MCE LOW-INCOME FAMILIES AND TENANTS PILOT PROGRAM EVALUATION

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DNV

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1 EXECUTIVE SUMMARY

This report provides the results of DNV's evaluation of Marin Clean Energy's (MCE) Low-Income Families and Tenants (LIFT) pilot program for 2017-2020. This includes results across the key performance metrics of the program, focusing on successes and challenges. The conclusions are drawn from participant surveys, program records, and interviews for insights on program delivery and participant experience. Insights on initial program performance were also obtained from site visits and field measurements for a sample of participant heat pump projects.

1.1 Background

MCE is California's first Community Choice Aggregation program. MCE focuses on addressing climate change by reducing energy related greenhouse gas emissions through renewable energy supply and energy efficiency. MCE serves residents in Marin and Napa Counties, unincorporated Contra Costa and Solano Counties, and the Cities and Towns of Benicia, Concord, Danville, El Cerrito, Lafayette, Martinez, Moraga, Oakley, Pinole, Pittsburg, Pleasant Hill, Richmond, San Pablo, San Ramon, Vallejo and Walnut Creek.

In November of 2016, California Public Utilities Commission (CPUC) Decision (D.) 16-11-022 approved MCE's LIFT pilot program under the investor-owned utilities' (IOU) Energy Savings Assistance (ESA) and California Alternate Rates for Energy (CARE) Programs and Budget Applications.[1] The LIFT Pilot aimed to reduce the energy burden and improve the quality of life of residents in income qualified multifamily properties in MCE's service territory through energy efficiency, electrification, and health, safety and comfort upgrades. The CPUC granted MCE $3.5 million over two years to deliver the LIFT pilot program. The pilot launched on October 31, 2017. In October 2019, LIFT was granted an initial timeline extension, which ended on May 31, 2021.[2]

Residents of income-qualified multifamily housing face multiple barriers to participating in energy efficiency programs, including fear of property owner retaliation, lack of control over any significant upgrades made to their units, concerns about sharing personal information, immigration enforcement actions, and financial constraints. MCE developed the LIFT program to better serve income-qualified multifamily property owners and tenants who are not currently benefiting from other low-income energy efficiency and decarbonization programs. The program aimed to incentivize switching gas and propane heating equipment to high-efficiency electric heat pumps to help decarbonize space and water heating loads.

In addition to heat pump incentives, the pilot program provided up to $1,200 per unit for energy efficiency improvements that could be layered with MCE's existing Multifamily Energy Savings (MFES) program. With the additional incentives, LIFT covered a significant portion of total project costs (up to 80% if customers participated in both the LIFT and MFES programs).

[1] D.16-11-022, *Decision of Large Investor-Owned Utilities' California Alternate Rates for Energy ("CARE") and Energy Savings Assistance ("ESA") Program Applications*, Ordering Paragraph 148.

[2] D.21-06-015, issued June 7, 2021, authorized an extension of the LIFT pilot through 2023. Projects completed in the second phase of the pilot will be included in a future evaluation.

LIFT aimed to serve 1,482 dwelling units with energy efficiency measures and install 125 heat pumps serving 215 units.

1.2 Program Summary

MCE reported the following program expenses, savings, and households treated by the LIFT program for the period from 2017 – 2020.

MCE LIFT program period 2017 - 2020	
Program Expenses	$1,083,482
Estimated kW Savings	0.94
Estimated kWh Savings	7,818
Estimated Therms Savings	669
Treated households	682

1.3 Research objectives and approach

MCE set DNV's objectives for the evaluation, which were to:

- Estimate LIFT's energy impacts (site and source)
- Estimate emissions reductions
- Calculate energy bill impacts of switching from furnaces to heat pumps
- Determine heat pump installation costs
- Gain insights into the enablers and barriers to program participation
- Measure participant satisfaction and ease of program participation
- Assess the program's non-energy impacts and tenant experience

To assess performance against the program theory and logic model, DNV conducted interviews with six contractors and 14 property managers, representing over half of all LIFT tenant units. DNV also designed an occupant survey administered to 128 participating tenants to measure their satisfaction and perceived impacts of the upgrades.

DNV's approach to Measurement and Verification (M&V) focused on five project sites that received heat pump upgrades, representing over half of the LIFT heat pump tenant units. DNV's M&V approach combines on-site data collection, equipment data logging, and utility meter data analysis to determine pre- and post-retrofit energy consumption and costs. DNV worked with MCE to develop and apply alternative source energy values that are specific to MCE.[3]

1.4 Findings and recommendations

MCE established 13 specific program metrics for LIFT. The evaluation key findings and implications for each metric are summarized in Table 1-1, followed by recommendations. Table rows are hyperlinked to the respective sections.

[3] MCE offers customers rates that correspond to options ranging from 60% to 100% renewable energy content. The PG&E rate option corresponds to 29% renewable energy content.

Table 1-1. LIFT program performance metrics

Metric	Goal	Results	Data Source	Implications
Residents received program information in language other than English	40% meeting one or more of these three characteristics of "hidden communities"	42%	Occupant surveys	Surpassed goal – LIFT program is effectively reaching the "hidden communities" it seeks to serve. Per the Center for American Progress report on extended families, 17% of all households in the nation fit this descriptor. The program included several senior housing participants, that comprise of smaller single or two-person households. Given the program requirement of reaching tenants residing in multifamily properties, the number of extended families that fit this descriptor available to the program is reduced. Furthermore, the program seeks to serve those outside CalEnviroScreen 2.0. The intersection of these requirements further reduces the total number of extended families that fit this descriptor and are available to the program. The two households that participated in the survey and fit the extended family descriptor also stated that the primary language spoken in the home was Spanish. The results indicate the intersectional characteristics of "hidden communities".
LIFT residences are occupied by extended or multiple families		1.5%	Occupant surveys	
Residents outside of disadvantaged communities as defined by CalEnviroScreen 2.0		95%	Program tracking data	
Percent of units receiving comprehensive upgrades using both MCE's Energy Savings and LIFT program offerings	60%	76% units receiving comprehensive upgrades	Program tracking data	Surpassed goal – LIFT program is well integrated with other energy efficiency programs
Percent of eligible households that install efficiency measures through the LIFT program	1,482/56,087 - 3%	842/56,087 - 1.5%	Program tracking data	Short of goal on income eligible energy efficiency installations

Metric	Goal	Results	Data Source	Implications
Procurement and installation costs of heat pumps including costs of bulk purchase	Track, no goal set	On average, Central heat pump water heater - $2,760 (5 invoices) In-unit heat pump water heater - $3,420 (1 invoice), Ductless space heat pump - $10,902 (10 invoices)	AEA pass through of contractor invoices and bids	Current heat pump incentives cover approximately 30% - 91% of installation cost with some costs shared across projects with multiple measures (space and water heating).
Savings per unit for LIFT program	Average per unit LIFT savings is greater than Pacific Gas & Electric's (PG&E) Energy Savings Assistance (ESA) program per unit	Overall, LIFT EE and HP measures saved 50 kWh and 32 therms per dwelling units compared to PG&E's ESA reported 96 kWh and 9 therms. This translates to 3,404 kBtu for LIFT EE and HP versus 1,227 kBtu for multifamily projects in PG&E's ESA program.	M&V sample, tracking data & PG&E ESA data	The program achieved its goal of higher per unit savings due to the contribution of significant gas savings from heat pump installations.
The impacts of fuel switching on bill savings and net costs to the customers	Track, no goal set	On average, fuel substitution customers save $128 per year and fuel switching customers save $1,123 per year. Overall, average bill savings from heat pumps measures are estimated at $192 per year.	Site-level billing analysis, rates	There is strong evidence that fuel substitution customers are realizing bill savings from heat pump installations. It is likely that savings estimates for fuel switching are higher due to installation of solar at the sites concurrent with the program.
Reduction in greenhouse gas (GHG) emissions, nitrogen oxides, (NOx)	Track, no goal set	Heat pump fuel savings overall: 1.09 tons CO_2 annually per unit; site savings 2.08 lbs. CO, 0.99 lb. NOx Heat pump fuel substitution savings: 0.91 tons CO_2 annually per unit; site savings 2.22 lbs. CO, 0.87 lb. NOx Heat pump fuel switching savings: 3.69 tons CO_2 annually per unit; site savings 0.10 lbs. CO, 2.80 lb. NOx	MCE and CAISO generation mix; CPUC gas assumptions; DNV Spot Measurements	The MCE Light Green generation mix (60% renewable) plus heat pump retrofit saves significant CO_2 annually. CO_2 savings increase for Deep Green (100% renewable) customers. All on-site customers (tenants and employees) experience a reduction in toxic on-site CO and NOx emissions.

Metric	Goal	Results	Data Source	Implications
Source British thermal units (Btu) savings impact	Average savings per unit for LIFT is more than the average savings per unit for PG&E's ESA program's 3.32 MMBtu saved per unit (baseline)	Savings per unit for LIFT HPs was 9.4 MMBtu annually. Note the evaluation of PG&E's ESA program showed savings of 1.5 MMBtu annually overall and 1.2 MMBtu annually for multifamily projects.	Source energy savings are calculated based on-site savings and CEC or MCE specific values reflecting generation power mixes.	The source Btu savings per unit are much higher than the reported and evaluated PG&E ESA savings and those savings include a majority single-family homes.
Percent of property owners/managers that rate the ease of participation as high	80% of participants rate it is easy to participate in the program	90% (n=10)	Property manager interviews	Surpassed goal, some opportunities for improvement on program requirements related to verification and documentation
Percent of residents who report comfort and satisfaction with the heat pump technology	80%	84% very/ somewhat satisfied with heat pumps, 82% very/ somewhat satisfied with LIFT (n=38)	Occupant survey	Customers are satisfied with the heat pumps they received, and reviews of the LIFT program are positive
Impacts on residents' health, comfort, and safety	Track, no goal set	Some evidence of increased comfort, improved air quality, and reduced noise	Occupant survey	Evidence of non-energy benefits of heat pumps strengthens value offered by technology

Overall, LIFT succeeded in its goals to overcome key barriers to installing heat pumps that reduce customer energy use, energy bills, and associated emissions. The tenants receiving measures cannot afford discounted equipment or are underserved by general market programs, and are multifamily renters who have not been served by Pacific Gas & Electric's Energy Savings Assistance (ESA) program.[4] Many of the sites met MCE's initial target of small affordable housing areas within larger zip codes and census tracts that do not qualify for CalEnviroScreen disadvantaged communities (DAC) designation.

1.4.1 Key recommendations

Improve program tracking and record keeping requirements. Through the course of conducting the evaluation, DNV identified inconsistencies in program tracking data that required the implementer to rectify and reissue. Access to consumption data was a challenge due to issues with timeliness and completeness that required several iterative discussions and were ultimately only resolved partially.[5] DNV found gaps in the occupant survey data that were missing some months of survey responses and had to be appended upon discovery. Not all contractor invoices included the details that could improve the

[4] PG&E's Energy Savings Assistance Program provides qualified customers with energy-saving improvements at no charge. Participants must live in a house, mobile home, or apartment that is at least five years old. Income guidelines for the ESA program are same as those for CARE, the California Alternative Rates for Energy Program.

5 At one sampled project, three analyzed electric accounts had 1-2 months of post-retrofit meter data that the evaluation team was unable to obtain via the data requests made to MCE. For these missing data points, the analysis substitutes the average consumption across the remaining analyzed accounts (n=17) at that project as a proxy for the actual consumption that occurred.

usability of the data therein. As recommended in DNV's mid-term report, the program should also clarify expectations regarding contractor requirements for detailed cost information that breaks down hidden/soft costs such as for electrical panel upgrades.

Recognizing that the pilot was being developed and implemented simultaneously, DNV recommends that MCE address these gaps to improve data quality and evaluability of the program as it scales up. The program should develop and maintain a central, comprehensive, and compiled database that supports evaluability of key program metrics. The database should include granular information associated with each project site including, but not limited to: a unique identifier, building classification, project name, primary owner level contact (decision maker), site address, specific units treated, project status, measures installed, contractor information, incentives provided, equipment costs, labor costs, and survey responses etc. The data should be organized at the measure level with one measure per row, this is especially helpful to include as some measures have different number of units effected (e.g., central water heater boiler may serve multiple units in a building and may also include a mini-split which serves only a room within a unit.)

Continue with successful program elements. The LIFT program integrated well with the Multifamily Energy Savings (MFES) program and other program offerings. The program is reaching "hidden communities" of low-income tenants outside of designated DACs, those residing in extended families, and/or those who are in non-English/limited English-speaking households. The program is achieving most of its goals, the one exception being that the program is short of its goal to serve 1,482 income-eligible households at the current number of 842 income-eligible households served by the LIFT program. DNV recommends the program experiment further to increase the percentage of eligible customers who install measures by working with community organizations and deploying non-traditional marketing and enrollment methods. DNV also believes the program could leverage some of the techniques used by the investor-owned utility (IOU) programs, focusing on direct install and other[6] methods to increase in-unit energy-efficiency measure installations.

