Adoption of Natural Gas Water Heating Technology: Research and Analysis of Trends

Project Number ET22SWG0001

Prepared by ICF for submission to Southern California Gas Company

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Abbreviations and Acronyms

Name	Abbreviation
2021 Potential and Goals Study	PG Study
American Council for an Energy Efficiency Economy	ACEEE
California Energy Commission	CEC
California Energy Data and Reporting System	CEDARS
Cost Effectiveness Tool	CET
Department of Energy	DOE
Electronic Technical Reference Manual	eTRM
Energy Efficiency	EE
Estimated Useful Life	EUL
Gas Emerging Technologies	GET
Gas Technologies Institute	GTI
Incremental Measure Cost	IMC
Investor-Owned Utility	IOU
Net to Gross	NTG
Northwest Energy Efficiency Alliance	NEEA
Program Administrator	PA
Technology Priority Map	TPM
U.S. Energy Information Administration	EIA
Utilization Technology Development	UTD
Water Heating Technology Table	WHTT

Executive Summary

The Gas Emerging Technologies (GET) program initiated a study to analyze and research natural gas water heating technology adoption trends in existing California investor-owned utilities (IOUs) energy efficiency (EE) incentive programs, perform market research to understand technology adoption drivers and barriers, and provide actionable recommendations to guide GET investment in future research activities. This project was initiated because, according to the 2021 EE Potential and Goals Study Results Viewer, water heating has the highest technical and economic potential within the gas energy sector when all sectors and end uses are considered (California Public Utilities Commission, 2021). Other studies also show that the market penetration of gas-fired water heaters with above federal minimum standard efficiencies is low even though there have been many advancements in the technology in this market in recent years (Northwest Energy Efficiency Alliance, 2021); (Brio, Gas Technologies Institute, 2019).

Project Goal: The goal of this study was to gather EE program participation and market data on energy efficient water heating technologies to provide an understanding of programmatic uptake and related drivers and barriers for these technologies.

Technology Description: The first task of this project looked at existing and emerging water heating technologies and summarized them in a Water Heating Technology Table (WHTT). Once that task was completed, this project focused on existing water heating technologies, which had a measure package required to claim savings. A parallel project (ET22SWG002) is looking at emerging water heating technologies.

Key Project Findings:

- SME interviews identified the high cost of efficient equipment, lack of awareness by customers, and lack of training for installers/maintenance personnel as the highest barriers impacting program participation.
- The most significant drivers increasing participation are independent verification of performance, improved performance, and environmental compliance.
- Despite the market barriers cited by SMEs, higher priced condensing and tankless water heaters have seen increased participation in EE programs over the last five (5) years with greater uptake since 2020. This can partially be attributed to increased incentives. Other contributing factors appear to be site specific installation requirements that impact installation costs by technology, and the valuation of space afforded to the customer by installing tankless technologies.

- Additional analysis was undertaken to understand impacts of Air Quality Management District (AQMD) requirements on customer adoption. Regulations for Ultra Low NO_x technologies were found to especially limit the participation of storage water heaters and drive end users to other technologies.
- Although the participation of condensing efficiency water heaters has increased, there is still a gap between the historical participation and the projected incremental achievable potential from the 2021 Potential and Goals Study for condensing efficiency water heaters.
- Water heating controls were identified as a group of measures which have potential but there are some gaps in the measure packages related to water heating controls measures preventing higher participation through EE programs.
- The Multifamily segment was identified as one with less participation whose barriers are documented elsewhere. More marketing to and education for multifamily customers, training for maintenance personnel and installers may help increase participation in this segment for water heating measures.

Key Project Recommendations: The Study Team offers the following recommendations based on the findings:

- Evaluate NO_x emissions of water heating systems when testing emerging water heaters.
- Investigate technologies which can scrub the emissions of existing water heaters to make them Ultra Low NO_x or zero NO_x.
- Explore potential low-cost Ultra Low NO_x burner technologies in partnership with manufacturers and other market stakeholders.
- Undertake additional studies of water heating controls technologies to address measure package gaps.
- Support marketing and training activities to increase participation of water heating controls and condensing water heaters and resolve issues that could lead to lack of persistence of energy savings.
- Identify workforce education and training needs to address installation and maintenance issues that cause potential persistence issues.

Introduction

Water heating is the largest end-user of natural gas in California and has the most energy savings potential. A review of the California Emerging Technologies Coordinating Council (ETCC) published reports for completed studies shows that not many studies have been completed in the last 5 years on gas-fired water heating in comparison to the electric water heating technologies, and no study has looked at the water heating market in California. Studies from other industry organizations indicate that the market penetration of gas-fired water heaters with above federal minimum standard efficiencies is low even though there have been many advancements in the technology in this market in recent years.

Background

According to the 2021 EE Potential and Goals Study Results Viewer, water heating has the highest technical and economic potential within the gas energy sector (California Public Utilities Commission, 2021) (298 – 339 MMtherm/year) when all sectors and end uses are considered. According to the 2019 Residential Appliance Saturation Study (RASS), water heating accounts for 59% of residential gas consumption per household (California Energy Commission, 2021). This has increased from only 48% of total gas consumption per household in the 2009 Residential Appliance Saturation Study.

Figure 1: 2021 Potential and Goals Results Viewer for Economic Potential of Gas Energy Savings in Scenario 2: TRC Reference

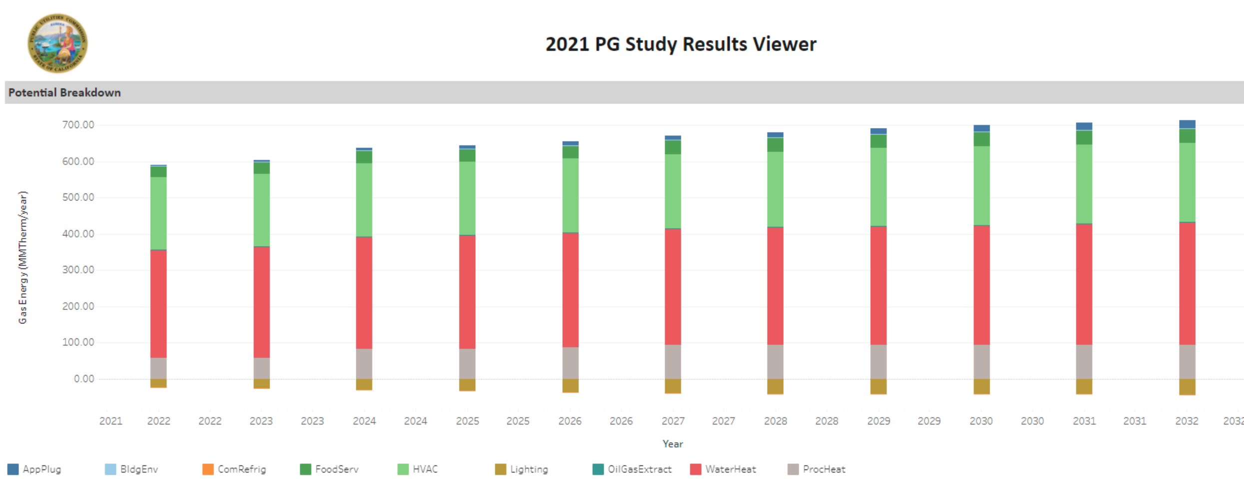
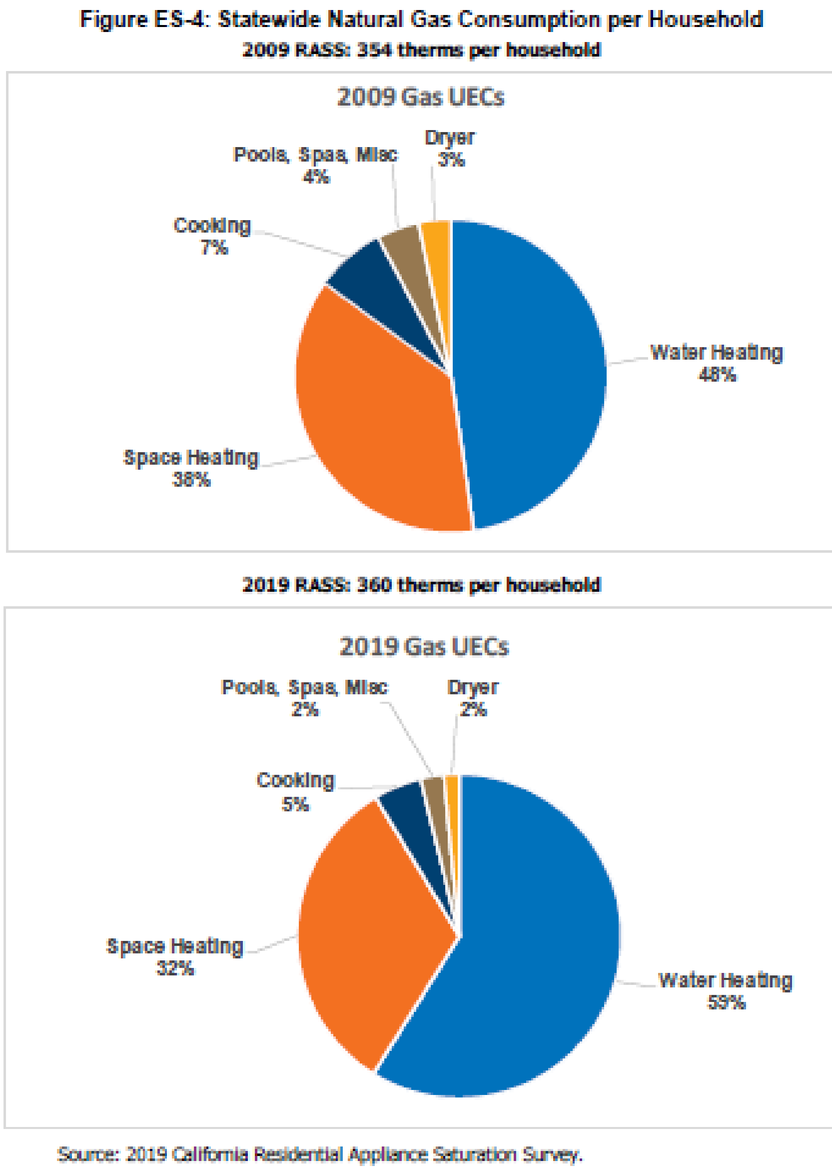


Figure 2: Statewide Natural Gas Consumption per Household from 2019 Residential Appliance Saturation Study Executive Summary (Page 9)



The gas water heating end-use has a high opportunity for therm savings and touches many customers across building types and customer types. A high-level glance at installed water heating measures from 2017 to 2021, relative to the potential, showed that there is room to drive much higher participation of efficient water heating measures. However, there are gaps in knowledge of what the barriers are to higher participation, what the market drivers are for water heating, what are the most promising efficient water heating measures, and how the Gas Emerging Technology (GET) program can prioritize and address barriers to higher participation.

Assessment Objectives

The goal of this study was to examine the current technology maturity status and EE program participation of commercially available gas-fired water heating technology in California to:

1) Create charts to assist GET program decision makers in understanding the water heating market, technologies, and market barriers
2) Identify level of successes for different water heating technologies in Investor-Owned Utility (IOU) EE programs
3) Identify opportunities and recommendations to drive higher participation of efficient water heating that are also attractive to end-use customers and Program Administrators

Water Heating Technologies

A water heating technology priority map (TPM) was created as part of GET non-project tasks. The TPM had technologies in various stages of development from initial concept to commercial availability. The TPM was a starting point but needed more information because there have been so many advances in the gas-fired water heating landscape since the last time a water heating TPM was created. The GET program scope includes increasing the participation of existing technologies as well as research on emerging technologies. The TPM had gaps in information about emerging technology water heaters (in this study, water heaters that are not yet commercially available are referred to as "emerging technology (ET) water heaters") and it did not give a good picture about historical participation or current market barriers/drivers of existing water heating technologies. Since water heating is the largest gas end use in California, historical participation and market information on existing water heaters is valuable for two reasons:

1) It will help the GET program boost EE program customer participation of existing water heating technologies
2) It gives a better idea of barriers and drivers that ET water heaters might face because high-efficiency water heaters that already exist in EE program share similar attributes to ET water heaters, such as:
    a. Condensing and ET water heaters have high first costs,
    b. Tankless and some ET water heaters have different physical sizes and shapes compared to the incumbent tank-type technology, and
    c. Solar thermal and some ET water heaters require outside installation and additional space to install

Therefore, a more detailed Water Heating Technology Table (WHTT) was created as part of this project which expands upon information that was in the water heating TPM. The WHTT will be used to update the TPM.

Water Heating Technology Priority Map

As stated above, the TPM includes technologies in various stages of development from initial concept to commercial availability and includes both water heaters and controls. Many technologies on the TPM already have measure packages and are available in EE programs while others were in various stages of research and development. Pertinent questions that the TPM does not answer and are of interest to the GET program include:

- What is the historical participation of condensing efficiency vs. non-condensing efficiency water heaters?
- What is the historical participation of tankless vs. storage water heaters?
- What drivers and barriers exist in the California specific water heating market?
- How to boost participation of solar thermal water heaters?[1]
- How to boost participation of gas-fired absorption heat pump water heaters?[2]
- How GET can boost low-participation-rated water heating technologies?
- Who are the ET water heater manufacturers?
- What is the status of each ET water heater, including its market and EE program readiness?
- What are the ET water heater technologies available?
- What is the TPM priority of each water heating technology?

Water Heating Technology Table

Through primary and secondary research, the water heating TPM was expanded to create a Water Heating Technology Table (WHTT). This includes commercially available technologies as well as those in research and development. The WHTT includes the following fields for all technologies.

[1] Solar thermal water heaters have been available for some time under the California Solar Initiative (CSI) program and were added to Energy Efficiency programs when CSI sunset. In 2022 two (2) measure packages were created for solar thermal water heaters: SWWH032 and SWWH034

[2] In 2022, a measure package for gas-fired absorption heat pump water heaters serving domestic hot water in a multifamily building was created: SWWH033

- Description of the technology
- Technology Family (Controls, Water-Heating Appliance, Water-Heating Generator, Distribution, Insulation, Appurtenances, Other)
- Technology Sub-Group (See the TPM for more details)
- Sector (Single-Family Residential, Multi-Family Residential, Commercial)
- Status of technology (is the technology commercially available or in development, are there proven energy savings, how many manufacturers have products, etc.)
- Manufacturers of technology (if any exist)
- Product Readiness
- Market Readiness
- EE Program Readiness
- Key barriers (if readily available)
- Customer feedback (if readily available)
- Priority (high, medium, low)

Over 30 documents were reviewed to create the WHTT including studies from the following organizations

- IOU ET programs from previous program cycles
- California Energy Commission (CEC)
- Consortium for Energy Efficiency (CEE)
- Gas Technologies Institute (GTI)
- Northwest Energy Efficiency Alliance (NEEA)
- Department of Energy (DOE)
- American Council for an Energy-Efficient Economy (ACEEE)
- Utilization Technology Development (UTD)

Additional information was gathered from subject matter expert (SME) interviews, manufacturer websites, and other websites with information about these technologies. The information was condensed into a table in Microsoft Excel.

The following information from the WHTT is presented in Table 1: technology family, technology sub-group, sector, description, status, priority, product readiness, market readiness, and EE program readiness. Not all technologies had information for key barriers or customer feedback for all technologies, so that information is presented in

Table *2* for only those technologies which had information in those two categories.

Once the WHTT was created, the emerging water heating technologies were further investigated in a parallel project (ET22SWG002) which focuses exclusively on ET water heaters. Further research in this project (ET22SWG0001) focuses on existing water heating technologies that have a measure package.[3]

[3] The exception is gas-fired absorption heat pump water heaters which have a measure package (SWWH033) but have seen no participation and have not participated in any other California incentive program. Solar thermal water heaters, on the other hand, were previously installed in CSI so they were considered to be existing water heating technologies even though they were new to EE programs.

Table 1: Water Heating Technology Table Part 1

Technology Name & Sector	Description	Current Status	Priority	Product Readiness	Market Readiness	Program Readiness
Programmable Water Heater Controls-Res	Programmable controls that save water heating energy by reducing temperature setpoint of hot water during low-demand times. (Single Family)	One (1) manufacturer with commercially available controller that has been on the market for many years.	Medium	Level 5: Fully Validated	Level 4: Growing	Level 2: Exploratory
Machine Learning Water Heating Controls-Res	Machine learning controls that save water heating energy by reducing temperature setpoint of hot water during low-demand times. Single Family	One (1) product commercially available but with little energy savings	Medium	Level 3: Lab Validation	Level 3: Niche Markets	Level 2: Exploratory
Water Heater Controls for Central Water Heaters-Res & Com	Controller that sequences and/or optimizes multiple water heaters for Multi-Family & Commercial	No market-ready plug-and-play commercial controllers that can sequence and optimize multiple water heaters/boilers and no known controllers in R&D.	Low	N/A	N/A	N/A
Boiler Controls for Central Domestic Hot Water Boilers-Res & Com	Programmable boiler controller that saves water heating energy by reducing the temperature setpoint of the DHW storage tank. Multifamily & Commercial.	Many commercially available units	Medium	Level 5: Fully Validated	Level 5: Mature	Level 5: Ready
Smart Pump-Res	A high-performance circulator pump which is a properly sized, high efficiency ECM pump for DHW recirculation with variable speed controls.	Multiple commercially available units.	Medium	Level 5: Fully Validated	Level 4: Growing	Level 5: Ready

Technology Name & Sector	Description	Current Status	Priority	Product Readiness	Market Readiness	Program Readiness
Demand Control for Central Recirculation Pumps-Res & Com	VFD or ON/OFF Controls for recirculation pumps in central DHW systems that reduce flow rate of recirculated water AND reduce average hot water loop temperature.	Multiple commercially available units.	Low	Level 5: Fully Validated	Level 5: Mature	Level 5: Ready
Recirculation Pump Timer-Com	Timer that turns off recirculation pump in a central DHW system when building is closed.	Multiple commercially available units.	Low	Level 5: Fully Validated	Level 5: Mature	Level 5: Ready
On-Demand Hot Water Circulator-Res	On-Demand hot water circulator. User activates a pump under a fixture which then pulls hot water from water heater and sends cooled-off water from the pipes back to the water heater.	Multiple commercially available units.	Medium	Level 5: Fully Validated	Level 5: Mature	Level 5: Ready
Hot Water Pipe Insulation-Res	Insulation for hot water pipes to minimize heat loss from water heater to fixtures	Understood and widely used. There is no known opportunity for a more efficient or cheaper insulation.	Low	Level 5: Fully Validated	Level 5: Mature	Level 5: Ready
Residential Gas Engine Heat Pump Water Heater-Res	Heat pump water heater utilizing **mechanical** output of a gas-driven internal combustion engine to drive a vapor compression cycle (Single Family)	No units commercially available or in development.	N/A	N/A	N/A	N/A

Technology Name & Sector	Description	Current Status	Priority	Product Readiness	Market Readiness	Program Readiness
Commercial Gas Engine Heat Pump Water Heater-Com	Heat pump water heater utilizing **mechanical** output of a gas-driven internal combustion engine to drive a vapor compression cycle (Multifamily & Commercial)	One (1) system commercially available.	High	Level 5: Fully Validated	Level 3: Niche Markets	Level 2: Exploratory
Residential Vapor Absorption Heat Pump Water Heater-Res	Heat pump water heater utilizing **thermal output** by combustion of natural gas to drive a thermodynamic absorption cycle with Ammonia/water solution or Lithium-Bromide/water solution (Single-Family)	Three (3) manufacturers have pre-commercialized units. Units are in various stages of development but at least one manufacturer is expected to start field testing in 2023[66].	Medium	Level 4: Limited Field Validation	Level 1: Pre-Commercialization	Level 1: Not ready
Commercial Vapor Absorption Heat Pump Water Heater-Com	Heat pump water heater utilizing **thermal output** by combustion of natural gas to drive a thermodynamic absorption cycle with Ammonia/water solution or Lithium-Bromide/water solution (Multifamily & Commercial)	(1) Product commercially available (1) Product planned to launch in 2023	High	Level 5: Fully Validated	Level 3: Niche Markets	Level 3: Preliminary Pilots
Residential Vapor Adsorption Heat Pump Water Heater-Res	Heat pump water heater utilizing **thermal output** from exothermic and endothermic reactions with a sorbent and solution. Sorbents can be zeolite or silica gel. (Single-Family)	Two (2) manufacturers developing units. One manufacturer's Prototype will be ready for field testing 2023.	High	Level 2: Engineering Validation	Level 1: Pre-Commercialization	Level 1: Not ready

Technology Name & Sector	Description	Current Status	Priority	Product Readiness	Market Readiness	Program Readiness
Commercial Vapor Adsorption Heat Pump Water Heater-Com	Heat pump water heater utilizing **thermal output** from exothermic and endothermic reactions with a sorbent and solution. Sorbents can be zeolite or silica gel. (Multifamily & Commercial)	No products on market or in development	Low	N/A	N/A	N/A
Thermal Compression Heat Pump Water Heater-Res	Thermal energy provided by the combustion of natural gas powers a thermodynamic compression cycle (Stirling Cycle). Helium is the working fluid.	There is no water heating only product on the market or in development.	Low	N/A	N/A	N/A
Ejector Sorption Assisted Heat Pump Water Heater-Res	Thermal energy provided by the combustion of natural gas drives an ejector heat pump system assisted by sorption to increase COP. Ejector replaces the compressor in a vapor-compression cycle[18].	One (1) product in R&D phase with DOE and other partners until 2023[2,19]	Low	Level 1: Unvalidated	Level 1: Pre-Commercialization	Level 1: Not ready
High Efficiency Boilers for Water Heating-Com	High Efficiency Boilers for Water Heating in Multifamily & Commercial applications	Multiple commercially available products on the market with no known emerging technology opportunity at this time.	Medium	Level 5: Fully Validated	Level 5: Mature	Level 5: Ready

Technology Name & Sector	Description	Current Status	Priority	Product Readiness	Market Readiness	Program Readiness
Self-Powered High Two-Phase Thermo-Syphoning Residential Storage Water Heaters-Res	Competitive cost higher efficiency (non-condensing) tank water heater utilizing Two-Phase Thermo-Syphoning Technology	Prototype of a self-powered higher efficiency storage tank water heater under development utilizing Two-phase Thermo-Syphoning technology and ultra-low-power gas heater control	Medium	Level 2: Engineering Validation	Level 1: Pre-Commercialization	Level 1: Not ready
Non-Powered Damper Commercial Storage Water Heaters-Res	Competitive cost higher efficiency tank water heater with non-powered damper	At least one (1) commercially available water heater. However, it does not meet Ultra-Low NOx requirements of many California Air Quality Management District's/Air Pollution Control Districts.	Low	Level 4: Limited Field Validation	Level 5: Mature	Level 2: Exploratory
Condensing Storage Water Heaters-Res&Com	Storage water heater that recovers heat from condensed steam inside the unit to increase efficiency	Multiple commercially available products on the market with no known emerging technology opportunity at this time.	Low	Level 5: Fully Validated	Level 5: Mature	Level 5: Ready
Non-Condensing Tankless Water Heaters-Res&Com	Water heater which provides on-demand hot water with no storage capability.	Multiple commercially available products on the market with no known emerging technology opportunity at this time.	Low	Level 5: Fully Validated	Level 5: Mature	Level 5: Ready

Technology Name & Sector	Description	Current Status	Priority	Product Readiness	Market Readiness	Program Readiness
Condensing Tankless Water Heaters-Res&Com	Water heater which provides on-demand hot water with no storage capability AND recovers heat from condensed liquids from condensed steam inside unit.	Multiple commercially available products on the market with no known emerging technology opportunity at this time.	Low	Level 5: Fully Validated	Level 5: Mature	Level 5: Ready
Dual Fuel Hot water Heaters-Res&Com	Water heaters that use gas along with solar thermal collectors	Multiple commercially available products This was under the California Solar Initiative-Thermal (CSI-Thermal) program and has been transitioned to the EE programs.	Medium	Level 5: Fully Validated	Level 3: Niche Markets	Level 2: Exploratory
Pool Water Heaters-Res&Com	Pool Water Heating	Multiple commercially available products on the market with no known emerging technology opportunity at this time.	Medium	Level 5: Fully Validated	Level 5: Mature	Level 5: Ready
Residential Wastewater Heat Recovery HX (Water Pre Heat)-Res	Utilizing a heat exchanger to use waste hot drain water to pre heat water going into a water heater (Single-family)	Multiple commercially available products.	Low	Level 4: Limited Field Validation	Level 3: Niche Markets	Level 1: Not ready
Commercial or Multifamily Wastewater Heat Recovery HX (Water Pre Heat)-Com	Utilizing a heat exchanger to use waste heat to pre heat water going into a water heater (Multifamily & Commercial)	Some products available. Drain water recovery in multifamily and commercial need of a field study to study pressure drop and congealing oils.	Low	Level 4: Limited Field Validation	Level 3: Niche Markets	Level 1: Not ready

Technology Name & Sector	Description	Current Status	Priority	Product Readiness	Market Readiness	Program Readiness
Equipment Specific Greywater Recycling with Heat Recovery-Res	Means to collect grey water and recover heat from it for pre-heating hot water for an individual piece of equipment or sink/shower	No known products commercially available in United States. Some products available in other markets but at a high cost. Early market challenges of uncleanliness stigma and updated health and safety standards still unaddressed	Medium	Level 1: Unvalidated	Level 1: Pre-Commercialization	Level 1: Not ready
Residential Flow Restrictors-Res	Faucet hot water limiters that save water and thermal energy.	Multiple commercially available products on the market with no known emerging technology opportunity at this time.	Low	Level 5: Fully Validated	Level 5: Mature	Level 5: Ready
Commercial Flow Restrictors-Com	Faucet hot water limiters that save water and thermal energy.	Multiple commercially available products on the market with no known emerging technology opportunity at this time.	Low	Level 5: Fully Validated	Level 5: Mature	Level 5: Ready
Residential Gas-Engine Heat Pump Combi System-Res	Heat pump utilizing **mechanical output** of a gas-driven internal combustion engine to drive a vapor compression cycle to provide 2+ of the following 1. Space heating 2. Space cooling 3. DHW heating	No products in the works or commercially available. There are units that provide some combination of space heating, space cooling, and DHW heating, but they also provide power.	Low	N/A	N/A	N/A

Technology Name & Sector	Description	Current Status	Priority	Product Readiness	Market Readiness	Program Readiness
Commercial Gas-engine Heat Pump Combi System-Com	Heat pump utilizing **mechanical output** of a gas-driven internal combustion engine to drive a vapor compression cycle to provide 2+ of the following 1. Space heating 2. Space cooling 3. DHW heating	At least one (1) product is commercially available.	High	Level 5: Fully Validated	Level 3: Niche Markets	Level 2: Exploratory
Residential Vapor Absorption Heat Pump Combi System-Res	Heat pump water heater utilizing **thermal output** by combustion of natural gas to drive a thermodynamic absorption cycle. Uses Ammonia/water solution or Lithium-Bromide/water solution. Provides 2+ of the following: 1. Space heating 2. Space cooling 3. DHW heating	Three (3) manufacturers have pre-commercialized units. Units are in various stages of development but at least one manufacturer is expected to start field testing in 2023[66].	Medium	Level 2: Engineering Validation	Level 1: Pre-Commercialization	Level 1: Not ready
Commercial Vapor Absorption Heat Pump Combi System-Com	Heat pump water heater utilizing **thermal output** by combustion of natural gas to drive a thermodynamic absorption cycle. Uses Ammonia/water solution or Lithium-Bromide/water solution. Provides 2+ of the following: 1. Space heating 2. Space cooling 3. DHW heating	(1) Product commercially available (1) Product planned to launch in 2023	High	Level 5: Fully Validated	Level 2: Limited Availability	Level 3: Preliminary Pilots

Technology Name & Sector	Description	Current Status	Priority	Product Readiness	Market Readiness	Program Readiness
Residential Vapor Adsorption Heat Pump Combi System-Res	Heat pump utilizing **thermal output** from exothermic and endothermic reactions with a sorbent and solution. Sorbents can be zeolite or silica gel. Provides 2+ of the following: 1. Space heating 2. Space cooling 3. DHW heating	No known units commercially available or in R&D. Three (3) units were previously in development or available commercially outside the USA but have since stopped development.	Low	Level 2: Engineering Validation	Level 1: Pre-Commercialization	Level 1: Not ready
Commercial Vapor Adsorption Heat Pump Combi System-Com	Heat pump utilizing **thermal output** from exothermic and endothermic reactions with a sorbent and solution. Sorbents can be zeolite or silica gel. Provides 2+ of the following: 1. Space heating 2. Space cooling 3. DHW heating	No known units available or under development for North America. One (1) European manufacturer participated in field trial in EU[11].	Low	Level 4: Limited Field Validation	Level 2: Limited Availability	Level 1: Not ready
Thermal Compression Heat Pump Combi System-Res&Com	Thermal energy provided by the combustion of natural gas powers a thermodynamic compression cycle. Helium is the working fluid. Provides 2+ of the following: 1. Space heating 2. Space cooling 3. DHW heating	One unit undergoing field testing. One (1) unit was commercially available but had reliability issues, so it is not currently being manufactured	High	Level 3: Lab Validation	Level 1: Pre-Commercialization	Level 1: Not ready

Technology Name & Sector	Description	Current Status	Priority	Product Readiness	Market Readiness	Program Readiness
Combination Space and Water Heating System Controls – Res&Com	Controls for equipment that provides heating and hot water using gas-burner.	Manufacturers and other organizations working on a controller to provide adequate space heating when hot water is also required	Medium	Level 3: Lab Validation	Level 1: Pre-Commercialization	Level 1: Not ready

Table 2: Water Heating Technology Table Part 2: Key Barriers and Customer Feedback

Technology Name & Sector	Key Barriers	Customer Feedback
Programmable Water Heater Controls-Res	1. Various controllers exist and various hot water heaters with integrated control exist, but many are not cross-compatible with other controllers/platforms. 2. Limited savings potential in RES applications.	
Machine Learning Water Heating Controls-Res	1. Low energy savings (1%-10%) 2. Payback period varies significantly	1. There is a need for better controls for water heaters and this can be an incremental step
Boiler Controls for Central Domestic Hot Water Boilers-Res & Com	1. There is a need for workforce education & training to ensure persistence of energy savings	
Smart Pump-Res	1. Existing measure package does not include water heater energy savings	
Demand Control for Central Recirculation Pumps-Res&Com	1. There is a need for workforce education & training to ensure persistence of energy savings	
Recirculation Pump Timer-Com	1. Required by Title 24 for new buildings, additions to existing buildings, and alterations to existing buildings	
On-Demand Hot Water Circulator-Res	1. This technology saves water, but it is unclear how much energy it saves making payback and Total Resource Cost (TRC) unclear.	
Hot Water Pipe Insulation-Res	1. Required by Title 24 for new buildings, additions to existing buildings, and alterations to existing buildings	

Technology Name & Sector	Key Barriers	Customer Feedback
Commercial Gas Engine Heat Pump Water Heater-Com	1. Customers not aware of technology 2. Customers not aware that they can decarbonize with these gas-fired units 3. High ICE maintenance requirements and costs that decrease overall cost savings 4. High purchase and installation price 5. More complex than a simple boiler 6. Performance degrades as Hot water supply temperature increases and ambient temperature decreases 7. Limited to facilities with large DHW use like very large nursing homes, hospitals, or hotels with on-site laundry[8] 8. Products not regulated now, but with some market momentum, AQMD may regulate it	1. Good product where reliability is an issue 2. Good product where there is no electrical service 3. Product comes with emission control system that meets AQMD standards 4. Better performance that standard water heaters
Residential Vapor Absorption Heat Pump Water Heater-Res	1. Units not commercially available 2. Need additional testing 3. Cost of units higher than most customers expect[62] 4. Units require power 5. Customers perceive units as "big" unlike tankless which are perceived as "space saving" and "aesthetically pleasing"[62] 6. Recharge time of unit perceived less favorably than tankless[62] 7. Customers skeptical about cost and payback[62]	1. Low cost of ownership over time 2. Affordable maintenance cost 3. 10-year warranty 4. Price perceived as between storage tank and tankless 5. Perceived to be environmentally friendly 6. Better performance that standard water heaters
Commercial Vapor Absorption Heat Pump Water Heater-Com	1. Customers not aware of technology 2. Customers not aware that they can decarbonize with these gas-fired units 3. High cost of systems relative to existing tankless or gas storage	1. Better performance that standard water heaters
Residential Vapor Adsorption Heat Pump Water Heater-Res	1. Adsorption systems typically have low power density, large size, high cost, and complex installation.	1. One (1) unit targeted to be a drop-in replacement with cost similar to other condensing efficiency water heaters.

