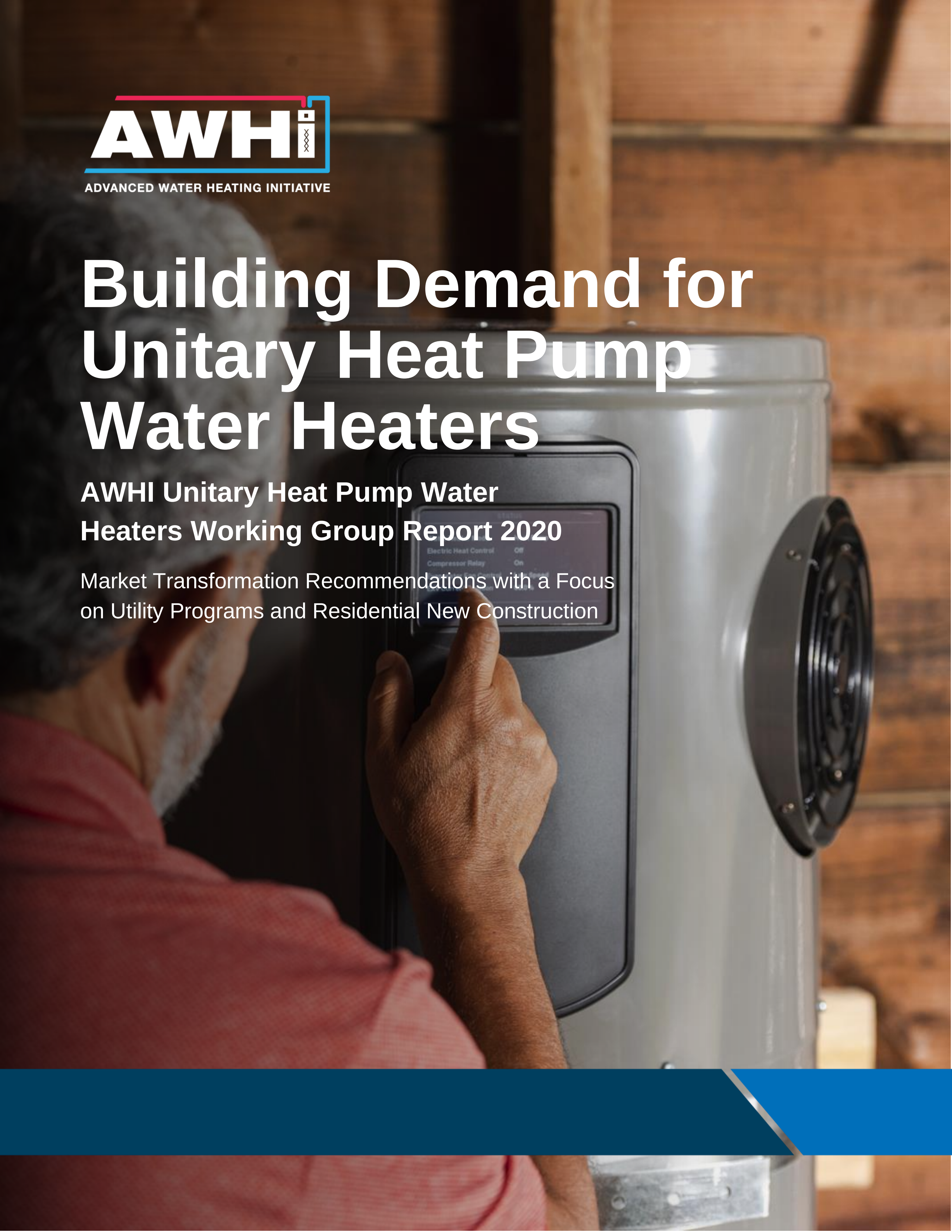
AWHI

ADVANCED WATER HEATING INITIATIVE

Building Demand for Unitary Heat Pump Water Heaters

AWHI Unitary Heat Pump Water Heaters Working Group Report 2020

Market Transformation Recommendations with a Focus on Utility Programs and Residential New Construction



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Silicon Valley Clean Energy

Sonoma Clean Power

Southern California Edison (SCE)

South Coast Air Quality Management District

StopWaste

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TRC Solutions

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1 Executive Summary

This report sets out a consensus position on the next steps necessary to transform the residential unitary water heater market toward heat pump water heaters. Because this technology is mostly mature, the report focuses on utility incentive programs and on steps toward code changes. The report is aimed initially at the California market, but most of the recommendations are applicable in all states.

Decarbonized residential water heating is necessary for California to meet its aggressive greenhouse gas (GHG) reduction goals, which set 2045 as the target date to achieve complete "carbon neutrality" in the state.[1] This will require that all, or nearly all, building heat, hot water, and cooking should be delivered by efficient electric technologies. Water heating is perhaps the most difficult of these three end uses to decarbonize, due to the cost of converting existing homes, small or negative bill savings in some cases, market unfamiliarity with the water heaters themselves, and the low visibility of the technology.

To reach the most cost-effective installations first, the Advanced Water Heating Initiative[2] (AWHI) has identified the following order of priority for transforming the water heater market:

Pathway 1:

Install heat pump water heaters (HPWHs) in all newly-constructed single-family and multifamily homes

Pathway 2:

Replace existing electric resistance water heaters with HPWH (240V)

Pathway 3:

Replace existing gas and propane water heaters with HPWH (240V or 120V)

Pathway 1 represents an opportunity to install 120,000 water heaters in California per year, and Pathway 2 another 60,000 (See Appendix C: Breakdown of Market Size for Unitary Water Heaters). Taken together, these two pathways represent a market more than twice as large as the number of HPWHs currently sold nationally. Pathway 3 represents another 600,000 water heaters per year, but will take longer to reach; developing strategies to identify the most likely and receptive customers will be key and is a primary goal of this report.

A rapid increase in HPWH sales in California on this scale would itself act as a significant catalyst for product manufacturing, distribution, and installation innovation by US manufacturers.

[1] *Executive Order B-55-18*. State of California. 2018. https://www.ca.gov/archive/gov39/wp-content/uploads/2018/09/9.10.18-Executive-Order.pdf

[2] *Bringing Heat Pump Water Heaters into the Mainstream.* New Buildings Institute. 2021. https://newbuildings.org/resource/bringing-heat-pump-water-heaters-into-the-mainstream/

1.1 Summary of Recommendations

This report presents recommended actions that utilities and other market actors can take to create a unified movement toward HPWH market transformation. Most of the recommendations, at this stage, are for utility and community choice aggregation program (CCA) incentive program design. The recommendations are for high-level program features, and do not yet cover specific features such as marketing initiatives, incentive levels, or product eligibility.

The most effective way to transform the HPWH market will be to eventually require their usage under state and local building codes, for both new construction and existing construction. This report does not include specific recommendations for code changes, but because code changes are usually based on proven energy and cost performance, this report does include multiple recommendations for ways to measure and document those quantitative outcomes. Note that Air Districts also have the ability to implement product regulations in favor of heat pump water heaters.

This report covers "unitary" heaters, which we define as any water heater used for residential buildings with four or fewer units.

1.1.1 INCENTIVE PROGRAM RECOMMENDATIONS

The following sections on program design provide a playbook for how to set up and continuously improve a HPWH program. The recommendations in this section are intended to be immediately actionable. We summarize the following program criteria at the executive summary level, and request that utilities, CCAs, and other providers adopt the following criteria to guide their program designs:

1.1.1.1 Program Design Best Practices (see Section 3.1)

- Use the three AWHI pathways to prioritize incentive program rollout and funding:
    1. New construction
    2. Electric resistance WH replacements
    3. Gas and propane WH replacements
- Implement incentives to contractor or distributor (midstream), instead of direct to customer (downstream).
- Create and actively maintain a Trade Ally Network.
- Engage with the HPWH supply chain (distributors and contractors) to ensure their business needs are met.
- Begin to combine HPWH incentives with other programs such as EVs, batteries, PV, electrification, and weatherization.
- Require incentivized HPWHs to have a universal CTA-2045 socket.
- Consider developing an automatic load shifting program for HPWHs.
- Consider "kicker" incentives for water heaters with low-global warming potential (GWP) refrigerants.

1.1.1.2 Approach to the New Construction Market (see Section 3.2)

- Obtain active support from new construction decision-makers (see Section 3.2.1).
- Smooth the procurement process for distributors and builders (see Section 3.2.2).

1.1.1.3 Inbuilt, Iterative Research (see Section 3.3)

- Collect data on customer participation, costs, and energy outcomes with other utilities using common data formats.
- Adopt specific time cycles for conducting research that will inform the next iteration of program design.
- Consider using common marketing resources shared with other utilities.

1.1.1.4 Critical Issues (see Section 3.4)

- Ensure equity by engaging and ground-truthing with target groups and community organizations early in program design (see Section 3.4.1).
- Develop financing options suited to the next target customer group(s) (see Section 3.4.2).
- Seek strategic partnerships with outside organizations to further program goals (see Section 3.4.3).
- Conduct customer research to broaden program reach to new customer types (see Section 3.4.4).

1.1.1.5 Education, Training, and Tools (see Section 4)

- Integrate the education and training of customers and contractors into program design (via the trade ally network), and measure outcomes.
- Build awareness through a coordinated statewide marketing campaign customized for various audiences to provide inspiration, awareness, confidence, and education.
- Coordinate with other utilities and market actors to provide training and sales tools to distributors, contractors, and installers.
- Leverage ENERGY STAR resources for education and training.

1.1.2 TECHNOLOGY RECOMMENDATIONS

Overall the working group found that at this stage, the unitary HPWHs currently on the market already have the level of performance and range of features needed to support market transformation. The group identified minor desirable next step technology improvements, most notably:

1. Create low-cost “base” units with minimum features, suitable for low-income or rental markets, and maintain the full-featured heaters for the general residential market.
2. Utilities should support and incentivize the recently-developed 120V and low-amp units for conversion of gas and propane units.
3. Ensure that HPWHs can be operated downstream of split charging devices that are designed to split a single 240V circuit between two loads such as an EV and a dryer.
4. Investigate the performance and design of “clustered” or “semi-central” systems, i.e., single large water heaters that provide domestic hot water (DHW) for 2–8 apartments.

At present, the working group has made no recommendation regarding which refrigerant(s) should be used in water heaters, though this is an area of active regulation including by California’s Air Resources Board (ARB). This is, in part, because HPWHs are factory-sealed and typically do not leak during their operating life, and because the amount of refrigerant leaked at end of life doesn’t significantly reduce the GHG savings from the water heater. Therefore, refrigerant regulation should not slow down market transformation efforts.

1.2 Next Steps for 2021–2022

In 2020, the Unitary Heat Pump Water Heaters Working Group focused on developing the program design, program strategy, and program/technology advancement recommendations in this report, as a shared resource for utilities. The focus of 2021 will be on encouraging utilities and developers to use and commit to these strategies, on achieving alignment and partnership between utility programs, and on developing shared research resources.

Per the 2009 California Residential Appliance Saturation Study (RASS), more than 80% of California's water heating stock is unitary systems so this working group plays an important role in shaping a large share of the market. A full description of next steps is given in Section 6; a summary of next steps for the AWHI Unitary Heat Pump Water Heaters Working Group is given below:

Market Engagement:

- Together with utility program staff and executive staff, engage the top production home builders in CA and get them to commit to HPWH for all new construction.
- Engage with the top five HPWH manufacturers to ensure that they are providing supply chain support and training to their distributors, per the guidance in this report.
- Expand the AWHI Unitary Heat Pump Water Heaters Working Group to include other areas of the country seeking HPWH market transformation.
- Develop a comprehensive, quantitative, shared market adoption model

Regulatory and Incentive Programs:

- Socialize this report among California utilities, seeking their commitment to consistent statewide program structures and incentives and to scale up their HPWH programs. Develop a commitment letter that will allow utilities and other stakeholders to indicate their alignment with AWHI program criteria and their commitment to continued funding of HPWH incentives and market transformation.
- Work with the California T24 codes team to determine what data and other information they need to make HPWHs the minimum requirement in new construction residential applications. Seek commitment from utilities and others to obtain and share that data.

The AWHI Unitary Heat Pump Water Heaters Working Group intends to develop further tools and processes during 2021 and 2022, if sufficient funding is available. An indicative list of those activities is given in Section 6. A complete list, integrated across HPWH technologies and markets, will be developed during 2021.

1.3 Background on Advanced Water Heating Initiative

The Advanced Water Heating Initiative (AWHI) is a collaborative effort led by New Buildings Institute along with partners and over 50 organizations, working to overcome market and technology barriers to catalyze and transform the market toward higher adoption of high-efficiency, grid-connected Heat Pump Water Heaters and make them a mainstream choice.

Since 2013, the affordable housing community of California has made an annual request at the ACEEE Hot Water Forum for “retrofit ready” heat pump water heaters to support the electrification of affordable housing. In December 2018, an informal group that was a precursor to the AWHI held a two-day “Water Heater Summit” in San Francisco to make recommendations for technology specifications and features, program best practices, and policy changes. In January 2020, a similar informal group held a two-day “Water Heater Expo” at SMUD to share knowledge, strategize market transformation, and demonstrate the latest HPWH technologies, including an early 120V prototype from GE. Based on the success of these events, NBI formed the official AWHI working groups in the summer of 2020.

AWHI and its precursor activities have borne some results—in 2018 Rheem released a 2250W (240V with 15A breaker) heater that cut in half the power demand of previous products. In 2020, GE demonstrated a 120V water heater, and in 2021 several manufacturers are planning to introduce 120V units. During this period, HPWH incentive programs have increased in number and their goals have increased sharply.

Several other important activities have taken place in parallel with the above actions. For instance, NEEA has revised and implemented its Advanced Water Heating Specification (AWHS) and funded Ecotope to produce several important pieces of technical research; NRDC led the process of developing Title 24 Joint Appendix 13 to provide a credit for water heater load shifting; California’s PUC has done groundwork to prepare for a statewide HPWH incentive through its Self-Generation Incentive Program (SGIP); and the Building Decarbonization Coalition has developed the collaborative “Switch Is On” marketing campaign to support HPWH and other electrification efforts.

2 Market Context and Market Goals

2.1 Value Propositions

For market transformation to be successful, HPWHs have to create value for every actor in the procurement chain. Where the value proposition is strong, it should be identified, clearly communicated, and leveraged to create change. Where the value proposition has weaknesses, those need to be eliminated or reduced, with implementation of temporary mitigations such as incentives or agreements to allow the market actors to participate in the meantime.

Historically, across many technologies, moving incentives midstream or upstream instead of providing them directly to the consumer (downstream) has been most successful, since upstream incentives reduce transaction costs for everyone in the chain, and maximize use of a given amount of incentive money.

Figure 1 describes all the customer relationships in the unitary HPWH procurement chain. Blue arrows represent procurement; brown arrows represent incentive payments.

FIGURE 1: CUSTOMER RELATIONSHIPS FOR HPWH PROCUREMENT
Source: AWHI Unitary Heat Pump Water Heaters Working Group

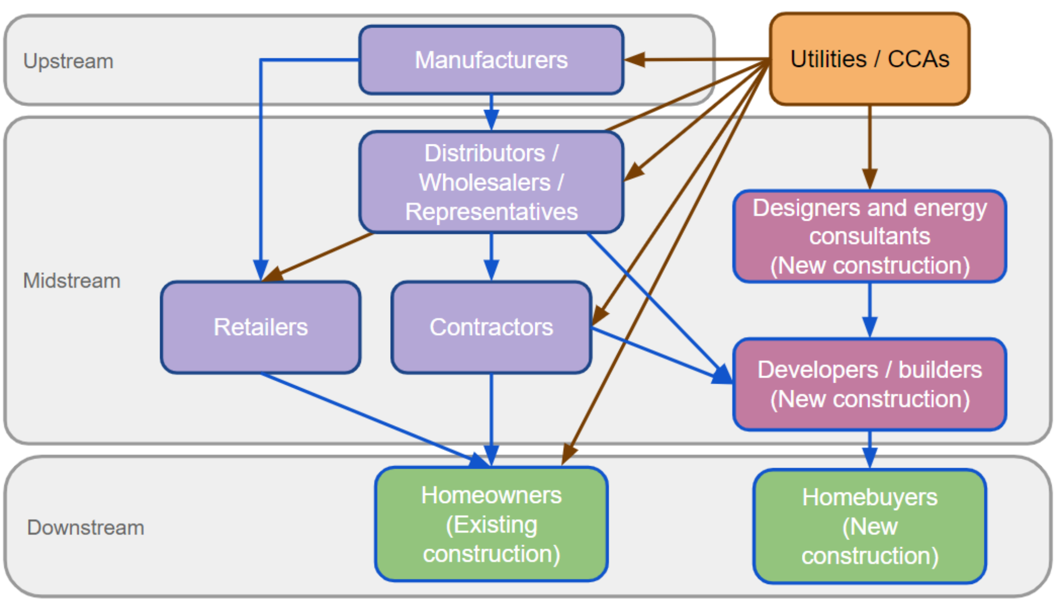


Table 1 shows the strengths and weaknesses of the value proposition to each customer in the chain. Where the value proposition is particularly strong the cell is colored green, where it's particularly weak the cell is colored red.

