



FINAL REPORT:
Systems Mapping Project:
Decarbonizing Existing Single-Family Homes
in the San Francisco Bay Area

Prepared by:
County of San Mateo Office of Sustainability
August 9, 2021

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1. Executive Summary

Decarbonizing homes is an important strategy to reach the goal of carbon neutrality. Unfortunately, there are many barriers to transitioning existing single-family homes from natural gas to electric appliances and HVAC. While there are many great initiatives and programs supporting this fuel switch, they suffer from a lack of consistency and coordination and don't address some of the core issues at the heart of the problem. That's why in the fall of 2020, the County of San Mateo Office of Sustainability received funding from the Bay Area Regional Energy Network (BayREN) to map out the challenges and identify the opportunities for regional collaboration to accelerate the conversion of homes to all-electric.

With assistance from Presidio Graduate School (PGS Consults), the County of San Mateo convened a multi-stakeholder group to analyze the current situation, uncover the barriers and inefficiencies, and recommend collaborative action. The process to achieve this result consisted of two multi-stakeholder workshops, as well as two focus groups conducted with two key stakeholders: contractors and homeowners.

After coming to a clearer common understanding of the complex system that governs home carbon emissions, the multi-stakeholder group agreed on four regionally coordinated actions that are believed to have the most significant impact. They include an instant rebate program, a "cash for clunkers"-style rebate program to encourage the replacement of inefficient appliances, a public/private partnership approach to financing improvement projects, and the simplification of the permit process.

In the six months since this project concluded, initial work for three of the interventions has already happened; next steps for the fourth intervention are being explored.

1.1 Problem Statement

This is the decade for real climate action. The Intergovernmental Panel on Climate Change (IPCC) warned that unless we achieve certain targets by 2030, we may pass the point of no return on many climate-related trends. California has always been a leader in the United States for climate action in wide ranging sectors, including residential energy efficiency. Building codes that have grown more stringent over time require that new homes are energy efficient and ready for renewable energy generation. However, that still leaves millions of existing buildings that fail to meet these new standards. The diversity of circumstances surrounding existing buildings, such as building vintage and type, tenant priorities, and financial constraints, have made them a more challenging sector. The efforts have been laudable, but insufficient to achieve the California goal of [increasing existing buildings' energy efficiency by 50 percent by 2030](#).

Late in 2020, the County Office of Sustainability convened dozens of Bay Area organizations to determine how best to convert existing single-family homes to all-electric, as part of the nine-county Bay Area's transition to an energy system free of greenhouse gas emissions. The County chose Presidio Graduate School's [PGS Consults](#) team to facilitate a systems-thinking approach to the challenge of converting single-family homes to all-electric in the region.

The [Bay Area Regional Energy Network](#) (BayREN) sponsored this multi-stakeholder process to understand the context in which efforts to convert homes to all-electric are taking place and to identify new strategies that would have the highest impact on progress with adequate coordination and attention.

1.2 Scope and Scale

This project used systems mapping methodology to identify opportunities with the greatest leverage for change. We did not attempt to fully document every detail of the system. That would have been a much more time-consuming project. It wasn't deemed necessary to fulfill the ultimate goal of looking for areas where collaborating regionally would enable us to accelerate and to increase the impact of our collective efforts to decarbonize existing single-family homes.

2. Methodology Overview

2.1 The Purpose

The goal of the project was to create a common understanding of the system that impacts carbon emissions from existing single-family homes in order to identify overlaps, dependencies, and gaps in services, and ultimately determine where and how to best intervene to make the system work better. Because the system involves so many players, each working independently to improve the system outcomes, the project sought to identify ways to coordinate efforts across the many organizations working in this area to remove barriers and identify opportunities to reduce emissions from existing single-family homes.

2.2 Sponsors and Project Team

BayREN sponsored the project. The County Office of Sustainability (a BayREN member agency), led by Susan Wright and Kim Springer, managed the effort and convened the dozens of Bay Area organizations working on the issue. The PGS Consults team (a full management-consultancy specializing in environmental and business sustainability and social equity), facilitated the systems-thinking approach, led by Dr. Marsha Willard, Laura Hoffacker, and Pamela Gordon. Emily Alvarez (StopWaste), Jenny Berg (ABAG/MTC), Karen Kristiansson (ABAG/MTC), Jeffery Liang (ABAG/MTC), and Denise Lin (County of San Mateo), provided advice and guidance throughout the project.

2.3 The Process

PGS Consults championed a systems mapping methodology deploying a series of workshops and focus groups with key players. The multi-stakeholder group included representatives from public agencies, nonprofits, and private companies from the Bay Area. A complete list of participants is in the Appendix. This group was convened for two virtual workshops. In between the workshops, the consultants conducted two information-gathering focus group sessions with two key stakeholders: contractors and homeowners.

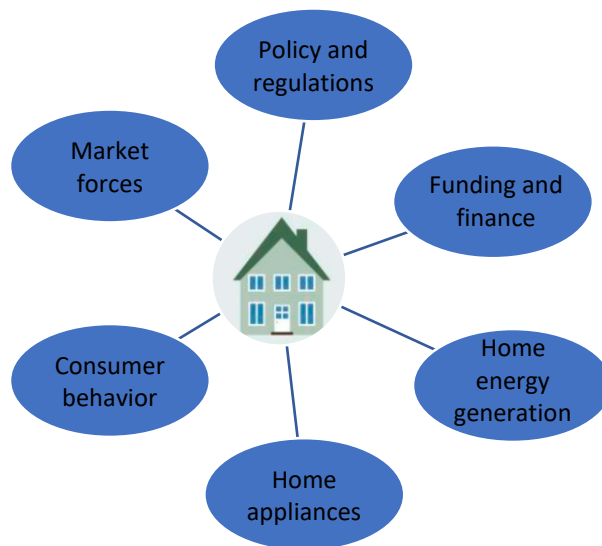
- Stakeholder Workshop 1: October 28, 2020
- Focus Group with Contractors: December 1, 2020
- Focus Group with Homeowners: December 2, 2020
- Stakeholder Workshop 2: December 9, 2020

The first multi-stakeholder workshop had two main goals:

- Create a system map of the critical aspects of converting homes to all-electric
- Identify the key players/stakeholders that influence those aspects

Participants focused on six factors critical to home carbon emissions reduction:

1. **Home energy appliances and mechanical systems** (e.g., HVAC, water heating, kitchen appliances, electrical panels, etc.)
2. **Funding and finance** (e.g., access to capital, rebates, tax credits, etc.)
3. **Home energy generation and storage** (e.g., solar, battery, resilience during power shut-offs, etc.)
4. **Market forces** (e.g., building trends, contractor and supplier behavior, price signals, real estate trends)
5. **Policy and regulations** (e.g., permits, building codes, restrictions, state law, ordinances, rates, etc.)
6. **Consumer behavior** (e.g., purchasing preferences, biases, overall knowledge, health concerns, attitudes and comfort and convenience, etc.)