Technology Name & Sector	Key Barriers	Customer Feedback
Ejector Sorption Assisted Heat Pump Water Heater-Res & Commercial	1. Performance of system is unvalidated	
High Efficiency Boilers for Water Heating-Com	1. High incremental cost of condensing efficiency equipment 2. Select installations require costly venting retrofits and drain retrofits due to condensate	
Non-Powered Damper Commercial Storage Water Heaters-Res	1. Doesn't meet AQMD requirements for most populated areas in California 2. Low awareness of this "in-between" technology among contractors and homeowners.	
Condensing Storage Water Heaters-Res & Com	1. High incremental cost for condensing products 2. Select installations require costly venting retrofits and drain retrofits due to condensate	
Non-Condensing Tankless Water Heaters-Res & Com	1. Installation may require relocation of electrical outlet which increases overall cost 2. Installation may require larger gas line which increases overall cost	1. Perceived unlimited supply of hot water 2. Takes up less space than storage water heater counter part
Condensing Tankless Water Heaters-Res&Com	1. Installation may require relocation of electrical outlet which increases overall cost 2. High incremental cost for condensing products 3. Select installations require costly venting retrofits and drain retrofits due to condensate	1. Perceived unlimited supply of hot water 2. Takes up less space than storage water heater counter part
Dual Fuel Hot water Heaters-Res & Com	1. High incremental costs 2. Added complexity 3. Sizing and controls needed to integrate multiple units	
Pool Water Heaters-Res&Com	1. Cost concerns 2. Disparate savings opportunities	

Technology Name & Sector	Key Barriers	Customer Feedback
Residential Wastewater Heat Recovery HX (Water Pre Heat)-Res	1. Vertical space requirement for vertical systems (3-5 feet) which is not always feasible 2. Invasive retrofit to install in existing home for little savings potential 3. Low energy savings for single-family homes	
Commercial or Multifamily Wastewater Heat Recovery HX (Water Pre Heat)-Com	1. High costs of equipment and low cost of gas make paybacks for heat recovery HVAC units attractive mostly in hot/dry climates with large hot water usage.[47,51] 2. Horizontal drain water recovery units have concerns with congealing oils and pressure drop across HX	
Equipment Specific Greywater Recycling with Heat Recovery-Res	1. Uncleanliness stigma 2 High cost of nascent technologies 3. Potential for fuel switching (re-heat often done with electric resistance heaters) 4. Heat exchanger clogging a key concern for dirty waste-air heat sources (e.g., clogging from link in commercial laundry) 5. Space constraints and complexity a barrier in food service 6. Health and Safety standards for shower water recycling non-existent	
Residential Flow Restrictors-Res	1. Further reductions in flow rates likely to generate pushback due to poor performance	
Commercial Flow Restrictors-Com	1. Commercial sinks often need high flow rates (e.g., utility sinks) so reducing flow rates is unlikely to be acceptable - need alternative approaches	

Technology Name & Sector	Key Barriers	Customer Feedback
Commercial Gas-engine Heat Pump Combi System-Com	1. Customers not aware of technology 2. Customers not aware that they can decarbonize with these gas-fired units 3. High ICE maintenance requirements and costs that decrease overall cost savings 4. High purchase and installation price 5. More complex than a simple boiler 6. Performance degrades as Hot water supply temperature increases and ambient temperature decreases 7. Limited to facilities with large DHW use like very large nursing homes, hospitals, or hotels with on-site laundry[8] 8. Products not regulated now, but with some market momentum, AQMD may regulate it	1. Good product where reliability is an issue 2. Good product where there is no electrical service 3. Product comes with emission control system that meets AQMD standards 4. Better performance that standard water heaters
Residential Vapor Absorption Heat Pump Combi System-Res	1. Combi system and hydronic heating options are not popular or well known in CA[57] 2. Need workforce training to support installation and service[57] 3. High cost - needs EE incentives[57] 4. higher cost/complexity than incumbent technologies 5. Fuel switching is a concern.	1. Better performance that standard water heaters 2. Can provide water heating & space heating
Commercial Vapor Absorption Heat Pump Combi System-Com	1. Customers not aware of technology 2. Customers not aware that they can decarbonize with these gas-fired units 3. High cost of systems relative to existing tankless or gas storage 4. Limits on supply water temperature and return water temperature 5. Potential for complex site integration 6. Need for training of the workforce to install and maintain 7.When system providing space cooling, small net electricity increase coming from the electricity for the GHP pumps and fans that is not completely offset by A/C savings.	1. Better performance that standard water heaters 2. Can provide water heating & space heating

Technology Name & Sector	Key Barriers	Customer Feedback
Residential Vapor Adsorption Heat Pump Combi System-Res	1. Adsorption systems typically have low power density, large size, high cost, and complex installation.	
Commercial Vapor Adsorption Heat Pump Combi System-Com	1. Adsorption systems typically have low power density, large size, high cost, and complex installation.	
Residential Thermal Compression Heat Pump Combi System-Res&Com	1. Customers not aware of technology 2. Customers not aware that they can decarbonize with these gas-fired units 3. High cost of systems relative to existing tankless or gas storage	1. Better performance that standard water heaters 2. Can provide water heating & space heating 3. Units being designed to be "hydrogen ready"
Combination Space and Water Heating System Controls -Res&Com	1. When condensing water heater introduced, introducing adequate space heating can be a challenge, lab studies ongoing on a new controller to address this issue. 2. Customers hesitant to replace two pieces of equipment when only one fails.	

Subject Matter Expert Interviews

During initial scanning and screening, no recent water heating market studies specific to California could be found. Market information is important because it affects participation of technologies in EE programs. Therefore, subject matter experts (SMEs) in water heating were contacted to understand:

- Market availability of emerging technologies
- Ease of adoption/use of identified emerging technologies
- Drivers and market barriers
- Installation and commissioning costs

This SME interview effort was done in conjunction with a parallel project (ET22SWG002).

Target Audience

SMEs were interviewed across multiple categories, including various water heating manufacturers (MFG), technical experts (TE), installers (INSTR), and distributors (DIST), to characterize the gas-fired water heating market. Experts were recruited from the following sources:

- ACEEE Hot Water Forum presenters
- Statewide Midstream Water Heating participation distributor list (Statewide Midstream Water Heating Program, 2022)
- South Coast Air Quality Management District List of Certified Units Pursuant to Rule 1146.2 & South Coast Air Quality Management District List of Certified Units Pursuant to Rule 1121 (which both contained contact information for certified units) (South Coast Air Quality Management District, 2022), (South Coast Air Quality Management District, 2022)
- Previous professional relationships with the GET team

Survey Questionnaire

The survey questionnaire was divided into two categories: technology participation drivers and technology participation barriers. The questions included the perspective of the SME, i.e., manufacturer, contractor, distributor, and the end-user. The questions used for the survey can be found in Appendix I.

SME Responses

The survey responses were recorded using a Five-Point Likert Scaling system to maintain consistency and provide quantifiable answers for statistical analysis. The scaling system is based on the importance of the specific driver or barrier being questioned. Some questions do not apply to all respondents, such as manufacturing-related questions for contractors, distributors, or technical experts, which are voided. The average, standard deviation (SD), and coefficient of variations are included at the bottom for later analysis. SME interviews for this study were conducted at the same time as the parallel project ET22SWG002. Table 3 and Table 4 summarize the responses from all SMEs interviewed. The information on market barriers and drivers and any relevant customer feedback was incorporated into the WHTT and is presented in

Table 2.

Table 3: Technology Participation Driver SME Responses

		Technology Participation Drivers															
No.	**Type**	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	**Q11**	**Q12**	**Q13**	**Q14**	**Q15**	**Q16**
1	MFG	4	3	2	3	2	1	4	2	3	4	5	5	4	4	3	3
2	MFG	5	5	5	2	2	2	2	2	2	5	5	4	4	5	4	2
3	MFG	5	1	2	5	1	4	2	3	3	2	2	4	3	5	5	3
4	MFG	3	3	3	5	–	4	4	3	4	4	4	5	4	4	5	4
5	MFG	5	3	3	5	5	5	4	4	2	4	5	5	3	3	5	5
6	MFG	4	4	3	5	5	4	3	2	4	5	–	5	4	5	5	5
7	MFG	4	2	2	5	5	3	4	1	2	5	4	5	5	4	3	3
8	TE	5	2	2	5	5	–	5	3	5	5	5	5	5	5	5	5
9	TE	4	2	2	5	–	–	2	–	–	5	–	–	3	5	3	3
10	INSTR	3	2	3	4	3	–	4	4	3	5	4	–	5	5	5	3
11	INSTR	5	2	3	5	4	–	4	1	4	5	5	5	4	4	4	3
12	INSTR	5	2	2	5	5	–	4	5	2	5	5	–	3	4	5	5
13	INSTR	3	2	2	4	4	–	2	2	3	3	5	–	3	2	5	–
14	INSTR	4	2	2	4	2	–	4	4	2	4	4	–	3	3	4	–
15	INSTR	5	4	4	3	4	–	5	3	3	4	1	–	4	4	5	–
16	DIST	5	5	2	5	5	–	2	5	4	5	3	4	4	3	5	3
Average:		4.3	2.7	2.5	4.5	3.7	3.3	3.3	2.9	3.1	4.4	4.3	4.7	3.8	4.1	4.4	3.6
STD DEV:		0.8	1.2	0.8	0.9	1.5	1.4	1.0	1.3	1.0	0.9	0.9	0.5	0.8	1.0	0.8	1.0
COV:		0.2	0.39	0.25	0.22	0.35	0.26	0.32	0.43	0.31	0.2	0.31	0.1	0.2	0.23	0.18	0.32

Table 4: Technology Participation Barrier SME Responses

		Technology Participation Barriers														
No.	**Type**	**Q17**	**Q18**	**Q19**	**Q20**	**Q21**	**Q22**	**Q23**	**Q24**	**Q25**	**Q26**	**Q27**	**Q28**	**Q29**	**Q30**	**Q31**
1	MFG	5	5	3	5	4	4	4	3	4	5	2	2	–	–	–
2	MFG	4	4	4	5	1	2	5	3	1	4	2	1	–	–	–
3	MFG	5	2	4	4	3	4	4	2	4	4	2	1	–	–	–
4	MFG	4	3	3	3	3	4	4	4	3	2	2	2	4	3	3
5	MFG	4	2	3	4	3	4	4	2	3	3	2	2	3	3	3
6	MFG	5	4	4	4	5	4	5	3	5	4	3	5	5	4	3
7	MFG	4	1	1	5	4	5	5	3	5	5	1	1	4	4	5
8	TE	5	5	5	2	4	1	5	2	1	5	1	1	–	–	–
9	TE	2	2	3	5	3	3	4	4	3	–	–	–	2	–	–
10	INSTR	5	5	5	5	5	5	5	3	2	2	–	2	3	3	3
11	INSTR	5	3	4	4	4	5	4	2	4	4	1	4	3	3	4
12	INSTR	4	4	2	2	4	3	3	3	4	5	2	2	3	2	3
13	INSTR	5	3	5	1	4	3	2	5	5	2	–	2	4	2	4
14	INSTR	5	3	5	4	4	4	3	4	3	1	4	4	4	4	4
15	INSTR	4	5	3	5	4	5	5	–	4	3	–	3	5	5	5
16	DIST	5	5	5	5	5	5	5	5	3	5	3	3	2	2	2
Average:		4.5	3.4	3.7	3.9	3.7	3.7	4.1	3.2	3.3	3.6	2.1	2.3	3.4	3.0	3.4
STD Dev:		0.8	1.3	1.2	1.3	1.0	1.2	0.9	1.0	1.3	1.4	0.9	1.3	0.9	0.8	0.8
COV:		0.18	0.38	0.32	0.38	0.27	0.31	0.21	0.31	0.37	0.38	0.43	0.53	0.29	0.31	0.26

Market Availability of Emerging Technologies

Manfacturer A has developed a high-efficiency absorption gas heat pump water heater named Brand A with the option for a fully hydronic combination of space heating and water heating. However, it is not available on the market yet, and is on track to start production in 2023 (according to Manufacturer A's website at the time of this report) (Manufacturer A, 2022). Manufacturer B offers air-source and water-source gas-fired vapor absorption heat pumps (Brand B) that can also provide hydronic space heating while reaching efficiencies above 100% (Manufacturer B, n.d.). The Manufacturer B units are currently commercially available. Manufacturer C offers Brand C, a unique thermal compression gas heat pump combination system that uses a non-toxic helium compression fuel instead of refrigerant (Manufacturer C, 2022). This unit is not yet commercially available and no date for availability is listed on their website. Manufacturer D has been developing a novel adsorption gas heat pump water heater, but it is still not market ready. Manufacturer E has introduced Brand E, the gas engine heat pump water heaters and combination systems that use a natural gas or propane-fired engine to drive the compression instead of an electric motor (Manufacturer E, 2022). It is commercially available but has not seen much adoption. Lastly, Manufacturer F offers Brand F, the self-powered damper non-condensing storage water heaters. However, the venturi air system technology used for the self-powered damper mechanism does not meet the AQMD ultra-low NO_x requirements.

Ease of participation

Several technologies are not yet market ready, so ease of adoption does not apply until the products enter the market. In most cases for commercially available technologies, the high cost hindered the initial adoption by customers or end-users. However, many of these technologies use refrigerants that have no global warming potential or are non-toxic which helps ease adoption.

The survey results indicate that lower production costs are essential for market adoption, which could subsequently lower the initial cost of these products to customers. Most respondents indicate that customers, or end-users, opt for the lowest first-cost water heater. Several respondents expressly indicate that cost-effectiveness and historically low natural gas prices are barriers to adopting emerging, energy-efficient water heating technologies. Respondent #1 indicates there is currently no cost-effective, contractor-friendly gas-fired heat pump in the market, and there is no clear path to getting incentives in place for emerging water heating technologies, which increases the risk to the manufacturers and stakeholders when introducing emerging technologies into the market. Respondent #6 claims that getting the customers to pay the extra premium for higher efficiency water heaters is especially challenging without incentives. Thus, providing a more straightforward means to obtain incentives for emerging technologies is critical for ease of market adoption. However, Respondent #1 has not entered the market yet but also proposed that current market research indicates a small segment of customers are willing to pay the premium. This response is consistent with Respondent #3 who states the bulk of the market sales is minimum efficiency water heaters with only a small customer base for the high-efficiency units, which indicates that large-scale manufacturers typically focus on the minimum efficiency bulk sales which effectively acts as a barrier to market adoption for high-efficiency water heaters. This could further indicate a need for more stringent codes/standards for material movement in average efficiency of new water heater units sold.

In addition, the emerging technologies evaluated in this study generally offer better performance, more advanced features, and are better for the environment due to lower emissions. From the survey questions, it appears that better performance is essential. However, it also appears that some manufacturing SMEs view performance uncertainty, from a customer perspective, as an issue only in some cases while not an issue in others. This could mean that customers generally trust the product to perform at levels indicated by the manufacturer. Similarly, the customer's need for advanced features was considered necessary in some cases, but some customers are concerned with reliability issues that may come with additional advanced features. Thus, basic controls are preferred to maintain a reliable and straightforward operation. Most manufacturers, and some installers, report that incompatibility with existing systems is of a lower concern to participation. This could be because some manufacturers design their products to cause minimal disruption during installations and ongoing operations. Most respondents also reported that most customers are not looking at lifecycle costs during their decision process, which could mean that some customer education is necessary to increase technology uptake. For example, Respondent #11 stated that customers look at the simple payback during the decision process, and the salesperson's job was to market the lifecycle cost advantages of the emerging technology.

Drivers and market barriers

Based on the survey results, lower production cost (Q12) is the most important driver, but primarily only considering manufacturers. The following top driver is independent verification of performance (Q15) with a slightly lower average, but lower variation compared to environmental compliance with regulations (Q4) and improved performance for the end-user (Q10). However, several respondents indicated that importance of improved performance, specifically energy efficiency being the most critical performance factor, followed by reliability.

As for the barriers, technology cost is the highest barrier, followed by a lack of awareness from the customers. The following significant barriers are (Q20) and (Q21) regarding the adverse regulatory environments and uncertainty in performance, respectively. The more considerable variation in (Q20) resulted from a few respondents scaling this low, such as

Respondent #13, which explained that adverse regulatory environments, such as gas-banned ordinances, are relatively new and they have not encountered this problem yet.

The survey results show that the most considerable participation drivers are independent verification of performance, environmental compliance with regulations, and improved performance. The most significant barriers are cost and lack of awareness from the customer or end-user. Also, a few respondents (2, 15) indicated that the lack of installer and maintenance personnel training for new water heating technologies are considerable participation barriers.

Installation Costs

For each of the emerging technology water heaters that are market ready, the installation costs are relatively high and act as a barrier. Most respondents indicated incompatibilities with the existing system were not a barrier and water heaters are typically independent units that require minor retrofitting, there was Respondent #13 explained that retrofitting tankless water heaters for specific situations can be a barrier, such as retrofitting for a multistory building without a proper ventilation system already in place. Typically, older vintage buildings were not designed for tankless water heaters, so those types of retrofits are a substantial barrier.

Survey Response Variation

The variation in responses is characterized by the coefficient of variation (CV). The top three responses with the lowest variation are (Q12), (Q15), and (Q17), showing the most agreement regarding lowering production costs as a driver, independent verification of performance as a driver, and cost of the technology as a barrier. Also, these questions scored nearly at the top, which means that these are important considerations for the respondents, and they agree on their importance.

The bottom three responses with the highest variation are (Q8), (Q27), and (Q28), revealing a wide disagreement on barriers regarding recyclability, the environmental impact of production, and adverse disposal effects. Also, these three questions averaged at the bottom of the scale, indicating that most respondents do not consider the issues raised very important in emerging technology scenarios. Furthermore, (Q1), (Q4), (Q10), (Q11), (Q14), and (Q23) scored high in the survey responses, indicating that positive public image, compliance with regulations, improved performance for the end user, the potential to increase customer base by utilizing emerging technology, any government support and customer lack of awareness were all identified as important considerations by the respondents.

Historical Water Heating Participation Trends

The water heating TPM and the WHTT did not include historical participation trends, nor did they pinpoint which technologies have low participation. As discussed in previous sections, this information is of interest to the GET program. California Energy Data and Reporting System (CEDARS) data was analyzed to provide these necessary participation trends.

Yearly claims data for all Program Administrators (PAs) was downloaded for 2017-2021 from CEDARS. This data contains a measure ID for each energy savings claim submitted. Measure IDs vary for the same technology from year to year and from PA to PA. Each measure ID that fell under the use categories "Recreation" and "Service and Domestic Hot Water Heating" were given a standardized measure name so that the trends for each measure could be compared from year to year and PA to PA (Recreation was included to capture pool heaters). Measure names were split up into non-condensing and condensing efficiency levels but were not split up into individual efficiency categories. For example, measure ID SWWH007**H** is a 90% thermal efficiency storage water heater and SWWH007**I** is a 96% thermal efficiency storage water heater. Both are called "Storage Water Heater, Commercial, Condensing." See Table 5 for details.

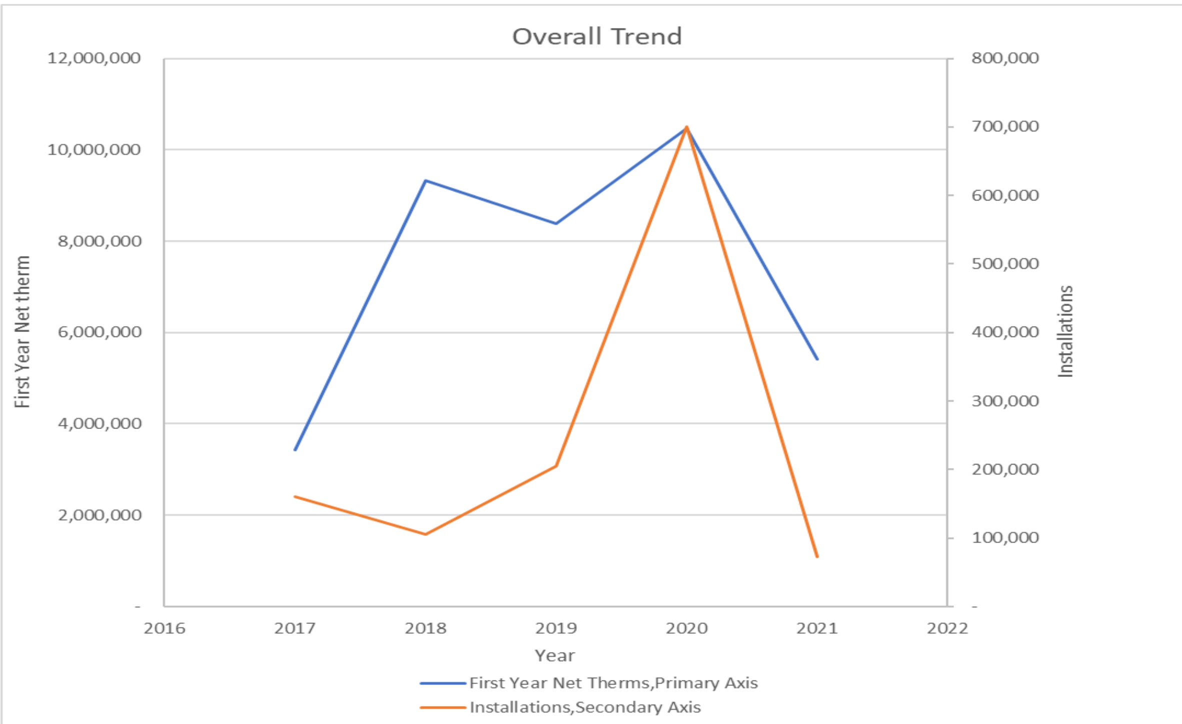
Table 5: Example of Measure ID to Measure Name: Storage Water Heater, Commercial

Measure ID	Measure Name
HA18	Storage Water Heater, Commercial, Condensing
NG-WtrHt-LrgStrg-Gas-gt75kBtuh-0p90Et	Storage Water Heater, Commercial, Condensing
NG-WtrHt-LrgStrg-Gas-gte75kBtuh-0p90Et	Storage Water Heater, Commercial, Condensing
SWWH007A	Storage Water Heater, Commercial, Non-condensing
SWWH007B	Storage Water Heater, Commercial, Non-condensing
SWWH007C	Storage Water Heater, Commercial, Non-condensing
SWWH007D	Storage Water Heater, Commercial, Non-condensing
SWWH007E	Storage Water Heater, Commercial, Non-condensing
SWWH007F	Storage Water Heater, Commercial, Non-condensing
SWWH007G	Storage Water Heater, Commercial, Non-condensing
SWWH007H	Storage Water Heater, Commercial, Condensing
SWWH007I	Storage Water Heater, Commercial, Condensing
WPSCGNRWH120206A-Rev11-Msr003	Storage Water Heater, Commercial, Non-condensing

The complete list of measure IDs and corresponding measure names for all the data used can be found in 0.

Overall TrendsFigure 3 shows the overall water heating net therms and approximate number of installations in EE programs from 2017 – 2021 for all PAs. Only the first-year net therms value is shown (gross therms post-multiplied by its respective net to gross (NTG) ratios) for each measure. The installations were approximated by counting the number of claims for each measure description. Some measures have a normalizing unit of “each,” and some have a normalizing unit of “Cap-kBtuh” or “household.” However, measures that have a normalizing unit of “Cap-kBtuh” or “household” will usually only have one row of energy savings claims per project even if they claim multiple households or large capacities.

Figure 3: Overall Water Heating Trends



From 2017 to 2020, there was an overall increase in energy savings claims and installations for water heating. The energy savings and installations reduced significantly in 2021, which was probably due to issues related to the COVID-19 pandemic. The amount of impact related to COVID-19 was outside the scope of this study.

The EE programs have seen many successes in increasing participation for water heating measures and have been able to overcome higher equipment first costs to do so. This is a good sign for energy efficient water heating both in boosting participation of existing measures and launching new measures into EE portfolios. There are also several opportunities for EE programs to increase the participation of water heating measures. The successes and opportunities found during this analysis are listed below:

Successes

1) Residential Tankless Condensing Water Heaters
2) Commercial Tankless Condensing Water Heaters
3) Commercial Tankless Non-Condensing Water Heaters

Opportunities

1) Domestic Hot Water Loop Temperature Controller (SWWH016)
2) Solar Thermal Water Heating System – Residential (SWWH032)
3) Solar Thermal Water Heating System – Multifamily (SWWH034)
4) Boiler – Multifamily (SWWH010)
5) Boiler – Commercial (SWWH005)
6) Pool Heater – Commercial (SWRE003)

Other important findings besides successes and opportunities in participation include:

1) Air Quality Management District (AQMD)/Air Pollution Control District (APCD) ultra-low NO_x requirements may affect participation because they limit the products that can be installed even when those products meet efficiency requirements. This will be an important consideration going forward for all Emerging Technology projects
2) Subject Matter Expert (SME) interviews indicate that one of the top drivers/barriers for water heating products is cost and incentives. However, higher costs and longer payback periods has not discouraged participation of tankless condensing water heaters (residential and commercial) so there are probably other reasons customers choose these systems. For example, installation of a tankless water heater instead of a storage water heater can save space which has a material value to both residential and commercial customers. Considerations of other factors besides energy savings and costs should be given when investigating emerging technologies and when investigating technologies to increase participation.
3) Controls measures typically need to be supported by workforce education and training so that the savings persist over time

Sector Trends

Each sector is discussed in the sections below. Overall, energy efficiency programs have been successful in driving greater participation of condensing efficiency water heaters and boilers in the commercial and single-family segments. The participation of condensing efficiency water heaters in the single-family residential market has seen a marked increase in participation from 2019-2021. The participation of condensing efficiency water heaters in the commercial sector has seen a decrease from 2019-2021, but it had been very strong in

2018-2019. Hot water tank and hot water pipe insulation have also seen increased participation over the last 3 years. There has been less participation of multifamily water heaters and boilers, and there has been less participation of water heating controls over the last 5 years. There is no savings claim data for solar-thermal water heaters since the time they were added to the EE programs (presumably because there were no approved measure packages until December 2021). The analysis of participation of solar water heating systems outside of EE programs is not within the scope of this project, but it is assumed they had participation before being transferred to EE programs.

Multi-family

CEDARS Data Findings

The CEDARS trend data for multifamily water heaters, boilers, and controls are shown in Figure 4 and

Figure 5 below.

Figure 4: Multifamily Water heaters vs Boilers First Year net therms 2017-21

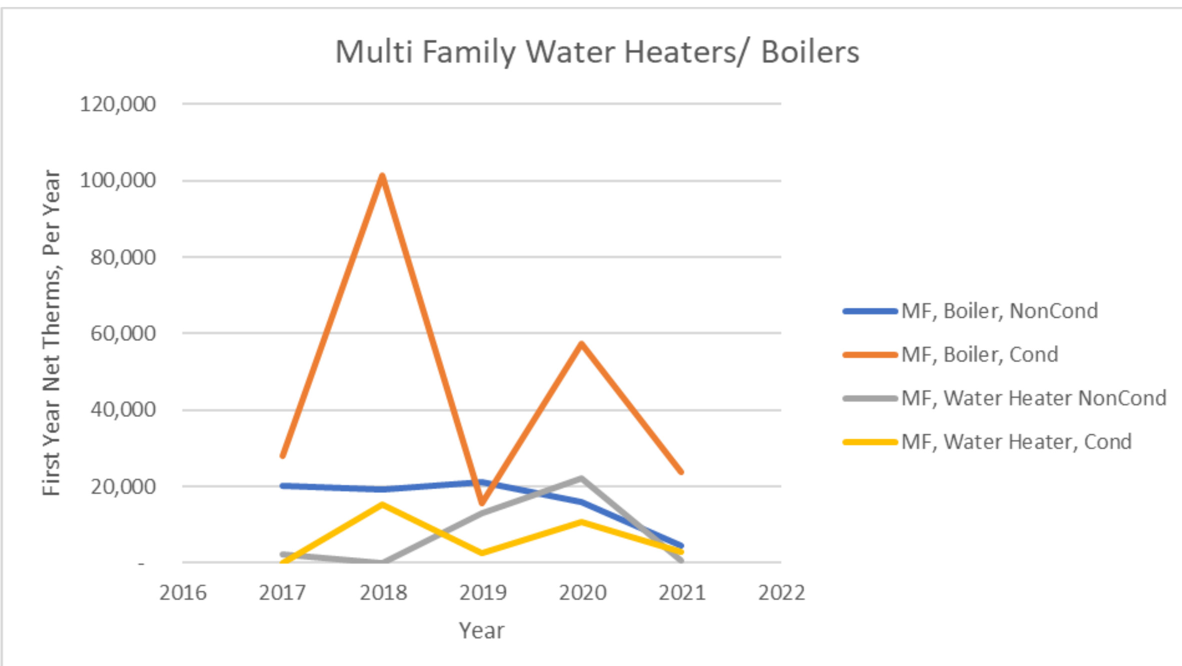


Figure 5: Multifamily Controls

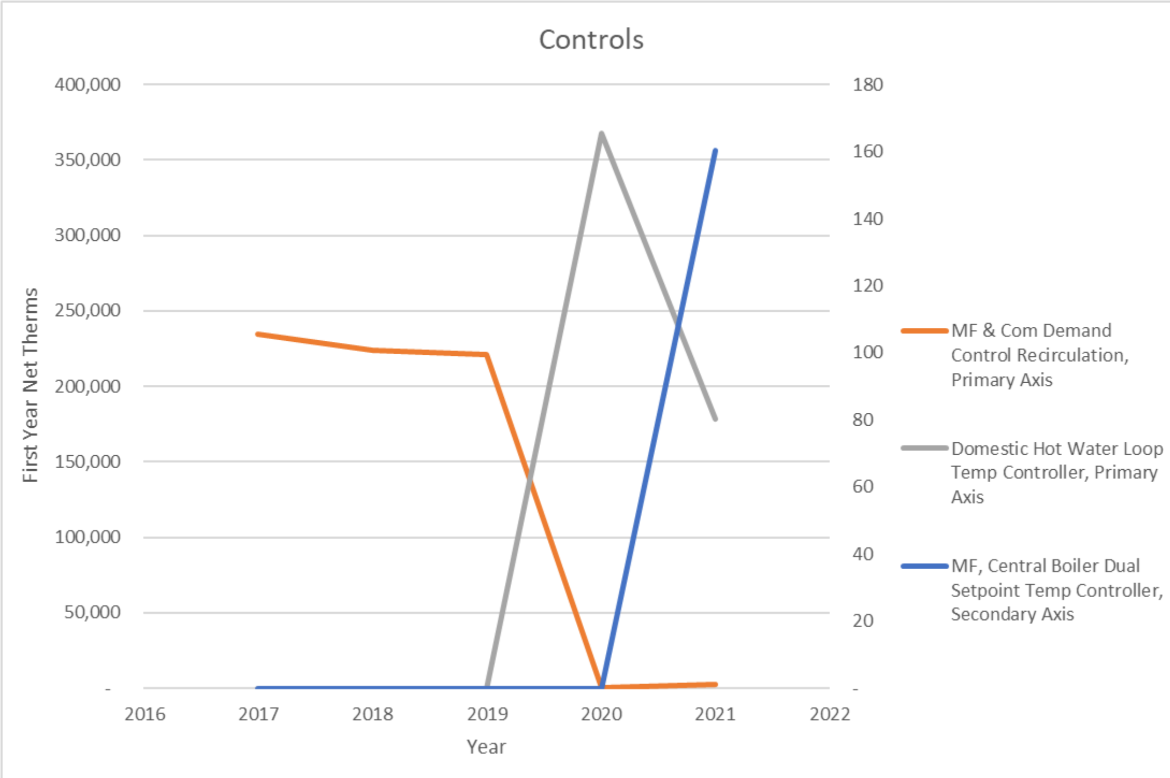


Figure 4 shows that condensing boilers are adopted much more than non-condensing boilers, but condensing water heaters are adopted at about the same amounts as non-condensing water heaters. Figure 5 shows that demand control recirculation participation has declined while domestic hot water loop temperature controller and central boiler dual setpoint temperature controller have increased. However, the central boiler dual setpoint temperature controller participation is much lower than the other two controls.