Continue studying impacts because savings goals were met on average but were highly variable.

- Highly variable savings are common for pilots due to the limited cases available and studied. Because of the variability in project scope and pre-existing conditions for multifamily properties, the variability in savings may remain high even after additional M&V. More stable per-unit energy savings may emerge after more projects are completed, specifically mini-split heat pumps or central heat-pump water heaters (HPWHs).
- The two M&V projects for central HPWHs showed high potential to produce consistent savings and were less complex. Notably, the sites also have on-site solar power generation, which further reduces carbon emissions and costs based on thermal storage potential. The mini-split heat pump M&V projects were more varied in scope. For example, the existing technologies within the unit showed variation and the condition of

[6] COVID related constraints may necessitate the use of virtual assistants that coach tenants and property managers on do-it-yourself measure installations.

the units varied as well, contributing to variability in savings. Therefore, future project evaluations will need to isolate heating system upgrades.

2 INTRODUCTION

Marin Clean Energy (MCE), California's first community choice aggregator (CCA), is a not-for-profit public agency that began service in 2010 with the goals of providing cleaner power at stable rates to its customers, reducing greenhouse emissions, and investing in energy programs that support communities' energy needs. MCE serves approximately 1,200 MW of peak load and provides generation services to more than 1.1 million people in 36 communities across Contra Costa, Marin, Napa, and Solano Counties.

On November 21, 2016, the California Public Utilities Commission (CPUC) granted MCE $3.5 million to deliver the Low-Income Families and Tenants (LIFT) program, originally scheduled as a two-year pilot program.[7] MCE developed the LIFT Program to better serve income-qualified multifamily properties and tenants who are not currently benefiting from other low-income programs. The pilot was originally scheduled to run until October 31, 2019. In October 2019, MCE was granted an extension of the pilot to the end of the then-current program cycle, with no additional funding, to meet the extended timelines of implementing energy efficiency upgrades in multifamily settings.

In addition to energy efficiency measures, the LIFT pilot offered additional incentives to encourage switching gas and propane heating equipment to high-efficiency electric heat pumps. Evaluating the performance of heat pumps in the low-income multifamily sector is a key research question for the LIFT pilot. MCE contracted with DNV to conduct this evaluation, and this report presents DNV's findings.

2.1 Background

MCE's LIFT pilot aimed to better serve income-qualified multifamily properties with additional incentives that would allow for deeper energy savings. The pilot program provided up to $1,200 per unit for energy efficiency improvements that could be layered with MCE's existing MFES program offerings. When properties participated in both MFES and LIFT, the incentives and savings were tracked separately for each program. While a property may receive funding from both programs, each individual measure was funded through only one program and the savings were tracked to the program that funded the measure. With the additional incentives, the LIFT pilot covered a significant portion of total project costs (up to 80% if customers participated in both the LIFT and MFES programs). The three-year LIFT pilot program aimed to serve 1,482 dwelling units with energy efficiency measures and also aimed to install 125 heat-pump units.

The pilot included additional incentives to encourage switching gas and propane heating equipment to high-efficiency electric heat pumps to help decarbonize space and water heating loads. Heat pumps can also offer additional non-energy benefits related to increased comfort (and possibly improved health) for customers by adding cooling, while switching to a zero-emission and more efficient heating source.

The pilot was administered and implemented by the following entities:

[7] D.16-11-022.

- **MCE** was responsible for program design, goal setting, preparing program materials, verifying income eligibility for LIFT measures, delivering incentives, and managing implementers. MCE also supported the pre- and post-occupant survey data collection efforts.
- **Association for Energy Affordability (AEA)** was the prime implementation contractor delivering both MFES and LIFT measures. For the LIFT pilot, AEA was responsible for daily operations, including but not limited to: identifying properties, pre-screening for eligibility, maintaining the database for all implementation data collected, vetting the measure selection, offering contractor support, technical assistance, day-to-day property manager interactions, project quality assurance and quality control, supporting project evaluation, measurement, and verification (EM&V) objectives and reporting progress to MCE.
- **Conservation Corps North Bay (CCNB)** for the first two years of the pilot, offered direct measure installations and supported the EM&V process with tenant surveying.
- **Franklin Energy** In 2020, Franklin took over the direct install[8] and tenant surveying responsibilities for the LIFT program.

2.2 Research objectives

DNV's research objectives for MCE's LIFT pilot program evaluation were to:

- Estimate energy impacts (site and source), emissions reductions, and energy bill impacts of switching from furnaces to heat pumps
- Determine the potential impacts of alternative MCE rate structures that would encourage the use of heat pumps
- Determine the installation costs of heat pumps
- Measure the non-energy impacts such as improved health, increased comfort, reduced noise, etc. resulting from fuel switching and added cooling from electric heat pump;
- Measure the ease of program participation and participant satisfaction
- Provide insights on the program factors that drive increased interest in and purchase of heat pumps

2.3 Evaluation methodology

This section provides a high-level summary of the M&V methodology used for the impact evaluation and the primary research methodology used for the process evaluation. Appendices A-E include further details on the survey guides for the property managers, contractors, and participants, and details of the M&V site visit sample plan.

[8] Measures direct installed under LIFT include low-flow showerheads and faucet aerators, LED bulbs and lighting fixtures, building insulation, Title-24 compliant windows, and Energy Star™ refrigerators.

DNV employed multiple data collection methods across the various delivery touchpoints to assess the pilot's progress and address the study objectives.

Program delivery. DNV conducted program staff and implementer interviews, contractor interviews, and property manager surveys across the various program touchpoints to assess program delivery.

Program performance. DNV's approach to M&V of energy and cost savings from heat pump retrofits involved combining on-site data collection, equipment data logging, and utility meter data analysis to determine pre- and post-retrofit energy consumption and costs at the point of consumption. DNV worked with MCE to develop and apply alternative source energy values that are specific to MCE.[9] DNV performed spot measurements, short-term data logging, and collected utility meter data to quantify energy, cost, and emissions reductions resulting from natural gas- or propane-fueled heating, ventilation, and air conditioning (HVAC) and domestic hot water (DHW) equipment retrofits to electric heat pump equipment. DNV used this data collection on existing and retrofitted equipment to develop robust M&V results. DNV also performed pre-retrofit spot emissions testing on existing equipment to quantify in situ emissions and assess the applicability of established findings of emission. Section 2.3.1 below provides further detail on the sampling plan for the study.

Program experience. DNV analyzed responses from the pre- and post-occupant surveys, property manager surveys, and contractor interviews to gauge the program participant and provider experience. Table 2-1 summarizes the topics and research efforts undertaken to assess LIFT program delivery and program experience.

Table 2-1. Topics by research effort to assess program experience

Research Topic	Occupants (n=128)	Property Owners/ Managers (n=14)	Contractors (n=6)
Sources of program awareness	■	■	
Effectiveness of marketing and outreach		■	■
Enablers of participation		■	■
Barriers to participation		■	■
Referrals to other income-qualified programs (MFES, ESA, GHHI)		■	■
Satisfaction with program	■	■	■
Perceptions regarding bill savings	■	■	■
Non-energy impacts (safety, air quality, noise, comfort)	■		
Program recommendations		■	■
Demographics/firmographics	■	■	■

[9] MCE offers customers rates that correspond to options ranging from 60% to 100% renewable energy content. The PG&E rate option corresponds to 29% renewable energy content.

2.3.1 Sampling

In order to produce results that would be available by the end of the pilot period, the LIFT impact evaluation assumed concurrent implementation and evaluation. Only the heat pump installations were targeted for on-site M&V and billing analysis as the EE measures were all well-established measures reported in other utility direct install programs in California. Because projects for on-site M&V needed to be selected before the pilot had concluded, there was not a fixed population sampled from and extrapolated to. All projects eligible for EM&V were targeted as a certainty sample given the time to enroll participants. Dwelling units within projects were sampled to conserve budget for sites enrolled later in the program's cycle. Table 2-2 shows the LIFT pilot program population and characteristics such as program year (PY), location, project scope, and number of LIFT impacted dwelling units. Only sites with heat pump scopes were sampled.

Table 2-2. Program population characteristics

Project Rebate Approval Date	PY	Project ID	Location	Heat Pump Measure Scope	Energy Efficiency Measure Name(s)	# of Dwelling Units
Dec-18	2018	5	Larkspur	-	Title 24 compliant windows	12
Dec-18	2018	7	Richmond	-	Title 24 compliant windows	4
Dec-18	2018	8	Richmond	-	Title 24 compliant windows	4
Dec-18	2018	4	San Rafael	-	Title 24 compliant windows	12
Jan-19	2019	6	San Rafael	Ductless HVAC (substitution)	ENERGY STAR® refrigerator	1
Mar-19	2019	2	Napa	Ductless HVAC (substitution)	Low-flow kitchen/bath aerators and showerheads, unit lighting	56
Jun-19	2019	3	Mill Valley	-	Low-flow kitchen/bath aerators and showerheads, LED Bulbs	24
Jul-19	2019	22	Belvedere	Ductless HVAC (substitution)	A19/21 LED bulbs	11[10]
Nov-19	2020	26	Mill Valley	-	Title 24 compliant windows, LED bulbs	1
Jun-20[11]	2020	29	Oakley	Central domestic hot water (DHW) (substitution)	Package terminal heat pump	24
Jun-20[12]	2020	9	Rodeo	Central DHW (substitution)	Low-flow kitchen/bath aerators and showerheads, unit lighting	50
Jan-20	2020	4	Napa	Ductless HVAC (substitution)	-	40

[10] 10 of 11 dwelling units received HP fuel substitution retrofits at this project.
[11] The M&V analysis recognizes a heat pump installation date of December 2019 for this project.
[12] The M&V analysis recognizes a heat pump installation date of December 2019 for this project.

Project Rebate Approval Date	PY	Project ID	Location	Heat Pump Measure Scope	Energy Efficiency Measure Name(s)	# of Dwelling Units
Feb-20	2020	11	Bolinas	Ductless HVAC & Central DHW (switching)	-	6
Feb-20	2020	13	Bolinas	Ductless HVAC & Central DHW (switching)	-	7
Jul-20	2020	26	Mill Valley	-	Title 24 compliant windows	1
Aug-20	2020	20	Point Reyes Station	-	Title 24 compliant windows, R-19 crawlspace insulation	2
Nov-20	2020	10	San Geronimo	Ductless HVAC & Central DHW (switching)	ENERGY STAR® refrigerator, LED Bulbs	6
Nov-20	2020	33	Richmond	Central DHW (substitution)	-	23
Dec-20	2020	38	San Rafael	Ductless HVAC (substitution)	Title 24 compliant windows	2
Jan-21	2021	36	Napa	-	Title 24 compliant windows	57
Mar-21	2021	34	San Rafael	-	Title 24 compliant windows	97
Mar-21	2021	16	Fairfax	Ductless HVAC (substitution)	Low-flow kitchen/bath aerators and showerheads, unit lighting	70
-	2021	30	Napa	-	LED Fixtures	146
-	2021	31	Napa	-	LED Fixtures	209

Since the program developed as the evaluation progressed, the tracking of project installations varied such that it caused some uncertainty in the identifying EM&V eligibility, i.e. whether sufficient time passed to allow for post measure installation measurement through utility meter data analysis, and lead to a recommendation to improve the consistency of the program's tracking. The overall sampling approach could not estimate precision prior to starting. The sampling focused on meeting a fixed number of heat pump units evaluated at all properties with heat pump scope if possible, to provide ex post rigor and insights on the pre-retrofit conditions, installation itself, and early feedback post installations from owners and tenants. Representation of space heating and water heating were factors as well as knowing many projects were underway but did not meet the timing for EM&V for the reporting schedule. Table 2-3 presents the subset of the overall pilot program population that benefitted from heat pump retrofits as well as details pertaining to each project's eligibility for and inclusion in the analysis for this report.

Table 2-3. Heat pump project population and analysis scope

Project Rebate Approval Date	PY	EM&V Scope	Sample Site ID	Project ID	Location	Heat Pump Project Scope	Net Metered During Analysis Period	Analyzed Dwelling Units	# of Dwelling Units
Jan-19	2019	Report eligible	A	6	San Rafael	Ductless HVAC (substitution)	-	0	1
Mar-19	2019	Analyzed	B-1	2	Napa	Ductless HVAC (substitution)	-	20	56
Jul-19	2019	Analyzed	C	22	Belvedere	Ductless HVAC (substitution)	Existing prior	8	10
Jun-20[13]	2020	Analyzed	D	29	Oakley	Central DHW (substitution)	Existing prior	24	24
Jun-20[14]	2020	Analyzed	E	9	Rodeo	Central DHW (substitution)	Existing prior	50	50
Jan-20	2020	Report eligible	B-2	4	Napa	Ductless HVAC (substitution)	-	0	40
Feb-20	2020	Analyzed	F-1	11	Bolinas	Ductless HVAC & Central DHW (switching)	Added during	6	6
Feb-20	2020	Report eligible	F-2	13	Bolinas	Ductless HVAC & Central DHW (switching)	Added during	0	7
Nov-20	2021	Not report eligible	G	10	San Geronimo	Ductless HVAC & Central DHW (switching)	Added during	0	6
Nov-20	2021	Not report eligible	H	33	Richmond	Central DHW (substitution)		0	23
Dec-20	2021	Not report eligible	I	38	San Rafael	Ductless HVAC (substitution)		0	2
Will complete 2021	2021	Not report eligible	J	16	Fairfax	Ductless HVAC (substitution)		0	70

The pilot's first project was a single dwelling unit and was not sampled. Beyond that, the sample consisted of heat pump units completed in time for EM&V reporting. A project had to have its retrofitted heat pump equipment installed by February 2020 to provide sufficient time for post-retrofit consumption data to accrue. Two of the three eligible projects that were not directly analyzed were properties adjacent to or staggered construction phases of projects represented in the analysis and are presumed to realize similar impacts as their analyzed counterparts. A total of eight projects at six sites constituting 194 dwelling units were eligible for analysis at onset of evaluation and when field activity occurred. From this pool, the heat pump measure analysis was conducted on five of these projects that had impacts on 108 dwelling units. Table 2-4 shows the composition of eligibility for EM&V analysis for the LIFT pilot heat pump projects.