For each of the categories, the participants identified key variables or factors that either contribute to or hinder the conversion to all-electric in existing homes. Once the variables were analyzed, the participants then identified stakeholders that controlled or influenced those variables. (See Appendix A1.1 for all responses.)

2.4 Questions Uncovered from the Systems Analysis

These questions arose during the first stakeholder workshop. Some were addressed in the focus groups and second stakeholder workshop; others warrant further discovery:

- What would simplify **financing** for homeowners? What kinds of **financing** could banks or utilities offer?
- How can we get retailers and **contractors** to help sell the idea of conversion to all-electric? What is the price point that makes it worthwhile?
- How do we encourage and/or coordinate with federal agencies and **regulations**?
- What about groups that advocate for **social justice**, housing equity, and environmental justice? What policies might also support their goals?
- How might **unions** support the move to transition to all-electric?
- What role can **realtors** play? What can we tell them to help sell homes?
- What motivates **landlords** to upgrade or retrofit a property?

2.5 Focus Groups

In between the first and second stakeholder workshop, the consultants conducted two focus groups -- one with homeowners and one with contractors. Both groups were asked to identify the primary barriers to the conversion of homes to all-electric across several areas (see below) and then to suggest actions that might be taken to remove or mitigate the barrier.

<p>Barriers to conversion for contractors:</p> <ul style="list-style-type: none"> • Financial: cost hurdles, financing, and incentives • Contractor resources: access to products, information, training, and other programs • Customer behavior: consumer knowledge, comfort, or enthusiasm • Regulation: permit requirements, licensing, building codes, and inspections • Workforce: qualified workers, cross trade connections <p>Barriers to conversion for homeowners:</p> <ul style="list-style-type: none"> • Financial: cost hurdles, financing, incentives • Effort: finding qualified contractors, access to necessary information, navigating options • Knowledge: having needed information, feeling confident about options

2.6 Social Equity

The homeowners that volunteered for the focus group were interested in converting their home to all-electric operation. Given the significant expense this conversion currently entails, we suspect that homeowners in our focus group had moderate to upper incomes. (Household income was not asked as a screening question.) While the scope of this project only enabled us to have one focus group for homeowners, there is a need to center equity in future efforts to ensure that conversion to all-electric homes is a possibility for everyone.

One potential next step for implementing the systems mapping recommendations is to convene an equity working group with key organizations and community members to assess the equity implications of the recommendations. We would also recommend convening a similar systems mapping process to better understand the needs of low-income households and households that rent their home. The groups could consider additional barriers to conversion to all-electric homes because of lower household incomes, substandard housing, and racial inequities.

3. Insights Gathered

Through the multi-stakeholder workshop and the two focus groups, a view of the system began to emerge that revealed key points of leverage.

3.1 Key Takeaways from the Workshops and Focus Groups

Home appliances & mechanical systems	<ul style="list-style-type: none"> • Consumers need to be aware of the options available to them and the costs/benefits associated with each option.
Policy & regulation	<ul style="list-style-type: none"> • Several innovative policies are already implemented and still emerging. • The permit process is difficult for both homeowners and contractors. There is inconsistency in requirements and processes across jurisdictions.
Consumer behavior	<ul style="list-style-type: none"> • In most cases homeowners only replace a home appliance when it fails and then are in a rush to replace it, leaving no time to investigate or install different technologies.

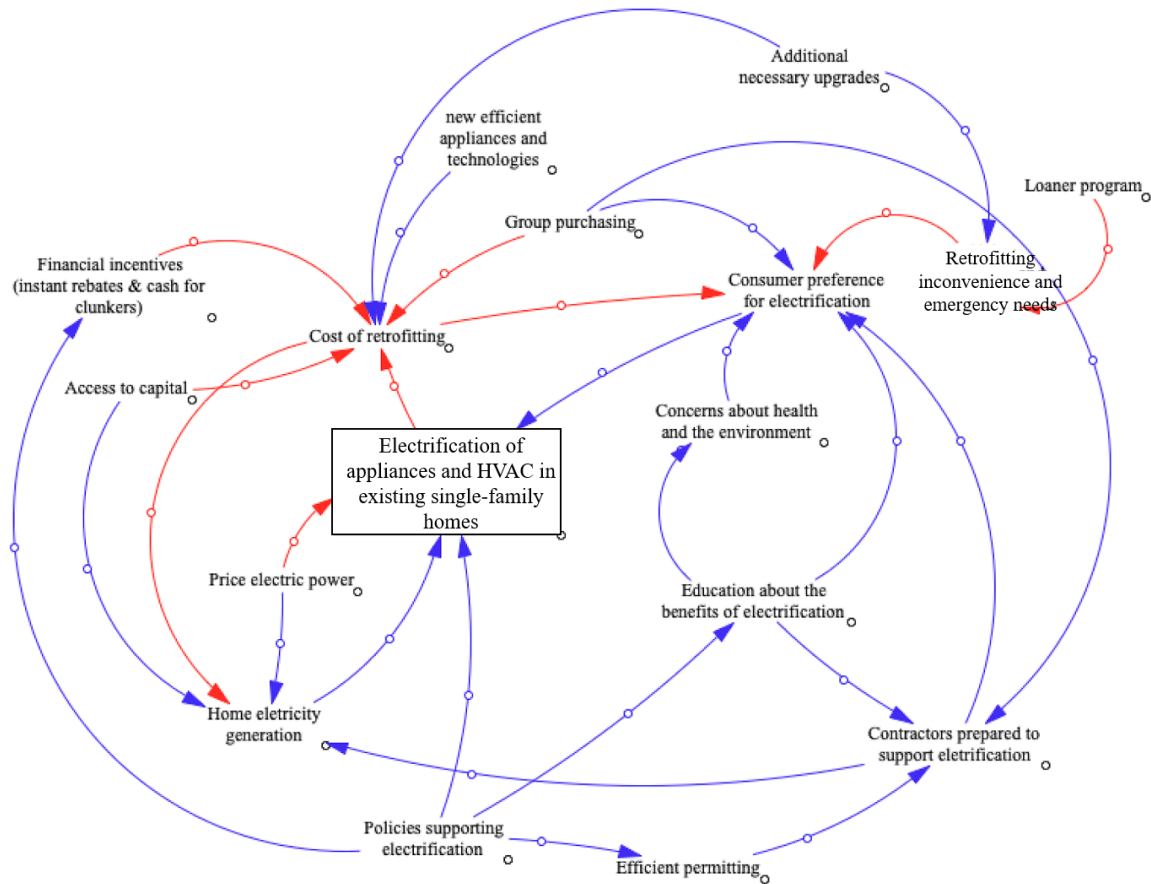
	<ul style="list-style-type: none"> • Both contractors and homeowners complained of not having enough information to make decisions. • Homeowners found it hard to find knowledgeable contractors.
Market forces	<ul style="list-style-type: none"> • Investment in home improvements related to fuel-switching does not significantly increase home values. • All stakeholders need more information/education about conversion to all-electric. • Contractors expressed difficulty in finding workers with the appropriate skills.
Home energy generation	<ul style="list-style-type: none"> • We need an understanding of how wind, PV, and hydrogen play a role for achieving community resiliency. • Currently the financial benefits (home equity and tax incentives) accrue only to the wealthy.
Funding & finance	<ul style="list-style-type: none"> • Contractors are a primary conduit for homeowners to access financing.