A deeper dive was taken into the CEDARS data and yearly energy savings were examined for water heating measures that have either participated through multifamily programs or for water heating measures specific to the multi-family building type. Table 6 is a summary of the results:

Table 6: Summary of Water Heating Measures in Multi-Family Buildings

Program	Total Net Therm Savings (Water Heating Measures,2017-2021)	Note
RES-Residential Energy Efficiency Program (SCG3702)	739,279	In 2019, this program absorbed SCG 3704
RES-MFEER (SCG3704)	117,255	In 2019 this program was absorbed into SCG 3702
Enhance Time Delay Relay (PGE21008)	53,215	
Multifamily Energy Savings (MCE01)	19,013	
Multifamily Program (PGE_Res_003)	17,201	

Notes:

- There are additional programs that include water heating measures in multifamily buildings, Table 6 presents the most impactful programs
- Programs may include other measures besides water heating
- All programs besides "Multifamily Energy Savings (MCE01)" and "Multifamily Program (PGE_Res_003)" may include building types other than multifamily

This table shows that most of the water heating energy savings for multifamily buildings comes through "RES-Residential Energy Efficiency Program (SCG3702)." Since SCG3702 absorbed SCG3704 in 2019, Table 7 shows the savings for both programs broken down by measure. The breakdown by measure for SCG3702 and SCG3704 individually can be found in 0.

Table 7: SCG3702 & SCG3704 Water Heating Measure Participation from 2017-2021

RES-Residential Energy Efficiency Program (SCG3702) & Res MFEER (SCG3704)	Total Yearly Net Therms					
Measure Description	**2017**	**2018**	**2019**	**2020**	**2021**	**Total**
Boiler, Multifamily, Condensing	2,903	49,441	15,717	57,242	21,061	146,363
Boiler, Multifamily, Non-condensing	19,898	19,068	21,082	15,951	4,445	80,443
Central Storage Water Heater, Multifamily, Condensing	4	15,320	1,499	5,746	1,314	23,881
Central Storage Water Heater, Multifamily, Non-condensing	1,633	-	13,021	21,446	484	36,585
Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial	-	-	-	-	-	-
Diverting Tub Spout with TSV, Residential	-	-	-	-	-	-
Domestic Hot Water Loop Temperature Controller, Multifamily & Commercial	-	-	-	367,953	161,366	529,319
Faucet Aerator, Residential	-	-	-	-	-	-
Heater for Pool or Spa, Commercial	479	2,931	4,198	2,131	1,331	11,069
Hot Water Pipe Insulation	-	-	-	-	-	-
Hot Water Tank Insulation	-	-	-	-	-	-
LF Showerhead, Residential	-	-	-	-	-	-
Pool Heater, Residential, Condensing	-	-	-	-	-	-
Pool Heater, Residential, Non-condensing	10	22	21	-	-	52
Storage Water Heater, Residential, Non-condensing	488	3,210	230	771	57	4,757
Tankless Water Heater, Residential, Condensing	368	1,031	1,497	9,260	5,562	17,717
Tankless Water Heater, Residential, Non-condensing	795	391	382	391	4,388	6,347
TSV only, Residential	-	-	-	-	-	-

Table 8: SCG3702 and SCG3704 Approximate Total Yearly Projects from 2017-2021

RES-Residential Energy Efficiency Program (SCG3702) & Res MFEER (SCG3704)	Yearly Approximate No. Projects					
Measure Description	**2017**	**2018**	**2019**	**2020**	**2021**	**Total**
Boiler, Multifamily, Condensing	45	57	13	38	38	191
Boiler, Multifamily, Non-condensing	40	48	20	14	26	148
Central Storage Water Heater, Multifamily, Condensing	4	17	1	4	3	29
Central Storage Water Heater, Multifamily, Non-condensing	7	-	25	35	2	69
Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial	-	-	-	-	-	-
Diverting Tub Spout with TSV, Residential	-	-	-	-	-	-
Domestic Hot Water Loop Temperature Controller, Multifamily & Commercial	-	-	-	976	430	1,406
Faucet Aerator, Residential	-	-	-	-	-	-
Heater for Pool or Spa, Commercial	1	6	5	4	3	19
Hot Water Pipe Insulation	-	-	-	-	-	-
Hot Water Tank Insulation	-	-	-	-	-	-
LF Showerhead, Residential	-	-	-	-	-	-
Pool Heater, Residential, Condensing	-	-	-	-	-	-
Pool Heater, Residential, Non-condensing	1	4	4	-	-	9
Storage Water Heater, Residential, Non-condensing	44	39	18	5	5	111
Tankless Water Heater, Residential, Condensing	10	37	46	342	115	550
Tankless Water Heater, Residential, Non-condensing	50	24	17	21	104	216
TSV only, Residential	-	-	-	-	-	-

Savings can go up or down due to measure package revisions, so the number of projects was also analyzed. Those results are shown in Table 8. The approximate number of projects track with the net therm savings trends indicating that the increase in net therm savings are not driven by measure package revisions.

The main takeaways from Table 7 and Table 8 are the following:

- In general, condensing equipment has more participation than non-condensing equipment (except for central storage water heaters)
- Participation for boilers and gas storage water heaters has decreased from 2017-2021
- Participation for tankless water heaters has increased significantly starting in 2020
- Participation for tankless condensing water heaters is significantly higher than non-condensing
- Domestic Hot Water Loop Temperature Controllers have only seen participation in 2020 and 2021
- Pool/spa heaters have seen steady but low participation

Program Staff Feedback

A summary of the observations from interviewing program staff is summarized below.

Condensing equipment is generally more expensive than non-condensing equipment and SME interviews indicated that cost of equipment is one of the most important decision-making factors. However, trend data showed that the more expensive condensing equipment out participated the non-condensing equipment. SCG3702 Program staff were interviewed to gain an understanding of this trend and get feedback on potential measures that have room for greater participation. The program staff provided the following feedback

- In 2020, the incentive for tankless water heaters included a “kicker” so in some cases, the total cost of the unit would be covered by the incentive and customers only had to pay for the installation labor
- An online platform was created and launched between 2017-2021 that makes it easier to participate and get an incentive
- When a central water heater or central boiler is replaced, there are usually multiple parties who need to understand the project and be convinced of the energy savings: The on-site property manager, the property owner, and sometimes the corporate property management company (if a property hired a large property management company). These parties are usually non-technical and need assistance evaluating boilers and water heaters. Program staff also indicated that on-site property

managers and/or property owners usually are not familiar with hiring contractors to do large rehabs so they may not do a project simply because the process of vetting and hiring a contractor seems daunting. Program staff suggested that a marketplace for boiler/water heater contractors similar to SCE's Solar Marketplace (Southern California Edison, 2022) might overcome this barrier.

- Demand Control for Centralized Water Heater Recirculation Pump (SWWH015) and Domestic Hot Water Loop Temperature Controller (SWWH0016) are competing measures. Program staff indicated that there is opportunity to increase the participation of SWWH016 with some additional marketing material for this measure.
- Program staff indicated that additional marketing for solar hot water heaters could help participation in EE programs.

Domestic Hot Water Loop Temperature Controller

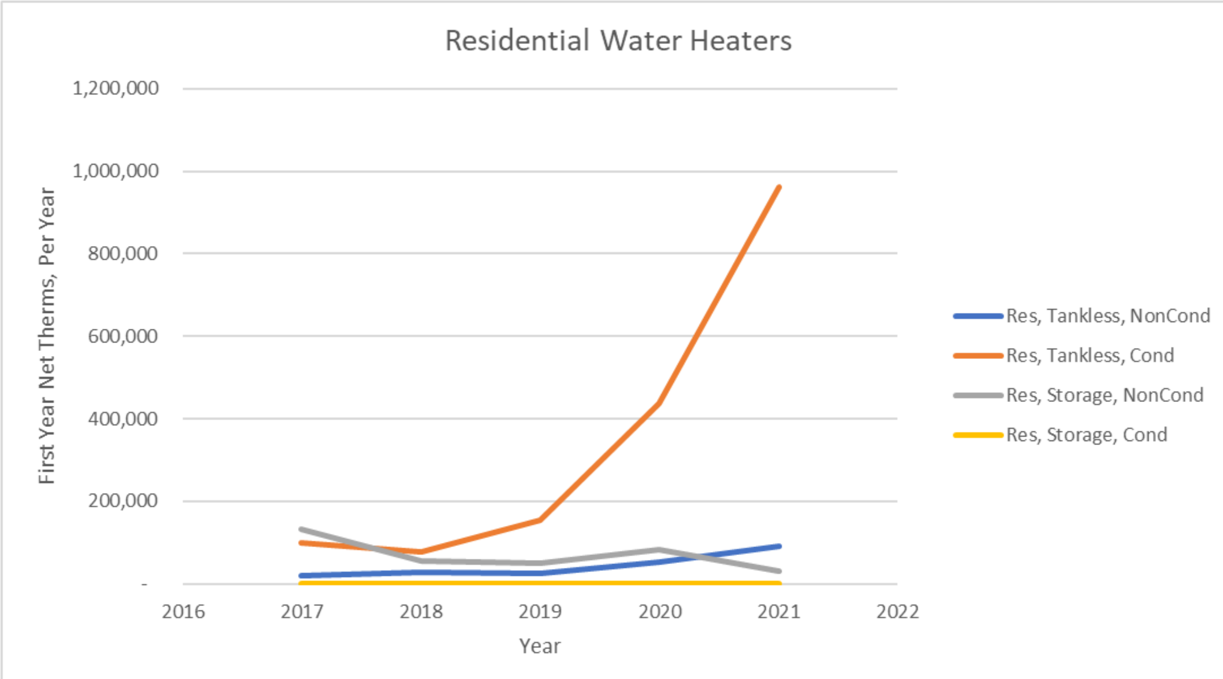
Two (2) SMEs that had been interviewed previously for this project were followed up to gain an understanding of what barriers might exist for this measure. Both SMEs indicated that lack of marketing to customers and workforce training for these controllers. Additionally, they mentioned that many controls manufacturers install the temperature controller but do not provide service or customer support. So, when the customer has an issue, they call their normal plumber who does not know how the controls work, so the controls are often bypassed, and this may impact persistence of savings. Selecting qualified controls contractors who also provide maintenance support and well as training customers to call the appropriate contractor can address this issue.

Single-family

CEDARS Data Findings

The CEDARS trend data for single family and mobile home residential buildings is shown in Figure 6 below.

Figure 6: Residential Tankless vs Storage Water Heaters First year net therms 2017-21



The yearly energy savings were examined for water heating measures that have participated and have a building type of Single-Family or Mobile Home. Below in Table 9 is a summary of the results:

Table 9: Summary of Water Heating Measures in Single Family and Mobile Home Buildings

Program	Total Net Therm (Water Heating Measures) 2017-2021	Notes
RES-Residential Energy Efficiency Program (SCG3702)	4,710,720	Faucet Aerators and Low Flow Showerheads account for >2.5 million of these therm savings.
WET&O-Educational Outreach Program (SCG3764)	2,708,520	All faucet aerators and low flow showerheads
RES-EE Kit Delivery Program (SCG3831)	1,827,247	All faucet aerators and low flow showerheads
RES-Plug Load and Appliances - POS (SCG3703)	202,052	
RES-Manufactured Mobile Home (SCG3765)	108,620	
SW-CALS-Plug Load and Appliances-POS Rebates (SDGE3204)	98,345	Non-Resource Program part of CalSPREE
Total	9,655,504	

Notes:

- There are additional programs that include water heating measures in single family and mobile homes, this table only presents the most impactful programs
- Some multi-family specific measures and multi-family specific programs have single family residential building type. Those were excluded from this data.
- Programs may include other measures besides water heating

Over 7.2 million therms from Table 9 come from faucet aerators or low flow showerheads through SCG 3702, SCG3764 and SCG3831. Those measures were not a primary concern for this study because they do not need additional work to increase participation and they are not emerging technologies. When the savings from those measures are removed, the net water heating therms per program is shown in Table 10 below:

Table 10: Adjusted Summary of Water Heating Measures in Single Family and Mobile Home Buildings

Program	Total Therm (Water Heating Measures, w/o Aerators & Low Flow Showerheads) 2017-2021	Notes
RES-Residential Energy Efficiency Program (SCG3702)	2,015,449	Faucet aerators and shower heads installed only in 2018
RES-Plug Load and Appliances - POS (SCG3703)	202,052	
RES-Manufactured Mobile Home (SCG3765)	108,620	
SW-CALS-Plug Load and Appliances-POS Rebates (SDGE3204)	98,345	Non-Resource Program part of CalSPREE
Total	2,424,466	

Most participation is through "RES-Residential Energy Efficiency Program" (SGG3702). The breakdown of measures through SCG3702 is below (this breakdown does not include faucet aerators or low flow showerheads).

Table 11: SCG3702 Water Heating Measure Participation in Single Family & Mobile Homes from 2017-2021 (Not Including Low-Flow Showerheads or Faucet Aerators)

RES-Residential Energy Efficiency Program (SCG3702)	Yearly Net Therm Savings					
Measure Description	**2017**	**2018**	**2019**	**2020**	**2021**	**Total**
Boiler, Multifamily, Condensing	-	-	-	-	-	-
Boiler, Multifamily, Non-condensing	-	-	-	-	-	-
Central Storage Water Heater, Multifamily, Condensing	-	-	-	-	-	-
Central Storage Water Heater, Multifamily, Non-condensing	-	-	-	-	-	-
Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial	-	-	-	-	-	-
Diverting Tub Spout with TSV, Residential	-	-	2,540	444	15	2,999
Domestic Hot Water Loop Temperature Controller, Multifamily & Commercial	-	-	-	-	-	-
Faucet Aerator, Residential	-	-	-	-	-	-
Heater for Pool or Spa, Commercial	-	-	-	-	-	-
Hot Water Pipe Insulation	-	-	-	-	-	-
Hot Water Tank Insulation	-	-	-	-	-	-
LF Showerhead, Residential	-	-	-	-	-	-
Pool Heater, Residential, Condensing	317	589	581	617	474	2,578
Pool Heater, Residential, Non-condensing	4,601	25,737	20,779	33,944	29,761	114,823
Storage Water Heater, Residential, Non-condensing	1,296	4,719	19,099	32,354	16,531	74,000
Tankless Water Heater, Residential, Condensing	95,418	76,310	140,526	361,777	942,621	1,616,651
Tankless Water Heater, Residential, Non-condensing	19,400	28,721	23,529	44,188	85,094	200,932
TSV only, Residential	-	2	-	2	-	3

Savings can go up or down due to workpaper revisions, so the number of projects was also analyzed. The approximate number of projects for SCG3702 in single family homes and mobile homes are presented in Table 12 below.

Table 12: SCG3702 Approximate Number of Projects in Single Family & Mobile Homes for Water Heating from 2017-2021 (Not including Low-Flow Showerheads or Faucet Aerators)

RES-Residential Energy Efficiency Program (SCG3702)	Approximate Yearly Number of Projects					
Measure Description	**2017**	**2018**	**2019**	**2020**	**2021**	**Total**
Boiler, Multifamily, Condensing	-	-	-	-	-	-
Boiler, Multifamily, Non-condensing	-	-	-	-	-	-
Central Storage Water Heater, Multifamily, Condensing	-	-	-	-	-	-
Central Storage Water Heater, Multifamily, Non-condensing	-	-	-	-	-	-
Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial	-	-	-	-	-	-
Diverting Tub Spout with TSV, Residential	-	-	435	90	3	528
Domestic Hot Water Loop Temperature Controller, Multifamily & Commercial	-	-	-	-	-	-
Faucet Aerator, Residential	-	-	-	-	-	-
Heater for Pool or Spa, Commercial	-	-	-	-	-	-
Hot Water Pipe Insulation	-	-	-	-	-	-
Hot Water Tank Insulation	-	-	-	-	-	-
LF Showerhead, Residential	-	-	-	-	-	-
Pool Heater, Residential, Condensing	9	20	19	20	14	82
Pool Heater, Residential, Non-condensing	886	3,488	2,796	4,554	4,399	16,123
Storage Water Heater, Residential, Non-condensing	114	299	1,223	2,060	1,196	4,892
Tankless Water Heater, Residential, Condensing	1,968	2,462	4,441	11,438	16,652	36,961
Tankless Water Heater, Residential, Non-condensing	1,124	1,260	999	1,884	1,836	7,103
TSV only, Residential	-	2	-	2	-	4

The main takeaways from Table 11 and Table 12 are the following:

- Tankless water heaters have much more participation than storage water heaters
- Tankless condensing water heaters have five (5) times more participation than non-condensing water heaters
- Tankless condensing water heaters and storage non-condensing water heaters have seen increased participation starting in 2019
- Most pool heaters that participate in SCG3702 are non-condensing
- There has not been much interest in Thermostatic Shut-Off Valves

Program Staff Feedback

Condensing equipment is generally more expensive than non-condensing equipment and SME interviews indicated that cost of equipment is one of the most important decision-making factors. However, trend data showed that the more expensive condensing equipment outperform the non-condensing equipment. Program staff for SCG3702 were interviewed to gain an understanding of this trend and get feedback on potential measures that have room for greater participation. The program staff provided the following feedback

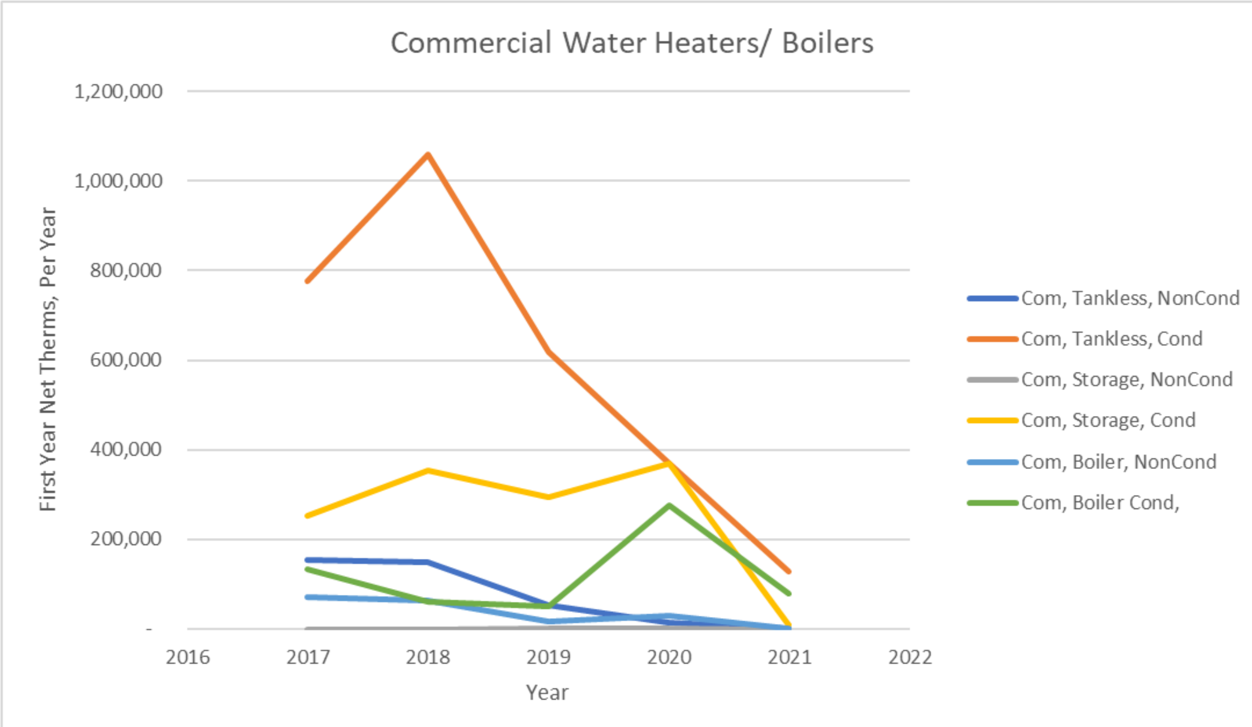
- In 2021 the incentive for tankless water heaters included a "kicker" so in some cases, the total cost of the unit would be covered by the incentive and customers only had to pay for the installation labor
- An online platform was created and launched between 2017-2021 that makes it easier to participate and get an incentive
- The program staff has established better relationships with plumbers over time
- Program staff mentioned that SoCalGas' Behavioral Program sends "Home Energy Reports" to randomly selected residential customers and this also may have boosted participation although the effect of that could not be measured in the scope of this project

Commercial

CEDARS Data Findings

The CEDARS trend data for multifamily water heaters, boilers, and controls are shown in Figure 7.

Figure 7: Commercial Water Heaters and Boilers First year net therms 2017-21



The COVID-19 pandemic appears to have had a greater impact on the participation of commercial water heaters and boilers. However, it is still clear that condensing efficiency equipment always has greater participation than non-condensing equipment even when the participation is declining.

The yearly energy savings were examined for water heating measures that have participated through commercial programs in commercial building types. Below is a summary of the results:

Table 13: Summary of Water Heating Measures in Commercial Buildings

Program	Total Net Therm Savings for Water Heating Measures (2017-2021)	Notes
COM-Direct Install Program (SCG3805)	3,239,139	All measures are tank/pipe insulation, aerators, or low flow showerheads
Commercial Deemed Incentives (PGE21012)	2,447,301	
COM-Deemed Incentives (SCG3711)	1,906,344	
PUB-Direct Install Program (SCG3817)	1,222,595	Most savings are from tank insulation
COM-Midstream Water Heating (SCG3814)	806,308	
PUB-Deemed Incentives (SCG3816)	756,792	

Notes:

- These programs (except SCG3814) may include other measures besides water heating measures

Programs SCG3802 and SCG3817 are all or mostly savings from pipe/tank insulation, aerators, and low flow showerheads. These programs were not analyzed further since those measures already have high participation and they are not emerging technologies. The programs with the most participation in water heating with measures other than pipe/tank insulation, aerators, and low flow showerheads is "Commercial Deemed Incentives (PGE21012)." "COM-Deemed Incentive (SCG3711)" and "PUB-Deemed Incentives (SCG3816)" also have high participation in water heating measures. However, although these programs have high participation of water heating measures, only "COM-Midstream Water Heating (SCG3814)" is focused on water heating. Since it would be too much information to show the details for all (4) of these programs, only the details for PGE21012 and SCG3814 are further explored.

Table 14: PGE21012 Water Heating Measure Participation in Commercial Buildings from 2017-2021

Commercial Deemed Incentives (PGE21012)	Yearly Net Therm Savings					
Measure Name	**2017**	**2018**	**2019**	**2020**	**2021**	**Total**
Boiler, Commercial, Condensing	–	–	–	236,188	10,495	246,682
Boiler, Commercial, Non-condensing	12,255	–	–	–	–	12,255
Central Storage Water Heater, Multifamily, Condensing	–	–	–	–	–	–
Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial	–	–	–	–	–	–
Faucet Aerator, Commercial	–	–	–	–	–	–
Faucet Aerator, Residential	–	–	–	–	–	–
Heater for Pool or Spa, Commercial	6,326	3,372	–	–	–	9,698
Hot Water Pipe Insulation	–	25,647	101,084	234,686	131,746	493,162
Hot Water Tank Insulation	–	–	–	–	–	–
Ignore	–	–	–	–	–	–
Laminar Flow Restrictor	–	–	–	–	–	–
LF Showerhead, Commercial	–	–	–	–	–	–
LF Showerhead, Residential	–	–	–	–	–	–
Pool Cover	–	–	–	–	–	–
Storage Water Heater, Commercial, Condensing	136,823	245,464	195,452	295,218	7,054	880,011
Storage Water Heater, Commercial, Non-condensing	–	–	–	–	–	–
Storage Water Heater, Residential, Non-condensing	3	15	–	–	–	18
Tankless Water Heater, Commercial, Condensing	186,503	303,765	176,859	–	–	667,127
Tankless Water Heater, Commercial, Non-condensing	46,253	78,488	13,607	–	–	138,348
Tankless Water Heater, Residential, Condensing	–	–	–	–	–	–

Table 15: SCG3814 Water Heating Measure Participation in Commercial Buildings from 2017-2021

COM-Midstream Water Heating (SCG3814)	Yearly Net Therm Savings					
Measure Name	**2017**	**2018**	**2019**	**2020**	**2021**	**Total**
Boiler, Commercial, Condensing	-	-	1,418	-	-	1,418
Boiler, Commercial, Non-condensing	-	-	1,241	-	-	1,241
Central Storage Water Heater, Multifamily, Condensing	-	-	927	5,113	-	6,040
Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial	-	-	-	-	-	-
Faucet Aerator, Commercial	-	-	-	-	-	-
Faucet Aerator, Residential	-	-	-	-	-	-
Heater for Pool or Spa, Commercial	-	-	-	-	-	-
Hot Water Pipe Insulation	-	-	-	-	-	-
Hot Water Tank Insulation	-	-	-	-	-	-
Ignore	-	-	-	-	-	-
Laminar Flow Restrictor	-	-	-	-	-	-
LF Showerhead, Commercial	-	-	-	-	-	-
LF Showerhead, Residential	-	-	-	-	-	-
Pool Cover	-	-	-	-	-	-
Storage Water Heater, Commercial, Condensing	-	-	34,541	28,769	849	64,159
Storage Water Heater, Commercial, Non-condensing	-	-	50	-	-	50
Storage Water Heater, Residential, Non-condensing	-	-	-	-	-	-
Tankless Water Heater, Commercial, Condensing	-	-	244,862	369,422	104,347	718,630
Tankless Water Heater, Commercial, Non-condensing	-	-	200	14,571	-	14,771
Tankless Water Heater, Residential, Condensing	-	-	-	-	-	-

The main takeaways from Table 14 and Table 15 are the following:

- Condensing efficiency equipment has higher participation than non-condensing efficiency equipment
- Tankless water heaters have higher participation than storage water heaters
- There is almost no participation for *non-condensing* storage water heaters (which is opposite of what is seen in residential buildings where there is no participation for *condensing* storage water heaters)
- Pool/spa heaters have low participation

Program Staff Feedback

Condensing equipment is generally more expensive than non-condensing equipment, and SME interviews indicated that the cost of equipment is one of the most important decision-making factors. However, trend data showed that the more expensive condensing equipment out participate the non-condensing equipment. Since SCG3814 was focused on water heating while PGE21012 was not, program staff of SCG3814 were interviewed to gain an understanding of this trend and get feedback on potential measures that have room for greater participation. The program staff for SCG3814 provided the following feedback:

- The incentive design is such that the distributors are rewarded for selling higher efficiency products
- The program implementer evaluates measures in order to increase their participation as part of their tasks to implement the program

Water Heater Participation Drivers

Across commercial and residential buildings and programs, it was observed that tankless water heaters have higher participation than storage water heaters. Among tankless water heaters, condensing water heaters have higher participation than non-condensing water heaters. Among storage water heaters, there is no participation of condensing water heaters in residential, and the opposite is true in commercial; in commercial there is participation in condensing and almost no participation in non-condensing. Some additional analysis was done to try to understand why these trends are present.

ENERGY STAR and Residential Water Heaters

One hypothesis for the increased participation among tankless water heaters over storage water heaters was that ENERGY STAR certification is a program requirement and ENERGY STAR may have a smaller number of qualified storage water heaters. The SoCalGas website for “IMPORTANT NOTICES AND DISCLAIMERS FOR AVAILABLE REBATES” indicates that (Southern California Gas, 2022)

- Gas storage water heaters must be ENERGY STAR certified
- There is a $600 rebate for tankless water heaters that are not ENERGY STAR certified and have a UEF of 0.82-0.86
- There is an $800-$1000 rebate available for tankless water heaters that are ENERGY STAR certified and have a UEF of 0.87 and above (rebate depends upon UEF)

There are a total of (369) gas-fired storage water heaters and (276) gas tankless water heaters that have Energy Star certification in the United States Market as of 8/24/22 (ENERGY STAR, 2022). It is unclear how many tankless water heaters are qualified for a $600 incentive. However, since there are more storage water heaters than tankless that meet the current Energy Star certification, Energy Star certification program requirements are probably not the reason for increased tankless water heater participation.. Note that the Energy Star requirements will be updated in April of 2023 and at that time, only the most efficient condensing water heater and tankless water heaters will be eligible as the requirements will primarily focus on heat pump water heaters.

Commercial Water Heaters

The midstream water heating program (SCG3814) does not indicate that commercial water heaters must be ENERGY STAR certified (Statewide Water Heating, 2022). The current Pacific Gas & Electric Business Rebate Catalog (Pacific Gas and Electric, 2022) does not list boilers or water heaters. This may be because the intent is to have all commercial boilers/water heaters participate through the midstream program. This finding further supports that the reason for the increased tankless participation and condensing efficiency participation is not related to ENERGY STAR requirements.

Air Quality Management District Information

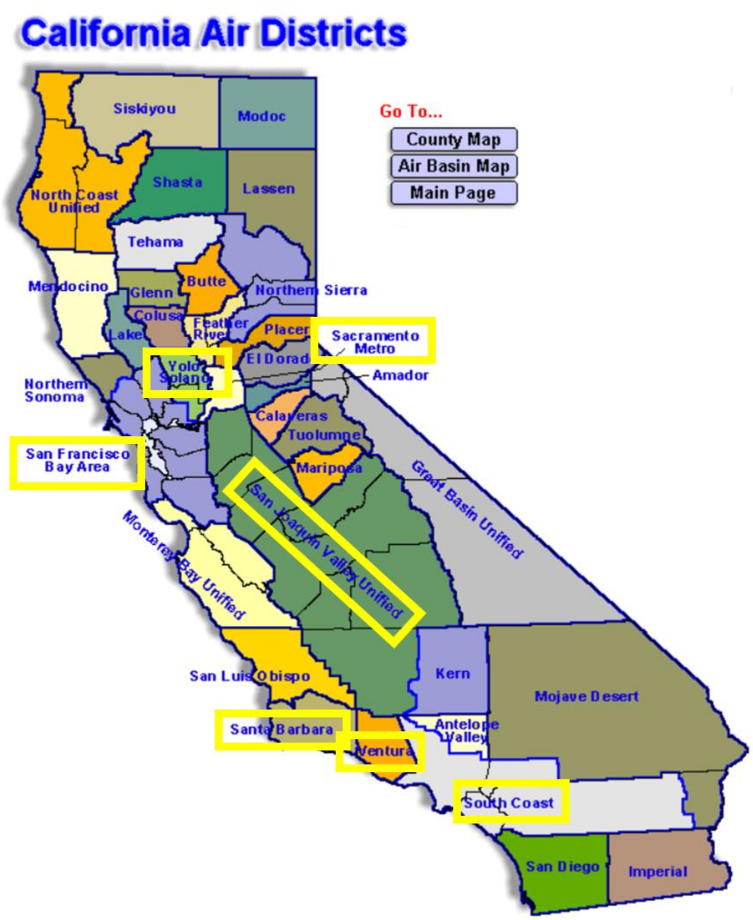
During a SME interview, one participant indicated that their water heater with a UEF of 0.64 did not meet South Coast Air Quality Management District (SCAQMD)’s Ultra-Low NO_x requirement due to the burner design. The water heater is Energy Star certified and meets the minimum efficiency requirements (at the time of this writing) for an incentive. Therefore, it was hypothesized that the Ultra-Low NO_x requirement of many Air Quality Management Districts (AQMDs) or Air Pollution Control Districts (APCDs) might be the reason for the increased participation of tankless and condensing efficiency water heaters.

Ultra-Low NO_x burners in water heaters are required in the following air quality management districts AQMDs or APDs (HD Supply Solutions, 2022).

- Bay Area AQMD (Reg 9, Rule 6)
- Sacramento Metropolitan AQMD (Rule 411)
- San Joaquin Valley APCD (Rule 4902)
- Santa Barbara County APCD (Rule 352)
- South Coast AQMD (Rule 1146 & 1121)
- Ventura County AQMD (Rule 74-11)
- Yolo-Solano AQMD (Rule 2.37)

To visualize this, see Figure 8 which has the AQMDs/APCDs that require Ultra-Low NO_x in yellow boxes. The AQMD/APDs that require Ultra Low NOx are usually in heavily populated areas in California. Subject matter experts indicated that SCAQMD usually leads the way in tighter NO_x restrictions and other AQMD/APDs follow suit.

