California Energy Commission

PROGRAM DOCUMENT

Technology Demonstration Program Implementation Plan

Lead Locally, EPIC Grant EPC-17-041

Prepared for: **California Energy Commission**
Prepared by: **Sonoma Clean Power Authority**

Sonoma Clean Power

California Energy Commission

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PROJECT OVERVIEW

Sonoma Clean Power's (SCP) "Lead Locally" project (Project), funded through the California Energy Commission's (CEC) GFO-17-304 aims to identify strategies and technologies that can assist with the State's goals of doubling the efficiency of existing buildings by 2030. The Project will include applied research and technology deployment activities, each of which will propose innovations that could stimulate the energy efficiency market. With the applied research work, the team will investigate a series of innovative technologies that have the potential to be integrated into existing program models. Lessons learned from the applied research projects will be funneled directly to consumers, contractors, real estate professionals, and building officials through SCP and its local partner organizations. This technology demonstration and deployment work will be driven in part through the SCP "Advanced Energy Center", a physical storefront where consumers can directly procure energy efficient products and services. The Advanced Energy Center has the potential to:

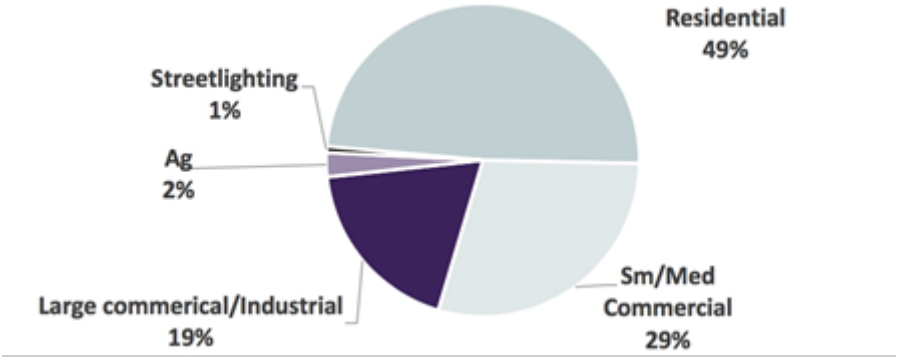
- demonstrate the appeal, impact, and efficiency of multiple advanced energy technologies through technologies showcases and displays, trainings, and the results from performance data at active Lead Locally demonstration sites
- speed deployment of energy efficiency, make energy efficiency programs more accessible to all customers, and increase customer knowledge of energy efficiency and energy code requirements.

About Sonoma Clean Power and its Customers

SCP is a public power provider operating as a community choice aggregator (CCA) and the default electricity provider for Sonoma and Mendocino Counties. SCP exists to provide broad public benefits relating to affordability, reliability, climate change and sustainability, coordination with local agencies, customer programs, and to support the local economy. The default service for SCP customers is CleanStart, which provides customer with 45% renewable power and 87% carbon free power (2017 Climate Registry certified values). SCP customers also have the option to select EverGreen service, which is 100% renewable power produced entirely within the SCP service area.

SCP serves just over 220,000 accounts, of which 86% are residential accounts. On an annual basis, SCP's load is comprised of about 50% residential energy use as shown in Figure P-1.

Fig P-1. SCP Customer Load for 2017



Sonoma Clean Power Authority (SCP), its employees, agents, contractors, and affiliates shall maintain the confidentiality of individual customers' names, service addresses, billing addresses, telephone numbers, email addresses, account numbers, and electricity consumption, except where reasonably necessary to conduct SCP's business or to provide services to customers as required by the California Public Utilities Commission (CPUC). SCP shall not, under any circumstance, disclose customer information for third-party telemarketing, e-mail, or direct mail solicitation. Aggregated data that cannot be traced to specific customers may be released at SCP's discretion.

Any questions or concerns regarding the collection, storage, use, or distribution of customer information, or those who wish to view, inquire about, or dispute any customer information held by SCP or limit the collection, use, or disclosure of such information, may contact Erica Torgerson, Director of Customer Service, via email at etorgerson@sonomacleanpower.org.

Project Team, Roles and Responsibilities

The technology demonstration team is comprised of the following parties (referenced in this document as the Team), with roles and responsibilities outlined below.

Sonoma Clean Power serves as the prime coordinator with the CEC, and will be responsible for identifying project sites, initial outreach to customers, operation of the Advanced Energy Center, customer records, and reporting Project progress to the CEC.

Frontier Energy's lead roles are management of the applied research and technology demonstration activities and associated subcontractors, execution of laboratory testing, installation of instrumentation at test sites, analysis of monitored data, energy modeling, and technical reporting. Frontier also provides technical and program support to SCP for Lead Locally and Advanced Energy Center customer engagement and project performance.

DNV-GL will provide independent Evaluation, Measurement, and Verification (EM&V) for the Project, specify required measurement points and accuracy levels for the instrumentation package, and evaluate performance relative to the metrics for success.

California Lighting Technology Center (CLTC) will manage the commercial daylighting applied research project, select and evaluate daylighting technologies in both laboratory and field test

settings, and assist in extrapolating field performance to estimate energy savings and peak electricity demand reduction for other space types and locations across California. CLTC will advise the Team during the technology demonstration and deployment phases.

Energy Docs and **Rick Chitwood** will design and install the ducted mini-split heat pumps and load reduction retrofits, and advise the Team during the radiant panel and mini-split technology demonstration and deployment phases.

PLT Multipoint and **Huvco** will serve as vendors for daylight harvesting sensors and daylight enhancement technologies, respectively, and provide informal design guidance and field test support throughout the project. Additional product vendors may join the Team and provide support as the Project proceeds.

Winwerks will serve as the vendor for phase change materials for commercial applications and will provide informal design guidance and field test support throughout the project. Insolcorp will provide additional advice and peer review technical plans and reports.

Aeroseal will participate in the planning of the aerosol sealing demonstration project and will provide peer reviews of all key reports.

Airscape will be consulted during the planning of the NightBreeze project and may serve as the vendor for key components of the selected system.

Mitsubishi will provide minisplit heat pumps at a discounted rate, and provide technical support to test activities and contractor training.

Chiltrix will provide air-to-water heat pumps at a discounted rate and assist with field test planning.

AO Smith and Rheem will provide heat pump water heaters at a discounted rate.

Warmboard will serve as the vendor for radiant panels and provide technical advice.

Ecodrain will provide discounted drainwater heat recovery devices and provide technical advice on lab and field test planning.

Olivine will support the enablement of the demand response component for grid-interactive heat pump water heaters through SCP's GridSavvy Community.

Sonoma County Regional Climate Protection Agency and BayREN will assist with training and staffing of the Advanced Energy Center.

Sonoma County Office of Energy and Sustainability will assist with training and staffing of the Advanced Energy Center.

Design Avenues LLC will assist with training and staffing of the Advanced Energy Center.

ABSTRACT

The purpose of this Technology Demonstration Program Implementation Plan (Plan) is to identify the activities and approaches that will be used by the project team to demonstrate how proven energy efficiency technologies can be installed, optimized, bundled, and promoted to effectively overcome known (and newly discovered) market barriers. The ultimate goal of the demonstration work is to provide lessons learned and momentum to accelerate the adoption of the most viable measures and in doing so contribute to meeting and potentially exceeding the Project's retrofit performance goals of 10% residential and 20% commercial site electric savings in a total of 300,000 square feet of existing building space.

This Plan presents high level baseline data on the energy efficiency market in Sonoma and Mendocino counties and outlines how that data and results from the applied research and technology demonstration sites will be used in the Advanced Energy Center to accelerate technology deployment. The Appendices of this Plan further detail currently available technology specific research plans and program policies, procedures, tools, and supports as relevant and necessary for the technology demonstration and deployment activities, including but not limited to: program implementation guidelines, program implementation schedule, and program reporting guidelines.

This Implementation Plan is a living document that will be updated quarterly for the duration of the Lead Locally Project. Updates will be informed by and consistent with evolving Project activities, including but not be limited to: findings from applied research and technology demonstration test sites; the plan and results of the *Optimal Retrofit Strategies Analysis*; successes and opportunities developed through the Advanced Energy Center and other Sonoma Clean Power initiatives; changes in the Sonoma/Mendocino building market and specifically fire-rebuild efforts.

Keywords: California Energy Commission, energy, buildings, technology demonstration, research, measurement, verification, EM&V, energy efficiency, low and moderate income; time-of-use; Advanced Energy Center; on-bill financing; minisplit heat pumps; heat recovery; aerosol sealing; phase change materials; heat pump water heaters; night ventilation; induction cooking.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

This Technology Demonstration Program Implementation Plan identifies the activities and approaches that will be used by the project team to demonstrate how proven energy efficiency technologies can be installed, optimized, bundled, and promoted to effectively overcome known (and newly discovered) market barriers. Technology demonstration activities will examine various drivers and barriers in the energy efficiency market in Sonoma and Mendocino counties and will establish how that data and results from the applied research and technology demonstration sites will be used in the Advanced Energy Center to accelerate technology deployment.

This Plan is a living document that will:

1. Address specific technologies potentially eligible for the Advanced Energy Center and as applicable provide research plans and data collection points for:

    a. Proven technologies, targeted for Applied Research and Technology Demonstration, which face market barriers, including: ducted mini-split heat pumps, grid-integrated heat pump water heaters, induction cooking, aerosol envelope sealing, waste heat recovery, PCMs in commercial applications, and economizer/ventilation cooling retrofits.

    b. Pre-commercial technologies demonstrated to be reliable and cost-effective based on Applied Research findings, including: optimizing control strategies for grid-integrated heat pump water heaters, radiant heating and cooling, enhanced commercial daylighting, and PCMs in residential applications.

    c. Other advanced energy efficiency and distributed energy technologies as necessary and as solicited through the Advanced Energy Center Request for Proposals.

2. Map how technologies will be supported for various customer classes and rate structures and integrate findings related to customer service, Demand Response, and grid-integration opportunities for appropriate technologies.

3. Outline business models for building professional/contractor services and customer and market demands.

4. Document existing energy efficiency programs offered to local customers and map how technologies will be supported with available incentives, including a combination of midstream rebates and on-bill repayment.

5. Establish program implementation guidelines, program implementation schedule, program reporting guidelines and technology and customer-class specific research questions for technology deployment.

CHAPTER 1: Introduction

The Lead Locally Grant is an innovative programmatic approach to existing buildings research, development and demonstration that includes a range of innovative technologies, program features, and market strategies to engage new customers in energy efficiency upgrades and deliver benefits to California's electric ratepayers. The Grant is led by Sonoma Clean Power (SCP) under funding by the California Energy Commission (CEC) through the Electric Program Investment Charge (EPIC) program. SCP is a community choice energy program providing electricity to 189,000 residential and 31,000 commercial customers in Sonoma and Mendocino Counties. This robust existing building initiative will also serve to complement current fire recovery efforts in Sonoma and Mendocino Counties, enabling SCP programs to have impact far and beyond the scope of this project.

The technology demonstration and deployment portion of Lead Locally focus on accelerating the adoption of proven technologies in existing residential and commercial buildings through demonstration sites and innovative program strategies and channels driven through the Sonoma Clean Power Advanced Energy Center. This includes:

- Technology Demonstration activities to demonstrate how proven energy efficiency technologies can be installed, optimized, bundled, and promoted to effectively overcome known (and newly discovered) market barriers.

- Technology Deployment activities to accelerate the adoption of the most viable Lead Locally measures and in doing so contribute to meeting and potentially exceeding the Project's retrofit performance goals of 10% residential and 20% commercial site electric savings in a total of 300,000 square feet of existing building space.

This Technology Demonstration Program Implementation Plan will support that work. It will document the activities and approaches that will be used by the project team to demonstrate how underutilized energy efficiency technologies perform in targeted applications, and how they might be effectively deployed to maximize energy savings in California. Technology demonstration activities will examine various drivers and barriers in the energy efficiency market in Sonoma and Mendocino counties and will establish how that data and results from the applied research and technology demonstration sites will be used in the Advanced Energy Center to accelerate technology deployment.

Purpose

This Plan presents high level baseline data on the energy efficiency market in Sonoma and Mendocino counties and outlines how that data and results from the applied research and technology demonstration sites will be used in the Advanced Energy Center to accelerate technology deployment. The Appendices of this Plan further detail currently available technology specific research plans and program policies, procedures, tools, and supports as relevant and necessary for the technology demonstration and deployment activities, including

but not limited to: program implementation guidelines, program implementation schedule, and program reporting guidelines.

Scope

This Implementation Plan is a living document that will be updated quarterly for the duration of the Lead Locally Project. Updates will be informed by and consistent with evolving Project activities, including but not be limited to: findings from applied research and technology demonstration test sites; the plan and results of the *Optimal Retrofit Strategies Analysis*; successes and opportunities developed through the Advanced Energy Center and other Sonoma Clean Power initiatives; changes in the Sonoma/Mendocino building market and specifically fire-rebuild efforts.

The Plan will be coordinated with the following Lead Locally activities:

- Input from Program Partners and the Technical Advisory Committee
- Ongoing engagement with administrators and implementers of complementary energy programs
- EM&V led by team member DNV-GL
- Other currently planned deliverables, including but not limited to:
    - *Advanced Energy Center RFP*
    - *Advanced Energy Center Outreach and Communication Plan*
    - *Advanced Energy Center Training Plan*
    - *Efficiency Optimizing Control Strategies for Grid Integrated Heat Pump Water Heater Report*
    - *Radiant Ceiling Heating and Cooling/Air to Water Heat Pumps Sizing and Installation Guide*
    - *Phase Change Materials in Residential Applications Best Practice Installation Guide*
    - *Optimal Retrofit Strategies Analysis*
    - *Technology Demonstration and Deployment EM&V Framework*

CHAPTER 2:
Lead Locally Technology Overview

This chapter describes the technologies that will be evaluated during the technology demonstration stage of Lead Locally. This includes expanded field demonstrations of the four applied research technologies, along with limited field verification of several additional market-ready technologies with some degree of performance or cost uncertainty when applied as retrofits in common building sectors in the relatively mild climates of Sonoma and Mendocino counties. Technical features are presented, along with discussion of target markets, energy savings potential, and preliminary deployment strategies.

Targeted Technologies

The first step in the selection of technologies for the demonstration phase of Lead Locally was to evaluate their potential relative to the priorities established through the CEC solicitation and the objectives of the proposed project:

- Commercially available
- Significant electricity savings potential that can help meet the target of 10% savings for residential buildings and 20% savings for commercial buildings
- Meaningful potential for load shifting, natural gas savings, and non-energy benefits
- Uncertain energy savings for the targeted application in the mild climates in the SCP service territory
- Uncertainty in cost of installation
- Uncertain customer acceptance based on comfort, aesthetics, or convenience
- Underutilization due to market, cost, or technology barriers that could be overcome to a large extent through Lead Locally initiatives

Successful completion of the Applied Research phase is an additional requirement for four of the technologies. Success factors are described in the Phase 1 and Phase 2 Research, Instrumentation, and Monitoring Plans (Hendron, et al., 2018) (Hendron, et al., 2019).

- Radiant panels with air-to-water heat pumps
- Phase change materials for residential attics
- Efficiency optimizing control strategies for grid interactive heat pump water heaters
- Commercial daylighting retrofits

Technology Overviews

Brief technology descriptions are provided in the following sections, along with a summary of key technology attributes in Table 1. More comprehensive technology overviews and detailed technology demonstration plans are included in APPENDIX A: Demonstration Research Plans.

Radiant Panels with Air-to-Water Heat Pumps

Radiant ceiling panels are surfaces imbedded in the ceiling that heat and cool a house without moving air. This is done by heating and cooling water that is pumped through tubing in the panels. Conventional air conditioners and furnaces provide comfort by heating and cooling air and circulating it through ducts, which often waste 20% of heating and cooling energy through air leakage into the attic or crawlspace. Radiant ceiling panels solve this problem by directly heating or cooling the ceiling surface, increasing comfort through radiative heat transfer while reducing the perception of drafts and minimizing energy losses to the attic. This technology will be considered for residential and small commercial applications.

Grid-integrated Heat Pump Water Heaters

Grid integrated heat pump water heaters (HPWHs) communicate with their local utility and can use this connectivity to enable more advanced control strategies. Currently this takes the form of implementing load shifting. Signals from the utility drive the HPWH to operate in a manner that shifts electricity use from the peak demand period by pre-heating hot water to a higher temperature in mid-afternoon when solar electricity contributes more power to the grid. This project demonstrates and verifies the performance of those systems by installing grid integrated HPWHs in houses in Sonoma Clean Power's service territory and monitoring utility bills pre and post retrofit to estimate their performance.

There is a related Applied Research topic, focusing on implementing machine learning and model predictive controls to minimize the electricity cost of operating HPWHs while maintaining hot water delivery performance. If the laboratory testing and simulation modeling in the Applied Research phase shows that the technology is viable, this project will implement and monitor it in a few demonstration sites as well.

These technologies are relevant primarily to single-family residential buildings but may also be viable in multi-family residential buildings with individual water heaters or some small commercial buildings with significant water heating loads.

Phase Change Materials

PCMs are materials that absorb heat as they melt and release heat as they freeze. Unlike sensible energy storage in thermal mass, energy storage in a phase change occurs over a relatively constant temperature and requires much less volume. PCM melting points can be tuned to match the needs of the application, making PCMs an appealing technology for use in building envelopes, including in walls and attics. PCMs do not contribute to the R-value of the building envelope, but when installed adjacent to the insulation, the PCM can reduce the temperature difference across the insulation while it freezes or melts, thereby reducing heat transfer into or out of the conditioned space. For Lead Locally, a macro-encapsulated PCM product called Infinite R will be studied as a method for enhancing the effectiveness of attic insulation in both residential and commercial buildings.

Commercial Daylighting Retrofits

Recent advances in daylight harvesting technologies and control algorithms have opened the door to greater integration with related building systems and optimized overall performance, offering the potential for significant energy savings and peak load reduction in the commercial retrofit market. However, some of these technologies require further evaluation individually and in combination before lighting designers will feel comfortable including them for commercial building retrofits. Specific technologies that will be investigated include dimmable light-emitting diode (LED) lighting with motion- and photo-sensor-based controls and integrated communication technologies. In addition, daylighting management technologies will also be considered to help realize electric lighting savings and provide additional HVAC energy savings through automated management of solar heat gain and possibly natural ventilation and cooling. These technologies include automated Venetian blinds, roll-down shades, electrochromic glazing, tubular daylighting devices, sun-tracking skylights with mirrors and/or optical fibers, along with motion-sensing for detection of occupancy and photo-sensing to determine light levels for illumination and potential for glare from direct solar penetration.

Ducted Mini-Split Heat Pump

A “heat pump” is a highly efficient air conditioner that can also work in reverse and provide heat during the winter. A “split” system is one that is split into two pieces: an “indoor unit” and an “outdoor unit.” A mini-split heat pump (MSHP) is just a smaller version that can vary the speed of its components to match the current needs of the home, using less energy in the process. A ducted mini-split typically has one indoor unit and distributes conditioned air throughout the house using compact ductwork, in contrast to a ductless mini-split which typically distributes refrigerant to multiple small indoor units, each with its own fan-coil and often with a separate thermostat. The retrofit package that will be evaluated for Lead Locally includes envelope improvements that will reduce the required capacity of the MSHP, and integrated supply ventilation to improve indoor air quality. This technology will be targeted primarily to the single-family residential market.

Induction Cooking

Natural gas and electric resistance cooktops and ranges currently share the vast majority of the residential and commercial markets in California. Electric induction cooktops offer increased efficiencies over both natural gas and coil electric resistance cooktops due to more efficient energy transfer and faster cook times. Induction cooking uses electromagnetism to heat the cookware, which must be made primarily of iron or another metal that responds to magnetic fields. Induction cooktops are market ready and have proven benefits, but there is uncertainty in market acceptance and installed energy savings for the technology. Lead Locally will provide an opportunity for customer education, deployment of induction stoves, quantification of savings through installation of circuit-level monitors, and evaluation of customer acceptance of the technology through post-installation surveys. This technology can be applied to both residential and commercial buildings.

Waste Heat Recovery

Lead Locally will examine the potential benefits and cost-effectiveness of several promising heat recovery technologies. Heat recovery ventilation (HRV) (which is a balanced system that exchanges energy between supply and exhaust air) is coming down in cost, though the technology has had reliability problems in the past, and energy savings tends to be lower in moderate climates like Sonoma County. Drain water heat recovery (DWHR) systems works in much the same way as heat recovery ventilation where incoming cold water is pre-heated by outgoing warm drain water from showers or dishwashers. Drain water heat exchangers can also be placed on the sewer main, where they capture heat from water exiting the building from all sources. During the cooling season, a direct expansion (DX) space cooling system condenser rejects heat to the outdoors. This heat can instead be used to heat the domestic hot water. A retrofit desuperheater is available on the market that we will investigate as a retrofit for residential DX units. Finally, a ducting kit to make use of "waste" cooling from a heat pump water heater will be studied. Several heat pump water heater manufacturers make a ducting kit to convey cold air off the heat pump evaporator to an area of the house that requires cooling, such as the kitchen. Depending on the specific technologies selected for further evaluation, they may be considered for either residential or commercial applications, or both.

Aerosol Envelope Sealing

The aerosol duct sealing process known as Aeroseal uses a vinyl compound suspended in a water solution, which is atomized and pumped through HVAC ducts and deposited at leakage points without coating the inside of the ducts. Responding to the need for an inexpensive, effective means of sealing building envelopes, a similar aerosol sealing process called Aerobarrier was developed. This process involves briefly pressurizing a building using a blower door, while injecting an aerosol "fog". As the air escapes through leaks in the exterior shell of the building, the aerosolized sealant is transported to the leaks, accumulates, and seals the leakage path as pressurized air tries to escape. The technology appears to be most promising for residential building applications, especially multi-family.

Nightbreeze/Economizer

Air-side economizers use low temperature outside air to provide cooling and can also be used to pre-cool buildings at night to offset next day air conditioner loads. Title 24 requires economizers for rooftop package units exceeding 54,000 Btuh in non-residential buildings, but the majority of existing small rooftop package units do not include them. Air-side economizers have the potential to mitigate the impact of air conditioning on California's increasing peak load by providing an alternative to air conditioners in milder climates that only rarely need them, such as much of Sonoma County. This project will evaluate the performance of a nighttime ventilation cooling system called NightBreeze that can be integrated with hydronic air handlers and furnaces. This technology will be targeted to the residential and small commercial markets.

Comparison of Selected Technologies

Important attributes of the nine technologies selected for technology demonstration projects, either directly or following successful completion of the applied research phase, are summarized in Table 1.

Table 1: Key Attributes of Proposed Technologies Selected for Demonstration.

Technology	Potential Electricity Savings	Other Benefits	Interactions with Other Measures	Targeted SCP Customer Segments
Radiant panels with air-to-water heat pumps	• 30% cooling • 20% heating (vs air-source heat pump)	• Comfort • Less allergen dispersion • Customizable	• Lower required capacity/cost when combined with load reduction • May require extra dehumidification	• Single-family • Small commercial
Grid-interactive heat pump water heaters	• 60% hot water (vs electric resistance water heater)	• Load shifting • Hot water availability during peak hours	• Savings may be enhanced by tank insulation or by moving into conditioned space	• Single-family • Small restaurants
Phase change materials	• 30% cooling • 10% heating	• Load shifting • Thermal comfort • Gas savings	• Whole house fan could accelerate energy discharge to attic at night • Less cost-effective if cooling load is reduced • Radiant barrier reduces PCM effectiveness	• Single-family • Small food service • Small industrial • Warehouses
Commercial daylighting retrofits	• 30-40% lighting • 10-15% cooling • -5% heating	• Peak load reduction • Less glare • Consistent light levels	• Less cost-effective when combined with high efficiency cooling system or LEDs • Control logic can include window operation for ventilation cooling	• Small/medium office • Small/medium retail • K-12 school
Ducted mini-split heat pump	• 20-30% heating and cooling (vs standard air-source heat pump)	• Peak load reduction • Reduced on/off cycling • Greater comfort	• Lower required capacity/cost when combined with load reduction • Allows integrated supply ventilation	• Single-family • Multi-family • Small office
Induction cooking	• 10-40% cooking (vs electric resistance)	• Cooking speed • Safety • Cleanliness • Peak load reduction	• May reduce kitchen ventilation hood requirements slightly	• Single-family • Commercial kitchens
Waste heat recovery for commercial dishwashers	• 30-50% hot water (for exhaust heat recovery)	• Gas savings • Thermal comfort (for HRV)	• Air-sealing retrofits may require addition of whole-house ventilation	• Single-family • Multi-family • Commercial kitchens • Small office
Aerosol envelope sealing	• 20% heating and cooling	• Gas savings • Less drafts	• Less cost-effective when combined with high efficiency cooling system	• Rented single-family (tenant turnover) • Multi-family (tenant turnover)
Residential nighttime ventilation	• 30% cooling	• Peak load reduction • Indoor air quality	• Less cost-effective when combined with high efficiency cooling system	• Single-family • Small commercial

Solicited Technologies

Several additional technology demonstrations will be conducted based on ideas presented through the Advanced Energy Center Vendor Request for Proposals. Manufacturers and vendors will be encouraged to present information about well-established market-ready retrofit products through a display booth at the Advanced Energy Center in Santa Rosa, while at the same time volunteering for demonstration projects that can verify the performance of new or unproven technologies. SCP and Frontier Energy will select 3-5 promising technologies and support site selection and field testing of the technologies in Sonoma or Mendocino County. More projects may be possible if one or more of the nine technologies discussed in the preceding section do not show sufficient promise relative to the success factors defined in Appendix A for technologies ready for demonstration, or the *Phase 1* or *Phase 2 Research, Instrumentation, and Monitoring Plan* for applied research technologies.

