Light-Duty Commercial Heat Pump Water Heater Focused Pilot

Final Report

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Executive Summary

The primary objective of the Light-Duty Commercial Heat Pump Water Heater Focused Pilot is to identify and address barriers to greater adoption of light-duty heat pump water heaters in California's commercial buildings. The pilot targeted five barriers to heat pump water heater adoption in commercial buildings:

- Lack of customer and contractor familiarity with heat pump water heaters.
  1. Existing water heating program eligibility limitations.
  2. Electrical capacity requirements associated with the installation of heat pump water heaters.
  3. Lack of participation in existing heat pump water heater programs.
- Limited understanding of the businesses and buildings best suited for commercial heat pump water heaters.

The project team hypothesized that improved contractor and customer familiarity with heat pump water heaters will increase commercial customers' willingness to undertake a heat pump water heater conversion and overcome the barriers listed above.

Key findings of the pilot include:

- The greatest barrier to adoption of light-duty heat pump water heaters in commercial buildings identified through this pilot is cost. Higher heat pump water heater installation costs are primarily driven by the diversity of buildings, the relative installation complexity, and existing building and water heater conditions.
- Additional barriers associated with costs include limited capital budgets for commercial building owners, renters, and property managers, as well as the potential increase in energy costs when shifting from natural gas to electricity.
- Commercial buildings require an increased focus on matching heat pump water heater capacity to meet a diverse set of hot water needs, especially in high-demand or recirculation applications. Limitations of heat pump water heaters relative to existing natural gas systems in high-demand applications, existing distribution inefficiencies, and lack of customer familiarity with the technology all serve as barriers to scaling adoption.
- Current water heating rebate eligibility and amounts favor gas-to-heat pump water heater conversions, which manufacturers indicated during interviews are a greater challenge than electric-to-heat pump water heater conversions.
- Demographic analysis established that the key building typologies with the most immediate opportunity for heat pump water heater adoption in the state are small offices (71,000 sites) and warehouses (74,000 sites).
- Generally, commercial end users have other priorities that are more important to their operations than electrifying their buildings, and few have a person or team dedicated to working on electrification projects.
- Measure packages should be updated to allow for lower rated Uniform Energy Factor requirements to include 120-volt heat pump water heaters that are gaining popularity within the market. Updates should also include larger tank size changes for gas-to-heat pump water heater conversions to account for performance differences.

Abbreviations and Acronyms

Acronym	Meaning
AHRI	Air-Conditioning, Heating, and Refrigeration Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
CBECS	Commercial Building Energy Consumption Survey
eTRM	electronic Technical Reference Manual
FHR	First-hour rating
HPWH	Heat pump water heater
IOU	Investor-owned utility
IRA	Inflation Reduction Act
TE	Thermal efficiency
TECH	Technology and Equipment for Clean Heating
TRM	Technical Reference Manual
UEF	Uniform Energy Factor

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Introduction

Heat pump water heaters (HPWHs) are an energy-efficient, reliable source of hot water for households and businesses, with the added benefits of reducing carbon emissions and dehumidification. However, despite available incentives from existing investor-owned utility (IOU) efficiency programs, the Technology and Equipment for Clean Heating Program, (TECH Clean California), and the Inflation Reduction Act (IRA), commercial uptake of HPWH installations must dramatically increase to decarbonize the existing commercial building stock and meet California's ambitious carbon neutrality goals set forth by Senate Bill (SB) 1477. There are obstacles that prevent the market from adopting these heat pump water heaters; this pilot aims to address those obstacles in commercial settings.

Through the Light-Duty Commercial HPWH Focused Pilot, the project team sought to explore potential solutions to the barriers to commercial HPWH adoption. The pilot targeted five significant barriers identified by the Technology Priority Map (TPM) to assess if the piloted solutions would increase adoption of HPWHs in commercial sites. These barriers are:

- Lack of customer and contractor familiarity with HPWHs in a commercial setting
- Existing water heating program eligibility limitations
- Electrical capacity requirements associated with the installation of HPWHs
- Lack of participation in existing energy efficiency programs
- Limited understanding of customers best suited for commercial HPWHs

The team hypothesized that improved contractor and customer familiarity with HPWHs would increase commercial customers' willingness to undertake an HPWH conversion and to overcome the barriers to the adoption of this new technology. The Focused Pilot offered targeted customers a no-cost light-duty HPWH as a demonstration to encourage these commercial sites to adopt new technology and give contractors experience installing HPWHs in a commercial setting. When necessary, the project team connected the commercial site with a contractor in network to get the equipment installed. The pilot developed marketing materials on HPWH installations to inform contractors of commercial customers best suited for HPWHs. This project provides program implementers with findings and recommendations to inform new and existing HPWH programs about approaches to cost-effectively increase participation and reduce barriers for commercial sites.

Background

The term "light-duty commercial HPWH" describes a unitary or split HPWH, such as those used in many single-family and multifamily residences and in small- to medium-sized commercial settings. For our initial research and analysis, we focused on commercially available 65-, 80-, and 120-gallon HPWHs. The primary comparative metric for commercial applications is the first-hour rating and recovery rate. There is significant disparity between the recovery rate of light-duty commercial HPWHs and that of larger commercial HPWHs and smaller gas water heaters. The diversity of hot water end uses and building types—food service, retail, schools, offices, and others—requires an increased understanding of the capability of HPWHs to not only meet short-term, one-hour needs, but also potentially more continuous, sustained water demands found in certain applications. Longer two-hour demand and gallons per day (GPD) delivery can be calculated from the recovery rate and storage volume of the unit. These measurements serve as reliable performance metrics to determine the viability of specific unitary HPWH models for installation in a broad spectrum of small- to medium-sized commercial business types.

