“Solar Access Program”
Achieving Energy and Cost Savings for Middle Income (60%-80% SMI) Homeowners in Central and Western Massachusetts

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Solar Access Program – Project Team:

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Abstract

An equitable and resilient clean energy future requires programs to address the obstacles and barriers that low- and middle-income residents face in retrofitting their homes to efficiently electrified homes utilizing renewable generation. To improve access to clean energy technologies for Massachusetts' low- and middle-income residents (60-80% of median income), the Solar Access Program (SAP) delivered a residential clean energy loan deploying solar photovoltaics (PV) and installation of cold climate air source heat pumps (ccASHP) with no cash flow impact to customers. Funded by the Massachusetts Clean Energy Center and Department of Energy Resources, the "Solar Access Program" bundled rebates, incentives, and tax credits and applied them to the loan to reduce the monthly payment, resulting in a guaranteed neutral or better customer cash flow. Installation was coordinated with the help of an energy advisor who assisted the homeowners. The sizing of the solar and heat pumps, intended to partially offset existing heating consumption, was determined by a financial tool incorporating current heat-related costs and energy usage, and balancing these with expected savings over the ten-year loan term, after which the homeowner owns the system outright. Actual energy and cost savings for the 49 sites (based on review and analysis of pre- and post-installation fuel consumption and monitoring from 28 of the sites) shows an estimated lifetime reduction of 12 million pounds of greenhouse gas emissions (CO_2 equivalent) and \$2.8 million in homeowner net energy savings.

Figure 1. SAP Participating Home

Executive Summary

From 2018 to 2022, the Solar Access Program (SAP) completed 49 solar-plus-heat pump projects in existing, single-family residences in central and western Massachusetts. Funded by the Massachusetts Clean Energy Center (MasCEC) and Department of Energy Resources (DOER), the primary intent of SAP was to assist lower-income Massachusetts' residents in accessing cost-saving, clean and efficient technologies such as solar (PV) and cold climate air source heat pumps (ccASHP). Energy Futures Group (EFG) led the project, which involved seven partnering entities: the Center for Ecotechnology (CET), SunBug Solar, Girard Heating and Air Conditioning, UMassFive Credit Union, Integral Building and Design, and Bruce Harley Energy Consulting.

SAP was designed to address various market, technology and financial barriers to clean energy by offering the following:

- Targeted marketing to identify and reach the specified income-eligible demographic and spread awareness of energy savings opportunities available through SAP,
- Easy-to-understand, objective information,
- Bundling of all available incentives and applicable credits,
- Attractive financing,
- Guaranteed energy savings,
- Technical guidance regarding installation sizing and selection,
- Optional, post-installation energy data monitoring, and
- One-on-one assistance throughout the process.

Installation was coordinated with the help of an energy advisor who assisted the homeowners. The sizing of the solar and heat pumps, intended to partially offset existing heating consumption, was determined by a financial tool incorporating current heat-related costs and energy usage, and balancing these with expected savings over the ten-year loan term, after which the homeowner owns the system outright.

> "Amazing program that the state would do well to replicate or replace with something comparable in the future." SAP Participant

Ultimately, SAP targeted and reached a narrow economic demographic of 60%-80% state median income (SMI), significantly reducing participants' energy burden and, presumably, increasing their financial stability. This was achieved by designing and implementing a residential clean energy loan product deploying solar photovoltaics (PV) and installation of cold climate air source heat pumps with neutral or positive annual cash flow impact to customers. Elements of the loan product included a loan loss reserve (LLR) for the lender and the following elements for the homeowner:

- Bundling of seven incentives and rebates (cold climate air source heat pump rebate, federal investment tax credit, state solar tax credit, Massachusetts SRECs/SMART, a SAP "6-month" payment subsidy, and pre-negotiated discounts from the solar installer and heat pump manufacturer),
- A single (PV plus ccASHP loans combined), 10-year fixed rate loan,

- Loan financed 100% of the project cost,
- Deferred payment: no loan payment for 3 months,
- PV financing: 35% upon project acceptance; 65% upon project connectivity, and
- ccASHP financing: 100% upon project completion.

SAP was highly successful in achieving energy and cost savings, as reflected by Table 1.

Table 1. Greenhouse gas reductions and financial savings, per home

	Results (n=28)	% of projected	Notes
GHG annual savings lb. CO2e	**10,305[1]**	**96%**	Calculated with the **same factors as original projections, for comparison**
Fuel annual cost savings	**$881**	**109%**	Calculated at **the same fuel/electric prices used in original projections**
Electricity annual savings	**$1672[2]**		
Cost savings, HVAC only	**$213**	N/A	Net of fuel savings + ASHP heating cost
Savings at today's fuel/electric prices	**$3,787**	N/A	**48% increase** > original of $2,553

[1] Based on original CO2e values used in proposal development. Actual values of both projected and reported GHG reductions should be approximately 20% higher, so the % of projected is still correct. (x1.216, eGrid 2014; x1.184, eGrid 2020.

[2] Does not account for unrealized savings due to excess PV production

SAP also achieved a high level of customer satisfaction for the program overall, as well as the ccASHP, PV and loan products, as shown in Figure 2.

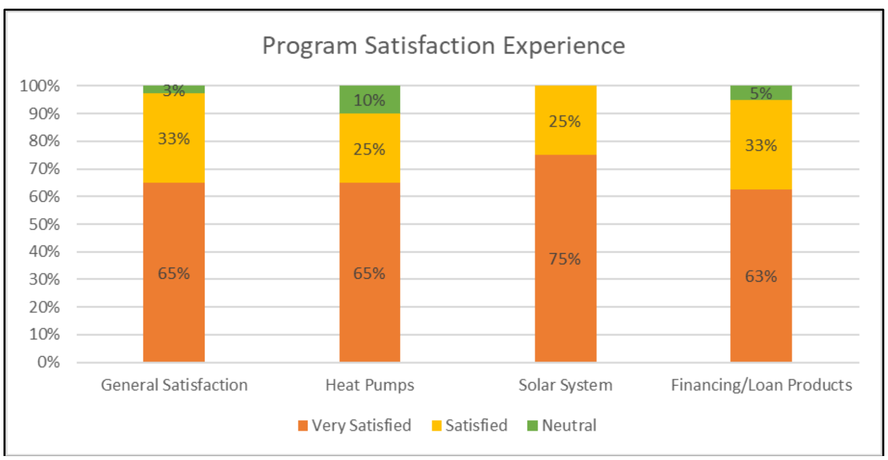


Figure 2. Customer satisfaction with SAP overall, heat pump technology, solar technology, and loan product

Beyond success of SAP, key findings and areas for further consideration include:

- The need for policy makers, regulators, utilities, program designers and administrators to minimize program complexity (or, at the least, to coordinate offerings) so that more property owners can upgrade their building stock at scale,

- The need for additional incentives and specific loan products – as well as unique marketing initiatives – in order to serve unique economic market demographics (e.g., homeowners falling between 60% - 80% SMI),
- The value of (and need for) neutral, "hand-holding" support in order for homeowners to understand the retrofit and financing options available to them and be willing to move forward with large energy projects requiring loans, and
- The value of (and need for) post-project energy monitoring and analysis to identify project performance, thereby allowing for follow up with customers to harness further energy and cost savings.

As policy makers in Massachusetts' seek to achieve the state's 2025, 2030 and 2050 climate goals, it will be critical to ensure that energy burden does not increase for those with limited income. The SAP provides multiple examples of how to reduce energy burden, as well as ways to scale up energy improvements in existing housing stock.

Figure 3. Collage of SAP Participating Homes

Project Background, Concept and Goals

The Solar Access Program (SAP) was a clean energy initiative designed in response to the 2017 competitively solicited request for proposals (RFP) entitled "Affordable Clean Residential Energy Program", developed by the Massachusetts Clean Energy Center (MassCEC) and Department of Energy Resources (DOER). From 2018 to 2022, SAP completed 49 solar-plus-heat pump projects in existing, single-family residences in central and western Massachusetts. The primary intent of SAP was "to help low- and moderate- income Massachusetts residents access cost-saving, clean and efficient technologies".

The original RFP had the following additional goals[1]:

1. To stimulate innovative, replicable solutions to install cost saving clean energy technologies to greater numbers of low-income customers living in single family residences through more efficient use of DOER and MassCEC funding,
2. To deliver the highest, long-term cost savings,
3. To demonstrate the potential of solar PV systems in combination with air-source heat pumps for reducing the energy burden of low-income customers living in single family residences, and

[1] Request for Proposals: Affordable Clean Residential Energy Program (ACRE). Massachusetts Clean Energy Center and Massachusetts Department of Energy Resources. Release Date: April 21, 2017. Applications Due: May 19, 2017.

4. To collect data to inform design and administration of future programs benefiting low-income residents.

In response to this RFP, Energy Futures Group[2] (EFG), a clean energy consulting firm based in Hinesburg, Vermont, worked with six other entities to design and implement SAP (this group of seven entities is referred to as the "SAP Team"). EFG administered the program and led the project as the prime contractor to MassCEC and DOER. SAP participants typically worked directly with several of the other SAP Team project partners. These entities and their roles included:

- The Center for Ecotechnology (CET) led the outreach and marketing campaign, and as well as the direct customer-service and sales efforts from 2018 – 2019,
- SunBug Solar (SunBug) led the solar installations as well as the customer-service work during 2020,
- Girard Heating and Air Conditioning (Girard) led the heat pump installation work,
- UMassFive Credit Union (UMassFive) oversaw the loan approval process and continues to oversee the loan servicing process,
- Integral Building and Design (IBD) provided technical assistance and led the selection and installation process of data monitoring units, and,
- Bruce Harley Energy Consulting (BHEC) provided technical assistance in project and program design and energy savings analysis.

The goal of SAP was to design and deliver a program using an integrated approach to successfully increase access to cost-saving clean energy technologies for 100 low-income residents while delivering significant energy and cost savings for each dollar of public investments.

SAP was designed to address various barriers to low-income access to clean energy by offering the following:

- Targeted marketing to identify and reach the specified income-eligible demographic and spread awareness of energy savings opportunities available through SAP,
- Easy-to-understand, objective information,
- Bundling of all available incentives and applicable credits,
- Attractive financing,
- Guaranteed energy savings,
- Technical guidance regarding installation sizing and selection,
- Optional, post-installation energy data monitoring, and
- One-on-one assistance throughout the process.

From the RFP stage through to the completion of 49 installations in December of 2020, the program underwent several modifications, as will be described further below. The targeted

[2] www.energyfuturesgroup.com

economic demographic ended up being 60% - 80% of state median income, with participants primarily located in western Massachusetts (as well as a handful in central Massachusetts). In part due to the difficulty in targeting this narrow economic range, and in part due to the onset of COVID, 49 installations were completed, out of the initial goal of 100. However, as described below, the goals of providing installations of these clean energy technologies to a hard-to-reach segment of Massachusetts homeowners and achieving significant cost and energy savings were certainly achieved.

Project Design

Financial Considerations and Financial Tool

Given that a primary goal of SAP was to address access to and affordability of clean energy technologies by low- to middle-income homeowners, the SAP Team negotiated and decided upon key financial elements for SAP prior to the project outset, as part of the proposal response to the original RFP. Specifically, the SAP Team secured cost reductions for heat pumps (from the manufacturer, Mitsubishi) and solar (from SunBug solar), identified the mechanisms that would assist in reducing risk resulting from potential loan losses for UMassFive, established and offered a "savings guarantee" to customers, and developed an excel-based "Financial Tool" to approximately balance pre-project energy consumption and energy expenses against post-project loan costs and energy dollar savings. In response to incentive and rebate changes the Financial Tool was updated several times throughout SAP implementation.

Ultimately, SAP financial criteria required that a project could only move forward if annually, the homeowner experienced cash flow neutrality, with no one month being more than $25 cash flow negative (with the goal for most projects to be cash flow positive). Additionally, the maximum additional subsidy that SAP would provide to homeowners was to be $5,500 or less. This SAP "six month payment subsidy" provided a bridge between the beginning of loan payments (at closing) and the time when credits and incentives could be realized from the installed solar PV and heat pump systems. For example, rebate processing was expected to take several months; net benefits of PV operation would accrue in the summer, and heat pump savings in the winter; federal and state tax credits could involve a much longer delay before the homeowner received their tax credit.

Another key program design element was a Loan Loss Reserve (LLR), held by MassCEC, for UMassFive to utilize in the event of losses associated with defaulted loans. In the event of a default, MassCEC would provide funds to UMassFive based on the formula presented in Table 2:

Table 2. Loan Loss Reserve funding formula

Loan Class	Credit Score	% of Loan Allocated to Reserve Fund	Coverage Ratio (% of Principal Loss)
A	750	5%	50%
B	700 – 749	10%	75%
C	660 – 699	20%	90%
D	Under 660	40%	100%

The importance of bundling the available incentives, credits, and loans on behalf of the homeowner cannot be understated. This action was a key benefit for homeowners and a significant effort and implementation challenge for SAP. Table 3 presents the individual products that were effectively rolled into one overarching “Solar Access” loan provided by UMassFive (Table 4).