This section will be expanded once technologies have been selected, and further details are available about their energy savings potential, target markets, and other attributes.

Table 2: Key Attributes of Solicited Technologies Selected for Demonstration.

Technology	Potential Electricity Savings	Other Benefits	Interactions with Other Measures	Targeted SCP Customer Segments
To be determined				
To be determined				
To be determined				
To be determined				
To be determined				

Barriers to Adoption

Each of the technologies that will be included as demonstration projects must overcome one or more barriers to widespread adoption in Northern California. Some of these barriers are technical in nature, requiring improved engineering or manufacturing processes, or greater understanding of the interactions among technologies and the influence of climatic conditions. Cost barriers can sometimes be overcome through manufacturing improvements, or by greatly increasing the scale of production so equipment and facility costs can be spread among more products. Cost barriers can also be mitigated through performance improvements where the value of greater energy savings outweighs the high cost of the technology, or through special financing mechanisms such as rebates or on-bill financing. Finally, market barriers may be present due to a dominant market share owned by an existing company (often with a patent), regulatory hurdles (energy code, safety requirements, permitting), inadequate supply infrastructure, or simply lack of awareness by contractors and potential customers. Key barriers for each technology are summarized in Table 3.

Table 3: Barriers to adoption for Lead Locally technologies.

Technology	Technology Barriers	Cost Barriers	Market Barriers/ Knowledge Gaps
Radiant panels with air-to-water heat pumps	• Proof of effectiveness in occupied homes • Panel sizing methods	• High installation cost • Uncertain economic return • Low cost of gas vs electricity	• Perceived risk • Uncertain energy savings • Lack of infrastructure
Grid-integrated heat pump water heaters	• Load shifting not customized to occupants • Impossible to predict water use with certainty	• May only be cost-effective with time-of-use rates	• Unfamiliar to homeowners • Uncertain impact on hot water availability
Phase change materials	• Performance dependent on large temperature swings	• High material cost • Uncertain economic return	• Guidance required for design and installation • Unfamiliar to homeowners
Commercial daylighting retrofits	• Complex interactions may require extensive customization • Benefits mostly accrue off-peak	• May not be as cost effective as LEDs improve • High cost for some components	• Uncertain benefits • Guidance required for design and installation
Ducted mini-split heat pump	• Installed efficiency is often less than predicted • Envelope improvements often required	• High installation cost • Low cost of gas vs electricity	• Benefits can be difficult to explain to homeowners • Guidance required for design and installation
Induction cooking	• Requires iron cookware • May require electrical upgrade	• Low cost of gas vs electricity • Uncertain economic return	• General preference for gas cooking
Waste heat recovery	• Less effective in mild climates	• Uncertain economic return	• Lack of infrastructure
Aerosol envelope sealing	• Can be messy • Limited evidence of effectiveness for retrofits	• Expensive equipment required • Less cost-effective in mild climates	• May require unoccupied housing unit • Unfamiliar to homeowners • Lack of infrastructure
Night ventilation	• Controls unproven • May require pre-cooling	• High equipment cost	• May be negative comfort impacts • Lack of infrastructure

In addition to technology-specific barriers, there are broader structural, policy and program barriers and local small business challenges that limit customers', especially low-income customers', access to energy retrofits in existing buildings. These barriers often overlap, compounding one another, and may be mitigated but difficult to eradicate. Characteristics for each of these barriers and challenges as documented generally in California are summarized in Table 4. Many of these barriers are applicable in Sonoma and Mendocino territories and the Lead Locally team will further document relevant local conditions in the course of the Project.

Table 4: Broader barriers limiting access to energy retrofits in existing buildings.

Barriers/Challenges	Characteristics
Structural barriers	• Low home ownership • Complex needs, ownership, and financial arrangements of multifamily dwellings • Lack of access to capital or credit • Structural or design issues of a home due to building age • Remote locality
Policy and program barriers	• Ineffective market delivery • Poor integration, collaboration or leveraging among existing programs • Insecure, inadequate, or inequitable program funding • Data limitations • Unrecognized non-energy benefits
Local small business challenges	• Lack of incentives for local hiring and training • Insufficient targeted outreach • Financial obstacles related to business cost structure, self-financing requirements, and insufficient access to private funding • Lack of access to mentorship, networking, and subcontracting opportunities

Proposed Strategies for Technology Demonstration and Deployment

The Lead Locally team will leverage multiple strategies to advance the Technology Demonstration and Deployment activities in the Project.

Technology Demonstration activities are intended to demonstrate how proven energy efficiency technologies can be installed, optimized, bundled, and promoted to effectively overcome known (and newly discovered) market barriers. These activities will include:

- Site recruitment and selection activities similar to those outlined in the Project's *Report on Pre-Monitoring Activities* and *Research, Instrumentation, and Monitoring Plans*, including but not limited to:

    1. Site-Selection Criteria – essential, important, and desired test site features and conditions.
    2. Customer Data – review of existing Sonoma Clean Power customer data sets related to identified site-selection criteria.
    3. Customer Recruitment – outreach communications aligned with site-selection criteria and existing customer data, including interest form and customer calls to evaluate additional site-selection criteria not included in SCP data sets
    4. Site Visits and Analysis of Findings – visits to all interested and qualified sites to confirm eligibility and alignment with the needs of the technology demonstration projects.
    5. Engagement with Selected Sites – confirmation of the site's program participation, including SCP customer signature on the Program Participation Agreement.

- Research and data collection activities at Technology Demonstration test sites as documented in the Appendices of this Plan and as necessary for the Project's consideration of each technology. Test sites for these technologies are anticipated to include the following:

Table 5: Technology Demonstration Test Sites.

Technology	Targeted Number of Test Sites
Grid-Integrated Heat Pump Water Heaters	10 residential and commercial sites
Phase Change Materials	10 commercial sites
Ducted Mini-Split Heat Pumps	5 residential sites
Induction Cooking	5 residential and 2 commercial sites
Waste Heat Recovery for Commercial Dishwashing	3 commercial sites
Aerosol Envelope Sealing	10 residential sites
Nighttime Ventilation	10 residential sites

- Coordination with the Project's analysis of optimal retrofit strategies to inform potential bundling of measures and market deployment strategies. The analysis will be delivered in the *Optimal Retrofit Strategies Analysis Plan*.
- Further planning, coordination with, and launch of Lead Locally and other aligned resources to overcome identified market barriers during Technology Deployment activities.

Technology Deployment activities are intended accelerate the adoption of the most viable Lead Locally measures and in doing so contribute to meeting and potentially exceeding the Project's retrofit performance goals of 10% residential and 20% commercial site electric savings in a total of 300,000 square feet of existing building space. These activities will include:

- Development and operation of the Advanced Energy Center to:
    - demonstrate the appeal, impact, and efficiency of multiple advanced energy technologies through technology showcases and displays, trainings, and the results from performance data at active Lead Locally demonstration sites
    - speed deployment of energy efficiency, make energy efficiency programs more accessible to all customers, and increase customer knowledge of energy efficiency and energy code requirements.
- Development and hosting of trainings as identified in the *Advanced Energy Center Training Plan*.
- Leveraging of existing rebates and incentives (on-bill, etc.), including those documented later in this Implementation Plan
- Leveraging existing Lead Locally funded/SCP match funded incentives and developing new mechanisms as necessary, which will be further documented either in updates to this Implementation Plan or separate Lead Locally deliverables.
- Identifying opportunities for Demand Response and Grid-Integration and, based on information provided by SCP, strategies to maximize customer and system benefits for appropriate technologies such as heat pump water heaters and commercial daylighting.

- Coordination with the Sonoma County Office of Energy and Sustainability Programs and the Bay Area Regional Energy Network through the Sonoma County Reginal Climate Protection Authority.
- Coordination with Sonoma/Mendocino Wildfire Recovery and Reconstruction, including promotion of the SCP and PG&E Advanced Rebuild Program through the Advanced Energy Center and all appropriate and feasible local government channels including partnerships with Sonoma County agencies discussed above.

CHAPTER 3:
Serving SCP Customers through Lead Locally

Lead Locally activities are generally aligned with SCP's primary objectives for serving its customers. These are to:

- Provide cost competitive electric services;
- Stimulate and sustain the local economy by developing local jobs in renewable energy and energy efficiency;
- Reduce greenhouse gas emissions related to use of power in Sonoma and Mendocino Counties; implement energy efficiency and demand reduction programs;
- Develop long-term rate stability and energy reliability for residents through local control.

The Lead Locally Program will seek to deliver and document benefits consistent with these objectives, including: strategies and solutions that can deliver a substantial decrease in site greenhouse gas emissions; stable and competitive electric rates; public participation in determining which technologies are utilized to meet local electricity needs; and local/regional economic benefits.

Summary of SCP customer base

As of September 2018, SCP serves a population of approximately 525,000 people with 224,000 electric accounts across Sonoma and Mendocino counties, excluding only the incorporated cities of Healdsburg and Ukiah, which are served by municipal utility districts. These values factor in the 4,800 accounts lost when thousands of structures were destroyed (and several others yellow-tagged) due to the Wine Country fires in October 2017.

In aggregate, 86% of SCP's accounts are residential, accounting for approximately 50% of its load. Table 6 shows the load breakdown in SCP territory relative to the State of California.

Table 6: Share of Total Electricity Consumption for SCP and California

Territory	Residential	Sm/Med Commercial	Large Commercial /Industrial	Agriculture	Transportation/ Streetlighting
SCP	49%	29%	19%	2%	1%
California	32%	37%	17%	8%	6%

The population in Sonoma and Mendocino County have experienced similar significant shifts in the composition of its population, for example:

- Hispanic or Latinos represented 24 percent of Sonoma County and 22 percent of Mendocino County residents in 2010, up from 17 percent and 16 percent in 2000, respectively
- Over 28 percent of Sonoma County residents and 32 percent of Mendocino County are now 55 years or older and the county's median age is five and seven years older than the state median of 34, respectively
- Ten percent of Sonoma County and seven percent of Mendocino County residents were living at or below the Federal Poverty level (of $10,956 per year) in 2008 and 2010, respectively

Table 7 summarizes the additional information on SCP customer classes.

Table 7: SCP Customer Classes

Low income CARE/FERA customers	Solar customers (all on TOU rates)	EV customers (all on TOU rates)	TOU Customers (including Solar/EV customers)
16%	3.6%	1.3%	18.5%

Table 8 demonstrates the housing composition of residential SCP customers relative to the State of California.

Table 8: Housing Composition of SCP Customers and California[1]

Geography	Single Family Homes (detached and attached)	Multi-Family Units (2+)
Sonoma County	159,048	38,556
Menodcino County	31,124	5,325
California	9,109,826	4,352,807

Economic drivers, including touring, agriculture and ranching, are also shared by Sonoma County and Mendocino County. Other industries specific to Sonoma County include healthcare and medical devices, technology and education. Table 9 demonstrates the composition of commercial and industrial SCP customers relative to the State of California.

[1] 2017 American Community Survey; Selected Housing Characteristics. https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml

Table 9: Composition of commercial and industrial SCP Customers and California[2]

Territory	Sm/Med Commercial	Large Commercial/ Industrial	Municipal/ Government	Agriculture
Sonoma County	18,137	0	N/A	539
California	1,472,721	1,944	36,019	16,402

Additionally, the buildings characteristics of SCP customers vary depending on the age and locality of the structure. Recently built or renovated buildings may be equipped with rooftop solar panel (PV) systems and electrical vehicle service equipment (EVSE), and, buildings in more remote areas may rely on propane or wood for heating.

Lead Locally Technologies and SCP Customers

While Lead Locally technologies will be available to all SCP customers, the associated impacts, concerns and needs will depend on the customer segment. Customer segmentation includes:

1. **Low-income customers**. Low-income customers will require access to capital or credit unavailable through existing incentive programs.
2. **Photovoltaic (PV) system and electric vehicle (EV) owners.** Customers with installed PV systems and EVSE will require information about how Lead Locally technologies may interact with these systems.
3. **Time of Use (TOU) customers.** TOU customers will need to be aware of how specific Lead Locally technologies impact their electricity costs during times of peak pricing.
4. **Propane users.** Propane users will need to know that Lead Locally technologies are functional alongside propane fueled equipment without causing any disruptions, or know the cost and greenhouse gas savings of replacing their propane appliances.
5. **Yellow-tagged property owners.** A yellow-tagged building means Cal Fire deemed the structure is safe to occupy after the 2017 wine country fires, but that it requires repairs and permits from the City. Installation of Lead Locally technologies may require additional work and financial investment.

Anticipated impacts, interactions or concerns between customer segment and Lead Locally technologies are outlined in Table 9.

[2] State of California Employment Development Department; Size of Business Data including Data for Metropolitan Areas for Santa Rosa – Petaluma MSA and Third Quarter Payroll and Number of Businesses by Size of Business - Classified by Industry (Table 2A) for 2017; https://www.labormarketinfo.edd.ca.gov/LMID/Size_of_Business_Data.html. Small/Medium Commercial for purposes of this table is defined as businesses with less than 500 employees.

Table 10: Impacts, Interactions and Concerns Between Customer and Lead Locally technologies

Technology	Low income CARE/FERA customers	Solar/EV customers (all on TOU rates)	TOU Customers (including Solar/EV customers)	Propane Users	Yellow tagged properties
Radiant panels with air-to-water heat pumps	• May be eligible for existing programs incentivizing heat pumps. May need financing to combat high initial installation costs.	• May reduce electric bill by greatly reducing load during the high price late afternoon period • No interaction with EV	• Little impact	• No available existing programs to help offset costs, so additional financing/funding may be needed.	• May ease installation in buildings replacing heavily damaged roofs and HVAC systems
Grid-integrated heat pump water heaters	• May be eligible for existing programs incentivizing heat pump water heater replacements if replacing electric water heater. May need financing to combat high initial installation costs.	• May reduce electric bill by shifting load from the high price late afternoon period to a lower price mid-day period	• May reduce electric bill by shifting load from the high price late afternoon period to a lower price mid-day period	• No available existing programs to help offset costs, so additional financing/funding may be needed.	• May be too expensive for homeowners without an existing electric water heater
Phase change materials	• Ineligible for incentives as a stand alone technology; if integrated into an insulation package then that package could be rebate eligible reducing overall costs	• PCM will reduce electricity demand during peak periods when TOU rates are high, and shift some of the electricity use to off-peak hours when TOU rates are low	• PCM will reduce electricity demand during peak periods when TOU rates are high, and shift some of the electricity use to off-peak hours when TOU rates are low	• PCM may reduce heating energy from propane systems	• If insulation is heavily damaged and must be replaced, including PCM under insulation will make it cheaper to install
Commercial daylighting retrofits	• May be eligible for existing program incentives	• No interaction with PV or EV	• Little impact	• No interaction with propane heating systems	• May ease installation in buildings replacing heavily damaged fenestration
Ducted mini-split heat pump	• May be eligible for ducted system and mini split heat pump incentives	• May reduce electricity demand during peak periods when TOU rates are high • No interaction with EV	• Little impact	• No available existing programs to help offset costs, so additional financing/funding may be needed.	• May be ideal for yellow-tagged properties where insulation and the HVAC system are heavily damaged and must be replaced

Induction cooking	• Ineligible for existing program incentives	• May reduce electricity demand during peak periods when TOU rates are high • No interaction with EV	• Little impact	• No interaction with propane heating systems	• May be a concern for yellow-tagged homes requiring kitchen counter rearrangement or new electrical lines
Waste heat recovery for commercial dishwashers	• Ineligible for existing program incentives	• May reduce electricity demand during peak periods when TOU rates are high • No interaction with EV	• May impact time TOU rates depending on water heating fuel source and usage pattern	• May lower the use of a propane heater by lowering the total CFM load	• May ease installation in the whole kitchen/scullery space if exhaust hoods are heavily damaged and need to be replaced
Aerosol envelope sealing	• May be eligible for existing programs incentivizing envelope measures	• No interaction with PV or EV	• Little impact	• Housing units using unvented propone heaters should be approached with caution	• Unoccupied housing units would make a good candidate
Nighttime ventilation	• Ineligible for existing program incentives	• No interaction with PV or EV	• No impact	• No interaction with propane heating systems	• May be less expensive if replacing heavily damaged attic

CHAPTER 4:
Engaging Building Professionals

The Lead Locally project will build on lessons learned by SCP and Lead Locally team members through multiple existing building retrofit programs and initiatives. Leveraging SCP's strong market presence and its ability to aggregate customer demand and access, the Lead Locally program will seek to engage building professionals in several ways.

Technology Demonstration activities that specifically focus on supporting contractors and other building professionals will include:

- Support for the *Advanced Energy Center Training Plan*, including the integration of Applied Research deliverables into contractor trainings and other workforce education including but not limited to the following:
    - *Efficiency Optimizing Control Strategies for Grid Integrated Heat Pump Water Heater Report*
    - *Radiant Ceiling Heating and Cooling/Air to Water Heat Pumps Sizing and Installation Guide*
    - *Phase Change Materials in Residential Applications Best Practice Installation Guide*
- Assessment of business models for building professional/contractor services and customer and market demands and mapping these models to Advanced Energy Center technologies and available incentives.
- Alignment of contractor and building professional messaging and outreach with the *Advanced Energy Center Outreach and Communication Plan*.

Technology Deployment activities that focus on building professionals will include:

- Trainings as discussed in the *Advanced Energy Center Training Plan*. While the topics of these trainings may evolve over the life of the contract, the team anticipates the first training topics to be focused on:
    - Installation best practices (targeting contractors);
    - Permitting, energy modeling, and inspections (targeting building officials and HERS raters);
    - Energy efficiency valuation, energy feature search optimization for the Multiple Listing Service (MLS), and permitting benefits (targeting assessors, mortgage underwriters, and other real estate professionals).
- A suite of monthly workshops and contractor "meet and greet" events, including technology demonstrations and other programming to connect consumers to contractors and HERS raters.

- General efforts to promote existing efficiency programs to building professionals to facilitate their understanding of program benefits, eligibility and enrollment requirements.
- Specific efforts to tailor energy efficiency and other incentive programs offered by SCP to allow for easy access from Sonoma and Mendocino contractor communities as further profiled in this section of the Implementation Plan.

Overview of contractor/workforce in SCP territory

The energy efficiency workforce in SCP territory must navigate many of the same barriers and issues based by contractors performing this type of work across the state. Sonoma has urban as well as very rural communities. Contractors typically cover a large geography and provide services to a range of customers and building types with multiple energy end uses and fuel types. Understanding this workforce and the pressures and opportunities it faces will help Lead Locally align program activities in a way to drive success towards Lead Locally program objectives. It is important to note that for the duration of the Lead Locally project these pressures are likely to include pressures related to the fire rebuild process, including but not limited to increased labor costs, shortages of potential high demand contractor skill sets and building materials, and building department approval and inspection delays.

Table 11: Summary of Contractor Community in SCP Territory.[3]

Technology	CSLB License					PG&E Home Upgrade	BayREN Single Family	SCEIP
	B General	C-2 Insulation	C-10 Electrical	C-20 HVAC	C-36 Plumbing			
Sonoma County	2,385	34	500	161	273	6*	24	93
Mendocino County	482	3	98	31	57	1^	0	0
Statewide or Program Total	*96,401*	*987*	*23,047*	*10,745*	*13,950*	*N/A*	*89*	*128*

* Participating contractors located within 50-mile radius from zip code 95404 (Santa Rosa)

^ Participating contractors located within 50-mile radius from zip code 95490 (Willits)

[3] Information regarding CSLB licensing is based on list of licensed California contractors provided by CSLB to members of the Lead Locally team in January 2018. Program information is from program websites accessed February 1, 2019, including: https://www.pge.com/en_US/residential/save-energy-money/savings-programs/home-upgrade/find-contractors.page; https://www.bayareaenergyupgrade.org/find-a-contractor.html; https://sonomacountyenergy.force.com/financing/s/find-a-contractor

Existing Local Training Resources

There are multiple existing training resources that may be able to support Lead Locally's engagement of building professionals contingent upon availability and ease of access. Training channels and opportunities will be leveraged as appropriate from the statewide Energy Upgrade Program and local efforts by PG&E, BayREN, and partnered agencies. These trainings currently address topics as outlined below; supporting websites are listed to provide access to the most up-to-date training information from these partners. Training activities will be more fully detailed in the *Advanced Energy Center Training Plan* and will include but not be limited to:

- Energy Upgrade Trainings. http://homeupgrade.org/events/; https://www.bayareaenergyupgrade.org/for-contractors.html
    - Home Upgrade Core Training: This course provides essential training for contractors who wish to offer Home Upgrade rebates to their clients who receive Pacific Gas and Electric Company (PG&E) gas or electric service. Teaches fundamentals of building science and gain practical experience with core measures in the Home Upgrade program.
    - AC Quality Care Technical Training: This one-day technical training prepares contractors and their staff to participate in the AC Quality Care Rebate Program. Provides experienced HVAC technicians with the knowledge and hands-on experience to perform ACCA 4 (Residential HVAC Quality Maintenance) assessments and repairs. Topics include duct repair and replacement, air distribution, refrigeration, and other best practices.
    - Advanced Technical Training for Home Upgrade: This two-day course is required for all Building Performance Institute (BPI) professionals or raters/analysts who wish to submit combustion appliance safety test results to Pacific Gas and Electric Company's (PG&E) Home Upgrade Program. The course focuses on supplementary combustion appliance safety protocols that augment those specified by BPI. It also provides training on proper duct testing techniques, which are not covered by BPI-certified professional training, and program installation specifications.
- The Sonoma County Office of Energy and Sustainability Trainings: https://sonomacounty.ca.gov/General-Services/Energy-and-Sustainability/Calendar/
- The North Coast Builders Exchange Trainings: http://ncbeonline.com/seminars-and-events/
- Trainings for specific Lead Locally technologies as provided by participating vendors.

Lead Locally Technologies and Building Professionals

All contractors installing Lead Locally technologies and/or promoted through the Advanced Energy Center will be required to hold an active Contractor's State License Board (CSLB) license appropriate for the scope of work. Contractors will be required to document commercial general liability insurance policy or policies and appropriate bonding. The team will verify that CSLB license number matches business name or DBA (doing business as) on record.

Table 12: Contractor Business Requirements for Lead Locally Technologies.

Technology	Required Licenses/ Certifications*	Best fit existing business models	Lead Locally Strategies to accelerate contractor participation
Radiant panels with air-to-water heat pumps	• CSLB B • C-20 • C-36	• Plumber • HVAC • Remodel/ Additions • New construction design-build	• Trade and industry group • Permit counters • Workforce training centers • Outreach to contractors participating in energy programs across CCAs, utilities and regional energy network programs • Team provided training and support to support quality installations • Lead Locally will rely on trained licensed contractors who can serve as models for others in their trades and for this reason case studies can be created in shared across contractor networks
Grid-integrated heat pump water heaters	• C-10 • C-36	• HVAC • Remodel/ Additions • New construction design-build	
Phase change materials	• C-2	• Insulation • Remodel/ Additions • New construction design-build	
Commercial daylighting retrofits	• CSLB B • C-10	• Electrician • Remodel/ Additions • New construction design-build	
Ducted mini-split heat pump	• C-20	• HVAC • Remodel/ Additions • New construction design-build	
Induction cooking	• None required	• Kitchen Equipment Retailers	
Waste heat recovery	• C-20 • C-36	• Plumber • HVAC • Remodel/ Additions • New construction design-build	
Aerosol envelope sealing	• C-2	• HVAC	
Nightbreeze/ Economizer	• C-20	• HVAC	

* **Contractor State License Board License key**: CSLB B - General Building Contractor; C-2 - Insulation and Acoustical Contractor; C10 - Electrical Contractor; C20 - Warm-Air Heating, Ventilating and Air-Conditioning Contractor; C36 - Plumbing Contractor

Lead Locally will use a variety of contractor outreach approaches, including:

- Licensed and qualified contractors will be listed on a consumer website, sending leads directly to contractors.
- Contractors will attend orientation and training sessions, to learn best practices and proper installation of the various technologies.
- Key messages that resonate with homeowners along with information to give potential customers will be provided through flyers, webinars and other training channels.
- An online resource library will reinforce and supplement classroom training.