Table 2-4. Composition of LIFT pilot heat pump project EM&V analysis eligibility

EM&V analysis eligibility	Installs by	EM&V Eligible	Number of projects and dwelling units
EM&V Pilot sample	February 2020	March 2021	5 projects with 108 dwelling units
MCE LIFT HP installs with sufficient post-data not sampled	Mid 2020	March 2021	1 project with 1 dwelling unit – Not adjacent 2 projects with 47 dwelling units – Adjacent to sampled projects
MCE LIFT recent installs still without sufficient post data	Mid 2020 - present	Late 2021-Early 2022	4 projects with 101 dwelling units

[13] The M&V analysis recognizes a heat pump installation date of December 2019 for this project.
[14] The M&V analysis recognizes a heat pump installation date of December 2019 for this project.

The estimated precision of results was better than 90/10, since five of six properties were included in the overall estimates and over half of the units were sampled exceeding the evaluation plan target. Additional analyses could be conducted, but they will unlikely change sampling precision since most units are adjacent and similar in construction and scope as sampled units. The largest projects did comprise more of the sample and no additional weighting was conducted. The original analysis plan was to evaluate 15 of 30 units in the first year and 15 of 60 in the second year for a total of 30 of 90 units. In the end, five of six timeline eligible properties were sampled for analysis comprising 108 impacted dwelling units out of possible pool of 194 timeline eligible impacted dwelling units.

3 LIFT PILOT – PROGRAM METRICS

DNV tracked progress against program-defined goals via a set of three overarching categories of metrics that map directly to the program design and anticipated outcomes—program delivery, program performance, and participant experience. This section presents the impacts of the program by individual metrics within each overarching category. For each metric, DNV provides the data source and definition, results achieved versus stated goals, and key findings.

3.1 Program delivery

In this section, DNV presents metrics related to program delivery. The metrics aim to capture whether the program provided services successfully to its target market of "hidden communities" and whether these services provided were comprehensive and cost-efficient. For the LIFT Pilot, MCE defined "hidden communities" as households meeting one or more of the following criteria: 1) residents receive program information in a language other than English, 2) the home is occupied by extended or multiple families, and/or 3) the property is located outside of a DAC according to CalEnviroScreen 2.0.

3.1.1 Percent of non-English speaking households

The 2019 American Community Survey indicates that 45% of California households speak a language other than English at home. The LIFT pilot aimed to track the proportion of multifamily residents that received program information in a language other than English. This is a key program delivery metric used to measure how effectively LIFT performed against its stated goal to ease program participation barriers for hidden community multifamily renters.

3.1.1.1 Data source and definition

The results of the pre-post occupant survey administered to LIFT multifamily program participants[15] is the data source used to compute this metric. CCNB administered the in-person surveys in English and Spanish from 2017 to early 2019. In late 2019, the surveys shifted to Franklin Energy, which continued to conduct in-person surveys in both languages. In 2020, the survey transitioned to a telephone survey in response to COVID-19 restrictions.

Surveyors asked respondents to indicate the primary language spoken in their home. Response options included English, Spanish, Mandarin or Cantonese, Tagalog, Vietnamese, Korean, Farsi, Japanese, German, and Armenian. The full survey is presented in APPENDIX A.

[15] A participating unit is generally defined as a unit that has passed the income-qualification process, paid a refundable good faith deposit, and received a site assessment from the program's technical assistance provider. All tenant survey respondents were qualified as participants. The 128 individual households that responded to the occupant survey are a mix of tenants intercepted at the pre-retrofit stage and/or the post-retrofit stage.

The metric is computed as follows:

Percent of non-English/limited English-speaking households =

(Number of non-English/limited English households survey respondents)/Total number of survey respondents

3.1.1.2 Results versus goals

The results presented here are based on responses from 128 individual households that were served by the LIFT program and that completed the survey. While all households that receive upgrades are invited to participate in the survey, the households included in the utility meter data analysis are restricted to a subset of projects that were timeline eligible. The program was unable to conduct surveys with every household served by the LIFT program. Survey activities were paused from March 2020 to September 2020 as Franklin Energy adapted the surveys to fit COVID-19 safety guidelines. The program pivoted to phone surveys due to the shelter-in-place order in effect at the time. Respondents were provided a gift card as an incentive to boost participation in the survey.

Results indicate that 42% of customers who received LIFT program services and responded to the survey (54 out of 128 individual households) are in non-English or limited English-speaking households. The LIFT program goal is to ensure that at least 40% of participants satisfy any one of the three "hidden community" characteristics.[16] "Hidden communities" by definition are difficult to identify and it is not possible to know the total population of households that meet one or more of the characteristics while also being renters who qualify based on income. The goal of 40% was established through discussion with CPUC Energy Division staff as a reasonable target to ensure the program was reaching households that may not typically be served with EE programs.

3.1.1.3 Key finding

With 42% of LIFT pilot participants residing in non-English or limited English-speaking households, the program surpassed its goal of 40% of program participants meeting at least one "hidden community" criteria.

3.1.2 Percent of extended family households

The LIFT program tracks the percent of extended family households that participated in the program. This is a key program delivery metric used to measure how effectively it is performing against its stated goal to ease program participation for "hidden community" multifamily renters.

Recent census reports indicate that the US population living in extended families is approximately one-fifth of all households. The term "extended family" refers to the living arrangement of groups of individuals whose relationships to each other extend beyond the

[16] Hidden community customer characteristics measured by this study include non-English or limited English-speaking households, extended family households, and households outside a disadvantaged community as defined by CalEnviroScreen 2.0.

nuclear family.[17] Examples of extended families include families that take in parents who may be widowed, ill, disabled, or in need of economic and other types of support; and families that take in the householders' siblings or other relatives.

3.1.2.1 Data source and definition

The pre-post occupant survey administered to LIFT program participants is the data source used to compute this metric. CCNB administered the in-person surveys in English and Spanish from 2017 to early 2019. In late 2019, the surveys shifted to Franklin Energy, which continued to conduct in-person surveys in both languages. In 2020, the survey transitioned to a telephone survey in response to COVID-19 restrictions.

Surveyors asked respondents to describe their household. Response options included the following options: 1) one family, 2) extended family with relatives/multiple generations in the household, and 3) two or more unrelated families in the household. The full survey is presented in APPENDIX A.

The metric is computed as follows:

Percent of extended family households =

(Number of extended family households survey respondents)/Total number of survey respondents

3.1.2.2 Results versus goals

As noted in the previous section, the results presented here are based on responses from 128 individual households that participated in the LIFT program and completed the survey.

Results indicate that 1.6% of LIFT program participants who responded to the survey (2 out of 128 individual households) are in extended family households. The LIFT program goal was to ensure that at least 40% of participants satisfy any **one** of the three "hidden community" customer segment descriptors. The households that fit the extended family description also state that the primary language spoken in the home is Spanish.

3.1.2.3 Key finding

Though survey responses indicate that only 1.6% of households that received program services fit the extended family household description, the program surpassed its goal of at least 40% of participants satisfying any **one** of the three "hidden community" customer segment descriptors.

The program included several senior housing participants, that comprise of smaller single or two-person households. Given the program requirement of reaching tenants residing in multifamily properties, the number of extended families that fit this descriptor available to the program is reduced. Furthermore, the program seeks to serve those outside CalEnviroScreen 2.0. These requirements further reduce the total number of extended families that fit this descriptor and are available to the program.

[17] Housing the Extended Family, Center for American Progress, October 2016. https://cdn.americanprogress.org/wp-content/uploads/2016/10/18155730/ExtendedFamilies-report.pdf.

The two households that participated in the survey and fit the extended family descriptor also stated that the primary language spoken in the home was Spanish. The results indicate the intersectional characteristics of "hidden communities".

Per the Center for American Progress (CAP) report on extended families, 17% of all households in the nation fit this descriptor. The CAP report also states that the U.S. population living in extended families increased from 58 million in 2001 to 85 million in 2014. Given the paucity of affordable housing in Northern California that is a contributing factor to the prevalence of extended family households and the low-income target market for the LIFT program that is more likely to be found in such housing arrangements, DNV recommends that the LIFT program continue to track this metric.

3.1.3 Percent of households outside of CalEnviroScreen 2.0

CalEnviroScreen is a mapping tool that helps identify California communities that are most affected by multiple sources of pollution, and where people are often especially vulnerable to pollution's effects. CalEnviroScreen uses environmental, health, and socioeconomic information to produce scores for every census tract in the state. An area with a high score is one that experiences a much higher pollution burden than areas with low scores. DACs are defined as the 25% top-scoring areas according to CalEnviroScreen, along with other areas that record high amounts of pollution and low populations.

The LIFT program seeks to identify and serve residents located outside of CalEnviroScreen 2.0 designated DACs. This metric tracks participants who are financially disadvantaged but may live in a more affluent or less polluted area.

3.1.3.1 Data source and definition

Program tracking data provided by the prime program implementation contractor, AEA, is the data source used to compute this metric. The metric is computed as:

Percent of LIFT treated income-qualified dwelling units outside CalEnviroScreen 2.0 designated DACs=

(Number of LIFT treated income-qualified dwelling units[18] outside of CalEnviroScreen 2.0 DAC compliance)/Total number of LIFT treated income-qualified dwelling units

3.1.3.2 Results versus goals

Of the 865 units treated by the LIFT program, 842 units were income qualified and the remaining 23 units received LIFT program services as they were in properties where greater than 80% of the treated units were income qualified. Results indicate that 794 out of the 842 LIFT treated income-qualified dwelling units (94%) are outside of CalEnviroScreen 2.0 DAC compliance per the tracking data provided by AEA (Table 3-1).

[18] Qualified dwelling units are those that meet the program eligibility criterion of income at or below 200% Federal Poverty Guidelines. This could include both units that have submitted an intent to proceed but not yet undertaken upgrades and units that have completed energy efficiency upgrades.

Table 3-1. CalEnviroScreen 2.0 DAC compliance

Description	In CalEnviroScreen 2.0 DAC compliance	Not in CalEnviroScreen 2.0 DAC compliance
Number of LIFT qualified dwelling units	48	794
Percent of LIFT qualified dwelling units	6%	94%

3.1.3.3 Key finding

Given that 94% of LIFT qualified dwelling units are outside of CalEnviroScreen 2.0 DAC compliance, the program surpassed its goal of at least 40% of participants satisfying any **one** of the three hidden community customer segment descriptors.

3.1.4 Percent of units receiving comprehensive upgrades

By blending LIFT program incentives with MFES program rebates, MCE aims to provide maximum incentives to property owners to achieve the full potential for comprehensive savings from energy upgrades. The desired outcome is cost effective delivery of program services with maximization of benefits to owners and tenants.

3.1.4.1 Data source and definition

Program tracking data provided by the prime program implementation contractor, AEA, is the data source used to compute this metric. The program aims to deliver comprehensive upgrades, which MCE refers to as projects receiving MFES rebates on top of LIFT incentives; and projects with measures that fall into two or more end-use categories (lighting, building envelope, space heating, etc.). The metric is computed as:

Percent of dwelling units receiving comprehensive upgrades[19] =

(Number of dwelling units receiving comprehensive upgrades using both MCE's MFES and LIFT program offerings)/Total number of LIFT dwelling units

3.1.4.2 Results versus goals

Program tracking data indicate that 387 out of 510[20] dwelling units (76%) received comprehensive upgrades. The LIFT program goal is to ensure that at least 60% of dwelling units receive upgrades using both MCE's MFES and LIFT program offerings.

3.1.4.3 Key finding

The program defines comprehensive upgrades as projects with measures that fall in two or more end-use categories. Given that 76% of dwelling units received upgrades for two or

[19] This metric is based on dwelling units that have completed energy efficiency upgrades and have received funding from MFES and LIFT combined.