Table 3. Summary of bundled offerings

Offering	Amount
ccASHP rebates	$1,100: ($800 from MassCEC + $300 from utility)
Federal Investment Tax Credit	30%
State Solar Tax Credit	15% up to $1,000
SRECs then SMART	Varied
SAP “6-month” Payment Subsidy	Up to $5,500 per project to fund loan payments until credits and incentives “kicked in”
SunBug pre-negotiated discount (e.g. Solarize)	20% off avg. statewide price for homeowner-owned PV
Mitsubishi pre-negotiated discount (e.g. HeatSmart)	Reduced cost by $200/ton (or 12,000 Btu/hour)

Table 4. Elements within the Solar Access Loan product

Solar Access Loan Product
A single (PV plus ccASHP loans combined), 10-year fixed rate loan – for customer
Loan financed 100% of the project cost – for customer
Deferred payment: no loan payment for 3 months – for customer
PV financing: 35% upon project acceptance; 65% upon project connectivity – for customer
ccASHP financing: 100% upon project completion – for customer
Loan Loss Reserve: sliding scale default lender guaranty based on borrower’s creditworthiness – for lender

The SAP Financial Tool was developed to generally “optimize” the pre-project costs with post-project savings, within the financial constraints mentioned above. An example of the worksheet of the Financial Tool is presented as Figure 4.

	Solar Access Financial Tool		v2019-4-9
	Customer		First and last name(s)
	Address		Include street address, city, state, zip
	Date		Date you are updating this spreadsheet
	Stage		Use Preliminary before installation and Final after installation
	Energy Bill inputs		
Baseload:	3,232	Baseload use, kWh	Electric results: "paste values" from weather normalization calculator (*see example at right*):
Heating:	423	Heating use, kWh	
Cooling:	-	Cooling use, kWh	
Hot Water:	-	Hot water use, gallon	For wood or wood pellets enter estimated annual use. Otherwise, "paste values" from weather normalization calculator (leave blank if electric heat)
Heating	805	Heating use, gallon	
	Existing heating system inputs		
	propane	Primary Heating Fuel	From site visit data collection form
	Boiler	Heating Type	From site visit data collection form
	Air source heat pump inputs		
	$ 10,536	Heat pump cost (before rebates)	From Girard proposal
		MassCEC heat pump rebate	From Girard proposal - cross check
	$ 300	Mass Save heat pump rebate	From Girard proposal - cross check
	$ 400	Mitsubishi rebate	From Girard proposal
	27.2	Heat Pump Size (kBtu/h)	From Girard proposal
	83%	Heat pump sizing (vs. 90% offset)	Typically 25-150%
	5,847	Net heat pump electricity consumption	Enter into Salesforce at project completion
	9,502	Projected total electricity consumption	Provide to Sunbug once heat pump data has been filled in
	Solar PV Inputs		
	$ 24,824	Solar panel cost	From Sunbug proposal
	9,687	System Production (kWh)	From Sunbug proposal
	$ 2,400	Federal Tax Amount (one year)	From customer tax return (enter last year's taxes paid)
		Total federal tax credit	Enter into Salesforce at project completion
	$ 500	State Tax Amount	Modify this only if customer pays less than $1000 in state taxes
	60-80%	Verified income category	
	4.75%	Mass Solar Loan interest rate	Update this to actual rate at project completion
	August	Expected Online (+4 Months)	Four months after site visit
	Eversource West R1	Utility Code	From customer electric bill
	$ 0.220	Utility Rate	
	$ 0.253	SMART Rate	
	$ 0.191	SMART "Value of Energy"	
	3,840	Net electricity saved	Enter into Salesforce at project completion
	$ 845	Electricity $ saved	
	725	gallons saved	Enter into Salesforce at project completion
	$ 2,218	Fuel $ saved	
	$ 3,063	**Total energy $ saved per year**	
	NO	Annual Negative Cash Flow?	
		$ (637.49)	per year (worst case)
		$ (53.12)	per month on average
		$ 25.00	worst month's cash flow (up to $25 okay)
		($0)	needed for extra subsidy + buydown
	2128	Extra Subsidy Amount - manual entry	Note: maximum total subsidy amount is $4000
		Customer buy down - manual entry	
	$ 4,020	Total Payment Subsidy	Enter into Salesforce at project proposal (update at completion)
	$ 16,817	Total 10-year benefit	
	67	Number of Similar Projects	
	Subsidy exceeds allowable amount		
	$ 804	existing electric cost	
	$ 2,464	existing fuel cost	
	$ 3,268	**existing total cost**	
	$ (41)	estimated new electric cost	
	$ 246	estimated new fuel cost	
	$ 206	**estimated new total energy cost**	
	3,655	Pre-installation electric consumption -kWh	Enter into Salesforce at project proposal (update at completion)
	805	Pre-installation fuel consumption -gallon	Enter into Salesforce at project proposal (update at completion)
	(185)	Post-installation electric consumption -kWh	
	81	Post-installation fuel consumption -gallon	

Figure 4. Solar Access Financial Tool

The Financial Tool has multiple worksheets (e.g., loan financing calculations, electric rates, and Solar Massachusetts Renewable Target (SMART) incentives), including a financial proposal in an easy-to-understand, customer-facing format (Figure 5).

CENTER FOR ECOTECHNOLOGY

Solar Access Cost Summary

January 0, 1900

January 0, 1900

	Monthly	Yearly
What you pay now	$272	$3,268
What you will pay after installation	$212	$2,548
What you will pay after 7 years	$98	$1,176
What you will pay after 10 years	$26	$311

Includes the combined cost of electricity, heating fuel, and loan payments minus the income from SMART payments.

Assumptions include:

- Electricity and fuel use stay the same once new systems are installed
- Electricity and fuel costs stay the same
- HEAT Loan for heat pump at 0% interest (7 years)
- Mass Solar Loan for solar panels at 4.75% interest (10 years)
- MassCEC heat pump rebate used to pay down Mass Solar Loan principal
- First year's state and federal tax credits used to pay down Mass Solar Loan principal

Figure 5. Solar Access cost summary for customers

Technology Selection and Implementation

The SAP Team had originally included cost-effective weatherization within the suite of offered "clean energy technologies". This was ultimately not included as part of SAP for multiple reasons. Initially the SAP Team did not build the finances associated with air sealing and insulation work into the initial proposal and Financial Tool. As the project evolved, it became clear that balancing the pre-project costs and post-project savings allowed for a relatively thin margin of flexibility, with just the solar and heat pump technologies included. Including air sealing and insulation would have complicated the program offering significantly. Finally, the number of steps and hand-offs required to provide the solar and heat pumps was significant enough, that adding another time-consuming step involving one or more additional contractors would have been prohibitive. For example, the following *high-level* steps were required for SAP[3]:

1. Drive marketing to develop leads
2. Intake process of leads
3. Initial, remote evaluation of site/customer and education for potential customer
4. Site assessment (often more than one visit per technology)
5. PV system design
6. Heat pump system design
7. Proposal presentation
8. Proposal adoption (with modifications, if applicable)
9. Permits, interconnection, SREC/SMART
10. Scheduling and installation of two systems by separate contractors
11. Address any unplanned site issues if applicable
12. System quality assurance
13. Close out of incentives and shifting of secondary loan product

While weatherization was not a required element of SAP, all projects did receive an audit and audit report, and many of the sites had some air sealing and/or insulation work completed prior to SAP. This is discussed further, below. Nevertheless, if SAP were to be offered again, ideally the program would more directly incorporate energy efficiency, as then the heat pumps and solar could potentially be "right-sized" to meet the reduced demand.

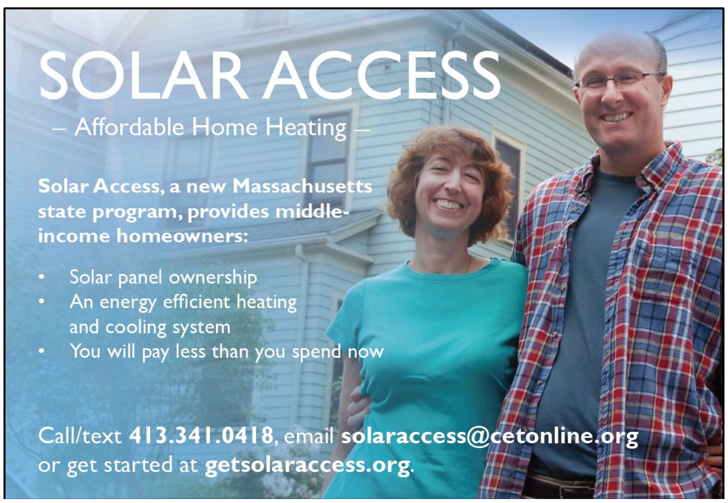


Figure 6. SAP Postcard

[3] Figure 4, a sample Financial Tool input sheet, also provides a sense of the multiple hand-offs that had to occur between members of the SAP Team in the column on the far right. For the first eighteen months, CET oversaw the initial customer outreach, handholding, site visit and data collection and input; this involved collating information from the customer, other utilities and incentive providers, Girard Heating and Air Conditioning and SunBug Solar. In January of 2020, the customer handholding shifted from CET to SunBug as the initial customer recruitment phase for SAP neared completion, and most customer interactions were centered around technology selection and installation.

Marketing

To ensure that 100 installations could be completed, the SAP Team included a targeted, comprehensive, strategic marketing plan within the framework of the initial SAP proposal. Integral to this plan was the intention to leverage CET's brand as a trusted, innovative, local non-profit providing practical solutions to save money and increase the health and comfort of homes for more than 45 years. This approach became even more critical when the initial RFP goal of reaching "low-income customers living in single family residences" was further refined to a market segment comprising 60% - 80% of state median income. Ultimately, CET and the SAP Team utilized multiple marketing strategies including building on CET's and others' previously planned events and networks, as well as deploying direct mail, social media, and print.

Additional program design elements

Leveraging CET's credibility was a purposeful action intended to boost potential customers' confidence in the validity of SAP. To further boost confidence, the SAP Team also offered a guarantee of energy savings; specifically, that "the net energy cost savings for any home participating in the 'Solar Access' program will equal or exceed the projected amount shown on the Solar Access Final Report…In the event that the actual net energy cost savings is less than the adjusted projection, EFG will refund the difference in cost between what was actually consumed and the adjusted projection". The maximum payout was $1,000 per participant, with a set-aside for a maximum of $50,000 across all sites (see Appendix 1 for more information).

To provide further assurance, the SAP Team completed quality assurance inspections at more than 15% of the sites, utilizing a comprehensive checklist based on the Northeast Energy Efficiency Partnerships' *Guide to Installing Air-Source Heat Pumps in Cold Climates*[4]. Finally, homeowners were offered the opportunity to have an eGauge™ energy data monitoring system installed at their home at no cost, to allow the SAP Team and the homeowner to measure electric consumption and generation post-project installation.[5] Additional program design elements include a customer survey and billing analysis.

Program Implementation Results

SAP was highly effective regarding energy and cost savings and customer satisfaction. However, the combination of the onset of COVID and the narrowness of the targeted economic

[4] https://neep.org/sites/default/files/Installing%20Air-Source%20Heat%20Pumps%20in%20Cold%20Climates.pdf

[5] The eGauge™ is one of a class of open-source, subscription-free metering devices that can serve as the basis of a custom design and install by a measurement and verification (M&V) contractor, and can be used for a variety of analytical purposes. This "mid level" professional system was selected because it balanced technical accuracy and capacity with cost-effectiveness. Other M&V contractors may use arrays of more specific sensors and monitors for detailed research, but those are designed and installed at a significantly higher cost. Those systems also typically consist of equipment that are only suitable for temporary installation during the study period, and are not useful to the homeowner. At the other end of the spectrum are "consumer-grade" wireless systems which are much less expensive, but also less reliable and less accurate.

demographic ultimately led to 49, rather than the original goal of 100 completed installations. Figure 7 shows the locations for completed SAP projects.