TABLE 1: SUMMARY OF VALUE PROPOSITIONS

Value propositions *Red or green color in cells represents a particularly strong or weak value proposition*		
	Strengths of HPWH value proposition	**Weaknesses and gaps of HPWH value proposition**
To state government (for incentive programs and code)	Carbon reduction, cleaner air especially in disadvantaged communities.	Weak sales to date. Lack of firm data on installation cost and bill savings for new and existing construction to base code changes on, esp. relative to gas tankless.
Local government (for permitting, reach codes)	Easy to verify installation-no CAZ test required. Health & Safety of occupants. Reduces dampness. Reduces bills, helps meet SB375 Sustainable Communities Strategy requirements.	Lack of firm data on installation costs for new and existing construction on which to base code changes.
To philanthropic orgs	Carbon reduction, bill reductions esp. to low-income customers.	Competing causes/technologies, HPWHs unfamiliar to consumers.
To utilities and community choice aggregation programs (CCAs)	Carbon reduction, efficiency targets, kWh sales, better load shapes and grid utilization.	Potential for peak load from resistance elements, esp. due to shutoffs and restarts due to PSPS during wildfires.
To manufacturer	Incentive from utility. New market opportunity, production efficiency.	Weak sales to date. Risk that the market will not develop. Low consumer awareness and understanding.
To distributor	Higher margin ($) per unit Incentive or favorable financial terms from utility.	More SKUs, more stock, more product support, additional working capital, additional training to contractors. Delay in payment depending on utility reporting requirements.
To retailer	Higher margin per unit. Incentive from utility.	More SKUs, more stock, more product support, additional working capital, limited shelf space, Training of staff and contractors.
To contractor	Meet needs of enviro customers, reduce customers' utility bills, upsell. Incentive from utility.	More callbacks, more complex installation, additional installation time, warranty risk. These may be perceptions more than reality. Delay in payment depending on util reporting requirements. Additional permit requirements e.g., panel calcs. Need for multiple trade licenses. Reduce truck rolls. Contractor may push back on new construction design decisions.

TABLE 1: SUMMARY OF VALUE PROPOSITIONS *(CONTINUED)*

NEW CONSTRUCTION		
To developer / builder including general contractors building custom homes	Easier, cheaper installation than gas. Increase in home sales. Avoided gas infrastructure cost and gas utility/connection delays. Simpler build without flue. Higher point values with raters and RESNET.	Unsure about home buyers' reactions. HPWHs unfamiliar to installers, warranty risk. Loss of square footage in home, fewer viable locations for WH. AHJ inspector lack of knowledge.
To low-income multifamily developers	More appealing green home, potentially lower tenant utility bills. Avoided gas infrastructure cost and gas utility/connection delays. Simpler build without flue.	Concern about whether tenant utility bills will really be lower. Perceived technology risk. HPWHs (resistance elements) displace panel space from EVs (15 Amp and 120V models leave Amps for EVs)
To home designers	Cleaner roof space without flue allows more space for photovoltaics. No gas piping in home design.	
To homebuyer	Lower home price, potentially lower utility bills than gas WH, green home, contributing to a greater good.	Potentially higher utility bills than gas tankless WH, perceived technology risk, unknown technology.
RETROFITS		
To home owner-occupier	Incentive from utility, potentially lower utility bills, green home, potentially perceived as safer than gas.	Potentially higher utility bills, perceived technology risk.
To landlord	More appealing green home for tenants, potentially lower utility bills for tenants (esp. low-income), potentially perceived as safer than gas. Incentive from utility.	Potentially higher utility bills, perceived technology risk.
To renters (bill payers)	Potentially lower utility bills, green home, perceived as safer.	Potentially higher utility bills.
To low-income multifamily developers	Can free up roof space for solar, potentially lower bills for tenants allows rent increase. Utility incentive.	HPWH displaces panel space from EVs. Potentially higher bills, perceived technology risk.

2.2 Recommended Statewide Water Heater Market Goals

Although the AWHI doesn't seek to set goals for HPWH adoption, this section is intended to help utilities, jurisdictions, and regulators set their own organizational goals by giving approximate figures for the number of HPWHs to be incentivized or installed to keep up with overall statewide needs. This assumes that the market should be completely transformed by 2030–2040. California does not yet have specific statewide electrification goals, or specific water heater goals.

The actual rate of market transformation could be higher if additional state, local, or air district regulations are passed to restrict or prohibit gas appliances; in those cases, utilities may still want to provide incentives, education, and assistance.

2.2.1 SALES GOALS

The California statewide market for unitary water heaters (including both new construction and retrofits) is around 800,000 units per year (See Appendix C: Breakdown of Market Size for Unitary Water Heaters). To capture approximately 10% of this market—an initial goal on the way to 100% adoption—the number of HPWHs sold statewide and in each utility territory would have to be approximately as shown below in Table 2: Market Penetration Goals for HPWHs

(Units sold per year). By meeting this goal of installing about 80,000 HPWHs per year statewide, the California market would be approximately the same size as the current national market for HPWHs.

TABLE 2: MARKET PENETRATION GOALS FOR HPWHS (UNITS SOLD PER YEAR)[3]

		CA total	PG&E	SCE	SDG&E	LADWP	SMUD
New construction							
Single-Family	Electric	30,000	11,500	10,800	3,200	1,900	1,500
Multifamily	Electric	9,000	3,800	3,500	1,100	300	400
Existing construction							
Single-Family	Gas/ propane	20,900	7,800	7,700	2,300	1,300	1,000
	Electric	14,700	8,300	3,300	1,200	700	1,600
Multifamily	Gas/ propane	2,100	900	800	200	100	100
	Electric	4,600	1,700	1,800	700	200	200
Total unitary HPWH per year		81,300	34,000	27,900	8,700	4,500	4,800

Table 2: Market Penetration Goals for HPWHs

(Units sold per year) assumes market penetration percentages by building type and existing fuel type as summarized in Table 3: short-term Market Penetration Goals for HPWHs (Percentage of sales by building/fuel type). These are intended to be feasible short-term (3–5 year) goals for incentive programs. Appendix C: Breakdown of Market Size for Unitary Water Heaters provides further details. Note that these numbers assume that half of water heaters in existing multifamily buildings are central systems, and half are unitary.

[3] The "CA total" is greater than the sum of the utilities because not all California customers fall within these five territories. Some rows do not add directly, due to rounding of the totals.

TABLE 3: SHORT-TERM MARKET PENETRATION GOALS FOR HPWHS (PERCENTAGE OF SALES BY BUILDING/FUEL TYPE)

Building Type	Sector	Fuel Type	Short-term market penetration goal (i.e., market share)
New construction	Single-Family	N/A	50%
	Multifamily	N/A	50%
Existing construction	Single-Family	Gas/propane	4%
		Electric	40%
	Multifamily	Gas/propane	2%
		Electric	20%

Table 2 shows that AWHI expects the number of gas water heaters being replaced to be as high or higher than the number of electric resistance water heaters being replaced in existing construction. This seems at odds with AWHI's approach of seeing the electric replacement market as the first priority.

The high number of gas replacements in Table 2 is due to four reasons:

- Demographics: the current small scale of incentive programs means that a high percentage of participants are "innovators" and "early adopters" who are motivated to install the most environmentally friendly water heater, despite the high cost of converting from gas to electric.
- Experience from SMUD's program shows that more than half of program participants have been gas conversions. This could, however, be due to the higher incentive SMUD has provided to gas customers ($3,000 vs. $1,000).
- Anecdotal evidence, also from SMUD, that same-day installation of gas-replacement HPWHs is usually possible. This is true even if additional wiring is required, but not if the panel needs to be replaced.
- The simple fact that electric resistance water heaters are installed in only 7% of California households, according to the 2009 California Residential Appliance Saturation Study (RASS). Therefore, getting to 10% market adoption requires that most projects be gas replacement.

Similarly, the goals show as many HPWHs going into existing buildings as into new construction, which seems at odds with AWHI's goal to prioritize new construction. This is simply because so many more water heaters go into existing homes, that even a low level of market penetration results in a large number of units being sold.

The goals above assume that 40% of single-family customers with existing electric water heaters will install HPWHs; 40% is a high adoption rate that requires programs to reach types of customers that do not yet participate in programs (see Section 3.4.4).

The sales goals assume that program participation will remain predominately composed of planned replacements (not replace-on-burnout) in the immediate future, which is the current case.

2.2.2 MARKET PROGRESS INDICATORS

In California, the most common practice for incentive programs is to use quantitative outcome goals to track program progress. These usually include the number of units incentivized, along with ex-post measures such as net-to-gross ratio. A complementary approach is to use quantitative and qualitative “market progress indicators" such as those used by NEEA. Some of NEEA’s MPIs for HPWHs have been reproduced in Table 4, with minor adaptations.

TABLE 4: MARKET PROGRESS INDICATORS

Outcome	Market Progress Indicator (How measured or determined)	Metrics	Data Source
1. Installers increasingly recommend/ sell/install HPWHs.	a. Trained installers report higher confidence in and awareness of HPWHs.		Installer survey
	b. Trained installers' year-over-year installations of [HPWHs] increase.	Number of trained installers	Installer data
	c. Share of professional installers that have installed [HPWHs] increases each year.	Number of installers that have installed [HPWHs]	Installer survey
	d. Installers’ recommendation of HPWHs in emergency scenarios (and also pending failure) increases year-over-year.		
	e. Share of sales for emergency replacement increases each year.	Emergency replacement sales	Installer survey
	f. Increase in referral traffic from [program website] to installer websites.		
2. Retailers increasingly stock/sell HPWHs.	Year-over-year sales of [HPWHs] increase through the retail channel.	Retail sales of [HPWHs]	TBD
3. Distributors increasingly stock/sell HPWHs.	a. Year-over-year sales of HPWHs increase.	Distributor stock	Distributor SMIT Data
	b. Share of sales for emergency replacement increases each year.	Emergency replacement sales	Distributor SMIT Data
	c. Year-over-year turns of HPWHs increases.	Distributor stock	Distributor SMIT Data
4. Purchasers continue to be satisfied with HPWHs.	a. At least 90% of purchasers are satisfied with qualified products.	Purchaser satisfaction rate	Participant/ purchaser survey
	b. Percent of purchasers who would recommend HPWHs does not decline year-over-year.	Purchaser likelihood to recommend	Participant/ purchaser survey

Although the AWHI doesn’t seek to set utility goals for market transformation, if utilities and CCAs used MPIs such as those shown above, it would help to ensure the “deep engagement of supply chain actors” and “active trade ally networks” recommended in Section 3.1 on “Best Practices” in this report. Equity goals are becoming increasingly common; as they develop, they could be used by incentive program managers in addition to the list of market progress indicators in the table above.

3 Utility and CCA Program Recommendations

To implement heat pump water heater programs intended to quickly transform the residential unitary water heater market to HPWHs by 2030–2040, we recommend the following steps:

1. **For utilities that don't already have a HPWH program:**
   Implement a midstream program as quickly as possible, based on the best practices model in Section 3.1.

2. **Once a program is running (or for utilities that already have a program):**
   Start at the "Discover" phase of the research loop shown in Figure 2, to plan the next program iteration. Use in-house staff and consultants as needed.

   » Focus first on the new construction market; reach out to new construction developers using the techniques described in Section 3.2.

   » During program development, give specific consideration to the issues listed in Section 3.4.

3. **Use the research loop shown in Section 3.3 to generate research-based analysis that will inform iterations of the HPWH program.**
   Research efforts should be timed to coincide with the utility's planning and budgeting cycles, so that analysis is available to inform program investment and staffing decisions at the right time.

We recommend starting at the "discover" phase to avoid carrying over assumptions from previous program designs into the HPWH program. Previous assumptions are likely to be unhelpful and misleading in many cases because HPWHs are unfamiliar and they change the customer's experience in many ways, both in terms of the purchase experience and their experience of using the product. For instance, they:

- May be more expensive, disruptive, and time-consuming to install than customers would expect from a water heater replacement
- May require a panel changeout, additional wiring, and more than one trade to be on site
- May be perceived as having lower performance or higher costs than gas water heaters
- Have different performance specifications—most customers don't know what Uniform Energy Factor or decibel levels are, or how to make sense of them
- Require supporting devices such as a thermostatic mixing valve or a communications module
- May require more space to operate in, or adaptations for venting
- Have unfamiliar features such as cold air exhaust, condensation management, different operating modes, and noise during operation
- May produce insufficient hot water unless the temperature and/or mode are adjusted
- Require different maintenance, such as filter cleaning and anode rod changes

3.1 Current Best Practices from Successful Single-Family HPWH Retrofit Programs

Several highly successful heat pump water heater programs are already deployed in the US. The working group has identified the common characteristics of these programs and synthesized them into a template logic model that can be used by utilities to quickly develop a new HPWH program or to add elements to their existing program. The successful programs have increased the market share of HPWHs anywhere from 10% to 30% in the Northwest, Vermont, and Maine, though there are also useful lessons from programs already deployed in California that are gaining ground.

Rebates and incentives vary from mail-in rebates to consumer-direct retail incentives, where the unit is fully discounted at the retail register at the time of purchase. Appendix D: Snapshots of Successful Customer Program Webpages provides snapshots of several successful customer program webpages.

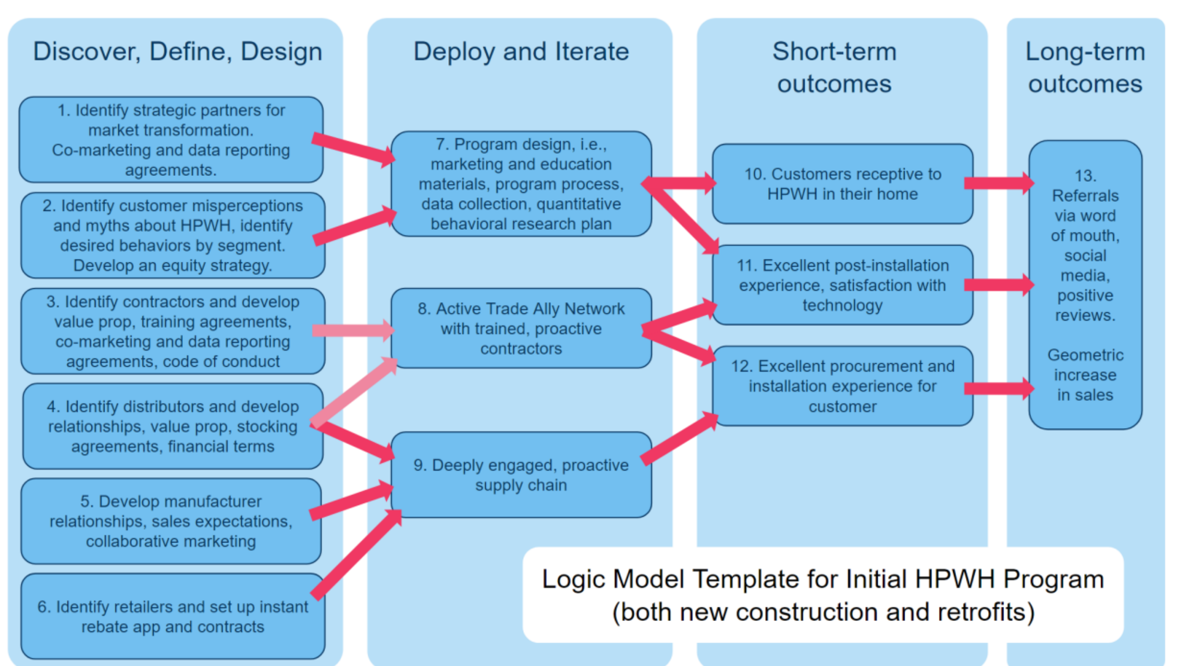
The logic model for current best practice HPWH programs, shown in Figure 2, is synthesized from the successful programs referenced in Appendix D. The columns have been adapted from a conventional logic model nomenclature to align with the quantitative research phases described in Section 3.