Figure 8: CA AQMDs/ACPD (California Air Resources Board, 2019)



Rule 1121

The rule that applies to residential gas storage water heaters is SCAQMD Rule 1121. Rule 1121 applies to water heaters that are <75,000 btu/hr. This rule defines a water heater as:

> "a closed vessel other than a mobile home water heater in which water is heated by combustion of gaseous fuel and is withdrawn for use external to the vessel at pressures not exceeding 160 psig, including the apparatus by which heat is generated and all controls and devices necessary to prevent water temperatures from exceeding 210°F (99°C)."

Section (c)3 is applicable to residential gas storage water heaters. It states that applicable water heaters must be certified to show a NOx emission level of less than or equal to:

A. 10 nanograms of NOx (calculated as NO2) per joule of heat output (23lb per billion BTU of heat output) or

B. 15 ppmv at 3%O2, dry (17.5 lb per billion Btu of heat input).

SCAQMD has a list of certified products under Rule 1121 which has 200+ water heater models on it. Of those 200+ models, only (41) residential gas storage water heaters are also on the ENERGY STAR Qualified Products List.

Rule 1146.2

Tankless residential water heaters generally have a higher input rating than 75,000 btu/hr so they fall under a different SCAQMD rule. The rule applying to tankless water heaters is SCAQMD Rule 1146.2. Rule 1146.2 applies to Type 1 units that are defined as

"any WATER HEATER, BOILER or PROCESS HEATER with a RATED HEAT INPUT CAPACITY less than or equal to 400,000 BTU per hour excluding TANK TYPE WATER HEATERS subject to the limits of District Rule 1121"

Section (c)(2) is applicable to tankless water heaters. It states that applicable water heaters must be certified to show a NOx emission level of less than or equal to:

A. 40 nanograms of NOx (calculated as NO2) per joule (93 lb per Billion BTU), or

B. 55 ppm NOx emissions (at 3% O2, dry)

SCAQMD has a list of certified products under Rule 1146.2. Of those products, (147) residential tankless water heaters are also on the ENERGY STAR qualified products list.

AQMD/APCD Summary

The SCAQMD rules do not state that Rule 1121 applies to residential storage water heaters and Rule 1146.2 applies to residential tankless water heaters. However, tankless water heaters generally have input ratings above 75,000 btu/hr so that is why they fall under Rule 1146.2. Note that commercial storage water heaters with an input rating greater than 75,000 btu/hr may also fall under Rule 1146.2

The impact of these rules was confirmed by trying to potentially buy some of these through a retailer like Lowes.COM where impacted CA addresses could not buy non-compliant units, even if they were on the Energy Star list.

Among residential products, there are four times more tankless water heaters on both the SCAQMD qualified products and the ENERGY STAR qualified products list than gas-storage water heaters. This is a potential reason there is more tankless water heater participation than storage water heater participation.

Incentives and Total Cost

Higher incentives for condensing level efficiency water heaters might explain the higher participation of those units over non-condensing units. So, an analysis of incentives of commercial and residential water heaters was undertaken.

The historical incentives are shown below in Table 16 (2017-2018) and

Table 17 (2019-2021). These tables show the average total incentive for a project. The incentives are paid on a normalized $/kBtuh basis, so the average incentive goes up and down based on the size of water heaters and boilers that participated each year. The average customer cost is also a $/kBtuh value and is calculated as the gross measure cost minus the incentive.

Equation 1: Customer Cost for EE Water Heater/Boiler

$$Cust\_Cost = GMC - Incentive$$

Where:

Cust_Cost = the cost to the customer for the water heater after incentives

GMC = Gross measure cost reported in CEDARS data

Incentive = incentive given to the customer for the installed water heater

Since gross measure cost is dependent upon the workpaper or measure package used for that year, that cost also changes. When there is a negative customer cost, that means that a customer received an incentive that was higher than the gross measure cost in the workpaper/measure package. It does not necessarily mean that a customer received an incentive that was higher than what they paid for the water heater.

Table 16: Commercial Incentive & Payback Analysis 2017-2018 (PGE21012 & SCG3814)

	2017				2018			
Measure	**Avg Size [kBtuh]**	**Avg Incentive**	**Avg Customer Cost**	**Avg Simple Payback**	**Avg Size**	**Avg Incentive**	**Avg Customer Cost**	**Avg Simple Payback**
Boiler, Commercial, Condensing	–	–	–	–	–	–	–	–
Boiler, Commercial, Non-condensing	767	$1,150	-$360	-0.27	–	–	–	–
Storage Water Heater, Commercial, Condensing	206	$615	$5	-0.27	204	$613	$278	0.81
Storage Water Heater, Commercial, Non-condensing	–	–	–	–	–	–	–	–
Tankless Water Heater, Commercial, Condensing	294	$883	$3,299	2.59	406	$1,219	$7,296	7.80
Tankless Water Heater, Commercial, Non-condensing	451	$451	$1,638	1.72	599	$599	$2,751	2.86

Table 17: Commercial Incentive & Payback Analysis 2019-2021 (PGE21012 & SCG3814)

	2019				2020				2021			
Measure	**Avg Size [kBtuh]**	**Avg Incentive**	**Avg Customer Cost**	**Avg Simple Payback**	**Avg Size [kBtuh]**	**Avg Incentive**	**Avg Customer Cost**	**Avg Simple Payback**	**Avg Size [kBtuh]**	**Avg Incentive**	**Avg Cost to Customer**	**Avg Simple Payback**
Boiler, Commercial, Condensing	250	$750	$268	0.59	654	$1,963	$721	0.57	901	$2,702	$964	0.52
Boiler, Commercial, Non-condensing	990	$495	$3,000	3.16	-	-	-	-	-	-	-	-
Storage Water Heater, Commercial, Condensing	195	$646	$390	1.16	178	$561	$1,280	3.58	153	$518	$1,078	3.45
Storage Water Heater, Commercial, Non-condensing	-	-	-	-	-	-	-	-	-	-	-	-
Tankless Water Heater, Commercial, Condensing	449	$1,495	$6,486	5.24	736	$2,944	$7,268	6.67	206	$823	$989	1.40
Tankless Water Heater, Commercial, Non-condensing	597	$597	$2,847	4.02	194	$194	$1,061	3.23	-	-	-	-

Over time, the average incentives for tankless water heaters are much higher than for storage water heaters and boilers. Similarly, the incentives for condensing water heaters/boilers are more than their non-condensing counterparts. However, the average customer cost for tankless water heaters go up in the measure packages when incentives go up, which doesn't explain why customers choose these units since their overall first cost is still higher for condensing equipment. An analysis of the customer's simple payback based upon the energy savings values from the workpapers/measure packages was also done. However, Table 16 and

Table 17 show that the simple paybacks for tankless condensing water heaters are longer than for tankless non-condensing water heaters and condensing storage water heaters. This also does not explain why tankless condensing water heaters have so much more participation.

The conclusion is that incentives are not the only thing that drives the customer toward higher efficiency equipment. Some factors that may drive customers toward tankless water heaters are

1) Decreased size of the equipment which frees up space
2) The perception of endless hot water

The installation of condensing equipment over non-condensing equipment may be driven by the lower exhaust gas temperatures. During the SME interviews, one SME who is a contractor, indicated that the existing configuration of water heaters can cause the labor cost of installing new water heaters to fluctuate quite a bit. It may be that it is easier to vent a tankless condensing water heater than a tankless non-condensing water heater.

A similar analysis of residential incentives, cost to customer, and simple payback was attempted. However, there were many rows in the CEDARS data that had zeroed out incentives, measure costs and therm savings which caused non-sensical results. The data could not be cleaned without a large effort in order to get correct results, and based upon the results for the commercial analysis, the correct results for residential will probably not give any additional insight.

Summary

It was concluded that the main reason storage water heaters have much less participation than tankless water heaters is that there are many more tankless products that meet both Ultra-Low NO_x requirements and Energy Star /Efficiency requirements so there are more tankless products to choose from. To overcome this barrier, different burner designs or different catalytic converter type systems would need to be investigated that can achieve Ultra-Low NO_x or Zero NO_x.

The reason for increased participation of tankless condensing water heaters over tankless non-condensing water heaters was inconclusive. Other factors besides incentive amounts that may also affect a customer's decision to install tankless condensing water heaters over tankless non-condensing water heaters such as:

1) Perception of endless hot water on demand
2) Decreased footprint of equipment resulting in more usable space

3) Installation requirements specific to the site

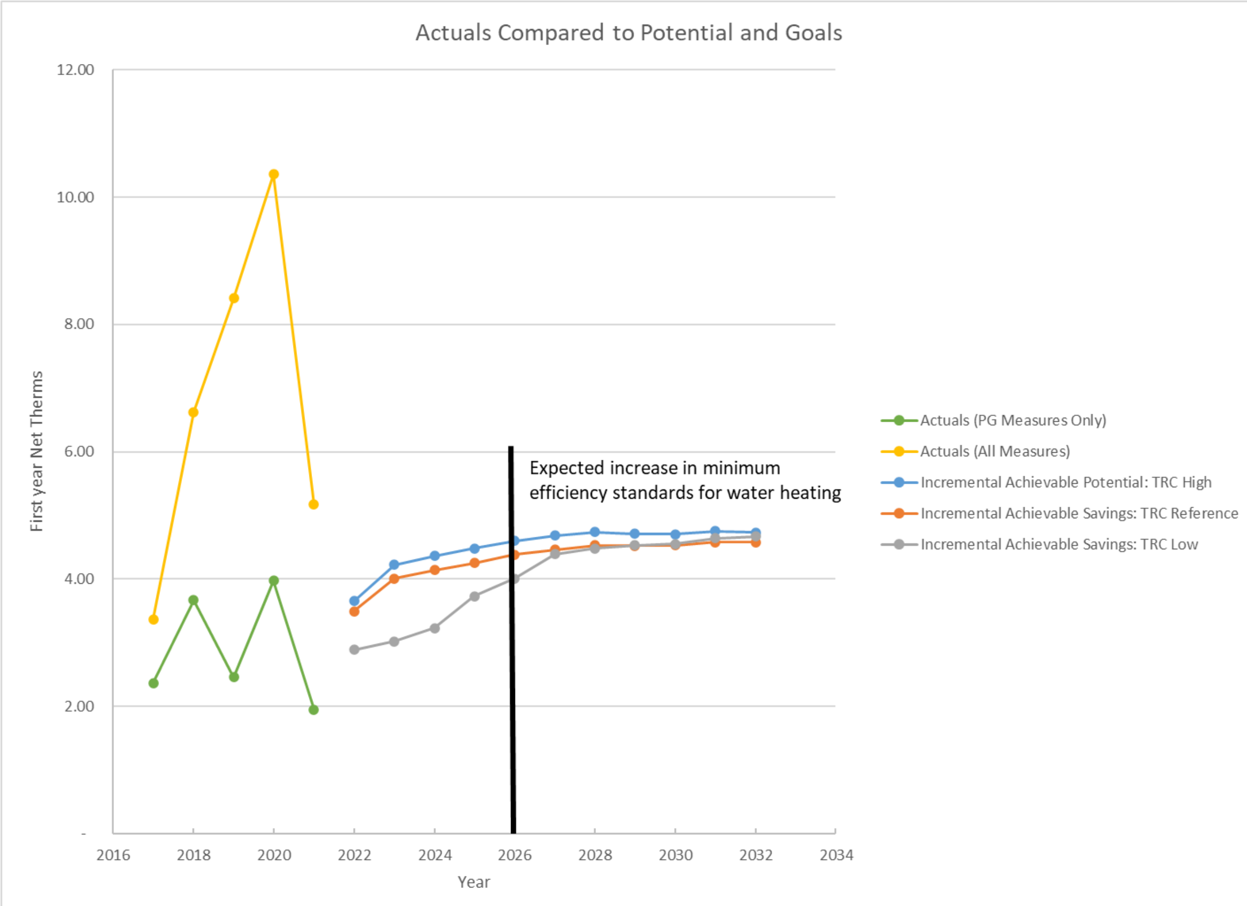
Historical Water Heating Savings vs. Statewide Potential

In addition to analyzing the current trends in the water heating market, the GET team also wanted to know if the water heating participation is on track to meet statewide potential. This will give insight into how much effort should be given to water heating measures in emerging technologies. The CEDARS trend data used for the participation trend analysis was further broken down into measure names that matched up with measure names from the 2021 Potential and Goals Study (PG Study) so the trend data and PG study data could be compared. The actual California statewide claimed net therm savings for water heating from 2017-2021 was compared to the PG Study Incremental Achievable Potential for water heating.

Overall Results

Figure 9 below shows the comparison of the actual savings claims and the PG Study potential forecasts. The PG study does not include all water heating measures in its forecasts. The series "Actual (All Measures)" represents all the water heating measures that have claims in CEDARS from 2017 -2021. The series "Actual (PG Measures) Only" includes only those measures in CEDARS that are also included in the PG Study. "Actual (All Measures) was adjusted in 2018 because there are over 2.5 million therms coming from one program for faucet aerators and low flow showerheads and they were only in that program for 2018. This was an anomaly, so it was removed from the data used for this analysis.

Figure 9: Actual Therm Savings vs. PG Study Incremental Achievable Potential Therm Savings



The PG Study only includes the following measures in its forecasted Incremental Achievable Potential

- Commercial, Condensing Storage Water Heater
- Commercial, Condensing Boiler
- Commercial, Fuel Substitution Heat Pump Water Heater
- Commercial, Fuel Substitution Smart Heat Pump Water Heater
- Commercial, Tankless Condensing Water Heater
- Commercial, Low Flow Pre-Rinse Spray Valve
- Residential, Faucet Aerators
- Residential, Low Flow Showerheads

- Residential, Condensing Storage Water Heater[4]
- Residential, Condensing Tankless Water Heater
- Residential, Water Heating Controls

Actual savings claims from 2017-2021 include the following additional measures not forecasted by the PG Study

- Commercial, Non-Condensing Boiler
- Commercial, Non-Condensing Storage Water Heater
- Commercial, Non-Condensing Tankless Water Heater
- Commercial, Faucet Aerator
- Commercial, Laminar Flow Restrictor
- Commercial, Low Flow Showerhead
- Commercial, Pool/Spa Heater
- Commercial/Residential, Hot Water Pipe Insulation
- Commercial/Residential, Hot Water Tank Insulation
- Residential, Condensing Pool Heater
- Residential, Non-Condensing Pool Heater
- Residential, Non-Condensing Storage Water Heater
- Residential, Non-Condensing Tankless Water Heater

The measures that contribute the most to the difference between "Actuals (All Measures)" and "Actuals (PG Measures Only)" are "Commercial/Residential, Hot Water Pipe Insulation" and "Commercial/Residential, Hot Water Tank Insulation." These measures are add-on measures and Title 24 and OSHA have code requirements that will eventually eat away at the market for them. However, the total net therm for these two measures was still very strong in 2021 (1.83 MM therm for Pipe Insulation and 1.25 MM therm for tank insulation). These are good measures to leverage while California waits for emerging technology water heaters that are not yet commercialized.

Water Heater Results

Since most emerging technology efforts in North America are around water heaters and their controls (rather than low flow fixtures or insulation) water heater and controls

[4] Though this measure is included in the list of forecasted measures, it has 0 therm savings in all years in all scenarios, and it also has no energy savings claims from 2017 -2021

measures were looked at more closely to see how the actual savings compares to the incremental achievable savings. Figure 10, Figure 11, and

Figure 12 below show those comparisons. The PG Study includes multifamily in the residential sector. However, there are specific California programs that target multifamily buildings, and multifamily buildings have different barriers that make them less likely to participate in EE programs. Therefore, multifamily was compared separately from single family. This was done by filtering for the multifamily building type and singe family building type in the PG Study data. The actual data is charted from 2017-2021 and the PG Study data is charted from 2022-2032. "Actual, Total (All Measures)" and "PG, Total" are shown for reference.

Figure 10: Commercial Water Heater Actuals vs. PG Study Incremental Achievable Potential

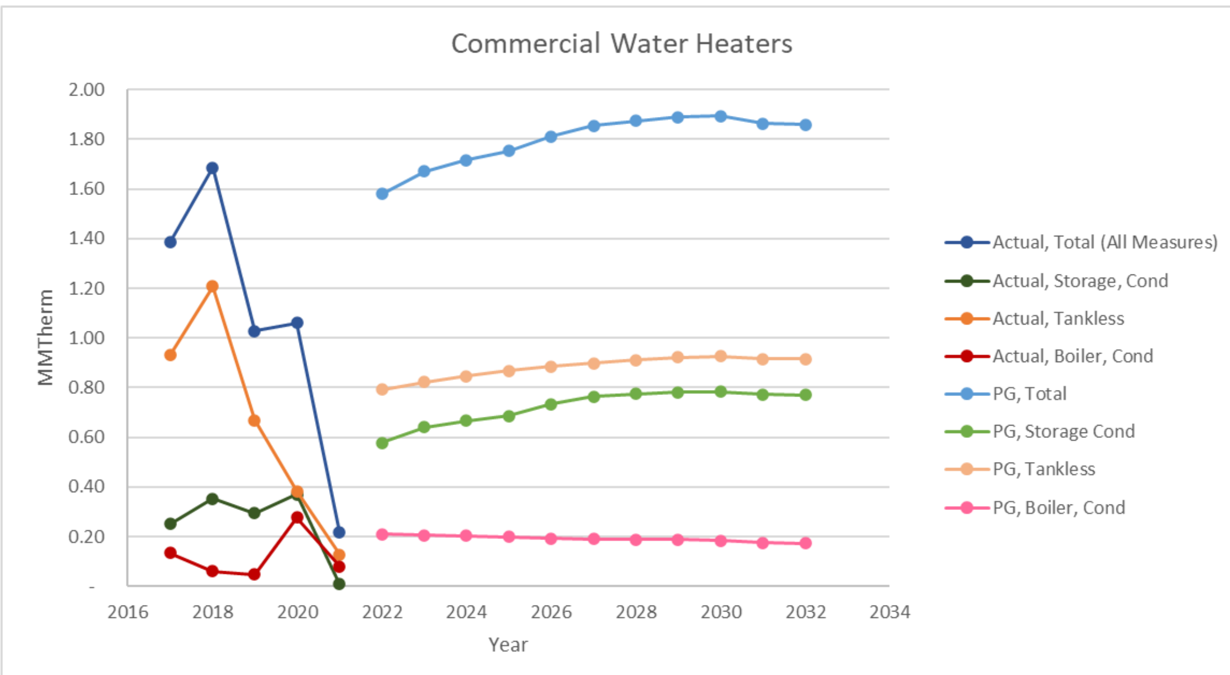


Figure 11: Single Family Water Heater Actuals vs. PG Study Incremental Achievable Potential

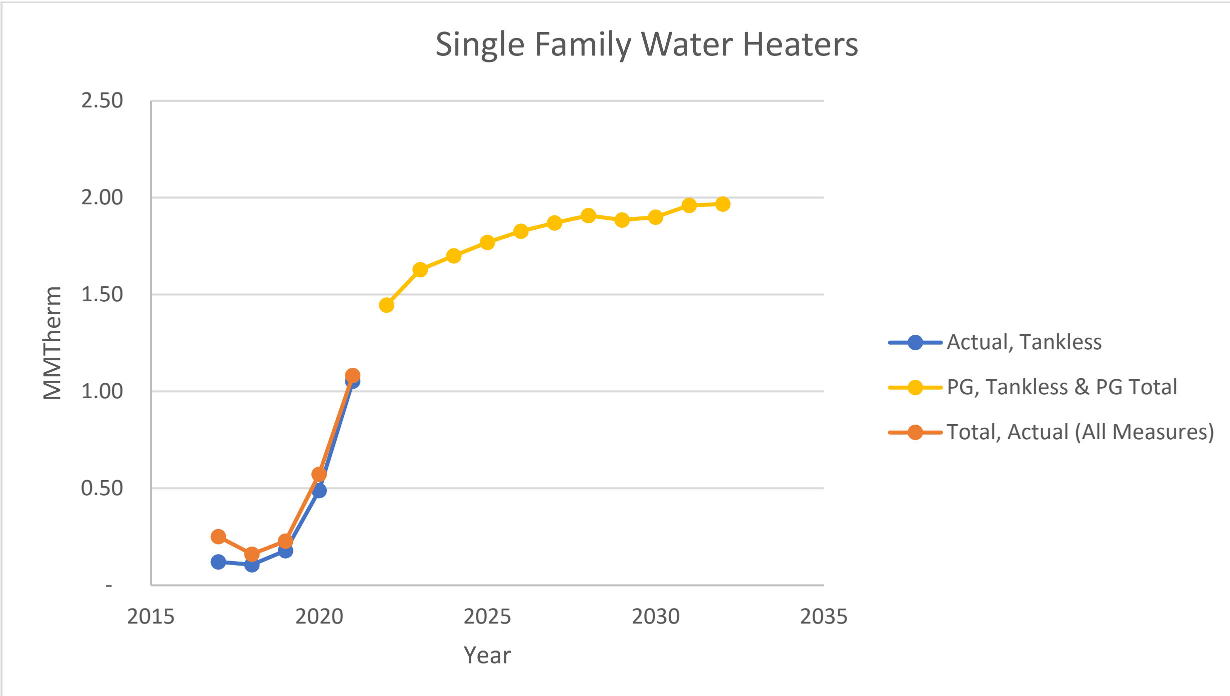
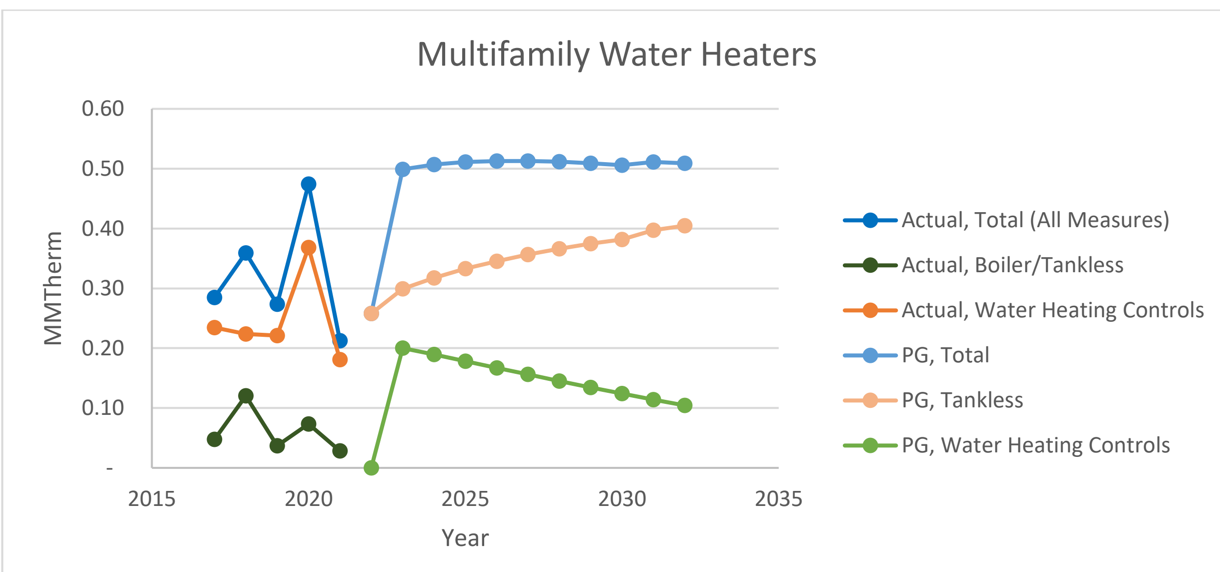


Figure 12: Multifamily Water Heaters and Controls vs. PG Study Incremental Achievable Potential



All of these charts show that California needs to be aggressive in driving participation of condensing efficiency level water heaters in addition to driving participation of water heating controls. Most of the emerging technology water heaters are at or above condensing efficiency, but many are 1-3 years from being commercialized. The existing suite of water heating measures will probably make up the difference in the near term. The success of increasing the participation of condensing efficiency water heaters and boilers in EE programs should be leveraged to create a welcoming environment for the participation of emerging technology water heaters and controls when they are ready for commercial launch.

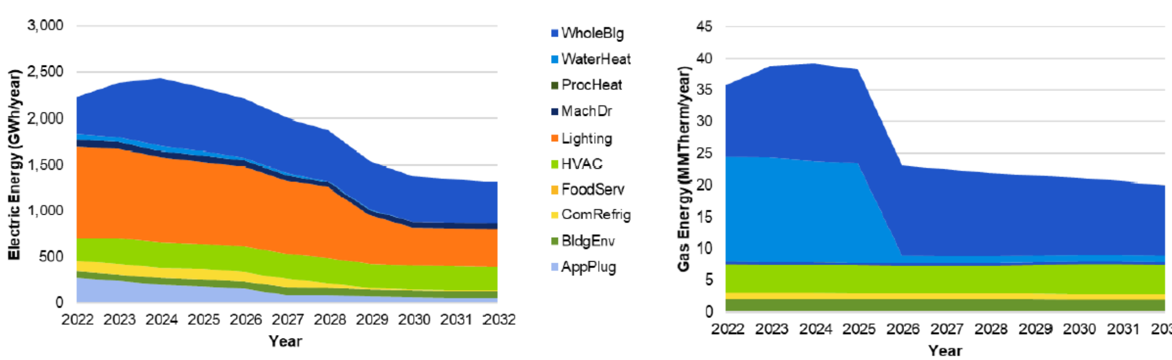
Codes & Standards Updates

The PG Study states

> "C&S savings do not vary across each scenario and tend to be larger than the magnitude of savings from any other source. Thus, they are presented as a single set of results separate from EE equipment, fuel substitution equipment, and BROs savings. Incremental annual savings EE equipment, fuel substitution equipment, and BROs savings. Incremental annual savings from C&S that have been passed into law and C&S that are reasonably expected to be passed into law are illustrated in Figure ES-2."

Figure ES-2 from the PG Study is shown below in Figure 13. Figure 13 shows a sharp decline in gas water heating savings potential in 2026 indicating an expectation that minimum efficiencies for water heaters will rise and some other measures (e.g., controls) may be required. This further reiterates that the emerging technologies program should prioritize technologies that meet or exceed condensing efficiency if they are more than 3 years from commercialization.

Figure 13: PG Study Figure ES-2



Summary

When all water heating measures from the CEDARS 2017-2021 data are considered, California is on track to meet the PG Study Incremental Achievable Potential in the near-term. COVID19 clearly had an impact on claimed therm savings in 2020 and 2021. The PG Study adjusted for COVID19 impacts by reducing restaurant and retail building stock by 20% and 1.5% respectively and by assuming that the eligible population of households for the ESA program that serves low-income customers has increased 10-20%. (California Public Utilities Commission, 2021) The PG Study assumes that these shifts are not permanent and that program activity/claims resume to pre-pandemic levels by 2026. Assuming that is the case, California should be able to exceed the Incremental Achievable Potential each year in the near term.

However, when only the measures in the PG Study are considered, California may have difficulty meeting the Incremental Achievable Potential in the long-term. The total statewide savings claims in 2021 for "Actuals (PG Measures Only)" was 1.95 MMTherm while the projected incremental savings claims from the PG Study for Scenario 2: TRC Reference for 2022 is 3.49 MMTherm. That is a gap of about 1.54 MMTherm. The PG Study shows a very slow increase in incremental gas energy savings each year that tops out at 4.5-4.7 MMTherm for Scenarios 1-3. However, actual trend data from 2017-2019 show a sharp increase in savings claims. It is assumed that the relationships and learning that happened to create that sharp increase will again create an increase in the post-pandemic years of 2022 and beyond. Three main risks to achieving these savings are:

1) California's push for electrification which will cannibalize gas energy savings
2) Codes and Standards revisions that increase the minimum efficiencies of water heaters and may require certain EE measures such as controls and insulation
3) Codes and Standards revisions that require the use of electric heat pump water heaters in certain situations
4) Other regulations that limit the use of gas-fired water heating such as natural gas bans or requirements for zero emissions water heaters

This data shows that the Gas Emerging Technologies Program should focus resources on emerging technologies that are expected to meet or exceed future codes and standards and comply with other regulations affecting gas-fired equipment in order to ensure California can continue to meet or exceed savings goals. The GET program can also provide assistance to increase the adoption of technologies that are in the market and being claimed in EE portfolios but are not seeing as much participation as they could.

Cost Effectiveness Analysis

During the trend data analysis, several measures were identified as opportunities for increased participation in EE programs. These measures all have measure packages, and some are currently offered in EE programs while some are not (at the time of this report). Five (5) of these were selected for further analysis in order to select some for further study to support increased participation. That analysis sought to determine which measures are the best ones for further study based upon the end-user perspective and the program administrator perspective.

Selected Measures

The following five (5) measures were selected for further analysis:

- SWRE003- Heater for Pool or Spa, Commercial
- SWWH010 -Boiler, Multifamily
- SWWH016 - Domestic Hot Water Loop Temperature Controller, Multifamily & Commercial
- SWWH032 - Solar Thermal Water Heating System, Residential
- SWWH034 - Solar thermal water heating system, multifamily

These measures were selected based upon program staff feedback, what other projects are in flight in the GET program, and to ensure a diversity of measures is represented. For all five (5) measures the Total Resource Cost (TRC), Total System Benefit (TSB), cost to the end-user, and end-user simple payback were calculated. TRC and TSB were calculated using the Cost Effectiveness Tool (CET) found on CEDARS. Measure Costs were calculated using the permutations file from each measure package found on the Electronic Technical Reference Manual (eTRM). The simple payback was calculated using therm cost data from Sempra and the U.S. Energy Information Administration (EIA) and therm savings from measure packages on eTRM.

Therm Cost Analysis

The simple payback to the end user is dependent upon the price of natural gas, so an analysis was done on the historical price of natural gas. The cost per therm of natural gas was determined using several data sources. A separate price for residential and commercial building types was calculated. Residential costs for single-family and multifamily were grouped because the Tariffs were the same for both building types.

The average therms per year for each building type is estimated using the customer meter count by sector from page 18 of the Sempra Energy 2020 Annual Report (Sempra Energy,

2021) and the deliveries by end-use from page 28 of the 2021 Supplemental California Gas Report (California Gas & Electric Utilities, 2021). Reported values for the meter count and deliveries by Southern California Gas Company are used for this analysis. Residential data includes both single family and multi-family buildings. An average yearly consumption is calculated using this data.

Table 18: Average Yearly Consumption Analysis

	Residential (Single Family & Multifamily)	Commercial
Total Deliveries (MMcf/yr)	231,775	92,345
Total # Meters	5,792,600	248,720
Avg Yearly Therm Consumption	400	3,713

Monthly therm usage fluctuates throughout the year, and gas prices also change as the season goes from summer to winter. To estimate the monthly consumption, a consumption profile was calculated using the monthly consumption values provided by the EIA Natural Gas Consumption by End Use (U.S. Energy Information Administration, 2022). This monthly consumption profile is applied to the annual consumption value in Table 18 to determine the consumption each month.

Using tariffs for natural gas from Southern California Gas Company (Southern California Gas Company, 2022), each month's cost of natural gas can be calculated, and the average of these values is used in the analysis of the CET results. The full analysis for each sector is shown in Table 19 and Table 20.

