2023 Water Heating Technology Priority Map

Final Report

ET23SWE0016

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Abbreviations and Acronyms

Acronym	Meaning
ACEEE	American Council for an Energy-Efficient Economy
ATC	Available Transfer Capability
CBECC	California Buildings Energy Code Compliance
BTU/h	British Thermal Unit/Hour
BUILD	Building Initiative for Low-Emissions Development Program
CEC	California Energy Commission
CEC-EPIC	California Energy Commission - Electric Program Investment Charge
CPUC	California Public Utilities Commission
CSLB	Contractor State Licensing Board
DER	Distributed Energy Resource
DOE	Department of Energy
DR	Demand Response
EE	Energy Efficiency
EPA	Environmental Product Agency
ET	Emerging Technology
ETCC	Emerging Technology Coordinating Council
FDAS	Flexible Demand Appliance Standards
FHR	First Hour Rating
GHG	Greenhouse Gas
GWP	Global Warming Potential
HP	Heat Pump
HPPH	Heat Pump Pool Heaters
HPWH	Heat Pump Water Heater
HVAC	Heating, Ventilation, and Air Conditioning

Acronym	Meaning
IDSM	Integrated Demand-Side Management
IOUs	Investor-Owned Utilities
NEB	Non-Energy Benefits
NEEA	Northwest Energy Efficiency Alliance
NEEP	Northeast Energy Efficiency Partnerships
NYSERDA	New York State Energy Research and Development Authority
POU	Point-of-Use
PV	Photovoltaic
SB-49	California Senate Bill 49 (2019-2020): flexible appliance standards
SCE	Southern California Edison
SDG&E	San Diego Gas and Electric
SGIP	Self-Generation Incentive Program
SME	Subject Matter Expert
TAC	Technical Advisory Committee
TECH	Technology and Equipment for Clean Heating
TPM	Technology Priority Map
TSB	Total System Benefit
U.S.	United States
WH	Water Heating

Glossary	Meaning
Technology Category	One of six broad technology categories (e.g., Whole Building, HVAC, Water Heating (WH), Plug Loads, Lighting, Process Loads).
Technology Family	Functional grouping that provides description of program role, opportunities, and barriers.
Subgroups	Common examples to further describe each technology family.
Definitions	Narrative to provide additional clarification on the technology family scope.
Opportunities	Description of potential impacts and potential research areas.
Barriers	Description of key barriers and potential barriers research.
CalNEXT Role	Describes general level of engagement by CalNEXT SMEs. *Note: Roles will change as research is completed.*
Lead	"Lead" – CalNEXT expects to take on most or all of the work and cost burden.
Collaborate	"Collaborate" – CalNEXT is interested in collaborating and co-funding projects.
Observe	"Observe" – CalNEXT will track progress but also encourage external programs to take the lead in unlocking these opportunities.
CALNEXT Priority	Communicates expected level of focus by CalNEXT SMEs. *Note: Priorities will change as research is completed.*
High	"High" - CalNEXT SME team has highlighted this technology family as having high impacts within the Technology Category.
Medium	"Medium" - CalNEXT SME team determined this technology family has moderate overall impacts within the Technology Category.
Low	"Low" - CalNEXT SME team has highlighted this technology family as having low relative impacts within the Technology Category.
Impact Factor	One of four broad impact areas (energy savings potential, demand flexibility potential, decarbonization potential, and other GHG impacts).
Impact Factor Ratings	A qualitative rating (High-Medium-Low) by the CalNEXT SME team on impact potential if technological advancements are made in key subgroups.
Knowledge Index	One of three types of knowledge areas (technical performance, market understanding, and program intervention) used to assess types of barriers studies necessary to obtain the stated impact potential.
Knowledge Index Rating	A qualitative rating (High-Medium-Low) by the CalNEXT SME team on the relative knowledge of most subgroups within a technology family. A higher rating means the topic is well understood.

Introduction

The Technology Priority Maps (TPMs) provide the CalNEXT Program a framework to externally communicate priorities of the program, clearly define the central focus areas of the program, and assist with project screening. They will document the impact potential, programmatic research needs, and market readiness of all technology families across each of the end-use technology areas. The TPMs will drive product ideation and inform project selection. This Final Report documents the revision activities, outreach activities, feedback, and adjustments related to the 2023 Water Heating TPM.

Background

The TPMs were originally developed by Southern California Edison's Emerging Technologies program in 2017. They have been incorporated as a key element of the CalNEXT program to provide clarity to the program on our priorities. They require frequent updates to reflect technical advancement, policy changes, and market developments in order to maintain their relevance. The current Water Heating TPM was developed by CalNEXT in 2022. The 2022 Water Heating TPM can be found on the resources section of the CalNEXT website.