3.2 Systems Map – Causal Loop Diagram

The causal loop diagram below shows the interrelationship among the variables uncovered from the stakeholder workshops and focus groups. It reveals the most impactful points of intervention.

The causal loop diagram illustrates the cause and effect relationships among the key variables impacting the goal of transitioning home appliances and heating/cooling systems to all-electric. Red arrows represent an inverse relationship (when one variable *increases* the variable it affects *decreases* and vice versa) while blue arrows indicate a direct causal relationship (the variables both increase or decrease together). For example, when policies supporting electrification (bottom left) increase, so does the electrification of appliances and HVAC in existing single-family homes (center left). When the cost of retrofitting (upper right) increases, electrification of appliances and HVAC in existing single-family homes decreases.

The busiest nodes on the diagram suggest that the greatest impact on the system would involve reducing costs, motivating consumers, and preparing contractors. There are, however, particular challenges associated with each of these factors that fall into three categories: technical challenges, structural issues, and consumer attitudes and information. More information can be found in the Appendix on how these challenges were derived from the focus groups.



3.3 Technical Challenges to Decarbonizing Existing Homes

We have the technology we need to solve our climate crisis; it's just that *implementing* that technology poses *technical* challenges. While not insurmountable, these barriers are daunting enough to dramatically slow the process of switching completely from natural gas to electricity in existing homes. Many older homes, for example, are insufficiently wired to handle the electrical power requirements of additional mechanical systems. Even switching from a gas water heater to an electric heat pump can sometimes require an expanded electrical panel, adding unexpected cost to the project. In other cases, the costs of purchasing electric appliances such as heat pump space heaters and the wiring and venting changes needed to install them lead to more extended remodeling than initially anticipated. Homeowners we talked with were also frustrated because few contractors in the area had the requisite combined knowledge of plumbing and electrical systems, so tended to give bids higher than the jobs warranted. In California in the last decade, it has also been challenging to convince the public to switch from gas to electric when power outages are becoming more frequent.

3.4 Structural Issues Caused by Market Trends and Policy Implementation

Addressing only the technical challenges, however, still leaves us in the place of nibbling around the edges of a problem. Systems thinkers know to look at the structure of the system in which the problem exists to understand the larger forces at play that keep the system operating as it is. As stakeholders examined some of these forces, they realized that market forces, public policies, and even regulations were presenting larger

barriers to the changes they were seeking. Homeowners are rightfully nervous about switching from natural gas to electricity given the price difference in the two energy sources.

And while California leads the nation in climate policies, we learned that those policies are not always consistently implemented from jurisdiction to jurisdiction, creating confusion among homeowners and contractors. Additionally, the implementation of some policies created ripple effects in terms of more complicated approval processes, additional paperwork, and added inspection requirements that discourage the very projects the regulation was intended to foster. The same was found to be true even with the many financial assistance mechanisms created to support the change. While there are rebates and incentives available for various home conversion projects, they are inconsistently applied, inadequate to cover the incremental cost of an electric appliance, and time consuming to apply for. Energy rate reform is needed to support switching to electric appliances. There are disincentives with current rates to fully electrify associated with tiered energy use structures (i.e. your bill may go up if you only electrify your water heater) and time-of-use rates. Contractors mentioned that the labor required to complete rebate paperwork often outweighs the incentive value itself. Finally, policies and rebates need to be designed so that homeowners in all income brackets can participate in the climate transition.

3.5 Financial and Informational Barriers for Homeowners

The groups uncovered a host of barriers that discourage the home conversion effort. Foremost among them is the concept of initial cost. While for many, the upfront capital cost of home conversion is simply too large of an investment, for those who can afford it, there is a payoff down the line. Many of the changes suggested by energy experts require the purchase of equipment that is more expensive than traditional natural gas appliances, but that return greater value over time when paired with renewable energy sources and storage.

Many consumers either can't afford the upfront cost or don't understand the long-term benefit. The upfront costs also drive consumers to wait until existing appliances have reached their end of life before replacing them. While not illogical, if they wait until equipment fails, they usually miss the opportunity to convert to an electric appliance, as the conversion can take several days to implement. When someone suddenly has no hot water, they're not inclined to wait several days to make the switch.

Next, the homeowner is easily baffled as to what to do, because they do not have a whole-house conversion plan to help them avoid pitfalls as they more affordably convert their homes to all-electric one mechanical system at a time. Finally, the real estate market has been slow to value energy efficiency and all-electric homes, so investments in energy conservation may not be adequately factored into a home's valuation, often making granite countertops a better selling point than wall insulation or air sealing.

4. Recommendations

Armed with the insights from the first workshop as well as the input from the focus group members, the multi-stakeholder group reconvened to craft a way forward with actions that would have the highest impact on the system.

Working in small groups, participants analyzed a set of proposed ideas and narrowed them down to the most promising to present to the larger group. The whole group discussed the prioritized ideas and agreed on the top four interventions that merited further action. Additionally, participants identified the necessary next steps to move the ideas forward. The results are summarized in Section 4.2 below.

4.1 Selection Criteria

Participants were asked to score the ideas in two categories: Impact (How well would this idea move the needle) and feasibility (How realistic would this idea be to implement? Are there the resources, political will, staffing to implement?). In finalizing the list of recommended interventions, the group prioritized ideas that needed regional collaboration and implementation to be successful. Ideas that could be implemented immediately by an individual organization weren't included in the top solutions.

4.2 Top 4 Solutions for Regional Coordination

4.2.1 Instant rebates

Description: Minimize or eliminate paperwork for homeowners and contractors by providing upstream rebates. Start with electric heat pump water heaters, then add measures for other conversions.

Rationale: This would help develop the market and establish demand. The customer experience would be seamless. It would be beneficial to get distributors to sell the technologies; contractors would know the price when making quotes. It would lead to distributor relationships and encourage stocking of products. The California Energy Commission's (CEC) funding for the Technology and Equipment for Clean Heating (TECH) initiative includes support for conversion projects in existing homes and promoting instant rebates as a part of that effort would have a great impact. Regional coordination, communication, and consistency would benefit everyone.