Table 19: Residential (Single Family & Multifamily) Cost per Therm Analysis

Month	California Natural Gas Residential Consumption (MMcf)*	Percent Consumption	Estimated Therm/month @ 400 therm/year [therm]	Monthly Allowance (based on tariff)** [therm]	Total Cost	Cost/therm [$/Therm]
Jan	68,688	15%	59.59	49.60	$111.10	$1.86
Feb	52,885	11%	45.88	44.80	$82.80	$1.80
Mar	54,997	12%	47.72	27.09	$94.17	$1.97
Apr	41,417	9%	35.93	26.22	$68.51	$1.91
May	27,837	6%	24.15	13.14	$47.90	$1.98
June	22,064	5%	19.14	12.72	$37.02	$1.93
Jul	20,822	5%	18.07	13.14	$34.46	$1.91
Aug	18,826	4%	16.33	13.14	$30.64	$1.88
Sept	21,069	5%	18.28	12.72	$35.11	$1.92
Oct	24,981	5%	21.67	13.14	$42.43	$1.96
Nov	35,143	8%	30.49	26.22	$56.49	$1.85
Dec	72,315	16%	62.74	49.60	$118.05	$1.88
Average $/therm						$1.91

* EIA Data (U.S. Energy Information Administration, 2022)

** (Southern California Gas Company, 2022)

Table 20: Commercial Cost per Therm Analysis

Month	California Natural Gas Commercial Consumption (MMcf)*	Percent Consumption	Estimated Therm/month @ 3,713 therm/year [therm]	Tier 1 Energy Costs (based on tariff)**	Tier 2 Energy Costs (based on tariff)**	Total Cost	Cost/therm [$/Therm]
Jan	23,798	10%	362.2083	$507.60	$176.87	$684.48	$1.89
Feb	21,768	9%	331.3114	$507.60	$128.17	$635.77	$1.92
Mar	22,356	9%	340.2609	$507.60	$142.28	$649.88	$1.91
Apr	19,400.5	8%	295.2778	$507.60	$71.37	$578.97	$1.96
May	16,445	7%	250.2948	$507.60	$0.46	$508.07	$2.03
June	16,214	7%	246.7789	$501.06	$0.00	$501.06	$2.03
Jul	17,215	7%	262.0143	$507.60	$18.94	$526.54	$2.01
Aug	16,483	7%	250.8731	$507.60	$1.38	$508.98	$2.03
Sept	19,198	8%	292.1957	$507.60	$66.51	$574.12	$1.96
Oct	19,447	8%	295.9856	$507.60	$72.49	$580.09	$1.96
Nov	22,656	9%	344.8269	$507.60	$149.47	$657.08	$1.91
Dec	28,973	12%	440.9724	$507.60	$301.03	$808.63	$1.83
Average $/therm							$1.95

* EIA Data (U.S. Energy Information Administration, 2022)

** (Southern California Gas Company, 2022)

Simple Payback

Simple Payback to the customer was calculated using the equation below:

Equation 2: Customer Simple Payback:

$$SP = \frac{Measure\_Cost \;\; - Measure\_Incentive}{Therm\_Savings \;\; * Therm\_Cost}$$

Where:

SP = Simple Payback

Measure_Cost = Measure Cost

Measure_Incentive = Measure Incentive

Therm_Savings = Therm savings of the measure

Therm_Cost = Cost per therm

The measure cost and therm savings come from the “Permutations” file that is available for each measure from eTRM. The measure costs are the same across building type and climate zone for the same measure offering ID, but therm savings differs for each offering ID, climate zone, and building type permutation. Therefore, the measure costs and them savings were summarized by each offering ID. Simple Paybacks were likewise summarized by each offering ID.

Results

All measures have a “CET Integration” file that is available on the Electronic Technical Reference Manual (eTRM). This file was downloaded for each measure and the incentives were changed and the file was run through the CET with 2022 avoided costs. Incentive levels are:

- None: no incentive to see what the highest TRC and lowest simple payback would be
- Available: Currently available incentives (from the SoCalGas 2022 Business Rebate Guide (SoCalGas, 2022), SoCalGas 2022 Multifamily Rebate Application (SoCalGas, 2022), and the SoCalGas 2022 Multifamily Boiler Controller Rebate Application (SoCalGas, 2022))
- Other: Another incentive that was selected based on the simple payback to the customer. See each measure’s analysis for details

The most recent revision of the measure package and corresponding CET Integration file were used for this analysis. All of these measure package versions are applicable beginning on January 1, 2023. Some 2023 measure packages have added additional tiers of efficiency, but those tiers are not yet reflected in the existing incentive rates. This is the case for

Pool/Spa Heaters (SWRE003) and Multifamily Boiler (SWWH010). In this case calculations, were not done with the available incentive since there is no available incentive.

The simple payback was calculated based upon the incremental measure cost (IMC). This is because the customer would have to spend some amount of money to replace their existing systems with a code compliant or industry standard practice piece of equipment. The additional energy savings are reported above the code/industry standard baseline, and the cost considered here is the cost to get those savings above the code/industry standard baseline.

Table 21: SWRE003- Heater for Pool or Spa, Commercial

Measure Offering ID	Measure Offering Description	Normalizing Unit	First Baseline – Gas Savings [therm]	Incremental Measure Cost	Incentive Level	Incentive	TSB	TRC	Simple Payback
A	Tier 1 efficient commercial pool and spa heater, indoor (TE >= 84%)	Cap – kBtuh	0.49	$9.58	None	$0.00	$1.11	0.20	10.2
			0.49	$9.58	Available	$2.00	$1.11	0.17	8.1
			0.49	$9.58	Other	$5.80	$1.11	0.14	4.0
B	Tier 1 efficient commercial pool and spa heater, outdoor (TE >= 84%)		1.04	$9.58	None	$0.00	$2.38	0.42	4.7
			2.04	$9.58	Available	$2.00	$2.38	0.37	3.7
			3.04	$9.58	Other	$5.80	$2.38	0.30	1.9
C	Tier 2 efficient commercial pool and spa heater, indoor (TE >= 94%)		1.91	$16.40	None	$0.00	$4.41	0.47	4.4
			3.91	$16.40	Other	$5.80	$4.41	0.37	2.8
D	Tier 2 efficient commercial pool and spa heater, outdoor (TE >= 94%)		2.49	$16.40	None	$0.00	$5.69	0.59	3.4
			4.49	$16.40	Other	$5.80	$5.69	0.47	2.2

Four (4) measures offerings were analyzed for Commercial Pool/Spa Heaters, two (2) describing pool heaters with greater than or equal to 84% efficiency (indoor and outdoor), and the other two describing pool heaters with efficiencies greater than or equal to 94% (indoor and outdoor). There is an available incentive for pool heaters at a rate of $2/MBtuh for indoor and outdoor at the 84% efficiency level (SoCalGas, 2022). This is only about 21% of the IMC for these offerings and results in simple payback periods that are higher than the estimated useful life (EUL) of pool heaters. Incentives are not yet available for the 94% efficiency level.

The estimated useful life (EUL) of pool heaters is only five (5) years. It was hypothesized that a customer would want their extra cost to pay off before the end of the equipment's useful life (payback in four (4) years or less). However, because the EUL is short for pool heaters, a payback period of four (4) years would only give an additional benefit of one (1) year. On the other hand, the TRC for these measures is less than 1 so reducing the simple payback to one (1) year or less so that the benefit could be four (4) years was not deemed reasonable either. Therefore, the incentive necessary for each offering to have a payback period in the middle of the EUL (2.5 years) was calculated. The necessary incentive level varies due to the difference in therm savings. An average of $5.80/cap- kBtuh was found to get a 2.5 year simple payback period.

Table 22: Pool/Spa Heater Incentives for 2.5 Year Simple Payback Period

Measure Offering ID	Incentive Level for 2.5 yr Simple Payback Period
A	$ 7.24
B	$ 4.50
C	$ 7.09
D	$ 4.26
Average	5.80

The TRC at $5.80/Cap-kBtuh is less than 1 but the TRC at the available incentive is also less than 1. It is recommended that higher incentive levels be evaluated for this measure in the commercial sector to see if the higher incentives could be supported especially for the tier II pool heater that has more therm savings and better TRC.

Table 23: SWWH010 -Boiler, Multifamily

Measure Offering ID	Measure Offering Description	Normalizing Unit	First Baseline - Gas Savings [therm]	Incremental Measure Cost	Incentive Level	Incentive	TSB	TRC	Simple Payback
B	Central domestic hot water boiler, 90% TE	Cap-kBtuh	4.84	$6.73	None	$0.00	$35.29	9.53	0.7
			4.84	$6.73	Available	$4.00	$35.29	6.42	0.3
C	Central domestic hot water boiler, 96% TE		7.67	$12.40	None	$0.00	$55.96	8.21	0.8

Two (2) measure offerings are included in this analysis, one for boilers with greater than or equal to 90% efficiency and the other for boilers with efficiencies greater than or equal to 96%. There is an available incentive for multifamily boilers at a rate of $4/MBtuh for boilers at the 90% efficiency level (SoCalGas, 2022) There is currently no available incentive for boilers at or above 96% efficiency. The payback periods for these offerings are less than 1 so no additional incentive was calculated. The savings of this measure are significant enough without any incentive to offer a payback of less than a year. Since multifamily boilers see low participation compared to commercial boilers, it is probably due to other issues that they see low participation. This indicates that the suggestions brought by the SoCalGas multifamily program staff ought to be investigated further.

Table 24: SWWH016 - Domestic Hot Water Loop Temperature Controller, Multifamily & Commercial

Measure Offering ID	Total Number of Dwelling Units	Normalizing Unit	Gas Savings [therm]	Full Measure Cost	Incentive Level	Average Households	Average Incentive Per Household	TSB	TRC	Simple Payback
A-G	1 – 35 units	Household/ Dwelling	16.56	$103.71	$0.00	18	$0.00	$44.25	0.93	3.3
			16.56	$103.71	$700.00	18	$38.89	$44.25	0.72	2.0
H-J	36-50 units		16.56	$31.37	$0.00	43	$0.00	$44.25	2.09	1.0
			16.56	$31.37	$1,400.00	43	$32.56	$44.25	1.40	0.0

This measure is broken out into several measure IDs with each having a different range of households. The incentives for this measure are $700 for 35 households and under and $1400 for 36 or more households (SoCalGas, 2022). Since the incentives are grouped by 1-35 households and 36+ households, the energy savings, measure cost, TSB, TRC, and simple payback are also grouped together. The gas savings, measure cost, TSB, and TRC are showing the averages for the measure IDs in each group. The average incentive per household is showing the average incentive for 18 units for offerings A-G and the average incentive for 43 units for offerings H-J. The simple payback is less than half of the measure EUL of 5 years with the current incentive levels, so another incentive level was not calculated. The low participation of this measure with simple paybacks of 2 years or less also indicates that there are different issues in multifamily that are causing participation to be low.

Table 25: SWWH032 – Solar Thermal Water Heating System, Residential

Offering ID	Normalizing Unit	Measure Description	Gas Savings [therm]	Incremental Measure Cost	Incentive Level	Incentive	TSB	TRC	Simple Payback
A	Each	Solar thermal water heating system with storage gas backup, replacing gas storage water heater	94.11	$7,146.06	None	$0.00	$486.25	0.12	39.8
			94.11	$7,146.06	Available	$3,500.00	$486.25	0.09	20.3
			94.11	$7,146.06	75% IMC	$5,359.55	$486.25	0.08	9.9
B		Solar thermal water heating system with tankless gas backup, replacing gas storage water heater	169.75	$7,807.90	None	$0.00	$931.50	0.22	24.1
			169.75	$7,807.90	Available	$4,500.00	$931.50	0.15	10.2
			169.75	$7,807.90	75% IMC	$5,855.93	$931.50	0.13	6.0
C		Solar thermal water heating system with tankless gas backup, replacing gas tankless water heater	79.93	$6,427.14	None	$0.00	$407.36	0.12	42.1
			79.93	$6,427.14	Available	$4,500.00	$407.36	0.07	12.6
			79.93	$6,427.14	75% IMC	$4,820.36	$407.36	0.07	10.5

This measure has three (3) offering IDs. The difference between the offering IDs is whether the new solar thermal system has storage or tankless back up and whether it is replacing a storage or tankless water heater. The EUL of this measure is 15 years and without an incentive, the payback periods for this measure greatly exceed its useful life probably acting as a deterrent. With the available incentives, the simple payback is less than but still very close to the EUL and in the case of Offering ID A, is still greater than the EUL. An average incentive of 75% of the incremental measure cost was found to bring the average simple payback down to 10 years so that the system pays itself off 5 years before the end of its useful life. The TRC for the measure is already very low, so programs would have to be consulted to see if the even lower TRC at 75% of the IMC could be supported.

Table 26: SWWH034 – Solar thermal water heating system, multifamily

Offering ID	Measure Description	Normalizing Unit	Incentive Level	Gas Savings [therm]	Incremental Measure Cost	Incentive	TSB	TRC	Simple Payback
A	Solar thermal water heating system, multifamily	Area-Ft^2	None	6.62	$204.29	$0.00	$36.32	0.32	16.2
			38%	6.62	$204.29	$77.63	$36.32	0.25	10.0
			50%	6.62	$204.29	$102.15	$36.32	0.23	8.1
			68%	6.62	$204.29	$138.92	$36.32	0.26	5.2
			100%	6.62	$204.29	$204.29	$36.32	0.18	0.0

There is only one (1) offering ID for this measure and there are currently no available incentives for it. With no incentive, the simple payback is greater than the EUL of 15 years. Four (4) additional incentive levels were analyzed to determine the cost effectiveness at these varying levels. Incentives range from 0% to 100% of the IMC. A simple payback of 10 years is achieved with an incentive of 38% of the IMC.

Discussion & Recommendations

The emerging technologies from the WHTT are discussed and analyzed further in a parallel project ET22SWG0002. This discussion is focused on the existing water heater market and water heating technologies.

Condensing Efficiency Water Heaters/Boilers

The 2021 Potential and Goals study forecasts annual incremental achievable energy savings using mostly condensing level efficiency technologies (low flow fixtures and some controls are also included in the PG Study). When those forecasts are compared with actual data from 2017-2021, it shows a need to boost participation of the condensing level efficiency water heaters to meet those goals. The PG Study does not include emerging technologies (like gas-fired absorption heat pump water heaters) in the forecasts nor does it include all available water heating controls. Emerging technologies are discussed in the parallel project ET22SWG0002 and controls are discussed in another section.

EE programs have seen success in increasing participation of condensing efficiency water heaters and boilers over the last five (5) years. This is an encouraging finding since condensing efficiency water heaters and boilers have higher costs than non-condensing efficiency water heaters. The findings from the subject matter expert interviews indicate that cost of equipment & installation is a very important consideration to a customer when choosing efficiency levels of equipment to install. The success in increasing participation of condensing efficiency water heaters indicates that this barrier can be overcome in EE programs. What is unclear is why the cost barrier has been overcome without increasing incentives so that the customer's overall cost for a condensing efficiency water heater is less than a non-condensing water heater. Other considerations that may affect this are:

- AQMD requirements
- Space requirements of new water heaters
- Installation considerations and costs
- Positive perception of condensing efficiency products

Future GET projects need to take these other considerations into account to give a better picture of how emerging technologies fit into the water heating market. Since condensing efficiency water heaters and boilers are showing strong participation (in both residential and commercial) and the feedback from the does not indicate there is any opportunity for GET to do activities to further boost participation, no further study on condensing efficiency systems is recommended at this time.

Ultra-Low NO_x

It was found that Ultra Low NO_x requirements by AQMD/APCDs limits the participation of water heaters that would qualify for incentives based solely on their efficiency ratings. It is recommended that the GET program consider other state and local regulations that limit the emissions of gas-fired water heaters when ideas are submitted for new projects. Additionally, technologies that can scrub the emissions of gas-fired water heaters should also be investigated.

Controls

The PG Study also did not include all of the currently available controls measures, so there is an opportunity to invest more in boosting participation of water heating controls to meet statewide therms savings goals. Over the course of this study, it was found that the measures "Domestic Hot Water Temperature Controller" (SWWH016) and "Demand Control for Centralized Water Heater Recirculation Pump" (SWWH015) have separate measure packages, but they can be installed in the same water heating system. However, the measure package for Domestic Hot Water Temperature Controller is not eligible on systems that already have Demand Control for Centralized Water Heater Recirculation Pump. A scan of available studies did not yield any modeling or field testing for these two systems operating together. Further, it was also found during this study that continuous monitoring of these controls system exists which could increase the persistence of savings for these controls measures.

A CASE study from 2013 that evaluated the savings for continuous monitoring using a multifamily DHW system model was found, but the existing measure packages do not account for continuous monitoring and no field studies comparing persistence with and without continuous monitoring could be found. This appears to be a gap that warrants further investigation.

Lastly, "Smart Pump, Residential" (SWWH022) is a high-performance circulator pump for single family and multifamily buildings. The measure package for this pump states "Gas savings were not calculated for this measure; the gas consumption for the measure case is assumed to equal the gas consumption of the base case. There is a possibility that with temperature control, and/or a lower flow rate that gas usage may be reduced, but this has not been calculated and is not being claimed" (CA Energy Efficiency Measure Data, 2022). There is also an opportunity to investigate this technology further to see if it yields therm savings in addition to electric savings. It is recommended that the GET program do further field or lab studies on domestic hot water recirculation loop controls in multifamily and commercial buildings to close the gaps identified above.

Multifamily

Analysis of pool/spa heaters, domestic hot water temperature controllers, and multifamily boilers shows that the simple paybacks on these measures are 5 years or less at the current incentive levels (except indoor 84% efficient pool/spa heater). Pool/Spa heaters and domestic hot water temperature controllers are available in both commercial and multifamily buildings. The simple payback for multifamily boilers is less than 1 year, but multifamily boilers have much less participation than commercial boilers. Since the payback periods are reasonable but these technologies still see low participation, it is probably due to other factors besides the cost of the technologies. Multifamily properties present additional barriers including split incentives, property owner lack of cohesiveness as a group making them difficult to reach, limited energy efficiency knowledge, and out-of-pocket costs (SoCalGas, 2022). Conversations with multifamily program staff recommended that tools be created to help multifamily property owners and managers understand different energy efficient options for water heating and to help them hire qualified contractors to do the energy efficient upgrades.

Technologies that are investigated by GET that are applicable to multifamily properties should also consider and address (as much as possible) these other things that act as barriers to multifamily properties. It is recommended that the GET program bring these findings to the multifamily program staff to see what activities in GET's purview could support increased participation of water heating measures that are applicable to multifamily.

Solar Thermal Water Heaters

Single-family and multi-family residential solar thermal water heaters are new to EE programs. The measure package for single family (SWWH032) was approved in December 2021, and the measure package for multi-family (SWWH034) was approved in April 2022. Residential solar thermal water heaters are currently offered in EE programs, and simple paybacks with available incentives range from 10-20 years. Multifamily solar thermal water heaters are not yet offered in EE programs, but the incentive for that measure needs to be about 38% of the measure cost in order to bring the payback period down to ten (10) years (which is five (5) years less than the EUL). It is recommended that the GET program approach the program staff for SCG3702 to see what activities in GET could do to support participation of these measures in EE programs.

Training

More training of contractor/maintenance personnel and more marketing of specific technologies would also increase participation of condensing level efficiency water heaters as well as water heating controls. SME interviews indicate that customer lack of awareness and lack of installer/maintenance personnel training are considerable participation barriers for high efficiency water heating technologies. Subsequent interviews with program staff and contractor SMEs affirm the need for training and further indicate that increased marketing would help to boost participation of water heating controls. Further studies on water heating controls by GET should provide recommendations for training that can be shared with "Workforce Education & Training" programs.

Appendices

SME Interview Questions

Technology Participation Drivers

1. How much of a driver is a positive public image for your emerging or existing technologies?
2. How much of a driver is it for end-users to reduce dependence on fossil fuels?
3. How much of a driver is it for end-users to reduce GHG emissions?
4. How much of a driver is the compliance with environmental regulations?
5. How much of a driver is the reduction of pollutants other than CO_2, such as SO_x and NOx?
6. How much of a driver is the reduction in manufacturing waste?
7. How much of a driver are new or added advanced (smart) features for the end-user?
8. How much of a driver is the recyclability of your units?
9. How much of a driver is local manufacturing to the end-user? i.e., Made in the USA.
10. How much of a driver is improved performance for the end-user?
11. How much of a driver is the potential to increase your customer base?
12. How much of a driver is lowering production costs?
13. How much of a driver is the customer's willingness to pay a premium for a better product?
14. How much of a driver is government support for technology uptake for you?
15. How much of a driver is independent verification of performance?
16. How much of a driver is a shorter-to-market cycle when it was entering the market?

Technology Participation Barriers

17. How much of a barrier is the cost of your technologies?
18. How much of a barrier is the uncertainty of future codes/standards?
19. How much of a barrier are the market fluctuations in price and cost?
20. How much of a barrier is adverse regulatory environments?
21. How much of a barrier is the uncertainty of technology performance by the end-user?

22. How much of a barrier is uncertain reliability in your product by the end-user?
23. How much of a market barrier is the lack of awareness from the customers?
24. How much of a market barrier is incompatibility with existing systems for your technology?
25. How much of a market barrier is higher lifecycle costs to the end user?
26. How much of a barrier is the lack of awareness of GHG savings by the end-user?
27. How much of a barrier is any possible environmental impact of manufacturing?
28. How much of a barrier is any adverse disposal effects? i.e., refrigerant.
29. How much of a barrier is the lack of installer and/or contractor training?
30. How much of a barrier is the lack of maintenance personnel training?
31. How much of a barrier is the lack of awareness among designers and engineers?

Raw SME Responses

Respondent #1

1.1. How much of a driver is a positive public image?

1	2	**3**	4	5

1.2. How much of a driver is it for end-users to reduce dependence on fossil fuels?

1	2	**3**	4	5

1.3. How much of a driver is it for end-users to reduce GHG emissions?

1	**2**	3	4	5

1.4. How much of a driver is the compliance with environmental regulations?

1	2	**3**	4	5

1.5. How much of a driver is the reduction of pollutants other than CO_2? i.e., SO_x and NO_x?

1	**2**	3	4	5

- End-users is 2 (being generous), regulators are 4.

1.6. How much of a driver is the reduction of manufacturing waste?

1	2	3	**4**	5

1.7. How much of a driver are new or added advanced (smart) features for the end-user?

1	2	3	**4**	5

1.8. How much of a driver is the recyclability of your units?

1	**2**	3	4	5

1.9. How much of a driver is local manufacturing to the end-user? i.e., Made in the USA.

1	2	**3**	4	5

1.10. How much of a driver is improved performance for the end-user?

1	2	3	**4**	5

- Most important performance factor is reduction in utility bills, or improved efficiency.

1.11. How much of a driver is the potential to increase your customer base?

1	2	3	4	**5**

1.12. How much of a driver is lowering production costs?

1	2	3	4	**5**

1.13. How much of a driver is the customer's willingness to pay for a better product?

1	2	3	4	5

- Not in market yet, but market research indicates there is small segment that will pay a premium.

1.14. How much of a driver is government support for technology uptake for you?

1	2	3	4	5

1.15. How much of a driver is independent verification of performance?

1	2	3	4	5

- Residential homeowners not important, but commercial is more important.

1.16. How much of a driver is a shorter-to-market cycle when it was entering the market?

1	2	3	4	5

- Manufacturer A has been developing for 12 years.

1.17. How much of a barrier is the cost of your technologies?

1	2	3	4	5

1.18. How much of a barrier is the uncertainty of future codes/standards?

1	2	3	4	5

- Critically important for investors since gas-fired appliances are being avoided.

1.19. How much of a barrier are the market fluctuations in price and cost?

1	2	3	4	5

- Costs goes up, along with competitors costs. That should balance out.
- Natural gas prices have been going up, so payback (ROI) is going down.
- Supply chain issues cause everyone to increase/decrease equally.

1.20. How much of a barrier is adverse regulatory environments?

1	2	3	4	5

1.21. How much of a barrier is the uncertainty of technology performance by the end-user?

1	2	3	4	5

- Take time for people to become aware of the technology after entering the market.

1.22. How much of a barrier is uncertain reliability in your product by the end-user?

1	2	3	4	5

1.23. How much of a barrier is the lack of awareness from the customers?

1	2	3	**4**	5

1.24. How much of a barrier is incompatibility with existing systems for your technology?

1	2	**3**	4	5

- They "go out of their way" to make products compatibility. However, still important.

1.25. How much of a barrier is higher lifecycle costs to the end user?

1	2	3	**4**	5

1.26. How much of a barrier is the lack of awareness of GHG savings by the end-user?

1	2	3	4	**5**

1.27. How much of a barrier is any possible environmental impact of manufacturing?

1	**2**	3	4	5

1.28. How much of a barrier is any adverse disposal effects?

1	**2**	3	4	5

- Ammonia alternative to refrigerant can dissipate into the air, without any harmful effects. Advantage for Manufacturer A Brand A Heat Pump.

Respondent #2

1.29. How much of a driver is a positive public image?

1	2	3	4	**5**

1.30. How much of a driver is it for end-users to reduce dependence on fossil fuels?

1	2	**3**	4	5

1.31. How much of a driver is it for end-users to reduce GHG emissions?

1	2	**3**	4	5

1.32. How much of a driver is the compliance with environmental regulations?

1	2	3	**4**	5

- Industry trying to rid of all gas appliances, working against Manufacturer B

1.33. How much of a driver is the reduction of pollutants other than CO_2? i.e., SO_x and NO_x?

1	**2**	3	4	5

1.34. How much of a driver is the reduction in manufacturing waste?

1	2	3	4	5

1.35. How much of a driver are new or added advanced (smart) features for the end-user?

1	2	3	4	5

- Concerns: Is they don't know something exist; how can they want it added? Manufacturer B is a new product. We need to be more specific about what that would be for water heating.

1.36. How much of a driver is the recyclability of your units?

1	2	3	4	5

1.37. How much of a driver is local manufacturing to the end-user? i.e., Made in the USA.

1	2	3	4	5

- Doesn't think people care about where it comes from.

1.38. How much of a driver is improved performance for the end-user?

1	2	3	4	5

- Efficiency most important.

1.39. How much of a driver is the potential to increase your customer base?

1	2	3	4	5

1.40. How much of a driver is lowering production costs?

1	2	3	4	5

- Supply-and-demand issues; increase awareness so price will go down.

1.41. How much of a driver is the customer's willingness to pay for a better product?

1	2	3	4	5

1.42. How much of a driver is government support for technology uptake for you?

1	2	3	4	5

1.43. How much of a driver is independent verification of performance?

1	2	3	4	5

1.44. How much of a driver is a shorter-to-market cycle when it was entering the market?

1	2	3	4	5

- Commercial is 2, but Residential is 4. (In regard to the upcoming unit)

1.45. How much of a barrier is the cost of your technologies?

1	2	3	4	5

- They are more expensive, and "everybody talks a big game until it comes to the wallet."

1.46. How much of a barrier is the uncertainty of future codes/standards?

1	2	3	4	5

1.47. How much of a barrier are the market fluctuations in price and cost?

1	2	3	4	5

1.48. How much of a barrier is adverse regulatory environments?

1	2	3	4	5

- Legislation is a huge challenge. Such as outlawing gas.

1.49. How much of a barrier is the uncertainty of technology performance by the end-user?

1	2	3	4	5

- No issues based on performance. "It would be the opposite."

1.50. How much of a barrier is uncertain reliability in your product by the end-user?

1	2	3	4	5

1.51. How much of a barrier is the lack of awareness from the customers?

1	2	3	4	5

- He would not have a job if there was already awareness. He gave it a 6.

1.52. How much of a barrier is incompatibility with existing systems for your technology?

1	2	3	4	5

1.53. How much of a barrier is higher lifecycle costs to the end user?

1	2	3	4	5

1.54. How much of a barrier is the lack of awareness of GHG savings by the end-user?

1	2	3	4	5

- Relatively newer awareness, as GHG has become more general.

1.55. How much of a barrier is any possible environmental impact of manufacturing?

1	2	3	4	5

1.56. How much of a barrier is any adverse disposal effects?

1	2	3	4	5

- No effects from Manufacturer B units.

Respondent #3

1.57. How much of a driver is a positive public image?

1	2	3	4	5

1.58. How much of a driver is it for end-users to reduce dependence on fossil fuels?

1	2	3	4	5

- Consumers not concerned with using less gas, from market research. High-efficiency gas units are very small % of production, mostly low efficiency.

1.59. How much of a driver is it for end-users to reduce GHG emissions?

1	2	3	4	5

- Some people think about this, but they don't see to pursuing when purchasing.

1.60. How much of a driver is the compliance with environmental regulations?

1	2	3	4	5

- They make sure to offer right product available regardless of jurisdictional guidelines set.

1.61. How much of a driver is the reduction of pollutants other than CO_2? i.e., SO_x and NO_x?

1	2	3	4	5

- Most consumers do not know understand why it cost more for Low-NOx

1.62. How much of a driver is the reduction in manufacturing waste?

1	2	3	4	5

- Corporate waste goals, sometimes unavoidable, but they try to reduce.

1.63. How much of a driver are new or added advanced (smart) features for the end-user?

1	2	3	4	5

- "Heater must heat water." Consumers are not concerned about other advanced features.

1.64. How much of a driver is the recyclability of your units?

1	2	3	4	5

- Almost everything in a water heater is recyclable. Only half of consumers care about it.

1.65. How much of a driver is local manufacturing to the end-user? i.e., Made in the USA.

1	2	3	4	5

- Wants to say it a 4, but the market is continually changing to outsourced gas tankless.

1.66. How much of a driver is improved performance for the end-user?

1	2	3	4	5

- Readily information available to show bulk sales is **minimum efficiency WH**. So, if people are voting with their dollars, then it is very low.

1.67. How much of a driver is the potential to increase your customer base?

1	2	3	4	5

- US market is saturated, everybody has a WH, low number people looking for new EE units. Advanced technology help improve margins. But market is relatively flat and not growing, so it's hard to gain market share with just higher efficiency products.

1.68. How much of a driver is lowering production costs?

1	2	3	4	5

- Spend up to 80% of his time doing this.

1.69. How much of a driver is the customer's willingness to pay for a better product?

1	2	3	4	5

- They want to offer that have a premium, or additional benefit. But not important.

1.70. How much of a driver is government support for technology uptake for you?

1	2	3	4	5

- They put out high EE product. But they are not promoting fed/state to create mandates. But when they are available, then it is beneficial to them.

1.71. How much of a driver is independent verification of performance?

1	2	3	4	5

- Makes sure everyone is one is on a "Level-playing field."

1.72. How much of a driver is a shorter-to-market cycle when it was entering the market?

1	2	3	4	5

- Speed to market is generally very slow for new products and is not dependent on business health.

1.73. How much of a barrier is the cost of your technologies?

1	2	3	4	5

1.74. How much of a barrier is the uncertainty of future codes/standards?

1	2	3	4	5

- Code/standards change on slow cycle. i.e. NECA 7 years away from being enacted into law.
- New trends in CA have been known about for years, so they are not actually new codes/standards.

1.75. How much of a barrier are the market fluctuations in price and cost?

1	2	3	4	5

- Most customers looking for lowest priced units, not efficiency. Cheaper options will also drive the bulk of the market. “Nobody wants to go buy a new water heater.” i.e., buying a car.

1.76. How much of a barrier is adverse regulatory environments?

1	2	3	4	5

- When they must build very specific products to meet regs. Then it becomes a barrier.
- State of Utah also Low-NOx. But CA is 10% of US market, so they can build specific products to meet the market. Opposed to small markets, where they are not too worried about it.
- Non-powered damper units: Same technology doesn’t work on venturi air system Low-NOx water heaters. If 0.68 UEF becomes a standard, then they will need to develop a design to meet the req’s.

1.77. How much of a barrier is the uncertainty of technology performance by the end-user?

1	2	3	4	5

1.78. How much of a barrier is uncertain reliability in your product by the end-user?

1	2	3	**4**	5

- More important than efficiency. Newer technologies have better chance to fail, more complex.

1.79. How much of a barrier is the lack of awareness from the customers?

1	2	3	**4**	5

- “Knowing what’s available, know what the difference is, education is the key.”

1.80. How much of a barrier is incompatibility with existing systems for your technology?

1	**2**	3	4	5

- Not many issues with fitting into existing gas systems.

1.81. How much of a barrier is higher lifecycle costs to the end user?

1	2	3	**4**	5

- Based on low volumes of high EE units.