Objectives

The prior revision of the Water Heating TPM included a significant reorganization of the technology families and subgroups to improve clarity and reflect significant changes in the market landscape compared to the time at which the previous TPM was developed. This 2023 Water Heating TPM revision aims to improve clarity of program priorities for prospective participants by making updates to the current technology families and adding new technology families as appropriate.

Methodology

The Program Team has established a detailed development process for TPM development. This process is shown in Figure 1.

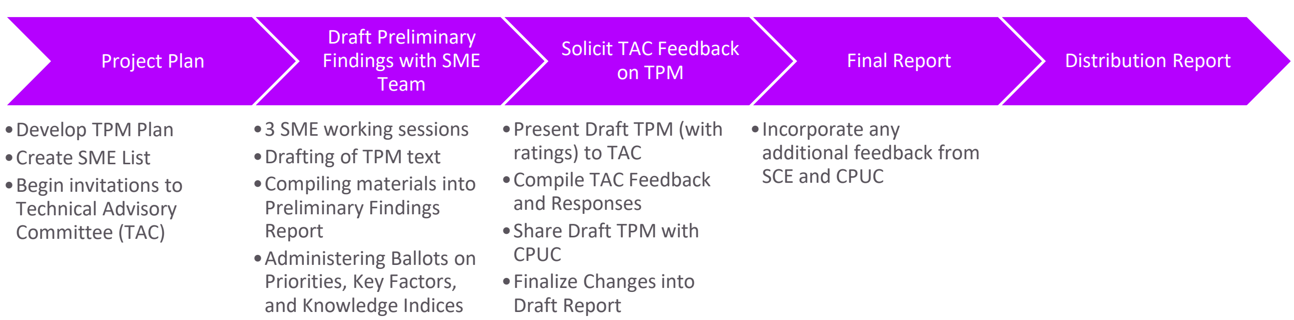

Figure 1: TPM development process

The CalNEXT Program Team established a robust process for TPM development. This started with the formation of the Water Heating TPM SME Team, with representatives from each of the Program Team partners: VEIC, AESC, TRC, UC Davis, and Energy Solutions. The Water Heating SME team represents members that collectively support an array of EE and IDSM programs using technologies covered by the Water Heating TPM as well as members who support the California IOUs' Codes and Standards program. The team met three times between June and August 2023 to develop this draft Water Heating TPM. A list of participants is included in Table 1.

Table 1: Water Heating TPM Subject Matter Experts

Name	Organization
Zoe Mies (facilitating)	Energy Solutions
Greg Barker	Energy Solutions
Helen Davis	Energy Solutions
Daniela Urigwe	Energy Solutions
Kyle Booth	Energy Solutions
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Prior to starting development of the 2023 TPM, the SMEs reviewed the previous TPM from 2022. After this review, the SMEs held a kickoff meeting to discuss high-level changes to national policies (new funding, new programs, new standards) and state-wide policies (California state law and CPUC decisions), as well as reviewed related EE portfolio measures and potential codes and standards efforts related to water heating.

The SMEs then discussed the state of the current TPM and considered different approaches to reorganize the technology families and subgroups and begin work on those revisions. The second meeting was held to finalize technology families and assign SMEs to revise initial definitions, opportunities, and barriers. The narratives developed by the SME team for definitions, opportunities, and barriers were presented as part of the Preliminary Findings Report.

Following this, SMEs conducted secondary research related to their assigned technology family which includes a review of emerging technology (ET) studies and other market changes relevant to different technology families. Key revisions were highlighted to the working group for feedback. The SMEs then developed draft revisions to each technology family and presented final recommendations to the working group. At the conclusion of the working group sessions, SMEs were provided a web-based ballot to determine the recommended revisions to the gradings for key factors, knowledge indices, ET priority and ET program role.

On September 11, 2023, the Preliminary Findings report was presented to the Water Heating TPM Technical Advisory Committee in order to obtain broad feedback on the Water Heating research priorities of CalNEXT. This external committee includes the California Investor-Owned Utility (IOU) Program Administrators (PAs) as well as stakeholders with ET interests from the State of California, other regions, and those with national interests.

The Water Heating lead communicated between the Technology and Equipment for Clean Heating (TECH) and Self-Generation Incentive (SGIP) programs as well this revision cycle. Contributions from those individuals were incorporated into subsequent versions of the TPM (e.g., the Draft Report and this Final Report).

The SMEs refined the Water Heating TPM based on the initial stakeholder feedback from the Technical Advisory Committee and incorporated changes into subsequent versions of the Water Heating TPM Final Report. If any technology families show potential for a focused pilot, they will be identified in this Water Heating TPM Final Report and developed further under a separate Focused Pilot TPM.