Key Players to Involve:

- BayREN
- Contractor community
- Community Choice Aggregators (CCAs)
- Energy Solutions, TECH program implementer
- Energy Star and retail products platforms
- Manufacturers (Energy Star has manufacturing council)

Next Steps: This idea could be implemented through the BayREN Single-family (Home+) Program, given additional funding. Following the completion of the systems mapping project, Jeffery Liang (Program Manager) began discussing funding and implementation strategies for this intervention with CLEAResult (Single-family Program Implementer). This effort is currently on pause, since the CEC's TECH program may be providing a similar solution.

4.2.2 "Cash for clunkers"-style rebates

Description: Offer an incremental incentive for residents who replace water heaters that still work. On paper, the existing rebates for heat pump water heaters can be used to replace any water heater, whether the original appliance works or not. In practice, residents are rarely able to convert from a natural gas water heater that has failed to a heat pump water heater because of the time and permit requirements. "Cash for clunkers"-style rebates would be primarily a marketing effort, drawing attention to the extra incentive offered for planning ahead to convert to heat pump equipment. A marketing plan (downstream and midstream) would need to be developed for homeowners and contractors. Recycling logistics and documentation requirements to avoid abuse would need to be considered, as would understanding the regulatory implications.

Rationale: This is similar to current incentives for trading-in old items (i.e., cars and refrigerators) for efficient ones. This will encourage homeowners to avoid emergencies from failed equipment. When homeowners

aren't operating in panic mode, contractors can offer the best choice rather than the cheapest or quickest to obtain.

Key Players to Involve:

- BayREN
- Contractor community
- CCAs
- Building Decarbonization Coalition
- Transfer stations (recycling)
- Policy makers
- PG&E (ask about their refrigerator recycling program)

Next Steps: This idea could be implemented through the BayREN Single-family (Home+) Program, given additional funding. Following the completion of the systems mapping project, Jeffery Liang (Program Manager) began discussing funding and implementation strategies for this intervention with CLEAResult (Single-family Program Implementer). The current BayREN program already allows for early retirement of equipment, so a next step may be to draft program marketing that will have a “cash for clunkers” message. This could be piloted in one county, potentially San Mateo County. BayREN does not currently have recycling requirements. Part of pilot could include reaching out to contractors to gather feedback and pilot responsible recycling of appliances.

4.2.3 Public/private financing

Description: Support the development of a financing instrument that emphasizes leveraging public/private partnerships to make it easier for customers to access. These partnerships could take many forms:

- public entities could provide capital to protect lenders against loss either through subordinated capital or loan loss reserve structures
- public dollars could be used to “buy down” interest rates, keeping financing costs lower for consumers
- public entities with access to billing systems – for example, water utilities or community choice aggregators – could potentially provide access to billing infrastructure to reduce interest rates

To ramp up financing solutions quickly, it is recommended to leverage existing programs such as those offered by the CPUC through the Residential Energy Efficiency Lending (REEL) program. It should be noted that many of the above suggestions center consumer lending as the primary delivery mechanism for financing solutions, and consumer lending may not be suitable for the low- to moderate-income communities in our region. For these customers, solutions that tie financing to the property, rather than the borrower, may expand the eligible population. These potential solutions include leveraging the energy as a service company (ESCO) model, rate-basing improvements to be amortized over time, or pursuing the possibility of tariffed on-bill financing, currently under consideration by the CPUC. All of these solutions must enable contractors to offer financing seamlessly to minimize or eliminate upfront costs for decarbonization projects.

Rationale: Many ideas and new programs are evolving in this space. For instance, the Building Decarbonization Coalition (BDC) produced a white paper on tariffed on-bill financing: [Towards an Accessible Financing Solution](#). The [REEL](#) program has financing for energy efficiency projects. The CEC TECH initiative will include incentives. Energy Solutions, the successful proposer, is working on innovative financing strategies. East Bay Community Energy (EBCE) has been looking at the financials and is exploring how to remove upfront cost barriers and add

value for the greatest number of customers. [Mosaic](#) and [Service Financing](#) already provide financing for some decarbonization projects. By coordinating efforts and leveraging private capital, the scale needed to transform the market could be achieved.

Key Players to Involve:

- Building Decarbonization Coalition
- East Bay Community Energy
- BayREN
- Coalition of CCAs
- Bay Area Council (BAC) to include the private sector
- Contractor community
- Financial institutions/banks
- Business Council on Climate Change (including community or mission-driven banks)

Next Steps:

This idea would benefit from convening stakeholders to participate in a systems mapping effort focused specifically on financing. County of San Mateo will discuss this option with BayREN to consider how it could be funded.

In addition, BayREN’s Water Upgrades \$ave program currently helps water utility customers install water and energy efficiency upgrades with little to no up-front cost by way of a monthly utility-approved on-bill charge that is significantly lower than the estimated savings. Program Manager Chris Cone is currently exploring options to include electrical conversion upgrades, such as heat pump water heaters, as part of this program.

4.2.4 Simplify permit process

Description: Make it easier and faster for contractors and residents to apply for and receive building permits for conversion to electric appliances and HVAC. Building permits are necessary to ensure that building projects are implemented in a safe and appropriate manner, but they cost money and each city has its own application process. To address this, engage building department officials to clarify the health and safety requirements of the permit process. Also solicit their ideas to identify inconsistent and time-consuming elements of the permit process. There are many considerations needed when changing the permit process; for example, expediting one permit type may cause other permit applications to take longer. In addition, permit fees are often an important source of funding for building departments to provide their services to the public. Engaging building department officials will help identify realistic solutions that work for those implementing the work day-to-day.

One idea is to work with building departments and other experts to create guidance on bundling electric conversion projects and creating an over-the-counter or one-stop permit for electric conversion projects. This information could be made available to building departments through online tools.

Rationale: Because of COVID-19 restrictions, building departments accelerated the transition to digital permits, which has the potential to make other permit process improvements easier. The CPUC/CEC TECH initiative, which will be rolling out in mid-2021, includes a small component for accelerating the permit process for heat pump water heaters. BayREN’s Codes & Standards Committee already supports building departments with implementing codes and the Codes & Standards Program has been talking with the TECH initiative about permit process improvements. A collaboration could pilot simplified permit processes in the San Francisco Bay Area as a first step to scaling best practices for electric conversion permits statewide.