To understand the relevant performance of water heaters, the team assessed various operational performance metrics for conventional water heaters and HPWHs based on fuel type, including gas and electric, as well as product designs, including storage, tankless, and integrated and split HPWH solutions. In general, gas water heaters have higher recovery rates, which permit smaller tank sizes or tankless or instantaneous models, allowing for faster heating and supporting high continuous hot water demand applications. While electric water heaters often have lower recovery rates, they can offer higher efficiency, especially in the case of HPWH models. Storage water heaters are rated based on their tank size and recovery rate. In contrast, tankless water heaters provide hot water on demand without storing it and are rated by their flow rate and temperature rise.

Single-family and multifamily residences are target customer segments for market transformation initiatives and incentive programs, including California Statewide Water Heating and TECH Clean California. This pilot evaluated the best practices developed and barriers identified through residential HPWH installations to better support commercial building installations, as well as to assess intervention and leverage points for commercial customers. The project team's analysis of the 2018 Commercial Building Energy Consumption Survey (CBECS) suggests that commercial segments—including retail, education, and office—are likely to see cost and energy savings from HPWH retrofits.

Related Research: CalNEXT Small Medium Business HPWH Emergency Deployments (ET24SWE0017)

The goals of this field study were to assess and validate the applicability of plug-in, 120-volt (120V), residential HPWHs in small- to medium-sized businesses. This involved evaluating small- to medium-sized business' hot water demand and draw profiles, aligning business needs with the HPWH capabilities, and validating the plug-in technology for emergency replacements.

Fuel switching from gas to heat pump water heating often triggers expensive and time-consuming electrical upgrades, including panel upgrades and rewiring to accommodate a new 240V appliance. Such upgrades can add thousands of dollars to retrofit costs, and the time and expense required pose significant barriers to fuel switching, especially when a customer is seeking an emergency water heater replacement. The plug-in 120V HPWH technology used in this field study could be plugged into existing wall outlets and did not require expensive electrical upgrades. The project lead partnered with two contracting companies that have successfully installed 120V HPWHs for emergency replacements in residential applications. The contractors identified viable sites and business types and plan to install up to 10 plug-in HPWHs in small- to medium-sized business applications. The project team collected installation cost data and conducted surveys on customer and installer satisfaction with the new equipment.

This field study has the potential to build credibility and showcase the financial benefits of 120V plug-in HPWHs in the small- to medium-sized business market. Lessons learned from this project can advance market adoption of this solution and provide important data for program and measure development.

Overview of Existing Water Heater Programs

TECH Clean California

Since October 31, 2023, TECH Clean California has offered HPWH installation incentives for nonresidential customers. There are two types of projects eligible for these incentives: small business unitary and large commercial unitary. For small business unitary, the projects applying for the incentive are limited to the residential-style HPWH models and follow the same rules and process as a single-family residential project. The incentive is $3,100 per unit with a low-global warming potential (GWP) bonus of $1,500 per unit. There is no maximum incentive for small business unitary projects under this program.

The following is a list of program eligibility criteria:

- Eligible sites include any nonresidential, non-multifamily facility with electric service from Pacific Gas and Electric Company (PG&E), Southern California Edison (SCE), San Diego Gas & Electric (SDG&E), or Sacramento Municipal Utility District (SMUD)
- Installed HPWHs may only serve the hot water needs of one business or entity.
- Incentives are only available to TECH Clean California-enrolled contractors.
- Eligible products must meet the minimum performance and demand response technology requirements and be listed on the TECH Clean California HPWH single-family qualified product list (QPL).[1]

These requirements present a point of confusion for potential applicants, as the documents associated with this incentive often refer to “single-family” requirements. In addition, this incentive can be complicated for small businesses and buildings due to the requirements for opting into a time-of-use rate. The program requirements include initiating demand response enrollment, which shifts HPWH operation away from utility peak hours. Certain business operations, such as food service, where there are significant continuous hot water needs, may be negatively impacted by these requirements and limited in their ability to participate.

Statewide Midstream Program

The Statewide Midstream Program offers business owners, contractors, and distributors an opportunity access commercial water heating incentives. Building managers can purchase the equipment at a reduced price, contractors can build lower-cost equipment into their bids, and distributors can receive incentives and program support for offering rebates to eligible commercial customers. Eligibility for this program depends on whether the customer is a commercial customer of SoCalGas, PG&E, SCE, or SDG&E and in an eligible region. There are program incentives available for high-efficiency gas and electric water heating equipment. Table 1 lists qualifying HPWH measures and associated maximum and minimum incentives.

[1] List accessed on August 21, 2025. https://frontierenergy-tech.my.salesforce.com/sfc/p/#5f000003GyZS/a/R000000059ib/_Y18CL9kmNgNcqh2MtyLFMN3tZTx6O5mT4yh1yhjkBk

Table 1: Statewide Midstream Water Heating Program–qualifying equipment types.

Category Name	Measure	Incentive per Equipment
Electric HPWH	45- to 55-gallon electric HPWHs — 3.30, 3.50, and 3.75 UEF	$1,082.88–$1,142.10
Electric HPWH	>55- to 75-gallon electric HPWHs — 3.30, 3.50 and 3.75 UEF	$424.34–$721.92
Electric HPWH	>75-gallon electric HPWHs — 3.30, 3.50, and 3.75 UEF	$392.98–$838.48
Fuel switch HPWH	45- to 55-gallon electric HPWHs — 3.30, 3.50, and 3.75 UEF	$994.56–$1,306.60
Fuel switch HPWH	>55- to 75-gallon electric HPWHs — 3.30, 3.50, and 3.75 UEF	$1,424.92–$1,681.66
Fuel switch HPWH	>75-gallon electric HPWHs — 3.30, 3.50, and 3.75 UEF	$688.94–$1,122.36
Split system HPWH	Split system HPWHs (Multifamily, COP 3.0)	$91.20/kBtu/h output capacity
Split system HPWH	Split system HPWHs (Commercial Building Types, UEF 3.0)	$29.40/kBtu/h output capacity
Split system HPWH	Split system HPWHs (Commercial Building Types, COP 4.3)	$91.20/kBtu/h output capacity

Note: COP: Coefficient of Performance.