Draft Report Feedback

TPM Advisory Committee Meeting

The TPM Advisory Committee meeting was held on September 11, 2023, via the Microsoft Teams platform. Invitees of the meeting are listed in the acknowledgements at the start of this report.

This meeting allowed advisory members to provide real-time, candid feedback with the opportunity to provide written comments and suggestions afterwards via a collaborative Word document hosted on Microsoft SharePoint. Suggestions were reviewed by the TPM coordinator and incorporated into the Revised 2023 Water Heating TPM section below. A detailed table of the changes made can be found in the Stakeholder Feedback & Resolution Matrix in Table 2 in the Appendix of this document.

CalNEXT Website TPM Mock-up (2022 Water Heating sample below)

The 2023 Water Heating TPM webpage update will be in the same format as the 2022 Water Heating TPM webpage update that can be seen below. An additional row will be added for the new technology family: Pool Heaters and Residential Pool Pumps. The CalNEXT role and priority for each technology family will also be updated based on the revised roles and priorities documented herein. The link to the 2023 Water Heating TPM Final Report will appear in the top right corner with the option to download.

2022 Technology Research Areas	Role	Priority	
Residential-Duty Water Heaters	LEAD	HIGH	+
Commercial-Duty Water Heaters	LEAD	HIGH	+
Grid Integration & Market Intervention	LEAD	MEDIUM	+
Alternative Design Strategies	LEAD	MEDIUM	+

2023 Water Heating TPM

Water Heating Technology Category Overview

This category covers one of the most rapidly changing end-uses as product availability, public funding, national standards, and the attention of EE and market transformation program efforts are converging to make changes in electric water heating. The decarbonization of water heating has been identified as an achievable and significant step toward California's overall decarbonization goals, and policies are changing to emphasize this end-use. These include the proposed DOE federal standards, the CEC's 2021 Integrated Energy Policy Report, the Flexible Demand Appliance Standards (FDAS) of SB-49, the CPUC's policies on fuel-switching EE measures and embrace of Total System Benefit (TSB) (D 21-05-031 R. 13-11-005).

California's TECH and Building Initiative for Low-Emissions Development Program (BUILD) market transformation programs are working on the market transformation of water heating and identifying key barriers for CalNEXT to continue addressing. Water heater manufacturers have made key strides in HPWH product development with recently introduced 110V products expanding the addressable market for residential HPWHs.

This TPM has introduced a new technology family for pool heaters and residential pool pumps as pool heating has been identified as a challenge to full electrification. The timing aligns with proposed T24 code changes for pool heaters that encourage the use of solar, Heat Pump Pool Heaters (HPPH), and heat recovery as the primary sources of heating for pools.

Unique Opportunities and Barriers

The electrification of water heating presents a key opportunity to build demand flexibility into this added electrical load. This defining moment could result in either added stress on California's electric grid in the crucial evening hours or true success in bringing grid interactivity to the mass market. Each technology family includes language supporting projects with demand flexibility components. Pool pumping is the first of the SB-49 standards to be developed by the CEC.

Unitary HPWHs are relatively well-understood and have achieved some market success, but there are still important questions around the performance of larger systems with heat recovery, mixing valves, and/or recirculation. CalNEXT can contribute to identifying and promoting best practices for commercial and multi-family HPWH systems.

Note: The Water Heating TPM primarily covers water heaters for domestic hot water systems (kitchens, bathrooms, and laundry) as well as those used in pool water heating. It does not cover hot water used in space heating systems which is covered by the HVAC TPM or for industrial process heating which is covered by the Process Loads TPM.

Highlighted Priority Areas

Technology Family	Definition	ETP Role	ETP Priority
Residential-Duty Water Heaters	Efficient, demand flexible, electric HPWHs are designed to meet the hot water demands of residential households or buildings with similar water heating needs. This technology family will help meet the California Energy Commission's goal of installing at least six million heat pumps by 2030.	1-Lead	1-High

Commercial-Duty Water Heaters	Efficient, demand-flexible electric water heating systems for non-residential applications (such as offices, hotels, healthcare, and food service) and multi-family residential applications (typically ≥5 dwelling units).	1-Lead	1-High

Residential-duty Water Heaters

(ETP Role: Lead, ETP Priority: High)

Key Factors

Energy Savings Potential: High
Decarbonization Potential: High
Demand Flexibility Potential: High
Other Emissions Impacts Potential: Low

Knowledge Index

Technical Performance: Medium
Market Understanding: Medium
Program Intervention: Medium

Note: This family is eligible for a Focused Pilot TPM project.

Example Technologies

Unitary and Split-System HPWH for single family and individual multi-family dwelling units; low-Global Warming Potential (GWP) refrigerants for residential-duty HPWH; 120V plug-in HPWHs; and grid and utility integration for connected residential-duty water heaters.