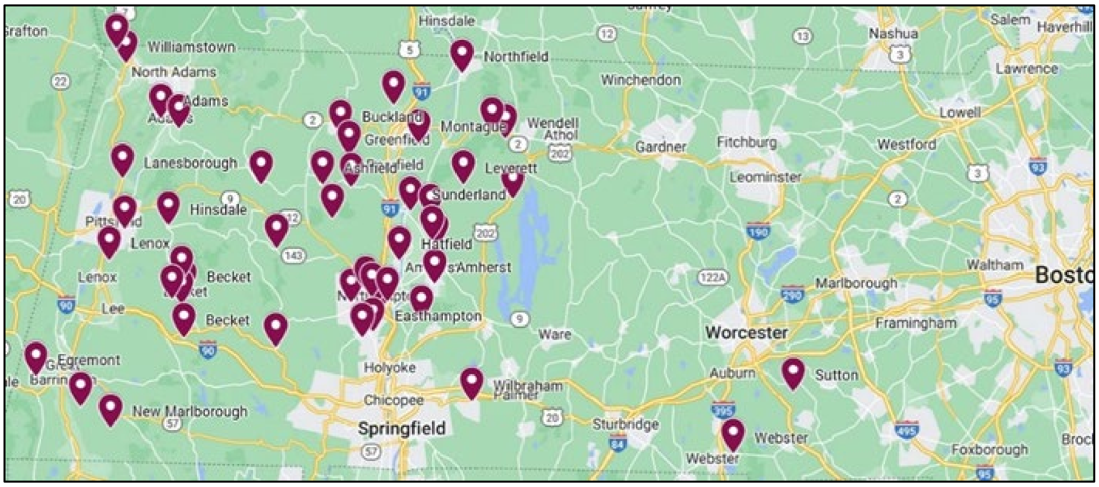


Figure 7. Locations of SAP Projects

SAP was very successful in bundling all opportunities for customers, identifying the most affordable financing option possible, and presenting the findings in an easy-to-understand format, essentially providing a “one-stop” service for customers. But the process of streamlining the offering for the customer did not result from a seamless or simple implementation process for the SAP Team. In addition to the limited target group, complex financial analysis and a multi-step process involving multiple parties and handoffs, there were multiple external programmatic and market changes that occurred during the program offering. These external shifts required ongoing program adjustments. A sampling of these market changes and associated timeline is presented in Table 5.

Table 5. Sampling of external market changes requiring program modifications

Date	**Event**
October 2018	First loan approved
November 2018	Solar credits shift from SREC to SMART[6]
January 2019	Determination regarding customer cashflow rules
March 2019	MassCEC heat pump rebate ends
March 2019	Determination that natural gas customers cannot be served
March 2019	Solar loan program ends
March 2020	COVID
Throughout Program	Lag time between (1) solar permission-to-operate, (2) inspections, (3) heat pump rebates

[6] SREC and SMART refer to Massachusetts’ solar incentive programs. More information can be found at: https://www.srectrade.com/markets/rps/srec/massachusetts and https://masmartsolar.com/.

Perhaps not surprisingly, the implementation costs for SAP were substantial. As shown in Table 6, the top two expense categories, “Contractor Liaison and Team Coordination” and “Customer Acquisition” consumed 50% of the actual expenditures. This reflects the difficulty of marketing to such a targeted consumer segment, the number of “hand-offs” required among the SAP Team and the need to respond to various market changes.

These top two expense categories are followed by the not-to-exceed-$5,500 SAP six-month payment subsidy. Program administration used 14% of the program cost, followed by technical support at 11% (which included quality assurance visits, energy monitoring and reporting). Nearly 10% of the budget was set aside in the form of the LLR and Savings Guarantee. At the time of the development of this report, neither of these funds have been utilized (meaning, no loan has defaulted and no homeowner has submitted a guarantee claim).

Table 6. Actual expenditure breakdown by category

Category	% of Actual Expenditure
Contractor liaison & team coordination	26%
Customer acquisition	24%
SAP 6-month payment subsidy	16%
Program administration	14%
Quality assurance, energy monitoring, reporting	11%
Loan Loss Reserve, Savings Guarantee	9% (really, 0%)

Included within “customer acquisition” was the marketing budget. The SAP Team deployed nearly every type of marketing strategy possible, making ongoing changes in an effort to develop more leads. In the SAP Team’s initial proposal, it was estimated that 1,000 leads would be needed to result in 100 projects. Ultimately, 1,105 leads were generated at a 4.4% lead closure rate. Of those that did not move forward with SAP, twenty-five were sent to low-income programs, 225 were referred to SunBug (of which 17 resulted in standalone PV projects), and 223 were sent to Girard Heating and Air Conditioning (of which 4 resulted in standalone heat pump projects). Thus, ~46 additional projects were developed and completed, likely due to SAP, although they did not go through the SAP program directly. The remainder dropped out for various reasons. These include sites with insufficient solar exposure, a poor layout for heat pumps, the customer losing interest (particularly once COVID began), and the limitation of the SAP six-month subsidy to a maximum of $5,500. Anecdotally, had the 60% - 80% range been widened (e.g. to 100% or 110%), roughly 50% of the leads that were screened out could have participated in the program.

Table 7 summarizes customer and program costs for the 49 completed projects.

Table 7. Summary of various financial data points from the 49 SAP projects

Financial Item	Data Result
Median SAP 6-month payment subsidy	$4,200
Median solar cost	$31,040
Median heat pump cost	$6,600
Median loan	$39,500
Number of federal tax credit recipients	26 (out of 49) – all in year one
Number of state tax credit recipients	33 (ranging from $94 - $1,000)

Summary of Installations

Photovoltaic systems summary

The installed photovoltaic (PV) systems ranged in size from 5.0 to 15.4 kW peak rating, with an average of 10 kW and a median of 9.4. The distribution is shown in Figure 8.

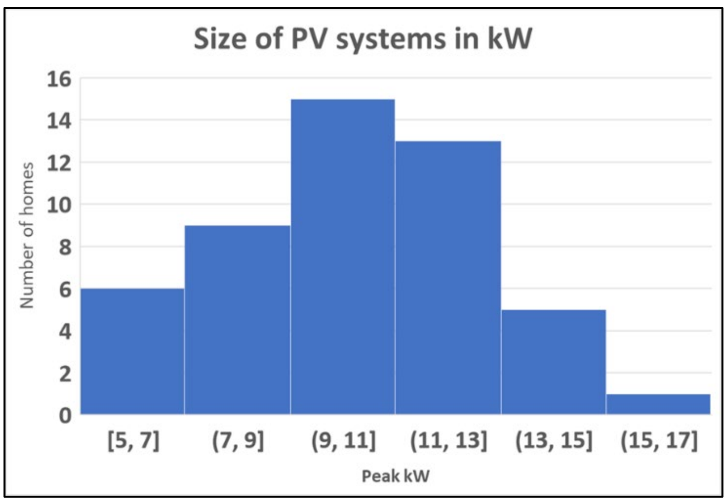


Figure 8. Distribution of PV system sizes (n=49).

The median cost of the PV installations was $31,040[7] and median cost/kW was $3,220. These prices are total cost, including any required electrical panel upgrades and roof repairs. Details about the contribution of those factors are not available, but for an income-targeted initiative this can be expected to be higher than average (for example, due to this income demographic having to defer home maintenance activities because of an inability to pay for them), and should be accounted for in project design. It is also notable that there was little correlation between the PV system size and the annual electricity consumption of the house, either pre-existing or projected after the heat pump installation (Figure 9). From a technical

[7] This is very close to reported statewide average cost of $31,100 for 10 kW system, according to http://news.energysage.com/how-much-does-the-average-solar-panel-installation-cost-in-the-u-s/

perspective, more attention to factors such as the annual electricity consumption of the house could help reduce oversizing of PV systems that would reduce both initial cost and unrealizable benefits to customers, who may not be able to use all the electricity produced, nor assign excess billing credit to another customer.

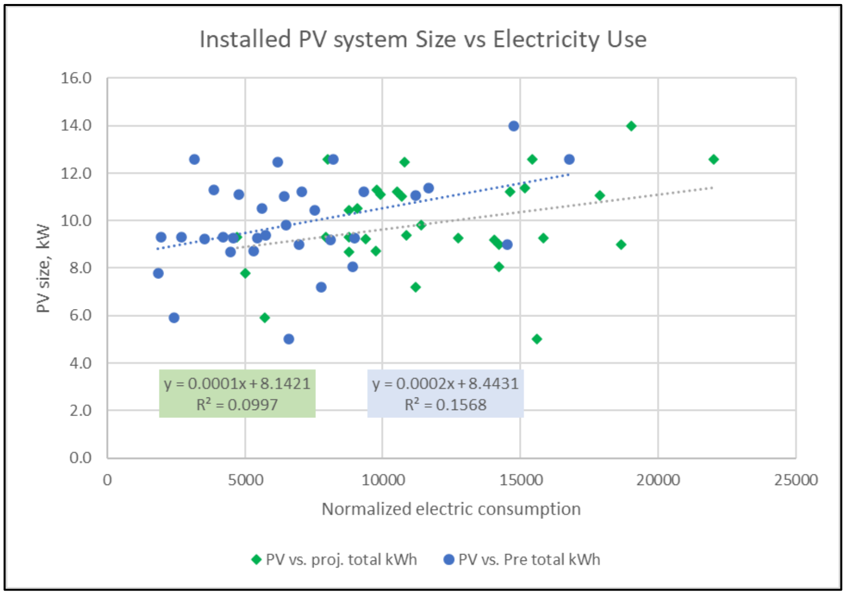


Figure 9. Correlation of installed PV size and projected / existing electricity use.

Heat pump systems summary

The installed heat pump systems ranged in size from 10,900 to 44,800 Btu/hour rating (heating capacity at 5°F) on a per-house basis, with an average of 22,100 and a median of 20,300 Btu/h. The distribution is shown in Figure 10, and the capacities are spread out fairly evenly in the range of 1 ton (=12,000 Btu/h) to 2.5 tons, with a few houses getting larger systems.

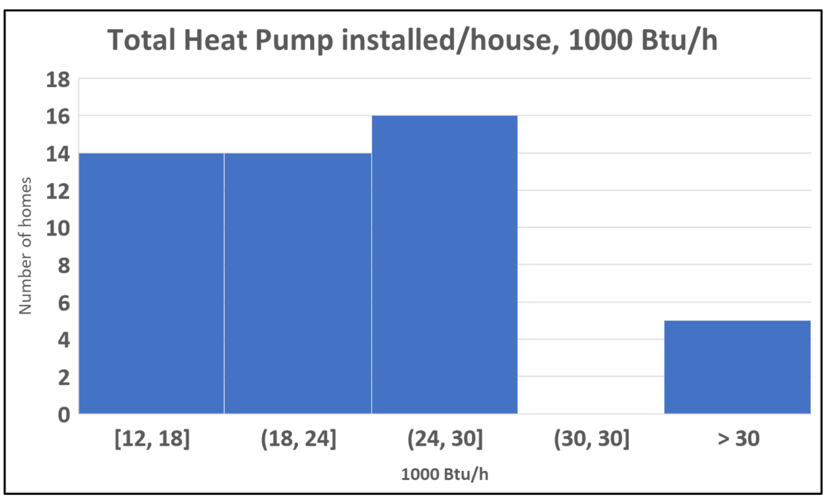


Figure 10. Distribution of heat pump system sizes per house (n=49).

A typical existing house in Massachusetts has a design load of around 40,000 Btu/h, so this range is consistent with the project target to provide offset, but not full heating system replacements.

The median cost of the heat pump installations was $6,663[8] (the average, $8,993 was significantly higher because of the five much larger systems). Median cost/ton was $4,899, and average was $4,845 (larger systems cost slightly *less* per heating capacity). These prices are in line with heat pump installations in general in Massachusetts (e.g. MassCEC $4,145/ton and NYSERDA $4,173/ton)[9]. Eight of the homes had multi-zone systems; all of those except one were 2-zone systems, and the one had 3 zones. All the indoor units were ductless. Table 8 shows the breakdown of system configurations:

Table 8. Heat pump configurations

Total heads/house	n	Notes
1	27	All single-head systems
2	19	13 2x single-zone; 6 2-zone
3	3	1 3-zone; 1 2-zone + 1-zone; 1 3x single-zone

Monitoring and Analysis Methodology

General Approach

The project team included "real-time" electrical energy monitoring and analysis of savings in the original proposal, as a way to "enhance the overall understanding of the drivers of energy savings specific to air-source heat pump retrofits." Although not primarily a field monitoring exercise, the project provided a good opportunity to understand heat pump utilization and fossil fuel savings without the expense of a fully instrumented study.

The proposal included an eGauge™ power metering system installed to measure and log circuit-level electric power use in 15 percent of the sites, or 15 sites based on the original target of 100 sites. The eGauge™ systems were eventually set up in 14 sites, 29% of the 49 completed projects. The measurements taken at each house included 1) all heat pump(s) in the home, 2) total house power, and 3) solar PV system output. Fifteen-minute interval readings were automatically transferred to a cloud server via wireless internet which was then saved in a database for each site. The eGauge™ monitoring provided detailed information regarding the power input to the heat pumps, as well as whole-house and PV system electric consumption. Other instrumentation that would measure or infer heat pump capacity, indoor temperatures, etc. was not installed, as would be typical in a more robust M&V study.

