about the project completion was handled; whether there were any unresolved issues and, if so, what level of effort the property owners/managers had to expend to resolve them
- Perception of benefits: whether the property owners/managers are seeing energy savings directly or, if the tenants are seeing the energy savings, whether that provides any

[18] Four of the interviewed building owners/managers indicated that the companies or organizations they work for had one or more buildings receive program services in addition to those buildings listed in the program database.

benefits to the property owners/managers; level of interest in pursuing projects for other properties; willingness to contribute co-pay

- The degree of influence that the program had on their decision to install the measures
- Additional energy-saving projects or actions undertaken at the participating property or other properties since program participation
- Ideas and recommendations for any program enhancements or modifications

These properties are located in 28 different towns representing ten of Maine's sixteen counties. In order to limit the administrative burden on the respondents, a participant was contacted for an interview only after that participant successfully provided energy usage data to the evaluation team. In this way, the team was able to focus the participants on the core task of providing data required for the impact evaluation, then release them for an interview.

The team spoke with people involved with the program who had a variety of different perspectives, including facilities directors for large real estate companies and housing authorities, site managers for individual buildings, building owners, office managers, and fiscal managers. In three cases, multiple people involved with the same properties were interviewed. The number of interviews by respondent role are shown in Table 1-5.

Table 1-5: Roles of Respondents

Role	Number of Interviews
Facilities/Maintenance	6
Site Manager	2
Tenant Liaison	1
Office/Overall Manager	2
High Level/Financial Oversight	2
Owner	2
Total Number of People Interviewed	*15*

The building owner/manager interviews were also well represented by buildings that only had heat pumps or weatherization measures installed and by buildings that had both types of measures installed, as shown in Table 1-6.

Table 1-6: Number of Buildings by Type of Installed Measures

Installed Measures	Number of Buildings Represented by Interviews
Weatherization Only	7
Heat Pumps Only	12
Weatherization and Heat Pumps	17

There was also considerable diversity among the people interviewed regarding the numbers of buildings and units that participated in the program. A few respondents represented only one

building and/or a few dozen units, while others represented eight or more buildings and/or 100 or more units.

1.3.2.4 Telephone Surveys with Tenants from Participating Properties

In order to gather data from tenants regarding the upgrades performed in their apartments, the evaluation team conducted computer-assisted telephone interview (CATI) surveys with 57 tenants in November 2014.

The objectives of the surveys were to assess the following items:

- Awareness of program participation
- Satisfaction with the overall program, specifically their interactions with contractors and each measure installed
- Verified installation of program measures, to the extent feasible
- Experience and use of installed measures, in particular ductless heat pumps
- Performance issues, concerns, and satisfaction with installed equipment
- Level of comfort before and after participation
- Perceived cost savings if they pay for their own electricity bills
- Demographics characteristics

The evaluation team developed the sample for the survey by asking building owners and managers from participating multifamily properties to share their tenants' contact information. The team worked to collect this contact information from May through October 2014. However, not all participating building owners or managers were willing to share tenant contact information due to privacy policies or other concerns. We were able to obtain contact information for 431 tenants from 24 participating properties, of which 57 tenants completed surveys from 20 different properties. These 57 tenants represent about 2.7% of the 2,088 units and 25% of the 80 properties that were included in the sample frame.

Participating properties could have received a variety of in-unit upgrades, including ductless heat pumps and direct install measures such as CFLs, low-flow showerheads, low-flow aerators, and hot water temperature turndowns. While the program records identified which properties received which measures, the database did not indicate which specific units within each property received which in-unit measures. Therefore, it was necessary to verify measure installations via the tenant surveys. Using the program records, the evaluation team created a flag for tenants who lived at properties that had ductless heat pumps installed. Similarly, the evaluation team created a flag for participants who lived at properties where direct install measures were included.

The evaluation team requested contact information for tenants who the building owners/managers thought had occupied the apartment for at least one year prior to the date that the program upgrades were performed at their respective buildings. The rationale was to identify tenants who could share their experience from the periods both before and after the upgrades. During the initial fielding of the survey, tenants were asked a question to help screen out those

who had lived in their apartments for less than a year prior to program participation. However, due to a low response rate, this question criterion was relaxed to allow tenants to participate if they had lived in their apartments during or prior to the time of the program upgrades. In addition, a $10 incentive was subsequently offered to tenants in order to encourage cooperation.

Table 1-7 shows that 63% of respondents had moved in at least one year prior to the time when the program upgrades were performed, and 37% had moved in less than one year prior to or during the time that the program upgrades were performed.

Table 1-7: Tenant Move-in Date

(Base: All Survey Tenants)

Tenant Move-in Date	All Tenants
Sample Size	*57*
Moved in at least one year prior to the month and year that the program upgrades were performed	63%
Moved in less than one year prior to or during the month and year that the program upgrades were performed	37%

The surveys averaged about 11 minutes in length and were conducted between November 6 and November 30, 2014 from 5:00 P.M. to 9:00 P.M. on weekdays, 11:00 A.M. to 5:00 P.M. on Saturdays, and 1:00 P.M. to 5:00 P.M. on Sundays. At least five attempts were made to reach each sampled customer. If a tenant was reached at an inconvenient time, the best time to call back was determined or an appointment scheduled. The sample precision of the 57 surveys at the 80% confidence level is ±8.4% and at the 90% confidence level it is ±10.9%.

2 Impact Evaluation

The impact evaluation section of this report consists of the gross savings analysis and net savings analysis, followed by the cost-effectiveness analysis.

2.1 Gross Savings Analysis

This section describes the results of the electric and gas billing analysis.

2.1.1 Electricity Savings

Table 2-1 summarizes the total gross electric usage impacts for the properties included in the billing analysis. Because the program screened properties based on their electric usage, those properties with higher usage received both weatherization and heat pumps while properties with lower usage received only weatherization or only heat pumps.

Average gross normalized annual electricity savings per multifamily housing unit was 996 kWh or 12.1% of the pre-weatherization usage. The 90% confidence interval around this savings estimate was ±100 kWh, which implies that the relative precision of the estimate was ±10% at a 90% confidence level.

Average gross annual savings per unit for properties that received heat pumps only was about 1,400 kWh or 15.6% of pre-weatherization usage, which was significantly higher than that for properties that received weatherization-only upgrades that saved about 300 kWh or 4.5% of pre-weatherization usage. Estimated savings for properties that received weatherization in addition to heat pumps were similar to those that received heat pumps only, which may be due to interactive effects between the measures.

Table 2-1: Total Electricity Savings by Upgrade Type

	Average Annual Normalized kWh per Unit				Percent Savings
	Pre	Post	Savings	±90% c.i.	
Weatherization Only	6,683	6,384	299	±98	4.5%
Heat Pumps Only	8,986	7,585	1,401	±166	15.6%
Weatherization and Heat Pumps	9,282	7,844	1,438	±204	15.5%
All	8,216	7,220	996	±100	12.1%

Figure 2-1 shows the distribution of percent savings for individual housing units by upgrade type. The vertical axis displays the percent of housing units and the horizontal axis displays the percent savings. The distribution of electricity savings for units in buildings that received heat pump-only upgrades (upper left corner of chart) has a peak around 15%, though some units had savings greater than 30% of pre-treatment usage. The distribution of electricity savings for units in buildings that received weatherization-only upgrades (upper right corner of chart) has a single peak around 0%, likely because not every housing unit in a property that received building-level weatherization upgrades would benefit.

Figure 2-1: Distribution of Percent Savings by Upgrade Type

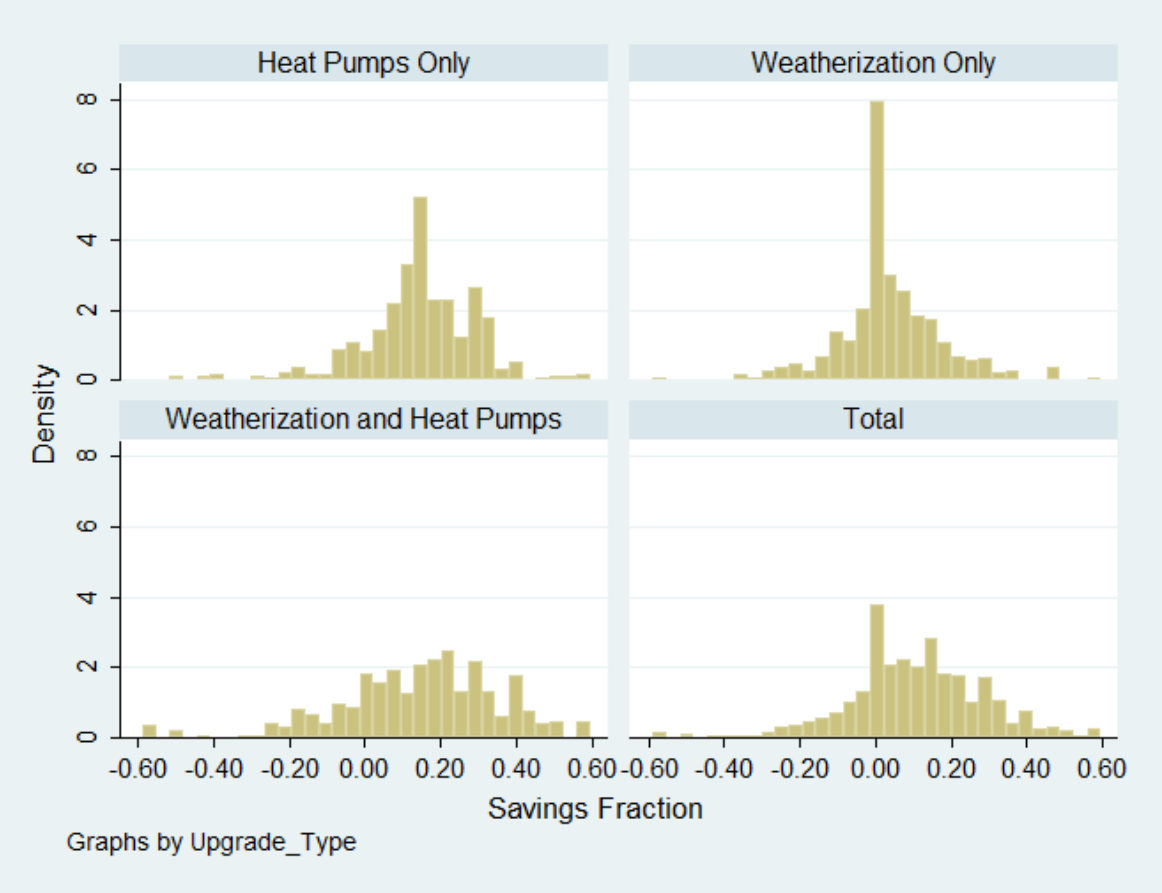


Table 2-2 shows the impacts of the program on electricity used for heating. Average gross normalized annual electricity savings for heating per multifamily housing unit was 846 kWh or 21.0% of the pre-weatherization heating usage. A comparison of the results in Table 2-1 and Table 2-2 indicates that the program achieved most of its savings through reducing electricity usage for heating, as would be expected given that Maine has a predominantly heating-based climate.

Table 2-2: Gross Heating Savings by Upgrade Type

	Average Annual Normalized Heating kWh per Unit				Percent Savings
	Pre	Post	Savings	±90% c.i.	
Weatherization Only	3,190	2,903	287	±96	9.0%
Heat Pumps Only	4,448	3,459	989	±145	22.2%
Weatherization and Heat Pumps	4,595	3,250	1,345	±165	29.3%
All	4,022	3,176	846	±85	21.0%

Table 2-3 shows the impacts of the program on baseload electricity usage. Average gross normalized annual baseload electricity savings per multifamily housing unit was 134 kWh or 3.3% of the pre-weatherization baseload usage. Multifamily properties that received only heat pumps were the sole group that had baseload savings that were significantly different from zero at a 90% confidence level. We are unclear as to why this is the case because the measures that should primarily contribute to baseload savings (domestic hot water and CFLs) were installed at most properties.

Table 2-3: Gross Baseload Savings by Upgrade Type

	Average Annual Normalized Baseload kWh per Unit*				Percent Savings
	Pre	Post	Savings	±90% c.i.	
Weatherization Only	3,444	3,438	5	±90	0.2%
Heat Pumps Only	4,469	4,086	383	±166	8.6%
Weatherization and Heat Pumps	4,599	4,522	77	±195	1.7%
All	4,126	3,991	134	±92	3.3%

*Due to rounding error, numbers may not sum to total

Table 2-4 shows the impacts of the program on electricity used for cooling. The results indicate that cooling, on average, constituted a tiny portion of total electricity usage for program participants. As a result, kWh savings for cooling usage were negligible even if the savings as a percentage of pre-treatment cooling usage were relatively high.

The installation of heat pumps could increase electricity demand and consumption during the summer if air conditioners were not used prior to participation. However, this analysis indicates that heat pumps did not result in an increase in cooling consumption.

Table 2-4: Gross Cooling Savings by Upgrade Type

	Average Annual Normalized Cooling kWh per Unit*				Percent Savings
	Pre	Post	Savings	±90% c.i.	
Weatherization Only	50	43	6	±12	13.0%
Heat Pumps Only	68	40	28	±18	41.2%
Weatherization and Heat Pumps	88	72	16	±21	18.2%
All	68	52	16	±10	23.1%

*Due to rounding error, numbers may not sum to total

2.1.2 Gas Savings

Table 2-5 presents the gas savings estimates for the sole gas-heated property, which was master-metered for gas. Average gross normalized annual gas savings for the property was 3,085 ccf or 13.7% of the pre-weatherization gas usage. About two-thirds of these savings were for heating and one-third was for baseload.

Table 2-5: Total Gross Gas Savings

	Average Annual Normalized Gas Usage (ccf)				Percent Savings
	Pre	Post	Savings	±90% c.i.	
Total Gas Usage	22,575	19,490	3,085	±1,745	13.7%
Gas Usage for Heating	15,748	13,822	1,926	±1,563	12.2%
Gas Usage for Baseload	6,828	5,668	1,159	±599	17.0%

2.1.3 Realization Rates

2.1.3.1 Electric Savings Realization Rates

The evaluation team compared the savings estimates from the billing analysis to the modeled savings assumptions from the Real Home Analyzer (RHA) software as well as to the lighting and domestic hot water measures in the program tracking database in order to compute a realization rate for electricity savings.