1.82. How much of a barrier is the lack of awareness of GHG savings by the end-user?

1	2	3	**4**	5

1.83. How much of a barrier is any possible environmental impact of manufacturing?

1	**2**	3	4	5

1.84. How much of a barrier is any adverse disposal effects?

1	2	3	4	5

Respondent #4

1.85. How much of a driver is a positive public image?

1	2	**3**	4	5

1.86. How much of a driver is it for end-users to reduce dependence on fossil fuels?

1	2	**3**	4	5

1.87. How much of a driver is it for end-users to reduce GHG emissions?

1	2	**3**	4	5

1.88. How much of a driver is the compliance with environmental regulations?

1	2	3	4	**5**

1.89. How much of a driver is the reduction of pollutants other than CO_2? i.e., SO_x and NO_x?

1	2	3	4	5

1.90. How much of a driver is the reduction in manufacturing waste?

1	2	3	**4**	5

1.91. How much of a driver are new or added advanced (smart) features for the end-user?

1	2	3	**4**	5

1.92. How much of a driver is the recyclability of your units?

1	2	**3**	4	5

1.93. How much of a driver is local manufacturing to the end-user? i.e., Made in the USA.

1	2	3	**4**	5

1.94. How much of a driver is improved performance for the end-user?

1	2	3	**4**	5

1.95. How much of a driver is the potential to increase your customer base?

1	2	3	**4**	5

1.96. How much of a driver is lowering production costs?

1	2	3	4	**5**

1.97. How much of a driver is the customer's willingness to pay for a better product?

1	2	3	**4**	5

1.98. How much of a driver is government support for technology uptake for you?

1	2	3	**4**	5

1.99. How much of a driver is independent verification of performance?

1	2	3	4	**5**

1.100. How much of a driver is a shorter-to-market cycle when it was entering the market?

1	2	3	**4**	5

1.101. How much of a barrier is the cost of your technologies?

1	2	3	**4**	5

1.102. How much of a barrier is the uncertainty of future codes/standards?

1	2	**3**	4	5

1.103. How much of a barrier are the market fluctuations in price and cost?

1	2	**3**	4	5

1.104. How much of a barrier is adverse regulatory environments?

1	2	**3**	4	5

1.105. How much of a barrier is the uncertainty of technology performance by the end-user?

1	2	**3**	4	5

1.106. How much of a barrier is uncertain reliability in your product by the end-user?

1	2	3	**4**	5

1.107. How much of a barrier is the lack of awareness from the customers?

1	2	3	**4**	5

1.108. How much of a barrier is incompatibility with existing systems for your technology?

1	2	3	**4**	5

1.109. How much of a barrier is higher lifecycle costs to the end user?

1	2	**3**	4	5

1.110. How much of a barrier is the lack of awareness of GHG savings by the end-user?

1	**2**	3	4	5

1.111. How much of a barrier is any possible environmental impact of manufacturing?

1	**2**	3	4	5

1.112. How much of a barrier is any adverse disposal effects?

1	**2**	3	4	5

1.113. How much of a barrier is the lack of installer and/or contractor training?

1	2	3	**4**	5

1.114. How much of a barrier is the lack of maintenance personnel training?

1	2	**3**	4	5

1.115. How much of a barrier is the lack of awareness among designers and/or engineers?

1	2	**3**	4	5

Respondent #5

1.116. How much of a driver is a positive public image?

1	2	3	4	5

1.117. How much of a driver is it for end-users to reduce dependence on fossil fuels?

1	2	3	4	5

1.118. How much of a driver is it for end-users to reduce GHG emissions?

1	2	3	4	5

1.119. How much of a driver is the compliance with environmental regulations?

1	2	3	4	5

1.120. How much of a driver is the reduction of pollutants other than CO_2? i.e., SO_x and NO_x?

1	2	3	4	5

1.121. How much of a driver is the reduction in manufacturing waste?

1	2	3	4	5

1.122. How much of a driver are new or added advanced (smart) features for the end-user?

1	2	3	4	5

1.123. How much of a driver is the recyclability of your units?

1	2	3	4	5

1.124. How much of a driver is local manufacturing to the end-user? i.e., Made in the USA.

1	2	3	4	5

1.125. How much of a driver is improved performance for the end-user?

1	2	3	4	5

1.126. How much of a driver is the potential to increase your customer base?

1	2	3	4	5

1.127. How much of a driver is lowering production costs?

1	2	3	4	5

1.128. How much of a driver is the customer's willingness to pay for a better product?

1	2	3	4	5

1.129. How much of a driver is government support for technology uptake for you?

1	2	3	4	5

1.130. How much of a driver is independent verification of performance?

1	2	3	4	5

1.131. How much of a driver is a shorter-to-market cycle when it was entering the market?

1	2	3	4	5

1.132. How much of a barrier is the cost of your technologies?

1	2	3	4	5

1.133. How much of a barrier is the uncertainty of future codes/standards?

1	2	3	4	5

1.134. How much of a barrier are the market fluctuations in price and cost?

1	2	3	4	5

1.135. How much of a barrier is adverse regulatory environments?

1	2	3	4	5

1.136. How much of a barrier is the uncertainty of technology performance by the end-user?

1	2	3	4	5

1.137. How much of a barrier is uncertain reliability in your product by the end-user?

1	2	3	4	5

1.138. How much of a barrier is the lack of awareness from the customers?

1	2	3	4	5

1.139. How much of a barrier is incompatibility with existing systems for your technology?

1	2	3	4	5

1.140. How much of a barrier is higher lifecycle costs to the end user?

1	2	3	4	5

1.141. How much of a barrier is the lack of awareness of GHG savings by the end-user?

1	2	3	4	5

1.142. How much of a barrier is any possible environmental impact of manufacturing?

1	2	3	4	5

1.143. How much of a barrier is any adverse disposal effects?

1	2	3	4	5

1.144. How much of a barrier is the lack of installer and/or contractor training?

1	2	**3**	4	5

1.145. How much of a barrier is the lack of maintenance personnel training?

1	2	**3**	4	5

1.146. How much of a barrier is the lack of awareness among designers and/or engineers?

1	2	**3**	4	5

Respondent #6

1.147. How much of a driver is a positive public image?

1	2	3	**4**	5

1.148. How much of a driver is it for end-users to reduce dependence on fossil fuels?

1	2	3	**4**	5

- It caused both saving money and CO2, so he thinks the issue will become very important and will help end-user to make the choice to pay extra in the future.

1.149. How much of a driver is it for end-users to reduce GHG emissions?

1	2	**3**	4	5

1.150. How much of a driver is the compliance with environmental regulations?

1	2	3	4	**5**

1.151. How much of a driver is the reduction of pollutants other than CO_2? i.e., SO_x and NO_x?

1	2	3	4	**5**

1.152. How much of a driver is the reduction in manufacturing waste?

1	2	3	**4**	5

- This has not been discussed for Manufacturer D yet, so this is an estimation.

1.153. How much of a driver are new or added advanced (smart) features for the end-user?

1	2	**3**	4	5

- New features come with problems, "Headaches."

1.154. How much of a driver is the recyclability of your units?

1	**2**	3	4	5

- Consumers are generally not concerned about this.

1.155. How much of a driver is local manufacturing to the end-user? i.e., Made in the USA.

1	2	3	**4**	5

- More important in US than other countries. Another aspect that has not been explored yet since he is in Sweden.

1.156. How much of a driver is improved performance for the end-user?

1	2	3	4	**5**

- Comes down to saving money, so more use with same amount of input fuel. But with higher performance. i.e. challenge with electric HPs. That want more heating capacity, or efficiency.

1.157. How much of a driver is the potential to increase your customer base?

1	2	3	4	5

1.158. How much of a driver is lowering production costs?

1	2	3	4	**5**

- Cost very important specifically the water heating industry.

1.159. How much of a driver is the customer's willingness to pay for a better product?

1	2	3	**4**	5

- Challenge to get customers to pay premium. Important to have incentive or legislations to help increase participation. They will go for the **cheapest.**

1.160. How much of a driver is government support for technology uptake for you?

1	2	3	4	**5**

1.161. How much of a driver is independent verification of performance?

1	2	3	4	**5**

1.162. How much of a driver is a shorter-to-market cycle when it was entering the market?

1	2	3	4	**5**

1.163. How much of a barrier is the cost of your technologies?

1	2	3	4	**5**

1.164. How much of a barrier is the uncertainty of future codes/standards?

1	2	3	**4**	5

1.165. How much of a barrier are the market fluctuations in price and cost?

1	2	3	4	5

1.166. How much of a barrier is adverse regulatory environments?

1	2	3	4	5

- Personally, he is not too worried about it. But still think it's important.

1.167. How much of a barrier is the uncertainty of technology performance by the end-user?

1	2	3	4	5

- i.e., New Electric HPs looks good on paper, but in reality, there is decreased performance.

1.168. How much of a barrier is uncertain reliability in your product by the end-user?

1	2	3	4	5

1.169. How much of a barrier is the lack of awareness from the customers?

1	2	3	4	5

1.170. How much of a barrier is incompatibility with existing systems for your technology?

1	2	3	4	5

- Compared to other technologies.

1.171. How much of a barrier is higher lifecycle costs to the end user?

1	2	3	4	5

- "You want to buy something, then you don't want to think about it later."

1.172. How much of a barrier is the lack of awareness of GHG savings by the end-user?

1	2	3	4	5

- Doesn't think many people are thinking about it.

1.173. How much of a barrier is any possible environmental impact of manufacturing?

1	2	3	4	5

1.174. How much of a barrier is any adverse disposal effects?

1	2	3	4	5

1.175. How much of a barrier is the lack of installer and/or contractor training?

1	2	3	4	5

1.176. How much of a barrier is the lack of maintenance personnel training?

1	2	3	4	5

1.177. How much of a barrier is the lack of awareness among designers and/or engineers?

1	2	3	4	5

Respondent #7

1.178. How much of a driver is a positive public image?

1	2	3	4	5

- If you have compelling story, then public image doesn't matter.

1.179. How much of a driver is it for end-users to reduce dependence on fossil fuels?

1	2	3	4	5

- Everyone wants to reduce fossil fuels, but consumers still motivated by cost.

1.180. How much of a driver is it for end-users to reduce GHG emissions?

1	2	3	4	5

1.181. How much of a driver is the compliance with environmental regulations?

1	2	3	4	5

- Regulations will kill a product. But if it's a 'Loosey-Goosey" regulation stated by politician, then it doesn't matter.

1.182. How much of a driver is the reduction of pollutants other than CO_2? i.e., SO_x and NO_x?

1	2	3	4	5

1.183. How much of a driver is the reduction in manufacturing waste?

1	2	3	4	5

- Not involved it MFG, but he thinks there is very little. And related to cost so it's important.

1.184. How much of a driver are new or added advanced (smart) features for the end-user?

1	2	3	4	5

- They feel there are still some refinements to be made for the Manufacturer E product.

1.185. How much of a driver is the recyclability of your units?

1	2	3	4	5

- Consumers do not care about this. i.e. do you think this when buying a car?

1.186. How much of a driver is local manufacturing to the end-user? i.e., Made in the USA.

1	**2**	3	4	5

- They feel it's an advantage for their product, but end-user not concerned about it. They would like to see this become more important. End-users do not value it.

1.187. How much of a driver is improved performance for the end-user?

1	2	3	4	**5**

- Reliability is most important. It must perform. But also, efficiency matters.

1.188. How much of a driver is the potential to increase your customer base?

1	2	3	**4**	5

1.189. How much of a driver is lowering production costs?

1	2	3	4	**5**

1.190. How much of a driver is the customer's willingness to pay for a better product?

1	2	3	4	**5**

1.191. How much of a driver is government support for technology uptake for you?

1	2	3	**4**	5

- No support from gov't, so they are learning the live without it. But gov't support would be very helpful.

1.192. How much of a driver is independent verification of performance?

1	2	**3**	4	5

1.193. How much of a driver is a shorter-to-market cycle when it was entering the market?

1	**2**	3	4	5

- Seems like markets are slow developing. Not worried about it.

1.194. How much of a barrier is the cost of your technologies?

1	2	3	**4**	5

- Premium isn't a problem if you can justify with ROI. Benefits are too small, or cost is too high.

1.195. How much of a barrier is the uncertainty of future codes/standards?

1	2	3	4	5

1.196. How much of a barrier are the market fluctuations in price and cost?

1	2	3	4	5

- Not worried about fluctuations, just the cost. Variation does not hurt them.

1.197. How much of a barrier is adverse regulatory environments?

1	2	3	4	5

- Regulations are being written in weird way. Specific regulations are problems with the way that they are being developed.

1.198. How much of a barrier is the uncertainty of technology performance by the end-user?

1	2	3	4	5

1.199. How much of a barrier is uncertain reliability in your product by the end-user?

1	2	3	4	5

1.200. How much of a barrier is the lack of awareness from the customers?

1	2	3	4	5

1.201. How much of a barrier is incompatibility with existing systems for your technology?

1	2	3	4	5

- Site issues such space, poor ventilation, etc. not boilers or pipe retrofitting.

1.202. How much of a barrier is higher lifecycle costs to the end user?

1	2	3	4	5

- Gives this one a "6", very important!

1.203. How much of a barrier is the lack of awareness of GHG savings by the end-user?

1	2	3	4	5

- Many customers, UPs, and consultants do not understand how something that burns fossil fuels can save fossil fuels.

1.204. How much of a barrier is any possible environmental impact of manufacturing?

1	2	3	4	5

- Compared to batteries, i.e., strip mining lithium.

1.205. How much of a barrier is any adverse disposal effects?

1	2	3	4	5

- Only a little refrigerant. You can recycle refrigerant.

1.206. How much of a barrier is the lack of installer and/or contractor training?

1	2	3	4	5

1.207. How much of a barrier is the lack of maintenance personnel training?

1	2	3	4	5

1.208. How much of a barrier is the lack of awareness among designers and/or engineers?

1	2	3	4	5

Respondent #8

1.209. How much of a driver is a positive public image?

1	2	3	4	5

1.210. How much of a driver is it for end-users to reduce dependence on fossil fuels?

1	2	3	4	5

1.211. How much of a driver is it for end-users to reduce GHG emissions?

1	2	3	4	5

1.212. How much of a driver is the compliance with environmental regulations?

1	2	3	4	5

1.213. How much of a driver is the reduction of pollutants other than CO_2? i.e., SO_x and NO_x?

1	2	3	4	5

1.214. How much of a driver is the reduction in manufacturing waste?

1	2	3	4	5

1.215. How much of a driver are new or added advanced (smart) features for the end-user?

1	2	3	4	5

1.216. How much of a driver is the recyclability of your units?

1	2	3	4	5

1.217. How much of a driver is local manufacturing to the end-user? i.e., Made in the USA.

1	2	3	4	**5**

1.218. How much of a driver is improved performance for the end-user?

1	2	3	4	**5**

1.219. How much of a driver is the potential to increase your customer base?

1	2	3	4	**5**

1.220. How much of a driver is lowering production costs?

1	2	3	4	**5**

1.221. How much of a driver is the customer's willingness to pay for a better product?

1	2	3	4	**5**

1.222. How much of a driver is government support for technology uptake for you?

1	2	3	4	**5**

1.223. How much of a driver is independent verification of performance?

1	2	3	4	**5**

1.224. How much of a driver is a shorter-to-market cycle when it was entering the market?

1	2	3	4	**5**

1.225. How much of a barrier is the cost of your technologies?

1	2	3	4	**5**

1.226. How much of a barrier is the uncertainty of future codes/standards?

1	2	3	4	**5**

1.227. How much of a barrier are the market fluctuations in price and cost?

1	2	3	4	**5**

1.228. How much of a barrier is adverse regulatory environments?

1	**2**	3	4	5

1.229. How much of a barrier is the uncertainty of technology performance by the end-user?

1	2	3	**4**	5

1.230. How much of a barrier is uncertain reliability in your product by the end-user?

1	2	3	4	5

1.231. How much of a barrier is the lack of awareness from the customers?

1	2	3	4	5

1.232. How much of a barrier is incompatibility with existing systems for your technology?

1	2	3	4	5

1.233. How much of a barrier is higher lifecycle costs to the end user?

1	2	3	4	5

1.234. How much of a barrier is the lack of awareness of GHG savings by the end-user?

1	2	3	4	5

1.235. How much of a barrier is any possible environmental impact of manufacturing?

1	2	3	4	5

1.236. How much of a barrier is any adverse disposal effects?

1	2	3	4	5

1.237. How much of a barrier is the lack of installer and/or contractor training?

1	2	3	4	5

1.238. How much of a barrier is the lack of maintenance personnel training?

1	2	3	4	5

1.239. How much of a barrier is the lack of awareness among designers and/or engineers?

1	2	3	4	5

Respondent #9

1.240. How much of a driver is a positive public image?

1	2	3	4	5

1.241. How much of a driver is it for end-users to reduce dependence on fossil fuels?

1	2	3	4	5

- Apartment house owner, assisted living owners are not concerned with this.

1.242. How much of a driver is it for end-users to reduce GHG emissions?

1	2	3	4	5

1.243. How much of a driver is the compliance with environmental regulations?

1	2	3	4	5

- Very important as it can lead to getting shutdown. Must comply.

1.244. How much of a driver is the reduction of pollutants other than CO_2? i.e., SO_x and NO_x?

1	2	3	4	5

1.245. How much of a driver is the reduction in manufacturing waste?

1	2	3	4	5

1.246. How much of a driver are new or added advanced (smart) features for the end-user?

1	2	3	4	5

- Many DHW systems are rooftop; so, it would be very hard to add features. And it would not be cost effective to put a HP rooftop vs DHW. So, they would not opt for combi system.

1.247. How much of a driver is the recyclability of your units?

1	2	3	4	5

1.248. How much of a driver is local manufacturing to the end-user? i.e., Made in the USA.

1	2	3	4	5

1.249. How much of a driver is improved performance for the end-user?

1	2	3	4	5

- Just installed (13) DWH in large complex in Upland. Performance was important to quality for the rebates. Apartment owners typically wait until last 6-months left on DHW. He tried to show them economic model to replace (early-retirement).

1.250. How much of a driver is the potential to increase your customer base?

1	2	3	4	5

1.251. How much of a driver is lowering production costs?

1	2	3	4	5

1.252. How much of a driver is the customer's willingness to pay for a better product?

1	2	3	4	5

- Based on behavior, customer will not pay a premium unless you really "paint a big economic benefit that arrive from the better product." i.e., apartment owner calculated the payback without rebates for baseline Manufacturer G of about 5 years. Owner was not happy. Wanted shorter payback.

1.253. How much of a driver is government support for technology uptake for you?

1	2	3	4	5

- Tremendously important!

1.254. How much of a driver is independent verification of performance?

1	2	3	4	5

- Sometime issues of "crossover" make it hard to verify, but still important.

1.255. How much of a driver is a shorter-to-market cycle when it was entering the market?

1	2	3	4	5

1.256. How much of a barrier is the cost of your technologies?

1	2	3	4	5

- State permits are granted for new constructions req' specific technologies to meet the regulations, but he does not think it is a decision breaker.

1.257. How much of a barrier is the uncertainty of future codes/standards?

1	2	3	4	5

- Many apartment owners ignore the codes until they must replace a water heater (then they become an expert). But there is not much uncertainty.

1.258. How much of a barrier are the market fluctuations in price and cost?

1	2	3	4	5

- If price is varying 15-20% per year, it can significantly affect the bottom line.

1.259. How much of a barrier is adverse regulatory environments?

1	2	3	4	5

- When servicing (125) unit complex, nameplates on Manufacturer G rooftop units worn-out. If they have to be replaced with a heat-pump, then regulations would make it very difficult being on the rooftop.

1.260. How much of a barrier is the uncertainty of technology performance by the end-user?

1	2	3	4	5

- It's very difficult to estimate performance, i.e., rooftop vs garage. If the customer holds you to it, then you would have to charge a premium to verify the performance. He relied on studies to show economic benefit.

1.261. How much of a barrier is uncertain reliability in your product by the end-user?

1	2	3	4	5

1.262. How much of a barrier is the lack of awareness from the customers?

1	2	3	4	5

- There is a lot of noise in the marketing channels these days, but once he has the customers attention, then it is Richard's job to make them aware.

1.263. How much of a barrier is incompatibility with existing systems for your technology?

1	2	3	4	5

- Rooftop heat-pump not the best location, specifically heating water in wintertime. But if systems are designed for rooftop plumbing, retrofitting would be too expensive.

1.264. How much of a barrier is higher lifecycle costs to the end user?

1	2	3	4	5

- Manufacturers do not push lifecycle costs up-front. They mention that you may need a water softening system. Customer not so concerned since they have seen water heaters fail before on the "weekends."

1.265. How much of a barrier is the lack of awareness of GHG savings by the end-user?

1	2	3	4	5

1.266. How much of a barrier is any possible environmental impact of manufacturing?

1	2	3	4	5

1.267. How much of a barrier is any adverse disposal effects?

1	2	3	4	5

1.268. How much of a barrier is the lack of installer and/or contractor training?

1	2	3	4	5

- His contractors already have training from Manufacturer H. There is a "good support network."

1.269. How much of a barrier is the lack of maintenance personnel training?

1	2	3	4	5

1.270. How much of a barrier is the lack of awareness among designers and/or engineers?

1	2	3	4	5

- Only works with his engineers that learn quickly.

Respondent #10

1.271. How much of a driver is a positive public image?

1	2	3	4	5

1.272. How much of a driver is it for end-users to reduce dependence on fossil fuels?

1	2	3	4	5

- Customers do not care; they are more concerned with economic benefits.

1.273. How much of a driver is it for end-users to reduce GHG emissions?

1	2	3	4	5

1.274. How much of a driver is the compliance with environmental regulations?

1	2	3	4	5

1.275. How much of a driver is the reduction of pollutants other than CO_2? i.e., SO_x and NO_x?

1	2	3	4	5

1.276. How much of a driver is the reduction in manufacturing waste?

1	2	3	4	5

1.277. How much of a driver are new or added advanced (smart) features for the end-user?

1	2	3	4	5

1.278. How much of a driver is the recyclability of your units?

1	2	3	4	5

1.279. How much of a driver is local manufacturing to the end-user? i.e., Made in the USA.

1	2	3	4	5

- Most supplies from overseas, so "Brand Name" are important. But not a driver.

1.280. How much of a driver is improved performance for the end-user?

1	2	3	4	5

1.281. How much of a driver is the potential to increase your customer base?

1	2	3	4	5

- Lighting/boiler projects are tied together, so it doesn't apply to his projects. But Peter still thinks it is important.

1.282. How much of a driver is lowering production costs?

1	2	3	4	5

1.283. How much of a driver is the customer's willingness to pay for a better product?

1	2	3	4	**5**

1.284. How much of a driver is government support for technology uptake for you?

1	2	3	4	**5**

1.285. How much of a driver is independent verification of performance?

1	2	3	4	**5**

1.286. How much of a driver is a shorter-to-market cycle when it was entering the market?

1	2	**3**	4	5

1.287. How much of a barrier is the cost of your technologies?

1	2	3	4	**5**

1.288. How much of a barrier is the uncertainty of future codes/standards?

1	2	3	4	**5**

- This is very important for contractors/installers.

1.289. How much of a barrier are the market fluctuations in price and cost?

1	2	3	4	**5**

1.290. How much of a barrier is adverse regulatory environments?

1	2	3	4	**5**

1.291. How much of a barrier is the uncertainty of technology performance by the end-user?

1	2	3	4	**5**

1.292. How much of a barrier is uncertain reliability in your product by the end-user?

1	2	3	4	**5**

1.293. How much of a barrier is the lack of awareness from the customers?

1	2	3	4	**5**

1.294. How much of a barrier is incompatibility with existing systems for your technology?

1	2	**3**	4	5

1.295. How much of a barrier is higher lifecycle costs to the end user?

1	2	3	4	5

1.296. How much of a barrier is the lack of awareness of GHG savings by the end-user?

1	2	3	4	5

1.297. How much of a barrier is any possible environmental impact of manufacturing?

1	2	3	4	5

1.298. How much of a barrier is any adverse disposal effects?

1	2	3	4	5

1.299. How much of a barrier is the lack of installer and/or contractor training?

1	2	3	4	5

1.300. How much of a barrier is the lack of maintenance personnel training?

1	2	3	4	5

1.301. How much of a barrier is the lack of awareness among designers and/or engineers?

1	2	3	4	5

Respondent #11

- Only in commercial market. He suggested that surgery centers, MOBs, or smaller healthcare facilities seem like a good fit for the pilot studies.

1.302. How much of a driver is a positive public image?

1	2	3	4	5

1.303. How much of a driver is it for end-users to reduce dependence on fossil fuels?

1	2	3	4	5

- Customers do not care.

1.304. How much of a driver is it for end-users to reduce GHG emissions?

1	2	3	4	5

- Good to have, but it is a driver for decision making.

1.305. How much of a driver is the compliance with environmental regulations?

1	2	3	4	5

1.306. How much of a driver is the reduction of pollutants other than CO_2? i.e., SO_x and NO_x?

1	2	3	4	5

- Only comes to mind when it affects the financial bottom-line. i.e. his customer was being fined on monthly bases unless they installed scrubbers, etc.

1.307. How much of a driver is the reduction of manufacturing waste?

1	2	3	4	5

1.308. How much of a driver are new or added advanced (smart) features for the end-user?

1	2	3	4	5

- Smart communicating devices are very beneficial. i.e. predictive maintenance very important these days, it will tell you before it fails. Shutting down operations cost money, so they want to avoid.

1.309. How much of a driver is the recyclability of your units?

1	2	3	4	5

1.310. How much of a driver is local manufacturing to the end-user? i.e., Made in the USA.

1	2	3	4	5

- Higher these days due to supply-chain issues. Long lead times are changing minds.

1.311. How much of a driver is improved performance for the end-user?

1	2	3	4	5

- Efficiency very important to the bottom-line.

1.312. How much of a driver is the potential to increase your customer base?

1	2	3	4	5

- Always trying to increase product line and improve offerings.

1.313. How much of a driver is lowering production costs?

1	2	3	4	5

1.314. How much of a driver is the customer's willingness to pay for a better product?

1	2	3	4	5

- Incentives, rebates will help drive this.

1.315. How much of a driver is government support for technology uptake for you?

1	2	3	**4**	5

1.316. How much of a driver is independent verification of performance?

1	2	3	**4**	5

- UL test, and all the certificates. Verifies the legitimacy of the product.

1.317. How much of a driver is a shorter-to-market cycle when it was entering the market?

1	2	**3**	4	5

1.318. How much of a barrier is the cost of your technologies?

1	2	3	4	**5**

- If payback is too long, then they will go for lower upfront costs.

1.319. How much of a barrier is the uncertainty of future codes/standards?

1	2	**3**	4	5

- Not really on his mind.

1.320. How much of a barrier are the market fluctuations in price and cost?

1	2	3	**4**	5

1.321. How much of a barrier is adverse regulatory environments?

1	2	3	**4**	5

1.322. How much of a barrier is the uncertainty of technology performance by the end-user?

1	2	3	**4**	5

1.323. How much of a barrier is uncertain reliability in your product by the end-user?

1	2	3	4	**5**

- There not going to invest if the product is going to fail.

1.324. How much of a barrier is the lack of awareness from the customers?

1	2	3	**4**	5

1.325. How much of a barrier is incompatibility with existing systems for your technology?

1	**2**	3	4	5

- Water heaters are independent units, so not many issues.

1.326. How much of a barrier is higher lifecycle costs to the end user?

1	2	3	**4**	5

- Most people look at simple payback. They focus on selling on the lifecycle costs.

1.327. How much of a barrier is the lack of awareness of GHG savings by the end-user?

1	2	3	**4**	5

1.328. How much of a barrier is any possible environmental impact of manufacturing?

1	2	3	4	5

1.329. How much of a barrier is any adverse disposal effects?

1	2	3	**4**	5

- Proper disposal of refrigerant is very important. Large fines for improper disposal.

1.330. How much of a barrier is the lack of installer and/or contractor training?

1	2	**3**	4	5

- They do not push products they are not comfortable with. Aftersales marketing is very important. So, they need to be knowledgeable about products.

1.331. How much of a barrier is the lack of maintenance personnel training?

1	2	**3**	4	5

- Customers do not think water heaters need maintenance. Just plug-it-in.

1.332. How much of a barrier is the lack of awareness among designers and/or engineers?

1	2	3	**4**	5

Respondent #12

1.333. How much of a driver is a positive public image?

1	2	3	4	**5**

1.334. How much of a driver is it for end-users to reduce dependence on fossil fuels?

1	**2**	3	4	5

1.335. How much of a driver is it for end-users to reduce GHG emissions?

1	**2**	3	4	5

1.336. How much of a driver is the compliance with environmental regulations?

1	2	3	4	**5**

1.337. How much of a driver is the reduction of pollutants other than CO_2? i.e., SO_x and NO_x?

1	2	3	4	**5**

1.338. How much of a driver is the reduction of manufacturing waste?

1	2	3	4	5

1.339. How much of a driver are new or added advanced (smart) features for the end-user?

1	2	3	**4**	5

1.340. How much of a driver is the recyclability of your units?

1	2	3	4	**5**

1.341. How much of a driver is local manufacturing to the end-user? i.e., Made in the USA.

1	**2**	3	4	5

1.342. How much of a driver is improved performance for the end-user?

1	2	3	4	**5**

1.343. How much of a driver is the potential to increase your customer base?

1	2	3	4	**5**

1.344. How much of a driver is lowering production costs?

1	2	3	4	5

1.345. How much of a driver is the customer's willingness to pay for a better product?

1	2	**3**	4	5

1.346. How much of a driver is government support for technology uptake for you?

1	2	3	**4**	5

1.347. How much of a driver is independent verification of performance?

1	2	3	4	**5**

1.348. How much of a driver is a shorter-to-market cycle when it was entering the market?

1	2	3	4	**5**

1.349. How much of a barrier is the cost of your technologies?

1	2	3	**4**	5

1.350. How much of a barrier is the uncertainty of future codes/standards?

1	2	3	**4**	5

1.351. How much of a barrier are the market fluctuations in price and cost?

1	**2**	3	4	5

1.352. How much of a barrier is adverse regulatory environments?

1	**2**	3	4	5

1.353. How much of a barrier is the uncertainty of technology performance by the end-user?

1	2	3	**4**	5

1.354. How much of a barrier is uncertain reliability in your product by the end-user?

1	2	**3**	4	5

1.355. How much of a barrier is the lack of awareness from the customers?

1	2	**3**	4	5

1.356. How much of a barrier is incompatibility with existing systems for your technology?

1	2	**3**	4	5

1.357. How much of a barrier is higher lifecycle costs to the end user?

1	2	3	**4**	5

1.358. How much of a barrier is the lack of awareness of GHG savings by the end-user?

1	2	3	4	**5**

1.359. How much of a barrier is any possible environmental impact of manufacturing?

1	**2**	3	4	5

1.360. How much of a barrier is any adverse disposal effects?

1	**2**	3	4	5

1.361. How much of a barrier is the lack of installer and/or contractor training?

1	2	**3**	4	5

1.362. How much of a barrier is the lack of maintenance personnel training?

1	**2**	3	4	5

1.363. How much of a barrier is the lack of awareness among designers and/or engineers?

1	2	**3**	4	5

Respondent #13

1.364. How much of a driver is a positive public image?

1	2	3	4	5

- A-listed property owners are more forward thinking, vs. B-listed focus on maximum occupancy only doing little-to-no cost.

1.365. How much of a driver is it for end-users to reduce dependence on fossil fuels?

1	2	3	4	5

1.366. How much of a driver is it for end-users to reduce GHG emissions?

1	2	3	4	5

1.367. How much of a driver is the compliance with environmental regulations?

1	2	3	4	5

- Very important under UIC program guidelines. i.e., water heaters in Inland Empire must have higher efficiency, ultra-low NOx. Versus coastal locations.

1.368. How much of a driver is the reduction of pollutants other than CO_2? i.e., SO_x and NO_x?

1	2	3	4	5

- Inherent in program guidelines, but not important for the customers.

1.369. How much of a driver is the reduction of manufacturing waste?

1	2	3	4	5

1.370. How much of a driver are new or added advanced (smart) features for the end-user?

1	2	3	4	5

- Millennials tend to use smart features more often, but important as a driver.

1.371. How much of a driver is the recyclability of your units?

1	2	3	4	5

1.372. How much of a driver is local manufacturing to the end-user? i.e., Made in the USA.

1	2	3	4	5

- Most things are made overseas, so customers do not options for local production.

1.373. How much of a driver is improved performance for the end-user?

1	2	3	4	5

- ROI, and lower maintenance are most important performance factors.

1.374. How much of a driver is the potential to increase your customer base?

1	2	3	4	5

- If they can offer something that is a positive for existing base and use that as a template to reach out to other management companies. If they see participation from another company, then they are more likely to adopt it.

1.375. How much of a driver is lowering production costs?

1	2	3	4	5

1.376. How much of a driver is the customer's willingness to pay for a better product?

1	2	3	4	5

- Depends on what "premium" means, ROI is the determining factor. 5 Years is the limit. 2 year ROI is "rubber stamped."

1.377. How much of a driver is government support for technology uptake for you?

1	2	3	4	5

- Sometime gov't can get in the way of these programs, such as Title 24 that kills programs making it hard for owners to adopt new technologies.

1.378. How much of a driver is independent verification of performance?

1	2	3	4	5

- As long as verification is not too cumbersome for contractors, it is very important.