- "Inputs" is not shown in the figure
- "Activities" is renamed to "Discover, Define, Design"
- "Outputs" is renamed to "Deploy and Iterate"
- "Outcomes" are shown in the conventional way

This program framework of 13 elements in four stages defines a straightforward approach to successful program design and deployment:

FIGURE 2: LOGIC MODEL TEMPLATE

Source: AWHI Unitary Heat Pump Water Heaters Working Group



The NRDC[4] details three successful program designs used by Efficiency Vermont, Association for Energy Affordability in California, and Efficiency Maine. To summarize, the most apparent features of currently-successful programs are:

- A midstream/upstream design with incentives that bring costs into parity or better
- Education and priming of customers through mass market and targeted outreach
- Deep engagement of supply chain actors through detailed business cases
- Active trade ally networks that provide a range of benefits to contractors and distributors (see also Section 4.1)
- Strong business referrals by word of mouth
- Most installations are planned (early) replacements, but emergency replacements (replace on burnout) can usually be installed within one day if a panel upgrade is not required

Table 5 summarizes the expectations and priorities we suggest for program setup.

TABLE 5: PROGRAM FRAMEWORK SUMMARY

HPWH Program Framework Summary for Unitary Water Heater Programs	
Scale	Program coordinated with other utilities statewide or nationally Use common data collection when possible Program volume calculated to reach eventual 100% market adoption of HPWHs
Duration	Commit to 10 years+
Incentive type	Upstream and Midstream 1. Incentives direct to distributors/installers, and/or manufacturers 2. Utility may require the entire incentive to be passed through to customers 3. For customers who use the retail channel, provide instant rebate at point of sale 4. See Appendix D for examples
Incentive amount	~$500 to ~$1,000 per unit initially $ additional for installation as required
Priorities	New Construction Pathway 1: New Construction
	Retrofit Programs (Including both planned replacement and replace-on-burnout) Pathway 2: Electric Resistance to HPWH (240V HPWHs) Pathway 3: Gas/Propane to HPWH 3.1: Gas to 240V HPWH 3.2: Gas to 120V HPWH

3.1.1 BEST PRACTICES FOR CONNECTIVITY AND CONTROL

The AWHI Connectivity Group met over a nine-month period in 2020—2021 and developed controls recommendations for the three main working groups (AWHI 120V, 240V, and central water heating). This group was made up of water heater manufacturers large and small, CEC, CPUC, utilities, energy advocates, labs, test facilities, aggregators, standards experts, and other market actors.

[4] *How to Design Building Electrification Programs that Work.* NRDC. 2020. https://www.nrdc.org/experts/alejandra-mejia/how-design-building-electrification-programs-work.

Consensus came around the following key elements:

1. Required connectivity pathway—CTA physical port at a minimum, and the ability to input TOU schedule as specified in CA Title 24 Part 6 Joint Appendix 13
2. TOU schedules and time variable rates are included in initial setup and commissioning
3. Minimum demand response command set of CTA-2045-B
4. Utilities should develop time-variable rates and device communication protocols aligned with the long-term solutions under development by the California Energy Commission

Connectivity Policy Landscape

State and local jurisdictions are developing infrastructure, credits, and requirements for water heater demand management controls, summarized in Table 6:

TABLE 6: CONNECTIVITY POLICIES AND PROGRAMS LANDSCAPE

Jurisdiction	Regulation	Date of Implementation	Details
Washington	SB 5115, HB 1444	January 1, 2021	Electric storage water heaters manufactured on or after January 1, 2021, are required to have a modular demand response communications port compliant with the March 2018 version of the CTA-2045-A communication interface standard, or equivalent. (Heat pump Jan. 2021, electric resistance Jan. 2022). This will be upgraded to CTA-2045-B.
Oregon	EO 2020-04	January 1, 2022	All new electric water heaters must have a modular demand response communications port compliant with the March 2018 version of the CTA-2045-A communication interface standard, or equivalent. (Heat pump Jan. 2021, electric resistance Jan. 2022). This will be upgraded to CTA-2045-B.
California	Title 24 Joint Appendix 13 (JA13)[5]	July 8, 2020	Requires NEEA AWHS v7 and Tier 3 or above, which requires a CTA-2045 port (New Construction). Provides compliance credit for controllable water heaters.
	MIDAS price portal[6]	TBD	Will publish flexible time-ahead pricing for controlled devices.
	Flexible Demand Appliance Standards		Being developed by the California Energy Commission in response to SB49.[7]
National	ENERGY STAR® Version 4.0	TBD 2021	Final draft released Feb. 2021, requires CTA-2045 or OpenADR.
	AHRI 1430	In progress	Proposing CTA-2045 B with optional OEM path customer via Wi-Fi, Bluetooth, or others.
NEEA	Version 7	July 1, 2020	Requires Tier 3 V7 and Tier 4 (CTA-2045) and higher HPWHs have CTA-2045.
AWHI	Current recommendation	December 1, 2020	Requires CTA-2045 for unitary with an optional vendor path and TOU loading for CA market.

[5] Resolution 20-0708-05. State of California Energy Resources Conservation and Development Commission. 2020. https://www.energy.ca.gov/filebrowser/download/2261
[6] Load Management Rulemaking Docket Log 19-OIR-01. California Energy Commission. 2020. https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=19-OIR-01
[7] Flexible Demand Appliance Standards Docket Log 20-FDAS-01. California Energy Commission. 2021. https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=20-FDAS-01

Connectivity Program Recommendations

Programs should be planned with the knowledge that load shifting controls will likely be required by regulations soon or in the future. We recommend the following program requirements for connectivity and control:

1. **All programs should require water heaters to be CTA-2045-compatible.** This will facilitate future load-shifting programs. CTA-2045 is the only available common standard for a physical control module port and instruction set, and can be coupled with an OpenADR 2.0b Virtual End Node (VEN) or a proprietary system to turn water heaters into grid assets for load control. CTA-2045 modules are easily replaceable by consumers, and are future compatible, so customers will be able to install or replace a CTA-2045 at any time in the future. All of the domestic heat pump water heater manufacturers are supportive of this standard. The AHRI 1430 Standard is coming out with industry support of the CTA-2045.
2. **For utilities intending to run a load shifting program:**
    a. Require a thermostatic mixing valve, preferably a built-in valve. This significantly increases the energy storage and load shifting capability of the water heater. For example, a standard 50 gallon water heater with a set point of 135 degrees F with a mixing valve will perform like a 65 gallon water with set point of 120 degrees F. Additionally, it will enable more integration of renewables and be able to withstand longer "shed" or "shift" commands.
    b. Consider requiring a CTA-2045 module to be installed with the water heater when new or during replacement either by the installer or the homeowner. This is easier than returning later to install it or requiring the customer to purchase and install the module. At present, CTA-2045 communications modules cost around $75/module, but as volume increases the price is expected to decrease, possibly to around $25/module.[8]

At present, two HPWH load shifting programs are operating in California: PG&E's WatterSaver program and SMUD's PowerMinder program.[9] Both programs require the customer to have a thermostatic mixing valve installed, to increase the heat storage capability of the water heater. In the future, HPWHs with integrated mixing valves are expected to be available. Both programs connect the water heater to a third-party network service that individually optimizes the charging schedule to minimize bills under time-of-day rates, and shift energy use to lower-GHG times of day, while maintaining sufficient hot water.

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[8] Eustis, Conrad. *CTA-2045 Enables Low-Cost Grid-Interactive Water Heaters.* ACEEE Hot Water Forum Session 7C. 2016. https://www.aceee.org/sites/default/files/files/pdf/conferences/hwf/2016/Eustis_Session7C_HWF16_2.23.16.pdf

[9] *SMUD's PowerMinder Pilot.* Sacramento Municipal Utility District. 2020. https://www.smud.org/-/media/Documents/Rebates-and-Savings-Tips/PowerMinder-Agreement.ashx

3.2 Recommended Approach to New Construction Programs in Single-Family and Multifamily Sectors

New construction programs need the active support of industry decision-makers to be successful. This includes large developers and the California Building Industry Association (CBIA), home designers, MEP consultants, and energy modelers. These decision-makers can actively promote HPWHs within a development project.

Additional market actors in residential development that are typically not decision-makers could steer a project away from HPWHs toward conventional water heaters; these include distributors and subcontractors.

We recommend that utilities actively engage decision-makers and other market actors in a listening/ stakeholder process, as described below for each group. These processes may result in the utility developing specific materials to support those market actors, or may result in training or certification requirements within programs. Whatever the outcome, active engagement of developers, builders, and contractors will make them more familiar with the benefits and characteristics of HPWH technology, installation, and with the program.

We also recommend that utilities should jointly fund a free advice service for single-family and multifamily development teams, which would allow designers and consultants to get fast, authoritative answers about building design, wiring needs, costs, loads, energy use, bills, etc., along with examples and case studies. Such a service may help to overcome the reluctance and lack of information that can prevent projects from using new technologies.

ENERGY STAR is not specifically shown as part of these processes, but is a potentially powerful ally in moving decision-makers to the “desired state” and has educational resources and contractor databases already developed for use. ENERGY STAR may be especially relevant to decision-makers who build in multiple state markets across the country.

3.2.1 OBTAINING ACTIVE SUPPORT FROM INDUSTRY DECISION-MAKERS

Table 7 shows the primary decision-makers, along with the “adverse state” and “desired state,” i.e., the shift in understanding and perception required for those market actors to become active promoters of HPWHs. Figure 3 shows a recommended engagement process that utilities and CCAs can conduct, with decision-makers as active participants, to move each actor from the adverse state to the desired state, and to identify program resources that will support their decision-making.

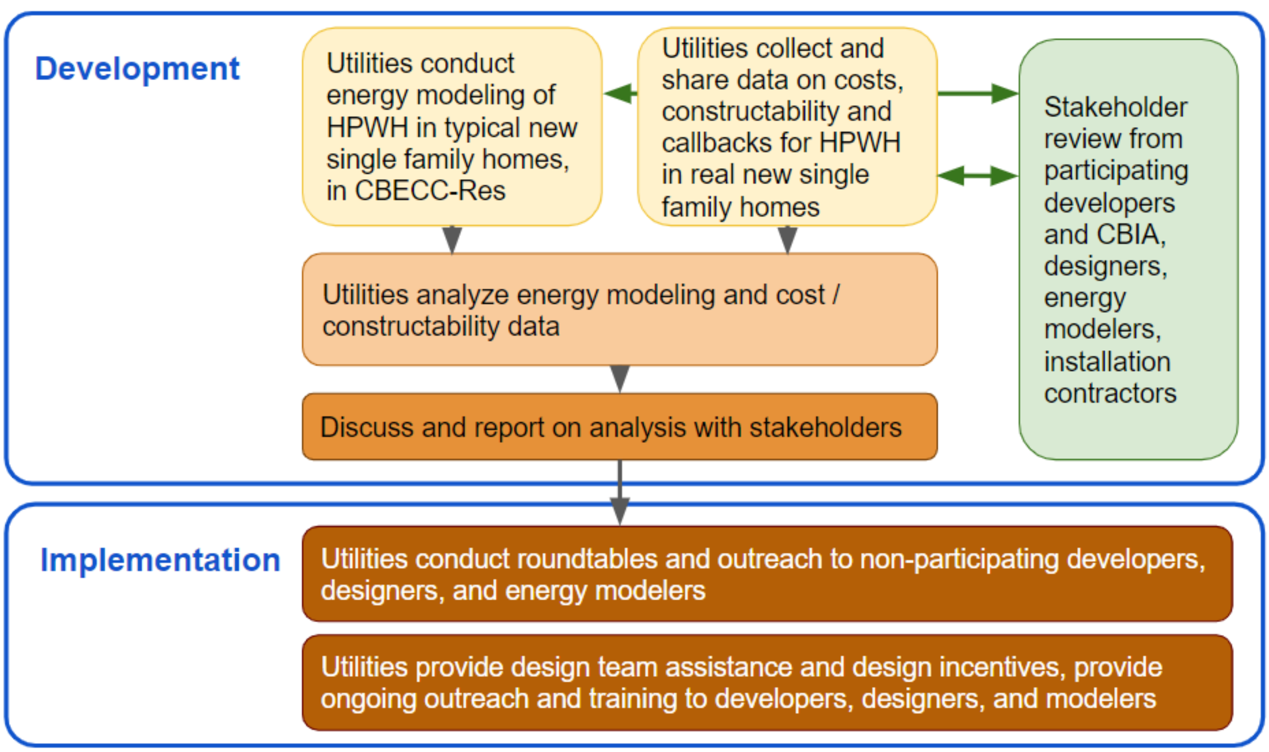
TABLE 7: NEW CONSTRUCTION DECISION-MAKERS; ADVERSE AND DESIRED STATES

Decision-maker(s)	Adverse state	Desired state
Developers	Perceive HPWHs as expensive and a source of risk for construction schedule and home warranty	Perceive HPWHs as a cost reducer with low risk. Perceive that HPWHs do not make buyers less likely to purchase the home.
California Building Industry Association (CBIA)	(See developers above): perceive HPWHs as expensive and risky	See HPWHs as a low-cost way to avoid future mandates. Do not see HPWHs as an undesirable imposition on builders.
Building designers	Perceive that HPWHs incur additional design time that will not be reimbursed until completion, and/or will be pushed back by distributors or contractors	Are familiar with HPWH design implications, have resources to resist pushback on design, and/or contractors and suppliers are supportive of HPWHs.
Energy modelers, MEP and energy consultants	Discourage HPWHs as a design element	Actively encourage HPWHs as a low-cost way to improve energy performance. Are familiar with features and sizing requirements.

Note that Table 7 and Figure 3 don't include the homebuyers themselves. This is based on the observation from several members of the AWHI working group that developers don't view homebuyers as a barrier to HPWHs, because homebuyers have no preference about what type of water heater they have.

FIGURE 3: NEW CONSTRUCTION DECISION-MAKER TRANSFORMATION

Source: AWHI Unitary Heat Pump Water Heaters Working Group



The discussions described above should include:

- "Incentive program layering," i.e., moving incentives upstream to the extent possible, as another tool to move developers and builders from an adverse state to a desired state; layering makes incentive payments available earlier in the procurement process. The CPUC's Self-Generation Incentive Program (SGIP) may facilitate this; see the "incentive layering" link at https://www.cpuc.ca.gov/BuildingDecarb/.
- Reductions in "amps per door" especially from lower power (120V or 15A) water heaters, with the resultant savings in terms of utility connection fees, transformer costs, and panel/wiring sizing.

Some of the elements described above have already been implemented in the Electrification Technical Assistance Program[10] run by Peninsula Clean Energy and Silicon Valley Clean Energy, SMUD's All-Electric Smart Homes program,[11] and a small number of similar programs. In many cases, the decision to include HPWHs in new homes will be made as part of a larger decision about whether to electrify the whole home,[12] in which case the process described above should include other electrification technologies as well as water heaters.

3.2.2 SMOOTHING THE PROCUREMENT PROCESS FOR DISTRIBUTORS AND BUILDERS

As described above, new construction programs need the active support of industry decision-makers to get HPWHs into new homes. However, they also need other supply chain actors to promote HPWHs in lieu of conventional water heaters. These other actors include distributors and subcontractors.

Table 8 shows the "adverse state" and "desired state" for each actor, i.e., the shift in understanding and perception required for those actors to become active promoters or at least not detractors from HPWHs.