An analysis of California Energy Data and Reporting System (CEDARS) data shows that very few HPWHs have been incentivized through this program. This could be due to competition with gas water heaters that are also incentivized through the program. Gas water heater incentives range from $220.50 to $2,256.00. Given HPWH installation may come with needed electric panel upgrades, the first cost for a gas water heater is often cheaper than switching to an HPWH. The measures in this program exclude 120V units due to UEF requirements and tank size limits, which prevent part of the market from participating.

Government and K-12 Energy Efficiency Program

The PG&E Government and K-12 Energy Efficiency Program (G12) offers incentives, financing, and technical services at low or no cost, with the goal of lowering or eliminating installation costs. There are over 200 technology options in the program, including boilers, ventilation, fan controls, and HPWHs. Local government, K-12 school facilities, federal buildings of all sizes, and county education offices are eligible to participate.

Eligibility for this program spans beyond building type, and also includes:

- Having an active PG&E electric and/or natural gas account
- Not applying for more than one California energy efficiency incentive or rebate program for the same upgrade
- Paying the Public Purpose Program surcharge on the account where the energy efficiency equipment is to be installed

Southern California Edison Commercial Energy Efficiency Program

The SCE Commercial Energy Efficiency Program (CEEP) is administered by Willdan and serves non-residential account customers located in the SCE service territory. CEEP provides rebates for a limited range of energy efficiency measures, including 80- and 120-gallon HPWHs, anti-sweat heater controls for grocery freezers, glass doors, and light emitting diode (LED) lighting for open vertical refrigerated grocery cases. Qualifying business types eligible to participate in the program include hotels, grocery stores, places of worship, nursing homes, fitness centers, large retail stores, convention centers, refrigerated warehouses, hospitals, and theaters and cinemas.

Both customers and contractors execute agreements with the program to participate, and rebates flow to the contractor for an approved project after Willdan receives required pre- and post-installation documentation. Rebates for HPWHs are relatively large at up to $10,000 per unit for 80-gallon HPWHs and up to $25,000 per unit for 120-gallon HPWHs, but incentivized HPWHs must replace a gas-fired unit.

Additional findings from the Willdan program are included below in the Market Characterization section.

Summary of Programs

Water heating incentive programs cover an array of technologies and geographies and incentivize the switch to HPWHs for commercial entities. However, current water heating rebate eligibility and amounts favor gas-to-HPWH conversion, which manufacturers indicated during interviews is more challenging than electric-to-HPWH conversions due to both cost and other installation complications. As seen above, there are a few incentive pathways for commercial HPWH installations, all with different incentives and requirements, which adds confusion for contractors and distributors trying to participate in the existing programs.

Market Research for HPWH Adoption

Barriers to HPWH Adoption

Many field studies and related reports address barriers to HPWH adoption. These documents cover different HPWH technologies and building types, including commercial, but many barriers cut across these differences. Common barriers to HPWH adoption include higher upfront costs, lack of awareness, limited installer experience, the need for electrical upgrades, and difficult installation logistics, as detailed below.

HIGHER UPFRONT COSTS

In a recent study on the water heating market in California, installers reported that one of the primary barriers to customer adoption of HPWHs is the higher upfront cost of HPWH equipment. Other market research reports have reached similar conclusions about the challenge of overcoming higher upfront equipment costs for HPWH installations in commercial buildings.

Factors beyond equipment costs can contribute to higher upfront costs for HPWHs. Many contractors are unfamiliar with HPWH technology, which may cause them to overestimate the time needed for installation, overdesign or oversize systems, and increase contingency costs due to the perception of HPWHs as a newer, riskier technology. These factors can lead to increased upfront costs for HPWH systems, as can electrical upgrades that may be required to install an HPWH system (see Electrical Upgrades below for more).

Incentives for HPWHs, like those offered in California, can help mitigate higher upfront costs. The increased efficiency of HPWHs often results in lower operating costs, which can also help convince consumers to opt for an HPWH system. However, even with these mitigating factors, high upfront costs are challenging for many consumers to overcome. This can be especially true for smaller commercial consumers with low overall water usage and, therefore, less opportunity for savings in operating costs.

LOW BUILDING OWNER AWARENESS

Lack of awareness from consumers about HPWH technology and its benefits is another barrier to adoption. A market study of water heating in commercial buildings prepared for the Northwest Energy Efficiency Alliance (NEEA) found that decision-makers for water heating purchases are generally unaware of the benefits of HPWHs for commercial applications. The study also reported a perception of limited marketing for HPWHs compared to traditional water heating systems, which may contribute to lower awareness. However, even when awareness of increased efficiency and longer-term cost savings are present, high upfront costs and a larger equipment footprint can dissuade commercial building decision-makers from choosing HPWH (see Installation Logistics, Including Space Constraints section below).

LIMITED INSTALLER EDUCATION AND EXPERIENCE

A barrier related to low consumer awareness is limited installer experience with HPWH technology, which manifests in several ways. HPWH adoption is still a relatively new trend. A study of the California water heating market found that many installers—roughly one-third of those surveyed—do not install any HPWHs, and a large portion of those that do only began installing HPWHs within the last few years. Installers may be less likely to recommend a product to a customer if they are not as familiar with it, especially if installers are not confident in the ability of HPWHs to meet the varying needs of different commercial hot water end uses.

HPWH installations can require both electrical and plumbing expertise. Electrical expertise is essential to assess whether the power for an HPWH can safely be provided by an existing circuit. Studies indicate that installers in many cases may be lacking electrical confidence. Nearly one-quarter of water heating installers surveyed by Opinion Dynamics in California reported needing training on “electrical concepts like currents, amps, and voltage,” while an additional 12 percent desired training on circuit breakers.

ELECTRICAL UPGRADES

Many homes and businesses have limited electrical panel space and require electrical upgrades before an HPWH can replace an existing water heater. Electrical upgrades add cost, time, and complexity to an HPWH installation, which can accumulate as increasingly difficult barriers to overcome.