In order to estimate pre-installation electric and fuel consumption, weather-normalized regressions of energy bills were conducted. For the eGauge™ sites, post-installation fuel bills were also analyzed to estimate the fuel savings, while whole-house and heat pump heating and cooling energy consumption were directly measured. In sites with no eGauge™ monitoring, the

[8] This is very close to reported statewide average cost of $31,100 for 10 kW system, according to http://news.energysage.com/how-much-does-the-average-solar-panel-installation-cost-in-the-u-s/

[9] *Residential ccASHP Building Electrification Study,* the Cadmus Group 2022. https://cadmusgroup.com/wp-content/uploads/2022/06/Residential-ccASHP-Building-Electrification-Study_Cadmus_Final_060322_Public.pdf

same billing analysis was conducted on the post-installation electric bills to estimate the changes in heating and cooling energy. In addition to the eGauge™ data, SunBug provided direct monitoring data of the PV systems on a daily basis.

Energy analysis was completed on 38 of the 49 sites. The remainder either had insufficient data (such as minimal delivery records of oil or propane gas (LP), significant solid fuel use that could not be quantified (such as wood, coal or pellet stoves), or other barriers such as customers who were non-responsive or had moved. Of the remaining 38, eight still had significant solid fuel consumption, and two had other data quality issues and could not be analyzed, leaving a total of 28 sites that had analyzable results. Ten of the 28 used eGauge™ data for the post-installation heat pump electric consumption (the other four eGauge™ sites had solid-fuel heating, or other data issues such that they could not be analyzed.

Figure 11 shows an example of the pre- and post-installation electric bill linear regressions for house 24. The post-installation analysis is done using the total electric consumption, *not* including any PV electric generation.

Figure 11. Electric bill data regressions for house 24.

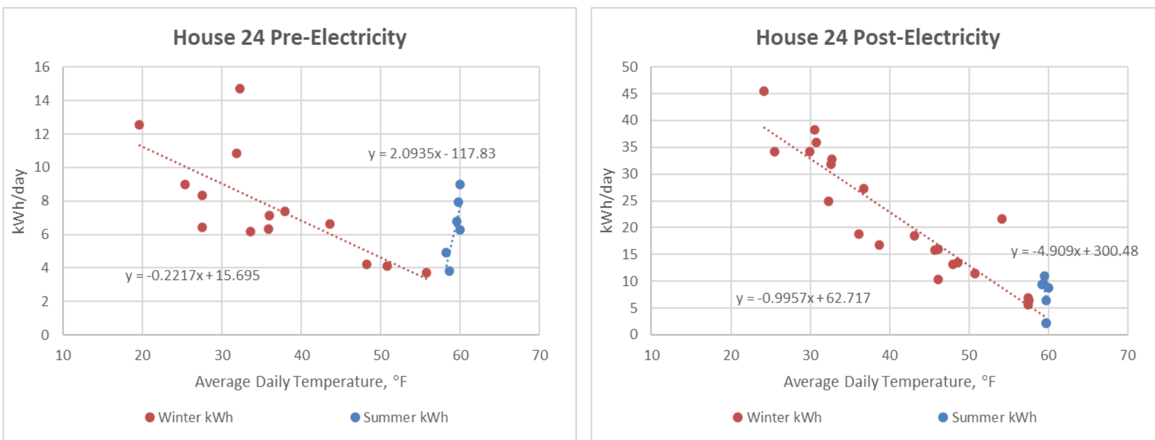


Table 9. Weather normalized heating, cooling and base kWh, house 24:

	Pre kWh:	Post kWh:
Heating season	1058	5040
Cooling season	316	255
Annual Base	1045	1267
Combined R^2	0.50	0.84

Table 9 shows the analysis results derived from those regressions. The house in this analysis had an increase of heating electricity consumption of about 4000 kWh, which is expected due to the installation of the heat pump. Cooling consumption appeared to drop slightly. And the baseload electricity (that component that is non weather dependent) appeared to increase by just over 20%, which is a normal variation from year to year. The combined R^2 parameter is a measure of how consistent the data is: the post-installation data lines up much better (0.84) than the pre-installation data (0.50). An R^2 of 1 corresponds to a perfect straight line, lower R^2 values indicate poorer correlations and thus lower confidence in the results. The combined R^2 average for the non-eGauge™ sites that completed analysis was 0.62, and for the eGauge™ sites it was 0.69. Similar analysis was conducted for fossil fuel bills (with only a heating and a base component, where the baseload typically represents water heating and/or cooking consumption if it exists). Fuel savings are calculated as the difference between the post-install and pre-install fuel consumption. All results and savings are weather-normalized, that is adjusted from the actual weather to a standardized weather for each weather site, in order to allow proper comparison across multiple years of data.

The eGauge™ regressions used daily data rather than monthly billing data, and they are specific to the heat pump itself, so the confidence in these results is higher, though it was still necessary to estimate the outdoor temperatures at which heating stopped and cooling began; in reality there may be some overlap. Figure 12 shows a regression for eGauge™ house 8. Estimated heating and cooling consumption for the eGauge™ sites are also weather-normalized.

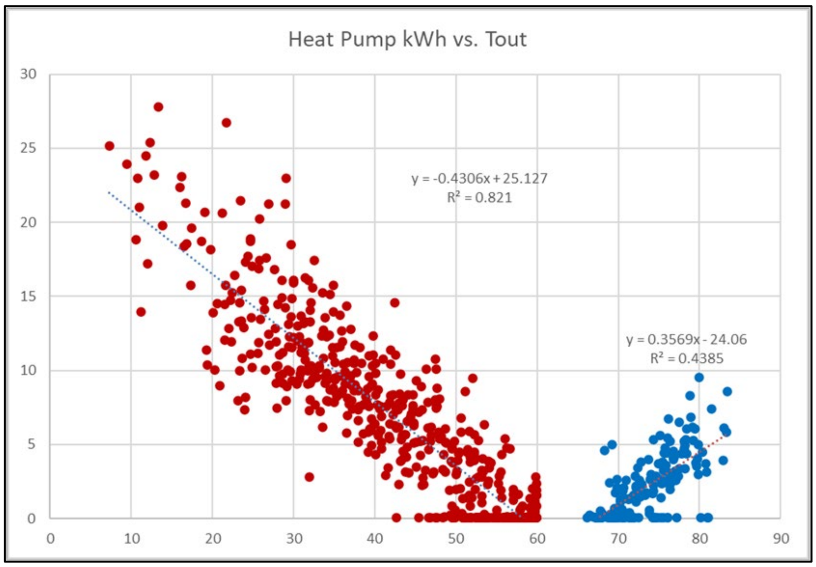


Figure 12. eGauge™ data regressions for heating and cooling of house 8.

Because the estimated fuel savings and heat pump electricity estimates were available for 29 sites, it is also possible to estimate the heat pump efficiency coefficient of performance (COP). COP is a dimensionless value, representing the ratio of energy in / energy out. A furnace with an 80% thermal efficiency, for example, has a COP of 0.8. Seasonal COPs are often used for heat pumps to represent measured seasonal efficiency, so they are not confused with the efficiency ratings such as Heating Seasonal Performance Factor (HSPF) or Seasonal Energy Efficiency Ratio (SEER) that are reported according to federal regulation for all heat pumps sold in the United States.

To estimate the COP of the heat pumps in this study, the following equation is used:

$$COP = \frac{Savings \times \eta_{equip}}{Input \times 3.412}$$

Where: *Savings* is the normalized annual fuel savings in Btu; η_{equip} is the deemed efficiency of the equipment, to convert energy consumed to energy load (generally 0.8 for fossil-fuel systems); and *Input* is the normalized annual heat pump heating consumption in kWh. The factor of 3.412 converts kWh to Btu, to provide COP in dimensionless units.

Results: Energy Impacts and Cost Savings

HVAC Impacts

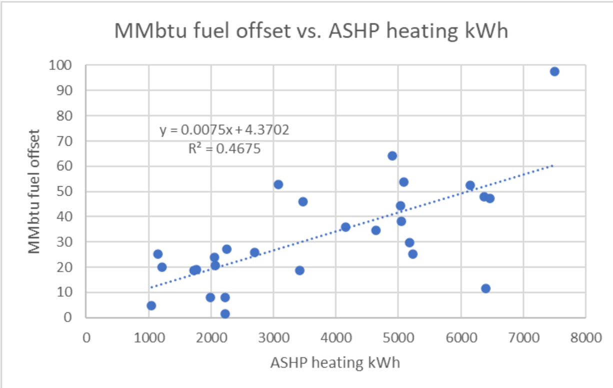
For the 28 houses with complete energy analysis, fuel savings averaged 46% of the pre-installation heating energy, though it was somewhat below the projections made for these houses. Table 10 summarizes the fuel savings, heat pump electric consumption, and COP results.

Table 10. Overall fuel savings and heat pump performance

	Results (n=28)	% of projected	Notes
Mmbtu fuel savings/house	**32.3**	**68%**	Homes with "consistent" heat pump use saved 40.6 Mmbtu / 65% of fuel
Fuel % saved	**46%**		
ASHP heating consumption kWh	**4,836**	**86%**	
Estimated (implied) heating COP	**2.3**	N/A	Virtually the same for multi- and single-zone; consistent with other studies
COP as a % of HSPF rating	**66%**	N/A	Consistent with other studies; was higher for multi-zone (78%) than single (63%)

Notably, by leaving out the 9 sites that had inconsistent heat pump usage, the heating savings increased to over 40 MMbtu (million Btu) or 65% of the heating fuel, which represents 79% of the projected savings for those 19 sites. Most of those with inconsistent heat pump use appeared to either use the heat pumps intermittently (such as, to heat a room or area only when it was occupied), or only during relatively mild weather. This suggests that customer education could increase the use of heat pumps and thus the fuel savings. The estimated COP averaged 2.3, and although it varied across all the sites (from 0.8 to 4.2), the average didn't vary much by various groupings; it was the same for the consistent-use sites as well as the inconsistent users, and was actually slightly higher for the several multi-zone systems (2.4). Although using monthly billing analysis has fairly high uncertainty for estimating COP, these results are consistent with other field studies.

In general, there was more fuel savings at sites with higher heat pump use, which is expected (Figure 13, left). There was considerably less correlation between heat pump use and the size of the installed systems (Figure 13, right) which implies that the heat pump use was limited less by the heating capacity and more by customer behavior, and to some extent the heat pump(s) application or placement in the home.



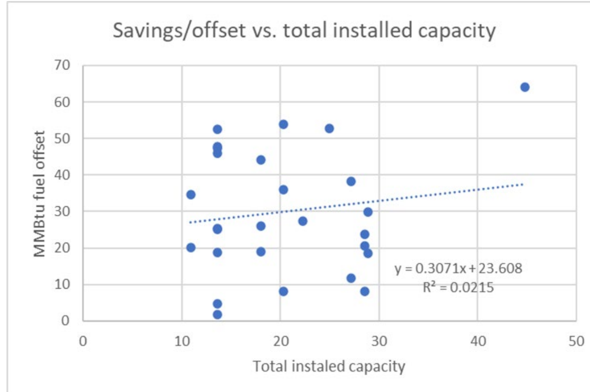


Figure 13. Fuel offset (savings) vs. heat pump kWh consumption and installed capacity

PV System Impacts

For consistency, and to allow the interaction of the PV systems with the HVAC systems, the PV performance summary uses the same 28 sites that had successful HVAC analysis. The annual electric generation from the PV systems was consistent with the projections, a little over 1000 kWh/year for each installed kW of PV, 105% of the projected generation. On average, it amounted to 115% of the total electricity consumption of the sites, resulting in an average excess PV system generation of 625 kWh/year. Table 11 summarizes the PV performance results.

Table 11. PV system electricity production

	Results (n=28)	% of projected	Notes
Annual PV produced kWh	**10,347**	**105%**	PV generation is predictable: 1000 kWh / kW in New England
PV as % of house electricity consumption	**115%**	**N/A**	
Excess PV generated (kWh/year)	**625**	**N/A**	Very wide range from -5300 to +7660

Although 625 kWh does not seem like a large excess PV generation, the *range* is quite large: the largest excess PV was 7664 kWh/year. By comparison, the average total electric bill for all houses before the project was 6423. The house with the largest excess PV (house 10) used only 4791 kWh/year before the project, and used their heat pump very little (only reduced their heating fuel use by 8 MMbtu, or 25% of the average savings), yet they had an 11 kW system installed. The breakdown of PV excess (or shortage) is shown in Figure 14. More sites had excess PV than not, but most were clustered around the neutral line.