TABLE 8: NEW CONSTRUCTION SUPPLY CHAIN ACTORS; ADVERSE AND DESIRED STATES

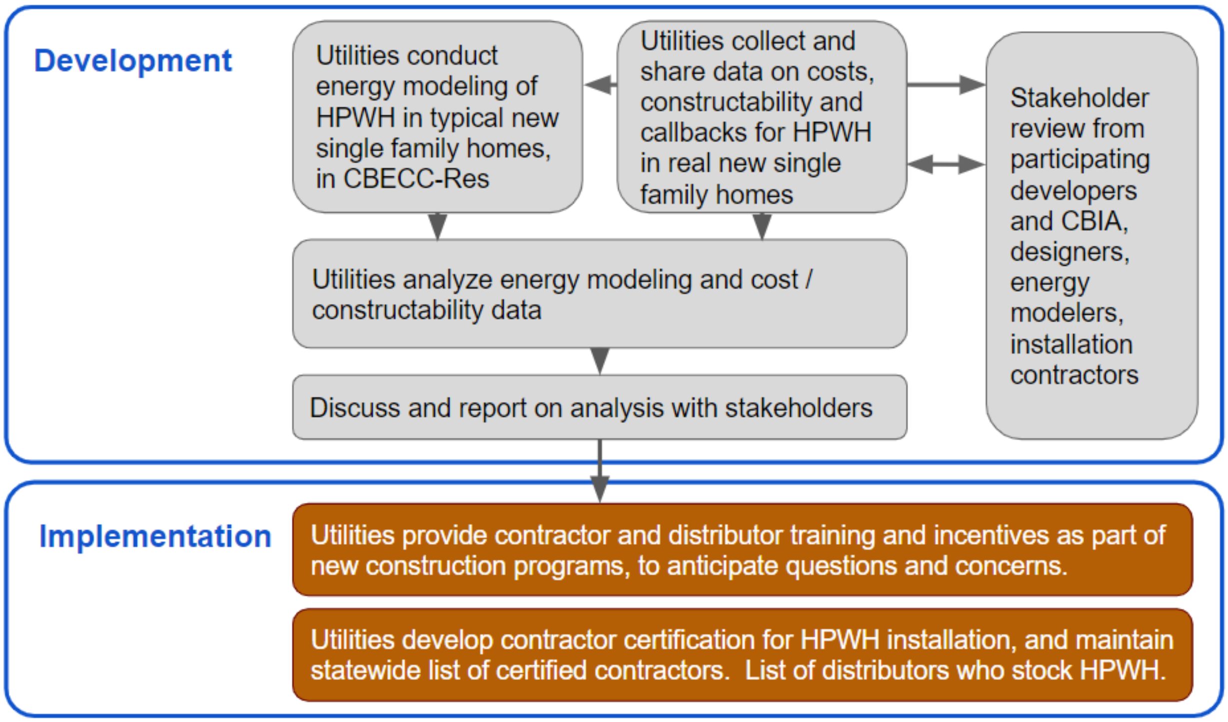
Supply chain actor	Adverse State	Desired State
Distributors	Perceive HPWHs as more SKUs, more stock, more training and support, additional working capital.	Perceive HPWHs as higher margin product with low overhead.
Contractors	Perceive HPWHs as a warranty risk, and could create construction delays. Potential trade licensing problems for subcontractors ("license balkanization"). Potential supply chain delays.	Perceive their own competence with HPWHs as a business advantage. Perceive HPWHs as a profit-maker with low risk of overruns on cost or schedule, or callbacks.

[10] *Electrification Technical Assistance Program.* 2021. https://allelectricdesign.org/
[11] *All-Electric Smart Homes.* Sacramento Municipal Utility District. 2021. https://www.smud.org/en/Going-Green/Smart-Homes
[12] Billimoria, Sherri et. al. *The Economics of Electrifying Buildings.* RMI. 2018. https://rmi.org/insight/the-economics-of-electrifying-buildings/

Figure 4 shows a recommended engagement process that utilities and CCAs can conduct, with decision-makers as active participants, to move each actor from the adverse state to the desired state, and to identify program resources that will support their decision-making. Note that the figure shows the same "development" process as the similar figure in the section above, so that is grayed out in this figure.

FIGURE 4: NEW CONSTRUCTION SUPPLY CHAIN ACTOR TRANSFORMATION

Source: AWHI Unitary Heat Pump Water Heaters Working Group



3.3 Using Research to Inform Program Iteration Decisions

For HPWH programs to reach the scale required by state GHG reduction goals, programs must learn how to quickly reach new types of customers that typically don't participate in incentive programs. Learning at this scale and pace requires a more prominent role for research in program development than it typically has had to date. This may require new research methods and new business processes, to integrate research more tightly into program development.

The working group took input from See Change Institute, a consulting company with expertise in quantitative behavioral research and program development, to develop future research methods for HPWH programs.

Research has always been used to guide incentive program design, but has typically been conducted either before, after, or in parallel with programs, not as part of the program itself. To reach the scale required to transform the water heater market, and to reach multiple new types of customer rapidly, programs will need to develop and course-correct more quickly and intentionally than they currently do.

Different types of research on energy outcomes, costs, and customer behaviors are typically conducted at each stage during the development of an incentive program. We recommend moving through the following program development stages, based on See Change's input and current best practices:

Discover

Explore the landscape and connect stakeholders. This could include:

- Define why are you intending to create a program, and what organizational or societal goals and strategies it will support.
- Identify "natural allies" and other stakeholders in the market transformation.
- Find out what other utilities and researchers have already done.
- Review Section 3.4, "Key Issues to Review During Program Development and Iteration."

Define

Determine the audience and the program's behavior goals. This could include:

- Define the demographic and behavioral characteristics, purchasing behaviors, and beliefs of the people the program is trying to reach. Segment into main groups. This may involve segmentation data, listening exercises, focus groups, surveys, ethnographic data.
- Establish baseline energy use patterns and likely savings/shifts, meter data, and modeling.
- Review available technologies and costs, characterize the supply chain.
- Describe typical baseline procurement/purchasing behaviors, and market channels.

Design

Develop and test content and delivery strategies. This could include:

- Business model or product development processes, for instance SWOT or product canvas.
- Agile process, or design thinking to develop program offerings. Conjoint analysis to test offerings. Hypothesis generation for resources and messaging.
- Pretotyping and hypothesis testing, e.g., A/B testing of program resources and messaging.
- Journey mapping of how customers will move through program stages and processes.

Deploy

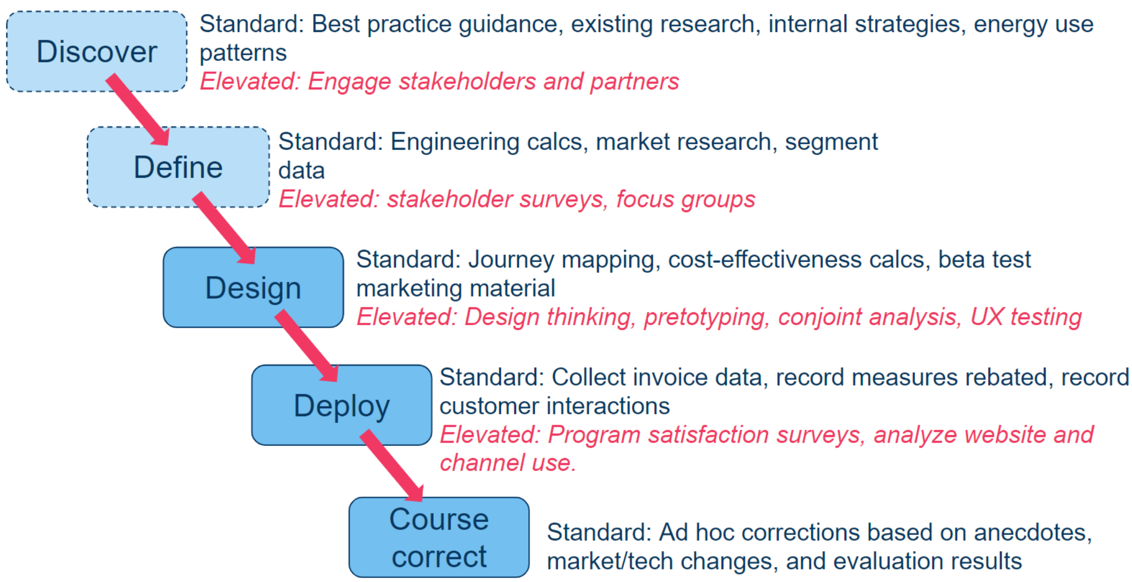
Launch and evaluate for ongoing learning. This could include:

- Describe what happened, for instance call volume, what questions were asked, what marketing or outreach was sent to each customer, web page clicks, contractors or customers attending online or in-person training.
- Investigate people's impressions of what happened, for instance satisfaction with specific program elements, customer affect, reasons for making choices, likelihood to recommend.
- Measure the outcomes, e.g., number and type of HPWHs installed in which type of homes. Which customers chose each of the available program options. Costs and savings for each party involved. Energy impacts. Quality of record-keeping.

Figure 5 shows a typical linear process, in which research is mostly conducted ad-hoc at the direction of program designers and managers, to inform the decisions needed at each stage. The first stages (“Discover” and “Define”) are shown grayed out because utilities sometimes move straight to the “Define” or “Design” stage because of constraints on time or expertise.

FIGURE 5: TYPICAL METHODS FOR RESEARCH, TESTING, AND DATA COLLECTION DURING PROGRAM LIFE CYCLE STAGES

Source: AWHI Unitary Heat Pump Water Heaters Working Group

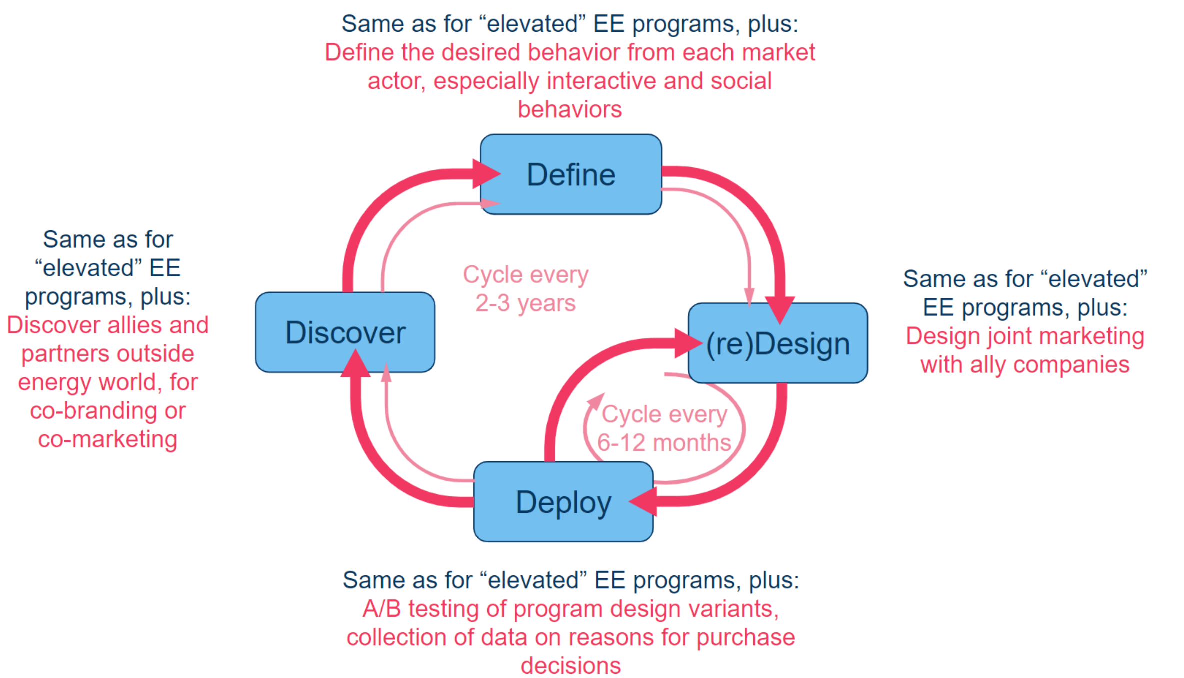


Note that Figure 5 is only a description of the research, testing, and data collection activities within the program, not a complete description of all program activities. In addition, the figure does not include research conducted prior to program development, such as emerging technology research.

Figure 6 shows how the linear, ad hoc research process described above can be turned into an intentional, scheduled process in which research is built into the program itself. Research often yields better answers when the research process is repeated, since the research design can be improved with each iteration.

FIGURE 6: PROPOSED METHODS FOR RAPID MARKET TRANSFORMATION

Source: AWHI Unitary Heat Pump Water Heaters Working Group



The following steps can turn the research process from a separate activity to an inbuilt part of a program:

Turn assumptions into hypotheses

» All programs are based on assumptions about customer behavior, costs, installation practices, and device performance. Most of these hypotheses are never tested during the life of the program. Identify each assumption and turn it into an explicit hypothesis that can be tested.

Collect data and conduct experiments within the program

» Determine what data are required to test the program’s hypotheses.

» Determine how to collect these data.

» Design experiments where possible, to test hypotheses in a controlled environment. For instance, A/B testing of marketing materials or program offerings can be conducted as part of the program itself, on a stratified and randomized sample of customers. This means the utility is running two program variants in parallel.

» Conduct new technology pilots within the program, so the pilot can collect data on marketing and sales as well as on technology performance.

Iterate the program on a regular cycle

» Some data collection and experimentation can be conducted on a fast cycle of 6–12 months, to provide continuous course-correction to the program. This includes variables and methods such as cost data, process surveys, A/B testing of marketing, and survey data on the reasons behind purchase decisions.

» Other analysis can be conducted on a longer cycle of 2–3 years, once enough data have been collected to inform larger changes to the program. This includes variables and methods such as physical data from homes, quantitative confirmation that journey mapping is accurate, analysis of customer retention during each program phase, data sharing with other utilities and CCAs, formal M&V, and review of ally relationships. Contracts with program implementers can be reviewed on the same cycle.

Leverage allies for joint research

» Identify ally organizations that are trying to reach the same or similar customers with a complementary product or service. Allies can help the utility to portray HPWHs as part of a wider social movement, not just an appliance choice. Allies could be other utilities and CCAs, or other types of organizations such as environmental advocates, research organizations, or for-profit companies.

» Identify opportunities to share data and conduct co-marketing activities.

» Coordinate data definitions and data collection instruments so that data are useful to both parties and can be combined for added statistical power.

» Allies should collect data and perform experiments on the same cycle so results are timely for program redesign.

3.3.1 IMPACT OF INBUILT RESEARCH ON THIRD-PARTY PROGRAM IMPLEMENTATION CONTRACTS AND PROCUREMENT

Conducting inbuilt and iterative research may require changes to the existing technical and legal language in RFPs and contracts for third-party program implementation. It will have at least the following impacts:

- Program RFPs and contracts should indicate that the program scope may be changed at specific times during the course of the contract. This is not typical in current program contracts, so new legal language may be required.
- Program RFPs and contracts should indicate the type and amount of data the implementer should collect from customers and subcontractors during program operations, along with how that data should be checked for quality and completeness, how it should be stored, how it should be conveyed to the utility, and with what regularity.
- Program RFPs and contracts should indicate that the implementer may need to work with multiple groups within the utility (such as market research, engineering research, IT, digital experience, etc.) The RFP and contract should set out expectations for the level of effort and deliverables expected from these interactions.

3.3.2 GENERATING SHARED DATA TO MAKE DECISIONS FASTER WITH MORE STATISTICAL POWER

We recommend that utilities, CCAs, and others use common data collection templates and data definitions, to increase the statistical power and speed of any analysis that might be conducted. Sharing data allows conclusions to be drawn sooner than they would if each utility were collecting data separately.

The tables below show questions developed at SMUD during alpha and beta testing of a cost survey. The questions are asked of the installation contractors rather than customers. To

reduce the time needed for field staff to fill in the data, the questions are multiple choice only, and can be used by researchers as factors in a multivariate regression of price that will be conducted once enough data are available. The questions are intended to cover only the main elements that affect the total price of the project. Further details on the choice of questions are provided in Appendix E: Rationale for Questions Asked of
Contractors to Collect Project Price Data

Price data can be used for a number of purposes that support market transformation:

- For building code change proposals, i.e., to provide cost-effectiveness data.
- To figure out how to exert downward pressure on price as programs progress. For instance:
  - » Are building officials interpreting code inconsistently?
  - » Are there code requirements that could be removed?
  - » Are there common installation practices that could be improved or streamlined?
  - » Is risk a big factor in pricing, and can utilities or others help with that?
  - » Can we provide customers with better guidance on scope and on getting quotes?
- To give customers better guidance on price up front when they first find out about the program, to improve the program uptake rate and reduce abortive effort.
- To educate customers about the likely price implications of any optional extra features.

3.3.2.1 Questions for Trade Ally Network Administrative Staff

When possible, questions are asked of the admin staff rather than the crew leads, to reduce time pressure on the crew leads.

	Question	Answer
1.	What was the total price charged to the customer for this job, by your company and your subs?	$
2.	Did you (or your sub) obtain the building permit for the customer?	Yes / no
3.	Did you (or your sub) provide the water heater and deliver it to the house?	Yes / no
4.	Did you (or your sub) haul away the old water heater?	Yes / no
5.	What size of water heater was installed?	[gallons]
6.	Which subs worked with you on this project?	[names of subs]

3.3.2.2 Questions for Crew Leads at Trade Ally Network, and Subs

Please provide answers only for the work your company did, not work done by others.