A 120V HPWH, which plugs into a standard wall outlet and uses less power than a 240V HPWH, can be a viable option to avoid electrical upgrades. In some cases, there may not be an outlet close enough to use. Field testing by the Electric Power Research Institute (EPRI) has demonstrated that HPWHs can be an appropriate solution in some smaller commercial settings, especially those with low water usage. However, the lower power requirements of 120V HPWHs come with a tradeoff of slower recovery rates, so they may not be a viable solution for some commercial buildings with higher water usage.

INSTALLATION LOGISTICS, INCLUDING SPACE CONSTRAINTS

Space constraints are a common and challenging barrier to overcome in all HPWH installations, and especially in smaller commercial buildings. HPWHs are larger than typical water heaters and may be too large for many sites. In a field study of 120V residential HPWH installations in California, space constraints were cited as the most common reason that sites were rejected for inclusion in the study. HPWHs also need adequate air volume and airflow to function efficiently, which can be challenging to accommodate in commercial buildings.

The barriers identified from prior studies closely align with and inform the primary challenges the team aimed to address during this pilot.

- There is a significant lack of familiarity among customers and contractors with HPWHs. This unfamiliarity can lead to hesitation in adopting this technology, as both groups may be unaware of the benefits and proper installation procedures.
- Existing water heating program eligibility limitations pose challenges. Many current programs have strict criteria that may exclude potential HPWH users, thereby limiting the adoption of this energy-efficient technology. Another critical barrier is the electrical capacity requirements associated with the installation of HPWHs.
- Participation in energy efficiency programs is lacking. This low engagement could be due to various factors, including insufficient awareness of the program or perceived complexity in participation.
- There is a limited understanding of the customers best suited for commercial HPWHs. Identifying and targeting the right customer segments is crucial for successfully deploying HPWHs. However, this requires detailed market analysis and customer profiling, which is a major part of what the engineering analysis and market characterization for this pilot sought to accomplish.

ADDRESSING PRIMARY BARRIERS TO HPWH INSTALLATIONS

Addressing these barriers is essential for successfully implementing the pilot project and the accelerating the broader adoption of HPWHs in commercial settings. By focusing on these challenges, we can develop strategies to overcome them and promote the benefits of HPWH technology.

A number of other field studies have examined the performance of HPWHs in residential settings. Barriers to HPWH installation identified in those reports that translate to small commercial installations have been included in the Barriers to HPWH Adoption section above.

Barriers to proactive HPWH installations by customers have been documented through multiple California evaluations, as well as nationally. Below, Table 2 lists the primary barriers identified by the TPM and the project team to guide targeted incentives and customer support strategies.

Table 2: Primary barriers to HPWH installations.

Barrier	Barrier Description
Lack of customer and contractor familiarity with HPWHs	Lack of customer awareness of HPWHs and their functionality can heighten the risk and effort required by contractors to support conversions.
Existing water heating program eligibility limitations	Water heating programs have capacity-change restrictions and efficiency criteria that limit the number of eligible installations through the program.
Electrical capacity requirements associated with the installation of HPWHs	Electrical upgrades required for an HPWH fuel substitution often cause complications in timing for an appliance that customers do not feel they can work without.
Limited understanding of customers best suited for commercial HPWHs	Unfamiliarity with areas to target for conversion leads to discouragement or hesitation from contractors to sell and install HPWHs in commercial settings.

Baseline Studies

Field and market studies have demonstrated the viability of HPWH technology and outlined lessons learned in a variety of settings. However, few of these studies have focused specifically on HPWH technology in smaller commercial buildings.

A field study of 120V HPWH installations in two light commercial applications in Southern California found that units performed well under limited circumstances. 120V HPWHs with 50-gallon tanks were installed at a hardware store and an auto tech shop, replacing the existing electrical water heaters: one 40-gallon resistance hot water heater and one floor-mounted on-demand electric water heater. Importantly, the daily hot water consumption at both sites was low, rarely exceeding 25 gallons. Over seven months, the HPWH units met all hot water needs at the sites with no complaints or issues from users about hot water availability. While the HPWH units demonstrated increased energy efficiency compared to the previously installed water heaters, the low water usage at both sites makes meaningful cost savings unlikely.

Ecotope prepared a market characterization study of centralized HPWHs in 2022 for NEEA, which assessed the potential for HPWH use in different commercial applications, including food service, grocery, and lodging. Restaurant and grocery sectors were identified as good candidates for deployment of unitary heat pump equipment due to several factors:

- HPWHs provide cooling in warm kitchen environments, leading to highly efficient HPWH operation.
- Many restaurant spaces lack viable options for gas venting.

Restaurants do, however, present some challenges to HPWH conversion, including:

- High demand for water heating loads
- Space constraints for equipment deployment
- Lower tolerance for compressor noise

The study concluded that HPWH suitability will often depend more on individual building characteristics than generalized building types.

Another field study of 120V HPWH installations is California concluded that small commercial buildings with existing water heaters under 80 gallons could be good candidates for HPWH installations. Two building types in particular—small office and retail buildings—were identified as strong fits for residential HPWH units due to limited hot water demand.

Overall, the low number of baseline studies addressing HPWHs in smaller commercial applications highlights the value of this pilot in helping to fill that information gap. Through this pilot, we evaluated how the relationship between building owners and tenants impacts the suitability of HPWHs in smaller commercial applications. For example, multiple tenants may cycle through a particular commercial building space over a given period of time, each of whom could have different hot water use patterns and needs. This creates an extra layer of complexity in assessing the suitability of HPWHs for a given site and could create barriers to successful HPWH installations.

Measure Package Review

Table 3: Measure case specification for SWWH031-05 and SWWH027-06.