Key Players to Involve:

- BayREN Codes & Standards program
- Energy Solutions, TECH program implementer
- California Energy Commission (compliance and enforcement division)
- International Code Council (ICC)
- Tri Chapter Uniform Code Committee and other ICC Chapters
- CALBO
- Chief building officials

Next Steps:

The stakeholder group wanted the next step to be the determination of whether it is better to work locally and regionally to support simplified permit processes or to work statewide to influence policy change. Since the time the group met, there have already been significant efforts to support improvements to the permit process locally and regionally. BayREN’s Codes and Standards Program has taken up this issue and is hosting a Regional Forum in June 2021 on “Building Permits and Clean Technology: Innovations and Challenges.” Silicon Valley Clean Energy (SVCE) researched permit processes in their member cities and produced a “Best Practices Guide for Streamlining Electrification Permitting.” The statewide TECH Program, which should start in the summer of 2021, includes a focus on a faster and easier process to get permits to install heat pump technologies. BayREN, SVCE, and TECH have started conversations about coordinating efforts, developing resources and approaches for local governments, and piloting their use in the Bay Area (these efforts will continue). In terms of statewide policy, there is a new, controversial bill pending in the legislature ([SB 617](#)) which would require local governments to use a particular electronic tool to streamline the permit process for PV systems. Since many of the permit process issues are the same for PV and electric conversions, this effort can show some of the benefits and challenges of taking this type of statewide policy approach. To summarize, the next steps are: 1) to be involved in local and regional efforts to support improvements to the permit process, such as the effort started by BayREN, SVCE, and TECH; and 2) to follow and assess the state policy approach taken by AB 617.

4.3 Other Notable Ideas

The four ideas above represent the highest priority strategies, but many other promising ideas were discussed by the group. Strategies listed below were offered as second phase programs:

4.3.1 Comprehensive roadmap for conversion to all-electric

A major theme that emerged from the homeowner focus group was the homeowners’ desire for a comprehensive plan to help them understand all the aspects of converting their home to all-electric and the pathway for proceeding. Homeowners were concerned that if they embark on the conversion of one appliance without an understanding of the costs and energy needs of the entire home, they may make mistakes that would add costs in the future. For instance, oversizing a heat pump water heater could trigger the need for an electrical panel upgrade at a later time.

Two ideas surfaced to address this need:

1. Offer an automated roadmap/project planning tool for converting a property to all-electric. The YellowTin platform has a roadmap feature that provides a basic plan for the customer to convert over time.

2. Offer a cooperative buying service that promotes group purchasing of electric conversion plans. Customized plans would be developed by building performance experts following in-home visits.

In April 2021, informed by the systems mapping project, the County began working on case studies to highlight the costs and strategies to decarbonize existing single-family homes. The primary deliverable of the project – case studies for each of 10 different home profiles outlining the strategy and costs for decarbonizing all at once or over time – will be a useful model for a customized roadmap. The case studies can help inform approaches for similar home types in the county and potentially in the Bay Area region. Information about the case study project is [here](#).

4.3.2 Emergency water heater loaner program for contractors

Unlike the “cash for clunkers”-style rebate which addresses the problem of homeowners waiting until equipment fails to investigate a replacement by incentivizing them to plan ahead, this solution doesn’t try to change human nature. Instead, contractors temporarily install a loaner hot water heater in place of the failed one, giving the household hot water while they work through the steps of getting a heat pump water heater permitted and installed. Although innovative, this idea warrants further work to determine whether an emergency loaner program would increase costs for the homeowner or not, and therefore whether it would be widely accessible. It would be helpful to explore whether a homeowner could sell a gas water heater back when replacing it with a heat pump water heater. An emergency water heater loaner program could be promoted to contractors once the idea has been further explored. It would not need a coordinated regional approach to execute.

5. Conclusion

As a culture, people and organizations try to fix obvious problems. Often, the technology, the will, and great thinking are there, but change, such as transitioning homes to all-electric, runs against a system with inertia. To effectively solve complex problems, synergistic efforts are required. A systems mapping approach identifies the root problems and the greatest leverage for changing the system.

In this project, we applied the systems-thinking lens to the challenge of decarbonizing existing single-family homes. It was a first step in what must be an ongoing effort to work collaboratively to identify barriers to progress and change systems. Together, we can accelerate the equitable transition to decarbonized homes in the San Francisco Bay Area.

Appendix

A1. Stakeholder Workshops

A1.1 Attendees

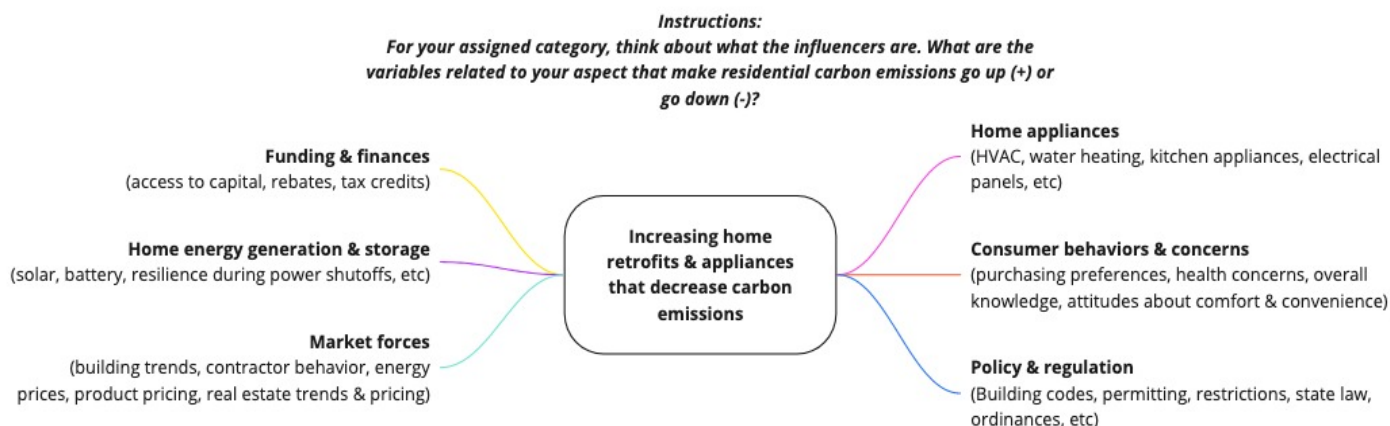
Both workshops were hosted on Zoom and lasted 90 minutes. Sessions were administered by Marsha Willard and Laura Hoffacker of Presidio Graduate School; the Planning Team also attended.