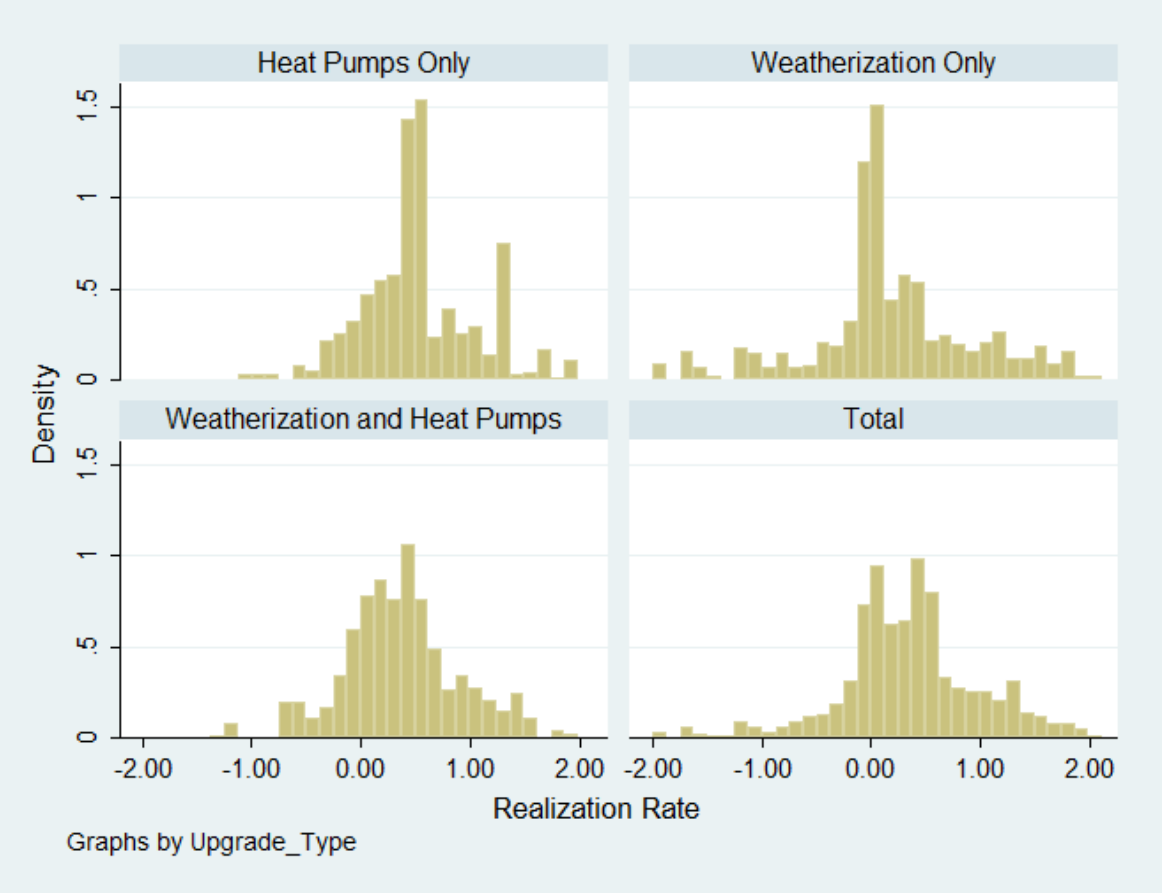
Table 2-6 shows the estimates of the realization rates for electricity savings. The overall savings realization rate was 40%. The savings realization rate for weatherization-only upgrades was 26%, which was lower than that for the other types of upgrades: 54% for heat pumps and 38% for weatherization plus heat pumps.

Table 2-6: Electricity Savings Realization Rates by Upgrade Type

	Evaluated Savings	Program Savings Assumptions	Realization Rate	±90% c.i.
Weatherization Only	299	1,140	26%	±8%
Heat Pumps Only	1,401	2,608	54%	±6%
Weatherization and Heat Pumps	1,438	3,824	38%	±5%
All	996	2,472	40%	±4%

Figure 2-2 shows the distribution of savings realization rates by upgrade type. While the distribution of savings realization rates for units in buildings that received heat pump-only upgrades (upper left corner of chart) has a single peak around 40%, a significant share of these units had realization rates greater than 100%. The distribution of realization rates for units in buildings that received only weatherization upgrades (upper right corner of chart) has a peak around 10%, though some units had savings that were greater than 30%. For the overall program (lower right corner of chart), the distribution of realization rates mostly fell between 0% and 50%.

Figure 2-2: Distribution of Savings Realization Rates by Upgrade Type



There were 17 tenants who received a ductless heat pump, responded to the telephone survey and were also included in the billing analysis. Eleven of these 17 tenants reported only using their ductless heat pump to heat their apartment and yielded an average of 16% savings, which reflects a 50% realization rate. In contrast, the five tenants who reported using both their electric baseboard system and the ductless heat pump had an average of −4% savings, which reflects a −13% realization rate. While this analysis is based on a small sample size, it indicates that the tenants who only used the ductless heat pump to heat their apartments realized more savings than those that also used their electric baseboard.

In addition, the recent Emera Maine heat pump study found that customer education is essential to maximizing savings because customers need to control both their existing heating system and their new DHP.[19] The study found that participants who utilized their DHP as the primary heating system achieved the highest savings.

A study conducted for the Bonneville Power Administration found that DHP heating savings in multifamily buildings were less than anticipated for two reasons.[20] Based on metering of 12 units, the study found "takeback"—significant increases in heat output after the installation of the DHP (from 39% to 78%). In addition, the DHPs were not fully utilized because electric resistance heating was estimated to account for 25% to 57% of input heating energy. The degree of conversion to DHP usage was strongly associated with the degree of savings.

2.1.3.1.1 Realization Rate Differences by Implementing Agency

During the FY2013 evaluation period, a higher percentage of weatherization-only projects were completed by subcontractors than either before or afterwards. Of the 23 FY2013 weatherization-only projects, 12 were performed by a subcontractor rather than the primary implementation contractor.

[19] Emera Maine Heat Pump Pilot Program, November 17, 2014. EMI Consulting. http://www.emiconsulting.com/assets/Emera-Maine-Heat-Pump-Final-Report-2014.09.30.pdf

[20] Ductless Heat Pump Retrofits in Multifamily and Small Commercial Buildings. December 7, 2012. Prepared for Bonneville Power Administration. Prepared by Ecotope, Inc. http://www.bpa.gov/EE/Sectors/Residential/Documents/DHPx_Multifamily%20_Small_Commercial_Report_02-08-13.pdf

Table 2-7 shows the annual electric savings and realization rates for the weatherization-only projects differentiated by prime contractor vs. subcontractors. Weatherization projects performed by the prime contractor yielded an average realization rate of 55% while the weatherization projects implemented by subcontractors yielded an average realization rate of 14%. This large difference in realization rates is driven by both inflated savings assumptions as well as lower evaluated savings values for the subcontractor-led projects. The program savings assumptions for the subcontractor-led projects are over twice as large as the assumptions for the prime contractor projects. In addition, the evaluated savings for the subcontractor-led projects are 57% of the evaluated savings for the prime contractor projects.

Table 2-7: Weatherization Electricity Savings Realization Rates by Implementing Agency

	Number of Wx-only projects	Evaluated Savings per Unit (Annual kWh)	Program Savings Assumptions per Unit (Annual kWh)	Realization Rate	±90% c.i.
Prime Contractor	11	387	708	55%	±21%
Subcontractors	12	220	1,525	14%	±8%
All Weatherization-only projects	23	299	1,140	26%	±8%

2.1.3.1.2 Comparison to Interim Billing Analysis

Due to the inherent challenges of billing data collection and the limited evaluation budget, the evaluation did not include a comparison group. A comparison group would have allowed the evaluation team to calculate the adjusted gross savings due to the program as the change in usage for the treatment group minus the change in usage for the comparison group. Because baseload electricity usage has generally increased over time as households use more devices and appliances, the inclusion of a comparison group might have shown a higher realization rate. In fact, the interim billing analysis, which included a small comparison group of two untreated properties, found that electricity usage increased by 673 kWh or 8% for the comparison group during the analysis period.

Table 2-8 summarizes the results of the interim billing analysis conducted by Efficiency Maine. The overall realization rate—prior to the comparison group adjustment—in the interim billing analysis was 39%, which is almost identical to the 40% program-level realization rate we computed for FY2013. However, for the interim billing analysis, the estimated per-unit savings were adjusted upward by 673 kWh (the increase in usage at the two comparison group properties) to arrive at the comparison-adjusted savings estimates. This adjustment increased the overall realization rate to 63% and the realization rate for weatherization-only properties to 107%. However, there are two issues about the validity of this adjustment approach:

- Sample size – The comparison group consisted of only two properties. Because of this small sample size, it may not serve as a statistically valid comparison group.
- Adjustment factor – Change in usage is usually a function of pre-treatment usage. As such, it would have been more appropriate to interpret the change in usage for the comparison group in relative terms rather than absolute terms in order to account for the differences in pre-treatment usage between the treatment and comparison group properties. This means that, in the absence of the program, the treatment group properties would have increased their per-unit usage by 8% rather than by 673 kWh. For example, an 8% comparison group adjustment would have increased the savings for the weatherization-only properties to 958 kWh rather than 1,152 kWh, which would have changed the comparison-adjusted realization rate from 107% to 89%. This 8% adjustment would have changed the overall comparison-adjusted realization rate from 63% to 66%.

Table 2-8: Interim Electric Billing Analysis Results per Housing Unit

	Pre Usage (kWh)	Post Usage (kWh)	Savings (kWh)	Percent Savings	Program Savings Assumptions	Unadjusted Realization Rate	Comparison Adjusted Savings	Comparison Adjusted Realization Rate
Treatment Group								
Weatherization Only	5,728	5,249	479	8%	1,074	45%	1,152	107%
Weatherization and/or Heat Pumps	10,365	9,137	1,228	12%	3,206	38%	1,901	59%
All	9,582	8,499	1,083	11%	2,799	39%	1,756	63%
Comparison Group								
Untreated	8,732	9,405	-673	-8%				

The team's experience with other program evaluations that used comparison groups of a sufficient sample size indicates that a comparison adjustment usually changes the gross savings estimates by up to ±3%. A comparison-adjustment of +3% would change the overall evaluated savings in the billing analysis from 994 kWh to 1,241 kWh and the overall realization rate from 40% to 50%.

2.1.3.2 Gas Savings Realization Rates

The evaluation team compared the estimates of gas savings from the billing analysis to the savings assumptions in the program tracking database in order to compute a realization rate for the sole gas property included in the billing analysis. The gross savings realization rate for this property was 69% (Table 2-9). While this gas realization rate is higher than the electric realization rates, it reflects only one property and the electrical analysis reflects the average estimates found from multiple properties representing a range of individual realization rates.

Table 2-9: Gas Savings Realization Rate

	Evaluated Savings	Program Savings Assumptions	Realization Rate	±90% c.i.
Gas Savings	3,085	4,462	69%	±57%

2.1.4 Measure-Level Electric Savings

In order to estimate measure-specific electric savings for key program measures, the evaluation team developed a linear regression model that predicted savings based on the program measures that were provided, using the following formula:

$$\Delta NAC_i = \alpha + \beta_1 * HP + \beta_2 * AS\_Insul + \beta_3 * DHW + \beta_4 * CFL + \mu_i,$$

Where:

ΔNAC_i is the change in normalized per-unit annual electricity consumption in property *i*,

HP is an indicator variable that equals 1 if property *i* received heat pumps and 0 otherwise,

AS_Insul is an indicator variable that equals 1 if property *i* received air sealing and insulation measures[21] and 0 otherwise,

DHW is an indicator variable that equals 1 if property *i* received any one of the domestic hot water measures, including tank wrap, pipe insulation, low-flow showerheads, faucet aerators, pipe insulation, or temperature turndown and 0 otherwise,

CFL is the number of CFLs per unit that were provided in property *i*,

μ_i is the regression error term.

[21] There was no property that received air sealing but no insulation or vice versa. Therefore, the impact of air sealing on savings could not be distinguished from that of insulation.

Table 2-10 provides the measure-specific savings estimates based on this regression analysis. Heat pumps were the only measure that had a statistically significant coefficient in the model. The results indicate that the heat pump savings per unit were 1,045 ± 322 kWh at the 90/10 confidence/precision level. Although not statistically significant, each CFL bulb reduced annual electricity usage by 28 ± 36 kWh.[22] Air sealing and insulation measures had very low savings estimates per unit.

Table 2-10: Measure-Level Savings Estimates

Measure	Estimated Annual Savings (kWh)	±90% c.i.
Heat Pumps	1,045	±322
Air Sealing and Insulation	24	±343
Domestic Hot Water	72	±389
CFL bulb	28	±36

[22] The program, on average, provided 5.3 CFLs per unit. This suggests that the contribution of CFLs to annual savings per unit, on average, was 28 kWh × 5.3=148 kWh.

2.1.5 Benchmarking

Table 2-11 compares the annual electricity savings to two other studies that estimated annual electricity savings for programs that serve low-income multifamily properties. A recent evaluation of the Connecticut Home Energy Services – Income Eligible (HES-IE) program[23]—which offers ductless heat pumps, weatherization, and other measures—found annual savings of 880 kWh per multifamily housing unit, representing 14% of pre-program usage. However, unlike the Efficiency Maine LIWx units, not all HES-IE units are electrically heated; the average annual pre-program usage was 6,143 kWh in Connecticut, less than the 8,216 kWh found in Maine.