CHAPTER 5:
Existing Aligned Energy Efficiency Programs

SCP customers have access to a myriad of federal, statewide, regional, and local energy efficiency programs designed to both incentivize single-measure and deep energy (comprehensive) retrofits for residential and commercial buildings. These incentives are provided in the form of rebates (downstream and mid-stream) and financing; however, eligibility can be inequitable for renters and customers of emerging technologies. Many programs are limited to property owners and, at least for those supported through the CPUC's Energy Efficiency Portfolio, require that eligible technologies have been approved for deemed energy savings or can be modeled in specific energy modeling software.

Overview of applicable Programs

To maintain a current understanding of how incentives may be leveraged to support the installation of Lead Locally technologies, SCP and the Lead Locally team researched applicable programs including but not limited to those identified below. This includes review of program websites and materials and direct engagement with program staff through phone calls and emails. Additional details on these programs are included in Appendix C.

Table 13: Lead Locally Technologies and Existing Energy Efficiency Programs

Program Name	Website (reviewed for program information)	Incentive Type	Direct Engagement	Sector Relevance	Lead Locally Technologies Supported
Sonoma County Energy Independence Program (SCEIP)	https://sonomacountyenergy.force.com/financing/s/	Financing (PACE)	Ongoing	RES, COM	DMSHP, Aerobarier Sealing, GIHPWH
PG&E Advanced Home Upgrade	https://www.pge.com/en_US/residential/save-energy-money/savings-programs/home-upgrade/home-upgrade.page	Rebates	Ongoing	RES	Awaiting program relaunch documents
PGE Residential Single Measure rebates	https://www.pge.com/en_US/small-medium-business/save-energy-and-money/rebates-and-incentives/product-rebates.page?WT.mc_id=Vanity_businessrebates	Rebates	Ongoing	RES	GIHPWH, Smart thermostats
PGE Commercial Single Measure Rebates	https://www.pge.com/en_US/small-medium-business/save-energy-and-money/rebates-and-incentives/product-rebates.page?WT.mc_id=Vanity_businessrebates	Rebates	Ongoing	COM	Nightbreeze/Economizer
PGE Multifamily Upgrade	https://www.pge.com/en_US/residential/save-energy-money/savings-solutions-and-rebates/multifamily-rebates/multifamily-rebates.page	Rebate	To be initiated	RES	To be determined based on engagement with program administrators
PG&E On-Bill Financing	https://www.pge.com/en_US/business/save-energy-money/financing/energy-efficiency-financing/energy-efficiency-financing.page	Financing	Ongoing	COM	All commercial technologies if part of a compliant project.
BayREN Home+	https://www.bayareaenergyupgrade.org/	Rebate	Ongoing	RES	DMSHP, Aerobarrier Sealing, RPAWHP, GIHPWH
BayREN Multifamily	https://bayareamultifamily.org/	Rebate	Ongoing	RES	Contingent on potential to model technology's energy savings; anticipate eligibility for MSHP, Aerobarrier Sealing, GIHPWH
BayREN Commercial	https://www.bayren.org/commercial	Rebate	To be initiated	COM	Program not launched yet.
SCP/PG&E Advanced Energy Rebuild	https://sonomacleanpower.org/programs/advanced-energy-rebuild	Rebate	Ongoing	RES	Induction Cooking, Aerobarrier Sealing, RPAWHP, GIHPWH, DMSHP
Energy Conservation Subsidy Exclusion (Personal & Corporate)	https://www.irs.gov/publications/p525	Tax Benefit	To be initiated	RES, COM	All measures receiving a public utility energy conservation subsidy.
Fannie Mae Green Initiative- Loan Program	https://www.fanniemae.com/singlefamily/homestyle-energy	Financing	To be initiated	RES	To be determined based on engagement with program administrators

Program Name	Website (reviewed for program information)	Incentive Type	Direct Engagement	Sector Relevance	Lead Locally Technologies Supported
Residential Energy Efficiency Loans (REEL)	https://gogreenfinancing.com/residential	Financing	Ongoing	RES	DMSHP, RPAWHP, GIHPWH, Aerobarrier Sealing
CAEATFA Small Business Financing	https://gogreenfinancing.com/smallbusiness	Financing	To be initiated	COM	Program not launched yet.
CaliforniaFIRST	https://renewfinancial.com/homeowners/california-first	Financing (PACE)	To be initiated	RES, COM	To be determined based on engagement with program administrators
Ygrene	https://ygrene.com/	Financing (PACE)	To be initiated	RES, COM	To be determined based on engagement with program administrators
Renovate America HERO	https://www.renovateamerica.com/financing/hero	Financing (PACE)	To be initiated	RES	To be determined based on engagement with program administrators
Weatherization Assistance Program (WAP)	https://www.energy.gov/eere/wipo/weatherization-assistance-program	Grant Program	Ongoing	RES	Not on offer at Sonoma & Mendocino Counties in current year.
FHA Energy Efficient Mortgage	https://www.hud.gov/program_offices/housing/sfh/eem/energy-r	Financing	To be initiated	RES	To be determined based on engagement with program administrators
FHA PowerSaver Loan	https://www.hud.gov/program_offices/housing/sfh/title/ti_abou	Financing	To be initiated	RES	To be determined based on engagement with program administrators
Veterans Administration Energy Mortgage	https://www.benefits.va.gov/warms/docs/admin26/pamphlet/pam26_7/ch07.doc	Financing	To be initiated	RES	To be determined based on engagement with program administrators

SCP incentives to address gaps in existing programs

SCP is currently evaluating gaps in these existing programs to determine if there is any need for SCP to offer additional incentives to further support Lead Locally technologies. SCP support may involve direct-to-consumer rebates, manufacturer/distributor up-stream rebates, and financing and or on-bill repayment. As necessary, any SCP incentive that will be included as part of the Lead Locally project will be detailed in updates to this Implementation Plan.

CHAPTER 6:
Advanced Energy Center Services

Lead Locally technology demonstration and deployment work will be driven in part through the SCP Advanced Energy Center, a physical storefront where consumers can directly procure energy efficient products and services. The Advanced Energy Center has the potential to:

- demonstrate the appeal, impact, and efficiency of multiple advanced energy technologies through technologies showcases and displays, trainings, and the results from performance data at active Lead Locally demonstration sites
- speed deployment of energy efficiency, make energy efficiency programs more accessible to all customers, and increase customer knowledge of energy efficiency and energy code requirements.

Advanced Energy Center Overview

The Advanced Energy Center will be a true innovation for energy efficiency - many utilities and local governments educate end users about energy efficiency generally, but few if any directly link those end-users to the products and services that will deliver energy savings. The project will provide the latest research results, demonstration data, case studies, installation details, and performance information to the Marketplace to break down that barrier to adoption and maximize the opportunity of the Sonoma Clean Power customer relationship to truly provide residents and businesses with actionable information, resources, and experiences to make energy efficiency purchases. The Advanced Energy Center will capitalize on extensive match funding from Sonoma Clean Power and in-kind staffing resources from the Sonoma County Regional Climate Protection Authority and the County of Sonoma's Office Energy and Sustainability.

Ultimately, the Advanced Energy Center will be a place for all SCP customers and community stakeholders (building professionals, real estate professionals, and other key audiences) to come together to learn about and access advanced energy technologies. General SCP and other leveraged communication and outreach channels through Office of Energy and Sustainability, the Sonoma County RCPA, PG&E, and other partners will be used to promote the Advanced Energy Center and its services. Special attention will be focused on customers with existing residential and commercial buildings. As the Advanced Energy Center evolves, targeting of specific customer groups is anticipated to include:

- General outreach to SCP residential and commercial customers.
- Customers on existing all-electric rates (i.e., already with electric space and water heating)
- Customers with peak summer electric use and high cooling loads
- Customer electric load shapes that would benefit from additional technologies to be identified through the *Advanced Energy Center RFP*

- Customers well suited for bundled technology packages, including those identified in *Optimal Retrofit Strategies Analysis*.
- Customers with high base natural gas loads that may benefit from water heater or cooking upgrades
- Customers applying for specific permits for retrofit or alteration projects aligned with Advanced Energy Center technologies, i.e., water heater replacement, through SCP partnerships with Sonoma and Mendocino County build departments.

The Advanced Energy Center will promote a wide range of energy efficient technologies, including proven technologies from the Applied Research and Technology Demonstration activities as well as market ready and common retrofit technologies solicited by SCP through the Lead Locally *Advanced Energy Center RFP*. SCP will add and/or rotate vendors as additional technologies become viable throughout the length on the contract. The research and development plan specific to each technology included in the Technology Demonstration work are detailed in the Appendices of this *Implementation Plan*.

With the creation of an Advanced Energy Center RFP, the team is primed to adapt and add technologies throughout and even after the life of the grant. If proven successful, Sonoma Clean Power has an annual programs-related budget of approximately $6,000,000-$7,000,000 which can be used to maintain the Advanced Energy Center. Additionally, due to the strong local partnerships of Sonoma Clean Power and the interest in the Advanced Energy Center concept, it is anticipated that there is the potential to work with organizations such as Sonoma and Mendocino counties, the Regional Climate Protection Authority, and the Sonoma County Water Agency--all of which have co-funded programs with Sonoma Clean Power in the past--to continue funding the Advanced Energy Center after the life of the grant.

Services and supports

The Advanced Energy Center will include a brick-and-mortar storefront as well as an online presence. Part museum and part store, the team envisions the Advanced Energy Center as not only an educational tool, but as a means for customers to more directly participate in energy efficiency programs. The store will be complemented by the online Advanced Energy Center Contractor Matching Tool. Lower costs will be achieved through a dual approach of leveraging all available incentives and decreasing contractor installation prices by providing training and direct customer access. Customer education and outreach will help drive sales by focusing on energy and non-energy benefits and the return on investment from reduced customer utility bills and other cost savings from the targeted energy efficiency measures.

- **Technology Displays and Demonstrations:** Participating vendors in the Advanced Energy Center will be required to provide an interactive technology display and product testing data to be used for EM&V purposes.
- **Program Information:** Collateral and educational displays will provide information, referral, and other enrollment details for complementary energy efficiency programs, including those identified in this Implementation Plan as supportive of Advanced Energy Center technologies

- **Purchase Options:** Technologies featured in the Advanced Energy Center will be available for use and purchase on-site. On-line and in-store visitors will enjoy easy to navigate information tools to calculate payback by make and model to find their ideal solution. A mobile app will scan QR codes in the Advanced Energy Center and other stores to create personalized lists of technologies and match technologies to available incentive programs.
- **Installation Support:** A contractor matching service will help customers a contractor to install the equipment within a week. To facilitate speedy installation, SCP will investigate an automated scheduling tool where participating contractors and HERS raters can input desired scheduling blocks. Customers can then be "matched" with a participating contractor with the appropriate schedule and training. The Advanced Energy Center will also feature contractor/property owner work spaces to allow for project consultations to take place alongside the technology demonstrations.
- **Demand Response/Grid-Integration:** For Lead Locally technologies that can be integrated into the existing Sonoma Clean Power DR platform for additional grid reliability gains, information on DR benefits (both from a technology as well as price savings perspective) and supporting rate structures will be provided through the Advanced Energy Center. As possible, DR benefits will be presented based on individual customer energy use profiles and project proposals.
- **Contractor and property owner trainings:** Trainings hosted at the Advanced Energy Center will address topics including but not limited to installation best practices, technology optimization and bundling options, safety benefits, and inspection techniques.
- **Coordination with Fire Recovery and Advanced Energy Rebuild**: The Advanced Energy Center will be open to and address the needs of all Sonoma Clean Power customers, including those with rebuild needs from the wild fire recovery.

Additional information related to these activities will be documented either in future updates to this Implementation Plan or other Lead Locally deliverables as appropriate, including the:

- *Advanced Energy Center RFP*
- *Energy Advanced Energy Center Outreach and Communication Plan*
- *Advanced Energy Center Training Plan*
- *Efficiency Optimizing Control Strategies for Grid Integrated Heat Pump Water Heater Report*
- *Radiant Ceiling Heating and Cooling/Air to Water Heat Pumps Sizing and Installation Guide*
- *Phase Change Materials in Residential Applications Best Practice Installation Guide*
- *Optimal Retrofit Strategies Analysis*

CHAPTER 7:
Documenting Program Activities

The Lead Locally program will rely heavily on documentation for effective management of research and deployment activities. All technical results will be reviewed for accuracy, objectivity, and validity. Outreach materials will be tailored to the appropriate audience and describe results and conclusions in a clear and concise manner. Documentation plays an important role in planning program activities, coordinating work efforts, evaluating retrofit performance, and communicating lessons learned to program partners and stakeholders throughout California. Key information to be documented depends on the purpose of the activity and key audiences, as described in the following sections. Additional

Phase 1 and Phase 2 Pre-Monitoring & Applied Research

For applied research projects it is essential to plan activities in sufficient detail to demonstrate that important research questions will be answered with sufficient accuracy to allow progression to the demonstration phase with high confidence that the technology will perform as expected in occupied buildings. Senior engineering staff at Frontier and DNV GL review all research plans to make sure the results will be meaningful and accurate. The TAC and selected experts in the field also review the plans for technical quality, objectivity and value to the industry. Finally, all plans are reviewed by industry partners to make sure they are comfortable that the results will be fair to their product and provide meaningful feedback for future product improvements if needed.

Results of laboratory testing, pre- and post-retrofit monitoring of field test sites, and building simulation will be fully documented through interim reports included in the *Monthly Progress Reports* (MPRs), and final reports when the research is complete. An additional round of peer reviews will verify that the results and conclusions are valid based on the data collected during the project. Installation guides will be developed for at least two technologies (PCMs and radiant panels) to help trades understand best practices for installing retrofits in a manner that results in high energy savings, improved occupant comfort, and affordable costs. Field test and simulation results will also feed into the EM&V process, where the results will be used to determine whether success factors have been achieved and to evaluate readiness for technology demonstrations and/or deployment throughout Northern California. Finally, the knowledge base will be expanded through technology transfer to energy efficiency programs and the scientific community, including presentations to stakeholders and peer-reviewed publications.

Technology Demonstration

Research plans for technology demonstrations are included in APPENDIX A: Demonstration Research Plans. These plans have been extensively reviewed by the Team, industry partners, and experts in the corresponding technical field. The TAC will also be invited to review these plans in late February 2019. Similar to applied research plans, the technology demonstration

plans document the technologies that will be evaluated, key research questions, and the steps necessary to answer those questions. Some details will evolve as the demonstrations are executed based on preliminary results, and these changes will be reflected in the quarterly updates to the Plan.

Research results will be thoroughly documented in interim and final reports, and conclusions will be drawn from these results to determine readiness for inclusion of the technology in the Advanced Energy Center and broader deployment through other vehicles. Internal and external peer reviews will be used to validate technical results and important conclusions. As described for applied research projects, key results and lessons learned will be communicated to industry partners and program implementers through Lead Locally technology transfer initiatives.

Technology Deployment

The Technology Deployment Phase of the Lead Locally project will build upon the lessons learned from the Applied Research and Technology Demo Phases. The team will devise fully optimized packages of energy saving interventions that will be on offer at the SCP Advanced Energy Center in addition to individual technologies. Participant customers who pursue installation of those pre-determined Lead Locally packages of measures will form the basis of the project meeting its goals:

- cumulatively retrofitting 300,000 square feet
- achieving 10% site electricity savings for residential participants
- achieving 20% electricity savings for commercial participants

Energy savings will be closely evaluated through the use of Advanced Metering Infrastructure (AMI) data and the findings documented for further strengthening the solutions offered by Sonoma Clean Power to its customers. The project will monitor enrolled project locations for ongoing savings and normalize savings for weather and other non-routine adjustments which will be determined through regular communications and surveys with participating customers.

The project is working to greatly surpass those initial targets and we are looking to have a much wider benefit to the communities of Sonoma and Mendocino counties. This will be achieved though the setting up of the Advanced Energy Center for long-term impact, - popularizing effective ways to save energy in both residential and commercial sectors. We envisage that the Advanced Energy Center will become a hub for accessing up-to-date information on advanced technologies to achieve deep energy savings for primarily retrofit projects, but also provide knowledge relevant to new construction projects that look for ways to go beyond current code requirements.

Metrics and other milestones that will be documented through existing Lead Locally reporting activities for Technology Deployment include:

- Number of visitors to the Advanced Energy Center store front and website
- Purchases made through the Advanced Energy Center store and website, including total value of products purchased; details on measures/specific technologies purchased including make/model, efficiency specifications, and costs; details on project scopes

facilitated through customer/contractor matching that happens through the Advanced Energy Center.

- Permits for projects paid for in whole or in part with Lead Locally funds and or SCP incentives.
- Contractors, building professionals, and customers attending trainings, training topics, and training curriculums.
- Customers enrolled in demand response programs.

CHAPTER 8:
Conclusion and Next Steps

This *Technology Demonstration Program Implementation Plan* identifies the activities and approaches that will be used by the project team to demonstrate how proven energy efficiency technologies can be installed, optimized, bundled, and promoted to effectively overcome known (and newly discovered) market barriers. Technology demonstration activities will examine various drivers and barriers in the energy efficiency market in Sonoma and Mendocino counties and will establish how that data and results from the applied research and technology demonstration sites will be used in the Advanced Energy Center to accelerate technology deployment.

This Plan is a living document that will evolve based on: findings from Lead Locally applied research and technology demonstration research activities; SCP's development of the Advanced Energy Center; changes to SCP customer side programs and energy efficiency programs offered by other program administrators; changes in building and construction market within SCP territory. Updates to this Plan will be made as necessary on a quarterly basis.

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GLOSSARY

Term	Definition
AC	Air Conditioner
ACCA	Air Conditioning Contractors of America
AQ	Air Quality
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
AWHP	Air to Water Heat Pump
BSRL	Building Science Research Laboratory
CAM	Commission Agreement Manager
CARE	California Alternate Rates for Energy Program
CEC	California Energy Commission
CFS	Commercial Foodservice
CLTC	California Lighting Technology Center
COM	Commercial
COP	Coefficient of Performance
CPUC	California Public Utilities Commission
CSLB	Contractors State Licensing Board
DBA	Doing Business As
DCS	Ducts in Conditioned Space
DMSHP	Ducted Mini Split Heat Pump
DWHR	Drain Water Heat Recovery
EER	Energy Efficiency Ratio
EF	Energy Factor
EHR	Exhaust Heat Recovery
EM&V	Evaluation, Measurement and Verification
EPIC	Electric Program Investment Charge

ERV	Energy Recovery Ventilator
ERWH	Electric Resistance Water Heater
EV	Electric Vehicle
FAU	Forced Air Unit
FERA	Family Electric Rate Assistance Program
FSTC	Food Service Technology Center
GIHPWH	Grid Interactive Heat Pump Water Heater
HPWH	Heat Pump Water Heater
HVAC	Heating, Ventilation, and Air Conditioning
IAQ	Indoor Air Quality
IOU	Investor Owned Utility
LED	Light-Emitting Diode
MLS	Multiple Listing Service
MSHP	Mini-Split Heat Pump
OA	Outside Air
PCM	Phase Change Material
PV	Photovoltaic
RES	Residential
RFP	Request for Proposals
RPAWHP	Radiant Panels with Air to Water Heat Pump
PG&E	Pacific Gas & Electric Company
SCEIP	Sonoma County Energy Independence Program
SCP	Sonoma Clean Power
SEER	Seasonal Energy Efficiency Ratio
SIR	Savings-To-Investment Ratio
Team	All Lead Locally Program Partners
TOU	Time of Use
VOC	Volatile Organic Compound

WCEC	Western Cooling Efficiency Center

APPENDIX A: Demonstration Research Plans

The Demonstration Research Plans included in this appendix provide clear descriptions of the technologies that will be evaluated through small-scale deployments at several test sites. Key research questions are described, along with the series of testing and modeling activities that will lead to clear answers. Finally, project timelines are provided to allow all partners to plan related activities, and to ensure that overall project goals are met within the 3½ year time frame of the program.

Plans for the following nine technologies are presented in subsequent sections:

1. Radiant panels with air-to-water heat pumps
2. Grid-integrated heat pump water heaters
3. Phase change materials
4. Commercial daylighting retrofits
5. Ducted mini-split heat pump
6. Induction cooking
7. Waste heat recovery
8. Aerosol envelope sealing
9. Nightbreeze/ Economizer

In addition to these technologies, which were identified in the Lead Locally proposal, up to three additional technologies solicited through the Advanced Energy Center Vendor RFP will be selected for demonstration projects later in the program. If at any point it becomes clear that one of the nine proposed technologie are not technically viable or cost-effective, the remaining funding for that technology will be added to the budget for the most promising technologies identified through the RFP.

APPENDIX A1: Radiant Panels with Air-to-Water Heat Pumps

The plan for evaluating radiant panels with air-to-water heat pumps was addressed in the *Phase 1 Research, Instrumentation, and Monitoring Plan* (Hendron, et al., 2018), and is not repeated here. Upon successful completion of the applied research phase, the radiant panels research will transition to the technology demonstration phase. Specific research questions and strategies for technology demonstration activities will be developed based on findings from Applied Research activities and included here in a future update to this document.

APPENDIX A2: Grid-Interactive Heat Pump Water Heaters

Technology Overview

This project focuses on demonstration and deployment of grid interactive heat pump water heaters (GIHPWHs). Heat pump water heaters (HPWHs) are an electrically powered, storage based type of residential sized water heater. They employ a small heat pump, typically drawing ~400 W of electricity as the primary heating source, and ~4 kW electric resistance elements as a backup heating source. Heat pumps are the primary heating source because they operate with a coefficient of performance (COP) averaging approximately 3, significantly higher than the typical ~0.95-1 COP of electric resistance elements. Since the heat pump provides heat relatively slowly, HPWHs employ 50-80 gallon hot water storage tanks. The storage tanks provide a thermal buffer, allowing the occupants to use hot water faster than the heat pump can provide it, enabling the heat pump to slowly reheat the water between draws. The electric resistance elements are only used when the water in the storage tank cools off significantly, creating the potential of occupants receiving water below the desired temperature.

Features

GIHPWHs are a new development in HPWH technology, providing the capability to communicate with the electric grid and improve the controls of the water heater accordingly. This communication enables more advanced control logic than is typical in HPWHs. The most common example is that of demand response and load shifting programs that utilities are now offering. In a demand response program, utilities pay their customers for the opportunity to remove power to their water heater as needed. This way utilities struggling with stress on the electricity grid can prevent HPWHs from heating the water at critical times, improving grid stability. Demand response programs typically have time windows running from 5-9 PM, with the utilities only removing power to the water heater at times of high grid stress. The downside is that building occupants may experience colder than desired water, because the HPWH is not able to heat the water without electricity. Load shifting is the next iteration of the demand response technology. In addition to giving the utility power to prevent the HPWH from heating the water during the peak period, it gives the utility power to engage the heat pump earlier in the day and heat the water to a higher temperature. By doing so, more heat is stored in the tank at the start of the peak period than would be typical. This improves on the traditional demand response programs both by increasing electricity use earlier in the day, when ample solar electricity is available, and by reducing the chances of occupants running out of hot water, because there's more stored energy in the tank. SCP now has a program partnering with Lead Locally partner Olivine implementing these load shifting controls in their service territory. The HPWHs receive signals from Olivine engaging the heat pumps from 3-5 PM superheating the water in the tank and receive signals from 5-9 PM instructing them to avoid heating the water.

This project will be deploying and monitoring the performance of GIHPWHs responding to the Olivine load shifting signals.

Technology Benefits

This technology has benefits for both individual building occupants and for the grid. The benefits for building occupants come from a reduced cost of using hot water, and a faster payback time for switching from an electric resistance water heater (ERWH) to a HPWH. In cases with time of use (TOU) rates, which are becoming more common, load shifting strategies will allow occupants to use electricity at cheaper times of day and avoid using it at more expensive times of day, which reduces the annual cost of operating the water heater. The reduced cost of operating a GIHPWH improves the payback time of switching from an ERWH to a GIHPWH, thus enabling further electricity savings. Using load shifting instead of traditional demand response increases the odds that the occupants can get their standard hot water delivery performance while still taking part in the program. From the grid point of view, reduced electricity consumption during the peak period helps improve grid stability.

This technology is primarily targeted at single family residential applications due to the prevalence of small-scale storage tank based water heaters in those buildings, and the demonstration project will be targeted accordingly. It is also possible to include this technology in multifamily buildings, particularly buildings with individual water heaters instead of central systems, or small-scale commercial buildings that use residential water heaters and have high water heating loads in the late afternoon.

Research Questions

There are three main research questions for this project:

- **What is the cost savings impact of replacing an ERWH with a GIHPWH and load shifting controls?**

This project focuses on the financial cost savings seen by the occupants when they replace an existing ERWH with a GIHPWH that has load shifting controls as these cost savings are likely to be the main driver for adoption. High cost savings will encourage occupants to pursue this technology, and lead to more market penetration. To address this question, data analysis will focus on comparing the utility bills of occupants' houses both before and after the installation to identify the difference.