Name	Organization	Workshop #1	Workshop #2
Abe Talakai	International Brotherhood of Electrical Workers	√	
Amy Rider	Building Decarb Coalition	√	
Avana Andrade	County of San Mateo	√	
Beckie Menten	East Bay Clean Energy		√
Billi Romain	City of Berkeley	√	√
Brett Gentry	Clean Tech Entrepreneur	√	√
Chris Cone	Regional Climate Protection Authority – Sonoma County Transportation Authority	√	√
Corinne Schrall	Frontier Energy		√
Dave Mauro	International Brotherhood of Electrical Workers	√	
David Hamburger	Building Efficiency	√	
Denise Lin	County of San Mateo	√	√
Diane Bailey	Menlo Spark	√	√
Diane Sweet	emeraldECO	√	
Emily Alvarez	StopWaste	√	√
Geneva Gondak	Rescape	√	
Hannah Kaye	PG&E	√	√
James Tuleya	Home Intel	√	
Jeffery Liang	ABAG/MTG	√	√
Jennifer Green	MCE	√	√
Jenny Berg	ABAG/MTC	√	√
Joe Koproski	CLEAResult	√	
JP Ross	East Bay Community Energy	√	
Juan Bernal	GRID Alternatives	√	√
Katie Van Dyke	City of Berkeley	√	
Kim Springer	County of San Mateo	√	√
Larry Waters	Electrify My Home	√	
Leslie Alden	Drawdown Bay Area	√	√
Lois Smith	Marin Clean Energy	√	
Marc Bigby	CLEAResult	√	√
Marc Costa	Energy Coalition	√	
Marcus Griswold	County of San Mateo	√	
Marwa Ali	JobTrain	√	
Mary Sutter	Grounded Research	√	√
Maureen Kennedy	Realtor	√	√
Mike Balma	SunWork	√	

Mike Beebe	Electrify My Home	√	
Rebecca Milliken	City of Berkeley	√	
Rick Raybin	Financial advisor	√	
Ryan Gardner	Rincon	√	
Shraddha Mutyal	Peninsula Clean Energy	√	√
Sooji Yang	Greenlining Institute	√	
Susan Wright	County of San Mateo	√	√
Tanya Narath	Regional Climate Protection Authority – Sonoma County Transportation Authority		√
Tom Kabat	Menlo Park Environmental Quality Commission	√	√
Tony Jung	CLEAResult	√	√
Vishwas Ganesan	Yellowtin	√	√

A1.1 Stakeholder Workshop #1 Raw Data

Participants used Miro, an online visual collaboration platform, to capture ideas. Participants were given the instructions below.



Participants were assigned to six different groups; each contributed to one of the sections of a basic systems map and listed key players in tables. The raw data can be viewed [here](#). You can use tools in the lower righthand part of the screen to zoom in and move around the space to see the content.

A1.2 Stakeholder Workshop #2 Raw Data

Participants used a Google spreadsheet to capture ideas. Groups were assigned to four different groups; each evaluated ideas that had come from the focus groups, and then decided on two ideas to present to the full group. The full group assigned scores to the proposed ideas; the top four scores were discussed further. The raw data can be viewed [here](#).

A2. Focus Groups

A2.1 Purpose and methodology

The purpose of the focus groups was to discover barriers and opportunities to converting single-family homes from natural gas to electricity. Building on past research, in these focus groups we focused on what makes it easier or harder to actually implement projects. We hosted two focus groups to hear directly from people interested in implementing electrification projects: contractors and homeowners. Each session was hosted on

Zoom and lasted 90 minutes. Sessions were administered by Marsha Willard and Laura Hoffacker of Presidio Graduate School; the Planning Team also attended. We were not able to offer any monetary payment for participation.

A2.2 Contractor Focus Group

A2.2.1 Attendees

Of the 13 contractors who registered for the session, four contractors participated. (One additional participant logged in but had to leave shortly afterward.)

A2.2.2 Introductions, barriers, and solutions

Participants contributed ideas by writing in a shared Google spreadsheet and then discussing their responses. Responses to prompts about barriers and solutions can be viewed [here](#).

A2.2.3 Responses to new ideas

At the end of the focus group, contractors were asked to comment on these specific ideas. These notes capture the essence of what was shared.

1. Group purchasing: Would you find those RFPs attractive? Why? would you participate? What would make it more attractive or unattractive?

- One example: SunShares
- Big buy approaches don't necessarily work for everyone (i.e. roof types); the program would need more parsing out to make sure people are eligible (average homeowner doesn't know/understand technical aspects about their home)
- Electrical panel big buy would make more sense
- Water heaters inside the home (not the right type of house always)
- Gather data first
- Heavily discounted is an attractive approach

2. Contractor Network: Would providing some networking amongst you be helpful to problem solve or surface new ideas? Would you join such a group?

- Yes +3
- Helpful to have a list of folks who are electricians; taking it a step further, meet periodically to talk about challenges, ideas, opportunities will create synergy. leads for HVACs or water heaters can be shared as well.
- From Susan Wright: potentially create a LinkedIn group. Would an online platform be helpful?
 - Virtual face-to-face meetings are much more engaging and helpful
 - Potentially doesn't exist right now + 1
- Electrification checklist for contractors to perform (have to wait for calls; hard to be proactive and reach out)

3. Rebates: There are currently a variety of rebates or financial incentives that promote electrification (name some if you can). What is your view of these programs? Do they help you? If you could redo rebate or incentive programs what would be ideal?

- Easier the better! Instant, simple, customer friendly
- Happen at the beginning of the process, not the end

- Barriers have stopped an onboarding process before
- Experience working with utilities along the west coast, and the most successful relationships have been the ones that have been easy – i.e. Puget Sound Energy, Seattle - pioneered instant rebates (rebates are right off invoice, no application needed)
- Tests and verifications – We understand the requirement because we don't want anyone gaming the system - make it have a lot of friction points. But we end up paying for the rebate with all of the complications.

4. Business model: Have you considered reshaping your business model around electrification as a comprehensive service? What is attractive or unattractive about this idea? Under what circumstances would you pursue this?

- Marketing campaign
 - partnerships around coop marketing / utilities / manufacturers
 - County info is potentially available. Who would be easiest and who should we target? Built-by date? Age of home? (8-12 yrs or 8-15 yrs) | Last major remodel? Contractors don't have easy access to this data for marketing purposes.
 - Can we target homeowners that apply through the city that are doing a remodel of any size or new construction project?
 - Find people who might already have upgraded panels (it will make it easier to implement)
 - Potentially target architects, designers, mechanical engineers
- This is our business model. Market is responding well (2 month wait time currently). We have needed C10 licenses, contracting out with other experts.
- Need to be nimble and agile because new challenges are always coming up
- Proficient at installing natural gas water heaters (50/day; 3 hrs). Heat pumps are more involved and take 4 hrs. + Electrical part is not included in this time estimate (Ranges from 4 hrs to 12 hrs based on infrastructure, what needs to be upgraded, etc.) + it might trigger a (sub)panel upgrade + regulations are complicated
- Sometimes it is possible to pull one permit for a heat pump water heater, but it is not standard
- Additional coordination is needed among contractors to take care of the homeowner
- Difficult to get customers to think ahead and not wait until their water heater breaks. Uphill battle: process is a bit longer, converting from gas to electric is a multi-step process: estimate from contractor, electrician, permitting on all sides.