In addition, an evaluation of the Ohio Electric Partnership Program estimated annual savings of 1,486 kWh for high usage apartments and 728 kWh for moderate usage apartments, with both savings representing between 11% and 13% of pre-program usage.[24] The Ohio program offered lighting retrofits, appliance replacements, DHW measures, and other miscellaneous measures.

Overall, these results indicate that the annual savings (996 kWh) and percentage savings (12%) from the Efficiency Maine program are similar to those of other low-income multifamily programs. However, the program's realization rate of 40% is substantially lower than the Connecticut realization rate of 64%.

Table 2-11: Benchmarking Comparison of Electric Savings for Other Low-income Multifamily Programs

	Evaluated Annual Savings per Housing Unit (kWh)	Pre-Program Annual Usage per Housing Unit (kWh)	Percent Savings	Realization Rate
Efficiency Maine LIWx Program				
Weatherization Only	*299*	*6,683*	*4.5%*	*26%*
Heat Pumps Only	*1,401*	*8,986*	*15.6%*	*54%*
Weatherization and Heat Pumps	*1,438*	*9,282*	*15.5%*	*38%*
Overall	*996*	*8,216*	*12.1%*	*40%*
Connecticut HES-IE Multifamily	880	6,143	14.3%	64%
Ohio Electric Partnership Program				
High Usage Apartments	1,486	11,721	12.7%	
Moderate Usage Apartments	728	6,308	11.5%	

[23] Final Report Impact Evaluation: Home Energy Services – Income Eligible and Home Energy Services Programs. Connecticut Energy Efficiency Fund. Cadmus Group and NMR Group. December 31, 2014. http://www.energizect.com/government-municipalities/hes-and-hes-ie-impact-evaluation-r16-final-report-12-31-14

[24] Ohio Electric Partnership Program Impact Evaluation Results for April 2004 – March 2005 Participants, Final Report. Prepared for the Ohio Office of Energy Efficiency. June 30, 2006. Prepared by: Michael Blasnik.

In addition, the Connecticut HES-IE evaluation found that ductless heat pumps yielded an annual savings of 803 kWh each, which is less than the Efficiency Maine LIWx annual savings of 1,045 kWh. The Connecticut HES-IE study also found a realization rate of 46% for ductless heat pumps, which is slightly less than the Efficiency Maine LIWx realization rate of 54% for heat pump projects (some of which also include CFLs and domestic hot water measures).

2.2 Net Savings

The evaluation team asked the 12 participating owners/managers a series of questions to delve into the level of influence the program had on their decision to implement the upgrades, in particular regarding free ridership and spillover.

2.2.1.1 Free Ridership

In response to questioning about whether or not the properties would have installed the weatherization measures or heat pumps if Efficiency Maine had not provided incentives, nine of the 12 owners/managers unequivocally said no. There were some common reasons for this response, such as lack of sufficient operating reserves to fund the project, prioritizing any available funds for roof repairs and other essential maintenance activities, or requirements to include any capital improvements in their long-term plan in order to obtain HUD authorization. Three owners/managers said they might have tried to install the program measures, but there would have been barriers such as additional research and analysis before they could present the owners with a clear return on investment (ROI). One of these three owners/managers noted that if his company did consider installing the measures on its own it would have been on a very limited basis—only a few units per year to start.

2.2.1.2 Spillover

Owners/managers were also asked about the extent to which they installed energy efficiency measures in other properties. Of the ten owners/managers who responded to this question, three indicated that they are considering installing heat pumps at other properties, which suggests the potential for spillover. At least one of these properties currently has oil heat, and the owner/manager was keenly aware of falling oil prices and the impact this would have on the cost-effectiveness of heat pump installations, which suggests that this owner/manager will be cautious about making this decision. One owner/manager has installed heat pumps at another property using Efficiency Maine's $500 market-based incentive, but reported that this was done to provide air conditioning without violating egress requirements; installing window air conditioners in the few windows that meet egress requirements would have violated those requirements. In addition, another respondent reported that his company installed heat pumps in the community buildings at its own expense.

2.2.1.3 Net-to-Gross Ratio

The interview findings described above indicate that the participants exhibit relatively modest free ridership and spillover, the effects of which likely counteract one other. In addition, the

experience of the evaluation team with low-income programs indicates that these programs typically have very limited free ridership and spillover, implying a net-to-gross (NTG) ratio of 100%. In addition, the recent Emera Maine heat pump pilot program study found an 88% NTG ratio for market-rate heat pump projects. Based on these results, the evaluation team believes that a NTG ratio of 100% is a reasonable assumption for the LIWx program.

2.3 Cost-Effectiveness Analysis

The evaluation team calculated cost-effectiveness using a Total Resource Cost (TRC) test, an industry standard for evaluating program cost-effectiveness. If the TRC benefit/cost ratio is greater than one, a program is considered cost-effective.

2.3.1 Cost-Effectiveness of Electric Measures

The evaluation team performed an electric cost-effectiveness analysis for the FY2013 projects using both the assumed and evaluated savings estimates. The evaluation team applied the 40% savings realization rate derived from the electric billing analysis to the program saving assumptions to arrive at the evaluated saving estimates. In computing the lifetime savings, the evaluation team used the same measure life assumptions as the implementation contractor.[25] The analysis utilized avoided costs from the Avoided Energy Supply Costs (AESC) in New England 2013 Report.[26] The avoided costs detailed in that report were presented annually for 2013 through 2043 in constant 2013 dollars. We computed the program benefits for each future year by multiplying annual energy savings by avoided costs for that year. We then adjusted the future benefits to the current year using a real discount rate of 1.36%.

[25] The measure life assumptions are as follows: air sealing and insulation - 30 years, heat pumps - 15 years, CFL bulbs - 12.5 years, showerheads and aerators - 5 years, pipe insulation - 14 years, and water heater temperature turndown - 4 years. For the most part, these assumptions are consistent with the Efficiency Maine Technical Reference Manual. However, the 2015 TRM assumes a measure life of 6 years for direct install CFL bulbs, 18 years for ductless heat pumps, and 15 years for pipe insulation offered through the low-income program, as well as 15 years for air insulation and 25 years for attic insulation offered through the Home Energy Savings program.

[26] Hornby, Rick, et al. *Avoided Energy Supply Costs in New England: 2013 Report*. Prepared for the Avoided Energy Supply Component (AESC) Study Group. July 12, 2013.

The first-year electric avoided costs used for this analysis are detailed in Table 2-12.

Table 2-12: First-Year Avoided Costs—2013 Dollars

Avoided Cost	Peak Period	Unit	Value
Electric Benefits			
Electric energy	Winter peak	$/kWh	$0.055
	Winter off-peak	$/kWh	$0.047
	Summer peak	$/kWh	$0.044
	Summer off-peak	$/kWh	$0.039
Electric capacity	Annual	$/kW/yr	$20.08
Transmission & distribution	Annual	$/kW/yr	$120.82
Intrastate DRIPE	Winter peak	$/kWh	$0.002
	Winter off-peak	$/kWh	$0.001
	Summer peak	$/kWh	$0.001
	Summer off-peak	$/kWh	$0.001
Rest-of-pool DRIPE	Winter peak	$/kWh	$0.010
	Winter off-peak	$/kWh	$0.003
	Summer peak	$/kWh	$0.008
	Summer off-peak	$/kWh	$0.003
Capacity DRIPE	Annual	$/kW/yr	$18.05

Table 2-13 presents the results of the cost-effectiveness analysis. The program's TRC benefit/cost ratio in FY2013 was 1.89 with assumed savings and 0.76 with evaluated savings. It should be noted that this benefit computation for the TRC test did not account for the non-energy benefits of the program, such as improved comfort, health, and safety of the participants; avoided greenhouse gas and criteria air pollutant emissions; and reduced utility collections costs associated with increases in energy affordability. The inclusion of these non-energy benefits would have resulted in a greater TRC ratio for the program.

Table 2-13: Cost-Effectiveness of Electricity Measures, TRC Test, FY2013

Benefits & Costs	Assumed	Evaluated
TRC Benefits		
Annual savings (MWh/year)	5,682	2,273
Lifetime savings (MWh)	101,922	40,769
Present value of lifetime savings ($ @ avoided cost)	$10,172,667	$4,069,067
TRC Costs		
Total measure costs	$4,731,146	
Total delivery costs	$652,645	
Total program costs	$5,383,791	
TRC Ratio	**1.89**	**0.76**

Due to the substantial difference in realization rates for weatherization-only projects completed by the prime contractor versus other subcontractors, TRC ratios were calculated by (1) upgrade type and (2) implementation contractor for weatherization-only projects. All projects that included ductless heat pumps were managed by the prime contractor, therefore we only present a single cost-effectiveness ratio for these projects.

The evaluated cost-effectiveness ratios for the ductless heat pump projects (0.78) and combined ductless heat pump & weatherization projects (0.74) were similar to the overall program value of 0.76 (Table 2-14). However, the evaluated cost-effectiveness ratio for all weatherization-only projects is 0.62, ranging from 0.31 for those projects implemented by subcontractors to 1.46 for those projects implemented by the prime contractor.

Table 2-14: Cost-Effectiveness by Electric Upgrade Type, TRC Test, FY2013

Upgrade Type	Assumed TRC Ratio	Evaluated TRC Ratio
Ductless Heat Pump Only	1.44	0.78
Ductless Heat Pump & Weatherization	1.96	0.74
Weatherization Only	2.37	0.62
Weatherization Only – Prime Contractor	*2.66*	*1.46*
Weatherization Only – Subcontractors	*2.23*	*0.31*
All Electric Upgrade Projects	**1.89**	**0.76**

2.3.2 Cost-Effectiveness of Gas Measures

The evaluation team performed a gas cost-effectiveness analysis for the sole FY2013 gas project included in the impact evaluation using both the assumed and evaluated savings estimates. The evaluation team applied the 69% savings realization rate derived from the gas billing analysis to the program savings assumptions to arrive at the evaluated savings estimates. In computing the lifetime savings, the evaluation team used the same measure life assumptions as the implementation contractor.[27] The analysis utilized avoided natural gas costs from the 2013 New England AESC report. The avoided natural gas costs detailed in that report were presented annually for 2013 through 2043 in constant 2013 dollars.[28] We computed the program benefits for each future year by multiplying annual energy savings by avoided costs for that year. We then adjusted the future benefits to the current year using a real discount rate of 1.36%.

[27] This property received weatherization measures, which were assumed to have a measure life of 30 years. The 2015 TRM assumes a measure life of 15 years for air insulation and 25 years for attic insulation offered through the Home Energy Savings program.

[28] The average avoided natural gas costs over this 30-year period was $10.85 per MMBtu.

Table 2-15 presents the results of the gas cost-effectiveness analysis. The program's gas TRC benefit/cost ratio in FY2013 was 1.18 with assumed savings and 0.82 with evaluated savings. Again, this benefit computation for the TRC test did not take into account the non-energy benefits of the program.

Table 2-15: Cost-Effectiveness of Gas Measures, FY2013

Benefits & Costs	Assumed	Evaluated
TRC Benefits		
Annual savings (Therms/year)	4,462	3,085
Lifetime savings (Therms)	133,860	92,550
Present value of lifetime savings ($ @ avoided cost)	$117,646	$81,339
TRC Costs		
Total measure costs	$77,000	
Total delivery costs	$22,693	
Total program costs	$99,693	
TRC Ratio	**1.18**	**0.82**

3 Process Evaluation

This section integrates the findings from the telephone interviews with program staff and participating owners and managers, the telephone surveys conducted with tenants and the best practices review.

3.1 Program Design and Responsibilities

3.1.1 Program Evolution

According to one of the staff respondents, the program design resulted from conversations with Maine Housing and the low-income Community Action Program (CAP) agencies that had been delivering low-income electric energy efficiency assistance for many years. These discussions indicated that the market for refrigerator replacements and direct-install lighting had been exhausted,[29] and that the remaining opportunity might lie in improving electric heating efficiency. One staff respondent said that the initial focus of the program was on shell improvements, and that it shifted to ductless heat pumps once they inspected buildings and realized how tight and well-insulated the buildings typically were. In both cases, however, the program found that neither building owners/managers nor tenants had much incentive to make improvements. Because energy bills are subsidized in this sector of housing, reliable and low maintenance electric resistance heat is not viewed nearly as negatively as it would be for market-rate housing for which tenants are paying the bills and have the option of finding housing with less costly heating. Building owners were perceived to have little reason to make improvements—by and large, they had neither fuel-switched nor insulated these buildings during several decades of operation at the time the program launched in 2012.

3.1.2 Program Goals

Based on the three staff interviews that the team conducted, program staff exhibited a strong common understanding of the program goals. All three staff members spoke about cost-effectively saving electricity as the primary goal of the program. One of the respondents also specifically referenced making sure that customers were happy, and although the other respondents did not specifically mention that as a goal, it is clear from responses to other questions that they also recognized the importance of customer satisfaction. Staff were asked if they felt the goals were reasonable and, with some qualifications, they agreed that they were. Two of the respondents explained that the electric savings targets were developed based on the minimum savings that needed to be captured with the available budgets in order for the program to be cost-effective. They ultimately thought this was reasonable, though one respondent referenced the challenges created by the eligibility criteria that were used at the outset of the program. This respondent thought that limiting participation to properties that were actually

[29] The Efficiency Maine Low-Income Appliance Replacement Program funded the installation of refrigerators and CFL bulbs in low-income homes.

receiving LIHEAP funds (rather than just eligible) and where the savings would also flow directly to the tenant created significant challenges to identifying and recruiting participants. Once these initial restrictions were eased, this respondent then thought that the goals were reasonable and achievable.

3.1.3 Roles and Responsibilities

There was a strong common understanding of roles and responsibilities among the three program staff members. The Efficiency Maine program manager was responsible for leading the design of the program and providing strategic direction, but did not have a hands-on role in delivery. CSG was responsible for program operations and implementation, including everything from reaching out to potential participants to providing payments at the completion of the job. The Efficiency Maine program manager invested an average of about 20% of his time in this program, whereas CSG's program manager put about 50% of his time into managing the operation. The CSG technical field representative spent approximately 80% to 90% of his time on this program.