[20] A base of 510 income eligible units is used to compute this metric (versus the total 865 income-eligible units treated by the LIFT program). While the remaining 355 additional units have received LIFT program services, at the time of completion of this report, these units were scheduled to but were yet to receive services from the MFES program and are hence excluded from inclusion in this metric. Program activity on the LIFT pilot continues to occur beyond the tome of completion of this report in July 2021.

more end uses, the program has surpassed its goal of 60% of units served by the program receiving comprehensive upgrades.

3.1.5 Percent of eligible households that install EE measures through LIFT

Low-income multifamily renters face a higher energy burden and face market barriers, such as the need for owner approval to improve the units, financial constraints, potential rent increases after upgrades, and the lack of financial incentives. The LIFT program seeks to overcome these barriers by targeting landlords and property owners and reaching a higher number of units more efficiently.

3.1.5.1 Data source and definition

Program tracking data provided by the prime program implementation contractor, AEA, is the data source used to compute this metric. The LIFT program used the same income eligibility threshold as the ESA program (household income at or below 200% of the federal poverty level) but was available only to multifamily properties. The metric is computed as:

Percent of income eligible households that install efficiency measures through the LIFT program =

(Number of income eligible households served by LIFT)/Total number of income eligible households in MCE's territory

3.1.5.2 Results versus goals

Program tracking data indicate that 842 dwelling units have received or will receive program services and were verified as income-eligible out of a total of 865 units served/to be served by the program. This is because MCE applies the 80% ESA-eligible tenant multifamily household eligibility rule, which states that if at least 80% of units at a given property qualify as income-eligible, all units are income-eligible. Thus, for properties that satisfy the 80% rule, the total number of participating units equals to the total number of units at the property (i.e., both income-eligible units and units that do not meet the income eligibility requirements, but are located at a property where 80% or more of the units are income-qualified).

The program sought to serve 550 income eligible households in MCE's service territory in the first year of the program and 932 income eligible households in the second year, which translates to a goal of 1,482 households out of 56,087 income eligible households in MCE's service territory through a two-year program period.[21]

3.1.5.3 Key finding

The MCE LIFT program treated 842 income-eligible households out of the 56,087 income eligible households in MCE's service territory over a three-year period. This is significantly lower than its stated goal of treating 1,482 income-eligible households out of 56,087 income eligible households in a two-year period.

[21] MCE. "MCE_LIFT Program Manual 4_16" 2018. PDF file.

3.1.6 Heat pump procurement and installation costs

The LIFT pilot aimed to value and quantify the full potential of fuel switching in space- and water-heating heat pump applications. The cost of implementing these measures is an important metric to measure as heat pumps are a more expensive retrofit as compared to a gas-fired replacement and thus currently necessitate an incentive to make them cost-competitive. Table 3-2 presents the incentives that MCE offered under the LIFT program for by measure for each dwelling type.

Table 3-2. MCE heat pump incentives for space and water heating measures

System Type	Heat Pump Type	Incentive per Dwelling
Hot Water Gas/Propane to HPWH	Central HPWH (not eligible for electrical upgrade add-ons)	$1,500
	Apartment HPWH	$2,000
	Apartment HPWH with newly installed hydronic fan coil/heat emitter	$3,000
Space Heating Gas/Propane Heating, without A/C	Ductless Heat Pump (assumes newly installed)	$5,000
	Central Heat Pump System (serving multiple units)	$3,750
	Package Terminal Heat Pump (assumes newly installed)	$2,500
	Ducted Split Heat Pump (assumes replacing gas furnace AHU)	$4,500
Space Heating Gas/Propane Heating, with A/C	Ductless Heat Pump (assumes newly installed)	$5,000
	Central Heat Pump System (serving multiple units)	$3,750
	Package Terminal Heat Pump (assumed replacing existing PTAC)	$1,500
	Ducted Split Heat Pump (assumes replacing existing split A/C)	$3,500
	Rooftop Packaged Heat Pump (assumes replacing existing gas-pack)	$3,000
Electrical Upgrades (as needed)	Panel Upgrade (Existing too small for newly added electrical load)	$1,200
	New Electrical Conduit to Heat Pump (per circuit)	$400

3.1.6.1 Data source

The evaluation team assessed contractor invoices provided by implementer AEA for 17 space heating and water heating heat pump projects. The team reviewed invoices with an intent to allocate procurement and installation costs for material, labor, and when necessary electrical or structural upgrades applied. Invoices for several projects were difficult to discern coupled with the absence of contractor tracking data scope, project cost and incentives paid. Invoices varied significantly; some were transparent while others consolidated all costs into a single line item. Projects varied widely as well from complete renovations, to rooftop or in-home unit installations. Through follow up data requests project details provided more scope. Therefore, for the purposes of the cost comparison, only total project costs are presented unless the contractors provided more detailed information.

3.1.6.2 Results versus goals

The program goal related to this metric is simply to gather information on procurement and installation costs of heat pumps including costs of bulk purchase to inform fuel switching

policies. The program aims to offer up to 80% of the cost when all measure opportunities are maximized. The following four tables present the total project costs for:

- Central HPWHs that serve multiple dwelling units
- In-unit HPWHs (tank) which typically serve individual dwelling units, but for this installation served multiple units
- Ductless heat pumps and central heat pump systems that provide heating and cooling to individual dwelling units
- Package terminal heat pumps that provide heating and cooling to individual dwelling units

Central HPWH. The costs associated with central HPWH projects, the number of dwelling units served by the water heaters, the cost by dwelling unit, and total cost as well as the incentive are provided in Table 3-3. The individual incentive for a central HPWH is $1,500 per dwelling and the mean cost is $2,763.

Central system water heaters vary in design based on the number of dwellings they are intended to serve, and because of this there are few similarities as it relates to equipment installation costs. Some HPWHs are similar to in-unit water heaters, with a larger capacity tank (e.g., 120-gal tank vs. 50-gal standard water heater tank), whereas others that serve numerous dwellings with a large capacity heat pump and separate water heater tanks.

DNV found the average cost of central water heating system per dwelling is $2,760 with a standard deviation of $813. The incentives for central HPWH systems vary widely due to the aforementioned variation in capacities and associated costs. In addition to the equipment cost, the following costs were included in the respective invoices:

- Project Richmond: Building Permit $358, demolition of gas lines and vents and carpentry $4,807, electrical, sub panel, wiring, conduit, sub panel $12,678, plumbing, (tubbing, gauges, brackets), water heating system 4.5kW Heat Pump and 119-gallon storage tank
- Project Rodeo: Electrical $13,514, recirculating pump and control $4,850, retro commissioning $3,604, and compressor warranty $2,763.
- Project Bolinas #11: Heat Pump Water Heater with time and materials for plumbing $1,800
- Project Bolinas #13: This is the same property as #11 and some costs are shared with this project which also included spacing heating. The water heater is a Heat Pump with the tank on the roof, includes roof penetrations $1500, and crane rental was $800. Additional cost added for lodging in remote area.
- Project Oakley: Electrical $9,760, recirculating Pump $5,200, and control, and retro-commissioning $2,393.

Table 3-3. Central HPWH total installation cost

Project ID	Location	Number of Systems Installed	Dwelling Units Served	Equipment	Other	Cost per Dwelling Served w/out Incentive	Total Cost without Incentive	Incentive
33	Richmond	1	23	$14,335	$32,733	$2,091	$47,057	$33,750
9	Rodeo	2	50	$112,464	$24,686	$2,743	$137,150	$75,000
11	Bolinas	1	3	$9,700	$1,800	$3,833	$11,500	$6,400
13	Bolinas	1	7	$12,200	$2,300	$2,071	$14,500	$11,500
29	Oakley	1	24	$79,871	$5,200	$3,545	$85,071	$36,000
Mean						**$2,760**		
Standard Deviation						**$813**		
Maximum						**$3,833**		
Minimum						**$2,071**		
Total		**6**	**107**	**$220,670**	**$74,619**	**-**	**$295,278**	**$162,650**

In-unit HPWH. Table 3-4 presents the single project with in-unit HPWH installation. This project was unique, as water heaters of this type and size (50-gallon tank) typically serve a single dwelling. However, these water heaters were plumbed to serve two dwellings for each water heater. The invoice included three hybrid heat pump water heaters that served six dwellings and at least one water heater included an expansion tank. The program adjusted the incentive to match a 'central system' design rebate at $1500 per dwelling as compared to the $2,000 per dwelling that would be typical if the water heater served a single dwelling. The incentive for the in-unit heat pump water heater covers approximately 44% of the total cost. Invoice details were limited on this project but included items for permits, pipe fitting and conduit.

Table 3-4: In-unit HPWH installation cost

Project ID	Location	# of Systems Installed	Dwelling Units Served	Equipment	Other	Cost per Dwelling Served	Total Cost without Incentive	Incentive
10	San Geronimo	3	6	$17,443	$3,076	$3,420	$20,519	$9,000

Ductless heat pumps. Table 3-5 presents the most common measure installed by the program, the ductless heat pump systems, which provides both hot and cold air. The following table shows the associated costs for 203 ductless heat pump systems across 10 projects. DNV found an average cost without the incentive at $10,902 per ductless heat pump system with a standard deviation of $4,268. The variation in costs is likely largely due to variation of equipment capacity. Higher capacity equipment typically costs more. With an incentive cost of $5,000 per ductless mini-split and $3,750 per central ductless heat pump, the incentive covers roughly 30% to 91% of the total cost. One

possible way to address the cost disparity is to incentivize by the installed capacity or by dollar per ton of cooling.

- Project San Rafael (#5): This project included a complete building renovation with a with ductless systems.
- Project Bolinas (12): Includes a 220V/ 20AMP circuit and moving a subpanel as well as new sub panel. Parts $700, labor $1100.
- Project Bolinas (13): This project is on the same property as site ID 12 and some costs and incentives are shared for building upgrades as well as contractor services (e.g., travel). It included a 220V, 20AMP panel, unit and sub panel as well as breaker (no line item costs were available).
- Fairfax: This project was a complete building renovation which included HVAC and electrical.
- Project Napa: Napa these two-phase projects were complete building renovations with a mini-split, multi-zone units, additional costs were wiring and interface kits.
- Project Belvedere: This project included a demolition of ceiling gas heaters, unit installation crane on roof, piping refrigerant, wiring, drain piping and permit (no line item costs were available).

Table 3-5. Ductless heat pump installation costs

Project ID	Project Name	# of Systems Installed/ Dwelling Units	Material & Parts	Other	Cost per Dwelling Unit	Total Cost w/o Incentive	Incentive
5	San Rafael	1	$1,800		$8,750	$10,550	$6,600
12	Bolinas	3		$975	$10,127	$15,447	$11,650
13	Bolinas	6			$3,862	$30,381	$22,500
12	Bolinas	8			$1,970	$15,760	$11,650
38	San Rafael	2			$6,250	$12,500	$10,000
10	San Geronimo	6			$15,630	$24,771	$22,500
16	Fairfax	70	$10,928	$3,529	$14,458	$1,012,036	$350,000
3	Napa	40			$6,763	$411,024	$196,000
2	Napa	56			$6,763	$575,434	$173,800
22	Belvedere	11		$16,960	$8,018	$105,160	$54,000
Mean					**$10,902**		
Standard Deviation					**$4,268**		
Maximum					**$15,630**		
Minimum					**$ 1,970**		
Total		**203**	**$12,728**	**$21,464**		**$2,213,063**	**$ 858,700**

3.1.6.3 Key finding

There were several challenges with aligning the costs in the invoices to specific records. In some instances, the invoices may have included equipment for multiple records. In other cases, it wasn't always apparent what the scope of work was and how it was associated with costs. To ensure that the project costs are accurate, best practices can be adopted. In cases where invoices information is omitted, documentation can be annotated and corrected. The program allows properties to use their own contractors for additional flexibility. DNV

recommends that the program prescribe participating contractors to use a program form that includes the following information in addition to submitting invoices:

- Unique record identifier: project name or number
- Program project overview and description on the scope of work
- Install location: the address where the work was done. If the work is for only one of multiple phases, include notes like apartment unit numbers
- Scope of work: quantity, type of equipment, make and model numbers
- Total project costs associated with that record. If unrelated costs are included on the invoice these should be excluded from that total. In some cases, costs for multiple records might be included on the same invoice, to the extent possible these costs should be allocated to each project

3.2 Program performance

In this section, DNV presents results on program performance metrics related to savings estimates and Btu savings impacts of heat pumps, bill impacts, and GHG impacts.

The program performance analysis primarily relies upon a utility meter data analysis that was used to inform multiple metrics with short term equipment monitoring to inform and support the utility meter analysis and spot flue gas measurements that were focused on specific metrics. The utility meter analysis approach uses weather data to set energy consumption pre- and post-retrofit on equal weather footing to isolate the effect of the retrofit from weather effects. The regression model treats energy consumption as a function of heating and cooling degree days. DNV uses actual weather data to find optimal heating and cooling temperature setpoints. Once regression coefficients are obtained, climate zone 2018 (CZ2018) typical meteorological year (TMY) weather data are used to produce weather-normalized consumption estimates. DNV runs this regression process for both pre- and post-retrofit periods for each unit and site.