4. What other ideas do you have?

- Targeted outreach to potential customers (e.g. age of home 8-15 years)
- Can we target homeowners that apply through there city that are doing a remodel of any size or new construction project?
- Hook homeowners up with financing
- Fyi - it is not difficult for contractors to get product (even with COVID raging)
- Building departments pass along information when they see permits being pulled for remodeling

projects. We could also target architects, designers, mechanical engineers, realtors, county assessor who notice home ownership turn over.

A2.3 Homeowner Focus Group

A2.3.1 Attendees

Of the 27 participants that registered for the session, 18 attended. All but two indicated they are “very interested” in converting the equipment in their home from natural gas to electric; the other two said they are “somewhat interested.” Participants were from San Francisco, Santa Clara, San Mateo, and Alameda counties.

A2.3.2 Introductions, barriers, and solutions

Participants contributed ideas by writing in a shared Google spreadsheet and then discussing their responses. Responses to prompts about barriers and solutions can be viewed [here](#).

A2.3.3 Responses to new ideas

At the end of the focus group, homeowners were asked to comment on these specific ideas. These notes capture the essence of what was shared.

1. *Group purchase opportunities: would be willing to participate in a “buying coop”? how do we scale for many people to do this?*

- One example: SunShares for solar. Similar program for heat pump water heaters or panels.
- Solar, panels, batteries - helpful for products. Group buying might be difficult with various custom appliances are harder to buy as a group. In addition, most of the cost is labor. +3
- Heat pump water heaters are standard enough for this to work
- When it’s possible (taking into account above), it can be a win-win
- Neighbors may not understand the issue
- Let’s separate electrification into two categories... replace a discrete product like a gas dryer VERSUS systemic labor intensive shifty of solar/battery/HVAC/water which is a very different project and set of needs.
- Education is key to do before this step
- I love the idea of bulk purchasing to get the cost down
- I’d like to see the county or PCE do an RFP for a contractor to perform several hundred electrical upgrades on older homes, so that those home-owners have a guaranteed price (based on the average across a large pool) and subsidized through the utility.
- I absolutely would participate in a group purchase program. I took advantage of SunShares
- Link to what Marlene referred to - <https://www.pbs.org/independentlens/films/jonathan-scotts-power-trip/>
- In Boulder, homes of similar characteristics were grouped and contractors could specialize in those unique needs. This allowed for more specialization and customization.

2. *Home advisor service: Would having access to a service like this be helpful? What additionally do you wish it would do?*

- +1 to advisor service. We have solar panel advisory built in before installing panels - not so much for individual appliances (getting a number on size requirement and cost would help)
- New codes require separate circuits for many things now. It is challenging to get the amps down enough to get by on a 100 amp circuit. And many places still have old knob and tube which aren’t

up to the electric stresses required by our electronics, etc.

- Most people may not need a panel upgrade, but the electricians (and others) tell them they do so that they can make a profit. Whoever is advising people, learn about the amp diet approach from Tom Kabat + 3
 - Include a site visit and help homeowners; analyze the systems now and compare them to what is place in other areas (like Boulder) + 1
 - Future Fit from SVCE - look at the whole house +1
 - Advisors have cursory knowledge, but not exactly what they need
 - Palo Alto Home Genie program covers the cost for home advisors to come in and help.
 - Whole home incentives (at one time).
- Would recommend development of standard "home upgrade roadmap" template with standard and optional sections that the homeowner can use to get a comprehensive approach and then chip away in stages over a number of years
- I love the idea of a holistic approach +1
 - If thinking ahead and understands the whole house, could make recs, help save costs, and remove barriers in the future +1
 - Good point about needing plan for whole house electrification when considering panel upgrade
 - Across discipline approach is key given specialty expertise needed
- Would recommend development of standard "home upgrade roadmap" template with standard and optional sections that the homeowner can use to get a comprehensive approach and then chip away in stages over a number of years +1
- I think I need a BayREN "electrification designer" service onsite, not an audit.
- !!! to BC Capps comment.
- Honest input about electrification is needed (not relying on someone who stands to make a profit)
- apart from info on appliance upgrades, knowledge about things like insulation to reduce electricity usage is also helpful

3. Homeowner network: Would it be helpful to connect with other homeowners to share learning or resources?

- Ambassadors, someone to call who has been through this. Homeowners know a lot about this. People have gone through this the hard way. Call in service through the county or city to connect with other homeowners. +1
 - Helpful to know the expectations and the process
 - Contractors, in the past, have avoiding directly answering questions on cost
 - Polling of people who have been through this before would be helpful. I.e. how much should x cost?
- Zoom meetings are helpful to share insights and tips - community leaders who have been through this before. Threshold for joining a zoom meeting is much lower than threshold for in-person public/city council meetings.

- Facebook group to serve as a network. Talk about who the big contractors are. Rate contractors who specifically do electric work. +1
 - Helps saves time (without having to do all of the research ourselves)
- It would be good to get recommendations from other homeowners on how to do the process and contractor they used +2
- I'm liking the WeRenew group that SM county is running to share across homeowners. But I'm missing trusted "consumer reports" style reviews of best products for heat pump water, battery, HVAC, stove, dryer etc. Europe, for example, has so many more choices than here it seems.
- Sharing a video of all electric homeowners journey would scale better
- Homeowners can talk more freely about contractor experiences, costs, problems than either BayREN advisors or other county energy staff who need to be "un-biased"
- Can there be "recipes" for electrification steps based on age and size of home, types of gas use, etc.? That would create patterns of steps and best ROI for each?
- local homeowners sharing info about financing, contractors, how to, when to, etc., research shows that getting people to participate in changes that may be difficult or expensive, or novel, is much more successful when they see their neighbors doing it. We are a species that, despite our emphasis on individualism, (often) unconsciously operate from a herd mentality. We are subject to what our neighbors and our community are doing and what they value. From a sociological and psychological perspective, it is very important, not only to inform, but to actively include everyone in the consideration and evolution of these significant and essential changes in energy sources and consumption. It might be helpful, for example, to have energy fairs as someone mentioned, and also have sign-up sheets where attendees can indicate their interest or need for information, with various neighborhood individuals would contact people and set up meetings with their neighbors.