Both the CSG and Efficiency Maine program managers indicated that communications between Efficiency Maine and CSG were regular and effective. One respondent indicated that roles were well-defined and there was good communication between the organizations. Another respondent described the communications as "superb." Both CSG and Efficiency Maine agreed that the Efficiency Maine manager was "hands-off," focused largely on strategy and program design. They also agreed that CSG was responsible for all of the customer interactions and assuring that customers were satisfied. With weekly data reviews and at least weekly communications between the two organizations, it was possible to make program adjustments on a rapid basis to assure that barriers were quickly addressed.

The senior technical field representative also had a clear view of his responsibilities and provided the evaluation team with a 30+ step procedure map that outlined his responsibilities for the program, from prioritizing initial contact with potential customers to developing the project scope of work and bid documents, documenting project information, and inspecting and closing out completed projects.

The sense of clear process and efficient program operations conveyed by the program staff was supported by the installation contractor that the evaluation team interviewed. This contractor indicated that he had had a very positive experience working with the Efficiency Maine team, and that the team was always available if needed for any reason.

3.1.4 Staff Reflections

As noted above, all four of the staff respondents had favorable experiences contributing to the development and operation of the program. One staff respondent described it as a "clean" program—one that was not overburdened with unnecessary complication—and said that once the program was up and running, it operated smoothly. This respondent also thinks the program did a good job across the board because it was cost-effective and targeted the appropriate properties.

He also thought that appropriate adjustments were made to program operations over time. An example adjustment is the weighting process used in selecting a winning bid for heat pump installations. The initial focus was on quality over price, but it was later adjusted to prioritize price over capability as the pool of bidding contractors self-selected to become more reliably capable of meeting the program's requirements. As discussed earlier, the program also shifted its focus from weatherization to heat pumps because field experience revealed that the weatherization opportunities in these buildings were less than anticipated. Given the higher realization rates for DHP projects, this decision appears to be justified.

The contractor respondent described the program as "fast and furious" and said that his company had gotten very good at streamlining the installation process. One of the staff respondents described the program as "fun and fast-paced" and thought that the program made significant progress. Another staff respondent said that it was satisfying to be involved in the adoption of heat pumps in Maine, and he believes that the program played a substantial role in accelerating this adoption.

However, two of the four staff respondents wished they had been able to find a way to cost-effectively provide services to smaller buildings. These respondents suggested that there may be a non-trivial number of smaller properties with income-eligible tenants where cost-effective improvements might be possible. They suggested that the requirement to ensure that the program itself was cost-effective prevented these buildings from being served on the assumption that the greater relative administrative cost per unit of savings for smaller buildings would have rendered the overall program not cost-effective.

Several of the staff respondents discussed the challenge of ensuring that tenants received some level of financial benefit from the installed measures. Because in most cases the tenants receive a subsidy toward their energy bills, they may be indifferent to their energy costs, which can provide a significant barrier to motivating tenants to use less energy. If their energy bills decrease, their energy subsidy decreases in proportion so they do not experience any financial savings. However, there may be a lag between when the bills are reduced and when the subsidy is adjusted which could result in short-term financial benefits for tenants, but in the long term this is likely a fairly trivial effect.

3.2 Program Implementation

In this section, we discuss the perspectives of the staff, participating owners/managers, and tenants from participating properties regarding the program implementation.

3.2.1 Identification of Eligible Properties

Both CSG and Efficiency Maine expressed some surprise at how challenging it was at first to recruit program participants, especially because the program offered to pay 100% of eligible project costs. The program staff started with a list of some 3,000+ units from Maine Housing that they expected to be eligible. They also targeted other organizations with connections to

affordable multifamily housing, such as the U.S. Department of Housing and Urban Development (HUD), the U.S. Department of Agriculture's Rural Development division, and approximately 16 local housing authorities. All staff respondents were surprised that the targeted buildings were generally far tighter and better insulated than they had expected, which they attributed to relatively good construction and ongoing maintenance programs driven by federal funding regulations. This situation posed challenges to the cost-effectiveness of building shell improvements and limited the pool of buildings where the program could make improvements. Staff noted that once a property was identified, it often led to projects at additional properties, either because the contact for the project owned or managed additional eligible properties, or because that person was connected with others who did. Of the estimated 10,000 units of electrically heated eligible housing in Maine, one staff respondent suggested that they had upgraded about one-third, and ruled out about one-third for various reasons such as the properties had been fuel-switched already or there were not any cost-effective opportunities. The remaining one-third were considered either too small to justify the program overhead or were not thought to have cost-effective opportunities.

While one staff member was confident that the program had reached virtually all of the potentially eligible properties in the state, another respondent was less sure, citing the possibility of privately held, smaller properties that might not be well-connected to affordable housing networks. These properties would be in addition to the smaller projects that were deemed to be too small for the savings to cover program overhead, as mentioned earlier.

3.2.2 Program Awareness

Eight owner/manager respondents first learned about the program through direct outreach by Efficiency Maine—either by email, phone, or a presentation at a professional or association gathering. One owner/manager found out about the program by being well-connected in housing networks. The remaining four owners/managers either did not remember how they first learned about the program, or were not involved in the early stages of participation. Clearly, outreach by the program accounted for the majority of participants, and no respondents reported that they had initially contacted Efficiency Maine for information.

All of the owners/managers had a clear understanding of the types of work that were done through the program in the buildings for which they were responsible. In most cases, this was a specific but non-technical knowledge, though several of the facilities directors demonstrated a thorough technical knowledge of the equipment or weatherization measures that had been installed. In two cases, this was due to significant complications with the project that the facilities directors felt required them to become deeply involved. In at least one case, it became evident that the owner/manager was making reference to a building that had gone through the program and received heat pump installations even though that building was not on the list of FY2013 projects that the evaluation team was referring to in the owner/manager's interview. This additional building may have received services later in the program, after the evaluation data set was prepared.

3.2.2.1 Tenant Perspectives

Because the LIWx program does not work directly with tenants, the telephone survey first asked tenants whether they were aware that their building participated in an Efficiency Maine program. Table 3-1 indicates that, overall, less than one-third (30%) of all 57 tenants reported this knowledge prior to the survey.

Table 3-1: Tenants' Awareness of Participation in an Efficiency Maine Program

(Base: All Survey Tenants)

Aware that building participated in an Efficiency Maine program prior to survey	Moved in at least one year prior to the month and year that the program upgrades were performed	Moved in less than one year before or during the month and year that the program upgrades were performed	All Tenants
Sample Size	*36*	*21*	*57*
Yes	28%	33%	30%
No	67%	62%	65%
Don't know	6%	5%	5%

Table 3-1 also compares tenant awareness of the Efficiency Maine program with the move-in date of the tenants. Tenants who had moved in at least one year prior to the program upgrades were slightly less likely (28%) to be aware of the program than tenants who had moved in after that time (33%).

3.2.3 Program Point of Contact

Of the 12 owner/manager firms, 11 indicated that it was clear to them at all times who their primary point of contact with the program was. One respondent indicated that this was the case even though the point of contact may have changed over time through the course of multiple buildings participating in the program. In one case, the evaluation team did not obtain a direct response to this question, though the respondent did later indicate that the program was easy to work with, which certainly suggests that there were no negative implications if s/he did not know the primary point of contact. Several respondents elaborated, with comments such as "Communications were very good," "Quite helpful, thorough, and available," "Clear and easy to get hold of," and "He was well-informed." It is worth noting that one of the facilities directors who had what he viewed as significant quality issues in two buildings also stated that he clearly knew his point of contact with the program.

3.2.4 Level of Effort

Eight of the twelve owner/manager respondents thought that the program required very little effort on their part to participate. One of these respondents indicated that s/he was "pleasantly surprised," which may suggest that the level of effort was significantly less than anticipated. Two of the owners/managers noted that obtaining the utility data (either to assess their eligibility for the program or for the impact evaluation) was the most challenging aspect of the whole program.

In addition, one of the owners/managers whose building(s) received weatherization said that the company felt they needed to have maintenance staff on site during the installations in case there were any issues. Another indicated that there was some effort required to repair ceiling damage that was caused when the attic was being insulated, but s/he did not seem to feel that this was outside of the normal course of events for a large construction project.

However, two of the owner/manager respondents believe that participating in the program had required a significant level of effort. In both cases, this was due to multiple quality or performance issues that were not easily resolved. In one of these cases, the respondent believed that participation was well worth it in the end because the improvements were significant.

3.2.5 Participation Process

In most cases, the building owners and managers had multiple buildings participate in the program. In some cases these respondents had essentially similar experiences across all of the participating buildings, but in other cases there were differences. For instance, one owner/manager thought that the heat pump installation was "very neat," but this is the same respondent who had to make ceiling repairs due to the installation of attic insulation. Another owner/manager with multiple buildings said that one of the installation contractors spent time in every unit talking with the tenant about their new heat pumps, while another contractor was less personable but mostly did a good job as well.

Seven of the owners/managers said that the installations went smoothly, fairly well with minimal disruptions, or "quick and smooth." However, three of the owners/managers experienced minor issues or were surprised that the installation took much longer than anticipated. The two remaining owner/manager respondents, whose projects required a fair amount of work on their part, experienced significant complications with an "installation" aspect of the projects. In one case, a manager with multiple buildings reported that a heat pump installer had to be pulled off the job due to poor performance. The installations were then completed by a different company. Nevertheless, the majority of the owners/managers indicated that the process of participating in the program was smooth.

3.2.6 Cost-Sharing

In light of the significant barriers to building owner investment, the program determined that it would be reasonable to pay the full cost of eligible measures. There is often debate in the design of energy efficiency programs regarding how large incentives must be in order to motivate action, and this is true for low-income programs as well. The evaluation team's review of best practices suggests that many successful low-income multifamily programs do require partial payment for efficiency improvements from landlords; thus, the team asked the interviewed owners/managers specific questions regarding whether or not they would have moved forward with their projects if partial payment had been required.

Owners/managers were asked if they would have considered making an investment if the program had paid one-half or three-quarters of the installation cost. However, answers to these questions were frequently vague, and in all cases the responses were highly speculative. In particular, one owner/manager observed that his response had the potential to reduce the future availability of incentives. Five of the owners/managers indicated that, at a 50% cost-share, they would have reviewed the opportunity. The same five respondents had a similar response at a 25% cost-share, though the perceived willingness to consider moving forward was greater the less the owner had to pay. The evaluation team does not find these answers particularly decisive; it appears that some of the owners would have been willing to consider making some level of investment to install heat pumps, given their relatively positive experiences. However, prior to these positive experiences, they would have been less likely to seriously consider installing heat pumps with reduced incentives.

It seems clear that the program would not have been able to achieve the same level of savings at the same pace had it required a cost-share from the owners/managers. The effect on overall program costs of paying 100% incentives appears to have been mitigated by the operating procedures put in place by staff, especially with respect to the installation of ductless heat pumps. Staff developed a streamlined bid procurement system that reportedly led to significantly lower-than-average costs. In fact, one of the staff respondents indicated that most of the vendors provided bids for the jobs sight unseen, based only on the detailed scope of work that CSG provided along with its detailed work standards manual. This process likely resulted in significant time savings for the vendors in preparing cost estimates. After the winning bid was selected, the program shared the pricing for each bid with all of the bidding contractors, which the respondents believe drove costs down to a common, low level. Vendors who were not able to be competitive simply stopped bidding.

3.2.7 Costs That the Program Did Not Cover

In general, building owners incurred little in the way of costs associated with participating in the program other than a minor amount of time on the part of a building management representative. As discussed earlier, one owner/manager had to make ceiling repairs due to damage caused during the insulation job, but he thought this was a minor issue. One of the owners/managers spent $1,000 on remote controls that he thought should have been included in the project. Lastly, another owner/manager who experienced installation issues related to operating instructions also experienced significant warranty issues with both insulation and heat pumps, which required a significant amount of his time to resolve, thereby resulting in a cost to the company.

3.2.8 Opportunities That the Program Did Not Address

Six of the twelve owner/manager respondents thought there were not any other energy efficiency opportunities that they were aware of in the participating properties that were not addressed by the program. One owner/manager mentioned older windows, and another said that some tenants report there is not enough insulation in the walls, though her reasons for thinking this were not

clear. Two managers mentioned oil- or propane-heated buildings that could benefit from heat pumps. Two respondents also mentioned aerators and low-flow showerheads, though both declined to have these measures installed through the program. One said that he had better luck installing them when the apartments turn over so that, rather than experiencing a change, tenants simply adjust to what is there when they move in.

According to one staff member, the program did not provide direct install services to all participating properties. For some properties, this was because of natural gas heating or because the primary HVAC or weatherization installation contractors were not well-suited for direct install projects, which require "sales" skills in interacting with tenants.

3.2.9 Building Manager and Tenant Education

In this section, we discuss the perspectives of program staff and owners/managers regarding education, followed by those of the tenants.

3.2.9.1 Staff and Owner/Manager Perspectives

For properties that received only weatherization improvements, staff did not perceive a need to provide education to tenants or property managers; however, the opposite was true for heat pumps. Two of the three staff respondents referenced challenges with determining the appropriate level of training, the correct person to provide training, and the most useful people to be trained on how to operate the heat pumps. Interviews with owners/managers confirmed that, in some cases, insufficient training on heat pump operation was viewed as a shortcoming of the program. Five of the twelve owner/manager respondents indicated that at least some of their tenants had experienced some level of confusion about the heat pumps, ranging from feeling like the systems were blowing cold air when they should be providing heat to not understanding how to use the remote controls (usually attributed to elderly tenants).