Note: The updates to this subgroup include 120V plug-in HPWHs; as they are now available on the market from two manufacturers, and grid and utility integration for connected residential-duty water heaters as the previous Grid Integration & Market Intervention technology family was removed, with this technology being the best fit.

Definition

Efficient, demand flexible, electric HPWHs are designed to meet the hot water demands of residential households or buildings with similar water heating needs. This technology family will help meet the California Energy Commission's goal of installing at least six million heat pumps by 2030.

Opportunities

Storage HPWHs are a critical residential building decarbonization strategy, providing a cost-effective, electric water heating solution for load reduction and shifting during peak utility periods. The potential for load shifting and shaping, load management from scale of day to half-hour, and the resulting GHG reduction from shifting the heating schedule(s) to times when the electricity grid has a lower marginal emissions rate and cost to operate.

Shifting to low-GWP refrigerants (e.g., CO_2) offers increased colder climate performance, higher water temperature capabilities and other direct greenhouse gas (GHG) emission benefits due to the risk of refrigerant leakage.

Assessment and attribution of non-energy benefits (NEBs) (e.g., reducing indoor exposure to combustion gases) and development of innovative solutions for increasing equitable access to HPWHs and load flexibility programs.

Assessment of innovative financing mechanisms, deployment interventions and behavioral programs that enable accelerated adoption of HPWHs.

Evaluation and adoption of new 120V plug-in models and support for HPWH manufacturer product improvements to address known electrical capacity constraints, installation complexity and costs, facilitate adequate airflow and/or venting, decrease unit size (for space-constrained scenarios), and increase capacity and efficiency.

Barriers

Technical performance of 240V unitary HPWHs is generally well-known due to mature testing and rating systems. With the emergence of 120V plug-in and split HPWHs, performance and suitability of existing testing and rating systems is less known.

Consumers and contractors general default sizing metric of tank capacity is insufficient in comparing gas heaters and HPWHs and especially 120V plug-in models. Industry-wide transitions to first hour rating (FHR) or another metric to account for the lower British thermal unit per hour (BTU/h) ratings of HPWHs will be necessary to ensure similar performance across products.

HPWHs have installation challenges and operational features not found in common gas storage alternatives that can make fuel-switching challenging:

1. Plumbing contractors generally lack expertise in disposal of condensate, adequate airflow, and venting to ensure proper performance of HPWHs.
2. Electrical service upgrades can be a significant cost barrier and may need load management strategies or deployment of 110V/120V products to delay or mitigate the expense of an electric service or panel upgrade.
3. Emergency replacements are the most common scenario for a new water heater installation in existing homes, which creates barriers to conversion to HPWHs from conventional gas water heaters.
4. Permitting processes and a need for a separate electrical contractor adds significant cost increases and delays in hot water restoration for the customer.
5. Market interventions necessary for rental ratepayers to see the benefits of HPWHs.
6. Cost-effectiveness of HPWH conversions can be impacted due to current electrical and gas tariff structure and/or grid integration incentives.

The 2022 Water Heating revisions consisted of four opportunities and two barriers. As this market has expanded and matured there are more specific areas to focus on for opportunities and more barriers have come to light, therefore the SME team has made these several additions. The key changes to this technology family for 2023 include:

2023 Key Changes:

- *Added 120V plug-in HPWHs as a new subgroup.*
- *Added grid-integrated components to the Res Duty technology family*
- *Discussion of whether this tech family is specific to HPWHs or more open to instantaneous / point-of-use (POU)*
- *Clarify/settle on some terminology across entire TPM (e.g., load flexibility/management/shifting)*
- *Added/shifted market development activities (financing, deployment, behavioral) to opportunities*

Focus for new research:

- *Increased evaluation on new 120V plug-ins and alternative retrofit solutions*

- *Phase Change Material (PCM) enhanced HPWHs*
- *Technology and strategies to streamline/enable grid-interactive functionality (SGIP)*
- *Need to delineate between CalNEXT, TECH, and MTA market development actions*

Commercial-duty Water Heaters

(ETP Role: Lead, ETP Priority: High)

Key Factors

Energy Savings Potential: High
Decarbonization Potential: High (increased)
Demand Flexibility Potential: High (increased)
Other Emissions Impacts Potential: Low

Knowledge Index

Technical Performance: Medium (increased)
Market Understanding: Low
Program Intervention: Low

Example Technologies

Central HPWH systems for multi-family, hotel/motel, food service, healthcare, and non-residential buildings; low-GWP refrigerants; dual-fuel water heaters; demand flexibility; grid and utility integration for connected commercial-duty water heaters; financing mechanisms; deployment interventions.