7.	Did you dismantle an existing flue or vent, or cap one off?	Dismantle / cap / neither
8.	Did you install a new service disconnect?	Yes / no
9.	Did you have to run new wiring?	Yes / no
10.	Did you install a new electrical panel?	Yes, outdoor panel / Yes, indoor panel / no
11.	Did you replace or add any breakers (other than the water heater's breaker)?	Yes / no
12.	Did you install a condensate drain?	Yes, rigid pipe / Yes, flexible pipe / no
13.	If yes, did the condensate drain need a pump?	Yes / no
14.	If yes, where did the condensate drain to?	Sink drain / laundry drain / outside the house / other
15.	Did you install an expansion tank?	Yes / no / replace / re-used existing
16.	Did you have to replace or re-route copper or PEX pipes around the water heater? (Not including flex lines)	Yes / no
17.	Did you install a recirculating pump or on-demand pump, either at the water heater or elsewhere in the home?	Yes, a recirc pump / Yes, an on-demand pump / no
18.	Did you install a thermostatic mixing valve?	Yes / no / replace / re-used existing
19.	Did you do any other work in the customer's home (excl. earthquake straps)?	[text]

3.4 Key Issues to Review During Program Development and Iteration

Conventions for the design of energy efficiency programs are well-established, but as utilities increasingly face the need for rapid scaling of electrification and efficiency to meet state and local climate goals, programs will need to learn and grow more quickly, and meet the needs of a wider range of customers. This section summarizes the characteristics that distinguish these next-generation programs from the existing portfolio. Recommendations for achieving these characteristics are given in the corresponding sections below.

1. **Equity.** Equity should be built into program design and actively monitored. This includes pricing, incentive levels, financing, and outreach.
2. **Financing Options for Customers.** Program experience suggests that relatively high incentives are necessary to get program participants to pay the higher purchase and installation costs associated with HPWHs. Financing can reduce the need for these incentives by lowering the upfront costs and spreading them out over time.
3. **Strategic Allies and Strategic Links**. New construction programs need the active support of industry actors to be successful. Retrofit programs and products should work as part of an overall incentive program strategy, where applicable, i.e., they should be offered in conjunction with other technologies, programs, and messaging. It may also be possible to encourage customers to think strategically about the eventual conversion of their own home to a HPWH, in conjunction with other electric technologies.
4. **Retrofits: Broad reach to different customer types**. Retrofit programs should be built to scale up rapidly, for both the electric- and gas-replacement markets. This means they will have to reach outside the typical pool of customers who take part in retrofit programs.

3.4.1 EQUITY

Summary:

- Conduct "equity screening" (defined below) of program designs, and ground-truth the assumptions the program makes about likely target customers, and the reasons why they are expected to participate or not participate in the program. Include low-income customers or advocates in program design.
- Include moderate-income customers as well as traditional low-income customers in program design. Consider tariffed on-bill investments as a way to extend the program to these customers.

During program development, consider especially the needs of hard-to-reach and rural customers with electric resistance water heaters, since they are a priority market with a good value proposition.

3.4.1.1 Background

Equity has been addressed for decades in California's efficiency programs, in the form of specific programs, incentives, or outreach to low-income customers or to owners of properties with low-income tenants. More recently, equity for people of color has become a more prominent concern, and may influence the success and speed of water heater market change because regulators want to ensure that utility and state initiatives serve all customer demographics equally. Because this represents a change from the status quo, additional conscious effort is likely necessary to achieve this equity. Specific areas of concern around electrification may include:

- Economic and cultural differences in the value people assign to different fuels or different types of appliances.
- Economic and cultural differences in how appliances are bought, maintained, and disposed of.
- Economic and cultural differences around the ability or willingness of customers to take advantage of financing mechanisms.

Another recent change has been a recognition that a binary distinction between "low-income" and non-low-income customers may leave moderate-income customers stranded because they can't afford new appliances but also don't qualify for assistance programs. Additional incentives or financing mechanisms could potentially help this "missing middle" group.

3.4.1.2 Recent Statewide Equity-Related Rulemakings

In 2017, the California Public Utilities Commission (CPUC) directed that 25% of funds for the Self-Generation Incentive Program (SGIP), which includes water heaters, be allocated to low-income households and environmentally burdened communities.[13] In 2018, the CPUC instituted a rulemaking[14] to develop a new, broader view of affordability in rates and programs, including "market-level metrics" to assess the "affordability impact of programmatic and tariff

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[13] *CPUC Directs Investment For Energy Storage Projects To Customers Located In Disadvantaged And Low Income Communities.* California Public Utilities Commission. 2017. https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M197/K258/197258268.PDF

[14] *Order Instituting Rulemaking to Develop Methods To Assess The Affordability Impacts Of Utility Rate Requests And Commission Proceedings.* California Public Utilities Commission. 2018. https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M218/K186/218186836.PDF

design changes." This rulemaking resulted in CPUC developing a new "progressive framework" in 2020 to assess affordability.[15]

These activities signal the State of California's intention that all Californians, regardless of income, should be able to take part in efficiency and electrification programs. Moreover, they signal a move away from the binary distinction between "low income" and "market rate," in favor of a more graduated idea of affordability that recognizes that many customers who are not traditionally income-qualified may also find it difficult to participate in market-rate programs.

The upper threshold for low-income program eligibility is typically 400% of the federal poverty level. The 2020 values for California are shown in Table 9.

TABLE 9: LOW-INCOME PROGRAM ELIGIBILITY IN CALIFORNIA[16]

Household size	1	2	3	4	5
Annual income	$51,040	$68,960	$86,880	$104,800	$122,720

3.4.1.3 Oakland Racial Equity Guide

Oakland published a Racial Equity Impact Assessment and Implementation Guide[17] as part of its 2030 Equitable Climate Action Plan. The Guide does not give specific recommendations for how to implement programs or change markets, but it does include a "preliminary equity screen" (p. 7) for public policy development, that can be adapted to water heater program design. The equity screen is shown below, with the questions most pertinent to heat pump water heaters shown in bold:

Does the draft Action:

1. ***Prioritize frontline communities and maximize the benefits of climate investments for frontline communities?[18]***
    a. *Does it address priority community needs?*
    b. ***Does it distribute climate benefits geographically, and/or by income, and/or by race, etc., responsive to the needs of each community?***
    c. *Does it preserve and strengthen local assets and cultural values?*
    d. *Does it reduce disparities by remedying/mitigating existing harms and avoiding additional harms?*

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15 *CPUC Adopts Progressive Framework To Assess Affordability Of Utility Services.* California Public Utilities Commission. 2020. https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M343/K980/343980714.PDF

16 *HHS Poverty Guidelines for 2021.* U.S. Department of Health & Human Services, Office of the Assistant Secretary for Planning and Evaluation. 2021. https://aspe.hhs.gov/poverty-guidelines

17 *Racial Equity Impact Assessment & Implementation Guide.* City of Oakland. 2020. https://www.oaklandca.gov/documents/racial-equity-impact-assessment-and-implementation-guide

18 "ECAP prioritizes investments and programs that benefit communities with high climate risk and high social vulnerability; where possible, frontline communities should receive the local benefits generated by climate action strategies first and should receive more than their per-capita share." *Racial Equity Impact Assessment & Implementation Guide.* City of Oakland. 2020. https://www.oaklandca.gov/documents/racial-equity-impact-assessment-and-implementation-guide

2. ***Require or incentivize large businesses/developers/industries to do their fair share to improve the environment and restore our communities?***
   [especially if businesses want to expand their land use or operations, and may create disadvantaged communities by doing so]

3. ***Foster local green job creation, entrepreneurship, and cooperative ownership opportunities for members of frontline communities?***

The guide also notes that policies should "Acknowledge blind spots. Groundtruth any/all assertions with frontline communities" (p.4, recommendation 1.b). This is relevant to program design and the equity checklist above, especially when programs are developed by people who are not themselves low-income. Ground-truthing the program design and equity checklist could be implemented using one or more of the following methods:

1. Journey map program participation from the point of view of one or more low-income customers.
2. Conduct focus groups on program design and participation with low-income customer subjects or community organizations.
3. Test permutations of program websites and marketing on low-income customers.
4. Allow disadvantaged communities to take part in grading and assessing program performance, and to influence future program direction. This could be accomplished by inviting community organizations to contribute.

The Guide also gives specific examples of equity gaps and desired outcomes for its "Plan for All Existing Buildings to be Efficient and All-Electric by 2040" (p. 37) that may be relevant to HPWH programs.

3.4.2 FINANCING OPTIONS FOR SINGLE-FAMILY CUSTOMERS

Unpublished data on program participation suggest that HWPH program participants are very often at one end of the income spectrum, i.e., they're either high-income risk-tolerant people, or they're people on the Federal poverty spectrum receiving a HPWH at zero cost to them. The number of moderate-income program participants so far is comparatively small, but these moderate-income customers will eventually make up the bulk of the market for HPWHs as sales volume expands. Consumer financing is a tool that utilities can explore, using a research-based approach, to reach moderate-income customers.

The majority of customers in the market for a residential water heater do not have sufficient savings on hand to purchase and install either a new conventional water heater or a HPWH. Most customers will charge the expense to a credit card; an alternative financing mechanism must be able to compete with a credit card on ease of access and on interest rate. HPWHs are more expensive to purchase and install than conventional water heaters, and customers tend to be reluctant to increase the amount of new debt they incur. Alternative financing must be attractive enough to convince them to do so.

Program experience so far suggests that relatively high incentives are necessary to get program participants to pay the higher purchase and installation costs associated with HPWHs. Financing can reduce the need for these incentives by lowering the upfront costs and spreading them out over time, but participants must have faith that the HPWH will generate energy savings and pay back the extra amount borrowed.

HPWH financing provides a benefit to the utility or CCA by creating a revenue stream that can be used for new loans, making the HPWH program financially sustainable. The costs of setting up and administering a financing program can be significant, but they are usually lower than the cost of incentives for larger programs that operate over time.

3.4.2.1 Incentive Payments to Contractors, Not to Customers

One simple financing innovation already being used is for a utility or CCA to pay the incentive to the contractor on project completion (instead of the customer paying the contractor the full amount for their work, and then receiving the incentive payment from the utility). This reduces the amount of money the customer must have on hand to pay the contractor, so is helpful to moderate-income customers who may not have $2,000–$5,000 available (more for larger whole-home projects).

This arrangement relies on a level of trust between the contractor and the utility or CCA, so it aligns well with "trade ally partnerships" and other forms of relationship for which the utility is more closely involved with approving or training contractors as part of the program. Although this arrangement does not create a revenue stream for the utility, it most likely improves the program participation rate.

3.4.2.2 Conventional Energy Efficiency Financing

Utilities have for decades offered commercial financing to help their customers pay for major energy efficiency improvements.[19] The utilities market the loans and may subsidize the interest rates charged, but the loans are issued by a partner financial institution. This means that the borrower usually must go through a commercial loan underwriting process to assess their creditworthiness. Commercial underwriting often excludes a large percentage of potential participants, particularly low- to moderate-income customers.

A well-designed conventional financing approach can address the initial cost barrier to installing HPWHs for at least some customers, when they have sufficient time to get credit approval. However, market transformation requires that, eventually, most residential water heater installations will replace existing units on failure; in those cases, the loan application and approval process must be fast and efficient so that it does not slow down the restoration of hot water service.

3.4.2.3 Tariffed On-Bill Financing

In its SB350 Barriers study, the California Energy Commission (CEC) identified five principal recommendations to address barriers to customer participation. The fourth recommendation is for utilities to pilot tariffed on-bill investments:

> *"The CPUC should consider developing a tariffed on-bill pilot for investments in energy efficiency that targets low-income customers regardless of credit score or renter status, and that do not pass on a debt obligation to the customer. Utilities could use the program to make energy upgrade investments and recover the cost through the bill, so long as the recovery charge is less than the estimated savings. The Energy Commission should encourage and provide technical assistance to POUs and other load-serving entities seeking to implement a tariffed on-bill pilot."*

[19] One example is the Mass Save HEAT loan program.

Like conventional financing, under tariffed on-bill financing, customers borrow to cover the cost of purchasing and installing a HPWH, and then repay the loan over time. The difference is that the utility is the lender and repayment is through a surcharge on the customer's utility bill. Tariffed on-bill financing usually avoids the commercial underwriting process and can therefore offer financing to low-income customers who might not otherwise qualify for a loan. Because non-payment of finance charges can result in interruption of utility service, default rates for tariffed on-bill financing loans tend to be very low. The utility also may assume the technology risk for the period of the loan and guarantee the energy savings from the HPWH. "Pay As You Save®" is a branded version of tariffed on-bill financing[20] in which the loan is explicitly structured to be paid back out of energy savings.

3.4.2.4 Water Heating Services Model

The Water Heating Services (WHS) concept recognizes that grid-connected HPWHs are able to provide both hot water services to customers and load management services to the electricity distribution system. Residential utility customers are not usually equipped to, or interested in, operating their HPWHs to provide grid services. WHS monetizes the grid services and uses that revenue stream to decrease the cost to participants. Under WHS a third party, which could be the utility or an independent business, owns the HPWH and sells hot water to the residential customer and demand services to the grid.

The WHS customer experience is similar to a water heater rental, already common in some parts of the country. Customers receive a new HPWH installed free of charge and pay a monthly fee. The revenue stream from grid services reduces the customer fee below what it would be for a non-grid-connected HPWH. Other advantages of third-party HPWH ownership are that the owner retains the risk for new technology performance and is able to negotiate bulk pricing with manufacturers and installers. Order 2222, released by the Federal Energy Regulatory Commission in 2020, requires independent system operators, including CalISO, to release rules in 2021 allowing such third parties to sell grid services[21] at the wholesale level.

3.4.3 STRATEGIC ALLIES AND STRATEGIC LINKS

Creating links among a utility's various incentive programs, such as electric vehicles and water heaters, may lead to faster adoption and fewer missed opportunities. Creating links with outside organizations (e.g., ENERGY STAR, community nonprofits, environmental advocates) and the utility's own customer service center and IT teams may create additional sales opportunities. Benefits could be gained from allowing customers to set their own replacement and upgrade timelines for water heaters and other equipment.

3.4.3.1 Retrofits: Strategic Opportunities from Integrating Programs

Utility programs are typically built around specific technologies, with the result that utilities miss opportunities to cross-promote their offerings.

[20] *How Pay As You Save® Works*. Energy Efficiency Institute, Inc. https://eeivt.com/wordpress/how-pays-works/
[21] *FERC Order No. 2222: Fact Sheet.* Federal Energy Regulatory Commission. 2020. https://www.ferc.gov/media/ferc-order-no-2222-fact-sheet

Many utilities offer programs that integrate similar technologies, such as HVAC, insulation, and water heating; however, few offer programs that integrate dissimilar technologies such as solar and HVAC, or electric vehicles and water heating. **Integrating these programs can increase participation through two main consequences:**

1

Cost reductions for customers, for instance installing wiring and breakers for an electric vehicle and a water heater at the same time in the same conduit. Combining several measures in a single customer interaction allows utilities to meet their goals more quickly.

2

Increased participation because, demographically, customers who participate in one program typically have the motivation and means to make decarbonization investments, so they are likely to want to participate in more than one program.

3.4.3.2 Retrofits: Strategic Opportunities Outside of Programs

Strategic links are also possible outside of programs, for instance via the marketing efforts of non-utility partner companies or advocacy organizations. These might include businesses or nonprofits with environmental goals, or low-income advocates who might help customers to apply for grants and engage with installers, or conduct a socially amplified event. These organizations may also have additional data on utility customers that will allow them to make better-tailored offers to those customers, in a timelier way, to create opportunities that the utility would not have by acting alone. Many customers now expect cross-promotions and may not view them negatively.

Utilities' own program records, customer service centers and IT teams also have extensive data on customers that could be used to generate more tailored and timely marketing; however, such data are typically unused because they are seen as potentially intrusive, raise privacy concerns, or due to IT limitations.

3.4.3.3 Retrofits: Customer-created Timelines

Another strategic opportunity to engage customers and to increase the timeliness of offerings may be to allow customers to create their own efficiency or electrification timelines. For instance, customers could enter data on the energy systems in their own homes, and create a customized timeline for the replacement or upgrading of those systems. The utility could send them an automated notification or have a contractor call when their water heater is nearing the end of its life and can cost-effectively be replaced. Customers may see such services as beneficial, and they may create other cross-promotion opportunities.

3.4.4 RETROFITS: BROAD REACH TO DIFFERENT CUSTOMER TYPES

To meet statewide goals, HPWH programs have to reach a much broader range of customers than current incentive programs typically do. This will include customers who are moderate-income, hard-to-reach, unengaged, or otherwise seen as low-propensity.

To reach large numbers of new customers, utilities can adopt more data-driven marketing approaches typical in other industries, to develop marketing tailored to individual customers or customer segments. This will require program designs based primarily on customer data rather than on engineering data.

The adoption curves and dynamics of social movements may provide an alternative and more actionable model for HPWH adoption than traditional technology adoption curves.