Two owners/managers experienced frustration with incomplete or inaccurate communication regarding the operation of the heat pumps. In one case, tenants were given operating information for remote controls when wall-mounted thermostats had been installed, which resulted in many phone calls to property management. This owner/manager also reported that the operating instructions said things like "set it on auto" without telling the user how to accomplish that. This owner/manager suggested that a clear online video would have been a huge help in educating tenants in how to operate their systems. This owner/manager also felt that decision-making on the part of the program and/or installation contractor regarding whether to install wall-mounted thermostats or remote controls was rife with problems. According to this owner/manager, the program decided to install wall-mounted thermostats rather than remotes, but the management company preferred the remotes because they found that the latter were easier for seniors to read than wall-mounted thermostats that may have been installed in locations with limited lighting. The job had been quoted with remote controls, but the installation contractor charged the management company $50 each to provide the remote controls. This manager paid $1,000 to obtain remote controls for his tenants, but thinks that it should have been the management

company's decision whether to have remotes or wall-mounted thermostats rather than the program's or contractor's decision. Their preference was to have both the wall-mount and the remote control so that the management company could decide what would work best for each tenant.

A second owner/manager described the installation of the heat pumps as "duck and run." Maintenance staff and tenants were supposed to receive operator training for the heat pumps, but they did not even receive the instructions that came with the equipment—apparently, the instructions were discarded with the packaging (this situation was also reported by another building manager). In some cases, it took months for the company to track down the operating manuals.

Conversations between the evaluation team and the installation contractor suggest that there was a strong focus on maximizing the efficiency of the installations, especially in light of the emphasis on low costs in order to meet program cost-effectiveness requirements. This approach may have led to less-than-optimal education from some of the contractors, though it was clear that the contractor we interviewed did make some efforts to provide training on how to operate the systems.

According to staff, the program initially relied on the installation contractors to ensure that the tenants knew how to operate their new heat pump systems. One of the staff members expected that the installer would leave operation manuals for the heat pumps with the property manager, who would be responsible for ensuring that they were distributed to the tenants. As evidenced by the building owner/manager interviews, this does not appear to have been done consistently or sufficiently in all cases.

One of the staff respondents indicated that the nature of the tenants (sometimes seniors and/or disabled) did not provide the most tech-savvy audience for learning how to use the controls for the new ductless heat pump systems. Toward the end of the program, an effort was made to systematically train building operations staff on the effective operation of the heat pumps with the understanding that the staff would then be best positioned to educate the tenants.

3.2.9.2 Tenant Perspectives

The tracking database includes flags for properties where a ductless heat pump was installed, but it does not indicate which units at each property received them, though the evaluation team understood that most, if not all, units would. Therefore, when conducting the survey, those tenants with DHP flags were asked to verify the installation of the DHP in their unit. Of these 42 tenants, almost all (93%) verified that they had a ductless heat pump installed (Table 3-2).[30]

Table 3-2: Ductless Heat Pump Verification

(Base: Tenants with program records indicating ductless heat pump installed)

Was a ductless heat pump installed through the program?	Program Records Indicate Heat Pump
Sample Size	*42*
Yes	93%
No	5%
Don't know	2%

The 40 tenants who verified the installation of a ductless heat pump were asked whether they had received any training or materials on how to operate the ductless heat pump properly (Table 3-3). Sixty-eight percent of these 40 tenants reported receiving training or materials.

Table 3-3: Received Ductless Heat Pump Training and Materials

(Base: Tenants verifying heat pump installation)

Received training or materials on how to properly operate ductless heat pump?	Verified Heat Pump Installation
Sample Size	*40*
Yes	68%
No	32%

[30] One tenant who initially was unsure if a ductless heat pump was installed later remembered having the heat pump installed during this question series.

Sixty-eight percent of the 28 tenants who received DHP training or materials reported receiving a brochure or leaflet describing how to operate the ductless heat pump (Table 3-4). Fifty-four percent had received in-person instructions from the installation contractor about how to operate the ductless heat pump. Just one tenant said he had received in-person instructions from the building manager about how to operate the DHP.

Table 3-4: Types of Ductless Heat Pump Training or Materials Received

(Base: Tenants who had received heat pump training or materials)

What types of training or materials were received?	Multiple Response
Sample Size	*28*
Brochure or leaflet	68%
In-person instructions from the installation contractor	54%
In-person instructions from the building manager	4%

All 40 DHP tenants were asked if there was a sticker on their thermostat that reads "Expensive Heat – Use Heat Pump First" (Table 3-5). These stickers were provided partway through the program to remind tenants to use the heat pump rather than the electric resistance baseboard. The majority of tenants (60%) did not have this sticker in place, although over one-third (35%) did.

Table 3-5: Sticker on Thermostat

(Base: Tenants verifying heat pump installation)

Is there a sticker on thermostat that says "Expensive Heat – Use Heat Pump First"?	Verified Heat Pump Installation
Sample Size	*40*
Yes	35%
No	60%
Don't know	5%

In order to assess if and how the sticker helped to educate tenants, an analysis was done to compare the responses of tenants who did and did not receive stickers with various survey questions (Table 3-6). The most clear difference was evident for the question on which heating system costs less to operate, where 93% of the 14 tenants who reported that a sticker was present believe that ductless heat pumps cost less to operate. In comparison, only 63% of the 24 tenants without a sticker thought that ductless heat pumps cost less to operate. While the information provided in the sticker and the question asked are very closely aligned, given the small sample sizes it may not be possible to draw a clear conclusion about the effect of the sticker on the tenants' perspectives regarding which heating system costs less to operate.

Responses to other questions were also compared to the presence or absence of the sticker, including the tenant perceptions of the ease of use of the ductless heat pump, how well the ductless heat pump has heated the apartment, and the tenants' sense of how their electric bill has

changed since participating in the program. While tenants with stickers present appear to be slightly more satisfied with the ease of use and heating capabilities, the differences are relatively minor and again based on small sample sizes.

Table 3-6: Comparison of Factors by Presence of Thermostat Sticker

(Base: Tenants verifying presence or absence of heat pump stickers)

	Is there a sticker on thermostat that says "Expensive Heat – Use Heat Pump First"?	
	Yes	**No**
Which heating system do you think costs less to heat your apartment?		
Sample Size	*14*	*24*
Ductless heat pump	93%	63%
Electric baseboard heating system	0%	8%
Don't know	7%	29%
Satisfaction with Ease of Use		
Sample Size	*14*	*24*
Very satisfied	71%	50%
Somewhat satisfied	29%	21%
Neither satisfied nor unsatisfied	0%	17%
Somewhat unsatisfied	0%	4%
Not at all satisfied	5	5
Don't know	0%	8%
Satisfaction with How Well DHP Heats Apartment		
Sample Size	*14*	*21*
Very satisfied	79%	54%
Somewhat satisfied	14%	17%
Neither satisfied nor unsatisfied	7%	13%
Somewhat unsatisfied	0%	0%
Not at all satisfied	0%	4%
Don't know	0%	0%
Has cost of monthly electric bill changed since building participated in program?		
Sample Size	*13*	*21*
Electric bills have gone up	0%	13%
Electric bills have stayed the same	64%	42%
Electric bills have gone down	14%	25%
Don't know/refused	14%	8%

3.3 Overall Perspectives from Owners

Owners/managers pointed out a number of things that had worked well in their experience with the program. These included the following:

- The weatherization contractor pointed out issues that needed to be corrected, such as a missing vent cap
- Flexibility in selecting the contractor
- Tenants enjoy reliable air conditioning, with better dehumidification and temperature control
- Heat pump installation was very quick
- Financial incentives overcame the cost challenge and tenants are saving money
- All around a good program that is well-done, with lots of QA focus
- Smooth, achieved improvement and protected attic pipes

In most cases, the problems that the building owners/managers reported were perceived to be relatively minor in comparison to the overall positive benefits of the program. These issues included the following:

- One of the heat pump contractors did not pay enough attention to detail, but had just experienced a family emergency so the owner/manager thought this was understandable
- There were some issues with follow-up from one contractor, but eventually the contractor was responsive
- Maintenance staff did not receive the training they were supposed to receive
- Operational changes needed for heat pumps due to the change of seasons were not explained and operation manuals were not provided as well as they should have been
- Some of the exterior units were noisier than expected and the contractor did not come when expected
- Multiple exterior units outside first floor apartments meant that first floor tenants experienced noise even when they chose not to use the heat pump for their own apartment
- The insulation contractor did not retrieve the insulation bags from the outside work site

Other than these relatively minor issues, two owner/manager respondents identified significant frustration with the lack of information provided regarding heat pump operation, as described earlier, and one of these respondents also experienced noteworthy problems related to what he described as inadequate quality assurance. This manager's experience contradicts staff reports of an excellent quality assurance protocol, and while it may be an isolated incident, it is, in the evaluation team's view, significant enough to merit discussion.

The building manager in question reported quality issues with both attic insulation and heat pumps. Regarding the attic insulation, the issue as described was that the insulation had been pulled back from the eaves in two buildings without doing air sealing or installing the specified

vent chutes, and then cellulose was simply blown over the perimeter. Failing to air seal the top plates led to ice dams in two properties. Note that a similar issue was described in one of the staff interviews, and may well refer to the same situation. Of special concern to this property manager was that, despite this deficiency, the project had passed inspection by the program. In fact, it was reported to the evaluation team that the project was inspected and passed again after the issue was supposedly fixed, though it actually had not been fixed. This manager seemed willing to accept that some jobs do not go as well as planned and will need to be fixed afterwards, but was less accepting of the fact that the program had two opportunities to identify and correct the issue and failed to do so.

The same building manager has had ongoing issues with heat pumps that are leaking refrigerant. The building owner has had to pay between $350 to $400 per leaking unit to evacuate and recharge the refrigerant for relatively new systems. This manager wondered whether these leaks should have been identified at system startup, but thinks that some of the contractors did not do sufficient checks at startup and that Efficiency Maine is not actively managing the inadequate contractors. However, this manager expressed a great deal of confidence in one particular heat pump contractor who has inspected the heat pumps at all of his properties.

3.4 Ductless Heat Pump Usage

All but one of the 40 tenants who verified having a DHP installed also reported that their electric baseboard heating systems were still installed in their apartments. These DHP tenants were asked which heating system they thought costs less to heat their apartments, and nearly three-fourths of tenants (73%) thought the ductless heat pump costs less to operate (Table 3-7). However, 23% did not know and 5% thought the electric baseboard system costs less to operate.

Table 3-7: Heating System Cost Comparison

(Base: Tenants verifying heat pump installation)

Which heating system do you think costs less to heat your apartment?	Verified Heat Pump Installation
Sample Size	*40*
Ductless heat pump	73%
Electric baseboard heating system	5%
Don’t know	23%

Fifty-nine percent of the 39 tenants with both heating systems present reported only using the ductless heat pump to heat their apartment, 31% reported using both the heat pump and the electric baseboard, and 5% each reported only using the electric baseboard or did not know (Table 3-8). Both tenants who said they only used the electric baseboard did not like the air blown out by the DHP.

Table 3-8: Heating System Used

(Base: Tenants with both baseboard heat and heat pump installed)

Which heating system do you use to heat your apartment?	Telephone Survey Respondents who Have Both Baseboard and Heat Pump	Billing Analysis		
		Sample Size	Avg % Savings (Verified)	% Realization Rate
Sample Size	*39*	*17*		
Only ductless heat pump	59%	11	16%	50%
Both heat pump and electric baseboard	31%	5	−4%	−13%
Only electric baseboard heating system	5%	0	N/A	N/A
Don't know/refused	5%	1	−14%	−38%

Table 3-8 also displays the average percent savings and percent realization rate for the 17 tenants who responded to this question and were also included in the billing analysis. For example, the 11 tenants who reported only using a ductless heat pump have an average of 16% savings, which reflects a 50% realization rate.[31] In contrast, the five tenants who reported using both the electric baseboard system and the ductless heat pump had an average of −4% savings, which reflects a −13% realization rate. While this analysis is based on a small sample size, it indicates that the tenants who only used the ductless heat pump to heat their apartments realized more savings than those that also used their electric baseboard.

[31] The evaluation team compared the savings estimates from the billing analysis to the modeled savings assumptions from the Real Home Analyzer software as well as to the lighting and domestic hot water measures in the program tracking database in order to compute a realization rate for electricity savings.

The 12 tenants who reported using both the ductless heat pump and the electric baseboard were then asked which system they turn on or turn up first when heating their apartments (Table 3-9). Eight of the twelve tenants turn on or turn up the ductless heat pump first, three tenants use the electric baseboard heating system first, and one tenant did not know.

Table 3-9: Heating System Used First

(Base: Tenants using both heat pump and baseboard)

When you first turn on your heat, which heating system do you turn on first?	Use Both Baseboard and Heat Pump
Sample Size	*12*
Ductless heat pump	8
Electric baseboard heating system	3
Don't know	1

The three tenants who turn on or turn up their electric baseboard first do so because the electric baseboard heats the home more effectively, because the electric baseboard is closer to where the tenant is located, and because the tenant is in and out of the apartment throughout the day and therefore always keeps the electric baseboard turned on.

Nearly all 40 DHP tenants (95%) had used their DHP to try to cool their apartment (Table 3-10).

Table 3-10: Ductless Heat Pump Used for Cooling in Summer

(Base: Tenants verifying heat pump installation)

Have you tried using your ductless heat pump in the summer to cool your apartment?	Verified Heat Pump Installation
Sample Size	40
Yes	95%
No	5%

The 40 DHP tenants were asked what types of problems, if any, they had encountered when using the ductless heat pump (Table 3-11). Over three-fourths of tenants (78%) had not encountered any problems with their ductless heat pump. A small percentage of tenants (5%) said that the ductless heat pump did not effectively heat their homes. Just under one-fifth of tenants (17%) encountered a variety of other problems, including blowing cold air when it is on "auto" mode (one tenant), emitting a strange smell (one tenant), making noise (one tenant), leaking water (one tenant), creating dust that triggers allergies (one tenant), going into "frost mode" without being prompted in fall and winter (one tenant), and the unit freezing when it rains (one tenant).