Equipment Type	Storage Capacity (gal)	UEF
HPWH	> 45 to ≤ 55	3.30
HPWH	> 45 to ≤ 55	3.50
HPWH	> 45 to ≤ 55	3.75
HPWH	> 55 to ≤ 75	3.30

Equipment Type	Storage Capacity (gal)	UEF
HPWH	> 55 to ≤ 75	3.50
HPWH	> 55 to ≤ 75	3.75
HPWH	> 75	3.30
HPWH	> 75	3.50
HPWH	> 75	3.75

SWWH031-05: Heat Pump Water Heater, Commercial

The base case in the SWWH031-05: Heat Pump Water Heater, Commercial measure package refers to either an electric storage water heater with a storage volume of 30, 40, or 50 gallons, or a HPWH with a storage volume of 60 or 75 gallons. The allowed increase in tank size depends on the baseline capacity:

- A typical electric storage baseline 30-gallon tank requires a 40-gallon tank for an HPWH.
- A typical electric storage baseline 40-gallon tank requires a 50-gallon tank for an HPWH.
- A typical electric storage baseline 50-gallon tank does not require a larger tank.
- A typical HPWH baseline does not require a larger tank.

For this measure package, split-system heat pump products are eligible, however, they shall be treated as a single product with a single product efficiency and storage volume. Efficiency and performance ratings shall be provided by the manufacturer. Larger HPWH offerings with nominal capacities in the 65- and 80-gallon categories use HPWH baseline assumptions in the calculations. Therefore, these offerings can be used to replace less efficient base equipment, such as electric resistance storage water heaters, since the savings are conservative.

Cases that are excluded in this measure package include:

- Replacement of an instantaneous or tankless water heater
- A new HPWH with a storage capacity of less than 45 gallons
- Replacement of non-electric baseline equipment
  - To replace existing gas water heating systems with a HPWH, refer to the SWWH027-06: Heat Pump Water Heater, Commercial, Fuel Substitution section.
- Replacement of a single existing water heater with multiple HPWHs

SWWH027-06: Heat Pump Water Heater, Commercial, Fuel Substitution

The base case in the SWWH027-06: Heat Pump Water Heater, Commercial, Fuel Substitution measure package is defined as a natural gas storage or instantaneous ("tankless") domestic hot water heater that meets the minimum federal code. Tank size increases are different than on the non-fuel substitution measure. The allowed HPWH capacities depend on the baseline capacity and type.

- A typical gas storage baseline 30-gallon tank requires a 40-gallon tank for an HPWH.
- A typical storage baseline 40-gallon tank requires a 50-gallon tank for an HPWH.
- Gas storage baseline 50-, 60-, and 75-gallon tanks do not require a larger tank.
- A gas tankless baseline requires a new tank that falls into the measure size category.
    - These are classified as “high draw.”

This measure is only applicable to one-for-one replacements. Projects where multiple HPWHs are replacing a different quantity of existing natural gas water heaters should refer to the most recent version of SWWH028-07: Large Heat Pump Water Heater, Commercial and Multifamily, Fuel Substitution. Split-system heat pump unit assemblies are eligible and shall have the same eligibility and data collection requirements as integrated tanked systems. However, they shall be treated as a single product with a single product efficiency and storage volume. Efficiency and performance ratings for the entire package shall be provided by the manufacturer.

Existing gas pipes servicing base equipment must be disconnected and capped. Any existing natural gas water heating system that is being displaced by HPWHs must be fully decommissioned and disposed of. Partial retrofits of existing water heating systems—i.e., replacing only some natural gas water heaters in a system with heat pumps—are eligible, but not all if the HPWHs are not backup or redundant systems and the natural gas water heaters that are being replaced are fully demolished. Both accelerated replacement (AR) and new construction (NC) are only eligible for downstream deemed and downstream direct install delivery types. New construction is allowed in the measure package because new services are eligible.

Different baseline equipment types have different eligible baseline tank sizes:

- Gas storage baseline eligible sizes: 30, 40, 50, 60, and 75 gallons
- Gas tankless baseline is considered high draw
- New construction measures are only eligible for downstream and direct install applications when at least one of the following conditions is met:
    - Measures are installed in new areas of an existing building.
    - Measures are installed in a major renovation of an existing building.
    - Measures are installed in capacity expansions of existing systems to serve existing and/or new load that requires additional water heating capacity. This includes installations where the new heat pump's system capacity (kBtu/h) is increased to larger than the existing system capacity.

Cases that are excluded in this measure package include:

- Water heaters that are used for non-domestic hot water uses, such as space conditioning. industrial (process) loads, and pool and/or spas applications.
- Combination systems that serve domestic hot water and space heating.
- Redundancy (backup) systems.
- However, heat pumps that are staged based on load or set up in a lead-lag configuration are eligible.

Table 4: Measure case specification for SWWH028-07.

Offering Type	Equipment Type	Capacity (Gallons or KBtu/h)	Minimum Efficiency
Multifamily	Central HPWH system	150 kBtu/h	3.0 COP
Commercial	Central HPWH system	75 ≤ to < 100 gallons	3.0 UEF
Commercial	Central HPWH system	≥ 100 gallons	4.3 COP

SWWH028-07: Large Heat Pump Water Heater, Commercial and Multifamily, Fuel Substitution

The base case equipment for the SWWH028-07: Large Heat Pump Water Heater, Commercial and Multifamily, Fuel Substitution measure package consists of natural gas storage hot water heaters that comply with federal codes. The measures are characterized by storage capacity (in gallons) and either the Uniform Energy Factor (UEF) or Coefficient of Performance (COP) which are dependent on size. Commercial offerings refer to large storage HPWH systems with storage volumes equal to or greater than 75 gallons. For water heaters with capacities less than 100 gallons, efficiency requirements are based on the UEF. Multifamily offerings are defined as large central HPWH systems with output heating capacities greater than 150 kBtu/h.