- **What is the payback period with this retrofit?**

Once the annual cost savings is identified, it will be possible to estimate the payback period of this retrofit. Short payback periods will encourage adoption of the technology, leading to more installations and more total energy savings. To identify and encourage the adoption of these devices, data analysis efforts will compare the annual energy savings to the installation costs and estimate the payback period of the retrofit.

- **How much energy is saved by these retrofits?**

The final research question for this project is that of how much electricity is saved by these retrofits. Data analysis for this project will include a comparison of the electricity consumption before and after the retrofit to identify the electricity savings from the retrofit.

Demonstration Plan

To demonstrate and verify the performance of this technology, it will be installed in 10 buildings throughout Sonoma Clean Power's service territory. Most sites will be residential buildings, but promising small commercial sites will be considered as well. Participants in the project will grant the project team, specifically Olivine and Frontier Energy, access to their monthly utility bills. To assess the performance of the device, Frontier Energy will compare the utility bills before and after the retrofit to estimate the impacts of the change.

Measure Package

The measure package for this project will consist of a GIHPWH, a communication device, and a thermostatic mixing valve. The GIHPWH will be the source of hot water for the house, and will be capable of receiving and utilizing signals from the utility grid. The communication device will act as the interface between the GIHPWH and the grid, sending and receiving signals between the two devices as necessary. The specific communication interface will vary depending on the company manufacturing each installed GIHPWH. For example, A.O. Smith GIHPWHs use the CTA-2045 communications protocol and will use a CTA-2045 approved communication device while Rheem GIHPWHs use their proprietary EcoNet communication method. A thermostatic mixing valve will be installed to control the outlet water temperature in all cases. With the GIHPWHs superheating the water to implement load shifting there is potential for the hot water in the tank to reach 150 or 160 degrees. The thermostatic mixing valve will add cold water to the outlet water, reducing the temperature at the fixture to a maximum of 125 degrees to avoid the potential for scalding. The cost of the retrofit will be subsidized through rebates from SCP using both CEC and match funding.

Site Selection

GIHPWHs are electrical water heaters with large storage tanks that communicate with the utility grid. As such, there are three important requirements for each site that is selected for participation in this project:

- **240V/30A Electrical Service**: The majority of GIHPWHs currently on the market require 240V/30A electrical service at the device to function properly. These high requirements are caused by the electric resistance backup units; in order for them to provide up to 5 kW of heating capacity there must be adequate electricity available to the device.
- **Large Physical Space**: GIHPWHs typically employ 50-80 gallon hot water storage tanks. These storage tanks provide a buffer so that the small heat pumps can slowly replace the heat in the tank between hot water uses, rather than using the resistance elements to add the heat rapidly. This means that larger storage tanks often perform better. The large storage tank means that these devices require a significant amount of physical space, possibly more than the existing hot water tank.

- **Internet Connectivity**: Since these devices will be communicating with local utility, it is important that they are able to establish a connection to the utility. To do so, they must have a reliable internet connection, preferably an ethernet connection not a wireless one, on site.

With California's recent push towards gas tankless water heaters and history of natural gas based water heating, it may be difficult to find sites that meet these requirements. Tankless water heaters require far less space, and gas water heaters require little to no electricity. To help identify the appropriate sites for the test, the project team will search for houses that already utilize ERWHs. Those installations are likely to have the required 240V/30A service and the large physical space that an ERWH requires.

Since the analysis on this project will consist of utility bill analysis, changes in water heating electricity use may be hard to identify in houses that have large electricity loads. If water heating electricity use is low relative to other electricity uses, the changes may not be large enough to identify with high accuracy. To avoid this problem, this project will target houses that do not have air conditioning systems and leverage a relatively large sample size to increase accuracy when calculating average electricity savings.

Establishing Baseline

The baseline for this project will be established by obtaining the utility bills at the house before installing the new technology. Ideally these bills will be available for a full year to establish the electricity consumed by the house each month, allowing the project team to identify how the performance changes with seasonal weather changes.

Post Retrofit

After the retrofit is completed, Olivine will run SCP's load shifting program. In doing so they will incorporate controls that engage the heat pump from 3-5 PM to superheat the water before the peak period, and instruct the GIHPWH to avoid using electricity whenever possible during the peak period from 5-9 PM. SCP will then provide the participants' utility bills to Frontier Energy for the post retrofit analysis.

Analysis

The analysis for this project will include two comparisons:

- **Total Electricity Consumption**: Reductions in electricity consumption before and after the retrofit will indicate the amount of energy saved by switching from an ERWH to a GIHPWH. This will be identified by comparing the amount of electricity consumed each month before and after the retrofit. Normalization relative to changes in weather between years will be performed if needed.
- **Changes in Average Cost of Electricity**: Load shifting controls have the potential to provide additional cost savings to the occupants by shifting electricity consumption from times of day when electricity is expensive to times of day when electricity is cheap. This will show up in the bills as a reduction in the average price per unit of electricity consumed. To identify this, Frontier Energy will identify the average price of electricity paid by the participant both before and after the retrofit to compare the two.

Success Metrics

The success of this technology will be determined based on the payback period from the retrofit. A payback period of less than five years indicates that the technology is economically viable, and that consumers will have adequate incentive to acquire it. The payback period will come from significant monthly cost savings for the consumer and an affordable cost for the retrofit. The cost savings will come partly from using electricity at a cheaper time of day, and partly from using less electricity.

Transition to Deployment

If the success factors have been met the remainder of the GIHPWH project will focus on preparing the customer base for wide-scale deployment of the technology.

Potential electricity savings

Electricity savings will vary depending on occupant behavior. HPWHs are extremely efficient in houses with limited hot water use, because large draws trigger the low efficiency resistance elements. Houses with favorable hot water use characteristics will exclusively use the heat pump, and savings may be as high as 80%. Even if the occupants use large volumes of hot water, HPWHs are far more efficient than ERWHs and savings are likely to be on the order of 60% of water heating energy. Load shifting features could slightly decrease electricity savings because tank losses may be higher or because lower refrigerant to water heat transfer results in lower COP.

Peak demand savings will depend on both the hot water use behavior of the occupants and the load shifting strategy. There is potential for a 100% reduction of peak load.

Synergies with other measures

GIHPWHS have synergistic effects with two other potential measures. The best synergy with HPWHs lies in the location of the device itself. Jacket losses and heat pump COP are both based on the surrounding ambient temperature, so locating the HPWH in a hot space will increase the performance of the device. This could include garages and attics. The second potential measures that synergizes with GIHPWHs is low-flow fixtures. They reduce the volume of hot water consumed by the occupants, thus reducing the possible energy savings from the GIHPWH but increasing the hot water delivery performance.

Targeted SCP customer segments

Based on information currently available, it is expected that buildings with the following characteristics would save the most energy:

- Single family residential buildings with high numbers of occupants
- Multi-family buildings with multiple apartments sharing a single water heater
- Small commercial buildings that utilize residential water heaters
- Buildings with high hot water loads in the evening, such as homes with people who shower after work, would save money from the load shifting controls of GIHPWHs

- Buildings with existing ERWH

Because of the prevalence of residential sized water heaters in single family houses and the limited budget, this demonstration project will target that market. Efforts will be made to identify houses with high numbers of occupants, for the higher hot water load.

Deployment strategies

Strategies for deploying PCMs through the Advanced Energy Center will focus on customer and contractor training education. Available information will teach them about:

- The energy and cost savings available through HPWHs
- The load shifting program available through Sonoma Clean Power and Olivine
- Impending TOU rates, and how they improve the value of load shifting devices
- Installation techniques and concerns for GIHPWHs

Potential Inclusion of Applied Research

As previously mentioned, there is an applied research topic that is closely related to this project. While this project focuses on deploying GIHPWHs with load shifting controls and standard signals from the utility, the applied research project focuses on developing model predictive controls to identify the optimal amount of load shifting and controlling the GIHPWH accordingly. The *Phase 2 Research, Instrumentation, and Monitoring Plan* (Hendron, et al., 2019) provides more detail.

Since the efficiency optimizing controls technology has not been previously tested in HPWHs, the applied research phase may or may not determine that the approach is viable. If it is considered viable, it will be tested in 1-5 houses. This testing will include:

- Determining the best method of implementing the controls. Depending on the required computing power, this could take the form of a local Raspberry Pi, local laptop, or remote server sending signals through the grid.
- Adding the new control logic to GIHPWHs already installed for the sake of the project. This means that the added retrofit only entails new controls and new monitoring equipment, while leveraging the fact that the houses have already received GIHPWHs.
- Installing the required sensors. For the controls, this means an additional water flow meter to identify the occupants' hot water use behavior. Additional inlet and outlet water temperature and electricity consumption will also be monitored to determine the performance of the device.

Project Timeline

Table 14 shows the high-level project milestones and deliverables with anticipated completion and due dates.

Table 14: Anticipated project schedule for research on GIHPWHs.

Project Milestones	Completion/Due Date
Field Tests - Site Screening/Selection	May 2019

Field Tests - Design Retrofits	October 2019
Field Tests - Baseline Monitoring	January 2020
Field Tests – Install Retrofits	March 2020
Field Tests - Retrofit Monitoring	March 2021
Program Participant Satisfaction Questionnaire for Homeowners	April 2021
Analysis of Alternative Applications	May 2021
Draft Input to Technology Demonstration Final Report	July 2021
Final Input to Technology Demonstration Final Report	October 2021

APPENDIX A3: Phase Change Materials

Lead Locally will evaluate phase change materials (PCMs) in two principal applications, one in residential attics and one in commercial roofs or top-floor ceilings. Wall PCMs were not considered to be a viable near-term retrofit option because the installation costs are very high compared to attics. The residential application of PCMs includes a significant number of performance and cost uncertainties and is considered an applied research technology. The plan for evaluating residential PCMs was addressed in the *Phase 2 Research, Instrumentation, and Monitoring Plan* (Hendron, et al., 2019). Upon successful completion of the applied research phase, residential PCMs will transition to the technology demonstration phase. Specific research questions and strategies for the demonstration of PCMs for residential attics will be developed based on findings from Applied Research activities and included in a future update to this document. It may be possible to skip the technology demonstration phase if testing in the five pilot homes is highly successful.

The remainder of this Appendix addresses the application of PCMs as a retrofit for commercial buildings, which is a more proven application involving less risk to building owners because many more commercial PCM installations exist, Cost remains a significant market barrier and ideal target building sectors are not well defined. As a result, more buildings will be tested, with less comprehensive instrumentation. For tech demos, our primary objective is to evaluate overall energy savings, cost-effectiveness, and occupant satisfaction in a variety of situations to identify unexpected systems interactions or other issues that could affect the range of building sectors or ceiling types for which the technology will be recommended or incentivized.

Technology Overview

PCMs are materials that absorb heat as they melt and release heat as they freeze. There are several types of PCMs with different strengths and weaknesses, including paraffins, hydrated salts, and organic materials. PCM melting points can be tuned to match the needs of the application, making PCMs an appealing technology for use in building envelopes, including in walls and attics. PCMs do not contribute to the R-value of the building envelope, but when installed adjacent to the insulation, PCMs can reduce or delay large temperature differences across the insulation, thereby reducing heat transfer into or out of the conditioned space.

Interest in the use of PCMs to reduce heating and cooling loads has increased greatly in the past 10-15 years due to advances in higher performance PCM compositions and the availability of a broader range of commercial products that can be readily integrated into building envelopes (James & Delaney, 2012). Products range from PCM embedded in wallboard to thin sheets with encapsulated PCM cells.

Features

The macro-encapsulated inorganic PCM product Infinite R, manufactured by Insolcorp and sold by Lead Locally partner Winwerks, will be the technology evaluated for this demonstration

project. The compound is stored in a white poly film pocket and sealed in a multilayer white poly film. The poly film packaging comes in 24” X 48” sheets and 16” X 48” as shown in Figure 1. The PCM comes in a variety of melting points ranging from 66-84˚F. Infinite R PCM sheets have the characteristics and performance values shown in Table 15 and Table 16.

Figure 1: Insolcorp Infinite R PCM mat

Image credit: Insolcorp, LLC

Table 15: Infinite R Physical Properties

Physical Properties	Values
Melting Point	66 - 84˚F
Specific Heat	1.35 BTU/lb·˚F
Latent Heat	~86 BTU/lb·˚F
Thermal Conductivity	~0.16 W/ft/K Liquid
	~0.33 W/ft/K Solid
Dimensions	24.5” X 48”
	16.5” X 48”
Thickness	0.25”
Weight	0.75 lb/sq. ft.

Table 16: Infinite R Fire Ratings

Fire Testing	UL 723
Flame Spread	5
Smoke Development	10

The preferred application of Infinite R is just above the tiles in a dropped ceiling, as shown in Figure 2. To charge and discharge heat from the PCM during the summer, it is important to have significantly lower temperature settings at night versus during the day, either through night ventilation cooling or pre-cooling using the HVAC system. During peak demand hours, the cooling system can be turned off or operated with a higher set point with minimal loss in comfort. Even with no change in set point, the PCM will likely reduce peak electricity use for cooling if it hasn't fully melted. During the winter, PCM works most effectively in applications where there are large internal heat gains during the day, and where the thermostat is set back at night. This reduces warm-up time in the morning while minimizing overheating during the day. Infinite R can also be applied as one component of a wind-vented roof system if a roof replacement is planned for a commercial building, and can be installed in exterior or interior walls. These applications are outside the scope of this technology demonstration project.

Figure 2: PCM mats installed over a dropped ceiling

Image credit: Insolcorp, LLC

Infinite R has been installed under flat roofs in numerous commercial building applications around the U.S., but the mild California climate may present some unique challenges. There is minimal performance risk for this technology, because the original insulation will remain in place, and the worst-case scenario is that the PCM does not melt and solidify consistently enough to have a measurable impact on energy use. But the product is not inexpensive, so there is significant economic risk if applications are not ideal (see *Targeted SCP customer segments* later in this Appendix)).

Technology Benefits

- Up to 10-30% heating and cooling energy savings
- Peak demand reduction
- More stable interior temperatures
- Material is thin and lightweight

- Easy to install in many applications, including dropped tile ceilings
- Less prone to water damage than insulation

Technology Uncertainties

- Savings may be less than expected due to mild Sonoma County climate
- Variations in operating profiles and internal gains may affect energy savings for different commercial building sectors
- Cost-effectiveness within a 5-10 year timeframe may be difficult to achieve
- Contractors and trades have minimal experience with PCMs in commercial applications.

Research Questions

The Team will attempt to answer the following research questions through the demonstration of PCMs installed in commercial roofs or ceilings:

1. What is the preferred melting point for the PCM in typical commercial applications?
2. Is there sufficient heat transfer rate to fully charge and discharge the PCM under a range of operating conditions representative of commercial buildings?
3. What is the heating/cooling load reduction and peak demand reduction that results from the addition of PCM?
4. What is the correlation between insulation level and the performance of the PCM?
5. What is the cost-effectiveness of adding PCMs to commercial roofs/ceilings in Sonoma and Mendocino Counties?
6. Does the PCM demonstrate durability and effectiveness after being installed in commercial ceilings for an extended period?
7. Which climates in Northern California provide the proper environmental conditions for PCM in commercial buildings to go through the proper thermal cycles to see significant energy savings?
8. What commercial building characteristics lead to cost effective installations of PCMs? How can building owners determine that their space is a good candidate for the technology?

Demonstration Plan

Lab Testing

No laboratory testing is envisioned for commercial applications of PCMs.

Field Testing

Retrofit Measure/Package

For the technology demonstration phase, the retrofit will consist of 1000-2000 ft^2 of Infinite R macro-encapsulated PCM mats installed in an existing dropped ceiling or under a metal roof deck. The area limit is based on rebate budget limitations for the demonstration project; there are no physical restrictions on ceiling area that may include PCMs. In some cases, it may be

necessary to add insulation to meet minimum code requirements and increase the ability of the PCM to maintain comfortable conditions inside the work space during peak demand periods. If insulation is added, the energy savings calculations will adjust for its impacts on energy use so the effects of the PCM can be isolated. For larger buildings, only a subset of the ceiling area will be retrofit unless the building owner is willing to fund the cost of the PCM mats for the remaining area. Roof replacement and/or installation of a dropped ceiling is not feasible within the project budget.

Site Selection

Ten field test sites will be selected within Sonoma and Mendocino Counties and will be recruited from the SCP customer base. The criteria for these sites are outlined in Table 17. Some criteria are essential for consideration of a test site, others receive a score from 1-10 based on importance. Owners of the sites with the highest scores will be offered a PCM retrofit using SCP match funding to subsidize the cost up to 100%, in exchange for supporting energy and comfort monitoring activities and allowing occupants to participate in a questionnaire about comfort impacts.

Table 17: Technology demonstration site selection criteria for PCMs in commercial buildings

Category	Criterion	Criterion Value	Criterion Weight (1-10)
Occupants/Owner	Owner occupied?	Yes	8
	Operational year long?	Yes	Essential
	Hours of operation	Daytime and evening	9
	Days of operation	5/week or more	7
	Realistic owner expectations?	Yes	Essential
	Financial support for retrofit by owner	Yes	10
	Owner enthusiastic?	Yes	8
Site	Number of floors	1	2
	Building type	Retail, restaurant, manufacturing	3
	Ceiling area	<2000	5
	Safe work environment?	Yes	Essential
	Practical installation barriers	No	Essential
	Practical installation challenges	No	10
	Located near other sites	Yes	6
	Features similar to other sites	Yes	1
Building Envelope	Roof type	Flat	8
	Ceiling type	Dropped	10
Mechanical	HVAC system functional?	Yes	Essential
	Central Cooling?	Yes	Essential
	Propane heating?	No	Essential
	Electric heating?	Yes	5
	Asbestos present?	No	Essential

	Building automation system?	Yes	4

Baseline

The baseline for the field testing will be the test sites prior to retrofit. Six months of monitored data will be collected following site selection, including partial winter and summer seasons. Operating conditions will also be monitored prior to retrofit, and adjustments will be made to the energy savings calculations if operational parameters such as occupancy level or thermostat setting change during the course of the monitoring period. For larger buildings with only partial installation of PCMs, similar spaces without PCMs may be used as an alternate baseline for comparison.

Key data points will include the following:

- Temperatures and humidity of the conditioned space
- Outside temperature and humidity
- Heat flux through the ceiling at several locations
- Air temperature inside the dropped ceiling (depending on application)
- Surface temperature inside the roof assembly (depending on application)

Post-Retrofit

Following the installation of PCM mats in the ceiling or roof, each test site will be further instrumented to quantify the reduction in cooling and heating load that enters the conditioned space through the roof/ceiling assembly. The frequency and extent to which the PCM freezes and melts over the course of a full year will be monitored to determine if design or installation changes could be beneficial prior to full-scale deployment.

Additional post-retrofit data points will include the following:

- Heat flux above and below the PCM at several locations
- Surface temperature above and below the PCM at several locations

Utility Bill Analysis

As a check on energy savings calculated using measured heat flux and estimated equipment efficiency, utility bills will be analyzed to determine the change in heating and cooling energy following the retrofit. Because a large number of variables can impact space conditioning loads, utility bills may not be able to capture the energy savings associated with the PCM if the impact is small and the variability in operating conditions is large.

Building Simulation

Once performance is verified through field testing, PCMs in commercial ceilings will be included in the analysis of optimal retrofit packages in Northern California climate zones. This analysis will examine the effect of climate, PCM melting point, internal gains, interior set points, and other variables that could affect energy and peak demand savings. Calibrated energy models of

the individual test sites will not be performed for this project, because the change in heating and cooling loads will be measured directly.

Success Metrics

PCMs for commercial roofs/ceilings will advance to the deployment phase and be included in the Advanced Energy Center if the following criteria are met.

- Heating and cooling electricity savings and peak demand reduction in excess of 10% for spaces retrofit with PCMs
- More stable interior temperatures during work hours
- No issues with durability when the PCMs are exposed to realistic operating conditions during the one-year test period
- Potential for cost-effectiveness in several building types and climate zones in Northern California
- No significant occupant complaints related to the PCMs

Transition to Deployment

If the success factors have been met for PCMs, an evaluation of alternative PCM products, target markets, training needs, and other activities necessary for deployment readiness will be performed.

Potential electricity savings

Electricity savings for heating and cooling are expected to range between 10%-30%, depending on the application. Peak electricity demand reduction may be significantly higher, depending on the ability of the PCM to maintain a constant temperature inside the space during peak hours. Because there may be a trade-off between heating and cooling savings based on melting point selection, savings likely be very climate-dependent. In applications with gas heating, maximum overall cost-effectiveness for the building owner will be the primary focus when designing the retrofit, not total electricity savings.

Synergies with other measures

The performance of PCMs in commercial buildings will be enhanced when combined with a building automation system that controls set points in a manner that maximizes energy storage and minimizes electricity use during the peak demand period. Improvements to the efficiency of the HVAC system will reduce the energy savings potential of PCMs and may be a more cost-effective options in some cases. Similarly, smaller thermal gains from improved lighting and equipment efficiency may negatively impact energy savings for PCMs, especially in the summer. If ducts are located in the dropped ceiling, they may be exposed to a somewhat milder environment during hot or cold weather and enhance overall energy savings.

Targeted SCP customer segments

Based on information currently available, it is expected that commercial buildings with the following characteristics would save the most energy:

- Large outdoor diurnal temperature swings during all seasons

- Wintertime thermostat set back and summertime set up at night, or willingness to include HVAC scheduling following the retrofit
- Year-round building occupancy
- Significant day and evening occupancy at least five days per week, with minimal operation at night
- Large internal heat gains
- Dropped tile ceilings

Commercial sectors such as retail, restaurants, office, and manufacturing appear to be the most promising applications. Schools and medical facilities may not be ideal locations. Mixed climate zones such as Sacramento and Fresno are likely to achieve greater energy savings than milder climates like Sonoma County or the Bay Area, although there is the potential to eliminate the need for cooling altogether in mild climates.

Deployment strategies

Strategies for deploying PCMs through the Advanced Energy Center will focus on overcoming the key barriers of low customer awareness, uncertain energy savings, and the lack of contractors familiar with proper installation methods. The following approaches will be employed:

- Analysis of cost-effectiveness in various commercial building types and climate zones
- Educational materials targeted to building owners
- Training in proper design and installation practices for architects and trades
- Financial incentives for early adopters

Project Timeline

Table 18 shows the high-level project milestones and deliverables with anticipated completion and due dates.

Table 18: Anticipated project schedule for research on PCMs in commercial buildings.

Project Milestones	Completion/Due Date
Field Tests - Site Screening/Selection	May 2019
Field Tests - Design Retrofits	October 2019
Field Tests - Baseline Monitoring	January 2020
Field Tests – Install Retrofits	March 2020
Field Tests - Retrofit Monitoring	March 2021
Program Participant Satisfaction Questionnaire for Homeowners	April 2021
Analysis of Alternative Applications	May 2021
Draft Input to Technology Demonstration Final Report	July 2021
Final Input to Technology Demonstration Final Report	October 2021

APPENDIX A4: Commercial Daylighting Retrofits

The plan for evaluating commercial daylighting technologies was addressed in the *Phase 2 Research, Instrumentation, and Monitoring Plan* (Hendron, et al., 2019), and is not repeated here. Upon successful completion of the applied research phase, several of the daylighting measures will transition to the technology demonstration phase. Specific research questions and strategies for technology demonstration activities will be developed based on findings from Applied Research activities and included in a future update to this document.

APPENDIX A5: Ducted Mini-Split Heat Pumps

Performing thermal load reduction measures, such as envelop sealing, increasing attic insulation, and replacing existing exhaust ventilation with energy recovery ventilation, allows installing smaller capacity forced air systems, such as mini-split heat pumps (MSHPs), in place of traditional large split systems. These smaller MSHPs use less energy, can be more efficient, and take up less space than traditional furnaces and air conditioners. This makes it easier to install them with more compact duct systems in conditioned space in existing homes.

Technology Overview

Features

A "heat pump" is an air conditioner that can also work in reverse and provide heat during cold weather. A "split" system is one that is split into two pieces: an "indoor unit" and an "outdoor unit." A mini-split heat pump (MSHP) is just a more physically compact and smaller capacity version that can vary the speed of its components to match the current needs of the home and operate more efficiently.

A ducted mini-split typically has a single indoor unit and distributes conditioned air throughout the house using compact ductwork, in contrast to a ductless mini-split which typically distributes refrigerant to multiple small indoor units, each with its own fan-coil (i.e. small indoor unit) and often with a separate thermostat. The retrofit package that will be evaluated for Lead Locally includes envelope improvements that will reduce the required capacity of the MSHP, and integrated supply ventilation to improve indoor air quality. This technology will be targeted primarily to the single-family residential market.

Technology Benefits

- 20-30% heating and cooling energy savings is possible
- Less cycling on and off, leading to better comfort and potentially less wear and tear on equipment
- Smaller temperature swings
- Better indoor air quality through addition of integrated supply ventilation

Technology Uncertainties

- Savings may not be enough to achieve cost-effectiveness due to mild Sonoma County climate.
- Questions about the real-world attainability of manufacturer efficiency ratings.
- Occupant acceptance of differences between operation of MSHPs and traditional systems (improved efficiency with longer system run times and without the use of a temperature setback control).