Table 3-11: Problems with Use of Ductless Heat Pump

(Base: Tenants verifying heat pump installation)

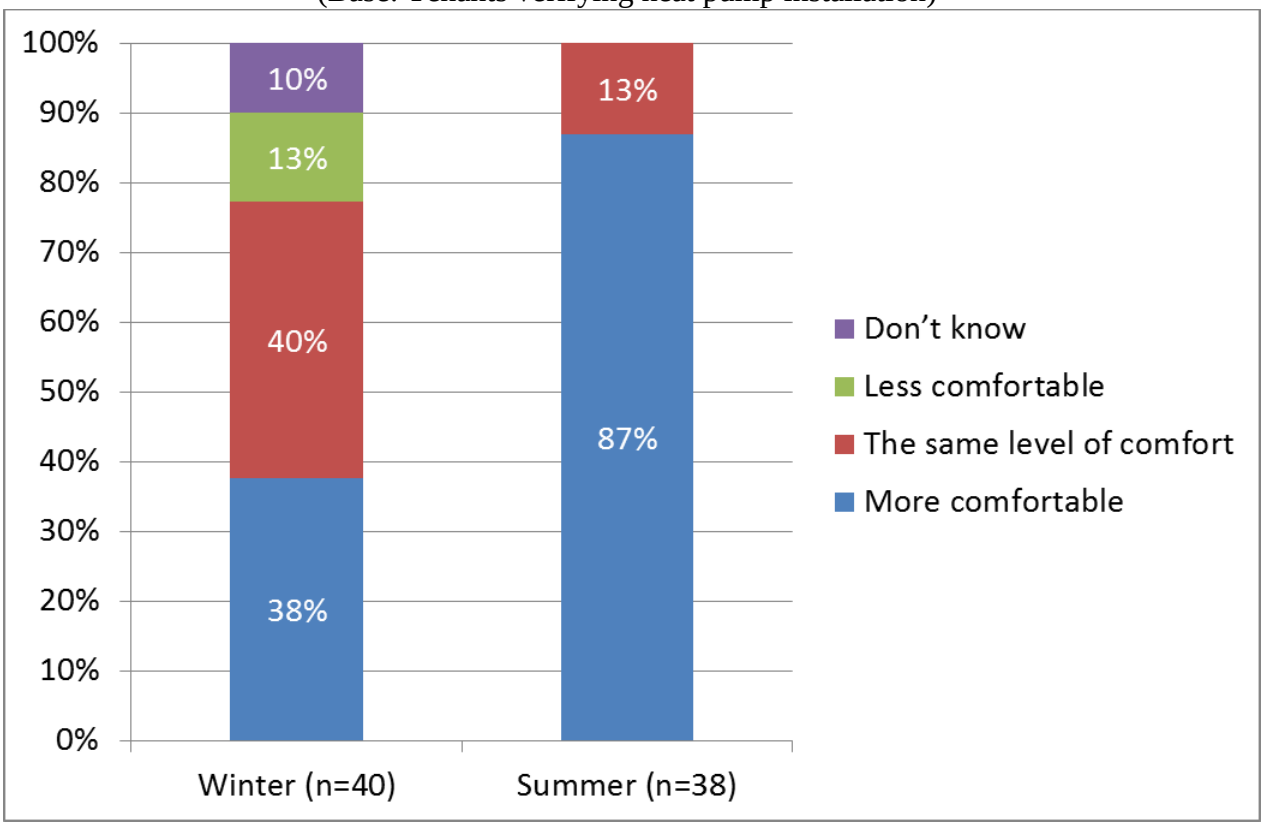
Have you encountered any problems with your ductless heat pump?	**Verified Heat Pump Installation**
Sample Size	*40*
The ductless heat pump does not effectively heat my home	5%
Other problems encountered	17%
No problems encountered	78%

The 40 DHP tenants were asked if the temperature in their apartments in the winter was more comfortable, less comfortable, or about the same as it was before the ductless heat pump was installed (Figure 3-1). Thirty-eight percent said the temperature was more comfortable and 40% said it provided the same level of comfort. About 13% of tenants were less comfortable, and 10% did not know. Tenants who experienced some degree of discomfort during the winter mentioned issues such as cold air blowing from the ductless heat pump.

The 38 tenants who had used their ductless heat pumps to help cool their apartments in the summer were asked whether the temperature in their apartments in the summer was more comfortable, less comfortable, or about the same as it was before the ductless heat pump was installed. The majority of tenants (87%) said the temperature in their apartments in the summer was more comfortable.

Figure 3-1: Comfort Level with Ductless Heat Pump

(Base: Tenants verifying heat pump installation)



3.5 Direct Install Measure Persistence

Of the 57 tenants who responded to the survey, 43 were listed in the program records as living at properties that had received in-unit direct install upgrades. These 43 tenants were asked to verify which of the upgrades were installed in their apartment, if any (Table 3-12). Eighty-four percent of these 43 tenants verified that one or more of the measures had been installed in their apartment.

Table 3-12: General In-Unit Measure Verification

(Base: Survey tenants with program records indicating that unit-level upgrades were installed)

Were upgrades performed in apartment?	Program Records Indicate Unit-Level Upgrades
Sample Size	*43*
Yes, one or more unit-level upgrade installed	84%
No unit-level upgrades performed	12%
Don't know	5%

Seventy-eight percent of the 36 tenants who reported receiving in-unit upgrades verified that their regular light bulbs had been replaced with CFL bulbs, 69% verified that their standard showerhead had been replaced with a low-flow showerhead, 72% verified that their faucet aerators had been replaced with low-flow aerators, and 50% verified[32] that the temperature of their hot water tank had been turned down (Table 3-13).

Table 3-13: Specific In-Unit Measure-level Verification

(Base: Survey tenants who verified that unit-level upgrades were installed)

What upgrades were performed in apartment?	Verified Unit-Level Upgrades
Sample Size	*36*
Replaced regular light bulbs with CFL bulbs	78%
Replaced standard showerhead with low-flow showerhead	69%
Replaced faucet aerators with low-flow aerators	72%
Reduced the temperature of hot water tank	50%
Other	8%

A small percentage of tenants reported that other upgrades were performed, including one tenant who reported that new weather stripping had been placed on his windows and doors, a second tenant who reported attic insulation, and a third tenant who reported a new thermostat. The weather stripping and attic insulation upgrades mentioned were likely part of larger building-

[32] Unlike CFL bulbs and aerators, the hot water temperature turndown is not visible to tenants, which may lead to the lower reported verification rate.

wide weatherization work performed through the program. In addition, those tenants who received the ductless heat pump also received new thermostats or remote controls to operate it.

3.5.1 CFLs

The 28 tenants who verified that their regular light bulbs had been replaced with CFL bulbs were asked if all of the CFLs were still installed in their apartments. Table 3-14 shows that almost all tenants (93%) reported that all of the bulbs were still installed at the time of the survey. One tenant said that one CFL bulb had been removed because the bulb was not bright enough.

Table 3-14: CFL Bulbs Still Installed

(Base: Tenants verifying CFL installation)

Are all of the CFLs still in place?	Verified CFL Installation
Sample Size	*28*
Yes	93%
No	4%
Don't know/Refused	4%

These 28 tenant respondents reported that an average and median count of seven bulbs were installed in their apartments, ranging from a minimum of three bulbs to a maximum of 15 bulbs.

3.5.2 Low-Flow Showerheads and Aerators

Table 3-15 shows that most (88%) of the 25 tenants who reported that their standard showerhead had been replaced with a low-flow showerhead still had their low-flow showerhead installed. The three tenants who said the low-flow showerheads were no longer installed were asked why they had been removed. Two tenants said they preferred a different type or brand of showerhead, and the third tenant never installed the low-flow showerhead after receiving it.[33]

The 26 tenants who reported that their standard aerators had been replaced with low-flow aerators were asked if the aerators were still in place. Nearly all of the tenants (92%) still had all of their low-flow aerators installed. The two tenants who indicated that low-flow aerators had been removed said they had each removed one aerator. One tenant removed it because she preferred a different type or brand of aerator, and the other said the seal on the aerator had broken and needed to be replaced.

Table 3-15: Low-Flow Devices Still Installed

(Base: Tenants verifying low-flow device installation)

Are the low-flow devices still installed?	Low-Flow Showerheads	Low-Flow Aerators
Sample Size	*25*	*26*
Yes	88%	92%
No	12%	8%

3.6 Program Satisfaction

3.6.1 Staff Satisfaction

There was general agreement among all three staff members and the contractor that the program was, in their experience, almost uniquely satisfying, perhaps because the program goals and expectations were unusually clear and the program was successful in meeting them. Staff respondents thought that the program had been able to achieve its goals in delivering cost-effective electric savings in low-income multifamily housing, and that it had done so quickly and effectively; this perception is generally supported by the building owner/manager interviews. Efficiency Maine and CSG staff believe they were able to generate significant numbers of heat pump installations at costs that were far lower than industry averages with customers who were largely satisfied with the installations and outcomes. This perception was also substantiated through the owner/manager interviews and, indeed, is borne out by the high satisfaction ratings recorded in the project tracking database.

[33] The evaluation team understands that low-flow showerheads were installed by the program weatherization contractors, but this response indicates that may not always be the case.

3.6.2 Owner/Manager Satisfaction

Overall, the building managers and owners had favorable impressions of the program. Seven reported that they were very satisfied, and three reported that they were between very satisfied and somewhat satisfied. One owner/manager was somewhat satisfied, and one owner/manager was between somewhat satisfied and neither satisfied nor dissatisfied (Table 3-16).

Table 3-16: Owner/Manager Satisfaction with Program

Satisfaction Rating	Count of owners/managers
Very satisfied	7
Between very and somewhat satisfied	3
Somewhat satisfied	1
Between somewhat satisfied and neither satisfied nor dissatisfied	1
Neither satisfied nor dissatisfied	0
Somewhat dissatisfied	0
Very dissatisfied	0

Staff reported that this high satisfaction rate was achieved by instituting rigorously detailed operating procedures, and by maintaining close communications with customers and contractors. Staff also reported that quality assurance measures contributed to positive outcomes and that QA was approached as a collaborative endeavor rather than as an enforcement issue, with a common desire on all parts to improve the quality of the work. Where this collaborative approach was not successful, contractors were asked to leave the program or simply were not given any more work.

The program also completed a significant number of attic air sealing/insulation (weatherization) jobs—though, according to one staff respondent, when it was not cost-effective to do both weatherization and heat pumps, he favored the measure that provided the greatest benefit, and that was typically heat pumps.

3.6.3 Tenant Satisfaction

The evaluation team asked building owners and managers to relay what they have heard from tenants regarding their satisfaction with the weatherization measures and heat pumps. Three interview respondents indicated that the tenants like the air conditioning, and one suggested that air conditioning is essential to encouraging tenants to use the heat pumps more frequently during the heating season. Some respondents thought the tenants were saving money on their electric bills, though most did not have firm information about this issue (more information will likely be found when the annual recalculation of energy subsidies occurs).

One manager reported that a tenant had said the building stayed much warmer during a power outage after the insulation had been installed. Another respondent believes the tenants are reacting as they do with anything else—some are happy and some are not, but there are no ongoing complaints.

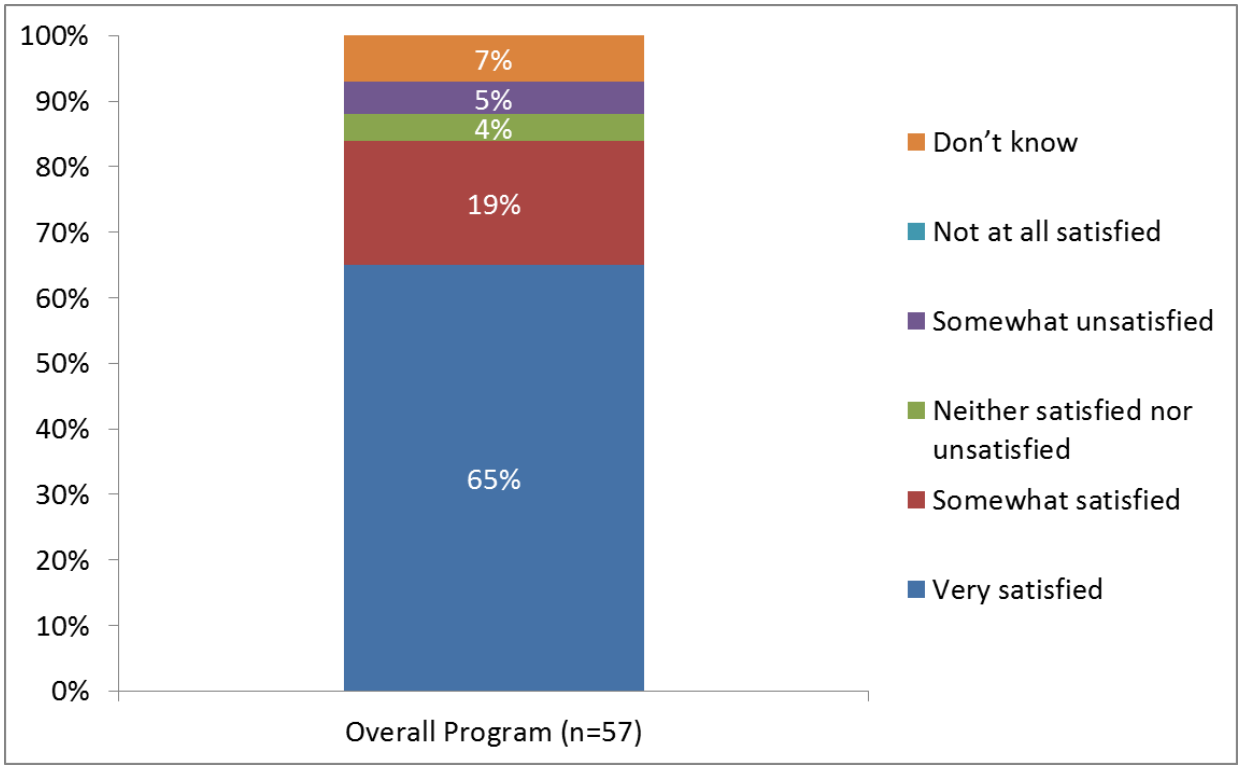
The remainder of this section provides the satisfaction levels as reported by the tenants during the telephone survey.