Cases eligible for this measure package include:

- HPWH must meet the storage capacity (75 ≤ to < 100 gallons, ≥ 100 gallons), heating output capacity, and minimum efficiency requirements (3.0 UEF, 4.3 COP).
    - Measure offering selections, based on storage volume or heating capacity, and incentivized output capacity should be calculated using the total number of eligible HPWHs participating in the incentive.
    - The rated COP and output capacity of heat pump equipment shall be used to determine eligibility and establish the incentivized output capacity for claims. Output capacity for claims shall exclude any capacity derived from electric resistance heating elements.
- Tankless and split HPWH technologies should claim offerings based on their specific efficiency (UEF or COP) and connected storage volumes, and the baseline system eligibility.
- Measure installation shall fully comply with all state and local requirements and regulations including but not limited to the National Electric Code and California Plumbing Code, Electric Code, and energy standards.
- This measure is applicable for all commercial and industrial building types, and the multifamily residential building type.
    - The sector-wide "commercial" building type is not eligible for downstream or direct-install delivery types.

Table 5: Eligible baseline criteria.

Offering ID	Offering Type	Base Case Equipment Type	Eligibility Criteria
I	Multifamily	Central boiler	Replacing a natural gas boiler system with total heating input capacity of greater than 150 kBtu/h; any storage volume associated with the system is eligible
J	Multifamily	Central storage	Replacing a natural gas storage water heater system with total heating input capacity of greater than 75 kBtu/h; any storage volume associated with the system is eligible
K*	Commercial	Storage	Replacing existing natural gas storage water heater system with total storage capacity of 80 gallons or greater; includes boiler systems with attached storage tanks in the appropriate storage volume range
L*	Commercial	Storage	Replacing existing natural gas storage water heater system with total storage capacity 80 gallons or greater; includes boiler systems with attached storage tanks in the appropriate storage volume range
M	Commercial	Instantaneous	Replacing existing natural tankless water heater system with total heating input capacity 200 kBtu/h or less; includes boiler systems with attached storage tanks of less than 80 gallons
N	Commercial	Instantaneous	Replacing existing natural tankless water heater system with total heating input capacity greater than 200 kBtu/h; includes boiler systems with attached storage tanks of less than 80 gallons

* Offerings K and L use the same assumed baseline, TechID. for calculating savings (Stor_TE-Gas-gt75kBtuh-0.80Et), so baseline eligibility for each offering is the same.

Cases that are excluded in this measure package include:

- Water heaters that are used for non-domestic hot water uses, such as space conditioning, industrial (process) loads, and pool and/or spa applications.
- Combination systems that serve domestic hot water and space heating.
- Baseline systems that use steam boilers.
- Heat pump systems where the total output heating capacity is greater than 1,000 kBtu/h.
    - If there are multiple separate hot water system loops in a building, the 1,000 kBtu/h capacity limit should be applied to each individually.
- Redundancy (backup) systems.
    - Heat pumps that are staged based on load or set up in a lead-lag configuration are eligible for this measure package.
- For AR offerings, the baseline systems must not be high-efficiency condensing systems.

Commercial Water Heater Performance

Understanding commercial water heater use and sales involves some standard terminology. The Engineering Analysis of this Focused Pilot includes several standard terms and metrics essential for understanding water heater performance:

- **Standard rise:** The increase in water temperature, typically measured in degrees Fahrenheit (°F), to raise the incoming cold-water temperature to the desired hot water outlet temperature of the water heater.
- **Storage capacity:** The volume of water a storage tank can hold, typically measured in gallons. This metric indicates the maximum amount of hot water available for use at any given time before the heater needs to reheat more water.
- **Heating capacity:** The amount of heat energy the unit can transfer to the water within a specific time frame, typically measured in Btus per hour. The heating capacity determines how quickly a water heater can raise the tank's water temperature.
- **First-hour rating (FHR):** A measure of the maximum amount of hot water the unit can supply in the first hour of operation, starting with a full tank already heated up to its design temperature.[3] This metric represents a combination of the storage capacity and the recovery rate, i.e., how quickly the unit can reheat water, to indicate the water heater's performance during peak usage times. This is a common metric of performance reported by manufacturers and used by contractors in residential water heater applications.
- **Second-hour performance:** A calculation to measure the maximum amount of hot water the unit can supply during a two-hour period of operation, starting with a partially depleted tank. This metric is more commonly used in commercial applications for understanding the water heater's performance during extended periods of high demand.
- **Recovery rate:** This is the amount of hot water a unit can reproduce over a given period, typically measured in gallons per hour (GPH). Factors influencing the recovery rate include the water heater's recovery efficiency, ambient temperature, and the initial temperature of the incoming water. Unlike conventional electric and gas water heaters, the recovery rate and recovery efficiency of HPWHs can be significantly affected by these factors.

Metrics for HPWH Applications

The Engineering Analysis section below includes several standard terms and metrics essential for understanding water heater building applications.

- **Water usage:** The amount of hot water a household or facility consumes over a specific period, typically measured in gallons per day or per year. This metric helps determine the appropriate size and capacity of the water heater to meet the demand.
- **Water/energy intensity:** The energy consumed to heat a specific volume of water to a desired temperature, typically measured in terms of energy per unit of water heated, such as kilowatt-hours (kWh) per gallon. Energy and water intensity is commonly also reported based on building area square footage or per square foot.
- **Draw profiles:** These profiles show hot water usage patterns over a specific period, typically 24 hours. Draw profiles help evaluate the water heater demand and efficiency under different usage scenarios, including hour-by-hour predictions for different building types and scenarios, maximum hourly use, maximum daily use, and average daily use.

Objectives

The primary objective of this study was to test the hypothesis that direct engagement with commercial contractors and sites would remove the barriers to adoption described above. To disseminate knowledge about commercial HPWHs and their applications, through this Focused Pilot, the project team conducted studies to aid contractors' understanding of which commercial building types to target and to make recommendations to expand measure packages with the goal of increasing participation in these measures.