- Occupant acceptance of reduced indoor space required to bring ducts into conditioned space.
- Occupants understanding of MSHP controls, operating characteristics, and required maintenance

Research Questions

The specific research questions for the field tests include:

- How do the indoor comfort, and energy use provided by the retrofit systems compare to the baseline systems for each house and in aggregate?
- How do the indoor comfort and energy use in the field tests differ from expectations based on building simulation?
- What are the annual cost savings and the payback period for the retrofit system, based on the energy use of the baseline system and billing data for the particular homeowner?
- What was learned about occupant behavior relative to the retrofit system? How does behavior impact performance?
- What home, climate, or occupant behavior factors led to higher savings for the retrofit systems at five test sites?

Demonstration Plan

MSHPs will be installed in five homes throughout Sonoma Clean Power's service territory to demonstrate and verify performance. Participants in the project will grant the project team, specifically Frontier Energy, access to their monthly utility bills. To assess the performance of the device, Frontier Energy will compare the utility bills for one year before and one year after the retrofit to identify the impacts of the change after adjusting for weather. Frontier Energy will also directly monitor indoor and outdoor conditions, system energy use, system control inputs, and occupant behavior at each test site.

Lab Testing

Because MSHPs do not use traditional HVAC controls, a Modbus device must be used to monitor the control inputs to the MSHP from the occupants, such as indoor temperature setpoint. This Modbus device is typically used to provide remote control of MSHPs in an energy management system for a large office building. Though the project plans only call for using this device to record inputs through the manufacturer provided controls, it is possible for this device to interfere with normal operation of the MSHP in a single-family residential application.

Therefore, limited lab testing will be performed in the Frontier Building Science Research Laboratory (BSRL) to ensure that planned field monitoring methods will not interfere with efficient operation of the MSHP units. This will include acquiring a slim-duct indoor unit and an outdoor unit from the manufacturer as an evaluation MSHP. The evaluation MSHP will have a capacity representative of what is planned for the selected field test sites. The evaluation MSHP will be set up at BSRL with the planned field instrumentation. Energy use will be measured with

and without the instrumentation under the same ambient air conditions to ensure that field instrumentation will not interfere with normal operation.

Field Testing

Field tests will be performed in five single-family houses that currently have central heating and cooling, with ducts in a vented attic or crawlspace. Multiple houses are necessary because occupant behavior and comfort considerations have a significant effect on the operation and perceived performance of any HVAC system. Home energy audits and envelope improvements will be performed prior to monitoring to limit differences between the houses and reduce the required system capacity. Six months of monitored baseline data will be collected prior to the retrofits, covering periods of both hot and cold weatherr, followed by one year of monitored data collection post-retrofit. Data will be collected on system performance (energy use, meeting set point, temperature uniformity), as well as occupant comfort and behavior. The cost of each retrofit will be recorded in detail, including equipment, installation, maintenance, and permitting costs. Eligible homeowners will be asked to complete a quarterly survey, provide access to their utility data, and allow technicians to enter the residence for data collection or repairs with reasonable notice.

Retrofit costs, energy use data, and utility bills will be used to estimate payback periods for the ducted MSHP technology. Occupant surveys, thermostat setting data, occupancy sensors, and window operation data will be used to evaluate occupant behavior both before and after retrofits are performed. Any comparisons of energy use will be performed using validated energy models, adjusted for differences in occupant behavior and weather conditions that could distort the results.

Retrofit Measure/Package

Specific system components and configurations will vary at each test site based on dwelling unit features and homeowner needs.

The following will be incorporated into each system design:

- Load reduction measures, including envelope sealing and new attic insulation.
- An MSHP system with a slim-duct style indoor unit.
- New ducts installed within the thermal envelope using furred or dropped ceilings, conversion of attic or crawlspace space into conditioned space, or one of several other options.
- Only one or two zones depending on loads and other site-specific issues.
- ASHRAE Standard 62.2 compliant indoor air quality ventilation will be installed (if not already present) in the form of an energy recovery ventilator (ERV) integrated into the new duct system.

Partners for this project include Energy Docs Home Performance (Energy Docs) and Rick Chitwood, BSME. Energy Docs Home Performance is a licensed General Building Contracting company in Redding, CA specializing in performing comprehensive home performance retrofits to existing homes. Rick Chitwood, BSME, owner of Chitwood Energy Management, is an expert

in energy-efficient residential building construction and a leader in building science-based design. Both Energy Docs and Rick Chitwood have substantial experience designing and installing these MSHP systems with DCS and integrated ERV as retrofits to existing homes.

Site Selection

Test sites will be located within Sonoma and Mendocino counties and will be selected from among SCP customers. The criteria for the field test locations are outlined in Table 19. These are research criteria constrained by project goals and resources and so should not be taken as limits of the technology. Results from these houses are likely to be better than average and will be extrapolated to other less favorable conditions using building simulation. These criteria are weighted by desirability as follows:

- Essential – Criteria must be met to be a candidate field test location for this project.
- Important – Criteria is flexible but would aid research goals.
- Desired – Criteria to be used only in an abundance of candidates. Locations that meet all criteria including "desired" would be considered "near perfect" candidates for the work.

Table 19: Field test site selection criteria.

Category	Criteria	Criteria Value	Criteria Weight
Occupant	Occupied?	Yes	Essential
	Owned by current residents?	Yes	Essential
	Occupants will remain for 2 years?	Yes	Essential
	Full time residence?	Yes	Essential
	Retired Residents?	No	Desired
	Resident Smokers?	No	Essential
	Anticipated change in occupancy?	No	Important
	Employees of Energy Industry?	No	Essential
Site	Year Built	1978 < x < 2005	Essential
	Dwelling Type	Single family detached	Essential
	Number of floors	1	Desired
	Sq. Ft. of conditioned living Space	< 2000	Essential
	Attached Garage	Yes	Desired
	Utility Data available	Yes	Essential
Building Envelope	Foundation Type	Slab on grade	Important
Mechanical	HVAC system functional?	Yes	Essential
	Cooling Type	Split system AC or HP	Essential
	Central Cooling?	Yes	Essential
	Heating Fuel	Electric	Desired
	Propane Heating?	No	Essential
	HVAC Age	10+ years	Essential
	HVAC Indoor Location	Garage or Attic	Important
	HVAC Duct Location	Attic	Important
	HVAC Asbestos Ducts	No	Essential
	Water Heater Location	Garage or Exterior	Desired

Once candidate test sites have been selected, the existing condition of each site and its systems will be evaluated in greater detail using standard field verification and diagnostic testing techniques. Heating and cooling loads will also be estimated by room using industry standard methods in ACCA Manual J (ACCA, 2011). The information collected will be sufficient to document the existing conditions and produce a detailed EnergyPlus model of each house and to produce home energy audit reports for each final test candidate. These reports will include summaries of the energy performance of the existing conditions and recommended renovations in a format that will be easily digestible for the homeowner.

The field verification and diagnostic tests to be performed will include envelope leakage, duct leakage, insulation levels, thermal images of interior surfaces of exterior walls and ceilings, supply and return airflows, ventilation airflows, and equipment power draws.

Baseline

The baseline for the field testing will be the test sites prior to retrofit. Six months of monitored data will be collected following site selection, including partial winter and summer seasons. Operating conditions will also be monitored prior to retrofit, and adjustments will be made to the energy savings calculations if operational parameters such as occupancy level or thermostat settings change over the course of the monitoring period.

Key data points will include the following:

- Temperatures and humidity of the conditioned space
- Outside temperature and humidity
- Electricity and gas use for indoor heating and cooling
- Window and door operation
- HVAC control settings
- Documentation of major equipment and its usage

Post-Retrofit

Following the installation of the technology, the new HVAC system will be instrumented similarly to the baseline system to quantify the reduction in HVAC energy use and to monitor occupant behavior that can impact HVAC system performance. Tests sites will be monitored for a full year to determine if design or installation changes could be beneficial prior to full-scale deployment. Data will be uploaded on a daily basis and analyzed using scripts for quality assurance purposes.

Utility Bill Analysis

Utility bills will be analyzed as a check on energy savings calculated using measured equipment energy use. In most cases these will be monthly utility bills, but more detailed data may be available for houses with smart meters.

Building Simulation

Baseline conditions collected during the energy audits will be used to develop detailed EnergyPlus models of the field test houses. Results from the models using the actual

meteorological year data covering the Baseline period will be compared to the actual monitored performance. These comparisons will be used to validate the baseline models of each field test site. Results from the validated baseline models using the actual meteorological year data covering the Retrofit period will be compared to the actual monitored performance of the Retrofit system. This will allow for comparing the Baseline and Retrofit systems in the same meteorological year. The validated models will also be used to disaggregate the contribution to energy savings for each component of the retrofit.

Success Metrics

Whether or not the technology is ready for larger deployment and inclusion in the Advanced Energy Center will be based on the results of the evaluations above and feedback from occupant surveys. The technology will be considered a quantitative success if it is able to produce comfort and energy performance results better than those of the Baseline systems. The technology will be considered a qualitative success if occupant feedback from the field tests is positive, and cost-effectiveness appears achievable in at least a few applications. In the event of an overall success, the occupant feedback will also be used to help inform customer decisions while they shop for retrofit systems in the Advanced Energy Center.

Transition to Deployment

If the success metrics have been met, an evaluation of alternative products, target markets, training needs, and other activities necessary for deployment readiness will be performed.

Potential electricity savings

Traditional ducts in attics and crawlspaces waste as much as 30 to 50% of heating and cooling energy through leaks and thermal losses. Moving ducts into conditioned space significantly reduce these losses. Additionally, MSHP efficiency ratings tend to be much higher than those of traditional heating and cooling systems. The addition of mechanical ventilation for indoor air quality is expected to reduce electricity savings to some extent, but energy recovery ventilators will be used for this purpose. These factors and thermal load reduction measures translate to the likelihood of 20 to 30% heating and cooling energy savings, depending on the application. However, these energy savings may not directly translate to monetary savings on utility energy bills. Typical space heating systems burn natural gas while MSHPs use electricity, which costs more than gas per unit of energy. Nonetheless, the reductions in cooling costs may be significant enough to compensate for increased heating costs and opens up the possibility of adding PV systems that can offset electric heating costs.

Synergies with other measures

MSHP performance can be improved through combination with any thermal load reduction measure. As the retrofit package evaluated in these field tests includes integrated ventilation, this is especially true for envelope sealing measures. While load reduction improves efficiency and comfort performance, cost-effectiveness for the MSHP itself compared to a standard HVAC system may not be quite as good.

There may also be an avenue to use the integrated ventilation with the nighttime precooling and economizer measure discussed in Appendix A9, but this would require coordination with MSHP manufacturers and product development.

Targeted SCP customer segments

- Existing all-electric houses with ducts in unconditioned space.
- Houses with sufficient cooling system use to compensate for conversion from gas to electric heating.
- Houses with rooftop solar PV systems.
- Customers interested in electrification for the purpose of reducing their use of carbon-based fuels.

Deployment strategies

Strategies for deploying MSHPs through the Advanced Energy Center will focus on overcoming the key barriers of low customer awareness, uncertain energy savings in the Sonoma and Mendocino climates, and the lack of contractors familiar with proper installation methods and the practice of coupling low capacity MSHPs with thermal load reduction measures and integrated ventilation:

- Educational materials targeted to homeowners
- Training in proper design and installation practices for architects and trades
- Financial incentives for early adopters

Project Timeline

Table 20 shows the high-level project milestones and deliverables with anticipated completion and due dates.

Table 20: Anticipated project schedule for research on ducted MSHPs.

Project Milestones	Completion/Due Date
Laboratory Tests	Mid-April 2019
Field Tests - Site Screening/Selection	January 2019
Field Tests - Energy Audits	February 2019
Field Tests - Design Retrofits	June 2019
Field Tests - Baseline Monitoring	November 2019
Field Tests – Install Retrofits	December 2019
Field Tests - Retrofit Monitoring	February 2021
Program Participant Satisfaction Questionnaire for Homeowners	April 2021
Draft Input to Technology Demonstration Final Report	July 2021
Final Input to Technology Demonstration Final Report	October 2021

APPENDIX A6: Induction Cooking

Technology Overview

Induction cooktops (see Figure 3) have been commercially available for both residential and commercial foodservice (CFS) applications for decades but are under-represented in both markets because they are typically more expensive to purchase than their gas and electric-resistance counterparts. The most commonly sold induction range unit in the U.S. is a stand-alone portable single-burner hot plate, even though induction cooktops are energy efficient, safe, and perform better than their alternatives.

Figure 3: Samsung Stand-Alone Residential Induction Rangetop

Photo Credit: Samsung

Induction refers to the fact that a current can be 'induced' by creating or manipulating a magnetic field. Induction heating takes advantage of this phenomenon, and uses a magnetic coil to induce a current in a piece of ferromagnetic cookware (i.e. cast iron, some alloys of stainless steel, etc.) The cookware discharges this energy as heat, which means that the piece of cookware itself is the heating element. This is necessarily more efficient than electric resistance heating, where a current is passed through a heating element, which then needs to transfer heat to a piece of cookware. The resistance heating element suffers losses to the ambient air around it during this process and therefore cannot transfer heat to the cookware at 100% efficiency. Induction cooking obviates these losses. One major barrier to market entry for induction ranges is that only magnetic cookware can be used, so there are some cases where people would have to replace their cookware when upgrading to induction. This can be quite costly, especially for some commercial operations or for home chefs with many specialized pieces.

For the residential market, two main classes of induction rangetops exist: stand-alone cooktop models, which include portable models as well as ranges intended to be integrated into a

counter space or a kitchen island, and models that are integrated with a convection oven designed to be a 1:1 replacement for an equivalent gas or electric-resistance configuration. Most models sold in the U.S. are designed to operate at either 120 or 240/208 volts to be easily installed and retrofittable.

There are commercial models available for the configurations listed above, but there are also commercial induction woks. These are not going to be considered for the purposes of this project, as there are many additional operator barriers to this technology. Many chefs prefer natural gas-fed water-cooled woks, and a retrofit study with the currently available induction wok models would require significant staff re-training and operator buy-in. Additionally, because most woks in California are fed with natural gas, this doesn't really fit the scope of the project, which is focused on electricity savings.

The main benefit to this technology is that it's more efficient than any other cooktop on the market. Based on FSTC testing induction cooktops are between 10 and 20% more efficient than other electric models and can be up to 40% more efficient than gas models. From a pure energy-efficiency standpoint, induction cooktops are a clear winner.

Electric resistance ranges have a few performance problems related to their operation that lead many chefs and home cooks to prefer gas ranges. Electric ranges take a longer time to heat up than gas ranges do, and also take a much longer time to cool down after being used. This is due to the resistance and heat capacity of the metal that makes up the metal coil. This phenomenon also leads to some uncertainty as to whether the coil has completed its preheat, and in the control of how much heat is being added to the cookware during the cooking process. Induction cooktops handle both of these issues by design. Their preheats are much more similar to gas ranges, and their control mechanisms are more visually intuitive. Induction cooktops effectively perform like a gas cooktop in terms of user experience.

Electric resistance cooking also leads to a safety concern, as the coil stays hot far after the cooking process has ended, so this is a potential burn hazard. Gas stovetops also present an obvious burn hazard, and both gas and electric resistance stovetops add significant amounts of heat to the kitchen space through losses. Induction cooktops have less heat loss to the environment and therefore add less heat to the space. They also lessen the burn hazard, as the range only works when a piece of cookware is placed directly on the surface. The surface of an induction cooktop doesn't get hot, and the induction coil stops adding heat to the cookware as soon as the cookware is removed from the surface at the completion of the cooking process.

One caveat to the potential energy savings documented by this project for combined ranges is the oven itself. For some applications where the oven is used more than the range (largely depending on a restaurant's menu or a residential customer's cooking/baking habits) the energy savings and ROI can be significantly undercut because the oven part of the package doesn't offer the same savings potential over its competitors that the range does. If, for example, the oven component of the retrofit model is less efficient, it's possible for the retrofit to produce negative overall savings even though the rangetop burners are more efficient. Therefore, for the purposes of this project, the energy of each component must be documented

separately. Data from previous lab monitoring projects will be used to select appropriate replacement models to ensure savings are achieved. The design of the oven doesn't vary with the type of rangetop used; in fact, for many residential combined range/ovens, the exact same oven design is used for both induction and electric coil cooktop options. Steps will need to be taken in the instrumentation and data analysis from any lab or field study to separate the range and oven energy usage to yield a true apples-to-apples comparison. For most residential convection ovens, the oven heating element has a discrete input rate which is higher than for any of the other components. With resolute enough data sampling, it will be possible to identify and filter the energy usage by component.

This phenomenon also leads to some concerns as to whether ranges with ovens can achieve short payback times upon mid-life replacement. Ovens that diminish energy savings will also reduce ROIs. Another concern with ROIs is that the replacement of a gas range with an induction cooktop may end up costing more because of the high cost of electricity relative to gas in California. End-of-life replacement of a range would generally produce more favorable ROI numbers because the incremental cost difference between an induction and non-induction could be considered.

Finally, there are some concerns about the maintenance and upkeep of induction stovetops. Induction stovetops are more complicated in design than either electric resistance or gas ranges, and therefore have more parts that can malfunction or break. Because the market penetration is so small, there is limited information to make estimates on an average lifespan of either a residential or commercial induction range. These concerns are mitigated somewhat by the relative ease of cleaning the surface, and the fact that there is no exposed heat element or burner that an operator can damage by misuse, corrosion or fouling.

This project is designed to demonstrate and quantify energy savings for a transition from conventional ranges to induction ranges. An important aspect of this project will be to survey both commercial and residential test sites at the end of the project. This survey will be designed to answer the following:

- What kinds of training measures will need to be implemented for commercial customers?
- How did commercial menus or residential cooking habits change as a result of this project?
- What additional barriers to widespread market adoption exist? How can we overcome them?

Demonstration Plan

The field testing will constitute the bulk of this project. To accurately assess the field readiness of this technology, two commercial sites and five residential sites will be identified for a retrofit through this project. The combined range/oven configuration will be the prioritized configuration considered for this project to augment existing commercial field data. Residential sites will need to fulfil three main criteria: existence of an electric stovetop, at least 2 people living in the home year-round, and customers will need to have eating habits such that they

actually use their oven and stovetop. Sites would ideally use their stovetops frequently and consistently throughout each week. For residential customers, this would mean using their stovetop to prepare at least five meals per week. The submetering data can be used to make a rough estimate of the number of meals cooked, so the data may need to be normalized to a per meal basis if a customer's eating habits change throughout the project. These criteria will be determined through an initial phone/e-mail survey and site survey. Commercial sites will just need to have a single range/oven that they are willing to change out for an induction cooker, and the chefs and line cooks will need to be excited about the project and ready to make a change. For commercial sites, the customer willingness to participate and handle a change of a major piece of equipment is paramount for the overall project success.

For residential sites, the electricity consumption of the existing range will be directly measured for at least three months to determine an energy baseline. An appropriate replacement range will be chosen based on a combination of existing lab data and the willingness of each manufacturer to participate by donating equipment. The appropriate cookware will be replaced with magnetic options designed for use on induction rangetops. Energy savings will be determined by continuing monitoring for at least three months after replacement. The customer's utility bill will be analyzed to determine how much of an impact the replacement had on the overall home's energy consumption, including possible effects on HVAC, range hood, and microwave use.

For commercial sites, the same experiment will be repeated. Commercial sites will likely need more support with the transition to using induction ranges. Menus and cooking procedures may need to be slightly modified to accommodate the new technology. Cooking times are typically shorter with induction ranges, and these ranges boast faster water boil times. This can lead to burnt food if handled incorrectly. Part of the training process will include an analysis of the baseline menu and range cooking procedures and suggestions on how to modify these procedures, as well as a live training of the cook staff on how these procedures changed. The replacement phase may need to be extended on a site-by-site basis if there is a period of growing pains after replacement.

Each participating site will be asked to complete a short survey to accomplish the goals laid out in Section 1.4. All survey results and energy data will be thoroughly analyzed, and the results of the field testing will be documented in the final report.

The Team will input energy consumption results into to simulation software. This approach will be used to calculate the average energy savings for commercial sites and the average energy savings for residential sites in a variety of applications.

The most basic metric for success during the field monitoring project is that energy savings is achieved in some fashion. The next will be a synthesis of the survey results, where the replacement at each site will be considered a success if the customer opts to keep the new equipment at the end of the project. Finally, the most important metric for success will be if we can use this information to successfully design a replacement program or some deemed measures for either residential or commercial customers through SCP.

Transition to Deployment

The results of the field study will be used in conjunction with other research to estimate the electricity savings of different deployment strategies for both the residential and commercial sectors. A market assessment will be performed for SCP customers, and a cost benefit analysis will be used to choose a deployment strategy that optimizes electricity savings in SCP service territory.

SCP already has a program through their equipment lending library where residential customers can try induction cooktops before upgrading. Similarly, the Food Service Technology Center hosts a try-before-you-buy program for commercial customers that includes induction ranges. Finally, PG&E hosts a rebate program for energy efficient commercial convection ovens that can be applied to induction ranges with convection bases.

The SCP customer segments that will be targeted for replacement will be residential customers with electric oven/rangetops that are over 5 years old that do most of their cooking at home to maximize savings. Commercial foodservice customers with large productions and customer throughputs that require ranges for their operations will also be targeted. Common commercial uses of ranges include boiling and simmering soups, sauces and water for small batches of pasta as well as finishing, which refers to searing, caramelizing or otherwise coloring an individual meat product which had been previously cooked all the way through in a large batch in an oven.

The survey in the field monitoring plan will be used to determine the most appropriate and efficient deployment strategy. Because the survey is designed to help identify operator issues currently unknown to researchers, it will be a critical set of information for determining customer eligibility in a deployment program. Generally, a deployment program for induction cooktops for either residential or commercial customers would have to include a way for the customer to self-identify some of the operating scenarios/current equipment/other barriers in order to avoid customer unhappiness with replacement.

The energy savings data will need to be used to help SCP determine how many resources to set aside for a deployment program to make a reasonable business case. It is possible for SCP to set aside funds for either the equipment itself, the retrofit labor, or any parts or combinations thereof. For residential customers, this is a relatively low-cost retrofit that SCP can simply market, and for commercial customers, SCP can take advantage of the existing PG&E rebate program.

Project Timeline

Table 21 shows the high-level project milestones and deliverables with anticipated completion and due dates. The monitoring timeframe for each site is only a month of premonitoring and a month of retrofit monitoring, so sites will be monitored on a rolling basis.

Table 21: Anticipated project schedule for research on Induction Stovetops.

Project Milestones	Completion/Due Date

Field Tests - Site Screening/Selection	July 2019
Field Tests – Baseline Monitoring	May 2020
Field Tests – Retrofit Installation	August 2020
Field Tests - Retrofit Monitoring	December 2020
Program Participant Satisfaction Questionnaire for Homeowners	December 2020
Analysis of Alternative Applications	December 2020
Draft Input to Technology Demonstration Final Report	January 2021
Final Input to Technology Demonstration Final Report	October 2021

APPENDIX A7: Waste Heat Recovery for Commercial Dishwashing Systems

Technology Overview

Heat recovery dishmachines are a relatively modern application of some old technologies. Heat exchangers and condensers are relatively common in industrial, commercial and residential settings alike, so it's only natural that dishmachine manufacturers have designed both exhaust-side heat recovery (EHR) and drain water-side heat recovery (DWHR) dishmachines. EHR is slowly generating some market share in the commercial foodservice industry and has shown some promise in previous lab and field testing conducted by researchers at the Food Service Technology Center. EHR is more market-ready than DWHR, and there are more companies that make EHR dishmachines than DWHR options, so EHR carries a substantially lower field-testing risk and will be the technology featured in this section of the project.

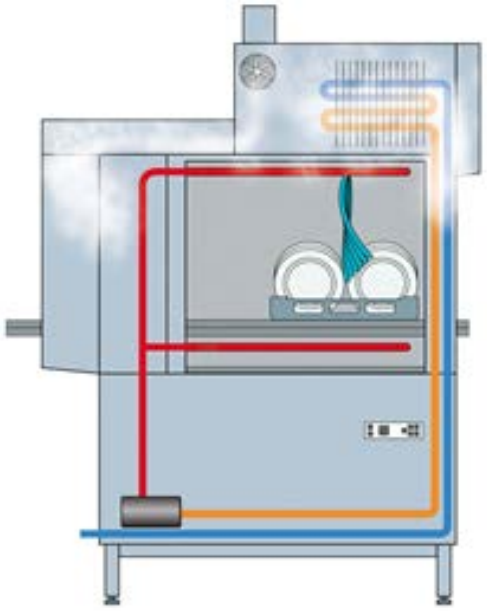
Heat recovery ventilation was considered for this project, but because of the mild climate of Sonoma county, a reasonable cost-savings case could not be made. Similarly, a technology to capture the waste heat from cooling systems was considered, but it was later realized (and confirmed by the site surveys done during the premonitoring stage) that many customers in Sonoma County rarely, if ever, use their conventional cooling systems and that this technology wouldn't be a good fit. Exhaust heat recovery is a superior choice for this project because in addition to its water heating savings, it offers direct HVAC savings by lessening the total CFM load on commercial buildings.