3.6.3.1 Overall Satisfaction

The majority of tenants were either very satisfied (65%) or somewhat satisfied (19%) with the Efficiency Maine program overall (Figure 3-2). Three tenants were somewhat unsatisfied, with two tenants stating that they were simply not satisfied with the program and one tenant reporting that the ductless heat pump did not heat her apartment efficiently.

Figure 3-2: Satisfaction with Efficiency Maine Program Overall

(Base: All Survey Tenants)



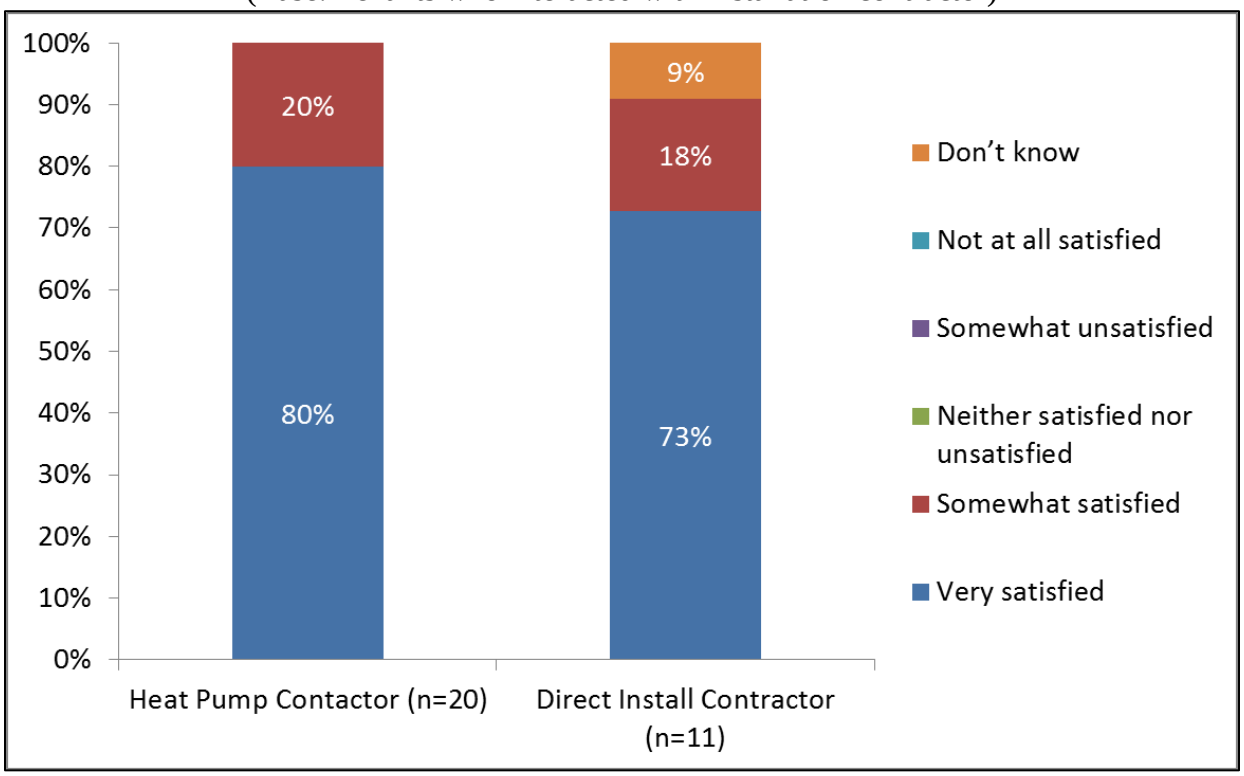
3.6.3.2 Installation Contractor Satisfaction

One-half of the 40 tenants who had a ductless heat pump installed reported interacting with the employees from the company who installed the ductless heat pumps in their apartment. In addition, 11 of the 36 tenants who had received in-unit upgrades reported interactions with the employees from the direct install contractor that performed these upgrades.

Most (80%) of the 20 tenants who had interacted with the DHP contractor were very satisfied and 20% were somewhat satisfied with their interactions (Figure 3-3). Similarly, eight of the eleven tenants were very satisfied and two were somewhat satisfied with their interactions with the employees from the direct install contractor.

Figure 3-3: Satisfaction with Installation Contractors

(Base: Tenants who interacted with installation contractor)



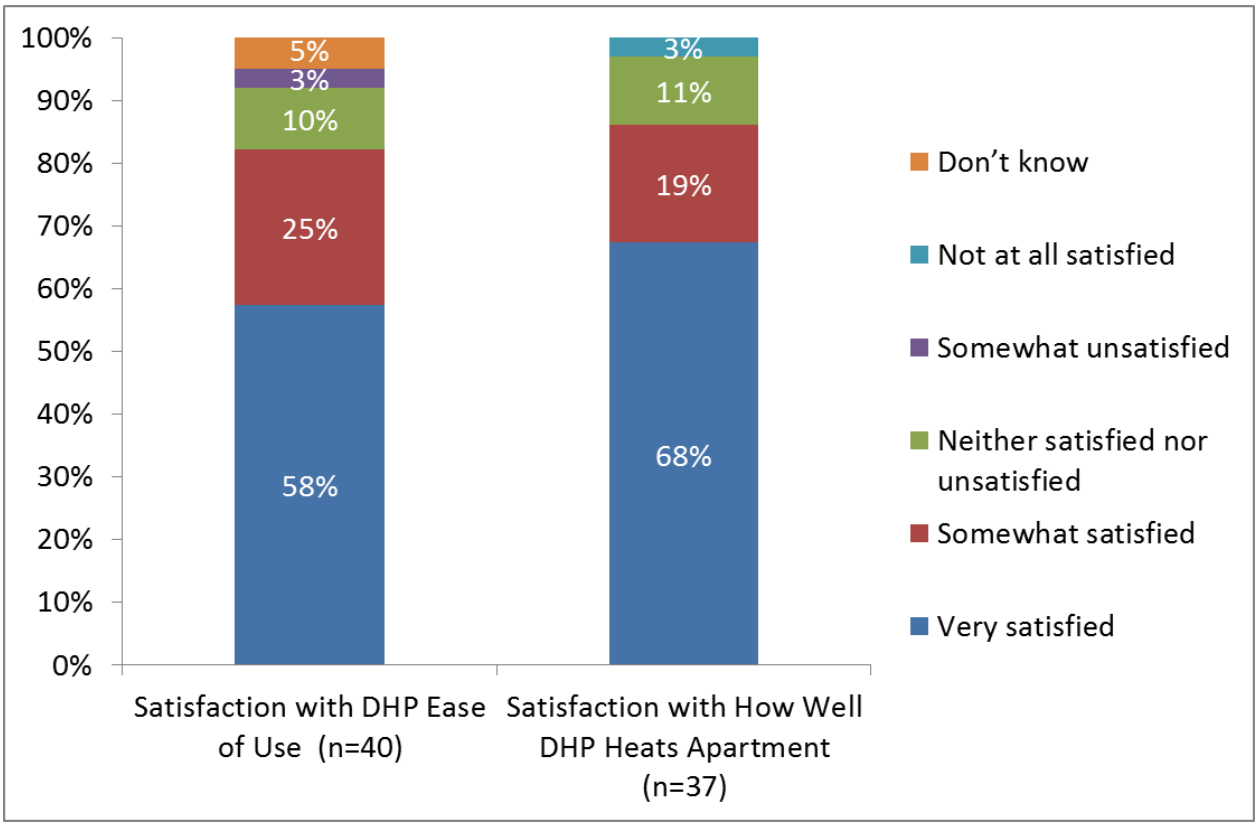
3.6.3.3 Satisfaction with Ductless Heat Pumps

The 40 tenants who had a ductless heat pump installed through the program were asked how satisfied they were with its ease of use as well as how satisfied they were with how well it heats the apartment (Figure 3-4). The majority of these tenants were either very satisfied (58%) or somewhat satisfied (25%) with its ease of use. One tenant said she was somewhat unsatisfied because the ductless heat pump did not heat her apartment efficiently.

The majority of the 37 tenants who use the ductless heat pump for all or some of their heating needs were either very satisfied (68%) or somewhat satisfied (19%) with how well it has heated their apartments. One tenant was not at all satisfied because it had not effectively heated the space.

Figure 3-4: Ductless Heat Pump Satisfaction

(Base: Tenants verifying heat pump installation; Tenants using DHP for all/some of heating)



3.6.3.4 Satisfaction with In-Unit Direct Install Measures

The majority of tenants who had CFL bulbs installed were either very satisfied (61%) or somewhat satisfied with the CFL bulbs (21%). Two tenants were somewhat unsatisfied, with one reporting that the bulb was not bright enough and the other reporting that he did not like the performance of the CFL bulbs (Figure 3-5).

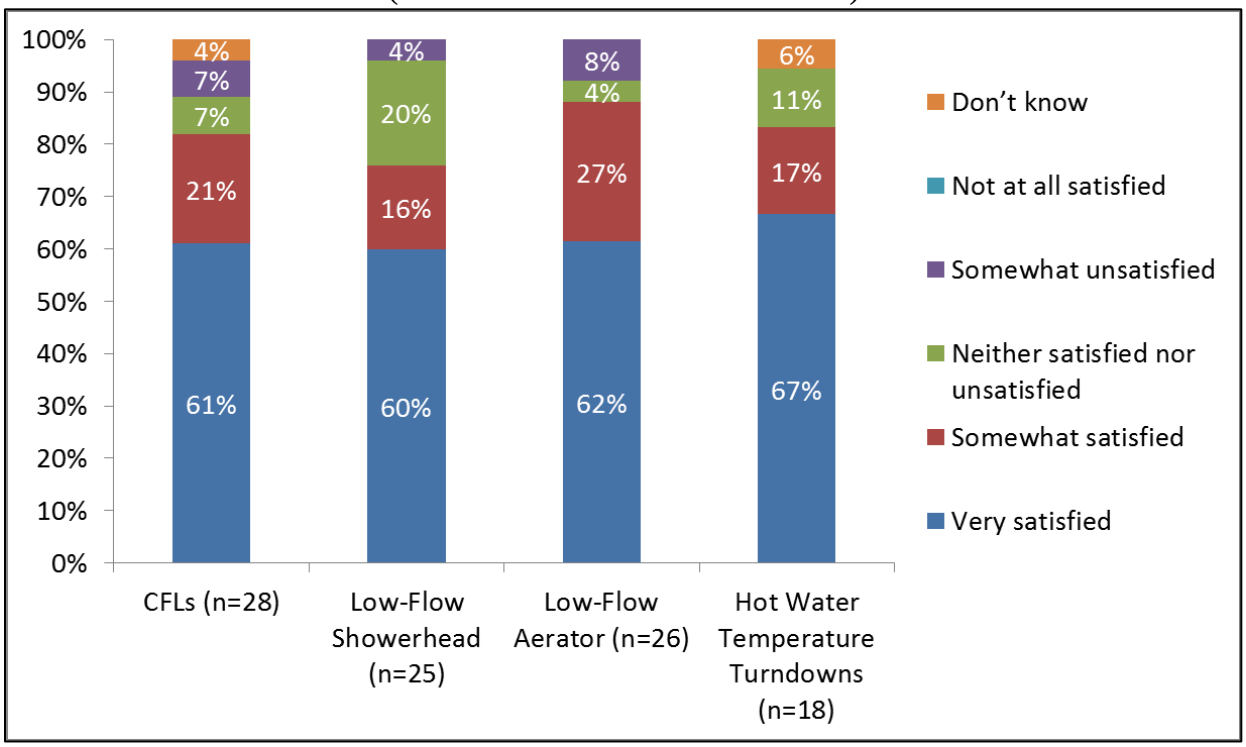
Just over three-fourths of the 25 tenants who had low-flow showerheads installed were either very satisfied (60%) or somewhat satisfied (16%) with the low-flow showerheads. One tenant was somewhat unsatisfied because the water volume or flow was too low/weak.

The majority of tenants who had low-flow aerators installed were either very satisfied (62%) or somewhat satisfied (27%) with the low-flow aerators. Two tenants were somewhat unsatisfied with the low-flow aerators, with one tenant reporting that the water volume or flow was too low/weak; the other tenant did not provide a reason.

The 18 tenants who reported that the temperature of their hot water tanks had been reduced were asked how satisfied they were with the temperature of their hot water. The majority of tenants were either very satisfied (12 tenants) or somewhat satisfied (3 tenants). Two tenants said they were somewhat unsatisfied due to the temperature being too cold or their preference for the previous temperature level.

Figure 3-5: Satisfaction with In-Unit Direct Install Measures

(Base: Verified measure installation)



3.6.3.5 Changes to Monthly Electric Bill

According to the property managers, tenants paid their own electricity bills at 21 of the 24 properties included in the telephone survey sample. Therefore, 51 of the 57 surveyed tenants were responsible for paying their own electric bills. These 51 tenants were asked if they thought that the cost of their monthly electric bills had changed since their buildings participated in the program (Table 3-17). Close to one-half of these tenants (45%) thought their electric bills had gone down, 26% thought their electric bills had stayed the same, 12% thought that their electric bills had gone up, and 18% either did not know or refused to answer the question.

Table 3-17: Changes to Electric Bill Since Program Upgrades

(Base: Tenants who pay own electric bill)

Has cost of monthly electric bill changed since building participated in program?	Telephone Survey Respondents who Pay Own Electric Bill (Self-reported)	Billing Analysis		
		Sample Size	Avg % Savings (Verified)	% Realization Rate
Sample Size	*51*	*33*		
Electric bills have gone up	12%	*4*	−2%	−4%
Electric bills have stayed the same	26%	*8*	9%	21%
Electric bills have gone down	45%	*12*	6%	49%
Don't know/refused	18%	*9*	5%	25%

Of these 51 tenants, 33 were included in the billing analysis. These 33 tenant respondents represented units that received different measure combinations (heat pump only, weatherization only, and both heat pump and weatherization upgrades), which naturally yield different savings levels. Table 3-17 displays the average percent savings and percent realization rate for these 33 customers, depending on their response to the question. [34] For example, the four respondents who said their electric bills had increased have an average of −2% savings, which reflects a −4% realization rate. In contrast, the 12 respondents who said that their electric bills had decreased have an average of 6% savings, which reflects a 49% realization rate. While the analysis is based on a small sample size, it indicates that the tenants perceive the changes in their bills with some degree of accuracy.