3.2.1 Savings per unit for LIFT program

The savings analysis of LIFT and other electrification programs differs from traditional energy efficiency programs because electric consumption is expected in many cases to increase (negative electric savings) and there will be significant reduction or elimination of gas consumption (high gas savings).

3.2.1.1 Data source and definition

The heat pump measure savings per unit for electric and gas were derived from the utility meter data analysis. 15-minute interval electric meter data and daily gas meter data were obtained for the analysis. The electric consumption was aggregated to the daily interval to match the resolution of the gas data, and the regression modeling was performed on daily-level, with outputs aggregated to the monthly interval. Peak demand savings estimates were not calculated for these heat pump measures. Impacts from the other energy

efficiency measures installed through the pilot program rely on program tracked deemed energy and demand estimates.

Three sampled heat pump projects also installed energy efficiency measures. One project claiming negligible lighting savings, one project claiming modest savings from a package terminal heat pump[22], and one claiming electric savings from low-flow water fixtures. The impact of low-flow water fixtures could be confounded with the added electric load of the heat pump water heaters.

The most recently published ESA impact evaluation (2015-2017) showed lower savings than ex ante using a metering data analysis approach. So, the impact evaluation PG&E results are referenced as well as the 2016 Annual Report MCE used when defining the metrics at program launch. The ESA program reports roughly 75% of homes are single family, further complicating direct comparison.

3.2.1.2 Results vs goal

MCE set a Btu goal, but not specific kWh and therm targets. Noting the most recent ESA impact evaluation represents mostly single-family homes—the savings reported averaged 96 kWh and 9 therms for multifamily projects in PG&E territory over the four program years and thousands of homes. Overall ESA reported savings was 3.2 MMBtu and the evaluation showed 1.5 MMBtu savings.

Table 3-6 below summarizes the site savings per dwelling unit achieved by the LIFT program through the energy efficiency upgrade and heat pump fuel switching measures. Per the program tracking data, 733 dwelling units received energy efficiency measure upgrades resulting in an average per dwelling unit annual energy savings of 86 kWh, 0.006 kW, and 5 therms. One subset of 276 dwelling units benefited from receiving fuel substitution heat pump measures through LIFT, while another subset of 19 dwelling units benefitted from receiving fuel (propane) switching heat pump measures through the pilot program. The evaluated per dwelling unit heat pump fuel substitution impacts were determined to be an increase of 150 kWh and a decrease of 72 therms, whereas the heat pump fuel switching impacts were determined to be a decrease of 1,130 kWh[23] and a decrease of 241 therms. The sample data supporting these results can be found in Table 5-1 within APPENDIX D. No estimates of electric demand impacts were calculated for the LIFT heat pump measures. Overall, the LIFT program realized 50 kWh of electric energy savings and 32 therms of gas energy savings per dwelling unit. This corresponds to less electric savings than the ESA impact evaluation but greater than three times the gas savings, with the combined LIFT per unit Btu savings nearly three times that of ESA multifamily projects.

[22] It is uncertain if this measure was installed under the same electric account that was analyzed for heat pump installation at this project.

[23] This value includes the impacts of onsite PV electric behind the meter generation installed during the analysis period for the single fuel switching project sampled. The other two fuel switching projects in the pilot program population also added onsite solar PV electric behind the meter generation during the analysis periods.

Table 3-6. Summary of LIFT site savings per dwelling unit for energy efficiency & heat pump measures

Measures	Total Number of LIFT Units	Electric Energy (kWh) Savings per Unit	Electric Demand (kW) Savings per Unit	Gas Energy (therm) Savings per Unit
LIFT Energy Efficiency	733	86	0.006	5
Heat Pump - Substitution	276	-150	-	72
Heat Pump - Switch	19	1,130	-	241
Total	**865**	**50**	**0.005**	**32**

3.2.1.3 Key Finding

LIFT far exceeded ESA gas savings through the heat pump measures but did not achieve ESA electric savings both because of the expected heat pump electric usage increase and because LIFT EE did not install all ESA weatherization measures.[24] Notably, unlike ESA, LIFT allowed properties to choose their own measures based on the property and units' needs. Several properties utilize the majority of their incentives to cover measures that improve the overall thermal comfort of the units and are not eligible under ESA such as windows.

3.2.2 Bill impact of fuel substitution or fuel switching

Uncertainty regarding potential utility bill increases is a key barrier to fuel substitution or fuel switching, whether it is tenant costs, heating costs, or property manager costs for central water heating systems. In addition to the LIFT program, customers could move to new time-of-use rates after retrofit, adding complexity. The evaluation analysis was designed to look at bill impacts the customer would have seen assuming the same rate before and after retrofit, as well as the actual monetary bill impact with the any rate changes that occurred.

3.2.2.1 Data source and definition

The customer bill impacts combine the utility meter analysis results and rate schedule information from MCE and the customers. Analysis was done using actual post-retrofit rates, all observed rate changes in the sample were from TOU-A to TOU-C rate schedules, as well as an alternative where the rates were assumed to stay the same to provide an apples-to-apples comparison of pre- and post-installation results.

3.2.2.2 Results versus goal

MCE did not set a goal for energy cost impacts resulting from fuel substitution or fuel switching heat pump measures but did seek to determine these impacts through the LIFT pilot evaluation. The results of the bill impact assessment are presented below in Table 3-7. On a per dwelling unit basis, LIFT heat pump recipients realized an annual energy cost

[24] ESA weatherization measures include attic insulation, weatherstripping, caulking, and door and building envelope repairs which reduce air infiltration. Per the tracking data, LIFT EE weatherization measures claimed include Title 24 compliant windows, crawl space insulation.

savings of $192[25]. This equates to a total annual savings of $56,603 across the entire LIFT program heat pump population included in this evaluation.

We observe that the calculated bill savings from fuel switching are significantly higher than the bill savings from fuel substitution at $1,123 versus $128 due to addition of solar PV at the sample fuel switching sites during the analysis period. All three fuel switching projects in the pilot population added solar PV during the analysis period. Therefore, for fuel-switching, no heat pump impacts independent of the addition of solar PV are available for analysis. The overall bill impact is weighted more heavily towards the fuel substitution impacts as these projects comprise the majority of the program population.

The sample data supporting these results can be found in Table 5-2, Table 5-3, Table 5-4, and Table 5-5 within APPENDIX D. Over 82% of the realized cost savings stems from the reduction in gas consumption, with changes in electric consumption making up the balance. Underlying this result is a rate schedule change for some sampled projects that slightly increased bill savings further.

DNV performed an analysis of energy cost impacts using an alternative rate case, where the energy cost impacts were assessed without any rate schedule change. In the alternative rate case scenario, the per dwelling-unit annual energy cost savings would be $187, and total annual savings across the LIFT program heat pump population would be $55,244.

Table 3-7. Summary of annual bill savings from heat pump measures

Measures	Total Number of LIFT Heat Pump Units	Rate Case	Bill ($) Savings per Unit	Bill ($) Savings, Program Total
LIFT Heat Pump Gas Fuel Substitution	276	Actual	$128	$35,262
		Alternative	$123	$33,903
LIFT Heat Pump Propane Fuel Switching	19	Actual	$1,123	$21,342
		Alternative	$1,123	$21,342
All LIFT Heat Pump	**295**	**Actual**	**$192**	**$56,603**
		Alternative	**$187**	**$55,244**

3.2.2.3 Key Finding

LIFT heat pump measures result in non-trivial realized annual energy cost savings and the rate schedule changes had a small positive contribution to this outcome.

3.2.3 GHG impact of heat pumps

Fuel switching focuses on reducing greenhouse gas emissions as the electric generation mix continues to decarbonize through renewables. The evaluation included all aspects of GHG including direct burning of gas, methane leakage (methane is 72 times more potent than carbon dioxide), and the emissions from electricity generation and line losses to run the heat pumps.

[25] For centralized heat pump systems, such as is common for DHW equipment multifamily buildings, these fuel cost savings are likely realized by the property owners or managers, and not the dwelling unit tenants.

3.2.3.1 Data source and definition

The GHG reduction analysis combines the utility meter data analysis, flue gas measurements, critical assumptions from the CPUC and the California Energy Commission (CEC) (leakage rates, emissions assumptions, and distribution losses), and assumptions for the MCE Light Green (60% renewable) generation mix[26]. The direct measurement of indoor air pollutants, which include carbon monoxide (CO) and nitrous oxides (NO_X) from gas-fired equipment do not have specific points of comparison.

3.2.3.2 Results vs goal

MCE set goals to reduce all emissions, but no specific GHG or other emissions targets. Overall, the program saves just over 1 metric ton of carbon dioxide annually per unit and 321 metric tons per year total across all heat pump sites. Notably, the dangerous indoor air pollutants, carbon monoxide (CO) and nitrogen oxide (NO_X) have OSHA limits measured in parts per million (PPM). Assuming an average size tenant unit and one air change per hour, the CO limit is 1 pound annually, not to exceed 50 PPM. The measured reduction was 2.08 lbs./unit. This means that before installation of heat pumps, the CO is over the national health and safety limit in tenant units or the space where the property management staff accesses the water heaters or both. The sample data supporting these results can be found in Table 5-6, Table 5-7, and Table 5-8 within APPENDIX D.

Table 3-8. Summary of annual GHG emissions impacts from fuel switching and fuel substitution heat pump measures

Measures	Total Number of LIFT Heat Pump Units	Emissions Savings per Unit	Emissions Savings, Program Total	Units
LIFT Heat Pump Gas Fuel Substitution	276	0.91	252	CO_2 (tons)
		2.22	612	CO (lbs.)
		0.87	239	NO_X (lbs.)
LIFT Heat Pump Propane Fuel Switching	19	3.69	69	CO2 (tons)
		0.10	2	CO (lbs.)
		2.80	53	NO_X (lbs.)
All LIFT Heat Pump	**295**	**1.09**	**321**	**CO_2 (tons)**
		2.08	**614**	**CO (lbs.)**
		0.99	**292**	**NO_X (lbs.)**

3.2.3.3 Key finding

The LIFT program realized significant annual carbon dioxide (CO_2) GHG reductions through the heat pump fuel switching measures. NOx, which is a GHG, was also reduced as a result of the heat pump measures, as well as CO, an indirect, toxic GHG.

[26] Savings would be significantly higher for customers receiving MCE's Deep Green service (100% renewable). DNV did not model those calculations for this report.

3.2.4 Btu savings impact of heat pumps

The source Btu impacts of switching from gas-fired equipment to electric heat pumps is a combination of the much greater efficiency of heat pumps and the energy used to generate the electricity. Some gas and other fuel are burned to generate electricity while also being subject to additional losses from transmission and distribution summarized in the site-to-source ratio. MCE generation mix at a minimum of 60% renewables means the site-to-source ratio is 2 or less and the heat pump's coefficient of performance is 3 to 4.

3.2.4.1 Data source and definition

Customer bill impacts were estimated using billing analysis results and MCE's generation mix which is minimum 60% renewables. DNV used the CPUC Avoided Cost Calculator and CAISO assumptions as a point of comparison for the kBtu/kWh assumptions. The ESA electric and therm savings translate into 3.2 source MMBtu which the program set as a target to exceed.

3.2.4.2 Results vs goal

Savings per unit of 9.4 MMBtu annually for LIFT HPs is almost triple the savings of 3.2 MMBtu documented in PG&E's 2016 ESA program report. The sample data supporting these results can be found in Table 5-9 within APPENDIX D.

Table 3-9 below summarizes the total number of dwelling units benefiting from LIFT heat pump fuel substitution or switching measures, the per dwelling unit annual source energy savings[27], and the program total annual source energy savings.

Table 3-9. Summary of source energy savings from fuel switching and fuel substitution heat pump measures

Measures	Total Number of LIFT Heat Pump Units	Source Energy (kBtu) Savings per Unit	Source Energy (kBtu) Savings, Program Total
LIFT Heat Pump Substitution	276	7,394	2,040,769
LIFT Heat Pump Switching	19	38,033	722,633
All LIFT Heat Pump	**295**	**9,367**	**2,763,402**

The evaluated savings for PG&E's ESA program was lower at 1.5 MMBtu than the reported value of 3.2 MMBtu. The source Btu savings per unit for LIFT were much higher than the reported and evaluated PG&E ESA savings. The ESA program includes larger residences that use more energy with more potential savings because they include a majority single family homes while LIFT served exclusively multifamily properties with lower per unit consumption.

[27] This estimate is for dwelling units only and is exclusive of common areas.

Compared to savings for multifamily projects in PG&E territory from the ESA 2015-2017 impact evaluation, LIFT's savings were almost eight times higher at 9.4 MMBtu versus of 1.2 MMBtu for ESA.

3.2.4.3 Key Finding

The source Btu savings per unit for LIFT were much higher than the reported and evaluated PG&E ESA savings.

3.3 Participant experience

In this section, DNV presents metrics on the program participant experience. The metrics capture property manager satisfaction with the program process and tenant satisfaction with the upgrades received.