Note: The updates to this subgroup include non-residential buildings; to catch all applications, demand flexibility; grid and utility integration for connected commercial-duty water heaters; as the previous Grid Integration & Market Intervention technology family was removed, financing mechanisms; deployment interventions as these are available on the market now.

Definition

Efficient, demand-flexible electric water heating systems for non-residential applications (such as offices, hotels, healthcare, and food service) and multi-family residential applications (typically ≥5 dwelling units).

Opportunities

Water heating is among the largest footprint end-uses positioned for decarbonization with all-electric HP options, with greater efficiency than electric resistance alternatives and source energy savings over natural gas alternatives. HPWHs are an emerging technology with new products reaching the market such as large water storage capacity hybrid water heaters and large heating capacity low-GWP refrigerant HPs.

HPWH systems present the potential for efficiency and demand flexibility with appropriate system designs that consider storage volume, system configuration options, HP heating capacity, primary heater design, heat exchangers, temperature maintenance systems, controls, and draw patterns. The potential for load shift, shape, and shimmy: demand flexibility on a scale of day to half-hour and GHG reductions resulting from shifting heating to times when the electrical grid has a lower marginal emissions rates and cost to operate. Prospective ET studies may focus on:

1. Improving the efficiency (for operating cost parity with natural gas-fired heaters) and reducing the complexity of all-electric centralized HPWHs.
2. Innovative program designs that can bring benefits of HPWHs to disadvantaged communities.
3. Developing incentive programs for medium and large low-GWP commercial HP in all building categories that use commercial heaters.
4. Demonstration of overseas HP technologies that use new low-GWP refrigerants and other form factors such as low-GWP integrated HPWH or 20 – 30-gallon integrated HPWHs for point-of-use applications.

5. Installed cost and space requirements compression of HPs and storage tanks.
6. Innovative program designs to ensure the multiple value-streams of efficiency, decarbonization, and grid-integration are all actualized.
7. Field assessments of dual-fuel water heating to address the needs of high-load, rapid-recovery applications such as existing commercial kitchens.
8. Demonstration projects that utilize the cold air by-product of air-source HPs to supplementally cool conditioned spaces.
9. Optimizing or eliminating heat exchangers between primary HPWH and secondary DHW loops or storage vessels.
10. Demand flexibility controls demonstration and implementation guidance.

Barriers

Commercial-duty HPWH systems are still in a nascent technological stage that continues to evolve. Physical space, electrical infrastructure, installed costs, and operating costs are some of the biggest limitations that have slowed fuel-switching in retrofit applications. Existing gas-fired hot water systems comprise 85 percent of the installed base of commercial WH. Other limitations include product availability of low-GWP four-season HPs, weight, and noise. Manufacturers and distributors have started to address the barriers of design complexity, installation, and commissioning through the development of factory-built and commissioned skid and packaged systems that can be scaled for a range of applications.

Researchers and design firms have developed better sizing tools to right size HPs for mitigating cost and space requirements in multi-family buildings, but similar tools are needed for the many other commercial HPWH applications. Current health department sizing requirements do not address the use of HPWH systems in commercial kitchens and do not account for storage volume as a factor in sizing water heater capacities. New programs have only begun to scratch the surface of addressing barriers to adopting commercial HPWHs.

Barriers to be addressed include:

1. Lack of diverse heat pump products such as 120 – 200-gallon 120V HP commercial integrated HPWHs
2. Lack of field performance data of various designs, configurations, and applications (including system reliability and cost-effectiveness).
3. Lack of easy to access case studies that span the diversity of buildings with commercial HPs (120V integrated, 240V hybrid integrated, and indirect central HPs and combined with complementing strategies including POU heaters, heat recovery, master mixing valves).
4. Lack of statewide incentive programs for medium and large commercial HPWHs for businesses.
5. Lack of design tools to select and appropriately size HPWHs outside of multifamily applications.
6. Minimal documentation and empirically determined hot water load profiles for various non-residential building types, important for developing sizing tools, design guidance, and regulatory updates.

7. Ways to streamline electrical panel upgrades to support HPWHs or using alternative technologies to minimize or eliminate the need for upgrades.
8. Lack of HPWH familiarity for building permitting authorities (and health departments).
9. Lack of coordination between trades (e.g., electrical and plumbing).
10. Lack of sector-specific knowledge in implementing HPWHs in disadvantaged communities (multi-family housing).
11. Changes in the tariff structure and/or grid integration incentives to mitigate cost-effectiveness concerns.
12. Lack of code readiness activities to support electric ready code requirements for all non-residential building types that utilize commercial water heaters.
13. Lack of demonstration, guidance, and simplified implementation procedures of dependable demand flexibility and load shifting controls.