To achieve these objectives, the pilot aimed to support the installation of 3 to 10 HPWH demonstrations—up to a maximum of 50—at commercial sites. The pilot was designed to allow contractors to install up to three HPWHs each to gain experience with the commercial sales and installation process. The team sought to target a diverse range of commercial sites, including a sample of hard-to-reach and disadvantaged communities. To understand opportunities for light-duty HPWH installations in commercial settings and increase knowledge of commercial HPWH applications, the team first conducted an engineering study and market characterization. The goal of the market characterization was to define the target market, leveraging tested limitations of a light-duty commercial HPWH. This portion of the project was supported by several data sources: the National Renewable Energy Laboratory's (NREL's) ComStock dataset provided modeled building stock for California, and the Air-Conditioning, Heating, and Refrigeration Institute's (AHRI's) tested product specifications determined the efficiency and hot water limitations of these units. This technical understanding was paired with actual contractor and manufacturer interviews to develop effective contractor marketing materials for use in future commercial sales.

The engineering analysis achieved two primary objectives: 1) a detailed comparison of the performance of conventional gas, electric, and HPWHs, and 2) an assessment of the capability of existing integrated and split HPWH models to meet the peak and sustained hot water demands of California commercial buildings. The engineering analysis provided the framework for characterizing the size of the market opportunity for HPWHs in commercial applications and identified gaps in reported performance specifications necessary to guide quality installations. This framework included several hot water draw thresholds (daily, two- hour, and six- hour) as well as determinations about systems setup (single tank with no recirculation loops) and volume. From the engineering analysis, we determined a light-duty commercial HPWH would have an average volume of 65 gallons, with a gallons-per-day threshold of 740. The thresholds for second-hour performance and six-hour performance were 124 gallons and 236 gallons, respectively.

Methodology and Approach

This Focused Pilot supports two primary methods for evaluating the opportunity and market strategy for scaling adoption of light-duty HPWHs in California's commercial buildings. Those methods include a technical evaluation, which comprised an engineering analysis; TRM measure package review and market characterization; and market development involving contractor engagement, marketing and education, and light-duty HPWH field demonstrations in community-based organizations (CBO).

Engineering Analysis

The pilot analyzed all commercial building types to determine which are best suited for installing a light-duty commercial HPWH. Analysis included understanding water heating requirements, electrical infrastructure requirements, and procurement procedures. The team matched resources that reviewed hot water requirements by building type with HPWH capacities to understand which building types would be a good fit for a light-duty HPWH. The information gathered will be used to generate a marketing piece to inform contractors of the best opportunities for light-duty commercial HPWH installations so they can target sales to customers who would most benefit from HPWH installations.

Although the efficiency of a water heater, UEF, is a standard performance metric for comparing different water heater solutions, the primary focus of our engineering analysis was on the capability of a water heater to meet hot water demands, reported as the recovery rate (RR). From this value, we calculated the gallons per day (GPD) delivery, second-hour performance, and six-hour performance.

The performance and capacity limits of various HPWH models served as a framework for assessing the California commercial building sector's hot water needs. Hot water demand varies significantly based on building type and usage. Residential buildings, for instance, have different hot water needs than commercial or industrial buildings. In California, the landscape of building types includes single-family homes, apartments, condos, offices, hotels, restaurants, retail spaces, factories, and warehouses. For this engineering analysis, we used various data sources to provide insights into water heater performance and usage across different building types to better define "best fit" for each. Table 6 provides an overview of public datasets and resources that contain information pertaining to water heaters.

Table 6: Public datasets used for the engineering analysis.

Data Source Names	Sector	Data Source Description	Associated Specifications
AHRI Certified Residential Water Heaters Product List	Residential	List of baseline and efficient water heaters	US Department of Energy (DOE) Office of Energy Efficiency and Renewable Energy (EERE) Federal Standards for Consumer Water Heaters, 10 CFR 430.32(d)
NEEA Commercial/ Multifamily HPWH Systems Qualified Products List	Commercial/ multifamily	List of energy efficient HPWHs	Advanced Water Heating Specification, V8.1
ENERGY STAR®-Certified Commercial Water Heaters Product List	Commercial	List of energy efficient water heaters	ENERGY STAR Commercial Water Heaters Requirements V2.0
ENERGY STAR Certified Heat Pump Water Heaters Product List	Residential	List of energy efficient HPWHs	ENERGY STAR V5.0 Water Heaters Final Specification
DOE EERE Compliance Certification Database for Water Heaters and Boilers: Commercial Instantaneous Water Heaters and Hot Water Supply Boilers[13] Commercial Electric Storage Water Heaters Commercial Gas and Oil-Fired Storage Water Heaters[15]	Commercial/ residential-duty	List of baseline water heaters	DOE EERE Federal Standards for Commercial Water Heating Equipment, 10 CFR 431.110
American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Handbook, Chapter 51, Service Water Heating	Commercial	Defines water-heating terminology, provides hot-water demands as well as hourly flow profiles for various buildings	N/A

Data Source Names	Sector	Data Source Description	Associated Specifications
CBECS	Commercial	Survey of commercial buildings, categorized by region rather than by state	N/A
ComStock	Commercial	Energy end-use modeling for the California commercial building stock	N/A

Error! Reference source not found.Error! Reference source not found.Market Characterization

Target Market

The team used the NREL ComStock dataset to develop a target market for commercial HPWH installations. ComStock offers a highly detailed and comprehensive US commercial building stock model. These datasets are built using a combination of physics-based computer modeling and high-performance computing, integrating data from CBECS, utility data, weather data, the Building Performance Database (BPD), and geographic information. ComStock's extensive capabilities allow users to explore energy use and savings potential across different building types, vintages, and geographic locations.

To identify a technically viable and strategically focused target market, the team employed a progressive refinement approach using ComStock metadata. This method involved applying a series of increasingly specific filters, each one narrowing the pool of eligible buildings based on engineering criteria and system compatibility.