Depending on one's perspective, excess PV production is of questionable value, because customers may not be able to easily realize the financial benefits. Account holders can only assign any net billing credit over time to another utility account, but cannot get reimbursed by their electric utility, so it is in their interest to use as much of the generated electricity as they can. At the same time, several legitimate factors lead to aiming "high" on the PV system size: uncertainty in predicting post-heat pump electricity consumption, the desire to make visuallyappealing arrays of uniform rows and columns, and the relatively low incremental cost of adding extra panels (compared with the per-kW cost of the whole system); also, PV output does drop somewhat over time (5-10% in 10 years, 10-20% in 25).

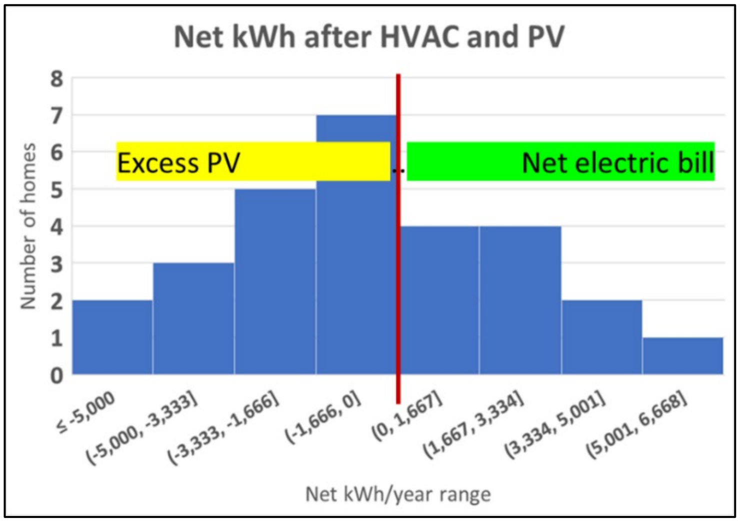


Figure 14. Excess PV generation (n=28)

Fortunately, there are potentially beneficial uses for that excess generation, and these customers have one already in their sites: the installed heat pump. Figure 15 shows the 17 sites with excess PV production, by the amount of heating fuel saved; although the correlation is modest, all of the sites with >4000 kWh of excess PV have less than 50% fuel savings. This implies that they could increase their heat pump use and fuel savings, while at the same time using more of the PV-generated electricity. Of the 17 sites with excess PV, 11 of them could use all that excess if they were able to use the heat pumps more to offset pre-existing heating load. The others have more excess PV, relative to the remaining heating load, than would allow for that.

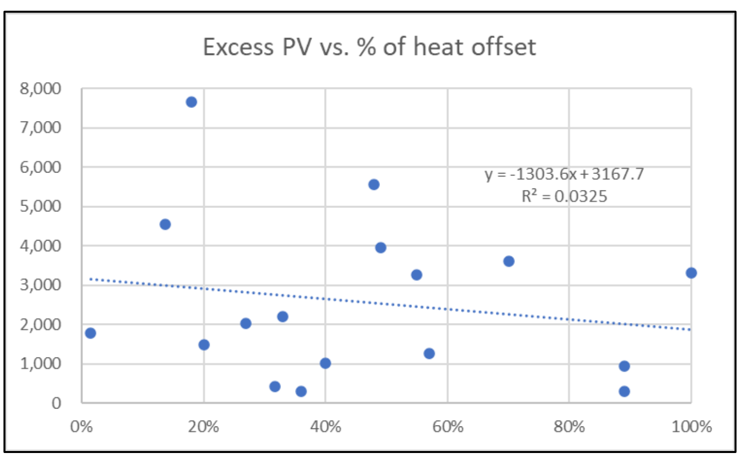


Figure 15. Excess PV system production vs. % of heat offset (n=17).

As a case in point, during the preparation of this report one of the customers inquired what they could do about the almost $2000 in electricity bill credits on their account. On investigating house 16, it appears that they are using the heat pumps fairly effectively (almost 50% reduction in fuel use). It's possible they could turn up the thermostats on the two existing zones (or turn down the central system a bit more) to heat more of the house. The homeowner could also consider installing one or two more heat pumps, to more effectively cover the heating needs of all, or nearly all, of the house. This would probably amount to no net cost for them, if they could utilize the Mass Save whole house heat pump incentive of at least $10,000 (or $16,000 if they meet the income qualifications for the Enhanced Residential program, which is likely for participants of the Solar Access initiative).[10] If the whole-house incentive didn't cover the entire cost of the upgrade to a whole-house system, the 7-year, no-interest financing through the HEAT loan should cover any remainder, probably no more than a few thousand. It would be in their interest to use more electricity for heat pump operation and reduce or eliminate their reliance on propane, and the additional propane savings combined with the dollar value of the subsequently "usable" electric bill credit should more than cover any small loan payment.

Other ways to utilize more of the excess PV generation include a heat pump water heater and/or an EV charger. Of course, the latter would also require a large expenditure on an electric vehicle (or a plug-in hybrid) that might only be viable at a time of needing to replace a car at some point. These approaches are likely to benefit any customer who finds they have more PV generation than they currently use, and at the same time will only increase the net savings and carbon reduction.

Regardless of whether the PV oversizing is considered a customer benefit or not, this issue highlights the value in capturing and reviewing energy savings and production. Identification of post-installation performance allows for the opportunity to discuss with the homeowner (if budget and time allow) how best to use their energy systems. This type of follow up – via brief, 15 minute phone calls, can result in greater energy and fuel cost savings overall – as will be discussed later in this report.

Greenhouse Gas and Energy Cost Reductions

The greenhouse gas reductions based on the savings analysis resulted in 10,305 lb. equivalent carbon dioxide (CO_2e) per house, or 96% of the savings projected by the calculation in the financial tool and reported as projected to MassCEC. The net of fuel and electricity saved was $2,553 ($881 in fuel cost savings, plus $1,672 in annual electric savings), or 109% of projected savings to the customers. The values shown in Table 12 are all based on the original values used in the proposal and in the financial tool, so that the values can be compared. The dollar savings are the net of fuel and electricity savings, and *do not* include the investment or financing, or other financial benefits; because the design of the initiative was to be cash-flow neutral (or better) over the life of the loans, these estimates are conservative. Also, because of changes in fuel and electricity costs, the annual financial savings have increased by 48% in just a few years, amounting to $3,787 based on October 2022 MA retail prices. Of course, this value

[10] https://www.masssave.com/residential/rebates-and-incentives/air-source-heat-pumps

will continue to fluctuate with changing fuel and electricity prices, but prices are not likely to drop over time so the economic benefit to the participants is likely to increase overall with time.

Table 12. Greenhouse gas reductions and financial savings, per home

	Results (n=28)	% of projected	Notes
GHG annual savings lb. CO2e	**10,305**[1]	**96%**	Calculated with the **same factors as original projections, for comparison**
Fuel annual cost savings	**$881**	**109%**	Calculated at **the same fuel/electric prices used in original projections**
Electricity annual savings	**$1672**[2]		
Cost savings, HVAC only	**$213**	N/A	Net of fuel savings + ASHP heating cost
Savings at today's fuel/electric prices	**$3,787**	N/A	**48% increase** > original of $2,553

[1] Based on original CO2e values used in proposal development. Actual values of both projected and reported GHG reductions should be approximately 20% higher, so the % of projected is still correct. (x1.216, eGrid 2014; x1.184, eGrid 2020.

[2] Does not account for unrealized savings due to excess PV production

It is worth noting that the greenhouse gas emissions factor for electricity that was used in the financial tool appears to understate the absolute values of the CO_2e by approximately 20%. When investigating the sources of the factors used in the financial calculator tool, it was unclear exactly what the source was for the CO_2e conversion for electricity, though it quoted an EPA calculator using 2014 values. On review of eGrid reports for Massachusetts[11], it appears that the correct 2014 value would be 264.8 lb/MMbtu (rather than 217.8, that was used). The most recent value for that conversion (eGrid 2020) would be 257.9, still 18.4 % higher than the financial tool.

Another notable point is that the absolute annual dollar savings from the HVAC system replacement, an average of $213 per house, is rather small. Heat pumps, although they are far more efficient than fossil-fuel heating systems, also operate on an energy source that is more expensive per Btu and so net cost savings are relatively modest. However, the average financial savings per project is large, due to packaging the HVAC upgrade with the PV system, resulting in an annual fossil fuel savings of $881/year, while the *net* of PV system generation along with increased electric usage due to the heat pumps is more than double at $1,672/year ($1,328/year when accounting for unrealized savings from excess PV production). The PV system accounts for 75% of the emission reductions, and 92% of the dollar savings. While on the surface that might suggest that customers could be better off investing only in PV, it is also worth noting that increasing heat pump use increases both net emission reductions and net cost savings to the customer. The unsubsidized cost per lb. CO_2e for the heat pumps was $3.38, compared with the unsubsidized cost per lb. CO_2e for the PV systems of $4.06. From a customer perspective, it makes sense to combine the two technologies so that the extra electricity needed for the heat pumps is covered (on an annual basis) by the PV system, in order to maximize the cost savings as well as emission reductions.

Figure 16 shows the lifetime emissions and cost savings per home, for the 28 sites in the analysis group. The percentage comparison between projected and measured varies slightly from

[11] https://www.epa.gov/egrid/summary-data

the annual values shown in Table 8 because the HVAC and PV lifetimes differ (20 and 25 years, respectively). The charts show the average projected lifetime savings for the entire project (n=49), which is very close to those of the 28-house analysis group, for reference, suggesting that the results should scale well for the entire project.

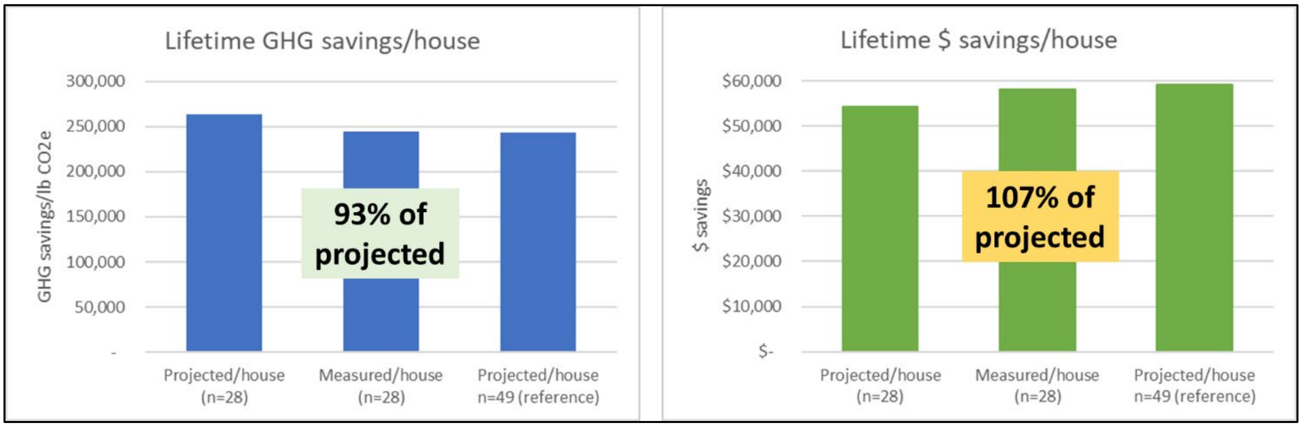


Figure 16. Measured and projected lifetime emissions and cost savings per home.

After accounting for unrealized savings from excess PV generation, the lifetime savings per house drops to $49,564, about 85% of the total savings, and 91% of the projected savings. On average this discrepancy is small compared with the large increases in savings as fuel and electricity consumer prices increase, but for individual customers with the largest excess PV it would still be very beneficial to use as much of that excess as possible.

As with all the reported results as compared with projections, these projected values are derived from the estimated savings that was generated on a per-project basis using the characteristics of each house and specific proposed equipment installations. Comparing the per-house results with the original performance criteria from the contract, shown in Table 13, shows that the contract projections were extremely conservative: the per-home lifetime savings was about 50% larger in both metrics, resulting in whole-project lifetime savings of over 70% even with just under half the total number of participants.

The total project lifetime savings (again, using the greenhouse emission factors and energy costs from the original proposal development) on a per-house basis greatly exceeds the contract projections largely because the contract included several conservative assumptions.

Table 13. Measured compared with contract projections, CO2e and dollars.

	Contract		Measured	
Lifetime savings	Total (100 sites)	Per home	Total (49 sites)	Per home
GHG CO_2e (lb.)	16,807,547	**168,075**	11,982,254	**244,536**
Customer energy, $	$3,749,730	**$37,497**	$2,849,333	**$58,150**

It is notable that the original savings projections were as close as they are to the monitored results. The estimates in the Financial Tool were based on the 2015-16 Cadmus evaluation study[12], using the reported values for the 75th percentile of heat pump users from the study. This validates the assertion from the original SAP proposal that these values would not be difficult to achieve with a focus on quality installation.