Note: The 2022 Water Heating revisions consisted of two numbered opportunities and five barriers. As this market has expanded and matured there are more specific areas to focus on for opportunities such as improving the efficiency (for operating cost parity with natural gas-fired heaters) and more barriers have come to light, including lack of diverse heat pumps products, lack of field performance data, among many other barriers listed above, therefore the SME team has made these several additions. The key changes to this technology family for 2023 include:

2023 Key Changes:

- *Added 120V plug-in integrated HPWHs as a new subgroup for small buildings (retail, salon, etc.)*
- *Added grid-integrated components to the Commercial Water Heating*
- *Discussion of whether this tech family is specific to HPWHs or more open to point-of-use (POU) heaters at sinks and integrated heat recovery/ER POU heating for sanitation equipment to size down or eliminate need for centralized heaters or continuous recirculation*

Focus for new research:

- *Case studies that span the diversity of building with commercial heaters and combination space conditioning and water heating systems*
- *120-to-200-gallon 120V and 240V integrated HPWHs without backup ER*
- *Cost compression for low-GWP HPs and storage tanks (non-pressurized storage tanks, reducing complexity, increase scale)*
- *Small volume 20-to-30-gallon HPWHs (e.g., office buildings) for POU sink and shower applications as alternative to centralized heating*

- *Footprint compression for storage tanks and HPs with optimized heating plant configurations, auto switching from single pass to multi pass operation HPs, and PCM material in tanks*
- *Statewide incentive programs for commercial HPs (not hybrid heaters) for businesses*
- *Code readiness activities to support electric ready code requirements for all commercial and industrial building types that utilize commercial heaters*

Alternative Design Strategies

(ETP: Lead, ETP Priority: Medium)

Key Factors

Energy Savings Potential: High
Decarbonization Potential: Medium
Demand Flexibility Potential: High (increased)
Other Emissions Impacts Potential: Low

Knowledge Index

Technical Performance: Low
Market Understanding: Low
Program Intervention: Low

Example Technologies

Recirculation systems; heat recovery systems; master mixing valves; thermal energy storage, residential, commercial, and community-scale solar and geothermal water heaters.

Definition

Distribution system and point-of-use design strategies and alternative heat sources to advance energy efficiency, water conservation, and GHG benefits.

Opportunities

Opportunities in this technology family will increase energy efficiency and demand flexibility through well designed hot water recirculation and heat recovery systems and the use of thermal energy storage systems and master mixing valves. Prospective ET studies should include software solutions, design guides, or field monitoring studies with these auxiliary components that address:

1. Bringing clarity to designers for cost-effective scenarios for drain water heat recovery.
2. Incorporating integrated exhaust air or refrigerant heat recovery systems at the water heater or point-of-use equipment location.
3. Novel recirculation and load-matching control strategies such as automatic balancing valves, combined optimization of temperature modulation, variable speed pumps with integrated constant return temperature control or occupancy-based pump controls and distributed isolating valves.
4. Incorporating high-performance master mixing valves to increase thermal storage capacity and utilization, increase tank water temperature stratification with continuous recirculation systems and reduce recirculation loop heat losses through precise temperature control.
5. Improving system efficiency through clustered centralized systems that reduce pipe heat losses and improve water heater efficiency versus one large, centralized water heating and distribution system
6. Enhancing energy density and load matching of solar thermal and photovoltaic (PV)-assisted water heater designs.
7. Increasing thermal energy storage density from the use of phase change materials for increasing renewable energy penetration and load flexibility.
8. Development of alternative techniques to mitigate legionella risk, enabling additional use cases for HPWH systems.

Barriers

Alternative hot water design strategies are an important approach to decarbonize many “hard-to-electrify” water heating scenarios. Recirculation systems, although important to improve hot water delivery time and minimize water waste, can heavily impact HPWH performance in central multi-family and commercial buildings. ET investments in this technology family can help bring greater awareness and highlight alternative decarbonization pathways.

Potential barriers studies should address:

1. Lack of trusted software tools and design guides to simplify large HPWH system.
2. Lack of trusted software tools and design guides to simplify solar hot water system designs.
3. Lack of consistency among code requirements related to hot water setpoint temperatures.
4. Lack of experience deploying drain water heat recovery, particularly with the variety of potential heat sources.
5. Lack of experienced practitioners in alternative strategies.
6. Potential degradation of energy efficiency with improperly designed, installed, and maintained designed recirculation systems for large HPWHs.