4. Bundling: do you see value in doing multiple jobs at once? What would make it more attractive?

- Bundling would be good if it is coupled with a holistic analysis and design. Sending a contractor to do everything could be worse than using individual contractors and suppliers.
- Cost is biggest barrier but I'd do steps if I had a comprehensive plan to guide me.
- Strong support for a comprehensive plan, with incremental installation upgrades
- Bundling.... I can replace a gas dryer or stove on my own. But the biggie is solar/battery/HVAC/Water as one cohesive plan and design. That's the biggest impact and most important to get right. And hardest
- Great to bundle the plan (cohesive, whole home plan)
 - Especially if pulling a line of credit; more efficient to do it all at once
 - Helpful to include the cost savings over time in the plan, and the energy savings in the plan
 - Barrier: costly to do this all at once; Helpful to have the work done all at once so the home is not disturbed more than necessary
 - Bundling incentives = great idea
 - If I were doing it all at once, it would be in conjunction with a remodel process -- I'd be

doing other things as well. So although contractor recommendations would be great, I wouldn't want rebates to be tied to using specific contractors, as I'd want to be able to use the subs already being utilized on the remodeling project.

- Resurfacing an “outcome” incentive too... \$\$\$ once electrification is all done as a carrot for the whole project.
- Consortium of contractors, plumbers, electricians, other experts are brought together (they need to have these relationships in advance to save the homeowner time and hassle) + 1
 - Efficient
- Bundle incentives +1
- Or scaled rebates, so we're still incentivizing projects that might have a sticking point -- a reason they can't electrify everything
- ADD these thoughts - contractors get used to working with each other and know how to follow one another. Not all electricians, plumbers, and carpenters are good at this.
- I've already done efficiency measures as they were easiest. SO next big nut is HVAC and water... and fix any remaining efficiency items as part of that.
- Sonoma Clean Power is working on a commercial showroom space where homeowners can browse and see new electric appliances in person before purchase. The intent is then to match owner w/ contractors + incentives using a "one stop shop" model.

5. Regarding upgrades or electrification projects, how do you take energy efficiency into account? Are you looking at appliance only?

- There aren't too many programs in place that are demanding the sealing; it is a big project and barrier.
- Incentives for lowering energy usage is helpful to encourage more optimization
- Concept can be bundled together with Clean Air days
- Response dependent on weather conditions (i.e. heat wave, wildfires - having a gas free home is healthier, new systems have heat on demand for rooms which is helpful in cold weather)
- sharing information about available rebates more widely might convince skeptics
- Education would be helpful, particularly when starting to look at appliances. Better understand what we additionally, holistically need to do. Specific insight for homeowner's unique home.
- Affordable housing - overtime, residents will benefit from these upgrades

6. What about a “cash for clunkers” rebate where if you want to replace a working hot water heater with a heat pump water heater, you get an additional incentive (~\$500) on top of the other rebate?

- Cash for Clunkers Idea for water heaters + 4
 - Greater incentives for switching
 - This is helpful for products, but not for labor involved in other categories of this issue
 - + furnaces; could technically work for a longer time and it is expensive to fix, but may not work well and need to be replaced

- Talk about how long water heaters last; educate; think proactively; this will be helpful in the long run and help homeowners plan for the future - financially especially
 - Some only have a 6-year warranty. This could be \$1000/year. Others have 12 yr warranty now.
- Avoid emergency situation (switch BEFORE) the water heater fails
- It would help to have an electricity rate schedule that rewarded electric upgrades with lower electricity rate.

7. How are you financing these projects? What financing programs would be attractive to you?

- PACE financing is a great fit for some, especially if they do not know how long they will stay in the home
- I've been saving up to cover this, but \$50K++ is just a bridge too far. So I need a comprehensive design that is 1/2 or 2/3 less... so the key to cost is in the options and design of affordable electrification overall
- I'm not interested in paying more in terms of interest rate than what is required for a product. I prefer to try and save for it. If not, I won't do the electrification.
- On-bill financing would be the easiest from a customer experience standpoint
- Loans are also good options; interest rates are low; especially for home*owners*
- Banks helped solar industry grow - Banks made financing solar simple and available. I.e. Silicon Valley Bank came to solar companies to offer this.
- When homeowners want to electrify their homes progressively by replacing gas appliances with electric, would there be incentives from PG&E because electrical infrastructure is increasingly less expensive to maintain than the aging gas infrastructure? The all electric appliances are often more expensive, so incentives are very helpful for these marginal cost increase decisions.
- Solar industry now has pay-as-you-go (via PCE perhaps?), lease, lease to own, and buy outright options. Need the same for a total electrification project. Buyer decides which.

8. Driving policy change

- County to have a model procedure/ordinance to make electrification easier (cities could cut and paste this. I.e. PCE model helpful in driving change) +1
- Contractors have discouraged from changes before because city regulations are so complicated (i.e. permitting costs, more inspections, whole house plan needed before they would put in a new heater)
- Previously mentioned, Sonoma County seemed to make electrified efficient rebuilds much easier with permitting and showroom and incentives after the fire. Can't we do the same and more in SM Co? For retro future fits?
- How about city/county fast-track for electrification permitting and incentive bundled? Really make this look easy in time and \$\$ as a type of project?
- Time-of-Remodel Electric-Ready: Would be useful to have policy changes to require running conduit to future-electrify appliances in areas of the home that are being remodeled, reducing

time-of-replacement costs later.

- One building official in my city told me earlier this year he thought electric water heaters were illegal
- workshops for city building officials next!
- ^Trainings include heat pump water heaters and reach codes. We are continuing to do outreach on these to building departments. Thank you for the feedback!
- Getting neighbors onboard; city council is not necessarily supporting the need for electrification. Other cities are completely supportive. It would be nice to have a collaborate with the messaging of the importance of electrification. (perspective is from San Mateo currently, experience around Bay Area counties and cities)
- Plug for building officials - who don't have the knowledge or experience - who implement. Help them on a county or regional level. Educate them on the guidelines for installing these. They could potentially be a stumbling block (for getting permits) if they aren't educated on this. +1, assist on a state-level as well
- I live in the east bay in a small city (Piedmont). City Council is currently planning to address the electrification building regulations. To that end the city has sent to all residents an online survey presenting various regulation options, which homeowners (in terms of remodel or construction costs) should be required to update or achieve which guidelines, attitudes towards changing energy sources and even attitudes/beliefs re climate change. This seemed like a really good idea to me because it accomplishes conveying info re: state and county projected guidelines as well as possible city regulation options, so it warns people and allows them to feel participatory in pending changes. It also gives the city some sense of the obstacles they are facing, e.g. the %age of those who don't believe in climate change may indicate the necessity of more basic education and possible methods of providing that info.

9. *Miscellaneous comments*

- Also need to deal with enormous costs of litigation/lawsuits when natural gas prohibitions are challenged by developers (Windsor, Santa Rosa, etc.)
- Would like to think about equity. There will be a future discussion on equity issues and how to involve lower income populations.