Figure 17. Photo of a Solar Access Program site

Findings & Lessons Learned

As shown in the previous section, SAP was very successful in achieving energy savings and cost savings. Nevertheless, there may be opportunities to improve regarding sizing of PV to energy consumption, and ensuring that homeowners use their heat pumps as effectively as possible. Similarly, SAP was very successful in a number of areas regarding program design and implementation. The bundling of all opportunities for customers, identification of the most affordable financing option for each customer, assisting the customer through the process (including describing the program's energy and financial options and savings in an understandable way), remaining flexible and responding to significant, ongoing external market changes are areas in which SAP succeeded.

Program Design and Implementation

Specifically, the SAP Team worked diligently to make the program as simple and straightforward for customers by bringing many energy retrofit and financing tasks "behind the scenes" into the SAP Team implementation process. For example, bundling of incentives and scheduling of multiple site visits were attended to by the SAP Team. But there are still many steps that invariably involve the customer: signatures are needed for multiple forms, approval is needed for utilities to release information, customers need to confirm the time for a site visit. Further, having the support and neutral advice provided by the SAP Team was appreciated and valued by the customer, as otherwise many of these homeowners may not have moved forward with such a large financial investment and loan. In sum, providing this "hand-holding" support was a critical necessity for many homeowners to successfully navigate and harness all available incentives and understand the energy, cost, and comfort benefits of the technologies. Nevertheless, implementation of SAP was still complex for several reasons.

[12] *Ductless Mini-Split Heat Pump Impact Evaluation,* the Cadmus Group, 2016. https://ma-eeac.org/wp-content/uploads/Ductless-Mini-Split-Heat-Pump-Impact-Evaluation.pdf

First, until energy efficiency and renewable energy programs are designed to be more streamlined and better integrated, customers (and the businesses serving them) will have to navigate a confusing, frustrating and time-consuming labyrinth of incentives and rebates that sometimes overlap but typically do not. The origin of this labyrinth often begins at the regulatory level; different entities (regulated, unregulated, and/or public), owned by varying interests and serving different but overlapping constituents, are contractually required to undertake certain initiatives and/or meet specific mandates. This results in a variety of disparate market services and offerings – e.g., with one entity undertaking audits, another providing weatherization services, and other entities (for example, utilities or contractor businesses), providing solar or heat pump services and/or rebates.

> "This program made it affordable for us to transform our fossil-fuel-heavy dependent house to one that generates clean energy and uses it much more efficiently." - SAP Participant

While programs like SAP and some businesses may hand-hold customers through this process, more often the customer needs to undertake the substantial endeavor to effectively take advantage of all incentives. The time and effort to understand, coordinate and collate various disparate energy retrofit opportunities into a more comprehensive (such as SAP, which didn't include weatherization) ultimately costs money, but with significant benefits to the customer. The cost to offer this service could be reduced by making the internal implementation processes as efficient as possible, and by having it all done in "one house" rather than across multiple businesses as was done with SAP. But there is a limit to the degree this cost can be reduced, given the multiple factors and entities involved in the energy retrofit market.

Second, there are few businesses that offer a full suite of energy retrofit options. Many businesses select one area of expertise, for example, weatherization, solar or heat pumps. Thus, offering customers more than one technology solution typically means coordinating with multiple businesses and therefore results in multiple site visits, site designs, scopes of work, and contracts. For example, as "simple" as SAP attempted to be, the final program documentation resulted in approximately 85 pages of documentation. Figure 18 presents the list of included information in a Solar Access close out package.

Included in this package you will find:

- **Heat pump rebates disclosure**
- **For your heat pumps:**
  - **Invoice**
  - **Mass Save rebate application form**
  - **Mass Save rebate terms and conditions**
  - **MassCEC rebate application form**
  - **MassCEC rebate terms and conditions**
- **For your solar panels:**
  - **SunSpotter Program welcome letter**
  - **Solar Edge Monitoring System information**
  - **SREC information**
  - **Form 5695 Residential Energy Credits**
  - **Massachusetts Department of Revenue Schedule EC Solar and Wind Energy Credit**
  - **Eversource Energy approval letter for interconnection**
  - **Turnkey Installation Agreement**
  - **Property and Construction Plans**
  - **EAH Structural Certification of Installation of Solar Panels letter**
  - **REC TwinPeak 2 Series solar panels product information**
  - **SolarEdge Single Phase Inverter product information**
  - **SolarEdge Power Optimizer product information**
  - **SnapNrack product information**
  - **SunModo EzMount L Foot for Shingle Roofs product information**
- **Energy savings guarantee disclosure**

Figure 18 List of materials in the Solar Access close out package

While SAP addressed these challenges as much as possible for the customer, this is an area that needs attention from regulators, utilities, policy/program designers and other market actors. If significant progress can be made to streamline and integrate these services, then energy improvements to existing buildings in Massachusetts could more easily be accomplished at scale, and could play a substantial role in whether Massachusetts' various climate mandates can be met.

A third area in which program complexity needs to be reduced, pertains to the financing product. As mentioned earlier (and highlighted by responses received in the post-project customer survey), many – if not all – of these homeowners would not have been able to install solar and heat pumps without the additional financial incentives provided by SAP, and in particular, the 6-month payment subsidy. However, this subsidy was particularly challenging for the lender to implement. Specifically, there were multiple events that impacted the homeowner's loan payment. These include:

1. Multiple loan disbursements for solar plus the MassSave HEAT loan disbursement
2. Before and after the installation (e.g. pre- and post-net metering)
3. Application of any investment backed lending support payment from MassCEC
4. Receipt of the heat pump rebate
5. Receipt of federal & state tax credits (depending on timing)
6. Re-amortization (depending on timing)

These multiple variables caused the monthly payment subsidy to change several times in the first year. This was managed with a complex spreadsheet, which is not a scalable solution. The original financing design, as presented in the grant proposal, was a single loan covering both the cold climate air source heat pump and solar financing, which would have made implementation somewhat simpler. Unfortunately, the SAP team was (logically) required to use existing programs to best garner the incentives available from the Mass Solar Loan and MassSave 0.00% HEAT Loan, because this then allowed the SAP team to harness existing funds, therefore requiring less funding for the pilot. But the end result of this was more complexity in program implementation for the lender. When asked how the lender might have designed this via an "easier" method, the response was to structure it as:

> "1. A single loan for both the solar and the cold climate air source heat pump.
> 2. Interest-only payment for 12-18 months. This would allow all the disbursements to be made and incentives collected over time including the 30% renewable energy tax credit and $1,000 from the state.
> 3. Subsidize the entire interest-only period. Not a big ask though it sounds like it is. Total per-consumer outlay should be under $2,000 for a 12-month period and under $3,000 for an 18-month period (assuming the average costs remain similar to what was experienced in SAP). With existing technology, those variable monthly payment amounts could be set-up for automatic payment from the funding source…which would be on deposit with the lender.
> 4. After the interest-only period, amortize the balance over 10-15 years. After applying the tax credits and rebates, you would have to assume that the fixed monthly loan payment is fully offset by net metering and SMART income.
> 5. Write a program where all you have to do is enter the loan amount, interest rate, and term, with all the incentives baked into the programming. The output would be an amortization schedule detailing what the interest-only funding needs to be and showing positive monthly benefit to the consumer (once their payments begin)."[13]

The lender states that not only would this be easier to market and sell, but there would also be no loan payments for 18 months, and positive cash-flow after making the loan payment. The lender would still need a LLR for homeowners with moderate or poor credit, or they would be declined. Ultimately, to achieve Massachusetts' emission reduction goals will require upgrading the energy performance of many existing homes – at scale. Thus, in designing future programs targeted at this economic demographic, program designers should identify ways to provide the necessary additional "bridge" funding via structures that are more easily implementable for the lender.

> "Super easy financing, we're still enjoying tax credits spread out over several years, and we are grateful for the loan." – SAP Participant

[13] Sent to the author via email in December, 2022, from the lender.

Marketing

Identifying and finding program participants was another area in which the SAP Team needed to continually adjust. The early shift to a narrow range between 60% - 80% of state median income meant the team had to modify marketing efforts throughout the entire program offering to continue generating leads. Even when leads were generated, quite a few dropped out, either due to site constraints (e.g., lack of sun, house layout not suitable for single zone heat pumps), program or market changes (e.g., halfway through SAP, it was determined that homeowners with natural gas could not participate), financing issues (e.g., a 6-month payment subsidy in excess of $5,550 in order for the homeowner to meet UMassFive loan criteria), or customers choosing not to move forward (e.g., in March of 2020 with the beginning of COVID).

The SAP Team utilized nearly every form of marketing and outreach possible, with the exception of radio and television. For example, the news of SAP was spread through mailings, paid print, social media, events, earned media, and leveraging partnering organizations. The SAP Team learned several lessons regarding how to effectively find and connect with the narrow economic demographic of 60% - 80% of SMI.

Specifically, the team found local, paid print to be relatively ineffective, but earned media that showcased a satisfied local customer did garner interest and leads. Similarly, direct mail was found to be ineffective. Direct mail initially seemed promising, because the mail house could pull demographic data and target certain addresses, but 11,240 letters sent to the targeted income range resulted in only six leads. Direct mail appears to be increasingly challenging to utilize successfully without a significant marketing budget. The time and cost of buying a list, combined with designing a postcard and tracking the leads did not result in a favorable return on investment.

However, working with trusted local partners to send out notices on behalf of SAP was much more effective. For example the Town of Lee, utility partners, and the Massachusetts DOER utilized their networks to spread the word about SAP, and homeowners responded. This was particularly true with UMassFive because the credit union was able to present SAP as a UMassFive offering, providing further credibility.

Social media was also found to be very cost-effective, running about $20 per day. It also allowed for frequent, small messaging changes that often generated surges in leads. At the outset of SAP, social media platforms allowed targeted demographic data – but that feature has since been removed. Nevertheless, the fact that social media can test for which combination of photos and messages develop the greatest interest provided significant value.

In-person events were also highly useful. CET generally attends over 100 events a year throughout western Massachusetts. These events were leveraged to spread the word about SAP while building on CET's credible local brand. Combining testimonials with other efforts such as a local press event to drive earned media was also found to be particularly effective.

While many homeowners had heard of solar, the concept of cold climate air source heat pumps (beginning in 2018), was still generally unfamiliar. Thus, marketing language led with solar and then explained heat pumps. At the same time this approach had to be carefully balanced with CET's brand as a trusted, local resource, as the solar marketplace is crowded. Many homeowners initially assumed that the cash-flow neutral promise of SAP was "too good to be true", and CET's image as a community partner helped many participants overcome their initial skepticism. Interestingly, although heat pumps were relatively unfamiliar to the target audience, messages focusing on comfort (such as “Beat the heat this summer with Solar Access, a state-funded program”) were more effective than messages focusing on saving money or saving energy.

Customer Surveys

A qualitative satisfaction survey was sent to all 49 participants; 41 responses were received. Questions included:

- Generally, how satisfied were you with the Solar Access Program?
- If there have been any changes to your household that might alter the household energy consumption, please describe them here. (This question was asked to assist the SAP Team in interpreting energy consumption during the billing analysis exercise).
- How satisfied are you with your heat pump(s)?
- How satisfied are you with your solar system?
- How satisfied were you with the financing and loan product?
- Do you feel like the Solar Access Program brought you and/or your home value?
- Do they think you have saved money?
- Do you think you have saved energy?
- As part of the Solar Access Program, you received a MassSave audit. Did you ultimately complete any energy efficiency work, such as weatherization and/or air sealing?

Figure 19 below shows a high level of customer satisfaction for the program overall, and specifically regarding the heat pump system, the solar system and the loan product. Generally, between 90% - 100% of the customers were either very satisfied or satisfied with all four areas of question.