3.3.1 Property owner/manager satisfaction

MCE designed the LIFT program to address some of the problems resulting from programs operating with siloed pots of funding. At the same time, there were opportunities to achieve greater cost efficiency, participation, and customer satisfaction. The LIFT program's vision was to deliver property owners, managers, and tenants maximum support by combining incentives and providing comprehensive upgrades for more significant benefits. The program sought to capture satisfaction levels by gathering feedback from property owners and managers that received heat pump and energy efficiency upgrades through the LIFT program.

3.3.1.1 Data source

The results presented in this section are based on responses from property managers who participated in the LIFT program and completed in-depth telephone interviews. The property manager interview guides for properties with and without heat pump installations are presented in APPENDIX B and APPENDIX A. DNV completed interviews with 11 out of the population of 20 property managers engaged by the program. DNV made a maximum of three contact attempts to reach property managers with working phone numbers to minimize the potential for non-response bias. These property managers had installed one or more of the heat pump measures for both central and point of use water heaters and/or space heaters. Five respondents represented individual properties, but all worked for the same organization.

Table 3-10. Sample disposition for property manager interviews

Interview disposition	Properties with heat pump installations	Properties without heat pump installations	Total (n=20)
Completed interviews	9	2	11
Incomplete interviews	2	1	3
No survey, non-response or disconnected			6

The interviews were primarily designed to gather input on the heat pump electrification measure and feedback on program experience. The interviews also included questions for property managers who participated in the program but did not install heat pumps in order to gain insights on their decision to not install and perceived barriers. Interviews also contained questions related to firmographics and program marketing and outreach.

3.3.1.2 Data source and definition

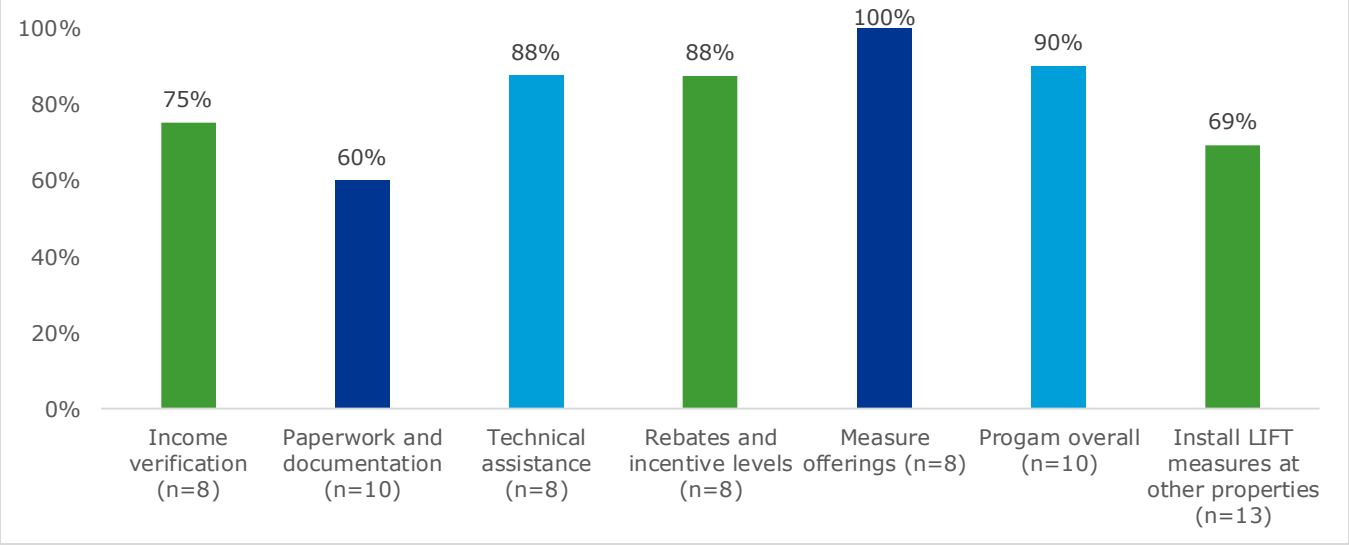
The program aims to achieve a satisfaction rating of 80% or better for ease of participation. To address the overall program experience, DNV inquired on six aspects of participation. Respondents rated their level of satisfaction on a 5-point Likert scale where "5" represents very satisfied and "1" represents very dissatisfied with the following program elements:

- Income verification process
- Paperwork or documentation requirements
- Project management and technical assistance provided
- Rebates and incentive levels
- The measure selection, heat pumps and energy efficiency
- Overall program satisfaction
- Likelihood of installing LIFT measures at other properties

3.3.1.3 Results versus goals

Figure 3-1 summarizes results for each satisfaction metric where respondents rated a 4 or 5 on a 5-point scale. As illustrated, a satisfaction rating of 80% or better was achieved on 3 of the 6 metrics and fell short slightly for income verification, program paperwork/ documentation, and likelihood of installing LIFT measures at other properties.

Figure 3-1. Property manager satisfaction rating with program elements



3.3.1.4 Key findings

Advancing electrification in a predominately natural gas driven economy requires agility, credible information, and an enticing incentive offering.

High overall program satisfaction. Survey respondents echoed these sentiments as part of their post-project feedback and engagement with the program. The program surpassed its goal of satisfaction ratings of 80% for 3 of the 6 metrics and respondents were overall very satisfied with the program. Some of the open-ended feedback illustrate these findings:

"On a scale of 1 of 5, I give them a 6."

"Very effective, meet expectations and to the point, they were very responsive."

"It was really compelling. The only issue we had was the funding. We had to pick and choose – we started small and moved to the water heaters that included the rebate."

"Very effective. The MCE part has been great, I went through all the steps, the reason we haven't done more is its very costly."

Some challenges with specific aspects of program delivery. Satisfaction with income verification and paperwork and documentation are slightly below the 80% goal at 75% and 60%, respectively. Property managers who installed heat pumps were more satisfied than those who did not. The satisfaction rating increased for income verification from 75% to 86% and ratings increased for the paperwork/documentation requirements from 60% to 75% among respondents who installed the heat pump measures.

Respondents were also asked if they would leverage the LIFT program at any of the other properties they managed. Nearly 70% of respondents stated they would install LIFT measures at other properties they manage. Reasons for not installing at other properties included: income requirements are too stringent, measures are not needed, limited financing, or building structural limitations (for heat pumps).

Some of the more specific program challenges with respect to satisfaction included:

- The program's implied or expressed requirement to install additional measures beyond the heat pumps resulted in dissatisfaction among some participants. A few respondents (n=3) expressed dissatisfaction and confusion related to whether they "had to" install the additional measures. Among them, two of the three stated they reluctantly went ahead with the additional measures.

  DNV recommends the program make clear requirements concerning added energy efficiency measures e.g., LEDs in-unit and that all additional measures are optional. By not installing the recommended measures lower incentives should be expected but they are not required. At least one respondent expressed dissatisfaction that they had to update their already existing LED lighting from screw-based to hard-wire to meet an implied program requirement.

- Another challenge for one property owner was that the installation costs for heat pumps were still not cost competitive as compared to the gas-fired units and the income requirements were too stringent, thus limiting their opportunity to expand the program to their other properties.

- A few respondents expressed frustration with the multiple visits and necessity to engage occupants to collect surveys.

Reasons for Installing Heat Pumps. The survey probed on a number of questions central to the theme of what convinced them to install heat pumps.

Electrification of space and water heating poses a number of hurdles. Commonly known one-for-one replacement barriers include, but are not limited to: gas-fired equipment offers a lower first cost, low or no reason for a panel or structural upgrades, users are already familiar with equipment operation and maintenance practices, and gas fired equipment often results in a lower operating cost when compared to standard electric rate plans.

Additional challenges in the advancement of electrification, as acknowledged by participants, include the necessity for a more robust HVAC workforce. Contractor awareness of the technology is low thus complicating the ability to get knowledgeable, competitive bids and quality installations. Typically, programs can rely on HVAC contactors as a trade ally resource to drive products and services to the market but knowledge gaps due to minimal use of heat pumps on the West Coast poses a gap that program staff have to bridge or make up by serving as an equipment advocate and educator.

Faced with the above challenges and more, the program sought to convince income qualified existing building property owners to electrify water heaters (in-unit and central) and space heating. Survey responses indicate the value of education and incentives as core components that ultimately convinced owners to electrify. Other drivers included: necessity as equipment was at the end of its useful life (this was a primary driver for all), lower cost of operation especially when paired with photovoltaics or when property owners were responsible for operating costs, and non-energy benefits: safety, corporate sustainability goals, and improved occupant comfort (through added air conditioning). As one respondent stated:

"It was just a really good opportunity to update our older units. We are in a time of growth and it is a nice message to the community that you are updating – want to show we are good at property management. And just the savings over time, more comfort to the tenants, and the program itself…is hard to say to no to with such a generous incentive."

3.3.2 Tenant satisfaction

Given the newness of the technology and the lack of customer exposure to it, there could be potential misconceptions about and misuse of heat pump technology. The program sought to measure tenants' satisfaction level with the heat pump technology, the information they received about the upgrade, and the LIFT program overall.

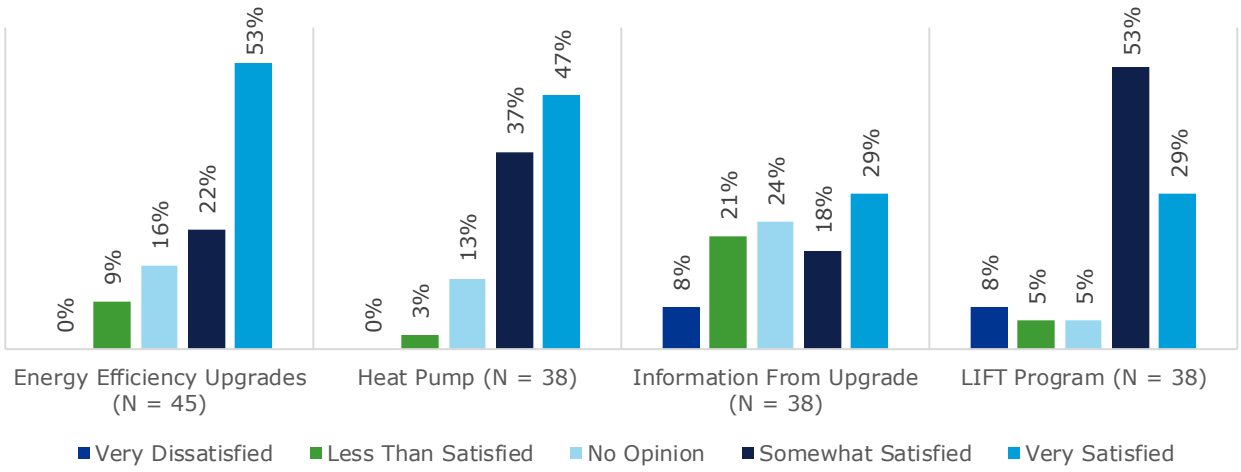
3.3.2.1 Data source and definition

The pre-post occupant survey, administered to customers who received services through the LIFT program, is the data source used to compute this metric. The full survey is included in APPENDIX A .Survey respondents were asked to rate their satisfaction with their energy efficiency upgrades, new heat pump, information on the benefits from the upgrade, and with the LIFT program overall.

3.3.2.2 Results versus goals

Seventy-five percent indicated that they were very or somewhat satisfied with their energy efficiency upgrades, 84% indicated satisfaction with the heat pump, 47% indicated satisfaction with information on program benefits, and 82% indicated satisfaction with the LIFT program overall (Figure 3-2).

Figure 3-2. Tenant satisfaction with LIFT



3.3.2.3 Key finding

With 84% customer satisfaction with the heat pump and 82% satisfaction with the LIFT program overall, the program is meeting its goal of 80% satisfaction for tenants with their heat pumps.

3.3.3 Non-energy impacts of fuel switching

The costs of fuel switching measures like heat pumps and heat pump water heaters are harder to justify when the health, comfort, and other non-energy impacts are not considered when compared to existing technology. The program seeks to measure tenant perceptions of the non-energy impacts from the upgrades in order to capture the full potential of fuel switching measures that may otherwise not be quantified and hence be undervalued.

3.3.3.1 Data source and definition

The pre-post occupant survey, administered to customers who received services through the LIFT program, is the data source used to capture information on non-energy impacts. The full survey is presented in APPENDIX A. Respondents who received energy efficiency upgrades through the LIFT program were asked about their level of comfort in the home, the air temperature in their apartment in hot and cold weather, the air quality, and noise level of their HVAC system.