3.4.4.1 Comparison of Utility Incentive Programs to Other Business Marketing

Residential energy efficiency incentive programs tend to attract specific types of customers. Often these are customers who:

1 **Have cash on hand for energy upgrades**

2 **Have time to devote to the project**

3 **Are tolerant of risk**

4 **Are motivated by environmental concerns**

In other words, these tend to be wealthier, older customers, described in segmentation analysis as environmentally aware. They comprise at most 20% of a utility's customer base, and each customer only participates in a program once every few years, which limits programs' reach to a very small percentage of homes each year. To reach the majority of customers within roughly a 15-year time span, HPWH programs have to reach not just *more* people but *different kinds* of people.

Residential energy efficiency programs also tend to use a single message and a single offering for the product or program and convey that message and offering to all potential customers. In modern marketing, however, this is just one of many approaches; tailoring the message and its timing to each segment, each channel, or to each individual customer is now a common and effective approach, and in many cases the offering itself is also tailored. To develop these new approaches, utilities may need to develop their own technical competence in marketing, and/or hire companies that bring that competence.

Utilities commonly collect data on customer interactions and customer behavior; this information is valuable, either for the utility's own use or for use by third parties. Activating these data for use in programs may lead to additional sources of income for the utility.

3.4.4.2 Social Movement Theory

The models used for customer adoption of new technologies are primarily economic, in part because economic models are easily justified in ways that seem objective. However, technologies are often widely adopted despite not being in the economic interest of their users, or have failed even though they save people money and effort.

An alternative adoption model is available from social movements. Mass adoption of HPWHs may have more in common with people's support for civil rights or recycling than it has with other technologies; in other words, people's reasons for purchasing HPWHs may have more in common with the reasons they donate to civil rights organizations or separate their plastics, than they have with the reasons they buy a cellphone or a flat screen TV. For instance:

1. **No instant gratification**: There's no aesthetic or experiential benefit to customers.
2. **Mixed social cachet**: Some people may be impressed by a water heater; most will likely not be.
3. **High risk**: Once installed, a HPWH is difficult and potentially expensive to uninstall. It may require modifications to a customer's home.
4. **Ethical component**: HPWHs can create a sense that the customer is doing the right thing.

Social movements are modeled as having four stages.[22] The stages are sequential and apply to the movement as a whole, not to individuals. The stages define what the movement needs to do to grow at each phase of its development, and they provide an actionable model that can be used in program design:

- **Emergence**: Highly motivated individuals take action on their own initiative
- **Coalescence**: Groups of similarly-minded individuals act together
- **Bureaucratization**: The social changes become routine and codified
- **Decline**: The movement becomes the new norm

These four stages are described in additional detail in Table 10 below. The descriptions have been adapted to fit with utility programs and utility customers.

[22] *Four Stages of Social Movements.* Christiansen, Jonathan. 2009. EBSCO Publishing. https://www.ebscohost.com/uploads/imported/thisTopic-dbTopic-1248.pdf

TABLE 10: STAGES OF SOCIAL MOVEMENTS

	Emergence	**Coalescence**
Emotional state	Emotional, a sense of personal discontent with the current order	Collective purpose, a sense that something must be done
Social media	Occasional sharing	Very active sharing and norming
Mass media	Sporadic, disconnected, often misinformed	High coverage, still novel
Collectivity	Actions are highly individual	Actions become standardized and collective
Geographic scale	Local movements emerge	State and national incentives emerge
Market conditions	Chaotic, callbacks, conflicting advice to customers, risk pricing	Forms nexus around a few key technologies and packages, advice is consistent, few callbacks
Understanding of impact	Incomplete understanding of bill impacts	High understanding among motivated individuals
Understanding of context	Uncertainty about how HPWHs relate to other environmental actions e.g., EE/PV/EV/storage	An emerging sense of priority about which personal environmental actions have the greatest impact
	Bureaucratization	**Decline**
Emotional state	Late majority acting because it's the social norm. Emotionally ambivalent.	Laggards are completing their HPWH installations, sometimes with shame or resentment
Social media	Little sharing	No sharing
Mass media	Media coverage tapers off, focuses on problem situations and holdouts.	Media coverage is retrospective only
Collectivity	Actions become routine and unremarkable	Individual responsibility returns—actions are perceived as overdue.
Geographic scale	Statewide and national incentives tail off in favor of code.	HPWHs are required under code in all circumstances
Market conditions	Local market is stratified, with standard pricing over the phone; contractors use consistent methods and terminology.	Local market continues as before
Understanding of impact	Universal understanding of the GHG and bill impacts of HPWHs	Non-heat-pump water heaters are seen as outdated energy hogs
Understanding of context	A clear and well-established priority of personal environmental actions	Remaining personal actions are being checked off as circumstances allow

4 Education and Training

In a survey of West-coast utility staff, education and training of customers and contractors was identified as being a high priority for the success of electrification technologies.[23] Education and training is also identified as one of the key best practices from successful HPWH programs, described in Section 3.1.

We recommend that utilities conduct education and training not as a separate activity, but as an integral part of the program that is included in the program design. We recommend that utilities collect data on education and training activities and outcomes as they would for any other program activity, as part of the "inbuilt research" process for measuring and iterating program designs.

We also recommend that a plan for education and training of contractors and other market actors should be one of the outcomes of the engagement process with developers and builders, outlined in Section 3.2.

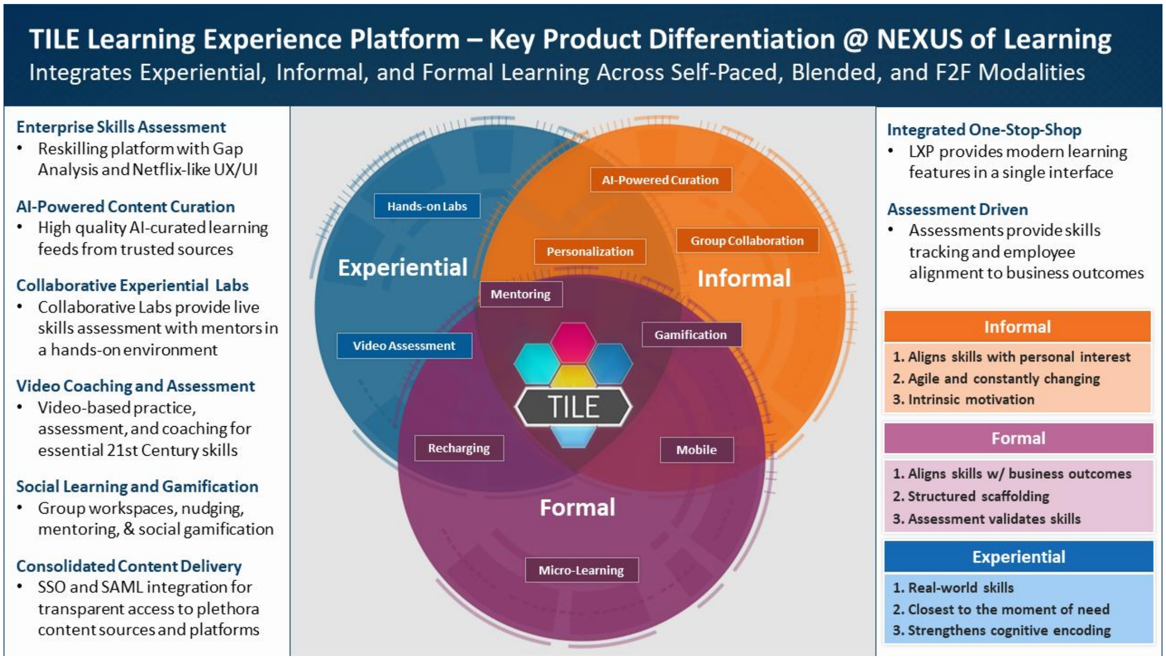
In some cases, utilities may not yet have the IT capability to link education and training activities to outcomes such as increased program participation or better installations. If not, creating a means to identify such connections should be a priority for program developers.

After extensively examining education and training options, the AWHI Central HPWH Working Group recommends that multiple modes of training and education should be delivered and monitored as part of an integrated learning experience platform. A schematic of the learning experience platform is shown below.

[23] Unpublished study, conducted by Cadmus for the Sacramento Municipal Utility District. 2020. Contact Owen.Howlett@smud.org for information.

FIGURE 7: LEARNING EXPERIENCE PLATFORM SCHEMATIC

Source: McVey, K. BPA.



4.1 Education and Training of Installation Contractors

Following Figure 1, training on product features and benefits, and on installation, is currently conducted primarily by manufacturers in coordination with distributors.

We recommend the following approaches for education and training within programs:

1. Utilities should make use of, and support these existing training processes rather than set up parallel processes. This approach will minimize cost, increase the speed to market, and encourage the “supply chain engagement” that characterizes existing successful HPWH programs.

2. Utilities should require contractors to complete and maintain their training as a condition of membership in the trade ally network, or to access additional incentives or program options.

3. Additionally, utilities may require that contractors carry the full range of required licenses, to ensure a single contractor can implement the whole project and don’t require the customer to hire two separate contractors to complete the job.

4. Utilities may provide additional training, developed by the utility, to identify appropriate homes and customers for 120V HPWHs, and to clarify how sizing and control requirements differ from 240V units. This additional training has not yet been developed.

5. Utilities may work with trade ally contractors to establish additional offerings and channels, for instance:

   i. “Pro Deal”: The utility and/or the OEM provides a HPWH to an influencer in the installer organization to live with the product and become an advocate.

ii. “Hyper Installers”: Identify and support installers that offer HPWHs as the first choice to customers. They proactively seek out customers based on existing water heater location within the home, or other characteristics of the home or customer.

iii. “Fixed” pricing model: Installers offer a standard fixed price for installations that meet certain criteria.

iv. “Targeted installations”: Known electric resistance installations with tailored marketing specifically for electric load congestion locations. Installation of HPWHs with CTA-2045 for load management.

v. “Social media”: Messaging for installers to promote products using Facebook, LinkedIn, Twitter, and Instagram. Leverage and amplify utility OEM awareness communication.

vi. “Targeted HPWH Promotion” programs: For example, an installer would run a contest asking customers to send in pictures of the “oldest” or “most unique” water heaters with a gift of a HPWH to replace the old or odd installation.

4.2 Education of Utility Customers

Some utilities have created instructive videos or in-person training to help customers to understand and feel familiar with HPWHs. In addition, many instructive videos are available online from sources like PBS’s *This Old House* or Matt Risinger’s *Build* channel, which can be linked from program websites. These resources could be expanded to include activities such as roadshows or media events. Increasing customer familiarity with HPWHs is likely to be essential to fast market transformation.

Ensuring equity in the reach of programs is an increasingly important factor in utility customer education. As described in the Equity section of this report (Section 3.4.1), the best practice would be to ground-truth assumptions and test educational materials in conjunction with the specific customer groups the utility is trying to reach. Partnerships with community groups and social advocates may result in better materials and increased outreach.

4.3 National Education via ENERGY STAR®

A priority for ENERGY STAR in 2021 is the facilitation of national training courses for installation contractors focused on heat pump water heaters that are collaboratively executed by industry partners including manufacturers, utilities, retailers, and regional organizations such as NEEA. Formats will continue to be virtual until social distancing restrictions are lifted and in-person training sessions again permitted.

In an approach similar to the format of this report, ENERGY STAR is building guidelines of best practices and resources developed collaboratively with the industry, including contractor training, certification, and ongoing advocacy tactics for the product. The guidelines will be shared with all related ENERGY STAR utility and energy efficiency program sponsor partners, leveraging the account management team that maintains these partner relationships.

ENERGY STAR collaborated with key stakeholders and subject matter experts to create a customer-facing educational tools repository on its product website. Utility program websites can reference these tools to help customers understand HPWHs before they commit to purchase: https://www.energystar.gov/products/water_heaters/heat_pump_water_heaters

Available tools include fact sheets, a guide on how heat pump water heaters work, Ask the Expert videos, the ENERGY STAR Product Finder tool, a Qualified Contractor Finder tool, the Water Heater Replacement Guide, a savings and benefits guide for heat pump water heaters, the ENERGY STAR Rebate Finder tool, a tax credit guide, and other specialized marketing materials for heat pump water heaters.

ENERGY STAR created a Technical Advisory Group (TAG) that includes representatives from utilities who have executed successful industry programs. This TAG provides knowledge sharing and discussion around best practices, as well as information on what has and has not worked.

ENERGY STAR will continue to issue quarterly Water Heater Newsletters to industry partners,[24] promoting product awareness, partner program successes, and recommended practices from qualified installers.

[24] *Join ENERGY STAR.* ENERGY STAR. 2021. https://www.energystar.gov/partner_resources/join-energy-star

5 Recommendations for HPWH Technology

Unitary HPWHs currently on the market already have the level of performance and range of features needed to support market transformation. Minor desirable next step technology improvements are not the highest priority; instead, market transformation efforts are the highest priority in the short term and should focus on supply chains, customer education, and program design.

One of the highest technology priorities is the need for lower-cost units that blend technology simplifications and market transformation, as described in recommendation #1 of section 5.1. Lower-cost units are needed to move HPWHs from a desirable measure under the building code, to a mandatory one. Some lower-cost units are already available from at least one manufacturer.

ENERGY STAR will be finalizing a new Water Heater Specification in Spring 2021 (to go into effect in late 2021/early 2022). In addition to providing new connectivity guidelines, the new specification's updated UEF requirements will support increased energy saving estimates over the life of today's product offerings.

5.1 Desirable Next Steps for Technology Improvements

1. **Work with manufacturers on a "base" unit with minimum features** that is minimum-cost suitable for low-income or rental markets, and maintain the full-featured heaters for the general residential market. This product segmentation is a normal market penetration strategy for wider early adoption. Lower-cost units would also help HPWHs to get into building codes and, ideally, would support a new federal code requirement for >2.0 UEF for all water heaters. The lower-cost units may be 120V or 240V, but would not include controls beyond the minimum required (i.e., JA-13 in California). This is in line with the recommendation of AWHI's working group on Connectivity and Controls. At the same time, full-featured HPWHs would suit the majority of homeowners and set the market expectation for full controls and grid integration.
2. Support the recently-developed **120V and low-amp units** (i.e., 15A 240V or 15A 120V) in both new construction and retrofit applications. Manufacturers have made significant investments in developing these units, and their success will facilitate further investments.
3. Ensure that **HPWHs can operate together with split charging devices,** such as Dryer Buddy, NeoCharge, and simpleSwitch, that can switch power as needed among different devices on a single circuit. HPWHs may share a circuit with an electric resistance dryer or with a level 2 electric vehicle charger. If HPWHs are not currently compatible with these devices, what changes to the water heaters or switching devices could achieve compatibility? Is a standard needed?
4. **Consider a built-in 120V outlet for a condensate pump**, since a 120V outlet may not necessarily be available close to the water heater in a retrofit project.
5. **A system to organize water piping in the space above the water heater** while ensuring access for filter cleaning would be a benefit, especially in retrofits with tight space constraints, and in projects where thermostatic mixing valves or recirc pumps are installed.

Currently, the piping above water heaters is often cluttered and messy-looking. A pipe organizing system may reduce callbacks due to incorrect installation of a mixing valve, and may make HPWHs a possibility in spaces that would otherwise be too tight, such as multifamily or manufactured housing retrofits.

6. For multifamily projects, a **water heater mesh network** would simplify the connection of multiple water heaters to a building's Wi-Fi or energy management system. A system that monitors when water heaters are malfunctioning or going into resistance mode would be a benefit to building maintenance staff, especially in low-income housing.
7. Design for plumber-centered installations to **allow or encourage plumbers to make the electrical connections** required for HPWH technology in retrofit projects. For instance, if electricians pre-install the circuit, can the terminations to the water heater be made in such a way that plumbers will feel able to make them without an electrician?
8. For customers who are committed to a future wiring upgrade, but are not yet ready (for instance, if they plan to install an EV, induction stove, or additional HVAC), **determine if a 240V water heater can be designed to connect to a 120V outlet in the absence of electric resistance backup**, either using circuitry inside the water heater, or a dedicated external transformer unit that would force the water heater into heat pump-only mode.
9. **All HPWHs (240V, 120V, and central systems) should be grid-connected and JA13-compatible.** Currently, California Demand Management specification (JA13) only requires 240V to be JA13-compatible, but as the 120V and central technologies get more advanced and are increasingly adopted, all the water heaters should be able to receive advance commands (CTA-2045-B) while connected to the grid or offline (TOU schedule-based load shifting).

5.2 Technology Improvements that Are Likely Not Needed

This section explains why we did not include the features below as desirable next steps.