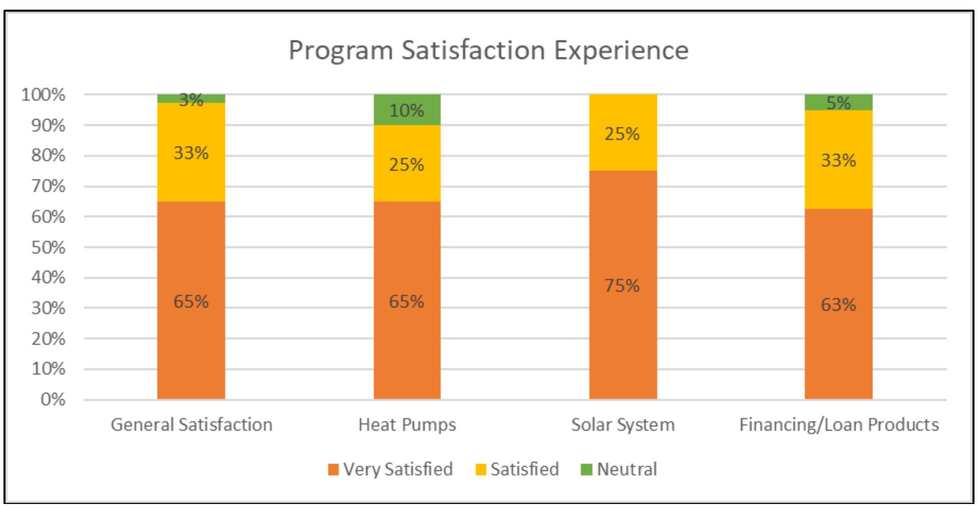


Figure 19. Customer Satisfaction with SAP Overall, Heat Pump Technology, Solar Technology and Loan Product

Homeowners were asked to provide additional comments, if they were so inclined. Eighteen stated that there would have been no way for them to do this work without SAP. For example, one customer stated that "the program made solar affordable…without the grant assistance I wouldn't have been able to install solar on my own", while another stated that "the Solar Access Program allowed someone on a limited income to be a part of the renewable energy world and upgrade a home's heating/cooling system at the same time". Many customers highlighted that the heat pumps heated and cooled well, that the air conditioning was a "life saver" (and that otherwise they would have purchased window air conditioning units), that they appreciated reducing their fossil fuel consumption, that their "backs were happier" because they needed less firewood for heating, that they appreciated their smaller (or negative) electricity bills, and other similar comments.

While the responses were generally very positive, a few areas of concern were raised by customers. Table 14 presents issues that were raised by more than two customers.[14]

Table 14. Issues raised by more than two customers

Issue	# of Customers Impacted
Noticed reduced heat pump performance[15] below 32° F	5
Has excess solar production	5
Experienced various equipment issues (e.g. inverter failure, power surge corrupting equipment)	4
Concerned about repair costs	4
Found it challenging to navigate SAP	3

Customers were also asked whether they had completed efficiency work, whether they thought they had saved energy and/or money, and whether they thought their home value had increased (Figure 20).

As discussed previously, SAP did not require weatherization but a completed energy audit was required. Of the 40 respondents, 58% did move forward with some form of efficiency improvements in response to the audit conducted as part of SAP. Seven out of the 17 respondents who said they did not do any additional work as part of SAP clarified that the reason was that they had previously had one or more weatherization improvement projects completed. Another respondent stated that they were moving forward with weatherization now (after SAP had been completed); another stated that the only audit recommendation was to address the attic, "but our attic is too full!". The remaining eight respondents did not provide additional context. Ultimately, out of 40 respondents, 31 already had or were receiving efficiency upgrades, for a total of 78% participation.

Generally, customers believe that the project improved their home value. Many of them felt it was saving them money, but others responded that until the loan was paid off, they weren't sure. The surveys were completed during the summer of 2022, at which time many news articles

[14] Issues raised by two or fewer customers included: snow avalanche from the heat pump outdoor unit, the need for the outdoor unit to be positioned higher to address snow accumulation, loan interest rate, high equipment cost, central heat performing better, and concerns with sound from the heat pump.

[15] Because the installed heat pump systems were all high-output cold climate units, we take this to mean that the limited heating distribution of 1-3 ductless indoor units were not adequate to deliver comfort throughout the house, rather than the heating "output" was actually significantly degraded at these temperatures.

were highlighting expected increases in fossil fuel costs. Respondents highlighted this as a benefit – that in the long run, as prices increase and the loans are paid off, they assume they will be in a far more secure place, financially, than had they not participated in SAP. With regards to saving energy, many of them questioned whether they actually saved energy or simply shifted from one form of energy (fossil fuels) to another (electricity).

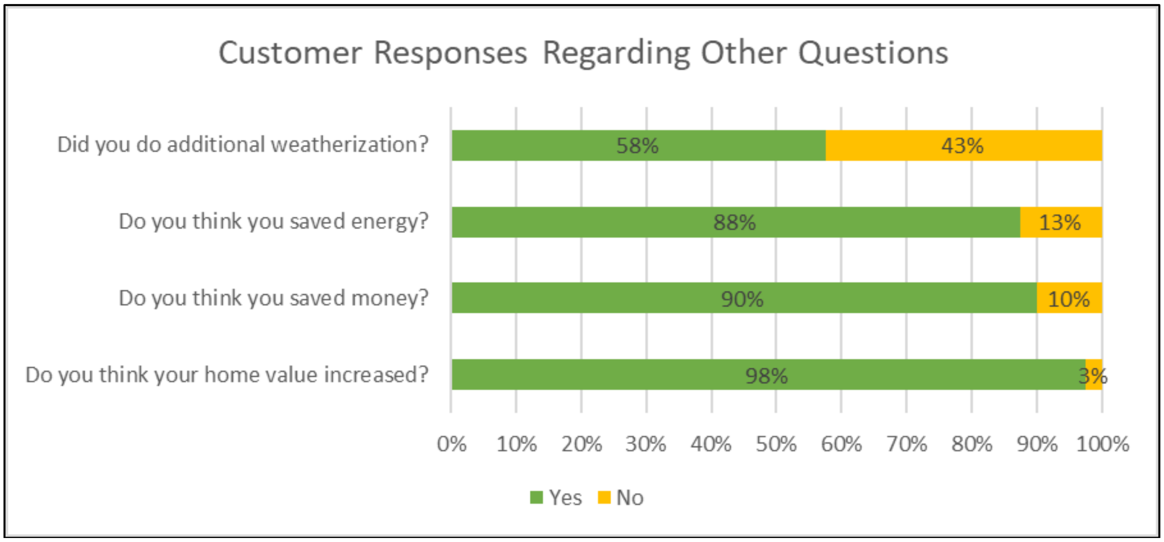


Figure 20. SAP customer responses to other questions

In response to the question "Would you like to add anything else?", many customers responded along the lines of these homeowners:

- "I have saved money on electricity, improved comfort, cooling + heating, and increased the value of my property."
- "Super easy financing, we're still enjoying tax credits spread out over several years, and we are grateful for the loan."
- "This program made it affordable for us to transform our fossil-fuel-heavy dependent house to one that generates clean energy and uses it much more efficiently."

And finally:

- "Amazing program that the state would do well to replicate or replace with something comparable in the future."

Based on customer responses, it is clear that few of these homeowners would have been able to invest in solar and heat pumps, thereby reducing their dependence on both grid power and fossil fuels. Overall, SAP appears to successfully address the participants' energy burden and financial constraints.

Other Lessons

As other studies have shown, the amount of savings realized from a heat pump installation depends on how much the customer uses it. For partial-offset systems with one to three indoor ductless zones, there is some limit to the amount of fossil heating that can be comfortably offset, especially if the heat pump heating is not evenly distributed in the house – which is a function of both house design and customer comfort tolerance. The one homeowner of site 28 who offset 100% of their fossil fuel had a fairly small (13.6 kBtu/h), single head system, but that approach won't work for most homeowners. The limits on heat pump installation cost were driven largely by the financing objectives and constraints on the six-month payment subsidy. With larger incentives already in place and increased federal tax credits coming in 2023, any future initiative could focus more on whole-house systems. Additionally, the constraints on monthly cash flow (that were capped at -$25/month for SAP) could be loosened slightly to allow more flexibility, while retaining an annual cash-flow neutral limit.

As discussed earlier, from a technical perspective, it would have helped to focus a bit more on optimizing the size of the installed PV systems, based on the pre-existing house electricity use along with projected heat pump electric consumption (although from the perspective of the solar installer, this may not always be the preferable approach due to the visual qualities of the array and degradation of the solar array over its' 25 year life span). In the SAP process, the financial tool was used to try to optimize PV sizing so that projected electricity generation would be balanced by the increased electricity use of the heat pump(s). There will always be some uncertainty in analyzing pre-existing heating fuel consumption, and projecting heat pump use and electricity consumption. However, focusing more on whole-house heat pump systems would help customers make the switch more fully, and the desire to avoid excess PV bill credits would be an additional incentive to actually run them as much as possible. Focusing on whole-house heat pumps would also close the gap between practical PV size and reasonable expected electric consumption.

Lessons were also learned with regards to energy monitoring and post-project analysis. Initially, there was no budget for an "evaluation"[16] of SAP. However, as only 49 out of (the budgeted) 100 projects were completed, the SAP Team was able to conduct the follow up billing analysis and customer survey that has informed this report. Because this "evaluation" work was not initially planned, not all of the quality assurance mechanisms were put into place at the level of detail required for a rigorous evaluation; for example, with regards to collecting solid fuel data pre-project installation. Further, had it been known that ~50 sites would have been achieved, ideally all would have had an eGauge™ unit (which was not possible due to various technical considerations such as the location of the electrical panel) and committed to providing post-project fuel release data. Nevertheless, the use of the eGauge™, in addition to the standard monitoring provided by SunBug as part of their typical solar installation, was useful in allowing for remote troubleshooting during the study period. This is valuable in identifying significant failures that could have disrupted the study if not recognized. While it is easier said than done,

[16] The word "evaluation" is placed in quotations in recognition that the analysis completed for this report is not akin to the methods and processes undertaken in a formal evaluation, verification and measurement study. https://www.energy.gov/sites/prod/files/2014/05/f16/what_is_emv.pdf

taking the time and setting aside the budget for data monitoring and occasional energy consumption analysis is highly valuable – particularly as energy prices increase. A New York State Energy Research Development Authority project presents an example of this value. In the first winter after the installation of a cold climate heat pump, the homeowner saved 33% in oil consumption; following a fifteen-minute conversation between the homeowner and the project evaluator, the homeowner increased their heat pump usage, ultimately saving 62% in oil consumption over the next heating season. As the energy infrastructure within our buildings, and our homes, becomes increasingly interconnected via technologies such as integrated controls, storage, solar and heat pumps, identifying ways to incorporate ongoing monitoring and occasional analysis into program design will ultimately improve technology performance, energy and cost savings.

Figure 21. Photo of a Solar Access Program site

Conclusions

SAP was a unique pilot initiative that enabled a particular economic demographic (60% - 80% of state median income) to participate in significant energy improvement retrofits. There were many areas of success, as well as lessons learned and opportunities for future program improvement. These are listed below.

Energy and Money

- SAP delivered on dollar savings. The initiative produced an estimated average of 71% fuel and electricity cost savings (using levelized fuel and electric costs). This is 9% more customer savings annually than projected on a per-house basis, and 45% more lifetime savings per house than in the initial SAP contract, even without adjusting for energy price increases over time.
- SAP delivered on emission reduction. The initiative produced an estimated savings of 65% of the homes' greenhouse gas from heating fuel and all electricity. This is 4% less annual greenhouse gas offsets than projected on a per-house basis, and 55% more lifetime savings per house than in the initial SAP contract. Both of those calculations used CO_2e factors for electricity that were conservative by about 20% to begin with, suggesting that the real CO_2e offsets exceeded expectations.

- About 75% of the greenhouse gas savings and 92% of the total potential dollar savings resulted from the PV systems, while the remainder resulted from the net change in the HVAC systems.
- Utilizing the existing heat pumps more would increase both customer dollar savings and emissions reduction for no added cost. Increasing the scope to focus on whole-house heat pump installations in the future would improve their usability, and thus the savings.
- More focus on sizing PV to pre-project energy consumption could decrease cost, with little negative impact on realizable cost savings; however, this may or may not be the preferred route, in the event that the homeowner is concerned with the visual perspective of the array or solar degradation over the 25 year life of the system.