1.379. How much of a driver is a shorter-to-market cycle when it was entering the market?

1	2	3	4	5

1.380. How much of a barrier is the cost of your technologies?

1	2	3	4	5

1.381. How much of a barrier is the uncertainty of future codes/standards?

1	2	3	4	5

- Future codes don't matter if you already installed the water heater, so the codes are grandfathered in.

1.382. How much of a barrier are the market fluctuations in price and cost?

1	2	3	4	5

- Supply chain issues have caused recent projects to go over budget, so they were ended.

1.383. How much of a barrier is adverse regulatory environments?

1	2	3	4	5

- Gas banning codes are rather new, so he has not encountered this yet. Not seen on the streets.

1.384. How much of a barrier is the uncertainty of technology performance by the end-user?

1	2	3	4	5

1.385. How much of a barrier is uncertain reliability in your product by the end-user?

1	2	3	4	5

- Gas appliances are well known so not a concern.

1.386. How much of a barrier is the lack of awareness from the customers?

1	2	3	4	5

1.387. How much of a barrier is incompatibility with existing systems for your technology?

1	2	3	4	5

- Depends on the building profile. Retrofitting tankless on 2nd story buildings is challenging. Typically, it is done on single story, garden-style communities. Very difficult to vent to the roof thru 2nd story unless the water heater is in the patio. This would be a question for the direct installers!

1.388. How much of a barrier is higher lifecycle costs to the end user?

1	2	3	4	5

- They want the best lifecycle cost, but we need to further define lifecycle costs. If they are paying 15% more, and getting %30 more lifecycle, then it becomes attractive. Ties directly into maintenance cost, if that exceed ROI, then they will not opt for the high efficiency unit.

1.389. How much of a barrier is the lack of awareness of GHG savings by the end-user?

1	2	3	4	5

1.390. How much of a barrier is any possible environmental impact of manufacturing?

1	2	3	4	5

1.391. How much of a barrier is any adverse disposal effects?

1	2	3	4	5

- People have been disposing of these materials for a long time.

1.392. How much of a barrier is the lack of installer and/or contractor training?

1	2	3	4	5

- Hard to find qualified installers for new emerging technologies.

1.393. How much of a barrier is the lack of maintenance personnel training?

1	2	3	4	5

- Typically, installers are qualified to perform maintenance. So, not an issue.

1.394. How much of a barrier is the lack of awareness among designers and/or engineers?

1	2	3	4	5

- Need more awareness among architects and engineers.

Respondent #14

1.395. How much of a driver is a positive public image?

1	2	3	4	5

1.396. How much of a driver is it for end-users to reduce dependence on fossil fuels?

1	2	3	4	5

1.397. How much of a driver is it for end-users to reduce GHG emissions?

1	2	3	4	5

1.398. How much of a driver is the compliance with environmental regulations?

1	2	3	4	5

1.399. How much of a driver is the reduction of pollutants other than CO_2? i.e., SO_x and NO_x?

1	2	3	4	5

1.400. How much of a driver is the reduction of manufacturing waste?

1	2	3	4	5

1.401. How much of a driver are new or added advanced (smart) features for the end-user?

1	2	3	4	5

1.402. How much of a driver is the recyclability of your units?

1	2	3	4	5

1.403. How much of a driver is local manufacturing to the end-user? i.e., Made in the USA.

1	2	3	4	5

1.404. How much of a driver is improved performance for the end-user?

1	2	3	4	5

1.405. How much of a driver is the potential to increase your customer base?

1	2	3	4	5

1.406. How much of a driver is lowering production costs?

1	2	3	4	5

1.407. How much of a driver is the customer's willingness to pay for a better product?

1	2	3	4	5

1.408. How much of a driver is government support for technology uptake for you?

1	2	3	4	5

1.409. How much of a driver is independent verification of performance?

1	2	3	4	5

1.410. How much of a driver is a shorter-to-market cycle when it was entering the market?

1	2	3	4	5

1.411. How much of a barrier is the cost of your technologies?

1	2	3	4	5

1.412. How much of a barrier is the uncertainty of future codes/standards?

1	2	3	4	5

1.413. How much of a barrier are the market fluctuations in price and cost?

1	2	3	4	5

1.414. How much of a barrier is adverse regulatory environments?

1	2	3	4	5

1.415. How much of a barrier is the uncertainty of technology performance by the end-user?

1	2	3	4	5

1.416. How much of a barrier is uncertain reliability in your product by the end-user?

1	2	3	4	5

1.417. How much of a barrier is the lack of awareness from the customers?

1	2	3	4	5

1.418. How much of a barrier is incompatibility with existing systems for your technology?

1	2	3	4	5

1.419. How much of a barrier is higher lifecycle costs to the end user?

1	2	3	4	5

1.420. How much of a barrier is the lack of awareness of GHG savings by the end-user?

1	2	3	4	5

1.421. How much of a barrier is any possible environmental impact of manufacturing?

1	2	3	4	5

1.422. How much of a barrier is any adverse disposal effects?

1	2	3	4	5

1.423. How much of a barrier is the lack of installer and/or contractor training?

1	2	3	4	5

1.424. How much of a barrier is the lack of maintenance personnel training?

1	2	3	4	5

1.425. How much of a barrier is the lack of awareness among designers and/or engineers?

1	2	3	4	5

Respondent #15

1.426. How much of a driver is a positive public image?

1	2	3	4	5

1.427. How much of a driver is it for end-users to reduce dependence on fossil fuels?

1	2	3	4	5

1.428. How much of a driver is it for end-users to reduce GHG emissions?

1	2	3	4	5

1.429. How much of a driver is the compliance with environmental regulations?

1	2	3	4	5

1.430. How much of a driver is the reduction of pollutants other than CO_2? i.e., SO_x and NO_x?

1	2	3	4	5

1.431. How much of a driver is the reduction of manufacturing waste?

1	2	3	4	5

1.432. How much of a driver are new or added advanced (smart) features for the end-user?

1	2	3	4	5

1.433. How much of a driver is the recyclability of your units?

1	2	3	4	5

1.434. How much of a driver is local manufacturing to the end-user? i.e., Made in the USA.

1	2	3	4	5

1.435. How much of a driver is improved performance for the end-user?

1	2	3	4	5

1.436. How much of a driver is the potential to increase your customer base?

1	2	3	4	5

1.437. How much of a driver is lowering production costs?

1	2	3	4	5

1.438. How much of a driver is the customer's willingness to pay for a better product?

1	2	3	4	5

1.439. How much of a driver is government support for technology uptake for you?

1	2	3	4	5

1.440. How much of a driver is independent verification of performance?

1	2	3	4	**5**

1.441. How much of a driver is a shorter-to-market cycle when it was entering the market?

1	2	3	4	5

1.442. How much of a barrier is the cost of your technologies?

1	2	3	**4**	5

1.443. How much of a barrier is the uncertainty of future codes/standards?

1	2	3	4	**5**

1.444. How much of a barrier are the market fluctuations in price and cost?

1	2	**3**	4	5

1.445. How much of a barrier is adverse regulatory environments?

1	2	3	4	**5**

1.446. How much of a barrier is the uncertainty of technology performance by the end-user?

1	2	3	**4**	5

1.447. How much of a barrier is uncertain reliability in your product by the end-user?

1	2	3	4	**5**

1.448. How much of a barrier is the lack of awareness from the customers?

1	2	3	4	**5**

1.449. How much of a barrier is incompatibility with existing systems for your technology?

1	2	3	4	5

1.450. How much of a barrier is higher lifecycle costs to the end user?

1	2	3	**4**	5

1.451. How much of a barrier is the lack of awareness of GHG savings by the end-user?

1	2	**3**	4	5

1.452. How much of a barrier is any possible environmental impact of manufacturing?

1	2	3	4	5

1.453. How much of a barrier is any adverse disposal effects?

1	2	**3**	4	5

1.454. How much of a barrier is the lack of installer and/or contractor training?

1	2	3	4	**5**

1.455. How much of a barrier is the lack of maintenance personnel training?

1	2	3	4	**5**

1.456. How much of a barrier is the lack of awareness among designers and/or engineers?

1	2	3	4	**5**

Respondent #16

1.457. How much of a driver is a positive public image?

1	2	3	4	**5**

1.458. How much of a driver is it for end-users to reduce dependence on fossil fuels?

1	2	3	4	**5**

1.459. How much of a driver is it for end-users to reduce GHG emissions?

1	**2**	3	4	5

1.460. How much of a driver is the compliance with environmental regulations?

1	2	3	4	**5**

1.461. How much of a driver is the reduction of pollutants other than CO_2? i.e., SO_x and NO_x?

1	2	3	4	**5**

1.462. How much of a driver is the reduction of manufacturing waste?

1	2	3	4	5

1.463. How much of a driver are new or added advanced (smart) features for the end-user?

1	**2**	3	4	5

1.464. How much of a driver is the recyclability of your units?

1	2	3	4	**5**

1.465. How much of a driver is local manufacturing to the end-user? i.e., Made in the USA.

1	2	3	**4**	5

1.466. How much of a driver is improved performance for the end-user?

1	2	3	4	5

1.467. How much of a driver is the potential to increase your customer base?

1	2	3	4	5

1.468. How much of a driver is lowering production costs?

1	2	3	4	5

1.469. How much of a driver is the customer's willingness to pay for a better product?

1	2	3	4	5

1.470. How much of a driver is government support for technology uptake for you?

1	2	3	4	5

1.471. How much of a driver is independent verification of performance?

1	2	3	4	5

1.472. How much of a driver is a shorter-to-market cycle when it was entering the market?

1	2	3	4	5

1.473. How much of a barrier is the cost of your technologies?

1	2	3	4	5

1.474. How much of a barrier is the uncertainty of future codes/standards?

1	2	3	4	5

1.475. How much of a barrier are the market fluctuations in price and cost?

1	2	3	4	5

1.476. How much of a barrier is adverse regulatory environments?

1	2	3	4	5

1.477. How much of a barrier is the uncertainty of technology performance by the end-user?

1	2	3	4	5

1.478. How much of a barrier is uncertain reliability in your product by the end-user?

1	2	3	4	5

1.479. How much of a barrier is the lack of awareness from the customers?

1	2	3	4	5

1.480. How much of a barrier is incompatibility with existing systems for your technology?

1	2	3	4	5

1.481. How much of a barrier is higher lifecycle costs to the end user?

1	2	3	4	5

1.482. How much of a barrier is the lack of awareness of GHG savings by the end-user?

1	2	3	4	5

1.483. How much of a barrier is any possible environmental impact of manufacturing?

1	2	3	4	5

1.484. How much of a barrier is any adverse disposal effects?

1	2	3	4	5

1.485. How much of a barrier is the lack of installer and/or contractor training?

1	2	3	4	5

1.486. How much of a barrier is the lack of maintenance personnel training?

1	2	3	4	5

1.487. How much of a barrier is the lack of awareness among designers and/or engineers?

1	2	3	4	5

CEDARS Measure IDs to Measure Names

Measure ID	Measure Name
SWWH005C	Boiler, Commercial, Condensing
SWWH005D	Boiler, Commercial, Condensing
WPSCGNRWH120206C-Rev06-Msr002	Boiler, Commercial, Condensing
WPSCGNRWH120206C-Rev06-Msr004	Boiler, Commercial, Condensing
H105	Boiler, Commercial, Non-condensing
SWWH005A	Boiler, Commercial, Non-condensing
SWWH005B	Boiler, Commercial, Non-condensing
WPSCGNRWH120206C-Rev06-Msr001	Boiler, Commercial, Non-condensing
WPSCGNRWH120206C-Rev06-Msr003	Boiler, Commercial, Non-condensing
SWWH010	Boiler, Multifamily
SWWH010B	Boiler, Multifamily, Condensing
WPSCGNRWH120206C-Rev05-Msr001	Boiler, Multifamily, Condensing
WPSCGREWH131030A-Rev01-Msr002	Boiler, Multifamily, Condensing
WPSDGEREWH0023-Rev00-Msr002	Boiler, Multifamily, Condensing
H719	Boiler, Multifamily, Non-condensing
SWWH010A	Boiler, Multifamily, Non-condensing
WPSCGREWH131030A-Rev01-Msr001	Boiler, Multifamily, Non-condensing
SWWH024A	Central Boiler Dual Setpoint Temperature Controller, Multifamily
SWWH011B	Central Storage Water Heater, Multifamily, Condensing
WPSCGREWH130613A-Rev01-Msr002	Central Storage Water Heater, Multifamily, Condensing
H150	Central Storage Water Heater, Multifamily, Non-condensing
SWWH011A	Central Storage Water Heater, Multifamily, Non-condensing
WPSCGREWH130613A-Rev01-Msr001	Central Storage Water Heater, Multifamily, Non-condensing
BW015	Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial
BW016	Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial

Measure ID	Measure Name
BW017	Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial
BW018	Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial
BW019	Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial
BW020	Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial
BW022	Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial
BW024	Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial
BW026	Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial
BW027	Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial
BW029	Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial
DemandCtl-WtrHt-Gas-44unitMFbldg	Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial
DemandCtl-WtrHt-Gas-88unitMFbldg	Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial
DemandCtl-WtrHt-HP-44unitMFbldg	Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial
SWWH015A	Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial
SWWH015B	Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial
SWWH015C	Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial
SWWH015D	Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial
SWWH015E	Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial
SWWH015F	Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial
SWWH015G	Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial

Measure ID	Measure Name
SWWH015H	Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial
SWWH015I	Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial
SWWH015J	Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial
SWWH015K	Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial
SWWH015L	Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial
SWWH015M	Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial
SWWH015N	Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial
SWWH015O	Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial
SWWH015P	Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial
SWWH015Q	Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial
WPSCGNRWH161128B-Rev01-Msr001	Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial
WPSCGREWH161128A-Rev00-Msr001	Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial
SWWH001-Rev00-Msr001	Diverting Tub Spout with TSV, Residential
SWWH001-Rev00-Msr003	Diverting Tub Spout with TSV, Residential
SWWH023A	Diverting Tub Spout with TSV, Residential
SWWH023B	Diverting Tub Spout with TSV, Residential
SWWH023C	Diverting Tub Spout with TSV, Residential
SWWH023D	Diverting Tub Spout with TSV, Residential
SWWH016A	Domestic Hot Water Loop Temperature Controller, Multifamily & Commercial
SWWH016B	Domestic Hot Water Loop Temperature Controller, Multifamily & Commercial
SWWH016C	Domestic Hot Water Loop Temperature Controller, Multifamily & Commercial
SWWH016D	Domestic Hot Water Loop Temperature Controller, Multifamily & Commercial

Measure ID	Measure Name
SWWH016E	Domestic Hot Water Loop Temperature Controller, Multifamily & Commercial
SWWH016F	Domestic Hot Water Loop Temperature Controller, Multifamily & Commercial
SWWH016G	Domestic Hot Water Loop Temperature Controller, Multifamily & Commercial
SWWH016H	Domestic Hot Water Loop Temperature Controller, Multifamily & Commercial
SWWH016I	Domestic Hot Water Loop Temperature Controller, Multifamily & Commercial
SWWH016J	Domestic Hot Water Loop Temperature Controller, Multifamily & Commercial
SWWH016K	Domestic Hot Water Loop Temperature Controller, Multifamily & Commercial
SWWH016L	Domestic Hot Water Loop Temperature Controller, Multifamily & Commercial
SWWH016M	Domestic Hot Water Loop Temperature Controller, Multifamily & Commercial
SWWH016N	Domestic Hot Water Loop Temperature Controller, Multifamily & Commercial
SWWH016O	Domestic Hot Water Loop Temperature Controller, Multifamily & Commercial
SWWH016P	Domestic Hot Water Loop Temperature Controller, Multifamily & Commercial
SWWH016Q	Domestic Hot Water Loop Temperature Controller, Multifamily & Commercial
SWWH019	Faucet Aerator, Commercial
SWWH019A	Faucet Aerator, Commercial
SWWH019B	Faucet Aerator, Commercial
SWWH019C	Faucet Aerator, Commercial
SWWH019D	Faucet Aerator, Commercial
SWWH019E	Faucet Aerator, Commercial
SWWH019F	Faucet Aerator, Commercial
SWWH019G	Faucet Aerator, Commercial
SWWH019H	Faucet Aerator, Commercial
WPSCGNRWH161222A-Rev00-Msr001	Faucet Aerator, Commercial
WPSCGNRWH161222A-Rev00-Msr002	Faucet Aerator, Commercial

Measure ID	Measure Name
WPSCGNRWH161222A-Rev00-Msr003	Faucet Aerator, Commercial
WPSCGNRWH161222A-Rev00-Msr004	Faucet Aerator, Commercial
WPSDGENRWH0014-Rev00-Msr001	Faucet Aerator, Commercial
WPSDGENRWH0014-Rev00-Msr002	Faucet Aerator, Commercial
WPSDGENRWH1209-Rev00-Msr007	Faucet Aerator, Commercial
AP005	Faucet Aerator, Residential
AP006	Faucet Aerator, Residential
BW042	Faucet Aerator, Residential
BW044	Faucet Aerator, Residential
Res-FaucetAerKit-Gas-1.5	Faucet Aerator, Residential
Res-FaucetAerLav-Gas-0.5	Faucet Aerator, Residential
Res-FaucetAerLav-Gas-1.0	Faucet Aerator, Residential
Res-FaucetAerLav-Gas-1.5	Faucet Aerator, Residential
S236	Faucet Aerator, Residential
S530	Faucet Aerator, Residential
S531	Faucet Aerator, Residential
SWWH001	Faucet Aerator, Residential
SWWH001A	Faucet Aerator, Residential
SWWH001B	Faucet Aerator, Residential
SWWH001C	Faucet Aerator, Residential
SWWH001D	Faucet Aerator, Residential
SWWH001I	Faucet Aerator, Residential
SWWH001J	Faucet Aerator, Residential
SWWH001K	Faucet Aerator, Residential
SWWH001L	Faucet Aerator, Residential
SWWH001Q	Faucet Aerator, Residential
SWWH001R	Faucet Aerator, Residential
SWWH001S	Faucet Aerator, Residential
SWWH001T	Faucet Aerator, Residential
WPSCGREWH120618A-Rev03-Msr001	Faucet Aerator, Residential
WPSCGREWH120618A-Rev03-Msr002	Faucet Aerator, Residential
WPSCGREWH120618A-Rev03-Msr003	Faucet Aerator, Residential
WPSCGREWH120618A-Rev03-Msr004	Faucet Aerator, Residential

Measure ID	Measure Name
WPSDGEREWH1012-Rev01-Msr004	Faucet Aerator, Residential
WPSDGEREWH1012-Rev02-Msr001	Faucet Aerator, Residential
WPSDGEREWH1012-Rev02-Msr002	Faucet Aerator, Residential
H103	Heater for Pool or Spa, Commercial
PGECOPRO105-R3-Rev03-Msr001	Heater for Pool or Spa, Commercial
PGECOPRO105-Rev01-Msr001	Heater for Pool or Spa, Commercial
SWRE003	Heater for Pool or Spa, Commercial
SWRE003A	Heater for Pool or Spa, Commercial
PR052	Hot Water Pipe Insulation
PR055	Hot Water Pipe Insulation
PR056	Hot Water Pipe Insulation
PR058	Hot Water Pipe Insulation
PR059	Hot Water Pipe Insulation
PR060	Hot Water Pipe Insulation
PR061	Hot Water Pipe Insulation
PR062	Hot Water Pipe Insulation
PR064	Hot Water Pipe Insulation
PR066	Hot Water Pipe Insulation
PR067	Hot Water Pipe Insulation
PR068	Hot Water Pipe Insulation
PR069	Hot Water Pipe Insulation
PR070	Hot Water Pipe Insulation
PR071	Hot Water Pipe Insulation
PR073	Hot Water Pipe Insulation
PR075	Hot Water Pipe Insulation
PR076	Hot Water Pipe Insulation
PR077	Hot Water Pipe Insulation
PR082	Hot Water Pipe Insulation
PR085	Hot Water Pipe Insulation
PR086	Hot Water Pipe Insulation
SCGWP110812A-Rev03-Msr001	Hot Water Pipe Insulation
SCGWP110812A-Rev03-Msr003	Hot Water Pipe Insulation
SCGWP110812A-Rev03-Msr004	Hot Water Pipe Insulation

Measure ID	Measure Name
SCGWP110812A-Rev03-Msr005	Hot Water Pipe Insulation
SCGWP110812A-Rev03-Msr006	Hot Water Pipe Insulation
SCGWP110812A-Rev03-Msr007	Hot Water Pipe Insulation
SCGWP110812A-Rev03-Msr008	Hot Water Pipe Insulation
SCGWP110812A-Rev03-Msr009	Hot Water Pipe Insulation
SCGWP110812A-Rev03-Msr010	Hot Water Pipe Insulation
SCGWP110812A-Rev03-Msr011	Hot Water Pipe Insulation
SCGWP110812A-Rev03-Msr012	Hot Water Pipe Insulation
SCGWP110812A-Rev03-Msr013	Hot Water Pipe Insulation
SCGWP110812A-Rev03-Msr014	Hot Water Pipe Insulation
SCGWP110812A-Rev03-Msr016	Hot Water Pipe Insulation
SCGWP110812A-Rev03-Msr018	Hot Water Pipe Insulation
SCGWP110812A-Rev03-Msr044	Hot Water Pipe Insulation
SCGWP110812A-Rev03-Msr047	Hot Water Pipe Insulation
SCGWP110812A-Rev03-Msr049	Hot Water Pipe Insulation
SCGWP110812A-Rev03-Msr050	Hot Water Pipe Insulation
SCGWP110812A-Rev03-Msr056	Hot Water Pipe Insulation
SCGWP110812A-Rev03-Msr057	Hot Water Pipe Insulation
SCGWP110812A-Rev03-Msr058	Hot Water Pipe Insulation
SCGWP110812A-Rev03-Msr059	Hot Water Pipe Insulation
SCGWP110812A-Rev03-Msr060	Hot Water Pipe Insulation
SWWH017A	Hot Water Pipe Insulation
SWWH017AA	Hot Water Pipe Insulation
SWWH017AB	Hot Water Pipe Insulation
SWWH017AC	Hot Water Pipe Insulation
SWWH017AD	Hot Water Pipe Insulation
SWWH017AE	Hot Water Pipe Insulation
SWWH017AF	Hot Water Pipe Insulation
SWWH017AG	Hot Water Pipe Insulation
SWWH017AH	Hot Water Pipe Insulation
SWWH017AI	Hot Water Pipe Insulation
SWWH017AJ	Hot Water Pipe Insulation
SWWH017B	Hot Water Pipe Insulation

Measure ID	Measure Name
SWWH017BC	Hot Water Pipe Insulation
SWWH017BD	Hot Water Pipe Insulation
SWWH017BG	Hot Water Pipe Insulation
SWWH017BI	Hot Water Pipe Insulation
SWWH017BJ	Hot Water Pipe Insulation
SWWH017BK	Hot Water Pipe Insulation
SWWH017C	Hot Water Pipe Insulation
SWWH017CD	Hot Water Pipe Insulation
SWWH017CE	Hot Water Pipe Insulation
SWWH017CH	Hot Water Pipe Insulation
SWWH017CK	Hot Water Pipe Insulation
SWWH017CL	Hot Water Pipe Insulation
SWWH017D	Hot Water Pipe Insulation
SWWH017E	Hot Water Pipe Insulation
SWWH017F	Hot Water Pipe Insulation
SWWH017G	Hot Water Pipe Insulation
SWWH017H	Hot Water Pipe Insulation
SWWH017I	Hot Water Pipe Insulation
SWWH017J	Hot Water Pipe Insulation
SWWH017K	Hot Water Pipe Insulation
SWWH017M	Hot Water Pipe Insulation
SWWH017N	Hot Water Pipe Insulation
SWWH017O	Hot Water Pipe Insulation
SWWH017P	Hot Water Pipe Insulation
SWWH017Q	Hot Water Pipe Insulation
SWWH017R	Hot Water Pipe Insulation
SWWH017S	Hot Water Pipe Insulation
SWWH017T	Hot Water Pipe Insulation
SWWH017U	Hot Water Pipe Insulation
SWWH017V	Hot Water Pipe Insulation
SWWH017W	Hot Water Pipe Insulation
SWWH017X	Hot Water Pipe Insulation
SWWH017Y	Hot Water Pipe Insulation

Measure ID	Measure Name
SWWH017Z	Hot Water Pipe Insulation
SWWH026A	Hot Water Pipe Insulation
SWWH026B	Hot Water Pipe Insulation
WPSCGWP110812A-Rev04-Msr002	Hot Water Pipe Insulation
WPSCGWP110812A-Rev04-Msr006	Hot Water Pipe Insulation
WPSCGWP110812A-Rev04-Msr007	Hot Water Pipe Insulation
WPSCGWP110812A-Rev04-Msr008	Hot Water Pipe Insulation
WPSCGWP110812A-Rev04-Msr011	Hot Water Pipe Insulation
WPSCGWP110812A-Rev04-Msr019	Hot Water Pipe Insulation
WPSCGWP110812A-Rev04-Msr020	Hot Water Pipe Insulation
WPSCGWP110812A-Rev04-Msr021	Hot Water Pipe Insulation
WPSCGWP110812A-Rev04-Msr036	Hot Water Pipe Insulation
WPSCGWP110812A-Rev04-Msr048	Hot Water Pipe Insulation
WPSCGWP110812A-Rev04-Msr055	Hot Water Pipe Insulation
WPSCGWP110812A-Rev04-Msr056	Hot Water Pipe Insulation
WPSCGWP110812A-Rev04-Msr062	Hot Water Pipe Insulation
WPSCGWP110812A-Rev04-Msr063	Hot Water Pipe Insulation
WPSCGWP110812A-Rev04-Msr064	Hot Water Pipe Insulation
WPSCGWP110812A-Rev04-Msr065	Hot Water Pipe Insulation
WPSCGWP110812A-Rev04-Msr066	Hot Water Pipe Insulation
WPSCGWP110812A-Rev04-Msr070	Hot Water Pipe Insulation
WPSCGWP110812A-Rev04-Msr071	Hot Water Pipe Insulation
WPSCGWP110812A-Rev04-Msr073	Hot Water Pipe Insulation
WPSCGWP110812A-Rev04-Msr074	Hot Water Pipe Insulation
WPSCGWP110812A-Rev04-Msr075	Hot Water Pipe Insulation
WPSCGWP110812A-Rev04-Msr079	Hot Water Pipe Insulation
WPSCGWP110812A-Rev04-Msr080	Hot Water Pipe Insulation
WPSCGWP110812A-Rev04-Msr081	Hot Water Pipe Insulation
WPSCGWP110812A-Rev04-Msr101	Hot Water Pipe Insulation
WPSCGWP110812A-Rev04-Msr102	Hot Water Pipe Insulation
WPSCGWP110812A-Rev05-Msr002	Hot Water Pipe Insulation
WPSCGWP110812A-Rev05-Msr003	Hot Water Pipe Insulation
WPSCGWP110812A-Rev05-Msr005	Hot Water Pipe Insulation

Measure ID	Measure Name
WPSCGWP110812A-Rev05-Msr008	Hot Water Pipe Insulation
WPSCGWP110812A-Rev05-Msr010	Hot Water Pipe Insulation
WPSCGWP110812A-Rev05-Msr011	Hot Water Pipe Insulation
WPSCGWP110812A-Rev05-Msr019	Hot Water Pipe Insulation
WPSCGWP110812A-Rev05-Msr020	Hot Water Pipe Insulation
WPSCGWP110812A-Rev05-Msr021	Hot Water Pipe Insulation
WPSCGWP110812A-Rev05-Msr023	Hot Water Pipe Insulation
WPSCGWP110812A-Rev05-Msr024	Hot Water Pipe Insulation
WPSCGWP110812A-Rev05-Msr029	Hot Water Pipe Insulation
WPSCGWP110812A-Rev05-Msr030	Hot Water Pipe Insulation
WPSCGWP110812A-Rev05-Msr035	Hot Water Pipe Insulation
WPSCGWP110812A-Rev05-Msr047	Hot Water Pipe Insulation
WPSCGWP110812A-Rev05-Msr048	Hot Water Pipe Insulation
WPSCGWP110812A-Rev05-Msr056	Hot Water Pipe Insulation
WPSCGWP110812A-Rev05-Msr059	Hot Water Pipe Insulation
WPSCGWP110812A-Rev05-Msr062	Hot Water Pipe Insulation
WPSCGWP110812A-Rev05-Msr063	Hot Water Pipe Insulation
WPSCGWP110812A-Rev05-Msr064	Hot Water Pipe Insulation
WPSCGWP110812A-Rev05-Msr065	Hot Water Pipe Insulation
WPSCGWP110812A-Rev05-Msr071	Hot Water Pipe Insulation
WPSCGWP110812A-Rev05-Msr073	Hot Water Pipe Insulation
WPSCGWP110812A-Rev05-Msr074	Hot Water Pipe Insulation
WPSCGWP110812A-Rev05-Msr075	Hot Water Pipe Insulation
WPSCGWP110812A-Rev05-Msr092	Hot Water Pipe Insulation
H18	Hot Water Tank Insulation
SWWH018A	Hot Water Tank Insulation
SWWH018B	Hot Water Tank Insulation
SWWH018C	Hot Water Tank Insulation
SWWH018E	Hot Water Tank Insulation
SWWH018H	Hot Water Tank Insulation
SWWH018I	Hot Water Tank Insulation
SWWH018J	Hot Water Tank Insulation
SWWH018K	Hot Water Tank Insulation

Measure ID	Measure Name
SWWH018L	Hot Water Tank Insulation
WPSCGNRM1050101A-Rev02-Msr002	Hot Water Tank Insulation
WPSCGNRM1050101A-Rev02-Msr003	Hot Water Tank Insulation
WPSCGNRM1050101A-Rev02-Msr004	Hot Water Tank Insulation
WPSCGNRM1050101A-Rev02-Msr005	Hot Water Tank Insulation
WPSCGNRM1050101A-Rev02-Msr007	Hot Water Tank Insulation
WPSCGNRM1050101A-Rev02-Msr008	Hot Water Tank Insulation
BW043	Ignore
BW045	Ignore
BW049	Ignore
G13	Ignore
LT-18465	Ignore
LT-18663	Ignore
LT-42086	Ignore
LT-50864	Ignore
LT-69385	Ignore
LT-79642	Ignore
MCE	Ignore
P107	Ignore
P108	Ignore
PL001	Ignore
PM-12046	Ignore
PM-19753	Ignore
PM-19754	Ignore
PM-69234	Ignore
PM-78394	Ignore
PM-79353	Ignore
PM-98422	Ignore
Res-FaucetAerKit-Elec-1.5	Ignore
Res-FaucetAerLav-Elec-0.5	Ignore
Res-FaucetAerLav-Elec-1.0	Ignore
Res-ShowerHd-Elec-1.6	Ignore
Res-ShowerHdFlowRes-Elec-1.6	Ignore

Measure ID	Measure Name
S235	Ignore
Stor_EF T20	Ignore
SWRE002	Ignore
SWRE002A	Ignore
SWRE002B	Ignore
SWRE002C	Ignore
SWRE002D	Ignore
SWRE002E	Ignore
SWRE002F	Ignore
SWRE002G	Ignore
SWRE002H	Ignore
SWRE002I	Ignore
SWRE002J	Ignore
SWRE002K	Ignore
SWRE002L	Ignore
SWWH001E	Ignore
SWWH001G	Ignore
SWWH001H	Ignore
SWWH002L	Ignore
SWWH002M	Ignore
SWWH002N	Ignore
SWWH002S	Ignore
SWWH003T	Ignore
SWWH003U	Ignore
SWWH014B	Ignore
SWWH014E	Ignore
VP0003	Ignore
WH-18930	Ignore
WH-19956	Ignore
WH-19961	Ignore
WH-20838	Ignore
WH-20840	Ignore
WH-20843	Ignore