1. Increased uniform energy factor (UEF) beyond the current typical value of 3.5 would not provide significant benefits, because energy use is already so low. A reduction in unit cost would likely be more beneficial to market uptake, especially via code, than would be improved performance.
2. The group discussed **wall-mounted unitary water heaters** to save space, but the weight of a full water heater would create structural and installation challenges. Outdoor wall-mounted unitary water heaters may be a problem-solver for Accessory Dwelling Unit (ADU) projects, or for homes in very moderate climates where water heaters are mounted outdoors (mainly in Southern California); however, the structural issues would need to be resolved, and the building code currently prohibits outdoor water heaters in new construction.
3. **A temporary or transitional water heater** for retrofit projects is not a market need. Contractors can usually install a HPWH in a single day with one operative even if an additional circuit is needed; less time if two operatives are on site. Reducing the total time needed to complete a water heater project is better solved by improving utility program design and contractor scheduling than by using temporary heaters.
4. Working group members with field experience agreed that **water heaters with smaller footprints** than the current NEEA "space-constrained" specification of 24" x 26" x 72" are not needed.
5. Working group members did not identify a need for **additional ducting options**.

5.3 Refrigerants

While we have made no recommendations regarding refrigerants, which are used by HPWHs to transfer heat, we have included the following discussion as a basis for possible future recommendations and to summarize the issue for readers.

In general, the greenhouse gas (GHG) impact of refrigerants is currently significantly less than the GHG reduction from using a HPWH compared to any other water heater type; however, as electricity generation becomes decarbonized, current refrigerants will become an ever-larger part of the total GHG emissions of HPWHs. Advancing HPWHs in the market must include advancements to reduce the GWP of refrigerants, and methods and advocacy for best practices in managing leaks and disposal of hydrofluorocarbons (HFCs).

Utilities that base their program goals explicitly on GHG impacts may choose to add “kicker” incentives for systems that use lower GWP refrigerants, based on a calculation of the likely magnitude of the impact. Utilities may also consider programs for end-of-life disposal of water heaters, since this is the point at which the refrigerant gases are actually released.

Refrigerant Evolution. Hydrofluorocarbons (HFCs), today’s “third-generation” refrigerants, as shown in Figure 8, are an improvement over first- and second-generation chlorofluorocarbon (CFC) refrigerants in reducing ozone depletion, but they remain a potent GHG. Today’s HPWH refrigerant is primarily HFC-134a, with a GWP of 1430, which remains in the high GWP category.

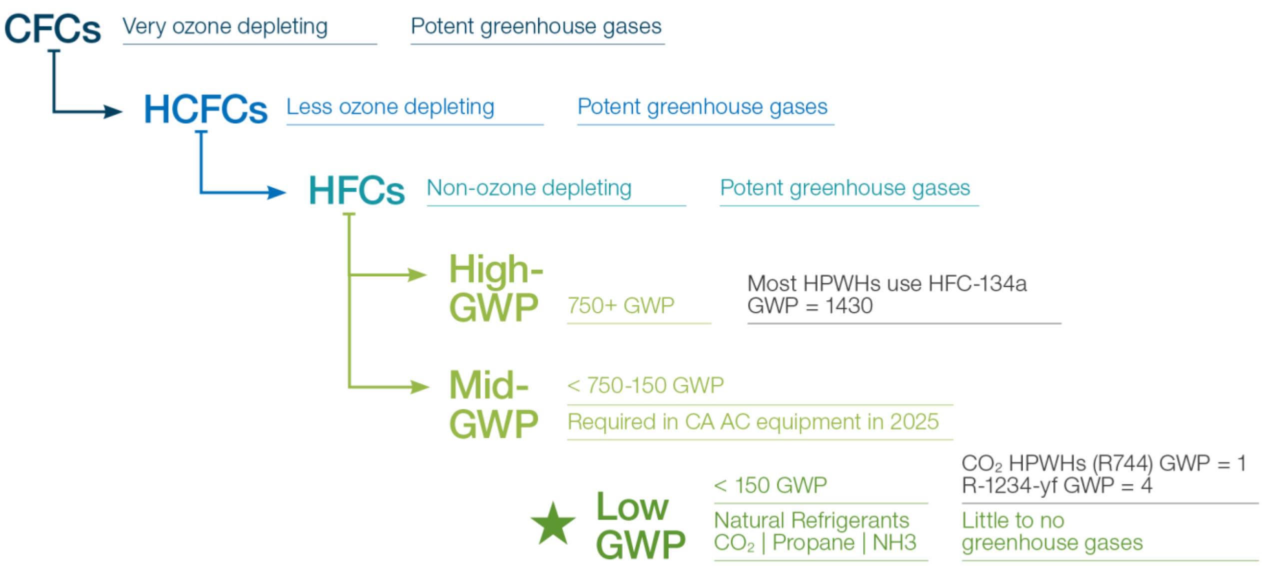
Major reductions in the GWP of refrigerants across all products is a critical part of meeting the California carbon neutral goals. Starting in 2025, many space heating products sold in California will be required to lower the global warming potential (GWP) refrigerants of their products to mid-GWP (<150–750 GWP).[25] While the requirement to transition to mid-GWP refrigerants will affect a majority of space heating systems, the California Air Resources Board (CARB) has HPWHs, which are currently not regulated for refrigerant type, on their agenda for similar regulations in the future.

The ultimate target is the use of low-GWP (<150) refrigerants, which rely on natural refrigerants such as CO_2—already adopted by Sanden in its unitary product and by Mitsubishi in its new central 10-ton HPWH—and through other methods such as propane or ammonia that have more complicated safety and code issues than does CO_2. Mid-GWP has been achievable through HFC-32 for space heating and is widely used in Europe, and 1234yf has a GWP of <1 and is used in car refrigerant systems.

[25] *California introduces groundbreaking program to reduce climate “super pollutants.”* California Air Resources Board (CARB). 2020. https://ww2.arb.ca.gov/news/california-introduces-groundbreaking-program-reduce-climate-super-pollutants

FIGURE 8: EVOLUTION OF REFRIGERANTS

Source: Higgins, C. NBI.



Parallel Adoption and Evolution. While the evolution of refrigerant types is important, it cannot be an impediment to rapidly accelerating today's HFC-based products. These products are market-ready, and their usage will have significant GHG benefits far beyond the incremental, yet valuable, gain that will occur when manufacturers can move to mid- or low-GWP products. The efficiency industry's support, advocacy, and incentives for today's HPWHs is the game-changer. Without it, there will be no market, and thus no manufacturer driver, for the next generation of low-GWP units.

Installation and Disposal. Today's HPWHs are factory sealed in a manner that eliminates potential leakage during installation. Nonetheless, plumbers and other installers that have traditionally not dealt with refrigerant-based technologies for water heating need to be aware of the issues and impacts of leakage, and particularly the procedures and regulations regarding disposal at end of life or upon failure.

6 Next Steps

As described in Section 1.2, the Unitary Heat Pump Water Heaters Working Group focused on developing program design and program/technology advancement recommendations to set the stage and provide guidance in 2020. The focus of 2021 will be on activities and efforts related to actual market penetration and transformation in coming years.

This report sets the direction and provides a resource for AWHI, but to be successful, AWHI must become an ongoing partner and facilitator for utility and CCA programs, to create the alignment, common resources, and amplified impacts that will lead to market transformation. Therefore, the working group developed the following draft list of next steps. This list, and inputs from other groups, will be used to inform AWHI's decisions about future activities, so this list should not be regarded as final or complete.

6.1 Next steps for the Unitary Working Group

To accelerate the market, the working group should focus on market activities that will engage the key stakeholders like builders, installers and retailers. Priority actions are summarized in Section 1.2 and below.

Market Engagement:

- Together with utility program staff and executive staff, engage the top production home builders in CA and get them to commit to HPWH for all new construction.
- Engage with the top five HPWH manufacturers to ensure that they're providing supply chain support and training to their distributors, per the guidance in this report.
- Expand the Unitary Working Group to include other areas of the country seeking HPWH market transformation.
- Develop a comprehensive, quantitative, shared market adoption model that:
  - Distinguishes between the various technologies and building types,
  - Allows utilities/CCAs and other stakeholders to conduct goal-setting and scenario planning for their territory in coordination with the rest of the state or region,
  - Includes the likely costs and savings to customers by utility, depending on rates and regional cost variations,
  - Is built on adoption s-curves, with stated assumptions that can easily be revised,
  - Includes <u>all</u> HPWH and building types, to make sure that things like clustered or mini central systems are captured by this working group.

Regulatory and Incentive Programs:

- Socialize this report among California utilities, seeking their commitment to consistent statewide program structures and incentives and to scale up their HPWH programs.
- Develop a commitment letter that will allow utilities and other stakeholders to indicate their alignment with AWHI program criteria and their commitment to continued funding of HPWH incentives and market transformation.
- Work with the California T24 codes team to determine what data and other information they need to make HPWHs the minimum requirement in new construction residential applications. Seek commitment from utilities and others to obtain and share that data.
- Hold 1:1 meetings between the AWHI team and utility program managers, planners and researchers to ideate the next steps in the development of their programs
- Conduct webinars and conference presentations featuring utilities and other stakeholders that have adopted some or all of AWHI program criteria.
- Gather feedback on the report from program managers, designers, and planners, and from regulators, manufacturers, and other stakeholders. Use this feedback to refine future updates to the report.

Collaboration:

- Feedback and problem solving between utilities and manufacturers.
- Sharing and coordination of marketing materials, messaging, customer tools, education and training materials, including ENERGY STAR.
- Coordination of incentive levels and specific program features, including:
    - Layering of incentives, greenhouse gas savings claims, and administrative coordination between different programs including TECH, BUILD, SGIP, and utility/CCA.
    - Possible move toward statewide upstream incentives.
    - Refrigerant kickers.
- Discussion of miscellaneous market barriers, such as how Authority Having Jurisdiction can streamline permitting, or potential changes to contractor licensing.
- Expand the group to include air quality regulators, since Air Districts have control over product regulations.

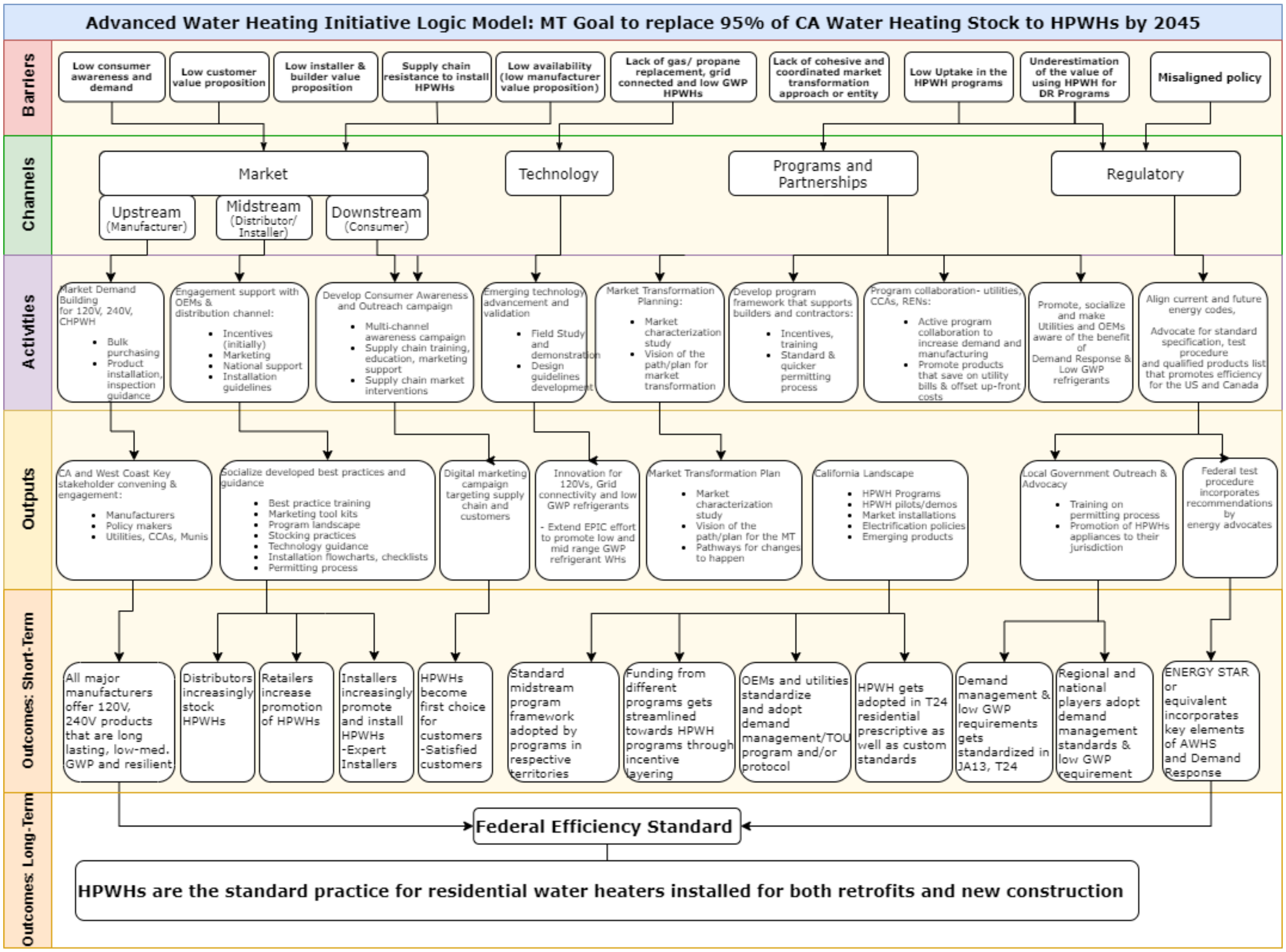
Appendices

Appendix A: NBI/AWHI Market Transformation Logic Model

Version 11/19/2020

FIGURE A1: AWHI MARKET TRANSFORMATION LOGIC MODEL

Source: NBI.



Source: NBI 2020

Appendix B: Barriers, Goals, and Principles of Decarbonization

FIGURE A2: DECARBONIZATION SUMMARY

Source: Building Decarbonization Coalition.[26]

BARRIERS, GOALS AND PRINCIPLES OF DECARBONIZATION

Between California's business as usual and its goals lie key barriers which must be overcome. These barriers include: low awareness and interest in building decarbonization measures, low perceived customer value, low perceived contractor and builder value, low availability, and misaligned policy.

LOW AWARENESS AND INTEREST	Currently there is a critical lack of awareness of and interest in decarbonized technology for residential and commercial buildings. Contributing factors include: • Lack of mainstream customer education on the health benefits and economic benefits of electrification of equipment and appliances • Lack of coordination among supportive organizations (e.g., policymakers, local governments, research institutions) • Lack of coordination with similarly focused initiatives, like the California Solar Initiative or promotion of electric vehicle adoption
LOW PERCEIVED CUSTOMER VALUE	Customers do not see a clear value proposition. Contributing factors include: • Lack of incentives encouraging customer adoption • Lack of financing solutions to help customers manage up-front costs • Lack of coordination with existing building weatherization support programs • Lack of paths to market for electric load shift enabled by heat pumps • Lack of customer bill savings in some utility service territories at current electric and gas rates • Lack of markets to monetize grid and climate values
LOW PERCEIVED CONTRACTOR AND BUILDER VALUE	Like customers, contractors and builders do not see a clear value proposition. Contributing factors include: • Lack of incentives encouraging builders to construct carbon-free structures • Lack of training for builders and contractors • Lack of recognition for builders and contractors promoting building decarbonization • Lack of coordination and support for local government permitting offices • Lack of adequate measurement and valuation of GHG emissions • Lack of consumer demand
LOW AVAILABILITY	Building decarbonization solutions are not readily available. Contributing factors include: • Lack of adequate electrical paneling at many homes and businesses • Lack of relevant, supportive appliance standards • Lack of coordination at a national-level necessary to induce increased manufacturing
MISALIGNED POLICY	Existing policy and codes support an outdated view of the energy landscape in California that does not reflect existing GHG priorities. Contributing factors include: • Lack of alignment between the state's goals, utility incentives, policies, programs and metrics • Lack of a plan for transitioning away from California's legacy infrastructure in a responsible and cost-effective manner • Lack of support for local governments who would adopt reach codes

[26] *A Roadmap to Decarbonize California's Buildings.* Building Decarbonization Coalition. 2019. http://www.buildingdecarb.org/archived/a-roadmap-to-decarbonize-californias-buildings

Appendix C: Breakdown of Market Size for Unitary Water Heaters

California Market Size Estimates—New Construction

The annual new construction market can be expected to be 60,000 single-family units and 60,000 multifamily units statewide, given current figures and trends.[27]

California Market Size Estimates—Existing Construction

Based on the number of homes in each IOU territory,[28] using 2010 US Census data to divide those homes into single-family and multifamily and scaling up to current population,[29] and using the 2009 California Residential Appliance Saturation Study (RASS) to further divide the homes according to fuel type, following are the estimated number of residential water heaters currently installed in California (as of April 2021). Data for the Los Angeles Dept. of Water & Power (LADWP) and SMUD came from those utilities' own annual reports.