Implementation

- Customers like the product-neutral handholding assistance – but the entity providing this service needs technical training. In Massachusetts, there could be opportunities to augment trainings currently offered through the MassSave Heat Pump Installer Network.
- It is very helpful to leverage the "trust" factor associated with state, non-profit partners, & customer testimonials – particularly if the offer seems too good to be true.
- Building upon relationships that already exist by partnering with local, community-embedded organizations is very helpful to connect with hard-to-reach segments of the population.
- Combining technologies makes sense for the customer and results in more energy savings for each project – but weatherization could have been included, too. Fortunately, as identified via the customer survey process, 31 out of the 40 survey respondents had or were receiving efficiency upgrades, for a total of 78% participation. Nevertheless, when a contractor (regardless of the area of specialty) is initially speaking with a customer, ideally all technologies would be mentioned to the homeowner to ensure that the most appropriate retrofit is selected. Combining and packaging multiple offerings requires coordination of various services and incentives, which takes time and money and may not provide an obvious return on investment. This could be a factor as to why so few businesses offer comprehensive building energy solutions, and could be an important leverage point to apply public and/or ratepayer funding.
- It is critical to identify ways to reduce time and complexity in approvals and hand-offs. Better design of incentives and other benefits for integration and coordination could have a major impact in reducing implementation costs, retrofit completion timelines, and ultimately, in significantly scaling up building decarbonization efforts.
- To the degree that it is possible, minimize policy changes and be consistent with offerings over time.
- The Savings Guarantee helps to reduce participants' fear that their investment may not be worth it. Because no savings guarantee claims were made, it seems that a well-designed guarantee has significant value for a low delivered cost. The total set-aside could clearly have been reduced. Guarantees could be offered more regularly to increase participation.
- The LLR is designed to reduce the lender's risk of loan default in an otherwise relatively credit-risky population, by setting aside a portion of the project budget to cover their loss in case of non-payment. At the time of the writing of this report no LLR claims have been

made. The reserve is costly. A larger subsidy could be a less expensive approach to reduce loan default risk for homeowners at lower income levels. It would be beneficial to understand the added benefit of net neutral cash flow, that by itself should also reduce default risk compared with the "normal" calculation (on credit scores and income/expense balance). Given the neutral cash-flow model, the reserve could potentially be substantially reduced while still managing risk effectively. It should be noted that the willingness of a financier to make loans to credit-challenged low-income borrowers is only strong with a third-party guarantor. However, low-income households with good credit generally should not require any loan loss funding. (Note that unused LLRs are ultimately returned to the CEC/DOER.)"

- Note that in a full-scale offering over time, set asides for both LLRs and savings guarantees could effectively act as as a "start-up" revolving fund that would not need to be scaled up with each new loan written. The savings guarantee sunsets after a year or two, and the net risk of default from earlier loans inherently decreases over time. Leveraging these factors could further reduce the net budget impact of these set asides.
- The six-month Solar Access payment subsidy made the investment cash neutral on a monthly basis. However, this additional up-to-$5,500 was only available for SAP. The Massachusetts Solar Loan middle income subsidy is also no longer available. SAP successfully reduced the energy burden for program participants, thereby likely assisting in improving participants' long-term financial stability. If policy makers desire for this outcome for moderate income homeowners, then these critical subsidies will likely need to be reinstated. However, due to the customization and manual intervention necessary on a per-contract basis, the month-over-month subsidy as designed in this pilot initiative would need to be modified (as discussed earlier) to make it scalable for a lender to implement in an ongoing fashion.
- Selling comfort is far more effective than selling energy or cost savings.
- For programs such as SAP (which are trying to reach a narrow demographic and offered handholding for bundled services and technologies), allowing for program flexibility is critical.
- As program designers work on new concepts, be sure to listen to customer and service provider feedback.
- Serving middle to lower income homeowners means addressing other issues such as the need for electric panel upgrades, or addressing roof integrity. These costs need to be accounted for.

Appendix 1

MassCEC Solar Access Program
Energy Cost Savings Guarantee

OVERVIEW

Energy Futures Group (EFG), operating the Solar Access Program for the Massachusetts Clean Energy Center (MassCEC) guarantees that for two years following retrofit completion, the net energy cost savings[17] for any home participating in the "Solar Access" program will equal or exceed the projected amount shown on the Solar Access Final Report provided by the Center for EcoTechnology (CET), as adjusted according to the terms of this guarantee[18]. Your projected energy bills, based on current prices, including both electricity and heating fuels after project completion, are listed in note 1. In the event that the actual net energy cost savings is less than the adjusted projection, EFG will refund the difference in cost between what was actually consumed and the adjusted projection, as calculated according to the terms of this guarantee. The maximum payout shall be $1,000 per participating property, and the maximum total shall be $50,000 across all participating properties.

APPLICABILITY

Eligible Properties. All properties participating in the Solar Access Program are eligible for this guarantee.

Alterations. If the building structure is altered in a manner that changes the square footage of conditioned space after the Solar Access Program project scope is complete, the guarantee shall be null and void.

Building Use. If building use or occupancy changes following completion of the retrofit and prior to the filing of a claim (e.g., new use as home day care or home office; new occupants), the guarantee shall be null and void. Reasonable determination of a change in use shall be at the sole discretion of EFG.

Owner's Responsibilities. This guarantee will be null and void if the Owner(s) fail to practice reasonable and prudent energy conservation habits, including but not limited to:

- Scheduling a service call whenever there appears to be a problem with the operation of any energy-related system, equipment, or feature of the building, and making repairs found to be necessary for proper operation during that service visit within 30 calendar days;
- Changing all filters (if present), and clearing snow as needed from outdoor units, according to the manufacturers' instructions;
- Maintaining all windows and doors and keeping them closed during heating system operation, except for normal use; and

[17] "Net energy cost savings" = your historical energy bills less your new energy bills including both electricity and heating fuels, adjusted for contemporary weather. This is "net" because it includes the total impact of heating fuel savings, increased electricity consumption for the heat pump, and solar PV electric production.
[18] The adjustments described in the guarantee are to account for variability in weather and occupancy.

- Setting all thermostats at or below 70 degrees during the heating season and at or above 78 degrees during the cooling season.

Disclosure. If the Owner(s) do not completely and accurately provide any and all information to the Solar Access Program related to the Solar Access Final Report, their energy bills as set forth below, and any subsequent claims, this guarantee will be considered null and void.

TERM

The term for coverage of the guarantee (the "Guarantee Period") is up to two calendar years from the date of retrofit completion, defined as the date of energizing of the heat pump. A claim may be filed any time between 12 months and 27 months following the retrofit completion.

CLAIMS PROCEDURES

Process. In order for a claim to be eligible and honored, the following steps must be taken by the Owner(s):

- The Owner(s) must submit a completed "MassCEC Solar Access Program Energy Savings Guarantee Claims Form" (hereinafter "Claims Form");
- Provide copies of all energy bills since the retrofit completion; and
- The Owner(s) will make the property available for inspection by Solar Access Program staff, in order to resolve any claims that may arise from this guarantee.

Burden of Proof. The Owner(s), and not MassCEC or EFG, shall be responsible for collecting and submitting all information required on the Claims Form in order to file a claim.

Turn-Around Time Frame. Within 60 days of receipt of a completed Claims Form, Solar Access Program staff shall review the Claims Form and submit claim to the Owner(s) if warranted, or, otherwise, state in writing the reason for denial of a reimbursement.

Calculations. The Owner(s) must first submit a complete and accurate Claims Form and copies of all electricity and fuel bills in question for the period following the retrofit completion, and for a period of at least one year (12 months) prior to the start of the retrofit. Based on this information, and any inspections of the building, if carried out, Solar Access Program staff will calculate total energy savings and compare to projected energy savings in order to determine the amount of the claim. Standard and accepted engineering calculations, analyses, and estimates will be used. The basic calculation will be as follows:

- Solar Access program staff will review the actual bills for each fuel used, generally limited to electricity and (if used) another primary heating fuel. Program staff will subtract the amount of any unused fuel remaining in the building, adjust for billing and fuel delivery schedules, and consider the net amount as the amount consumed for each fuel. Claims involving wood will be considered on a case by case basis, and may be denied unless there is clear documentation of deliveries and consumption both before and after the retrofit.

- The amount consumed as documented by the energy bills, both before and after retrofit work, will be adjusted for weather conditions using standard engineering calculations, and multiplied by the Massachusetts Department of Energy Resources reported price per unit of each fuel (see https://www.mass.gov/home-and-auto-fuel-prices). Further, adjustments will be made for any payments made by means of the Massachusetts SMART program. The current cost of energy calculated in this way for each fuel along with any SMART payment adjustments will be added together to determine a normalized net energy cost of actual energy savings, for the purpose of this guarantee.
- Program staff will also multiply the fuel savings projections from the Solar Access Final Report by the Massachusetts Department of Energy Resources reported price per unit of each fuel, adjusted for the time period covered by the filed claim, and adjusted for weather and building occupancy. The estimated production of solar energy from the installed PV array will be multiplied by a coefficient of 0.9 to adjust for weather uncertainty. The projected cost of energy for each fuel calculated in this way will be added together to determine a comparable projected net cost savings for purposes of this guarantee.

Subject to the terms of this guarantee, if the total cost of energy actually saved is less than the total cost of all projected energy savings, as calculated using the methodology described above, EFG will make a payment to the Owner(s) for the difference between the actual and projected total cost over the Guarantee Period, subject to the limitations stated in this agreement.

GUARANTEE LIMIT

Individual savings guarantee claims for any property participating in the Solar Access program shall be limited to $1,000. The total amount of claims paid out collectively to all Solar Access program participants shall be limited to $50,000.

ADJUSTMENTS

EFG reserves the right to modify and update the terms and conditions of this Guarantee at any time. The new Guarantee will be posted, and any previously filed claims will not be affected by the new terms.

MassCEC Solar Access Program
Energy Savings Guarantee Claims Form
OVERVIEW

Energy Futures Group (EFG), operating the Solar Access Program for the Massachusetts Clean Energy Center (MassCEC) guarantees that for two years following retrofit completion, the net energy cost savings[19] of sites participating in the program will equal or exceed the projected amount shown on the Solar Access Final Report. Your projected energy bills, based on current prices, including both electricity and heating fuels after project completion, are listed in note 1. If your actual net energy cost savings is less than the projection for the period, subject to the terms, restrictions, and adjustments (fuel prices, weather, occupancy, etc.) described in the guarantee language on the Solar Access Program website, you may be eligible to file a savings guarantee claim. After a claim has been filed, Solar Access program staff may conduct an in-home inspection to verify the validity of the claim and gather any relevant information. Solar Access Program staff will then calculate the amount of the claim according to the terms of the guarantee.

Claim calculations will be based on actual energy consumption as compared to projected consumption. The cost of both actual and projected consumption will be calculated based on the current price for each fuel at the time of the claim filing, as posted on the Massachusetts Department of Energy Resources "Home and Auto Fuel Prices" web page[20] Additional adjustments for weather conditions and SMART benefits will be made according to the terms of the savings guarantee as posted on the Solar Access program website[21].

Claims may be filed any time between 12 and 27 months following the retrofit completion (defined as the date of energizing of the heat pump system). Claims filed outside of this timeframe will be considered invalid.

Claims are limited to a maximum of $1,000 per property participating in the Solar Access program. The total amount of all claims paid out collectively to all Solar Access program participants will be limited to a maximum of $50,000.

CONTACT INFORMATION

Full Name: ______________________________

Address: ______________________________

____

[19] "Net energy cost savings" = your historical energy bills less your new energy bills including both electricity and heating fuels, adjusted for contemporary weather. This is "net" because it includes the total impact of heating fuel savings, increased electricity consumption for the heat pump, and solar PV electric production.
[20] https://www.mass.gov/home-and-auto-fuel-prices
[21] www.MassSolarAccess.org

Phone: ____

Email: ____

PROJECT INFORMATION

Date of Retrofit Completion (Heat Pump Energized): _______________

Total Projected Annual Fuel Usage ($): _____________________________

Period of Analysis (mm/dd/yr to mm/dd/yr):___________________________

Actual Total Fuel Usage for Period of Analysis ($): _______________

AVAILABILITY

Please indicate some dates and times when you would be available for Solar Access program staff person to inspect the issue and for your contractor to return to fix the issue identified.

____

____

REQUIRED: PLEASE ATTACH COPIES OF ALL FUEL BILLS COVERING THE PERDIOD FROM THE DATE OF RETROFIT COMPLETION (i.e., DATE OF THE BLOWER DOOR TEST-OUT PROCEDURE) TO ONE YEAR (365 DAYS) FOLLOWING THIS DATE. (ELECTRONICALLY SCANNED COPIES ARE ACCEPTABLE.)

Submit all forms to:
Electronic: SolarAccess@cetonline.org
Include in subject line: “Energy Savings Guarantee”
By Mail: Solar Access – Energy Savings Guarantee
Center for EcoTechnology
320 Riverside Dr., 1-A
Northampton, MA 01062
413-586-7350

SAVINGS GUARANTEE EXPENDITURE CERTIFICATION
(For Internal Use between EFG Team and MassCEC)

For submission with each invoice for Savings Guarantee Grant Funds. Include the following information:

Grantee Name: ____________________________________

Date Submitted: ____________________________________

Task Number: ______________________________________

Requested Amount: $________________________________

The following information about the customer should be included:

Full Name: ____

Address: ____

Phone:____

Email:____

Signature: ____

This Savings Guarantee Expenditure Certification is subject to the Agreement by and between Grantee and MassCEC. By signing below, the undersigned certifies that:

1. S/he is authorized to sign on behalf of the Grantee;

2. The amount requested accurately reflects the amount provided in Solar Access Savings Guarantees to consumers

By (signed): ______________________________________

Name: ______________________________________

Title: ______________________________________