High temperature door-type dishmachines use hot water in two ways: they recirculate and top-off tank water at about 150˚F (although this number varies between manufacturers) to wash any stuck-on debris from dishes, and they rinse the dishes with 180˚F water to sanitize them. In general, dishmachines are fed with hot water from the building water heater. They make up the difference between the building water heater's outlet temperature and operating temperatures by use of a tank heater for the wash water and a booster heater for the rinse water.

Exhaust heat recovery works by capturing the energy that would otherwise be released from a dishmachine as steam after the washing and rinsing processes are completed. It takes in cold water and preheats it with the steam energy to roughly 120°F and uses an appropriately sized booster heater to raise the water to its appropriate rinsing temperature. This preheated water then runs through the dishmachine's internal booster heater and becomes the sanitizing rinse water for the next rinse cycle (Figure 4). This allows many door-type dishmachines to be fed exclusively with cold water and allows for projects where existing dishmachines can be removed from the building's hot water system. This saves energy by lessening the load on the building's hot water system. A typical high-temperature door-type dishmachine will be the highest load on the building's hot water system, using up to 75% of the system's hot water. By using heat recovery to make up most of that load, sites can realize multiple benefits in addition

to the substantial energy savings. Conventional high-temperature dishmachines require an inlet temperature of 140°F, which means that the hot water system must supply this temperature even though most fixtures only require an inlet temperature of 125°F. By taking the dishmachine off the hot water system, the water heater setpoint can be turned down, which can yield additional energy savings. In some cases, the hot water system can also be downsized, and a wide range of energy and performance savings are possible through the retrofit of the hot water system. These benefits are dependent on design constraints specific to each site.

Figure 4: Exhaust Heat Recovery Dishmachine Schematic



EHR saves energy directly on water heating by capturing heat, so for buildings with electric water heaters, retrofits involving this technology get substantial and direct kWh savings. Additionally, most EHR dishmachines are more water efficient and operate at lower flow rates than conventional models, so additional electric savings are possible at the dishmachine's booster and tank heaters.

EHR saves energy indirectly in two important ways. First, it can reduce or eliminate the need for ventilation in the dishroom. The dishmachine is the largest contributor of heat and moisture gain to the space in commercial dishrooms, so by condensing the steam that would otherwise be vented to the space, it is possible to make dishrooms substantially more comfortable working environments without high-volume mechanical ventilation. There are also associated savings elsewhere on the HVAC system, such as at the make-up air unit. Second, dishmachines are generally the largest load on building water systems in commercial foodservice, and they're typically located far from the building water heater. It is possible to use EHR dishmachines to design substantially smaller and more efficient water heating systems. Frontier Energy covered

this savings aspect in great detail in a previous project[4]. All possible savings support current CEC efforts towards decarbonization and electrification.

One major uncertainty with EHR lies in its ability to reliably deliver cost savings to customers with gas water heaters. 85% of CFS customers in California use gas water heaters. In some applications, the customer may end up using substantially less energy for water heating overall, but more electricity at the booster heater. The ventilation and HVAC savings will be mostly electric energy. The decommissioning of a ventilation hood can save up to 15% of a large restaurant's total HVAC cost, and the payback periods of carrying out this kind of retrocommissioning tend to be less than 6 years. Another uncertainty is related to the maintenance of these new dishmachines. Because they're relatively new and underrepresented in the current dishmachine market, it's difficult to reliably estimate the lifespan of these machines. In particular, there may be maintenance issues with the heat exchanger or condenser such as fouling and depending on how often this happens and whether it's covered by the machine's warranty, it may translate to extra maintenance costs.

This demonstration project seeks to show how much energy EHR dishmachines can save at the building water heater, at the ventilation hood, and at the dishmachine itself.

Demonstration Plan

The field-testing part of this project will include monitoring existing dishmachine and dishroom ventilation equipment to establish a baseline, a warewasher retrofit, and decommissioning of the ventilation fan. This will involve a substantial amount of monitoring equipment, including multiple water meters and electric meters at the dishmachine, multiple electric meters on building HVAC equipment, and temperature and humidity monitoring equipment in the dishroom.

This demonstration project will only consist of three sites, so site selection will be rather important. The following site selection criteria must be fulfilled:

- The site has electric water heating
- The site's current dishmachine is:
    - A door-type dishmachine
    - About 5 years old
    - Has an internal or external electric booster heater
    - Has an electric tank heater
    - Has plumbing layout such that the installation of submetering equipment is possible
    - Has a standard size for all connected stainless steel tables (for ease of retrofit)
- Proprietors of the site are excited about the project

[4] https://caenergywise.com/design-guides/Water_Heating_Design_Guide.pdf

The dishmachine specifications are necessary for myriad reasons. The machine should be a door-type because exhaust heat recovery is most developed for this class of machine, and the cost savings are more substantial. Conveyor machines with EHR cannot be ventless because they still introduce heat and steam to the space; the heat capture is not perfect. Furthermore, undercounter dishmachines can currently be ventless by code regardless of if they have heat recovery. The age of the machine is specified to reflect the average age of door-type dishmachines in the field. The dishmachine needs to have an electric booster and tank heater and be fed with electric water heating to maximize the cost savings to the customer. The other specifications are designed such that the retrofit performed as a part of this demonstration is easy to accomplish and will yield accurate results.

The ideal site will also have some degree of thermal comfort problems so that the new machine's thermal comfort gains can be demonstrated through measurement and verification.

The site's existing dishmachine and ventilation system will be monitored for at least 6 months to establish a reasonable baseline. The energy use of both the dishmachine and the ventilation system are weather-dependent, so winter days (characterized by low outside ambient air and cold inlet water temperatures) and summer days can both be represented in the final data set. Similarly, after the replacement, the monitoring equipment must stay in place for at least 6 months for the same reason. The retrofit itself will include a training on the new dishmachine as well as some maintenance best practices so that operators can transition smoothly to using a new piece of equipment.

Thermal comfort will be determined both by the temperature and humidity monitoring data but will also be determined by a *Participant Questionnaire* given at the end of the project. This questionnaire will aim to reveal the following:

- Did the staff like the new machine overall? Was it easy to use?
- Is the staff more comfortable in the space after the retrofit?
- Were there any changes to operator behavior incurred by the new machine?
- Were there any additional maintenance requirements of the new machine?

Results from the field monitoring project will be inputted into the appropriate building modeling software and will also be logged in the Food Service Technology Center's ongoing dishmachine field monitoring data logs. The two most important metrics of success will be overall site energy consumption reductions contributing to the target of 20% electricity savings for commercial buildings, and customer satisfaction with the change overall.

Transition to Deployment

The results of the field study will be used in conjunction with other research to estimate the electricity savings of different deployment strategies for commercial dishrooms. A market assessment will be performed for SCP customers, and a cost benefit analysis will be used to choose a deployment strategy that optimizes electricity savings in the SCP service territory. Any

of these deployment strategies would need to include some training on the new dishmachine and associated maintenance practices to ensure the success of the deployment.

For Energy Star qualifying door-type dishmachines, PG&E currently offers a rebate of $600/unit. Because virtually all EHR door-type dishmachines meet the Energy Star threshold, this rebate would apply to this project unless the replacement machine is donated by a partnering manufacturer.

Deployment for this measure will be limited to SCP's commercial foodservice customers. If deployment is limited to door-type dishmachines, which may be preferable because of the relative ease and cost of replacement programs, most quick and full-service restaurants as well as cafes, small cafeterias and cantinas will be targeted. FSTC estimates more than 50% of new dishmachine sales each year are door-type machines.

The survey in the field monitoring plan will be used to determine the most appropriate and efficient deployment strategy. Ideally, the deployment would have a mid-life retrocommissioning component to it. Past research has shown that many dishmachines operate wildly out of specification in as little as 2 years after commissioning and in need of major repair or replacement within 10 years, although the average lifespan of a door-type dishmachine is around 15 years. Significant energy savings are possible for both mid and end-of-life replacements, and both can have payback times that make sense for most customers.

The energy savings data will be used to help SCP determine how many resources to set aside for a deployment program to make a reasonable business case. It is possible for SCP to set aside funds for either the equipment itself, the retrofit labor, or any parts or combinations thereof. The labor component of retrofitting a dishmachine is significant because this process can take up to 40 person-hours depending on the location of the existing dishmachine, the layout of the plumbing and electrical systems, and the configuration of the loading and unloading tables on either end of the machine. It also needs to be made clear to customers participating in a deployment program that it may be necessary to replace the other stainless steel in the dishroom, and that new tables may need to be fabricated as a part of a retrofit process. This can be quite costly, and ultimately, the team will need to make a decision on where to draw the line: would a deployment measure cover just the equipment, the equipment plus its auxiliary stainless pieces, or the equipment and the labor involved? Dishmachines are generally expensive pieces of equipment, so it's difficult to get a restaurant owner to voluntarily carry out a retrocommissioning project, but the savings potential is so substantial that even with high initial costs, paybacks from the water heating savings alone typically range between three and six years. Additionally, this program would need to cover retrocommissioning of the ventilation system. In some cases, this can be as simple as decommissioning an existing fan but leaving the ductwork and hood in place, but in some cases some of the ductwork would need to be altered to realize additional savings at the makeup air unit.

Project Timeline

Table 22 shows the high-level project milestones and deliverables with anticipated completion and due dates.

Table 22: Anticipated project schedule for research on EHR Door Type Dishmachines.

Project Milestones	Completion/Due Date
Field Tests - Site Screening/Selection	April 2019
Field Tests – Baseline Monitoring	February 2020
Field Tests - Retrofit Installation	March 2020
Field Tests - Retrofit Monitoring	December 2020
Program Participant Satisfaction Questionnaire	December 2020
Analysis of Alternative Applications	December 2020
Draft Input to Technology Demonstration Final Report	April 2021
Final Input to Technology Demonstration Final Report	October 2021

APPENDIX A8: Aerosol Envelope Sealing

Significant effort has been made to reduce the leaks in building envelopes using conventional (manual) caulking and sealing methods, but the problem remains one of excessive labor costs, quality control problems, and leaks that are neither visible nor accessible. This technology demonstration project will focus on an innovative technology, originally developed for duct sealing, that can seal those visible and invisible leaks by using a sealant in aerosol form that is pulled through leakage points by pressurizing the building interior. This project will evaluate the cost-effectiveness and practicality of sealing both building enclosures and ducts simultaneously, targeting single-family and/or multi-family homes. Installation costs, energy savings, and occupant satisfaction will be studied to determine the viability of the product in comparison to more traditional air sealing measures.

Technology Overview

A process for sealing ducts using an injected aerosol was developed by Dr. Mark Modera in 1994 at Lawrence Berkeley National Laboratory and is now owned by Lead Locally partner Aeroseal.[5] The technology uses a vinyl compound suspended in a water solution. Once atomized, the sealant is pumped through HVAC ducts and deposited at the leakage points. It does this without coating the inside of the ducts. Responding to the need for an inexpensive, effective means of sealing building envelopes, the UC Davis Western Cooling Efficiency Center (WCEC) began experimenting in 2014 with a similar aerosol sealing process for building envelopes, now called Aerobarrier.[6]

Features

The Aerobarrier process involves briefly pressurizing a building while injecting an aerosol "fog" (as shown in Figure 5). As the air escapes through leaks in the exterior shell of the building, the aerosolized sealant is transported to the leaks, accumulates, and seals the leakage path as pressurized air tries to escape. Existing blower door equipment is used to facilitate the sealing process as well as to provide real-time feedback and a permanent record of the sealing that is occurring. Because belongings and furnishings must be covered up or removed during sealant application, rental housing is the most appealing target market because application is more convenient and takes less time during tenant turnover when the unit is vacant and devoid of furnishings. With appropriate preparation work, however, it can be done also in occupied homes.

[5] https://aeroseal.com/aeroseal-history/

[6] http://aerobarrier.net/

Figure 5: Aerosolized sealant released into the interior of a building.

Photo credit: Aerobarrier

Following successful laboratory tests, the building envelope sealing technology was tested in multiple existing apartments in Queens, NY, where it reduced air leakage by at least 80% in less than two hours (Harrington & Modera, 2012). A subsequent test of six California production homes showed leakage reductions of 62 to 80% (1.8 to 5 ACH50) in less than 90 minutes (U.S. Department of Energy, 2016). WCEC estimated that a single-family home can be sealed for a materials cost of less than $500 (plus labor), much lower than the cost of traditional sealing methods that would achieve the same objective.

Technology Benefits

- 10-20% heating and cooling energy savings
- 5-10% peak demand reduction
- Fewer drafts leading to improved occupant thermal comfort
- Better control of outdoor pollutants such as smoke
- Better indoor air quality when bundled with whole house mechanical ventilation
- Effects on air infiltration rate can be measured directly during application process
- Duct sealing can be performed at the same time

Technology Uncertainties

- Application process requires significant preparation to protect belongings and decorative home features; the time and costs associated with this are the biggest uncertainty. There are a small number of contractors who routinely do this, and data will be collected from these contractors prior to making the final site selection.
- Sealing process could clog up electrical outlets, filters, and vents if proper precautions are not taken
- Clean-up of extraneous sealant is typically required

- Long-term durability of both aerosol-based and conventional air sealing have not been adequately documented
- Primarily designed for new construction during the rough-in stage, the technology has not been used to date as frequently for retrofits except when there is a change in tenants or ownership. Both applications will be investigated.

Research Questions

The Team will attempt to answer the following research questions through the demonstration of aerosol envelope sealing in residential buildings:

1. What is the typical absolute and percent reduction in air infiltration for existing homes? How does it compare to traditional air sealing methods?
2. Will the envelope sealing bring the house to tightness levels requiring mechanical ventilation according to Title 24 or ASHRAE 62.2?
3. Can the sealant be readily removed after it is deposited in undesired locations?
4. How much preparation and clean-up time is required?
5. Can the sealant be prevented from entering adjacent units in multi-family housing?
6. Does the sealant lose its effectiveness over time?
7. What is the cost-effectiveness of the technology in various Northern California climates and building applications?

Demonstration Plan

Lab Testing

No laboratory testing is envisioned for aerosol envelope sealing, because it is difficult to reproduce the air leakage characteristics of real buildings in a lab setting. The technology has been lab tested by WCEC and has been applied in several single-family and multi-family buildings, and the results should be adequate for characterizing any problems that may be encountered in the field.

Field Testing

This demonstration project will focus on field testing of the Aerobarrier process in ten houses or apartment units. The technology itself is proven to greatly reduce infiltration rates, but the process of masking and protecting furniture, household items, electrical outlets, vents, and other features of the house such as windows, doors, and molding introduces some level of risk. It will be implemented in a number of homes that are currently unoccupied, and if all goes well, will be implemented in occupied homes (by hiring movers to remove occupant belongings before hiring professional painters to do the sealing, and then hiring movers to replace the items).

Retrofit Measure/Package

The retrofit package will consist of three measures:

- Aerobarrier envelope sealing
- Aeroseal duct sealing, if ducts are in unconditioned space (potentially in the same application)
- Mechanical ventilation, likely an upgraded bathroom exhaust designed to operate continuously, if additional ventilation is required by code. (This measure may be deployed in conjunction with Residential Nighttime Ventilation cooling for homes without central air conditioning. See Appendix A9).

Site Selection

The test sites selected for this demonstration project will consist of ten rental housing units within Sonoma and Mendocino Counties, recruited from the SCP customer base. The criteria for these sites are outlined in Table 23. Some criteria are essential for consideration of a test site, others receive a score from 1-10 based on importance. Owners of the sites with the highest scores will be offered the Aerobarrier retrofit package using both CEC funding and SCP match funding to subsidize the cost up to 100%, in exchange for supporting limited monitoring activities and asking tenants to complete a questionnaire about comfort perceptions.

Table 23: Technology demonstration site selection criteria for aerosol envelope sealing

Category	Criterion	Criterion Value	Criterion Weight (1-10)
Occupants/Owner	Rental property?	Yes	5
	Operational year long?	Yes	3
	Currently occupied?[i]	No	10
	Realistic owner expectations?	Yes	Essential
	Owner enthusiastic?	Yes	8
Site	Renovation plans	Yes	7
	Building type	Single-family, multi-family	Essential
	Conditioned floor area	<2500	7
	Safe work environment?	Yes	Essential
	Practical installation barriers	No	Essential
	Practical installation challenges	No	10
	Located near other sites	Yes	4
	Features similar to other sites	Yes	2
Building Envelope	Building airsealed	No	Essential
Mechanical	HVAC system functional?	Yes	Essential
	Central Cooling?[ii]	Yes	3
	Central Heating?	Yes	7
	Duct location	Attic or crawlspace	8
	Electric heating?	Yes	4

[i] The first few homes will be unoccupied. Ideally they should be expected to be occupied prior to the retrofit, unoccupied around the time of the retrofit, and re-occupied shortly thereafter. Subsequent homes may be occupied.

[ii] If no central cooling, the home may be a candidate for Residential Nighttime Ventilation cooling)

Baseline

The pre-retrofit baseline for this project is the housing unit before retrofit. Infiltration as measured using a multi-point blower door test just prior to air sealing is expected to provide a clear indication of the initial air leakage rate.

Post-Retrofit

The air leakage rate will be monitored before, during, and after the aerosol sealing process. Air leakage will be assessed throughout the sealing process, and a post-retrofit leakage rate will be established. In addition, an additional blower door test will be performed after one year to confirm that there was no degradation of the air sealing over time.

A survey of occupant comfort perceptions will be performed during the post-retrofit period and at the end of the project, for both unoccupied and continuously occupied homes. While it will not be possible to evaluate the change in perceived comfort and indoor air quality for the unoccupied homes—because the retrofit will be performed between two sets of occupants with different attitudes about comfort and different pollutant sources—the survey will still provide valuable information about acceptability of the process and satisfaction with the sealed home.

Utility Bill Analysis

Utility bills before and after retrofit may be used to provide a very rough estimate of energy savings. However, because a change in occupancy will occur at the same time the retrofit is performed, the thermostat settings and internal gains may be very different.

Building Simulation

Once leakage reduction performance is verified through field testing, simulation will be used to estimate kWh and therm savings. Aerosol sealing will be included in the analysis of optimal retrofit packages in Northern California climate zones. Because air leakage is a commonly used input for residential building models, no special algorithms or modeling techniques will be developed. The simulations will examine the effect of climate and pre-retrofit envelope leakage, duct leakage, and mechanical ventilation rates, which could affect energy and peak demand savings potential. Calibrated energy models of the individual test sites will not be performed for this project, because the change in air leakage will be measured directly.

Success Metrics

Aerosol envelope sealing will advance to the deployment phase and be included in the Advanced Energy Center if the following criteria are met.

- Heating and cooling electricity savings in excess of 10%
- No issues with the persistence of air tightness when the sealant is exposed to realistic weather conditions over a one-year test period (with the understanding that air-tightness in even manually-sealed homes can degrade over time)
- Potential for cost-effectiveness in several building types and climate zones in Northern California. Pilot study costs are not a good representation of production costs, and the research team will you estimate what the costs would be if Aerobarrier were deployed in production mode. Costs will include all labor and materials costs (including any costs for removing or protecting household items and cleaning up the home and repairing or

replacing any items that cannot be cleaned). Non-energy impacts—such as improved comfort or air quality—will be documented and quantified, wherever possible.
- Manageable and definable site preparation and clean-up requirements
- No significant occupant complaints related to the sealing process

Transition to Deployment

Potential electricity savings

Effective envelope sealing can reduce heating and cooling energy use by 10-20% in existing buildings (Baechler, et al., 2010), and perhaps more in older California homes. Peak electricity use will also be reduced, but by a smaller percentage because air infiltration tends to be highest during cold weather. Similar energy savings is possible for aerosol duct sealing, and peak electricity use can be reduced by a comparable percentage.

Synergies with other measures

When air infiltration is significantly reduced, there is the potential for indoor air quality issues because insufficient fresh air is entering the building, especially more extreme weather when windows are unlikely to be opened by the occupants. As a result, mechanical whole-house ventilation will be required in most situations where aerosol envelope sealing is applied. As with other space conditioning load reduction measures, the cost-effectiveness of air sealing will be reduced if combined with heating and cooling efficiency improvements, because less energy would be required to meet the load introduced by air infiltration. For homes without central air conditioning, there will be a good deal of synergy with the Residential Nighttime Ventilation measure. Finally, cost synergies can be obtained by sealing air ducts at the same time the envelope is sealed, because much of the same equipment is used for both measures.

Targeted SCP customer segments

Aerosol sealing is likely to be most cost-effective when applied to older residential buildings, where infiltration represents a large fraction of the space conditioning load. Single-family detached homes have more surface area exposed to the outside than multi-family, making them a more attractive target. However, because the sealing process is fairly intrusive and presents some risk to occupant possessions, it is best performed between tenants. Multi-family rental housing has fairly high turnover rates. Single-family rental housing is a much smaller sector and would be more challenging to penetrate than multi-family rental units because of the diversity of ownership. Hence, multi-family housing is the primary target, with single-family rentals as a secondary target.

Deployment strategies

The greatest challenge for deploying aerosol envelope sealing involves customer acceptance of the potential risk of the sealant depositing in undesirable locations, resulting in a significant cleaning effort if not permanent damage to home components and occupants' belongings. This demonstration project may provide reassurance to homeowners and landlords that the sealing process can be well controlled when proper precautions are taken, or at least identify problems

that Aeroseal must address before deployment through the Advanced Energy Center is possible. Other barriers that must be overcome are low customer awareness, tenant-landlord economics and split-incentives, and the lack of infrastructure such as skilled contractors and specialized equipment. Primary strategies for deployment include the following:

- Analysis of cost-effectiveness in various residential building types and climate zones
- Educational materials targeted to both tenants and landlords
- Best practices guidance for trades
- Financial incentives for early adopters

Project Timeline

Table 24 shows the high-level project milestones and deliverables with anticipated completion and due dates.

Table 24: Anticipated project schedule for demonstration of aerosol envelope sealing.

Project Milestones	Completion/Due Date
Field Tests - Site Screening/Selection	September 2019
Field Tests – Retrofit Design	December 2019
Field Tests – Retrofit Package Installation	January 2020
Field Tests – Follow-up Durability Test	January 2021
Program Participant Satisfaction Questionnaire for Homeowners	March 2020 and February 2021
Analysis of Alternative Applications	April 2021
Draft Input to Technology Demonstration Final Report	July 2021
Final Input to Technology Demonstration Final Report	October 2021

APPENDIX A9: Nighttime Ventilation

Technology Overview

Residential Nighttime Ventilation control has demonstrated benefits for reducing energy used in residential cooling. This is achieved by flushing the home with cool outdoor air at night, to reduce indoor air temperatures throughout the day, and delay the time the air conditioner has to start working or eliminate the need for compressor-based cooling altogether on suitable days.

For homes that do not have central air conditioning (AC), however, this will not be an energy saving measure. Rather it will provide significant benefits by providing improved thermal comfort—it may reduce the number of, or even eliminate, days when the indoor temperatures become uncomfortably hot. This does have energy consequences, however, since many homeowners without AC contemplate adding it, so improving thermal comfort in these homes may prevent the installation of new central AC systems, which would come at a very steep energy cost.

One downside to relying on cool outdoor air (OA) to provide cooling is that it cannot be relied upon when the OA is even more unhealthy than the indoor air, such as during unhealthy outdoor air like those events caused by the recent wildfires in the region. During such events, occupants are advised to keep doors and windows closed, and on hot days, they could truly suffer in sweltering heat. To fully address the challenges of not having AC, then, it is helpful if a ventilation-based solution can address days with poor OA quality, by carefully controlling when and how outdoor air is introduced to the home. his project will adapt existing nighttime ventilation technology to provide optimal thermal comfort in homes without central AC (at night or any time the outdoor air is cool enough to be used), and to respond to unhealthy air events by facilitating the closing off of outdoor air inlets, recirculation of indoor air to improve filtration effectiveness, and introduction of outdoor air only at times when particulate levels are lower (often, early morning hours).

Features

- Bring in filtered outdoor air overnight as appropriate, to achieve a sufficiently low indoor air temperature by morning. (Designed to balance thermal comfort in both the morning and afternoon/evening).
- Develop a separate manual or automated “Unhealthy Day Mode”, for those days when outdoor air quality is unhealthy, with fan lockout function. Optionally bring in outdoor air in the early morning when particulate levels are lower. Recirculate indoor air to achieve better filtration.
- Proved at least the minimum ventilation air specified in ASHRAE 62.2 throughout the day and year.