Note that the "CA total" for all three tables below is greater than the sum of the utilities, because not all California customers fall within these five territories. Some rows do not add directly, due to rounding of the totals.

TABLE A1: ESTIMATED CALIFORNIA WATER HEATER STOCK

	Existing single family homes (millions)						Existing multifamily homes (millions)					
	CA total	PG&E	SCE	SDG&E	LADWP	SMUD	CA total	PG&E	SCE	SDG&E	LADWP	SMUD
All homes	8.39	3.22	3.01	0.9	0.52	0.43	3.83	1.6	1.48	0.45	0.13	0.15
Gas	7.40	2.65	2.81	0.80	0.49	0.36	3.05	1.27	1.20	0.34	0.10	0.12
Propane	0.42	0.26	0.08	0.05	0.00	0.00	0.08	0.06	0.02	0.01	0.00	0.00
Electric	0.55	0.31	0.12	0.05	0.03	0.06	0.69	0.26	0.26	0.11	0.03	0.03

Using data from the 2009 RASS, the percentage of currently-installed water heaters that are gas, propane, and electric for each housing type and utility are as follows:

TABLE A2: PERCENTAGE OF EXISTING STOCK BY FUEL TYPE

	Percentage of existing single-family homes with each water heater type (%)						Percentage of existing multifamily homes with each water heater type (%)					
	CA total	PG&E	SCE	SDG&E	LADWP	SMUD	CA total	PG&E	SCE	SDG&E	LADWP	SMUD
Gas	88%	82%	93%	89%	95%	85%	80%	79%	81%	75%	80%	80%
Propane	5%	8%	3%	6%	0%	0%	2%	4%	1%	1%	0%	0%
Electric	7%	10%	4%	5%	5%	15%	18%	16%	18%	24%	19%	20%

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27 *Construction Permits.* State of California Department of Finance. 2021. https://www.dof.ca.gov/Forecasting/Economics/Indicators/Construction_Permits/

28 Rockzsfforde, Reagan. *Geospatial Analysis of California's Utility Services.* California Public Utilities Commission. 2016. https://www.cpuc.ca.gov/uploadedFiles/CPUC_Public_Website/Content/About_Us/Organization/Divisions/Policy_and_Planning/PPD_Work/PPD_Work_Products_(2014_forward)/PPD%20Utility%20Service%20Report.pdf

29 Note that this table assumes that each utility has the same percentage of single-family and multifamily homes, i.e., the California statewide percentage from the 2010 US Census.

Assuming that water heaters are replaced on average every 15 years, the total numbers of water heaters that can be expected to be purchased each year are shown below, broken down by the fuel type of the *existing* water heater. Note that these numbers assume that half of water heaters in existing multifamily buildings are central systems, and half are unitary. This report only addresses unitary water heaters. Also note that for simplicity, the table assumes that the percentage of single-family and multifamily households in each utility service area is the same.

TABLE A3: PROJECTED REPLACEMENT MARKET

	Number of existing single-family homes that are likely to replace a unitary water heater each year						Number of existing multifamily homes that are likely to replace a unitary water heater each year					
	CA total	**PG&E**	**SCE**	**SDG&E**	**LADWP**	**SMUD**	**CA total**	**PG&E**	**SCE**	**SDG&E**	**LADWP**	**SMUD**
Gas	493,400	176,400	187,000	53,100	32,800	24,000	101,600	42,300	39,900	11,300	3,500	4,000
Propane	28,100	17,100	5,200	3,600	100	0	2,600	2,000	600	200	0	0
Electric	36,700	20,700	8,300	3,000	1,700	4,000	22,900	8,600	8,800	3,500	800	1,000
Total	**558,200**	**214,200**	**200,500**	**59,700**	**34,600**	**28,000**	**127,100**	**52,900**	**49,300**	**15,000**	**4,300**	**5,000**

Appendix D: Snapshots of Successful Customer Program Webpages

The following snapshots were taken in November 2020 and reflect the rebate amounts and program details at the time the snapshot was taken. Program details and rebate amounts are subject to change; the snapshots are provided here as examples to supplement section 3.1. Section 3.1 also provides a summary of the attributes of these programs that have made them a success.

The SMUD rebate program offers up to $2,500 through qualified contractors.

FIGURE A3: SMUD REBATE PROGRAM

Source: SMUD.[30]

Heat Pump Water Heaters, rebates up to $2,500

Choosing a more efficient heat pump water heater can help you reduce your monthly water heating bills and lower your home's emissions from natural gas.

Use the SMUD Contractor Network to find a qualified contractor to install your heat pump water heater.

Let's get started!

Find a contractor

When you upgrade to a heat pump water heater, you may be eligible to join our PowerMinder pilot and receive a $150 incentive plus a monthly bill credit.

Learn more

Peninsula Clean Energy offers midstream rebates to Participating Contractors.

FIGURE A4: PENINSULA CLEAN ENERGY REBATES

Source: Peninsula Clean Energy.[31]

HPWH Rebates

Heat Pump Water Heater*	Peninsula Clean Energy	BayREN	Total**
Replace methane gas water heater (any size)	$1,500***	$1,000	$2,500
Replace electric resistance water heater (>60 gals size)	$500	$1,000	$1,500
Additional Bonus Incentives			
CARE/FERA customers	$1,000	$0	$1,000
Electrical panel upgrade to 100 amps	$1,500	$0	$1,500
Electrical panel upgrade to 200 amps	$750	$0	$750

*Heat pumps must have UEF of 3.1 or greater
**Combined rebates are not to exceed project costs
***Available until 9/30/2021

Qualifications:

For San Mateo County residents

Must use a **BayREN** Participating Contractor (see table)

Your BayREN Participating Contractor will submit the rebate application for you and will make sure that all available incentives are applied.

BayREN Home Energy Advisors are available to assist the customer throughout the process.

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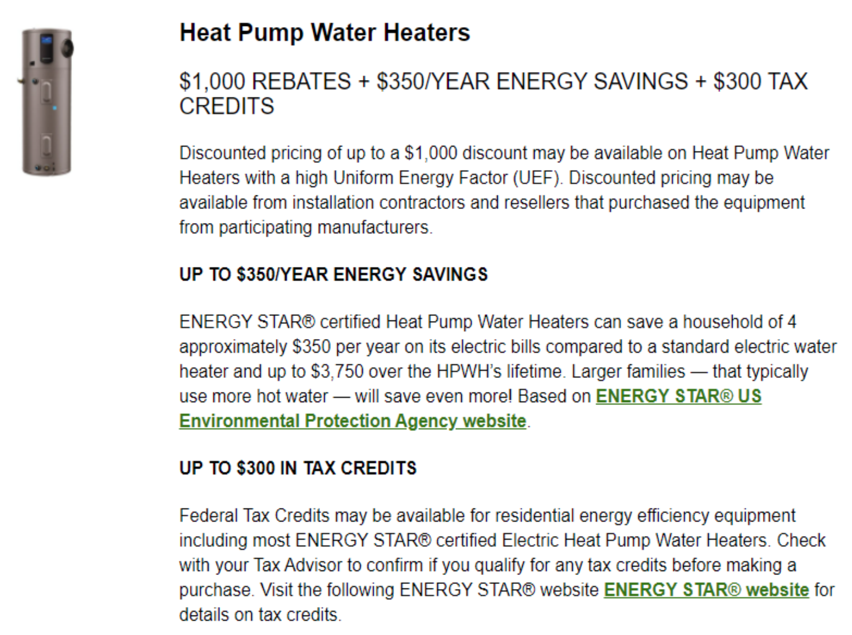
30 *Heat Pump Water Heaters, rebates up to $2,500.* Sacramento Municipal Utility District. 2021. https://www.smud.org/en/Rebates-and-Savings-Tips/Improve-Home-Efficiency/Heat-pump-water-heaters

31 *Heat pump water heater (HPWH).* Peninsula Clean Energy. 2021. https://www.peninsulacleanenergy.com/heat-pump-water-heater/

Southern California Edison offers up to $1,000 off HPWHs at retailers and through contractors:

FIGURE A5: SOUTHERN CALIFORNIA EDISON PROGRAM

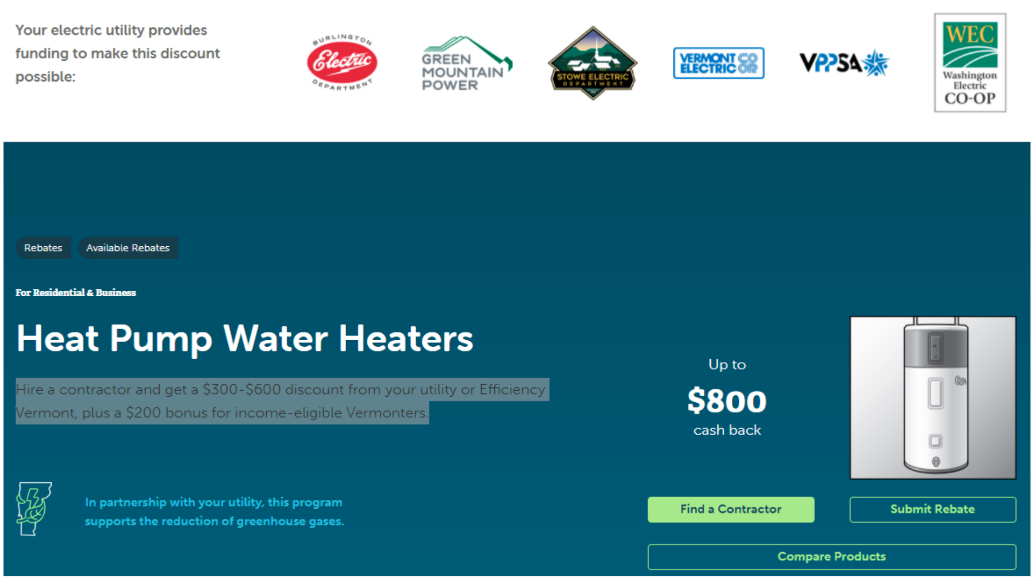
Source: SCE.[32]



Efficiency Vermont offers $300–$600 rebates from the customer's utility or from Efficiency Vermont, plus a $200 bonus for income-eligible Vermonters:

FIGURE A6: EFFICIENCY VERMONT PROGRAM

Source: Efficiency Vermont.[33]



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[32] *Current Rebates.* Southern California Edison. 2021. https://www.sce.com/residential/rebates-savings/rebates

[33] *Heat Pump Water Heaters.* Efficiency Vermont. 2021. https://www.efficiencyvermont.com/rebates/list/heat-pump-water-heaters

Efficiency Maine offers an instant rebate or mail-in rebate for HPWHs:

FIGURE A7: EFFICIENCY MAINE REBATE

Source: Efficiency Maine.[34]

Oregon residents receive an instant rebate from the retailer at the time of purchase.

FIGURE A8: ENERGY TRUST OF OREGON PROGRAM

Source: Energy Trust of Oregon.[35]

[34] *Water Heating Solutions.* Efficiency Maine. 2021. https://www.efficiencymaine.com/at-home/water-heating-solutions/

[35] *Retailers Offering Instant Discounts on Energy-Saving Water Heaters.* Energy Trust of Oregon. 2021. https://www.energytrust.org/residential/incentives/residential-instant-discounts/

Appendix E: Rationale for Questions Asked of Contractors to Collect Project Price Data

Rationale for Questions Included in the Scope Checklist

1. What was the total price charged to the customer by your company and your subs?

   Other work may have been done on site, but there's no way we could expect the prime to know what, or by whom. Answers would be inconsistent.

2. Did you obtain the permit for the customer?

   Permits are typically $90–$150, and getting the permit involves labor, so this is a major cost item. We are assuming that if the contractor obtains the permit, they also pay for it.

3. Did you provide the water heater and deliver it to the house?

   Either the water heater is provided by the contractor and they deliver it, or it's provided by the customer and the customer delivers it. To simplify the question, we are not considering other options.

4. Did you haul away the old water heater?

   This is a major cost element. We are assuming that if the contractor hauls away the water heater, they also pay the disposal fees.

5. What size of water heater was installed?

   This is a major cost element, and we don't know this from incentive paperwork.

6. Which subs worked with you on this project?

   Very often prime contractors are plumbers that employ electrical subs, or HVAC companies that employ plumbing subs.

7. Did you dismantle an existing flue or vent, or cap one off?

   Dismantling a flue is potentially a big cost because it may involve working on the roof, and/or asbestos. We don't currently know how commonly this is done.

8. Did you install a new service disconnect?

   Service disconnects only cost $10, but they involve additional labor that adds to the price.

9. Did you have to run new wiring?

   Any added wiring is a major cost. The question does not distinguish between surface wiring (in conduit) vs. wiring through the attic or crawl space, because many projects may involve *both*, and distinguishing between the two would make the question very complex.

10. Did you install a new electrical panel?

    An electrical panel costs $150–$200, with approximately a $50 increment for an outdoor panel over an indoor one. For outdoor panels, the contractor may also need to remove and replace the meter. There may be other unanticipated differences in labor for outdoor vs. indoor panels. Replacing a panel typically costs $1,000+, so this is a major cost element.

11. Did you replace any existing breakers (other than for the water heater)?

    The replacement of breakers is independent of the replacement of the panel, i.e., the breakers may be replaced without the panel being replaced, or vice-versa. The price for a complete set of new breakers is several hundred dollars, potentially over $1000.

12. Did you install a condensate drain?

    Condensate drains aren't necessarily installed with the HPWH—the customer may already have a condensate drain from a condensing gas water heater. But we believe that very few people are currently replacing condensing gas water heaters with HPWHs, and even if they are, they would still most likely need to heavily modify the condensate drain. However, we don't know what *type* of condensate drain they're installing, and flex pipe vs. rigid PVC may have price implications.

13. If yes, did the condensate drain need a pump?

    We believe that flexible condensate drains most likely also have pumps. Pumps are typically $50 and require an electrical connection and a mounting location.

14. If yes, where did the condensate drain to?

    The condensate can be drained to an existing indoor drain, or out via a pump. These options have significantly different price implications.

15. Did you install an expansion tank?

    Expansion tanks are required for all homes that have municipal water meters. Some homes already have them and some don't. The expansion tank costs around $30 and requires additional labor.

16. Did you have to replace or re-route copper or PEX pipes around the water heater?

    Some of the time, for instance with Bradford White WHs, the connectors are likely to be in the same place as the existing water heater, so no changes need to be made to the piping. Other times, for instance with Rheem WHs, changes are likely to be needed. The price of copper pipe and fittings is not insignificant, and it can be time-consuming to install.

17. Did you install a recirculating pump or on-demand pump?

    Both types of pump cost at least $300 and require some labor, so this is a major cost element. We believe that pumps are installed in 5%–10% of homes. Recirculating pumps require two hot pipes (out and return), whereas on-demand pumps bridge between the hot and cold pipes close to the fixture.

18. Did you install a thermostatic mixing valve?

    In a few cases, a thermostatic mixing valve may already have been present. If not, installation of one constitutes a significant cost, around $100 for the mixing valve itself, and unknown additional labor for installation.

19. Did you do any other work in the customer's home (excluding earthquake strapping)?

    This is potentially one of the biggest line items in the quote/invoice, because some customers have a significant amount of remodeling done around their water heater; for instance, existing piping may be re-routed, or sheetrock may be removed or added.

Rationale for Questions NOT Included in the Scope Checklist

20. What type of water heater was being replaced?

    We already know this from the rebate amount and the on-site photos. No sense in duplicating.

21. Did you add or replace flex lines?

    Flex lines are only $20 to $30 and require very little labor. Most of the time we expect they will be replaced, because they include rubber or silicone grommets that eventually fail.

22. Did you add or replace earthquake straps?

    Straps are only $15 and require very little labor. Most of the time we expect they will be re-used because they have no parts that fail.

23. Did you install a new stand?

    HPWHs do not need a stand, so we expect they will rarely be installed on one. A stand is around $40 and requires no labor.

24. Was the added wiring in conduit or not (e.g., through attic space or crawl space)?

    Many projects may involve both types of wiring, and distinguishing between the two would make the question very complex.

25. How many feet of new wiring did you add?

    The answer to this question wouldn't be actionable, because it would require customers to estimate how many feet of new wiring they need. In addition, the price would likely vary a lot depending on the routing of the wire.

26. Did you remove any asbestos?

    Asbestos can be a big added cost, but there are lots of other potentially large costs involved in any remodeling work, so this is already covered under the question "Did you do any other work in the customer's home?"