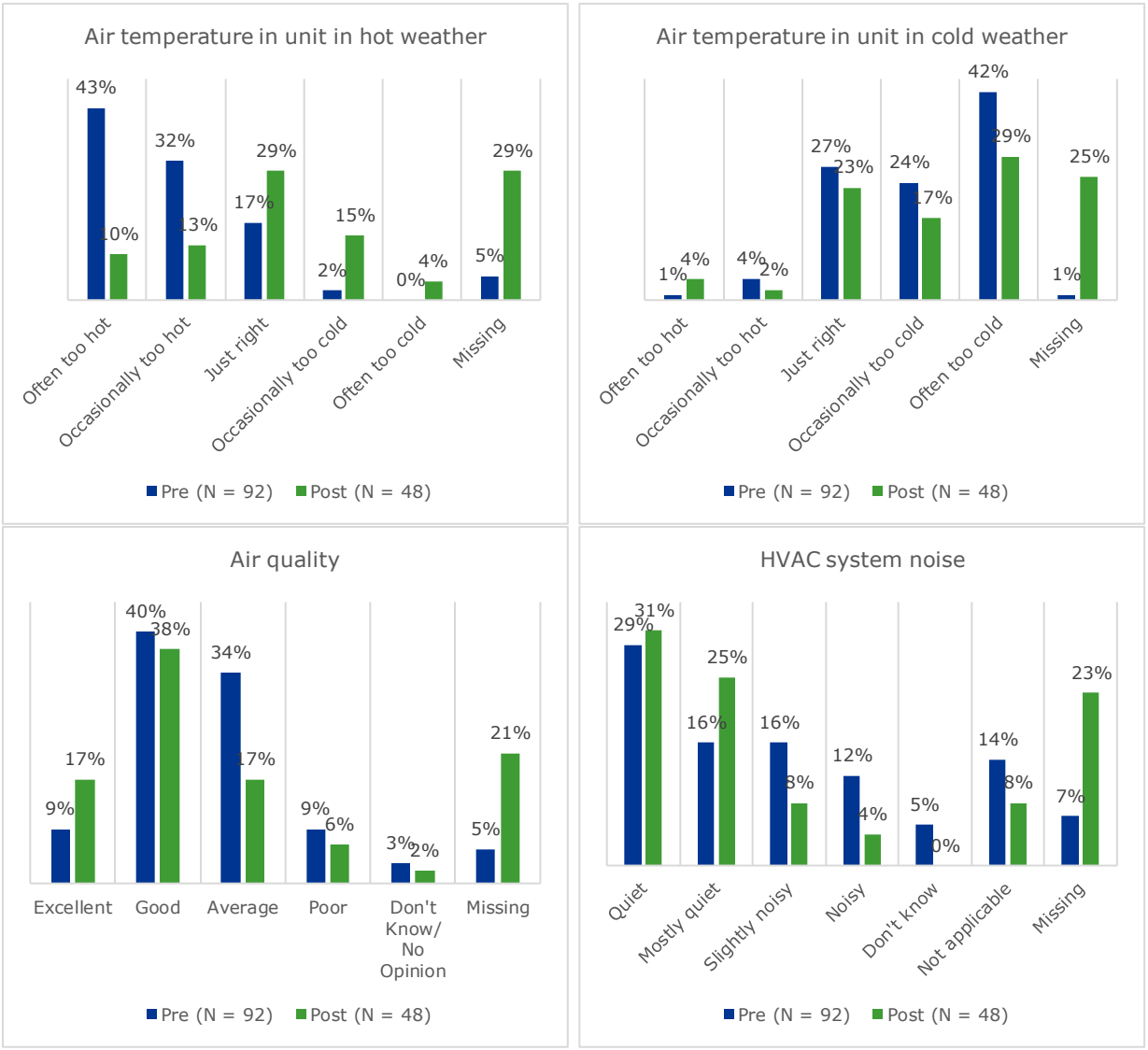
3.3.3.2 Results versus goals

The program does not have any metrics specified or goals related to non-energy impacts and mainly aims to track tenant perceptions of impacts. DNV discusses results related to tenant perceptions of the potential non-energy impacts of LIFT program upgrades in this section.

While results from occupant survey responses are not based on an exact matched set (pre-post), taken in aggregate these results provide directional insight on the potential non-energy impacts from fuel switching. Results indicate that tenants that received services from the LIFT program reported:

- indoor air temperature being just right even on very hot days
- better air quality
- lower noise from their HVAC systems

Figure 3-3. Comfort and other non-energy impacts following program upgrades



3.3.3.3 Key finding

There is some evidence of non-energy impacts perceived by tenants that received services through the LIFT program. The program can communicate the value of these benefits to property owners/managers and tenants to boost participation.

3.4 Contractor experience

DNV conducted interviews with heat pump installation contractors and contractors or consultants who participated in the MCE LIFT program sponsored workforce training class. The full contractor survey is presented in APPENDIX D.

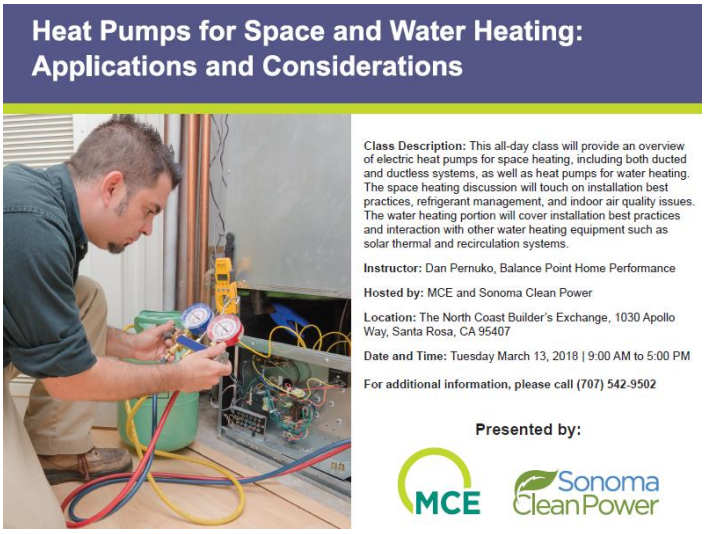
The evaluation team contacted 11 contractors of which, six interviews were completed. Among the six interviewees, four provided installation services to the program and two did not as presented in the table below.

Figure 3-4. Contractor interview sample disposition

Interviews	(N=11)
Not reachable	5
LIFT HP contractors – completes	4
Non-installing HP contractors – completes	2
Total - completes	6

3.4.1 Workforce education and training

The program recognizes that there is a knowledge gap in contractor marketplace readiness to support fuel-switching measures. Typically, programs can rely on contactors as a trade ally resource to drive products and services to the market, but this technology is still new to the California market.



At the onset of the program, in 2018, MCE and Sonoma Clean Power partnered to offer a free training on heat pump best practices, refrigerant management, and indoor air quality issues.

To address this limitation, program staff serve as an advocate and educator providing information on aspects such as the amount of

energy a customer could save by switching and are working with installing contractors to develop additional workforce training and participation.

The advancement of electrification will require a more robust and educated HVAC and plumber workforce. A minority of contractors offer heat pump fuel switching as part of their business model, and those that do are contractors that focus on more expensive, comprehensive upgrades. Because knowledge of the technology is low, there are resource limitations to acquire competitive bids and quality installations. Due to contractor inexperience, with the measure and scope of work, implementer AEA has found that project bids vary significantly for a single project.

The program aims to continue to support workforce education and training to develop contractors to serve the program but has had limited success engaging them. Interviews with the implementer, AEA, have found contractors are resistant to support this measure in their business model because installations are not "business as usual." Heat pumps require a larger suite of services and skillsets, particularly for existing buildings where installations may involve plumbing, HVAC, electrical, and carpentry, which can result in additional permit and building compliance requirements.

3.4.1.1 Market barriers and enablers

The survey asked respondents if their company promoted fuel switching from gas fired to all electric heat pumps. While respondents had a favorable opinion on the prospects of fuel switching, lack of experience was a key reason why some do not promote it. DNV asked contractors about their perception of barriers to adoption of heat pumps. Contractor responses to perceived barriers to heat pump adoption may be broadly categorized as financial, educational, structural, and operational (Table 3-11).

Table 3-11. Contractor perceived barriers to heat pump adoption

Financial Barriers	Education Barriers	Structural/ Technology Barriers	Operational Barriers
High upfront equipment costs *Insufficient incentives to attract customers.* *Insufficient savings/ payback is not favorable, cost more to operate (Market is not big enough to make it worthwhile due to) …incentive eligibility limitations – serving only income qualified customers.*	*Most contractors are unfamiliar and inexperienced with products.* *Fewer contractors and technicians are knowledgeable and familiar with heat pumps.* *Not very common. Can't always predict how much they will save, but if they couple with PV it makes sense to use heat pumps.*	*Building likely needs to upgrade electrical panels and related costs.* *Products may not be drop-in (physical, electric, plumbing) for existing natural gas equipment.* *Need better support from manufacturers – need technical guides for design build projects.* *Less availability of equipment*	*Maintenance needs to be done annually because systems use refrigerant. Remote controls can go wrong, it takes more upkeep of the system.* *Heat pumps heat slower and change temperatures slower than natural gas, in retrofits.* *Automation, they cycle on/off and need to defrost, fans can be loud.* *Noise of water heaters is an issue.* *Service requires different contractor skill set.*

DNV also asked contractors about their perception of enablers to adoption of heat pumps, and their responses broadly fell under sustainability/non-energy benefits or financial enablers (Table 3-12).

Table 3-12. Contractor perceived enablers to heat pumps

Sustainability/Non-Energy Benefits	Financial
A lot of people want to be green and lower their carbon footprint. *Net zero goals.* *Meets corporate sustainability goals.* *Non-energy benefits: increased safety, increase occupant comfort, improve health issues (indoor air quality, fires, explosions).*	*Lower cost of operation when coupled with photovoltaics.* *Lower utility bills can allow owners to charge higher rents.*[28] *New construction, avoiding the cost of natural gas connections and infrastructure.* *Incentives from MCE.* *Heat pump products can positively differentiate a business from competitors, wanting to keep up with latest technology.*

[28] These are benefits as quoted by contractors. MCE will develop renter protection measures for Naturally Occurring Affordable Housing (NOAHs), eliminating the potential risk of property owners benefiting from the upgrades.

4 CONCLUSIONS AND RECOMMENDATIONS

Overall, LIFT succeeded in its goals to overcome key barriers to install heat pumps that reduce customer energy use, energy bills, and emissions for tenants. The tenants receiving measures cannot afford discounted equipment or are underserved by mass market programs and are multifamily renters who are not fully served by the ESA program.[29] Many of the sites met MCE's initial target of small affordable housing areas within larger zip codes and census tracts that do not qualify for disadvantaged communities designation.

Presented below are key recommendations based on the findings from this evaluation for MCE's LIFT program.

4.1 Key recommendations

Improve program tracking and record keeping requirements. Through the course of conducting the evaluation, DNV identified inconsistencies in program tracking data that required the implementer to rectify and reissue. Access to consumption data was a challenge due to issues with timeliness and completeness that required several iterative discussions and were ultimately only resolved partially. DNV found gaps in the occupant survey data that were missing some months of survey responses and had to be appended upon discovery. Not all contractor invoices included the detail that could improve the usability of the data therein. As recommended in DNV's mid-term report, the program should also clarify expectations regarding contractor requirements for detailed cost information that breaks down hidden/soft costs such as for electrical panel upgrades.

Recognizing that the pilot was being developed and implemented simultaneously, DNV recommends that MCE address these gaps to improve data quality and evaluability of the program as it scales up. The program should develop and maintain a central, comprehensive, and compiled database that supports evaluability of key program metrics. The database should include granular data associated with each project site including, but not limited to: a unique identifier, building classification, site address including specific units treated, project status, measures installed, contractor information, incentives provided, equipment costs, labor costs, survey responses etc.

Continue with successful program elements. The LIFT program integrated well with the Multifamily Energy Savings (MFES) program and other program offerings. The program is reaching "hidden communities" of low-income tenants outside of designated DACs, e.g. those residing in extended families, and/or those who are in non-English/limited English-speaking households. The program is short of its goal to serve 1,482 income-eligible households at the current number of 842 income-eligible households through the LIFT program. DNV recommends the program experiment further to increase the percentage of eligible customers who install measures by working with community organizations and deploying non-traditional marketing and enrollment methods. DNV also believes the program could leverage some of the techniques used by the investor-owned utility (IOU)

[29] PG&E's Energy Savings Assistance Program provides qualified customers with energy-saving improvements at no charge. Participants must live in a house, mobile home or apartment that is at least five years old. Income guidelines for the ESA program are same as those for CARE, the California Alternative Rates for Energy Program.

programs, focusing on direct install and other[30] methods to increase in-unit energy-efficiency measure installations.

Continue studying impacts because savings goals were met on average but were highly variable.

- Highly variable savings are common for pilots due to the limited cases available and studied. Because of the variability in project scope and pre-existing conditions for multifamily properties, the variability in savings may remain high even after additional M&V. More stable per-unit energy savings may emerge after more projects are completed, specifically mini-split heat pumps or central heat-pump water heaters (HPWHs).
- The two M&V projects for central HPWHs showed high potential to produce consistent savings and were less complex. Notably, the sites also have on-site solar power generation, which further reduces carbon emissions and costs based on thermal storage potential. The mini-split heat pump M&V projects were more varied in scope. For example, the existing technologies within the unit showed variation and the condition of the units varied as well, contributing to variability in savings. Therefore, future projects' evaluations will need to isolate heating system upgrades.