Technology Benefits

- Provide some amount of cooling and improved thermal comfort for homes that do not have AC. Allows homes to add amenity while avoiding the threat of increasing utility loads from homes adding AC.
- To provide better indoor air quality by flushing Volatile Organic Compounds (VOCs) from new or remodeled homes.
- Provide an alternative to whole house fan. Allows filtered air—important in areas with wildfire smoke problems, optimized to provide more comfort next day.
- Provide a more efficient alternative to window-units and central air conditioners that also provide ventilation air and flushing of indoor contaminants.
- Combine with envelope sealing, to avoid uncontrolled and potentially unhealthy infiltration. This type of ventilation may be required when envelopes are well-sealed.
- Unhealthy Day Mode of operation: Can operate during sporadic unhealthy outdoor AQ days. Turns off OA when outdoor air quality (AQ) is unhealthy, optimize operation to run during the least-bad AQ time of day, filter the OA (perhaps encouraging temporary installation of high-MERV or carbon filters) when it does come in. (See Table 25 for a description of the type of scenario in which it can be used.)

Table 25: Scenario: Hot summer day, Unhealthy Day (unhealthy outdoor AQ).

- Baseline:
  - Very low energy use because there is no AC
  - Occupants have to choose between very unhealthy indoor air quality (IAQ) and very bad thermal comfort:
    - Unhealthy IAQ:
      - Open windows and/or operate window fans at night to improve comfort in afternoon.
      - Good thermal comfort, on most days.
      - BUT very bad IAQ. They flush indoor pollutants, but they have to bring in unhealthy outdoor air.
    - Bad Thermal Comfort:
      - Keep windows closed all day and night.
      - Decent IAQ (as good as possible given unhealthy outdoor air quality). No flushing of indoor pollutants. No filtering of indoor air.
      - BUT very bad thermal comfort as they can't do any night flushing.
      - Still bad IAQ if uncontrolled infiltration.
- Proposed:
  - Tighten shell, keep windows closed, bring in filtered air at night; lock out fan when outdoor air quality is sporadically unacceptable.
  - Low energy use, fan operates off peak TOU and off critical peak; higher than baseline, but better than if they resorted to installing AC.
  - Balance between IAQ and thermal comfort.
    - Decent IAQ:
      - IAQ as good as it can be on days with unhealthy outdoor air quality.
      - All ventilation air is filtered.
      - Fan can be turned off when outdoor air quality is particularly unhealthy (or only operated at times of the day with relatively lower particulates).
      - Indoor air can be recirculated to achieve improved filtration from multiple passes through the filter.
      - Good flushing of indoor pollutants on most days.

- Good Thermal Comfort:
  - Acceptable afternoon temperatures on most days (more days than baseline).
  - On days with unhealthy outdoor air quality, comfort will suffer, but no worse than baseline.

Technology Uncertainties

- There will be an unknown number of days when comfort cannot be ensured throughout the next day.
- Typical existing duct sizes compared with duct sizes that would be required to provide the required air exchange over the course of the night.
- Most furnace fans have two speeds: one for heating and a higher speed for cooling. It is not known if lower heating air-flow rates are sufficient to improve comfort during an adequate number of days.
- Use of existing FAU blower fan and motor: These are not optimized for efficiency, and their energy use in this application has not been well studied. Unknown whether typical dimensions allow for possibility for concurrent replacement with higher efficiency fans.
- Unknown whether "off the shelf" components will be appropriate or if there is additional configuration that is needed to test the technology.
- Unknown how much effort will be needed to implement Unhealthy Day Mode in existing controllers.

Research Questions

- Can nighttime ventilation maintain summertime comfort adequately in Sonoma county climates and with existing building stock (with its varying levels of thermal mass)? (What is the meaning of "maintaining comfort", and what comfort levels are considered acceptable?)
- How acceptable is it as a replacement for AC?
- Do the dimensions of typical furnace FAUs allow for replacement of existing inefficient fans with more efficient fans?
- For a range of homes with different maximum ventilation capacity, how often are afternoon conditions uncomfortable when considering both objective temperatures and thermal preference?
- How much improvement can we achieve in IAQ (eg, reduction in measured levels of important individual pollutants and occupant perceptions of smoke) on unhealthy air days compared to a house with closed windows and uncontrolled infiltration? Can we maintain good IAQ and thermal comfort using ventilation cooling during poor OAQ events such as wildfires?
- What are the energy impacts and long-term cost-effectiveness compared with baseline and with mechanical cooling?
- What are the training requirements and what installation problems should we anticipate?

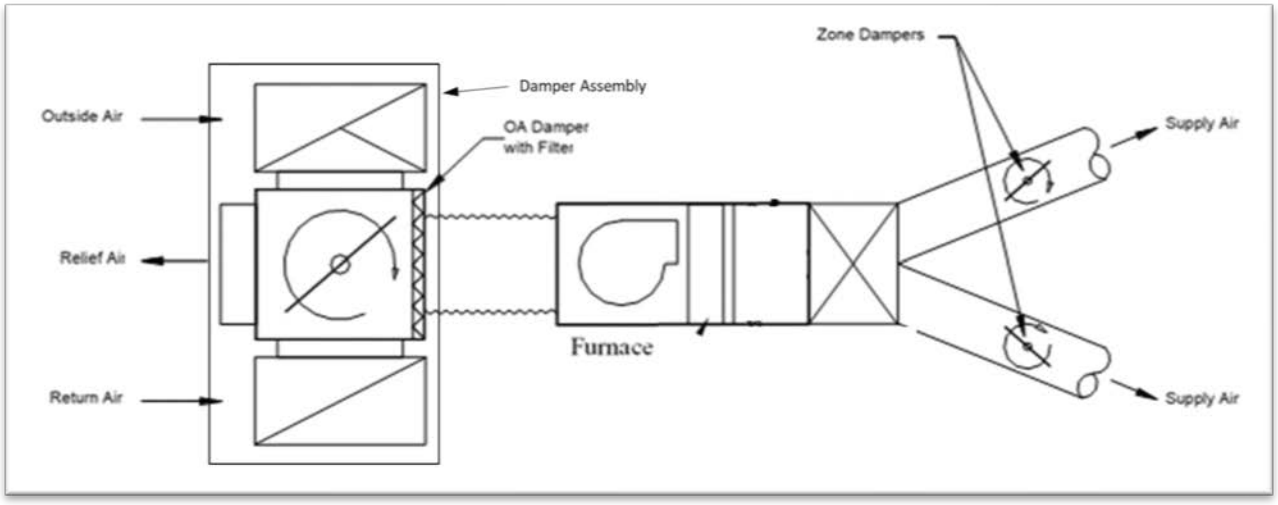
Demonstration Plan

Technology Configuration

There are several technology configurations that will be considered. One possibility is shown in Figure 6. Detail will be added as the plan is refined.

- Review capabilities of SmartVent, NighBreeze, and Ecobee and select the best starting point.
- Adapt controller to incorporate logic for Unhealthy Day Mode. Test Unhealthy Day mode operation in lab to fine tune optimal controls.
- Utilize "off the shelf" damper assembly (either SmartVent or AirScape).
- Demonstrate in homes with central heating (duct system) but no central cooling.

Figure 6: Possible night ventilation cooling diagram



Lab Testing

The controller will be reconfigured to add Unhealthy Day Mode. It will be installed on a residential split-system and tested in the BSRL. Testing will be done to ensure that it behaves as expected during all operating modes, and works as expected with a range of filtration ratings, total external static pressures, and airflow rates. We will evaluate the pressure drop added by the damper assembly during all modes.

Field Testing

Retrofit Measure/Package

- Air seal home (coordinating with Aeroseal demonstrations, if possible—manually sealing, if not).
- Install outdoor air gable vent in attic.
- Install damper assembly (AirScape Residential Economizer or SmartVent, with filter) in between existing (or relocated) return register and furnace forced-air-unit (FAU). Duct to outdoor air vent.
- Install controller (SmartVent, NightBreeze, or Ecobee—suitably adapted) and connect to or replace the existing thermostat, to operate FAU blower fan as necessary.

Site Selection

The field test is targeted to include approximately ten residential sites, depending on the scope of the final retrofit designs. The initial criteria for inclusion in the field study include the following:

Table 26: Field Test Site Selection Criteria

Category	Criterion	Criterion Value	Criterion Weight
Volunteer	Volunteer for heating and cooling retrofit?	Yes	Essential
	Volunteer for insulation and air sealing?	Yes	Desired
Occupant	Occupied?	Yes	Essential
	Owned by current residents?	Yes	Essential
	Occupants will remain for 2 years?	Yes	Essential
	Full time residence?	Yes	Essential
	Anticipated change in occupancy?	No	Important
Site	Dwelling Type	Single Family	Essential
	Utility data available	Yes	Important
	Climate Zone	2	Important
Building Envelope	Attic type	Traditional	Essential
Mechanical	Central Heating?	Yes	Essential
	Central Cooling?	No	Essential
	HVAC asbestos ducts?	No	Essential
	HVAC whole house fan?	No	Essential
Field Study Considerations	Realistic owner expectations?	Yes	Important
	Practical installation barriers?	No	Essential
	Safe work environment?	Yes	Essential
	Asbestos?	No	Essential

54 of the sites identified during the first round of site recruitment meet these criteria. Additional criteria will emerge as results of lab and simulation studies are evaluated. Some of these added criteria may require additional site assessment:

- Duct sizing
- Maximum airflow through Forced Air Unit
- Location of FAU and ducts (in attic?)
- Layout of heating system (including location of return) and space available for added components
- Overall condition of heating system (duct leakage, blower fan capacity, age)
- Occupant interest in pursuing ventilation cooling and unhealthy air exclusion
- Envelope airtightness (can it be brought to adequate levels of leakage?)

Baseline

Baseline monitoring will be used to determine the conditions prior to the energy efficiency technology being installed. Table 27 indicates the baseline characteristics that will be captured. This will include site condition measurements, equipment monitoring, and occupant surveys. In all cases, the Team will attempt to capture representative operating modes of the building or the equipment during several months of a normal cooling seasonal operating cycle, ideally capturing both a high outdoor temperature event and an unhealthy air event. If scheduling

permits, monitoring will also include some winter operation to confirm that there are no impacts on heating energy use.

As budget and participation agreements allow, the team may survey and monitor temperatures in other non-retrofit homes to serve as a control group.

Table 27: Measures to Evaluate Pre- and Post-Retrofit Performance

Characteristic	Pre	Post	Control	Source
Annual home energy use (kBtu)	•	•	•	Utility Bills
Seasonal HVAC (heating and ventilation) energy use (kBtu)	•	•		Submetered over a representative period during cooling season (ideally, capturing a heat storm).
Summer indoor air temperature, daily profiles	•	•	•	Temperature loggers in each home, measured over a representative period during cooling season (ideally, capturing a high outdoor temperature period)
Occupant thermal objectives, preferences, and tolerances	•	•	•	Occupant surveys
Indoor air quality metrics	•	•		IAQ loggers installed in each home to measure key pollutants (such as PM2.5, CO, VOCs, etc.), monitored over a representative period during cooling season (ideally, capturing an unhealthy air event).
Outdoor air quality metrics	•	•		One instrument, installed in each region or subregion (ideally, capturing an unhealthy air event).

Post-Retrofit

Table 27 also indicates the measurements needed to evaluate post-retrofit performance. These will be evaluated over one full post-retrofit heating and cooling season. Differences between pre- and post-retrofit performance will be used to analyze the costs and benefits of the technology application. Analysis will include weather normalization.

Utility Bill Analysis

Utility bill analysis will be done to estimate the impact of the retrofit on seasonal energy use and costs. It is anticipated that energy use will go up, but simulation analysis will be used to estimate the hypothetical consequences had the homeowners instead opted to install air conditioning.

Post-Occupancy Evaluation

Participant Questionnaires will be an important part of this study, as they will help to assess how much less likely a homeowner will be to install AC, which is a behavioral factor. These surveys will also assess perceived comfort during typical and extra-hot summer days, and the benefits (and thermal comfort reductions) from being able to avoid unhealthy air during any wildfire events that might happen during the monitoring period. Questionnaires will be administered both before and after the retrofit, to gauge changes in attitudes.

Building Simulation

Simulation will be used to update existing rules of thumb and develop design guidelines regarding the optimum outdoor airflow rates for nighttime ventilation cooling. The optimization objective will be to minimize both energy use and the number of days with unmet comfort criteria (defined by occupants). We will consider using the EnergyPlus model developed for Honda House as a starting point. Results will refine required characteristics for inclusion in the field study, such as required FAU airflow rates. Modelling may also be used for a representative home to estimate what the hypothetical energy use would have been if the owners had instead opted to install air conditioning.

Success Metrics

Specific success metrics have been defined for both the lab testing and field-testing stages which will need to be met in order to progress to the next stage and eventually be included in the Advanced Energy Center.

During the lab testing stage, success will be evaluated in terms of ability to pass functional performance tests, such as:

- Does the system behave as expected during each operating mode?
- Does the system works as expected with a range of filtration ratings, total external static pressures, and airflow rates?

During the field-testing stage, success will be evaluated in terms of the costs and benefits of the applied technologies (as itemized in Table 28).

Table 28: Cost Benefit Analysis Criteria

Costs	Benefits (Energy savings are relative to hypothetical scenario where central AC is added)
Administration/permitting	Gross site electricity savings (if any, compared to prior operation)
Equipment costs	Normalized site electricity savings

Installation costs	Gross site electrical demand savings
Bill increases (electricity and gas)	Normalized site demand savings
Maintenance costs	Bill reductions (electricity and gas)
Any negative impacts on thermal comfort	GHG reductions
	Load shifting
	Non-energy participant benefits, such as increased thermal comfort and improved IAQ
	Non-energy social and environmental benefits

Transition to Deployment

Potential electricity savings

Electricity consumption will increase after this retrofit, but it should significantly decrease the likelihood that a homeowner will opt to install central air conditioning, and thereby avoid a substantial increase in energy use. Building simulations will be needed to estimate this value.

Synergies with other measures

This measure has a great deal of synergy with the Aeroseal envelope sealing measure, since it enables a tighter envelope by providing the necessary mechanical ventilation when infiltration has been eliminated. It also has synergies with any measures that reduce cooling loads in a home—since they will serve to make the home more comfortable without resorting to installation of AC and improve the success of this measure.

Targeted SCP customer segments

SCP customer segments targeted include homes without central air conditioning, some of which are low-income homes. For low-income homes, this measure will either avoid increases in electricity costs (for homeowners who find themselves in the position to consider adding AC) or provide additional thermal comfort, to help their families tolerate the summer heat. The technology will also have application with homeowners without AC who are becoming increasingly concerned about IAQ (due to emerging health problems or increasing awareness of unhealthy internal and external air) by flushing high VOCs or compensating for a tight envelope.

Deployment strategies

This should be a relatively low-cost retrofit that can be marketed to a range of homeowners. It is a niche product, since it applies only to homes with central heating and without central cooling. Although existing configurations of the technology can provide benefits even with cooling, they are not the focus of this project. It should be evaluated on a case by case basis and installed by qualified HVAC contractors who are familiar with measuring airflow and making ducting modifications in the attic.

Project Timeline

Table 29 shows the high-level project milestones and deliverables with anticipated completion dates.

Table 29: Anticipated project schedule for research on Residential Nighttime Ventilation.

Project Milestones	Completion Date
Modeling - Optimization	May 2019
Field Tests - Site Screening/Selection	May 2019
Laboratory Tests	August 2019
Field Tests - Baseline Monitoring	August 2019
Field Tests – Procurement and Installation	February 2020
Homeowner Survey - Pre	May 2020
Homeowner Survey - Post	October 2020
Field Tests - Retrofit Monitoring	February 2021
Draft Installation Guide	February 2021
Modelling – Cost / Benefit Analysis	May 2021
Final Installation Guide	May 2021
Draft Input to Technology Demonstration Final Report	June 2021
Final Input to Technology Demonstration Final Report	October 2021

APPENDIX A10: Additional Technologies Identified by Vendor RFP

Additional content will be provided in future updates to this Implementation Plan as the project proceeds.

APPENDIX B: Implementation Guidelines by Program Subcomponent

Technology Demonstration and Deployment activities and program subcomponents will be developed by SCP and the Lead Locally team as necessary and included in this Appendix for reference as available. This includes multiple deliverables already proposed as part of the Lead Locally project, including but not limited to:

- *Advanced Energy Center RFP*
- *Advanced Energy Center Outreach and Communication Plan*
- *Advanced Energy Center Training Plan* and supporting documents, including:
    - *Efficiency Optimizing Control Strategies for Grid Integrated Heat Pump Water Heater Report*
    - *Radiant Ceiling Heating and Cooling/Air to Water Heat Pumps Sizing and Installation Guide*
    - *Phase Change Materials in Residential Applications Best Practice Installation Guide*

As necessary, additional guidelines will be developed as necessary to support the implementation of the Technology Demonstration and Deployment activities.

Technology Demonstration and Deployment Implementation Schedule

Technology Demonstration and Deployment activities will generally be implemented according to the following schedule. This schedule will be updated/maintained as necessary through quarterly updates to this Implementation Plan.

Table 30: Anticipated Technology Demonstration and Deployment Schedule.

Project Milestones	Completion/Due Date
Advanced Energy Center RFP	February 2019
Tech Demo Research Plans and Data Collection	March 2019
Advanced Energy Center Outreach and Communication Plan	June 2019
Advanced Energy Center Website Design	June 2019
Advanced Energy Center Training Plan	June 2019
Advanced Energy Center ribbon cutting (storefront)	October 2019
Mid-term Benefits Questionnaire	October 2019
Advanced Energy Center Update Reports	Quarterly after ribbon cutting
Tech Demo project installation	January-August, 2020
Optimal Retrofit Strategies Analysis	February 2020

Tech Demo Final Report	October 2021
Final Meeting & Benefits Questionnaire	March 2022

Reporting Activities and Guidelines

Lead Locally has developed, coordinated, and followed schedules for reviewing program progress against goals with relevant stakeholders including SCP, CEC CAM, and Technical Advisory Committee members. A variety of reporting activities and elements are underway as of the commencement of the grant, including:

- *Monthly Progress Report* and Invoice: this report compares actual accomplishments against planned accomplishments for the period. The report summarize progress made on all Agreement activities as specified in the Scope of Work for the preceding month, including accomplishments, problems, milestones, products, schedule, fiscal status, and an assessment of the ability to complete the Agreement within the current budget and any anticipated cost overruns.
- CPR Meetings: these meetings determine if the project should continue to receive CEC funding, and if so whether any modifications must be made to the tasks, products, schedule, or budget. They provide the opportunity for frank discussions between the CEC and the Lead Locally team. As determined by the CAM, discussions may include project status, challenges, successes, advisory group findings and recommendations, final report preparation, and progress on technical transfer and production readiness activities (if applicable).
- *Report on Pre-Monitoring Activities*: this report includes results of the customer data analysis and direct outreach and describes initial project progress. The report shall be incorporated into the associated Research, Instrumentation, Monitoring plan and EM&V framework
- *Project Benefits Questionnaire* (Initial; Mid-Term; Final): this report, provided at three intervals, provides data used to develop Project Benefits Questionnaires. This data includes, but is not limited to, the following: all key assumptions used to estimate projected benefits, including targeted market sector (e.g., population and geographic location), projected market penetration, baseline and projected energy use and cost, operating conditions, and emission reduction calculations. Examples of information that may be requested in questionnaires include:
    - For Product Development Projects and Project Demonstrations:
        - Published documents, including date, title, and periodical name.
        - Estimated or actual energy and cost savings, and estimated statewide energy savings once market potential has been realized. Identify all assumptions used in the estimates.
        - Greenhouse gas and criteria emissions reductions.
        - Other non-energy benefits such as reliability, public safety, lower operational cost, environmental improvement, indoor environmental quality, and societal benefits.
        - Data on potential job creation, market potential, economic development, and increased state revenue as a result of the project.

        - A discussion of project product downloads from websites, and publications in technical journals.
        - A comparison of project expectations and performance. Discuss whether the goals and objectives of the Agreement have been met and what improvements are needed, if any.
    - Additional Information for Product Development Projects:
        - Outcome of product development efforts, such copyrights and license agreements.
        - Units sold or projected to be sold in California and outside of California.
        - Total annual sales or projected annual sales (in dollars) of products developed under the Agreement.
        - Investment dollars/follow-on private funding as a result of Energy Commission funding.
        - Patent numbers and applications, along with dates and brief descriptions.
    - Additional Information for Product Demonstrations:
        - Outcome of demonstrations and status of technology.
        - Number of similar installations.
        - Jobs created/retained as a result of the Agreement.
    - For Information/Tools and Other Research Studies:
        - Outcome of project.
        - Published documents, including date, title, and periodical name.
        - A discussion of policy development. State if the project has been cited in government policy publications or technical journals, or has been used to inform regulatory bodies.
        - The number of website downloads.
        - An estimate of how the project information has affected energy use and cost, or have resulted in other non-energy benefits.
        - An estimate of energy and non-energy benefits.
        - Data on potential job creation, market potential, economic development, and increased state revenue as a result of project.
        - A discussion of project product downloads from websites, and publications in technical journals.
        - A comparison of project expectations and performance. Discuss whether the goals and objectives of the Agreement have been met and what improvements are needed, if any.
- *Final Report* and Final Meeting: This report and meeting is comprehensive *Final Report* that describes the original purpose, approach, results, and conclusions of the work performed under the Agreement. The CAM reviews the *Final Report* at least two months before the Agreement end date.

Reporting will evolve as the program progresses and more elements, including databases as approved by SCP and CAM, come online. Reporting will also integrate evaluation, measurement and verification protocols for data and information reporting as project components are prepared for evaluation.

APPENDIX C: Lead Locally and Existing Energy Efficiency Programs

To maintain a current understanding of how incentives may be leveraged to support the installation of Lead Locally technologies, SCP and the Lead Locally team researched applicable programs including but not limited to those identified below. This includes review of program websites and materials and direct engagement with program staff through phone calls and emails as noted. Additional details on how these programs support individual Lead Locally technologies are further detailed in the following sections of this Appendix.

The following programs are listed in the summary table below but not detailed in this version of the *Implementation Plan*. Details will be included on these program as it is gathered by the Lead Locally team.

- BayREN Commercial
- CAEATFA Small Business Financing
- CaliforniaFIRST
- Ygrene
- Renovate America HERO
- FHA Energy Efficient Mortgage
- FHA PowerSaver Loan
- Veterans Administration Energy Mortgage

Table 31: Lead Locally Technologies and Existing Energy Efficiency Programs.

Program Name	Website	Incentive Type	Direct Engagement (date of most recent)	Sector Relevance	Lead Locally Technologies Supported
Sonoma County Energy Independence Program (SCEIP)	https://sonomacountyenergy.force.com/financing/s/	Financing (PACE)	1/24/2019	RES, COM	DMSHP, Aerobarier Sealing, GIHPWH
PG&E Advanced Home Upgrade	https://www.pge.com/en_US/residential/save-energy-money/savings-programs/home-upgrade/home-upgrade.page	Rebates	1/22/2019	RES	Awaiting program relaunch documents
PGE Residential Single Measure rebates	https://www.pge.com/en_US/small-medium-business/save-energy-and-money/rebates-and-incentives/product-rebates.page?WT.mc_id=Vanity_businessrebates	Rebates	Not Applicable	RES	GIHPWH, Smart thermostats
PGE Commercial Single Measure Rebates	https://www.pge.com/en_US/small-medium-business/save-energy-and-money/rebates-and-incentives/product-rebates.page?WT.mc_id=Vanity_businessrebates	Rebates	Not Applicable	COM	Nightbreeze/Economizer
PGE Multifamily Upgrade	https://www.pge.com/en_US/residential/save-energy-money/savings-solutions-and-rebates/multifamily-rebates/multifamily-rebates.page	Rebate	To be initiated	RES	To be determined based on engagement with program administrators
PG&E On-Bill Financing	https://www.pge.com/en_US/business/save-energy-money/financing/energy-efficiency-financing/energy-efficiency-financing.page	Financing	1/22/2019	COM	All commercial technologies if part of a compliant project.
BayREN Home+	https://www.bayareaenergyupgrade.org/	Rebate	1/25/2019	RES	DMSHP, Aerobarrier Sealing, RPAWHP, GIHPWH
BayREN Multifamily	https://bayareamultifamily.org/	Rebate	2/13/2019	RES	Contingent on potential to model technology's energy savings; anticipate eligibility for MSHP, Aerobarrier Sealing, GIHPWH

BayREN Commercial*	https://www.bayren.org/commercial	Rebate	To be initiated following program launch	COM	Program not launched yet.
SCP/PG&E Advanced Energy Rebuild	https://sonomacleanpower.org/programs/advanced-energy-rebuild	Rebate	2/15/2019	RES	Induction Cooking, Aerobarrier Sealing, RPAWHP, GIHPWH, DMSHP
Energy Conservation Subsidy Exclusion (Personal & Corporate)	https://www.irs.gov/publications/p525	Tax Benefit	Not Applicable	RES, COM	All measures receiving a public utility energy conservation subsidy.
Fannie Mae Green Initiative- Loan Program *	https://www.fanniemae.com/singlefamily/homestyle-energy	Financing	To be initiated	RES	To be determined based on engagement with program administrators
Residential Energy Efficiency Loans (REEL)	https://gogreenfinancing.com/residential	Financing	1/18/2019	RES	DMSHP, RPAWHP, GIHPWH, Aerobarrier Sealing
CAEATFA Small Business Financing*	https://gogreenfinancing.com/smallbusiness	Financing	To be initiated following program launch	COM	Program not launched yet.
CaliforniaFIRST*	https://renewfinancial.com/homeowners/california-first	Financing (PACE)	To be initiated	RES, COM	To be determined based on engagement with program administrators
Ygrene*	https://ygrene.com/	Financing (PACE)	To be initiated	RES, COM	To be determined based on engagement with program administrators
Renovate America HERO*	https://www.renovateamerica.com/financing/hero	Financing (PACE)	To be initiated	RES	To be determined based on engagement with program administrators
Weatherization Assistance Program (WAP)	https://www.energy.gov/eere/wipo/weatherization-assistance-program	Grant Program	02/06/2019	RES	Not on offer at Sonoma & Mendocino Counties in current year.
FHA Energy Efficient Mortgage*	https://www.hud.gov/program_offices/housing/sfh/eem/energy-r	Financing	To be initiated	RES	To be determined based on engagement with program administrators
FHA PowerSaver Loan*	https://www.hud.gov/program_offices/housing/sfh/title/ti_abou	Financing	To be initiated	RES	To be determined based on engagement with program administrators
Veterans Administration Energy Mortgage*	https://www.benefits.va.gov/warms/docs/admin26/pamphlet/pam26_7/ch07.doc	Financing	To be initiated	RES	To be determined based on engagement with program administrators

* Indicates program that will be detailed in subsequent tables in a future version of this Implementation Plan.