Note: As ideas have been brought to market, new ideas have been formed resulting in an increased number of opportunities and barriers identified. It has also been seen that recirculating systems can be designed and installed, poorly resulting in increased heat loss through the large amount of surface area or stratification in tanks. The key changes to this technology family for 2023 include:

2023 Key Changes:

- *Technologies in this category such as drain water heat recovery led to increased energy efficiency*
- *Barriers in HPWH adoption due to decrease in energy efficiency from recirculation*

Focus for new research:

- *Drain water heat recovery*
- *Advanced/Smart recirculation systems*
- *Solar thermal and PV-assisted systems*
- *Improved mixing valves and auxiliary devices for increased utilization of TES*

Pool Heaters and Residential Pool Pumps

(ETP: Lead, ETP Priority: Medium)

Key Factors

Energy Savings Potential: Medium
Decarbonization Potential: High
Demand Flexibility Potential: Medium
Other Emissions Impacts Potential: Low

Knowledge Index

Technical Performance: High
Market Understanding: High
Program Intervention: Low

Note: This family is eligible for a Focused Pilot TPM project. This family was added to avoid a scenario where a new home has a gas line only for the pool heaters. The local reach codes program had heard that concern, which lead to the development of a cost effectiveness report comparing gas-fired pool heating to heat pump pool heaters and solar, which allows local jurisdictions to develop cost effective reach codes. *https://localenergycodes.com/download/1630/file_path/fieldList/2022%20Heat%20Pump%20Pool%20Heating%20Cost-Eff%20Report.pdf*

T24 2025 has a proposed measure to disallow gas-fired pool heating to be the primary source of heat. *https://title24stakeholders.com/measures/cycle-2025/swimming-pool-and-spa-heating/*

With these two efforts the program team felt it was appropriate to support the transition away from gas-fired pool heating.

The smaller group that developed the language for this new family rated the priority as high, but after discussing this with the larger group, it was agreed that the priority could be reduced to medium as pools are a luxury item, so not in every home, but still a large gas user and important for decarbonization.

Example Technologies

Residential and commercial electric pool heater equipment, HPPH, solar assisted HPPH, pool automation systems for pool pumps, and pool covers.

Definition

Electric pool heaters for residential and non-residential pool markets; pool pumps and pool controls designed for the residential and non-residential pool market to increase efficiency, performance, and enable load shifting; and alternative strategies for pool heating and maintenance. The technology family will help support the development of all-electric codes and ease pool heating loads to improve grid resiliency.

Opportunities

Opportunities in this technology family will increase efficiency with optimized equipment and designs, including optimized electrification of pool heating loads, pool operation controls and the incorporation of load shifting of electric pool loads. Prospective ET studies should include controls solutions, design guides, or demonstrations that address:

1. Projects that demonstrate the emergence of new technical innovations, such as smart controls, variable speed, hybrid units, low-temperature operability, and staggered start-up capability with HPPHs.
2. Projects that demonstrate electrification of pool heating loads as part of home electrification service assistance. Projects may include those that have homes with photovoltaic solar or plans for PV to be installed soon.
3. Projects that encourage HPPH or solar-assisted HPPH adoption in new home construction or newly constructed pools.
4. Innovative pool cover projects that encourage the consistent use of pool covers to enable wider adoption of HPPH. Project could include novel methods to reduce the installation and maintenance costs of automated pool covers.
5. Innovative projects to address electrical system requirements when the existing pool heater uses natural gas.
6. Innovative applications of HPPH to provide heating to inground spas. Projects that demonstrate the utility of hybrid HPPH to provide spontaneous heating.
7. Innovative projects to demonstrate ability of electrical system to accommodate startup surges due to HPPH compressor operations. Accommodation of other emergent loads on the home electrical system such as heat pump and electric car charging.
8. Projects that demonstrate the load shifting potential for both pool heating and pumping in coordination with proposed flexible demand appliance regulations by the CEC.

Barriers

HPPH installation face opposition where high electric rates discourage adoption of electric heating.

HPPHs lose heating capacity as temperatures decrease. While not a concern for spring, summer, and fall heating seasons, many climate zones within California present challenges to economical heating from HPPHs during the winter months due to increased heating load and decreased heating capacity.

Alternative hot water design strategies are an important approach to decarbonize many “hard-to-electrify” water heating scenarios. ET investments in this technology family can help bring greater awareness and highlight alternative decarbonization pathways.

Potential barriers studies should address:

1. Inconsistent design software
2. Ongoing practice to oversize heaters and pumps
3. Learning curve on pool heating operation with a HPPH versus a gas-fired pool heater regarding set back temperatures.
4. Limitations based on health code requirements
5. Roof space for solar thermal competing with PV

Next Steps

Following submittal of the 2023 Water Heating TPM Final Report, the Program Team will do the following:

- Update CalNEXT website with new 2023 Water Heating TPM.
- Launch email announcement through email outreach.
- Develop and submit 2023 Water Heating TPM Distribution Report.