[34] The evaluation team compared the savings estimates from the billing analysis to the modeled savings assumptions from the Real Home Analyzer software as well as to the lighting and domestic hot water measures in the program tracking database in order to compute a realization rate for electricity savings.

3.7 Tenant Demographics

In this section, we present selected demographic information from the tenant survey respondents. For comparison purposes, the evaluation team provides the demographic data from the 2009-2013 American Community Survey[35] (ACS) data for multifamily units in Maine, where available.

3.7.1 Occupancy

Nearly all tenants (98%) occupy their apartment year round (Table 3-18).

Table 3-18: Number of Months Per Year Home is Occupied

(Base: All Survey Tenants)

Number of months per year home is occupied?	All Survey Tenants
Number of Tenants	*57*
All year	98%
Don't know/Don't remember	2%

Eighty-three percent of the tenants' apartments had occupancy of one person for most of the year (Table 3-19). This differs from the overall population of multifamily units in Maine, where the number of occupants is somewhat more varied.

Table 3-19: Number of Occupants in Apartment

(Base: All Survey Tenants)

Counting yourself, how many people live in apartment for most of year?	All Survey Tenants	Maine Multifamily Units (ACS)
Sample Size	*57*	*117,552*[*]
1 person	83%	52%
2 people	11%	28%
3 people	-	12%
4 people	4%	6%
5 people	2%	2%
6 people	2%	1%
7 or more	-	0%

[*] Total occupied multifamily housing units.[36]

[35] American Community Survey website: www.census.gov/acs/www/

[36] According to the ACS definition, a housing unit is considered occupied if it is the current and continuous place of residence of a person or group of people. If all the people staying in the unit are staying there for two months or less, the unit is considered to be temporarily occupied and classified as "vacant." American Community Survey website: www.census.gov/acs/www/Downloads/data_documentation/SubjectDefinitions/2013_ACSSubjectDefinitions.pdf

Tenants were asked if they had used a room air conditioner to cool their apartments before or since the program upgrades were performed in their buildings (Table 3-20). Nearly one-half of the tenants (46%) have never used a room air conditioner to cool their apartment, and 23% only used a room air conditioner prior to the upgrades (all 13 of these respondents received a ductless heat pump). Close to one-fifth of tenants (18%) used a room air conditioner both prior to and since the upgrades were performed. Eleven percent said they have only used a room air conditioner since the upgrades were performed (five of these six respondents received a ductless heat pump).

Table 3-20: Room Air Conditioner Use

(Base: All Survey Tenants)

Used a room air conditioner prior to or since the upgrades were performed?	All Survey Tenants	Billing Analysis		
		Sample Size	Avg % Savings (Verified)	% Realization Rate
Sample Size	*57*	*33*		
Only used room air conditioner prior to upgrades	23%	7	17%	48%
Only used room air conditioner since upgrades	11%	3	−5%	−10%
Used room air conditioner both prior to and since upgrades	18%	8	3%	5%
Never used room air conditioner	46%	15	4%	21%
Don't know	4%	0	N/A	N/A

Table 3-20 also displays the average percent savings and percent realization rate for the 33 tenants who responded to this question and were included in the billing analysis. These 33 respondents represented units that received different measure combinations (heat pump-only, weatherization-only, and both heat pump and weatherization upgrades) which naturally yield different savings levels. The seven tenants who only used a room air conditioner prior to the upgrades have an average of 17% savings, which reflects a 48% realization rate.[37] In contrast, the 15 tenants who reported never using a room air conditioner had an average of 4% savings, which reflects a 21% realization rate. While this analysis is based on a small sample size, it indicates that savings may be greater when a ductless heat pump replaces a room air conditioner.

[37] The evaluation team compared the savings estimates from the billing analysis to the modeled savings assumptions from the Real Home Analyzer software as well as to the lighting and domestic hot water measures in the program tracking database in order to compute a realization rate for electricity savings.

3.7.2 Apartment Size and Number of Rooms

Tenants were asked how many total rooms were in their apartments, not counting bathrooms, halls, porches, or unfinished rooms (Table 3-21). The majority of tenants (95%) had between two and four rooms, with an average number of about three rooms per apartment. A similar trend is seen within the overall multifamily population in Maine, with the majority of occupants (88%) having between two and five rooms.

Table 3-21: Number of Rooms in Apartment

(Base: All Survey Tenants)

How many rooms in apartment?	All Survey Tenants	Maine Multifamily Units (ACS)
Sample Size	*57*	*140,078*[*]
Mean # of rooms	3.1	-
1 room	2%	8%
2 rooms	18%	18%
3 rooms	51%	23%
4 rooms	26%	29%
5 rooms	2%	18%
6 rooms	2%	8%
7 rooms	-	3%
8 rooms	-	1%
9 rooms	-	1%
10 rooms	-	1%

* Total multifamily housing units

One-bedroom apartments represented about three-fourths of the tenant sample (77%). This differs from the Maine multifamily population, where a mix of one- and two-bedroom homes is more common (Table 3-22).

Table 3-22: Number of Bedrooms in Apartment

(Base: All Survey Tenants)

How many bedrooms in apartment?	All Survey Tenants	Maine Multifamily Units (ACS)
Sample Size	*57*	*140,708*[*]
Mean # of bedrooms	1.4	-
1 room efficiency studio	2%	8%
1 bedroom	77%	33%
2 bedrooms	14%	40%
3 bedrooms	5%	14%
4 bedrooms	2%	3%
5 or more bedrooms	-	1%

[*] Total multifamily housing units

3.7.3 Income Status

Tenants were asked a battery of questions to assess their income status. This battery included questions about their household income in relation to Maine Low-Income Home Energy Assistance Program requirements.[38] Those tenants who refused to provide their income were asked about their receipt of federal or state benefits that would indicate low-income status. Most tenants (89%) were classified as low-income, which is much higher than the total multifamily population in Maine where under one-half (45%) are classified as low-income (Table 3-23).

Table 3-23: Income Status

(Base: All Survey Tenants)

Income Level	All Survey Tenants	Maine Multifamily Units (ACS)
Sample Size	*57*	*116,010*[*]
Low-income	89%	45%
Not low-income	11%	55%
Don't know	2%	-

[*] Total occupied multifamily housing units

3.8 Best Practices Review

The evaluation team conducted a brief review of literature describing energy efficiency program best practices focused on multifamily energy efficiency programs with a secondary focus on programs designed to meet the unique needs of low-income households. The primary sources of information that were reviewed included two reports conducted in 2013 and one in 2005 by the American Council for an Energy Efficient Economy (ACEEE), as well as a 2013 report on multifamily energy efficiency from the Energy Programs Consortium.

Best practice can mean different things, and for this purpose the context matters. For the authors of these reports, *best* consistently refers to practices that are deemed most successful in maximizing the energy savings from projects and programs. The reports all identify attributes of energy efficiency programs that lead to the attainment of this goal, gleaned from examples of real programs that demonstrate success.

In general, the authors believe that the most successful programs are those that create opportunities for comprehensive energy savings by recognizing and addressing multiple barriers in a strategic, coordinated fashion. In other words, best practice programs do not tend to only address single measure opportunities, and they do not tend to only address financial barriers without also providing information and workforce solutions. In the context of these reviews, *best* is also associated with programs that have a sustained impact in the market rather than programs that only operate for a limited duration.

[38] www.benefits.gov/benefits/benefit-details/1558

ACEEE identifies general trends exhibited by best-practice programs in *The Leaders of the Pack: ACEEE's Third National Review of Exemplary Energy Efficiency Programs*[39] and refines them for the multifamily market in *Apartment Hunters: Programs Searching for Energy Savings in Multifamily Buildings.*[40] Note that these reports do not focus on low-income programs, though both contain examples of low-income programs, and most of the best-practice attributes apply. *Apartment Hunters* identifies ten best practices of multifamily programs, which are paraphrased here:

1. Provide building owners/managers with a single point of contact for the program to make participation easier
2. Provide low-cost financing to address financial barriers (would not apply to a low-income program that pays 100% of the cost)
3. Direct-install services are integrated with more comprehensive rebate approaches to maximize savings
4. Programs address both in-unit and common area opportunities rather than have the customer deal with multiple programs to complete a comprehensive project
5. There is a multi-fuel approach that addresses multiple end-uses to streamline participation for the customer
6. Incentives are scaled to increase savings (would not apply to a low-income program that pays 100% of the cost)
7. Programs serve both low-income and market-rate housing
8. Services are coordinated with housing finance programs to take advantage of the opportunities presented when affordable housing is refinanced and redeveloped
9. Programs partner with the local multifamily housing industry to take advantage of networks of property managers and owners
10. There are multiple pathways for participation to build relationships with property managers and owners at varying stages of readiness or willingness to make improvements

There are two low-income or affordable multifamily programs highlighted within the nine leading multifamily programs identified in the report. The first—Energy Savers— is operated by CNT Energy and Community Investment Corporation in the greater Chicago area. This program is aimed at affordable housing rather than housing that is occupied by low-income residents who meet Weatherization Assistance Program income guidelines; as such, it does not provide incentives to cover 100% of the measure cost. Rather, it provides free assessments and technical and construction support for accessing utility incentives and low-cost financing. The program's success is attributed to its one-stop-shop approach, where building owners and managers are

[39] http://www.aceee.org/sites/default/files/publications/researchreports/u132.pdf
[40] http://www.aceee.org/sites/default/files/publications/researchreports/e13n.pdf

provided with a significant amount of technical and process support in navigating through program requirements and the technical opportunities available in their buildings.

The second low-income multifamily program identified in *Apartment Hunters* is the LEAN Massachusetts Low-Income Multifamily Retrofit program. According to the report, this program was created to address the challenges that property owners and managers faced in navigating multiple complex programs within a given utility and across multiple utilities, as well as address affordability barriers. Rather than addressing different portions of a single building with different programs (commercial for common areas and residential for in-unit), the program addresses all of the building opportunities through a single point of contact. Further, programs are coordinated across all of the Massachusetts utilities through an advisory committee, allowing for much greater consistency across utility territories. That said, there are still challenges that result from different cost-effectiveness protocols for different utilities and disproportionately higher program budgets for electricity compared to natural gas.

The Energy Programs Consortium produced its report, *Multifamily Energy Efficiency: Reported Barriers and Emerging Practices,*[41] in November 2013. The authors reviewed more than 40 studies on energy efficiency in low-income multifamily housing to identify barriers to increased efficiency. They also describe select programs that are trying to overcome these barriers and suggest approaches that programs and policymakers could undertake to increase efficiency investments in this sector.

The barriers that the report identifies are consistent with those that ACEEE's ten best practices overcome. They include barriers such as split incentives between building owner and tenant; dispersed and complex ownership structures; difficulty accessing financing; lack of data about energy use and retrofit performance; and legal and regulatory barriers associated with the U.S. Department of Housing and Urban Development, Low-Income Housing Tax Credit (LIHTC), utilities, and taxes. One practice that the report identified to help inform future multifamily program performance that is not called out by ACEEE is to track actual energy use for program participants over time to gain a better understanding of what works and what does not.

ACEEE's 2005 report, *Meeting Essential Needs: The Results of a National Search for Exemplary Utility-Funded Low-Income Energy Efficiency Programs,*[42] researches the many different types of low-income energy efficiency programs that are or have been implemented and identifies common traits among them. While the report is nearly ten years old, its findings are no less relevant now than they were in 2005. Some of these may be particularly relevant for Efficiency Maine, including but not limited to the following:

- Partnerships between utilities, community action agencies, housing providers, and others are common

[41] http://www.energyprograms.org/wp-content/uploads/2013/11/EPC_Report_MultiFamily_Housing.pdf
[42] http://www.aceee.org/sites/default/files/publications/researchreports/U053.pdf

- Combined services offered through a single point of contact or lead agency is a common approach to simplify participation
- Customer education is frequently included as one aspect of low-income programs
- Many low-income programs address both single-family and multifamily housing
- There is a trend toward comprehensive programs within the low-income sector

The report includes case studies of numerous programs, including two low-income multifamily programs: NYSERDA's Assisted Multifamily Building Program and the collaborative Multifamily Low-Income Program offered by Efficiency Vermont, Vermont Gas, and Burlington Electric. NYSERDA was highly successful at maximizing the impact of available funding for energy efficiency projects within affordable housing development budgets. They first identified additional non-program funding sources that could be applied to the projects, primarily by creating lending instruments that allowed debt payments to be funded through energy savings. This alternate funding allowed the program to only provide the minimum amount of NYSERDA funding that was required to move projects forward. This broad look at financial packaging sought to leverage program funds to their greatest benefit, as opposed to simply providing very large incentives directly from the program.

Vermont's program was, at the time, notable for its early focus on building long-term relationships with the organizations and individuals who develop and manage affordable housing in the state. These trusting relationships led to many repeat projects for multiple properties, thereby allowing for deeper savings in this hard-to-reach sector.

In order to provide an overall view of best practices in low-income multifamily energy efficiency programs, below is a summary of the insights from these different reports:

- Relationships are built with housing providers and property owners/managers in order to encourage sustained participation over time as new properties are developed and existing properties are renovated and refinanced.
- Programs collaborate with other stakeholders in this market and provide a single point of contact with properties for multiple services. In other words, a building owner can access all of the programs that are available from various organizations through a single lead program.
- Energy efficiency services for all end-uses, all fuel types, and both common areas and dwelling units are available through a single customer-facing program, even if this requires program administrators to manage tracking and reporting behind the scenes to comply with regulatory requirements.
- Funding is leveraged to stretch program dollars as far as possible. Programs understand funding options and financial requirements of affordable housing markets and offer incentives to fill the gap so that projects move forward.

- Programs provide education—both to tenants and to facilities staff—to ensure that savings are achieved.
- Results are tracked over time to foster continuous learning for program staff.