Lead Locally technologies and existing incentive programs in detail

PACE Financing (Property Accessed Clean Energy)*

Property Assessed Clean Energy (PACE) is a financing mechanism that enables long-term funding for energy efficiency, renewable energy and water conservation projects. PACE financing is repaid as an assessment on the property's regular tax bill and is processed the same way as other local public benefit assessments (sidewalks, sewers). Depending on local legislation, PACE can be used for commercial, nonprofit and residential properties. Regardless of model, there are several keystones that hold true for every PACE program.

- PACE is voluntary for all parties involved.
- PACE can cover 100% of an eligible project's hard and soft costs.
- Long financing terms up to 20 years.
- Can be combined with utility, local and federal incentive programs.
- Projects are permanently affixed to a property.
- The PACE assessment is filed with the local municipality as a lien on the property.

The table below summarizes providers offering PACE financing services in Sonoma and Mendocino Counties:

Table 32: PACE providers active in Sonoma/Mendocino Counties

Provider	Residential	Commercial
CALIFORNIA FIRST	Y	Y
HERO PROGRAM	Y	
SONOMA COUNTY ENERGY INDEPENDENCE PROGRAM (SCEIP)	Y	Y
YGRENE	Y	Y

* https://pacenation.us/pace-in-california/

Table 33: SCEIP Program Details

Sonoma County Energy Independence Program (SCEIP)

PACE Finance for residential and commercial property owners in the Sonoma County territory.

For more information visit: https://sonomacountyenergy.force.com/financing/s/

Lead Locally Technology	Sector	Supported by Program	Technology Requirements
Induction Cooking	Residential	No	Appliance installations not supported by program.
	Commercial	No	
Ducted Mini-Split	Residential	Yes	SEER > 15 or EER >12.5 or HSPF > 7.0 Duct Insulation: R8
Aerobarrier Sealing	Residential	Yes	Energy Star Air Sealing Specification
Phase Change Materials	Residential	No	Not directly supported, but potentially eligible for financing as a custom improvement project.
	Commercial	No	
Radiant Panels with Air-to-Water Heat Pumps	Residential	No	Not directly supported, but potentially eligible for financing as a custom improvement project (must be in combination with efficient water heating or Energy Star qualified Boiler with AFUE of 85% or greater).
Nightbreeze/Economizer	Residential	No	Not directly supported, but potentially eligible for financing as a custom improvement project.
	Commercial	No	
Grid-integrated Heat Pump Water Heaters	Residential	Yes	> 2.0 EF
	Commercial	Yes	
Waste Heat Recovery	Residential	No	Not directly supported, but potentially eligible for financing as a custom improvement project
	Commercial	No	
Commercial Daylighting Retrofits	Commercial	No	Not directly supported, but potentially eligible for financing as a custom improvement project.

Table 34: PG&E Advanced Home Upgrade Program Details

PG&E's Advanced Home Upgrade Program

The PG&E's implementation of the Advanced Home Upgrade is currently undergoing a major redesign which is due for a launch in April 2019, details are to be made publicly available in the upcoming months. We have been made aware through interviewing one of the program managers that the new program will be utilizing a pay for performance model based on Advance Metering Infrastructure (AMI) Data, with contractors developing projects using a deemed savings menu selection process.

For more information visit: https://homeupgrade.org/

Lead Locally Technology	Sector	Supported by Program	Technology Requirements
Induction Cooking	Residential	No	Appliances not supported through program.
Ducted Mini-Split	Residential	Likely	Awaiting Program relaunch
Aerobarrier Sealing	Residential	Likely	Awaiting Program relaunch
Phase Change Materials	Residential	No	Awaiting Program relaunch
Radiant Panels with Air-to-Water Heat Pumps	Residential	Likely	Awaiting Program relaunch
Nightbreeze/Economizer	Residential	TBD	Awaiting Program relaunch
Grid-integrated Heat Pump Water Heaters	Residential	Likely	Awaiting Program relaunch
Waste Heat Recovery	Residential	No	Awaiting Program relaunch
Radiant Panels with Air-to-Water Heat Pump	Residential	TBD	Awaiting Program relaunch

Table 35: PG&E Residential Direct to Customers Rebates

PG&E Direct to Customer Residential Rebates

Pacific Gas and Electric Company (PG&E) offers rebates to homeowners on qualified energy-efficient products and improvements for residential homes. Currently the only supported Lead Locally Technology is the Grid Integrated Heat Pump Water Heater.

For more information visit: https://www.pge.com/includes/docs/pdfs/shared/saveenergymoney/rebates/ee_residential_rebate_catalog.pdf

Lead Locally Technology	Sector	Supported by Program	Technology Requirements
Grid-integrated Heat Pump Water Heaters	Residential	Yes	New electric heat pump water heater must replace an existing electric-powered water heater. High-Efficiency Electric Heat Pump Storage Water Heater Uniform Energy Factor (UEF) of 3.09 or greater and/or Energy Factor (EF) of 3.24 or greater: $300 per household Must have a capacity greater than 40 gallons and less than or equal to 55 gallons Must be new and meet or exceed all applicable local, state and federal standards. Visit marketplace.pge.com for qualifying models

Table 36*:* PG&E Commercial Direct to Customer Rebates

PG&E Commercial direct to customer deemed rebates

PG&E offers a number of commercial rebates in the following categories:

Technology based	Industry Based
Pipe insulation	Agriculture and Food Processing
LED Lighting	Heavy Industrial
Heating, ventilation and air conditioning	Hotel and Lodging
Water Heating	K-12 Schools
Refrigeration	Restaurants
Food service equipment	New Construction

For more information visit: https://www.pge.com/en_US/small-medium-business/save-energy-and-money/rebates-and-incentives/product-rebates.page?WT.mc_id=Vanity_businessrebates

The only Lead Locally technology supported by the program are the Economizer Controls.

Lead Locally Technology	Sector	Supported by Program	Technology Requirements
Nightbreeze/Economizer	Commercial	Likely	Detailed in: https://www.pge.com/includes/docs/pdfs/mybusiness/energysavingsrebates/incentivesbyindustry/hvac_catalog_final.pdf

Table 37: PG&E Multifamily Upgrade Program Details

PG&E Multifamily Upgrade Program

The Pacific Gas and Electric Company (PG&E) Multifamily Upgrade Program (MUP) promotes and facilitates energy-efficient retrofits of multifamily housing ("projects") through program coordination, technical support, and cash incentives.

For more information visit: https://multifamilyupgrade.com/

Lead Locally Technology	Sector	Supported by Program	Technology Requirements
Induction Cooking	Residential	No at present	
Ducted Mini-Split	Residential	Likely if energy savings can be in compliance with program requirements.	TBD through an upcoming interview with PA.
Aerobarrier Sealing	Residential	Likely, as air sealing is verified via test-out procedure.	TBD through an upcoming interview with PA.
Phase Change Materials	Residential	No	TBD through an upcoming interview with PA.
Radiant Panels with Air-to-Water Heat Pumps	Residential	Likely, if measure energy savings can be in compliance with program requirements.	TBD through an upcoming interview with PA.
Nightbreeze/Economizer	Residential	Likely, if measure energy savings can be in compliance with program requirements.	TBD through an upcoming interview with PA.
Grid-integrated Heat Pump Water Heaters	Residential	Likely, if measure energy savings can be in compliance with program requirements.	TBD through an upcoming interview with PA.
Waste Heat Recovery	Residential	Likely, if measure energy savings can be in compliance with program requirements.	TBD through an upcoming interview with PA.
Radiant Panels with Air-to-Water Heat Pumps	Residential	Likely, if measure energy savings can be in compliance with program requirements.	TBD through an upcoming interview with PA.

Table 38: PG&E Commercial On-Bill Financing Loan Details

PG&E On-Bill Financing (OBF) Loan

On-Bill Financing (OBF) allows eligible PG&E commercial customers to obtain loans of $5,000-$100,000, with payback periods of up to 60 months, for a wide variety of energy efficient projects. Furthermore, government agencies within PG&E's service area can be eligible for loans of up to $250,000 that come with payback periods of up to 120 months.

With OBF, the loan is paid back based on projected energy savings, via installments on the customer's monthly PG&E bill. After the loan is repaid, any energy savings that result from the new, energy efficiency equipment will translate into lower utility costs – savings the customer can keep.

For more information visit:
https://www.pge.com/en/mybusiness/save/smbblog/article/the_abcs_of_obf_learning_how_pges_onbill_financing_works.page

Lead Locally Technology	Sector	Supported by Program	Technology Requirements
Induction Cooking	Commercial	Yes	Commercial Project must comply with program requirements.
Phase Change Materials	Commercial	Yes	Commercial Project must comply with program requirements.
Nightbreeze/Economizer	Commercial	Yes	Commercial Project must comply with program requirements.
Grid-integrated Heat Pump Water Heaters	Commercial	Yes	Commercial Project must comply with program requirements.
Waste Heat Recovery	Commercial	Yes	Commercial Project must comply with program requirements.
Commercial Daylighting Retrofits	Commercial	Yes	Commercial Project must comply with program requirements.

Table 39: PG&E Commercial Customized Incentive

PGE Commercial Customized Incentive

For large commercial projects where deemed or express rebate programs are not offered for the measure, PG&E's implementation of the 2019 Statewide Customized Offering Program can be utilized.

If a measure is not specifically excluded by the eligibility conditions and the Applicant can provide documentation supporting energy savings beyond baseline energy performance standards, it may be eligible for participation in the program.

Applicants need to demonstrate a case for energy savings of over the $5,000 threshold equivalent using the values in Table 4 as one of the prerequisites of the program:

Measure	kW	kWh	Therms
To code/ Standard Practice	$75.00	$0.06	$0.50
Above code/Standard Practice	$150.00	$0.12	$1.25

The 2018 rates above are likely to change during the course of 2019.

For more information visit: https://www.pge.com/en_US/large-business/save-energy-and-money/facility-improvement/custom-retrofit.page

Lead Locally Technology	Sector	Supported by Program	Technology Requirements
Induction Cooking	Commercial	Likely	Project Compliant with Program Requirements
Phase Change Materials	Commercial	No	
Nightbreeze/Economizer	Commercial	Likely	Project Compliant with Program Requirements
Grid-integrated Heat Pump Water Heaters	Commercial	Likely	Project Compliant with Program Requirements
Waste Heat Recovery	Commercial	Likely	Project Compliant with Program Requirements
Commercial Daylighting Retrofits	Commercial	Likely	Project Compliant with Program Requirements

Table 40: BayREN Single Family Upgrade Program (BayREN Home +)

BayREN Single Family Program (BayREN Home+)

The BayREN Single Family Program (BayREN Home+) takes a system based approach to increase a home's energy efficiency and can be utilized by for projects in the 9 member jurisdictions of the Association of Bay Area Governments (County of Alameda, County of Contra Costa, County of Marin, County of Napa, City and County of San Francisco, County of San Mateo, County of Santa Clara, County of Solano and County of Sonoma).

The program was relaunched in January 2019, switching to deemed measures only.

Measure Packages available are :

Operations & Maintenance; Building Shell ; Heating & Cooling Measures; Water Heating and Bonus Rebates when Building Shell measures are combined with a Heating or Cooling measure; Downsizing of heating and/or cooling system and Combustion Appliance Safety test-out.

For more information visit: https://www.bayareaenergyupgrade.org/

Lead Locally Technology	Sector	Supported by Program	Technology Requirements
Induction Cooking	Residential	No	Appliances not currently supported.
Ducted Mini-Split	Residential	Yes	High efficiency heat pump ⩾ 17 SEER / 9.4 HSPF (must replace entire load associated with existing central air conditioner or electric heating system or heat pump) Only for sites displacing electric heating. If site has natural gas heating - partial rebate can be awarded for cooling aspect of install if a lower efficiency cooling system is present in baseline conditions.
Aerobarrier Sealing	Residential	No	Mmust be combined with another measure, otherwise requires blower door test-in and test-out to qualify as a standalone building shell measure. Further program requirements : Building air sealing ⩾ 30% total leakage reduction
Phase Change Materials	Residential	No	Currently there are no approved workpapers incorporating PCM, but if that changes in the future the technology could be supported as a deemed rebate.

Radiant Panels with Air-to-Water Heat Pumps	Residential	Yes	High efficiency heat pump ⩾17 SEER / 9.4 HSPF (must replace entire load associated with existing central air conditioner or electric heating system or heat pump) Only for sites displacing electric heating. If site has natural gas heating - partial rebate can be awarded for cooling aspect of install if a lower efficiency cooling system is present in baseline conditions.
Nightbreeze/Economizer	Residential	TBD	Would need to reference an IOU Workpaper.
Grid-integrated Heat Pump Water Heaters	Residential	Yes	New electric heat pump water heater must replace an existing electric-powered water heater. High-Efficiency Electric Heat Pump Storage Water Heater Uniform Energy Factor (UEF) of 3.1 or greater. Must be new and meet or exceed all applicable local, state and federal standards
Waste Heat Recovery	Residential	No	Currently there are no approved workpapers incorporating Waste Heat Recovery, but if that changes in the future the technology could be supported as a deemed rebate.

Table 41: BayREN Multifamily Building Enhancements

BayREN Multifamily Building Enhancements

The BayREN Multifamily (MF) program offers property owners free technical assistance and rebates of $750 per unit for saving 15% or more of their whole building's energy usage.

Program is only offered in the 9 counties that are part of BayREN, hence not available in Mendocino County.

For more information visit: https://bayareamultifamily.org/

Lead Locally Technology	Sector	Supported by Program	Technology Requirements
Induction Cooking	Residential	Not at present	
Ducted Mini-Split	Residential	Likely, if measure energy savings can be in compliance with program requirements.	TBD through an upcoming interview with PA.
Aerobarrier Sealing	Residential	Likely, as air sealing is verified via test-out procedure.	TBD through an upcoming interview with PA.
Phase Change Materials	Residential	No	
Radiant Panels with Air-to-Water Heat Pumps	Residential	Likely, if measure energy savings can be in compliance with program requirements.	TBD through an upcoming interview with PA.
Nightbreeze/ Economizer	Residential	Likely, if measure energy savings can be in compliance with program requirements.	TBD through an upcoming interview with PA.
Grid-integrated Heat Pump Water Heaters	Residential	Likely, if measure energy savings can be in compliance with program requirements.	TBD through an upcoming interview with PA.
Waste Heat Recovery	Residential	Likely, if measure energy savings can be in compliance with program requirements.	TBD through an upcoming interview with PA.

Table 42: SCP/PG&E Advanced Energy Rebuild Program Details

Advanced Energy Rebuild

Sonoma Clean Power, Pacific Gas and Electric Company (PG&E), and Bay Area Air Quality Management District have joined efforts to help homeowners affected by the October 2017 firestorms rebuild energy efficient, sustainable homes. The program is an enhancement to PG&E's California Advanced Homes Program and offers two incentive packages tailored to Sonoma and Mendocino Counties.

There are two main options for the program: 1) Advanced Energy Home 2) All Electric Home. Both tracks offer a Flexible Performance Path (must be 20% more efficient than 2016 Title 24 code) or a Simple Menu-Based Path (prescriptive list of requirements).

For more information visit: https://sonomacleanpower.org/programs/advanced-energy-rebuild

Lead Locally Technology	Sector	Supported by Program	Technology Requirements
Induction Cooking	Residential	Yes	
Ducted Mini-Split	Residential	Yes	For menu based path: Ducts in conditioned space or deep buried, insulated to R8, HP 12.5 EER/ HSPF > 9.5
Aerobarrier Sealing	Residential	No	Not directly supported, but any increase in air tightness (maximum 3.0 ACH50) can count towards program requirements.
Phase Change Materials	Residential	No	Not directly supported, but any increase in insulation can count towards program requirements.
Radiant Panels with Air-to-Water Heat Pumps	Residential	Yes	For menu based path: HP 12.5 EER/ HSPF > 9.5
Nightbreeze/Economizer	Residential	No	Referencing an IOU Workpaper.
Grid-integrated Heat Pump Water Heaters	Residential	Yes	For menu based path: NEEA Tier 3 Heat Pump Water Heater w/ Grid-integration controls installed
Waste Heat Recovery	Residential	No	

The IRS Personal & Corporate Residential Energy Conservation Subsidy Exclusion

According to Section 136 of the U.S. Code, energy conservation subsidies provided (directly or indirectly) to customers by public utilities[†] are non-taxable.

If a taxpayer claims federal tax credits or deductions for the energy conservation property, the investment basis for the purpose of claiming the deduction or tax credit must be reduced by the value of the energy conservation subsidy (i.e., a taxpayer may not claim a tax credit for an expense that the taxpayer ultimately did not pay).

The term "energy conservation measure" includes installations or modifications primarily designed to reduce consumption of electricity or natural gas, or to improve the management of energy demand. Eligible dwelling units include houses, apartments, condominiums, mobile homes, boats and similar properties. If a building or structure contains both dwelling units and other units, any subsidy must be properly allocated.

[†] The term "public utility" is defined as an entity "engaged in the sale of electricity or natural gas to residential, commercial, or industrial customers for use by such customers." The term includes federal, state and local government entities.

Table 43: Fannie Mae Energy Mortgages Details

Fannie Mae Energy Improvement Feature/Home Style Energy Mortgages

Fannie Mae have mortgage products that incentivize energy improvements to reduce utility costs and improve the comfort and safety of their homes in both cases when a home is being purchased or for refinancing their current one

For more information visit:
https://www.fanniemae.com/content/guide/selling/b5/3.3/01.html

Lead Locally Technology	Sector	Supported by Program	Technology Requirements
Induction Cooking	Residential	No	
Ducted Mini-Split	Residential	Likely	TBD through upcoming interview with PA
Aerobarrier Sealing	Residential	Likely	TBD through upcoming interview with PA
Phase Change Materials	Residential	No	
Radiant Panels with Air-to-Water Heat Pumps	Residential	Likely	TBD through upcoming interview with PA
Nightbreeze/Economizer	Residential	Likely	TBD through upcoming interview with PA
Grid-integrated Heat Pump Water Heaters	Residential	Likely	TBD through upcoming interview with PA
Waste Heat Recovery	Residential	Likely	TBD through upcoming interview with PA
Radiant Panels with Air-to-Water Heat Pumps	Residential	Likely	TBD through upcoming interview with PA

Table 44: REEL Program Details

California Alternative Energy and Advanced Transportation Financing Authority (CAEATFA) California Hub for Energy Efficiency (CHEEF) Pilot REEL (Residential)

The Residential Energy Efficiency Loan (REEL) program has been designed to help California homeowners and renters access affordable financing for energy efficiency projects.

Owners of any residential property are eligible for the REEL program, as are renters at the discretion of the lender and with the property owner's permission. Customers may upgrade a single-family home, townhome, condo, duplex, triplex, fourplex or manufactured home. And, with REEL, renovations for up to four units can be bundled into the same loan.

For more information visit: https://gogreenfinancing.com/residential

Lead Locally Technology	Sector	Supported by Program	Technology Requirements
Induction Cooking	Residential	No	Appliances not supported through program.
Ducted Mini-Split	Residential	Yes	Rating of > SEER 18 18 SEER or greater SPLIT/PACKAGE HEAT PUMP min HSPF for package systems at 8.0 and split systems at 8.2. Ducts insulation > R8 Duct leakage < 10%
Aerobarrier Sealing	Residential	Yes	Whole building air sealing equal or greater than 30% leakage reduction. Or Whole building air sealing equal or greater than 15% leakage reduction.
Phase Change Materials	Residential	No	Can be supported if sufficient documentation proving savings and cost effectiveness is presented.
Radiant Panels with Air-to-Water Heat Pumps	Residential	Yes	Manufacturers installation guidance needs to be followed. Heat Pump: 18 SEER or greater SPLIT/PACKAGE HEAT PUMP min HSPF for

			package systems at 8.0 and split systems at 8.2.
Nightbreeze/Economizer	Residential	TBD	Can be supported if sufficient documentation proving savings and cost effectiveness is presented
Grid-integrated Heat Pump Water Heaters	Residential	Yes	ENERGY STAR Electric Heat Pump Water Heater (<=55 gallon with UEF >= 2.00; >55 gallons with UEF >= 2.20)
Waste Heat Recovery	Residential	TBD	Can be supported if sufficient documentation proving savings and cost effectiveness is presented

Table 45: DOE WAP Grant Program Details

Program Name: Weatherization Assistance Program

Program reduces energy costs for low-income households by increasing the energy efficiency of their homes, while ensuring their health and safety. Program requirements preclude fuel switching and energy measures must demonstrate a savings-to-investment ratio (SIR) greater than 1.

For more information visit: https://www.energy.gov/eere/wipo/weatherization-assistance-program

Lead Locally Technology	Sector	Supported by Program	Technology Requirements
Induction Cooking	Residential	No	
Ducted Mini-Split	Residential	No	Not directly supported, but potentially eligible if Lead Locally demonstrated cost effective benefits.
Aerobarrier Sealing	Residential	No	No directly supported, but any increase in air tightness can count toward program requirements.
Phase Change Materials	Residential	No	Not directly supported, but potentially eligible if Lead Locally demonstrated cost effective benefits.
Radiant Panels with Air-to-Water Heat Pumps	Residential	No	Not directly supported, but potentially eligible if Lead Locally demonstrated cost effective benefits.
Nightbreeze/Economizer	Residential	No	Not directly supported, but potentially eligible if Lead Locally demonstrated cost effective benefits.
Grid-integrated Heat Pump Water Heaters	Residential	Yes	For customers displacing an electric resistance water heater.
Waste Heat Recovery	Residential	No	Not directly supported, but potentially eligible if Lead Locally demonstrated cost effective benefits.

APPENDIX D: Post-Purchase Surveys

Post-purchase surveys will be developed with the communications team after the technology demonstration plans are finalized. Survey language will be developed in alignment with the *Advanced Energy Center RFP* to solicit final technologies for sale in the Advanced Energy Center, and finalized as technologies are selected.

Although technology-specific details cannot be provided at this stage, the program's general approach can be shared. Post-purchase surveys will be delivered to customers to capture:

- Customer feedback on the equipment shopping experience
- Factors that influenced the customer's purchasing decisions
- Information about the equipment being replaced

Surveys will be developed with a standard set of questions for residential surveys, and a standard set of questions for commercial surveys. Questions may be customized for each technology type, based on specific details for that technology.

Depending on the nature of programs available, post-purchase surveys may be triggered at one of two points. Surveys will likely be delivered by email, with the potential for phone survey administration for technologies with low participation rates or where the technology's audience may require (for example, high-end commercial equipment).

- If the customer purchases equipment directly through the Advanced Energy Center, surveys will be delivered with the target timeline of approximately four weeks after installation.
    - If estimated installation date is available, the survey will be delivered approximately four weeks after this date.
    - If no estimated installation date is available, surveys will be delivered approximately eight weeks after purchase date, plus or minus additional weeks based on the technology type and installation complexity.
- If the equipment was not purchased directly through the Advanced Energy Center but did receive an incentive or other program participation through the Advanced Energy Center, post-purchase surveys will be delivered approximately four weeks after incentive/program ending date, but not earlier than the projected timeline for the customer to receive program incentive.

Post-purchase survey data will be used to monitor how the Advanced Energy Center is impacting customer decision-making, to make improvements to the Advanced Energy Center experience, and to better target outreach by understanding the types of existing buildings and technologies that customers are upgrading.

APPENDIX E: Optimal Retrofit Strategies Analysis Plan

The details of the approach to development of optimal retrofit strategies will be developed as the project proceeds and documented in a future update to this plan.