Measure ID	Measure Name
WH-20844	Ignore
WH-21503	Ignore
WH-21505	Ignore
WH-21508	Ignore
WH-62220	Ignore
WH-79994	Ignore
Worksheet in 2013-2014_DHWFixtureMeasures_Disposition-1March2013-revised.xlsx	Ignore
WPSCGNRPH120206A-Rev05-Msr001	Ignore
WPSDGENRLG0028-Rev01-Msr015	Ignore
WPSDGENRLG0028-Rev01-Msr016	Ignore
WPSDGENRWH0012-Rev01-Msr003	Ignore
WPSDGEREWH0022-Rev02-Msr001	Ignore
WPSDGEREWH0022-Rev02-Msr002	Ignore
WPSDGEREWH0022-Rev03-Msr001	Ignore
WPSDGEREWH0022-Rev03-Msr002	Ignore
WPSDGEREWP0002-Rev06-Msr001	Ignore
WPSDGEREWP0002-Rev06-Msr003	Ignore
WPSDGEREWP0002-Rev08-Msr001	Ignore
WPSDGEREWP0002-Rev08-Msr007	Ignore
RE-WtrHt-SmlStrg-HP-lte12kW-rep50G-3p24EF	Ignore (heat pump)
RE-WtrHt-SmlStrg-HP-lte12kW-rep75G-3p06EF	Ignore (heat pump)
RE-WtrHt-SmlStrg-HP-lte6kW-rep40G-MD-3p09UEF-50g	Ignore (heat pump)
RE-WtrHt-SmlStrg-HP-lte6kW-rep50G-MD-3p09UEF-50g	Ignore (heat pump)
SWWH025-01	Ignore (heat pump)
SWWH025H	Ignore (heat pump)
SWWH025H	Ignore (heat pump)
SWWH025J	Ignore (heat pump)
SWWH025P	Ignore (heat pump)

Measure ID	Measure Name
SWWH027B	Ignore (heat pump)
BW032	Laminar Flow Restrictor
BW037	Laminar Flow Restrictor
BW038	Laminar Flow Restrictor
BW039	Laminar Flow Restrictor
SWWH004	Laminar Flow Restrictor
SWWH004A	Laminar Flow Restrictor
SWWH004B	Laminar Flow Restrictor
SWWH004C	Laminar Flow Restrictor
SWWH004D	Laminar Flow Restrictor
SWWH004E	Laminar Flow Restrictor
SWWH004F	Laminar Flow Restrictor
SWWH004G	Laminar Flow Restrictor
SWWH004H	Laminar Flow Restrictor
SWWH004I	Laminar Flow Restrictor
SWWH004J	Laminar Flow Restrictor
WPSCGNRWH150827A-Rev02-Msr001	Laminar Flow Restrictor
WPSCGNRWH150827A-Rev02-Msr002	Laminar Flow Restrictor
WPSCGNRWH150827A-Rev02-Msr003	Laminar Flow Restrictor
WPSCGNRWH150827A-Rev02-Msr004	Laminar Flow Restrictor
SWWH020	LF Showerhead, Commercial
SWWH020A	LF Showerhead, Commercial
SWWH020B	LF Showerhead, Commercial
SWWH020C	LF Showerhead, Commercial
WPSCGNRWH170412A-Rev01-Msr001	LF Showerhead, Commercial
WPSCGNRWH170412A-Rev01-Msr002	LF Showerhead, Commercial
BW046	LF Showerhead, Residential
BW047	LF Showerhead, Residential
G8	LF Showerhead, Residential
Res-ShowerHdFlowRes-Gas-1.6	LF Showerhead, Residential
Res-ShowerHd-Gas-1.5	LF Showerhead, Residential
Res-ShowerHd-Gas-1.6	LF Showerhead, Residential
SCGWP100303A-Rev05-Msr003	LF Showerhead, Residential

Measure ID	Measure Name
SCGWP100303A-Rev05-Msr008	LF Showerhead, Residential
SCGWP100303A-Rev05-Msr010	LF Showerhead, Residential
SWWH002	LF Showerhead, Residential
SWWH002-02	LF Showerhead, Residential
SWWH002A	LF Showerhead, Residential
SWWH002B	LF Showerhead, Residential
SWWH002C	LF Showerhead, Residential
SWWH002D	LF Showerhead, Residential
SWWH002E	LF Showerhead, Residential
SWWH002F	LF Showerhead, Residential
SWWH002G	LF Showerhead, Residential
SWWH002H	LF Showerhead, Residential
SWWH002I	LF Showerhead, Residential
SWWH002J	LF Showerhead, Residential
SWWH002U	LF Showerhead, Residential
SWWH002V	LF Showerhead, Residential
SWWH002W	LF Showerhead, Residential
SWWH002X	LF Showerhead, Residential
SWWH002Y	LF Showerhead, Residential
WPSDGEREWH1061A-Rev05-Msr001	LF Showerhead, Residential
SWRE001	Pool Cover
SWRE001A	Pool Cover
SWRE001B	Pool Cover
WPSCGNRWH150309A-Rev00-Msr001	Pool Cover
SWRE004	Pool Heater, Residential
SWRE004B	Pool Heater, Residential, Condensing
WPSCGREWH170412A-Rev00-Msr002	Pool Heater, Residential, Condensing
SWRE004A	Pool Heater, Residential, Non-condensing
WPSCGREWH170412A-Rev00-Msr001	Pool Heater, Residential, Non-condensing
SWWH021A	Recirculation Pump Timer, Commercial
SWWH021B	Recirculation Pump Timer, Commercial
SWWH021C	Recirculation Pump Timer, Commercial
PM001	Smart Pump

Measure ID	Measure Name
SWWH022A	Smart Pump
SWWH032	Solar Thermal Water Heating System, Residential
SWWH032A	Solar Thermal Water Heating System, Residential
SWWH032B	Solar Thermal Water Heating System, Residential
SWWH032C	Solar Thermal Water Heating System, Residential
HA18	Storage Water Heater, Commercial, Condensing
NG-WtrHt-LrgStrg-Gas-gt75kBtuh-0p90Et	Storage Water Heater, Commercial, Condensing
NG-WtrHt-LrgStrg-Gas-gte75kBtuh-0p90Et	Storage Water Heater, Commercial, Condensing
SWWH007H	Storage Water Heater, Commercial, Condensing
SWWH007I	Storage Water Heater, Commercial, Condensing
SWWH007A	Storage Water Heater, Commercial, Non-condensing
SWWH007B	Storage Water Heater, Commercial, Non-condensing
SWWH007C	Storage Water Heater, Commercial, Non-condensing
SWWH007D	Storage Water Heater, Commercial, Non-condensing
SWWH007E	Storage Water Heater, Commercial, Non-condensing
SWWH007F	Storage Water Heater, Commercial, Non-condensing
SWWH007G	Storage Water Heater, Commercial, Non-condensing
WPSCGNRWH120206A-Rev11-Msr003	Storage Water Heater, Commercial, Non-condensing
SWWH012K	Storage Water Heater, Residential, Condensing
SWWH012L	Storage Water Heater, Residential, Condensing
HA58	Storage Water Heater, Residential, Non-condensing
RG-WtrHt-SmlStrg-Gas-lte75kBtuh-40G-HD-0p68UEF	Storage Water Heater, Residential, Non-condensing
RG-WtrHt-SmlStrg-Gas-lte75kBtuh-40G-HI-0p68UEF	Storage Water Heater, Residential, Non-condensing
RG-WtrHt-SmlStrg-Gas-lte75kBtuh-40G-MD-0p64UEF	Storage Water Heater, Residential, Non-condensing

Measure ID	Measure Name
RG-WtrHt-SmlStrg-Gas-lte75kBtuh-50G-HI-0p68UEF	Storage Water Heater, Residential, Non-condensing
RG-WtrHt-SmlStrg-Gas-lte75kBtuh-50G-MD-0p64UEF	Storage Water Heater, Residential, Non-condensing
RG-WtrHt-SmlStrg-Gas-lte75kBtuh-40G-0p65EF	Storage Water Heater, Residential, Non-condensing
RG-WtrHt-SmlStrg-Gas-lte75kBtuh-40G-0p67EF	Storage Water Heater, Residential, Non-condensing
RG-WtrHt-SmlStrg-Gas-lte75kBtuh-40G-0p70EF	Storage Water Heater, Residential, Non-condensing
RG-WtrHt-SmlStrg-Gas-lte75kBtuh-50G-0p67EF	Storage Water Heater, Residential, Non-condensing
RG-WtrHt-SmlStrg-Gas-lte75kBtuh-50G-0p70EF	Storage Water Heater, Residential, Non-condensing
SWWH012	Storage Water Heater, Residential, Non-condensing
SWWH012B	Storage Water Heater, Residential, Non-condensing
SWWH012C	Storage Water Heater, Residential, Non-condensing
SWWH012E	Storage Water Heater, Residential, Non-condensing
SWWH012F	Storage Water Heater, Residential, Non-condensing
SWWH012G	Storage Water Heater, Residential, Non-condensing
SWWH012H	Storage Water Heater, Residential, Non-condensing
SWWH012I	Storage Water Heater, Residential, Non-condensing
SWWH012J	Storage Water Heater, Residential, Non-condensing
WPSCGREWH180207A-Rev00-Msr002	Storage Water Heater, Residential, Non-condensing
WPSCGREWH180207A-Rev00-Msr003	Storage Water Heater, Residential, Non-condensing
WPSDGEREWH0024-Rev01-Msr002	Storage Water Heater, Residential, Non-condensing
WPSDGEREWH0024-Rev01-Msr004	Storage Water Heater, Residential, Non-condensing
DWHC1	Tankless Water Heater, Commercial, Condensing
DWHC4	Tankless Water Heater, Commercial, Condensing
NG-WtrHt-LrgInst-Gas-gt200kBtuh-0p90Et	Tankless Water Heater, Commercial, Condensing
NG-WtrHt-MedInst-Gas-76to200kBtuh-0p90Et	Tankless Water Heater, Commercial, Condensing
SWWH006B	Tankless Water Heater, Commercial, Condensing
SWWH006D	Tankless Water Heater, Commercial, Condensing
SWWH006E	Tankless Water Heater, Commercial, Condensing

Measure ID	Measure Name
SWWH006F	Tankless Water Heater, Commercial, Condensing
WPSCGNRWH120206B-Rev06-Msr002	Tankless Water Heater, Commercial, Condensing
WPSCGNRWH120206B-Rev07-Msr002	Tankless Water Heater, Commercial, Condensing
WPSCGNRWH120206B-Rev08-Msr002	Tankless Water Heater, Commercial, Condensing
DWHC3	Tankless Water Heater, Commercial, Non-condensing
NG-WtrHt-LrgInst-Gas-gt200kBtuh-0p80Et	Tankless Water Heater, Commercial, Non-condensing
NG-WtrHt-LrgInst-Gas-gt200kBtuh-0p85Et	Tankless Water Heater, Commercial, Non-condensing
NG-WtrHt-SmlInst-Gas-150kBtuh-lt2G-0p82EF-40g	Tankless Water Heater, Commercial, Non-condensing
SWWH006A	Tankless Water Heater, Commercial, Non-condensing
SWWH006C	Tankless Water Heater, Commercial, Non-condensing
WPSCGNRWH120206B-Rev06-Msr001	Tankless Water Heater, Commercial, Non-condensing
WPSCGNRWH120206B-Rev07-Msr001	Tankless Water Heater, Commercial, Non-condensing
RG-WtrHt-SmlInst-Gas-150kBtuh-lt2G-0p92EF	Tankless Water Heater, Residential, Condensing
RG-WtrHt-SmlInst-Gas-150kBtuh-lt2G-0p92EF-40g	Tankless Water Heater, Residential, Condensing
RG-WtrHt-SmlInst-Gas-lte175kBtuh-lt2G-HI-0p87UEF-40g	Tankless Water Heater, Residential, Condensing
RG-WtrHt-SmlInst-Gas-lte175kBtuh-lt2G-MD-0p87UEF-40g	Tankless Water Heater, Residential, Condensing
SWWH013	Tankless Water Heater, Residential, Condensing
SWWH013D	Tankless Water Heater, Residential, Condensing
SWWH013E	Tankless Water Heater, Residential, Condensing
SWWH013F	Tankless Water Heater, Residential, Condensing
SWWH013G	Tankless Water Heater, Residential, Condensing
SWWH013H	Tankless Water Heater, Residential, Condensing
SWWH013I	Tankless Water Heater, Residential, Condensing
WPSCGREWH120919A-Rev04-Msr005	Tankless Water Heater, Residential, Condensing
WPSDGEREWH0025-Rev01-Msr004	Tankless Water Heater, Residential, Condensing

Measure ID	Measure Name
RG-WtrHt-SmlInst-Gas-150kBtuh-lt2G-0p82EF	Tankless Water Heater, Residential, Non-condensing
RG-WtrHt-SmlInst-Gas-150kBtuh-lt2G-0p82EF-40g	Tankless Water Heater, Residential, Non-condensing
RG-WtrHt-SmlInst-Gas-lte175kBtuh-lt2G-MD-0p81UEF-40g	Tankless Water Heater, Residential, Non-condensing
SWWH013A	Tankless Water Heater, Residential, Non-condensing
SWWH013B	Tankless Water Heater, Residential, Non-condensing
SWWH013C	Tankless Water Heater, Residential, Non-condensing
WPSCGREWH120919A-Rev04-Msr002	Tankless Water Heater, Residential, Non-condensing
BW048	TSV and LF Showerhead, Residential
G11	TSV and LF Showerhead, Residential
SCGWP100303B-Rev06-Msr005	TSV and LF Showerhead, Residential
SWWH003	TSV and LF Showerhead, Residential
SWWH003B	TSV and LF Showerhead, Residential
SWWH003C	TSV and LF Showerhead, Residential
SWWH003D	TSV and LF Showerhead, Residential
SWWH003E	TSV and LF Showerhead, Residential
SWWH003F	TSV and LF Showerhead, Residential
SWWH003G	TSV and LF Showerhead, Residential
SWWH003H	TSV and LF Showerhead, Residential
SWWH003I	TSV and LF Showerhead, Residential
SWWH003J	TSV and LF Showerhead, Residential
SWWH003K	TSV and LF Showerhead, Residential
SCGWP100303B-Rev06-Msr001	TSV only, Residential
SWWH003A	TSV only, Residential
Res-DHWSavingsKit-Gas	Water Savings Kit, Residential
SCGWP100309A-Rev05-Msr001	Water Savings Kit, Residential
WPSDGEREWH1062-Rev00-Msr001	Water Savings Kit, Residential

Trend Data Tables

Table 27: Water Heating Measures Total First Year Net Therms Savings

Year	2017	2018	2019	2020	2021
Measure	**First Year Net Therm**	**First Year Net Therm**	**First Year Net Therm**	**First Year Net Therm**	**First Year Net Therm**
Boiler, Commercial, Condensing	134,271	60,814	48,771	276,668	79,658
Boiler, Commercial, Non-condensing	69,742	63,088	15,299	29,887	172
Boiler, Multifamily	-	-	-	-	-
Boiler, Multifamily, Condensing	27,844	101,237	15,717	57,242	23,912
Boiler, Multifamily, Non-condensing	20,022	19,068	21,082	15,951	4,445
Central Boiler Dual Setpoint Temperature Controller, Multifamily	-	-	-	-	160
Central Storage Water Heater, Multifamily, Condensing	4	15,320	2,426	10,858	3,049
Central Storage Water Heater, Multifamily, Non-condensing	2,243	-	13,021	22,058	484
Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial	234,446	223,653	221,059	275	2,242
Diverting Tub Spout with TSV, Residential	493	389	7,719	5,231	4,832
Domestic Hot Water Loop Temperature Controller, Multifamily & Commercial	-	-	-	367,953	178,567
Faucet Aerator, Commercial	-	301	7,519	12,185	561
Faucet Aerator, Residential	214,708	1,681,482	328,830	934,168	222,251
Heater for Pool or Spa, Commercial	130,858	152,219	134,674	61,246	77,899
Hot Water Pipe Insulation	191,065	1,960,139	4,737,935	3,311,937	1,828,836
Hot Water Tank Insulation	161,945	368,151	690,295	2,750,365	1,250,830
Ignore	85,786	49,120	37,589	1,256	-

Year	2017	2018	2019	2020	2021
Measure	**First Year Net Therm**	**First Year Net Therm**	**First Year Net Therm**	**First Year Net Therm**	**First Year Net Therm**
Ignore (heat pump)	-	-	-	-	-
Laminar Flow Restrictor	68,961	37,384	173,704	28,140	1,481
LF Showerhead, Commercial	3,058	161,506	104,406	67,705	1,923
LF Showerhead, Residential	348,612	2,551,922	617,111	1,040,407	228,750
Pool Cover	154,034	52,924	16,400	110,899	236,756
Pool Heater, Residential, Condensing	317	589	581	647	474
Pool Heater, Residential, Non-condensing	4,611	25,886	22,683	36,157	29,761
Recirculation Pump Timer, Commercial	-	-	-	-	-
Smart Pump	-	-	-	-	-
Solar Thermal Water Heating System, Residential	-	-	-	-	-
Storage Water Heater, Commercial, Condensing	251,109	353,846	295,147	369,493	7,973
Storage Water Heater, Commercial, Non-condensing	-	-	50	7	-
Storage Water Heater, Residential, Condensing	-	-	-	-	-
Storage Water Heater, Residential, Non-condensing	131,085	54,251	50,209	83,075	29,496
Tankless Water Heater, Commercial, Condensing	776,138	1,059,361	617,746	369,422	128,597
Tankless Water Heater, Commercial, Non-condensing	153,793	148,982	51,506	14,571	329
Tankless Water Heater, Residential, Condensing	100,577	77,519	153,612	437,230	963,229
Tankless Water Heater, Residential, Non-condensing	20,258	29,112	24,879	52,251	89,702
TSV and LF Showerhead, Residential	395	340	16,328	1,636	3,506
TSV only, Residential	546	60	2,515	945	7,576
Water Savings Kit, Residential	235,329	118,244	-	-	-

Table 28: Water Heating Measures First Year Net Therm Savings 2017-2021

Year	2017	2018	2019	2020	2021
Measure					
Boiler, Commercial, Condensing	54	37	23	425	47
Boiler, Commercial, Non-condensing	106	67	13	158	3
Boiler, Multifamily	-	-	-	-	-
Boiler, Multifamily, Condensing	112	197	13	38	44
Boiler, Multifamily, Non-condensing	41	48	20	14	26
Central Boiler Dual Setpoint Temperature Controller, Multifamily	-	-	-	-	20
Central Storage Water Heater, Multifamily, Condensing	4	17	3	18	7
Central Storage Water Heater, Multifamily, Non-condensing	13	-	25	36	2
Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial	773	631	504	9	11
Diverting Tub Spout with TSV, Residential	45	47	1,320	544	711
Domestic Hot Water Loop Temperature Controller, Multifamily & Commercial	-	-	-	976	462
Faucet Aerator, Commercial	-	25	687	1,852	82

Year	2017	2018	2019	2020	2021
Measure					
Faucet Aerator, Residential	40,806	37,912	95,603	439,876	17,874
Heater for Pool or Spa, Commercial	91	81	98	32	54
Hot Water Pipe Insulation	130	638	1,145	2,684	9,517
Hot Water Tank Insulation	108	1,276	3,026	3,792	693
Ignore	27,187	14,742	13,492	4,791	2,992
Ignore (heat pump)	1	-	7	65	874
Laminar Flow Restrictor	43	37	128	95	12
LF Showerhead, Commercial	39	524	517	289	8
LF Showerhead, Residential	28,296	29,044	81,835	221,860	11,865
Pool Cover	56	19	5	10	20
Pool Heater, Residential, Condensing	9	20	19	21	14
Pool Heater, Residential, Non-condensing	887	3,509	3,065	4,849	4,399
Recirculation Pump Timer, Commercial	-	-	-	-	-
Smart Pump	-	-	28	18	-
Solar Thermal Water Heating System, Residential	-	-	-	-	-
Storage Water Heater, Commercial, Condensing	794	1,188	992	1,695	48
Storage Water Heater, Commercial, Non-condensing	-	-	1	1	-

Year	2017	2018	2019	2020	2021
Measure					
Storage Water Heater, Residential, Condensing	–	–	–	–	–
Storage Water Heater, Residential, Non-condensing	6,119	3,049	1,970	4,299	1,687
Tankless Water Heater, Commercial, Condensing	900	980	982	670	347
Tankless Water Heater, Commercial, Non-condensing	240	204	52	62	2
Tankless Water Heater, Residential, Condensing	2,086	2,505	4,692	13,154	17,029
Tankless Water Heater, Residential, Non-condensing	1,175	1,284	1,044	2,306	1,945
TSV and LF Showerhead, Residential	30	25	4,774	185	463
TSV only, Residential	314	42	1,845	613	5,004
Water Savings Kit, Residential	76,599	21,632	–	–	–

Table 29: SCG3702: RES-Residential Energy Efficiency Program Water Heating Measure Participation 2017-2021

RES-Residential Energy Efficiency Program (SCG3702)	Yearly Net Therm Savings					
Measure	**2017**	**2018**	**2019**	**2020**	**2021**	**Total**
Boiler, Multifamily, Condensing	–	–	15,717	57,242	21,061	94,020
Boiler, Multifamily, Non-condensing	–	–	21,082	15,951	4,445	41,478
Central Storage Water Heater, Multifamily, Condensing	–	–	1,499	5,746	1,314	8,558
Central Storage Water Heater, Multifamily, Non-condensing	–	–	13,021	21,446	484	34,952
Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial	–	–	–	–	–	–
Diverting Tub Spout with TSV, Residential	–	–	–	–	–	–
Domestic Hot Water Loop Temperature Controller, Multifamily & Commercial	–	–	–	367,953	161,366	529,319
Faucet Aerator, Residential	–	–	–	–	–	–
Heater for Pool or Spa, Commercial	–	–	4,198	2,131	1,331	7,659
Hot Water Pipe Insulation	–	–	–	–	–	–
Hot Water Tank Insulation	–	–	–	–	–	–
LF Showerhead, Residential	–	–	–	–	–	–
Pool Heater, Residential, Condensing	–	–	–	–	–	–
Pool Heater, Residential, Non-condensing	10	22	21	–	–	52
Storage Water Heater, Residential, Non-condensing	–	51	230	771	57	1,109

RES-Residential Energy Efficiency Program (SCG3702)	Yearly Net Therm Savings					
Measure	**2017**	**2018**	**2019**	**2020**	**2021**	**Total**
Tankless Water Heater, Residential, Condensing	–	507	1,497	9,260	5,562	16,825
Tankless Water Heater, Residential, Non-condensing	–	145	382	391	4,388	5,306
TSV only, Residential	–	–	–	–	–	–
TRC	0.8	1.24	0.57	0.37	0.56	N/A

Multi-Family Supplemental Tables

Table 30: SCG3704: RES-MFEER Water Heating Measure Participation 2017-2021

RES-MFEER (SCG3704)	Yearly Net Therms					
Measure	**2017**	**2018**	**2019**	**2020**	**2021**	**Total**
Boiler, Multifamily, Condensing	2,903	49,441	–	–	–	52,344
Boiler, Multifamily, Non-condensing	19,898	19,068	–	–	–	38,965
Central Storage Water Heater, Multifamily, Condensing	4	15,320	–	–	–	15,323
Central Storage Water Heater, Multifamily, Non-condensing	1,633	–	–	–	–	1,633
Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial	–	–	–	–	–	–
Diverting Tub Spout with TSV, Residential	–	–	–	–	–	–
Domestic Hot Water Loop Temperature Controller, Multifamily & Commercial	–	–	–	–	–	–
Faucet Aerator, Residential	–	–	–	–	–	–
Heater for Pool or Spa, Commercial	479	2,931	–	–	–	3,409
Hot Water Pipe Insulation	–	–	–	–	–	–
Hot Water Tank Insulation	–	–	–	–	–	–
LF Showerhead, Residential	–	–	–	–	–	–
Pool Heater, Residential, Condensing	–	–	–	–	–	–
Pool Heater, Residential, Non-condensing	–	–	–	–	–	–
Storage Water Heater, Residential, Non-condensing	488	3,159	–	–	–	3,648
Tankless Water Heater, Residential, Condensing	368	524	–	–	–	892
Tankless Water Heater, Residential, Non-condensing	795	246	–	–	–	1,041
TSV only, Residential	–	–	–	–	–	–

Methodology to Match CEDARS Trend Data to PG Study Data

This section describes the methodology used to compare the CEDARS trend data to the PG study data.

First, savings claims were downloaded from CEDARS (CEDARS Sound Data, 2022) and processed. A summary of the processing steps is provided below:

1) Files were loaded into a data model in MS Excel using a power pivot which creates a link to the data without loading it into Excel.
2) Pivot Tables were created for each year
3) For each year, the following filters were applied
    a. Filtered out Codes & Standards Programs using "Program Group"
    b. Filtered "Use Category" to only display "Recreation" and "Service and Domestic Water Heating". This returned only water heating and pool measures[5]. Pool measures are not included in the PG Study, but they are included in the TPM for water heating, so they were part of this scope.
4) Displayed "Measure ID" on the pivot table with the corresponding "First Year Net Therm" and "Count of First Year Net Therm." First Year Net Therm is the total savings claim after the appropriate GRR and NTG are applied. Count of First Year Net Therm is not used to compare actual savings to the PG Study, but it was used to pinpoint anomalies in the data. Many water heaters are normalized by "rated btuh" as common units. Therefore, Count of First Year Net Therms was used to capture the number of installed water heaters rather than the total btuh of installed water heaters. This metric does not account accurately for faucet aerators or low flow showerheads which might have more than one unit installed per project, but accurate counts of water heater installations were prioritized above accurate counts of other measures.
5) Translated each Measure ID into a Measure Description. Each Measure Description can have multiple measure IDs. This is because each IOU generally has a different Measure ID for the same measure, and some measures fall under the same general measure description (for example a 1.0 GPM low flow faucet aerator and a 1.5 GPM low flow faucet aerator both fall under "Faucet Aerator")
6) Made adjustments to therms savings in 2018. In 2018, the savings claims for Faucet Aerator, Residential and LF Showerhead, Residential increased significantly. In Table

[5] Pool measures are included in this analysis because they are under the Water Heating end use in the GET TPM

19 below, the total Savings claims for these measures is shown for 2017-2019. It was found that the large increase is due to savings claims for these measures in program SCG3702 "RES-Residential Energy Efficiency Program." However, each measure has only (18) unique claim ID rows and each unique Claim ID has total units installed ranging between 1-200,000. Installed units are typically 1-3 for each unique Claim ID which corresponds to the total number of low flow showerheads or faucet aerators installed in a single home. This can be higher in a multifamily building, but all installations of these measures were in single family homes. Further, these measures are not found in this program in 2017 or 2019. Table 31 shows the amount of savings in 2018 from SCG3702 for each measure. Since this was an anomaly that accounts for 60-70% of the savings for those measures in 2018, it was assumed to be an adjustment to the program's energy savings claims and was removed from the data to create an adjusted data set.

Table 31: Claims for Low Flow Fixtures in 2018

	Claims [MMTherm]				
Measure Desc	**2017**	**2018**	**2019**	**2018 Claims from SCG3702**	**2018 % of Savings from SCG3702**
LF Showerhead, Residential	0.21	2.55	0.62	1.52	60%
Faucet Aerator, Residential	0.35	1.68	0.33	1.17	70%
Total Savings for All Measures	3.44	9.32	8.39		
Total Savings Adjusted	N/A	6.56	N/A		

7) Calculated Total Therms Savings for two scenarios:
   a. Actuals (All Measures): This is the total yearly claimed net therms savings for all measure descriptions except pool covers. The PG Study includes Pool covers under the "AppPlug" End Use Category.
   b. Actuals (PG Measures): This is the total yearly claimed net therm savings for only those measures considered in the PG Study forecasted savings.

8) Plotted the following data on the same chart
   a. Actuals Therms (All Measures)
   b. Actuals Therms (PG Measures)
   c. PG Study Incremental Achievable Potential: TRC High
   d. PG Study Incremental Achievable Potential: TRC Reference
   e. PG Study Incremental Achievable Potential: TRC Low

This section describes how the Measure Descriptions for the actual savings claims were matched up with the PG Study measures.

The 2021 PG Study website has a file named “2021 PG Measure Results Database” that contains achievable potential for each measure (California Public Utilities Commission, 2021). This was downloaded and a pivot table was created from the sheet containing the Incremental Achievable Potential for all of the PG Study Measures. The following filters were used:

1) End Use: WaterHeat
2) Savings Type: Gas Energy (MM Therm/Year)
3) Sector: Res, Com

That returned a list of measures shown in the first column of Table 32. Those measures were translated to a “Simple PG Measure Description” shown in the second column of Table 32.

Next, the measure descriptions for the actual energy savings claims were mapped to the Simple PG Measure Descriptions. These are shown in the third column of Table 32. Measure descriptions were created from the Measure IDs in CEDARS data. These were discussed more thoroughly in the Task 4 deliverable.

Table 32: Mapping of PG Study Measures to Actual Savings Claim Measures

PG Measure Description	Simple PG Measure Description	Measure Description (Actual Savings Claims)
Com | Com Condensing Eff. Gas Storage Water Heater (0.90 & .96ET) – Cold	Commercial, Storage Water Heater, Condensing	Storage Water Heater, Commercial, Condensing
Com | Com Condensing Eff. Gas Storage Water Heater (0.90 & .96ET) – Hot-Dry		
Com | Com Condensing Eff. Gas Storage Water Heater (0.90 & .96ET) – Marine		
Com | Com Fuel Sub Heat Pump Water Heater (3.42 UEF – 80 Gal) – Cold	Fuel Substitution Heat Pump Water Heater	Ignore[6]
Com | Com Fuel Sub Heat Pump Water Heater (3.42 UEF – 80 Gal) – Hot-Dry		
Com | Com Fuel Sub Heat Pump Water Heater (3.42 UEF – 80 Gal) – Marine		
Com | Com Fuel Sub Smart Heat Pump Water Heater (3.42 UEF – 80 Gal) – Cold	Fuel Substitution Smart Heat Pump Water Heater	Ignore
Com | Com Fuel Sub Smart Heat Pump Water Heater (3.42 UEF – 80 Gal) – Hot-Dry		
Com | Com Fuel Sub Smart Heat Pump Water Heater (3.42 UEF – 80 Gal) – Marine		
Com | Com Instantaneous Gas Water Heater – Cold	Commercial, Tankless Water Heater	Tankless Water Heater, Commercial, Condensing

[6] The "Ignore" measure description includes things that were not in the scope of this project including: fuel substitution, low-flow pre-rinse spray valves, and process boilers. However, the PG Study did include these things in its forecast of incremental achievable energy savings, so the "Ignore" measure description was included in the "Actuals (PG Measures Only)".

PG Measure Description	Simple PG Measure Description	Measure Description (Actual Savings Claims)
Com | Com Instantaneous Gas Water Heater – Hot-Dry		
Com | Com Instantaneous Gas Water Heater – Marine		
Com | Condensing Eff. Gas Water Heating Boiler (0.90 EF) – Cold	Commercial, Boiler, Condensing	Boiler, Commercial, Condensing
Com | Condensing Eff. Gas Water Heating Boiler (0.90 EF) – Hot-Dry		
Com | Condensing Eff. Gas Water Heating Boiler (0.90 EF) – Marine		
Com | Low-flow Pre-Rinse Spray Valve – Cold	Low-Flow Pre-Rinse spray Valve	Ignore
Com | Low-flow Pre-Rinse Spray Valve – Hot-Dry		
Com | Low-flow Pre-Rinse Spray Valve – Marine		
Res | Faucet Aerators (Gas WH)	Residential, Faucet Aerators	Faucet Aerator, Residential
Res | Low Flow Showerheads (Gas WH)	Residential, Low Flow Showerheads	LF Showerhead, Residential Diverting Tub Spout with TSV, Residential TSV and LF Showerhead, Residential TSV only, Residential
Res | Res Condensing Eff. Small Gas Storage Water Heater (0.88 UEF – 50 Gal) – Cold	Residential, Storage Water Heater, Condensing	Storage Water Heater, Residential, Condensing
Res | Res Condensing Eff. Small Gas Storage Water Heater (0.88 UEF – 50 Gal) – Hot-Dry		

PG Measure Description	Simple PG Measure Description	Measure Description (Actual Savings Claims)
Res | Res Condensing Eff. Small Gas Storage Water Heater (0.88 UEF – 50 Gal) – Marine		
Res | Res Instantaneous Gas Water Heater – Cold	Residential, Tankless Water Heater	Tankless Water Heater, Residential, Condensing
Res | Res Instantaneous Gas Water Heater – Hot-Dry		
Res | Res Instantaneous Gas Water Heater – Marine		
Res | Water Heating Controls (Gas WH)	Water Heating Controls	Demand Control for Centralized Water Heater Recirculation Pump, Multifamily & Commercial, Domestic Hot Water Loop Temperature Controller, Multifamily & Commercial

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