4.2 Additional recommendations

Below DNV provides additional insights and recommendations that are broader and combine findings from this study with DNV's knowledge of the market, policy, and technological expertise for MCE's consideration and improved program outcomes:

- **Enhance Participant Experience.** To improve the participant experience, DNV recommends that MCE develop a customer journey map for the LIFT program that summarizes the roles, responsibilities, and touchpoints for all actors from start to finish and identifies opportunities to streamline and consolidate program process and reduce the transaction burden for participants, especially in cases where the upgrades involve multiple measure installations. Clarify program requirements as it relates to measure offerings and what is optional versus what is mandatory.
- **Quantify Non-energy Benefits (NEBs).** There is some evidence of customer perception of the non-energy-benefits from installation of heat pumps. MCE should emphasize the value of NEBs, in addition to energy savings, for decision-makers contractors, property owners, and tenants.
- **Leverage Funding.** MCE should continue to leverage funding sources from other programs, such as TECH and Self-Generation Incentive Program, to stack incentives to deliver comprehensive upgrades for maximum benefit. Other low-interest financing for "green" projects can also be explored.

[30] COVID related constraints may necessitate the use of virtual assistants that coach tenants and property managers on do-it-yourself measure installations.

- **Expand Program Technologies:**
  - MCE should consider synergistic measure offerings to heat pump water heaters and heat pumps – couple solar PV, EV chargers, and battery storage, electric appliances like heat pump dryers and cooktops.
  - MCE should consider low-amperage technologies to reduce program/end-user cost for panel upgrades as electrification measure adoption increases. A parallel effort should be undertaken to educate contractors on low-amperage alternatives.
- **Expand Market for LIFT:**
  - Income eligibility was a notable barrier expressed by property managers and contractors to develop the market for this program. Expanding the program offering by requiring less stringent income requirements and/or decreasing the minimum threshold of income qualified units in a property could boost participation.
  - Conduct follow-up interviews with participating property managers and installation contractors. Post-project feedback with participants may provide leads to additional projects. MCE should target potential participants with testimonials from past participants that can serve as a recommendation for the program.
- **Further Workforce Education and Training.** MCE should continue workforce education and training initiatives. Develop partnerships with leading contractors and equipment manufacturers to provide property managers with an informed supply chain resource.

5 APPENDICES

APPENDIX A. PRE-POST OCCUPANT SURVEY

Pre-Post Occupant Survey

APPENDIX B. PROPERTY MANAGER SURVEY

2020_DNV GL
Property Manager S

APPENDIX C. NON-HEAT PUMP PROPERTY MANAGER SURVEY

2020_DNV GL
Property Manager N

APPENDIX D. HEAT PUMP M&V SAMPLE

Table 5-1. Fuel switching and substitution heat pump measure energy impact by fuel

Sample Site ID	PY	Number of Dwelling Units Sampled	Heat Pump Project Scope	Fuel	Pre-retrofit annual energy	Post-retrofit annual energy	Difference in annual energy	Units
F-1	2020	6	Fuel switching ductless HVAC & central DHW	Electricity	38,297	31,516	-6,781	kWh
				Propane	2,096	515	-1,581	Gallons
C	2019	8	Fuel substitution ductless HVAC	Electricity	19,265	20,135	871	kWh
				Gas	306	0	-306	therms
B-1	2019	20	Fuel substitution ductless HVAC	Electricity	74,376	51,723	-22,654	kWh
				Gas	7,083	4,264	-2,819	therms
E	2020	50	Fuel substitution central DHW	Electricity	17,734	37,358	19,625	kWh
				Gas	2,677	278	-2,398	therms
D	2020	24	Fuel substitution central DHW	Electricity	-3,451	14,012	17,464	kWh
				Gas	2,891	1,041	-1,850	therms

Table 5-2. Fuel switching and substitution heat pump measure bill impacts of actual rate schedule analysis by fuel type

Sample Site ID	PY	Number of Dwelling Units Sampled	Heat Pump Project Scope	Fuel	Pre-retrofit Annual Energy Cost	Post-retrofit Annual Energy Cost	Difference in Annual Energy Cost
F-1	2020	6	Fuel switching ductless HVAC & Central DHW	Electricity	$7,603	$6,257	-$1,346
				Gas	$6,940	$1,547	-$5,393
C	2019	8	Fuel substitution ductless HVAC	Electricity	$3,294	$3,556	$261
				Gas	$365	$0	-$365
B-1	2019	20	Fuel substitution ductless HVAC	Electricity	$14,766	$8,728	-$6,038
				Gas	$9,751	$5,713	-$4,038
E	2020	50	Fuel substitution Central DHW	Electricity	$1,414	$3,932	$2,518
				Gas	$4,375	$389	-$3,987
D	2020	24	Fuel substitution Central DHW	Electricity	-$93	$1,004	$1,097
				Gas	$3,632	$1,151	-$2,481

Table 5-3. Fuel switching and substitution heat pump measure bill impacts of actual rate schedule analysis for overall project and per dwelling unit

Sample Site ID	Program Year	Number of Dwelling Units Sampled	Heat Pump Project Scope	Overall Difference in Annual Energy Cost	Overall Difference in Annual Energy Cost per Dwelling Unit
F-1	2020	6	Fuel switching ductless HVAC & central DHW	-$6,739	-$1,123
C	2019	8	Fuel substitution ductless HVAC	-$104	-$13
B-1	2019	20	Fuel substitution ductless HVAC	-$10,075	-$504
E	2020	50	Fuel substitution central DHW	-$1,468	-$29
D	2020	24	Fuel substitution central DHW	-$1,384	-$58

Table 5-4. Fuel switching and substitution heat pump measure bill impacts of alternative rate schedule analysis by fuel type

Sample Site ID	PY	Number of Dwelling Units Sampled	Heat Pump Project Scope	Fuel	Pre-retrofit Annual Energy Cost	Post-retrofit Annual Energy Cost	Difference in Annual Energy Cost
F-1	2020	6	Fuel switching ductless HVAC & Central DHW	Electricity	$7,603	$6,257	-$1,346
				Gas	$6,940	$1,547	-$5,393
C	2019	8	Fuel substitution ductless HVAC	Electricity	$3,294	$3,479	$185
				Gas	$365	$0	-$365
B-1	2019	20	Fuel substitution ductless HVAC	Electricity	$14,766	$10,268	-$4,497
				Gas	$9,751	$5,713	-$4,038
E	2020	50	Fuel substitution Central DHW	Electricity	$1,414	$2,977	$1,563
				Gas	$4,375	$389	-$3,987
D	2020	24	Fuel substitution Central DHW	Electricity	-$93	$998	$1,091
				Gas	$3,632	$1,151	-$2,481

Table 5-5. Fuel switching and substitution heat pump measure bill impacts of alternative rate schedule analysis for overall project and per dwelling unit

Sample Site ID	Program Year	Number of Dwelling Units Sampled	Heat Pump Project Scope	Overall Difference in Annual Energy Cost	Overall Difference in Annual Energy Cost per Dwelling Unit
F-1	2020	6	Fuel switching ductless HVAC & central DHW	-$6,739	-$1,123
C	2019	8	Fuel substitution ductless HVAC	-$181	-$23
B-1	2019	20	Fuel substitution ductless HVAC	-$8,535	-$427
E	2020	50	Fuel substitution central DHW	-$2,423	-$48
D	2020	24	Fuel substitution central DHW	-$1,390	-$58

Table 5-6. Fuel switching and substitution heat pump measure CO_2 impacts[31]

Sample Site ID	Program Year	Number of Dwelling Units Sampled	Heat Pump Project Scope	Fuel	Pre-retrofit annual CO_2	Post-retrofit annual CO_2	Difference in annual CO_2	Units
F-1	2020	6	Fuel switching ductless HVAC & central DHW	Electricity	0.734	0604	-.0130	tCO_2
				Propane	4.621	0.649	-3.486	tCO_2
C	2019	8	Fuel substitution ductless HVAC	Electricity	0.277	0.289	0.013	tCO_2
				Gas	0.492	0.000	-0.492	tCO_2
B-1	2019	20	Fuel substitution ductless HVAC	Electricity	0.428	0.297	-0.130	tCO_2
				Gas	4.554	2.742	-1.813	tCO_2
E	2020	50	Fuel substitution central DHW	Electricity	0.041	0.086	0.045	tCO_2
				Gas	0.688	0.072	-0.617	tCO_2
D	2020	24	Fuel substitution central DHW	Electricity	-0.017	0.067	0.084	tCO_2
				Gas	1.549	0.558	-0.992	tCO_2

[31] Propane and gas CO_2 impacts derived from spot flue gas measurement of existing combustion equipment and extrapolated to annual mass utilizing the utility meter data analysis results and equipment specifications. Electricity CO_2 impacts derived from rates taken from the MCE's Light Green service and extrapolated to annual mass utilizing the utility meter data analysis.

Table 5-7. Fuel switching and substitution heat pump measure CO impacts[32]

Sample Site ID	Program Year	Number of Dwelling Units Sampled	Heat Pump Project Scope	Fuel	Pre-retrofit annual CO	Post-retrofit annual CO	Difference in annual CO	Units
F-1	2020	6	Ductless HVAC & Central DHW	Electricity				
				Propane	0.13	0.03	-0.10	Lbs. CO
C	2019	8	Ductless HVAC	Electricity				
				Gas	8.53	0.00	-8.53	Lbs. CO
B-1	2019	20	Ductless HVAC	Electricity				
				Gas	0.10	0.06	-0.04	Lbs. CO
E	2020	50	Central DHW	Electricity				
				Gas	3.51	0.36	-3.14	Lbs. CO
D	2020	24	Central DHW	Electricity				
				Gas	0.00[33]	0.00	0.00	Lbs. CO

Table 5-8. Fuel switching and substitution heat pump measure NO_x impacts[34]

Sample Site ID	Program Year	Number of Dwelling Units Sampled	Heat Pump Project Scope	Fuel	Pre-retrofit annual NO_x	Post-retrofit annual NO_x	Difference in annual NO_x	Units
F-1	2020	6	Ductless HVAC & Central DHW	Electricity	1.36	1.12	-0.24	Lbs. NO_x
				Propane	3.39	0.83	-2.56	Lbs. NO_x
C	2019	8	Ductless HVAC	Electricity	0.56	0.58	0.03	Lbs. NO_x
				Gas	0.07	0.00	-0.07	Lbs. NO_x
B-1	2019	20	Ductless HVAC	Electricity	0.86	0.60	-0.26	Lbs. NO_x
				Gas	3.93	2.36	-1.56	Lbs. NO_x
E	2020	50	Central DHW	Electricity	0.08	0.17	0.09	Lbs. NO_x
				Gas	0.74	0.08	-0.66	Lbs. NO_x
D	2020	24	Central DHW	Electricity	-0.03	0.14	0.17	Lbs. NO_x
				Gas	1.77	0.64	-1.13	Lbs. NO_x

[32] Propane and gas CO impacts derived from spot flue gas measurement of existing combustion equipment and extrapolated to annual mass utilizing the utility meter data analysis results and equipment specifications. Electricity CO impacts derived from rates taken from the Avoided Cost Calculator and extrapolated to annual mass utilizing the utility meter data analysis.

[33] Measurements indicate 0 carbon monoxide emissions.

34 Propane and gas NOX impacts derived from spot flue gas measurement of existing combustion equipment and extrapolated to annual mass utilizing the utility meter data analysis results and equipment specifications. Electricity NOX impacts derived from rates taken from the Avoided Cost Calculator and extrapolated to annual mass utilizing the utility meter data analysis.

Table 5-9. Fuel switching and substitution heat pump measure source kBtu impacts[35]

Sample Site #	Program Year	Number of Dwelling Units Sampled	Heat Pump Project Scope	Fuel	Pre-retrofit annual kBtu	Post-retrofit annual kBtu	Difference in annual kBtu	Units
F-1	2020	6	Ductless HVAC & Central DHW	Electricity	42,190	34,720	-7,470	kBtu
				Propane	40,515	9,952	-30,563	kBtu
C	2019	8	Ductless HVAC	Electricity	15,917	16,637	719	kBtu
				Gas	4,434	0	-4,434	kBtu
B-1	2019	20	Ductless HVAC	Electricity	24,581	17,094	-7,487	kBtu
				Gas	41,081	24,730	-16,352	kBtu
E	2020	50	Central DHW	Electricity	2,344	4,939	2,594	kBtu
				Gas	6,210	645	-5,564	kBtu
D	2020	24	Central DHW	Electricity	-950	3,859	4,810	kBtu
				Gas	13,974	5,030	-8,944	kBtu

APPENDIX E. CONTRACTOR SURVEY

2020 DNV GL Contractor Survey L

[35] Source kBtu impacts derived from rates taken from the Avoided Cost Calculator and extrapolated to annual mass utilizing the utility meter data analysis.

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