Appendix A: Advisory Committee Feedback & Resolution Matrix

Table 2: Stakeholder Feedback & Resolution Matrix

Technology Family	Section	Suggestion or Comment	Action Taken & Justification
All	Key Factor & Knowledge Index	Request indication on how ratings changed vs. prior year	Noted as increased or decreased throughout the document.
All	Subgroups, Definition, Opportunities & Barriers	In the proceeding sections, is it possible for the report to give some kind of narrative to emphasize/explain the changes to the TPM structure and revised language? Trying to get a feel for what exactly changed since the last TPM. Would be good to be transparent about tracking the thinking in future TPM revisions as well.	Accepted, the technology family write-ups now include a narrative to emphasize/explain the changes to the TPM structure and revised language in the key factors, knowledge indices, subgroups, opportunities, and barriers sections.
All	Opportunities & Barriers	Did you cover refrigerants in HPWH? Current, upcoming, what will change in the next few years.	We have looked at some projects under this TPM. Leakage is a greater concern, but a significant amount of thought happens in HVAC. We are looking at new avoided cost calculation for CA EE programs in TSB, which includes GWP and refrigeration.
All	Opportunities & Barriers	Quick narrative behind why/how the language changed for Opportunities and	Accepted, it is broadly explained throughout each technology family

Technology Family	Section	Suggestion or Comment	Action Taken & Justification
		Barriers? New numbered items, new intel?	narrative that, as each market has expanded and matured there are more specific areas to focus on for opportunities and more barriers have come to light, therefore the SME team has made the several additions to the appropriate section. Further detail has been added to these technology families as well.
All	Opportunities & Barriers	Was low-GWP progress considered? There are difficulties getting manufacturer support here. SGIP WH Program has strong HPWH incentives, difficult and expensive to incorporate products, have been trying and not achieving to move the needle with manufacturers. Study to identify specific barriers from manufacturers needed. Confluence between grid integration and low-GWP refrigeration.	Low-GWP was not considered during this revision. The SME team acknowledges the importance and plans to consider this further throughout the next revision cycle.
Commercial-Duty Water Heaters	Key Factor & Knowledge Index	Explain increase from "medium and low?"	There is a better understanding now in Decarbonization and Demand Flexibility, there are more potential opportunities to shift load in a commercial or

Technology Family	Section	Suggestion or Comment	Action Taken & Justification
			multi-family setting. With a relatively significant amount of recent CHPWH projects moving forward in CA and the Northwest, the SME team believes that we can ratchet up at least the Technical Performance to Medium.
Commercial-Duty Water Heaters	Subgroups	No Lab assessment opportunities?	There is some lab testing at available transfer capability (ATS) to improve Title 24 the California Building Energy Code (CBECC) compliance software. There have also been many field studies conducted. The high cost of electricity vs. gas continues to be a barrier.
Grid Integration & Market Intervention	Narrative	Narrative for removing previous "Grid Integration & Market Intervention" section?	This section was removed as any applicable project could also apply to the residential-duty or commercial-duty technology families. The original intent of the section was to highlight the need; it was decided to

Technology Family	Section	Suggestion or Comment	Action Taken & Justification
			achieve that by adding language to all other sections. If this section were to be retained, it would need to be fully updated to include pool pumps and pool heaters. In the future, this topic could be further highlighted in the process loads or whole buildings TPMs.
Alternative Design Strategies	Opportunities & Barriers	Does this also apply to the Commercial Duty section? For this and other sections, are there any other barriers identified about degradation in in-field efficiency from other sources? Improper install/maintenance?	The SME team sees this importance and believes it applies to both areas but is more crucial to commercial, however still important, especially as we look at 120V HPWHs as an important alternative option. To the second part of this comment, we have edited the barrier to state, "improperly designed, installed and maintained," but it is specific to the recirc systems, as the SME team believes the design is likely the most important element

Technology Family	Section	Suggestion or Comment	Action Taken & Justification
			here. This barrier refers to hot water recirculation. Although it is likely that hot water recirculation systems are commonly used for commercial systems, they can very well be applied to residential systems especially if the domestic hot water is being provided over a large floor area. This particular barrier corresponds specifically to the "design" of the recirculation systems which degrades HPWH efficiency.
Alternative Design Strategies	Key Factor & Knowledge Index	Explain the increase from "medium?"	As the number of alternative designs for water heating has increased, many of those new designs include the potential for demand flexibility, and there is a clearer market need compared to one year ago.
Pool Heaters and Residential Pool Pumps	Key Factor & Knowledge Index	What are the gaps in our market knowledge?	There are minimal gaps in the understanding of these products, which is why market

Technology Family	Section	Suggestion or Comment	Action Taken & Justification
			understanding is ranked high. There is a lack of programs for this technology, likely because it is just gaining popularity.