1. **Fuel type filter:** The initial filter selected buildings that use electricity or natural gas for water heating, based on the primary service water heating fuel source. This ensured the dataset began with buildings to broadly align with most program interests.
2. **Single tank filter:** Buildings with more than one water heater were excluded. This filter targeted simpler systems, assuming that single-tank configurations are most suitable for HPWH retrofits.
3. **Recirculation filter:** Recirculation systems were identified using a derived metric: water heating intensity (kWh per cubic meter of water). Systems with intensity above 75 kWh/m^3 were considered to have recirculation, indicating multiple heating cycles and higher energy losses. These buildings were removed to keep the focus on simpler systems.
4. **24-hour draw threshold filter:** ComStock timeseries data was used to analyze peak 24-hour hot water usage. Buildings with demand exceeding 740 gallons per day—beyond the capacity of a 65-gallon HPWH—were excluded. This ensured that selected buildings could be adequately served by standard HPWH units.

5. **Six-hour performance threshold filter**: A similar analysis was performed for six-hour usage periods. Buildings with demand above 236 gallons were filtered out, aligning HPWH capacity with usage patterns based on engineering analysis.
6. **Second-hour performance threshold filter**: Finally, buildings with peak second-hour performance usage above 124 gallons were excluded. This step confirmed short-term demand compatibility with HPWH performance, ensuring reliability during peak usage.

Despite amazing detail and granularity, ComStock does have limitations when it comes to building stock representation. The dataset represents 14 of the most common commercial building types — small office, medium office, large office, retail, strip mall, warehouse, primary school, secondary school, full-service restaurant, quick-service restaurant, small hotel, large hotel, hospital, and outpatient. Collectively, these comprise about 65 percent of the commercial sector floor area in the United States, according to CBECS. This translates to approximately 71 percent of the US commercial building stock based on energy consumption. Less common building types, which comprise the remaining 35 percent of the commercial sector floor area, are unavailable in the ComStock dataset and cannot be modeled with the tool. As a result, there is little visibility into this remaining stock and it was not represented in the target market for this study.

Contractor and CBO Interviews

Along with the engineering analysis, this pilot also sought to gain a better understanding of how familiar contractors, distributors, and customers are with the installation of HPWHs in commercial settings. To be part of a demonstration project, contractors and community sites were asked to answer interview questions. Through initial outreach interviews and subsequent end-of-project interviews, the team gauged knowledge growth. The purpose of initial interviews was to learn about the participants' understanding of commercial HPWH applications and their knowledge of existing incentives offered through California energy efficiency programs. We included an assessment of existing program participation to understand if schools, governments, and other commercial areas are already adopting HPWH technology. Our aim was to discover any market successes or unknown market barriers and come up with a plan to resolve them.

Manufacturer Interviews

In addition to contractors, the team interviewed three HPWH manufacturers:

- A.O. Smith
- Bradford White
- Rheem

These interviews intended to gather insights from the manufacturers on the commercial light-duty HPWH landscape, especially as it intersects with their present and future product offerings. Manufacturers were also asked about key system design considerations for HPWH fit assessments for commercial buildings as well as the adoption barriers that they have encountered or have been made aware of. Lastly, they were asked about the existing resources and support materials that they provide to contractors in the realm of HPWH installation and maintenance.

Measure Package Review

The team reviewed existing measure packages for commercial HPWHs to identify limits on equipment eligibility and recommend updates to the measure packages to expand program eligibility for existing commercial water heating programs in California. We expected to find existing gaps and proposed to the California Technical Fortum (Cal TF) new commercial scenarios to add to the measure packages. Demonstration projects were not subject to tank-size-change limitations to determine if that made commercial sales more feasible. The team reviewed the following measure packages during the pilot:

- SWWH031-03: Heat Pump Water Heater, Commercial
- SWWH027-04: Heat Pump Water Heater, Commercial, Fuel Substitution
- SWWH028-04: Large Heat Pump Water Heater, Commercial and Multifamily, Fuel Substitution

Contractor Marketing and Education

Information gathered in the market characterization and engineering study was used to construct marketing materials for contractors to use in outreach to audiences that would benefit the most from HPWH adoption. By understanding available incentives for HPWHs, contractors were better equipped to handle conversations with commercial site representatives on installation opportunities. This gave the contractors a greater chance of completing an installation and provided more opportunity to become comfortable with these types of installations

Community-Facing Commercial HPWH Demonstrations

To build contractors' experience selling and installing commercial light-duty HPWHs, this pilot offered no-cost light-duty HPWHs for installation at select commercial sites. The pilot team targeted small- and medium-sized contractors and commercial sites like community centers and places of worship. These site types were chosen because of expected low hot water volumes easily served by light-duty HPWHs, and because they could expose other business owners to HPWH technology in a commercial setting. The pilot was open to customers in California IOU service territories. Each participating contractor was able to install up to three no-cost HPWHs provided by the pilot to increase their experience with the technology. CBOs and contractors were guided to a website to learn more about the pilot offering and complete an application to indicate their interest in participating. The application included site and participation questions to ensure that the pilot met its objective to capture a representative sample of CBOs most likely to benefit from an HPWH installation. Information on qualifying equipment and sites was included within the application. Once both a contractor and an eligible site were identified, both parties signed a Participation Agreement to ensure the demonstration HPWH was installed within the timeframe of the pilot.

Findings

Engineering Analysis

The engineering analysis encompassed four main components:

1. **Defining light-duty commercial water heaters and HPWH technology**: This included detailing the types, performance, and application requirements—such as draw profiles—for both conventional water heaters and HPWHs.
2. **Defining "best fit" commercial light-duty HPWH application:** This involved detailing the different types of water usage by building type and comparing these values with various data sources.
3. **Identifying and assessing water heater test procedures, specifications, and QPLs:** This component evaluated existing water heater test procedures, specifications, and QPLs.

Defining Commercial Buildings

The team delved into various data sources to understand water heater usage. Our research covered a range of sources that provided unique insights into aspects of water heater performance and specifications. These sources included data on residential and commercial water heaters, ENERGY STAR-certified product lists, and surveys of commercial buildings.

One key observation from the team's exploration was the high variability of building types among the commercial sector data sources. Various commercial buildings, from multifamily units to large commercial establishments, have distinct water heating needs and usage patterns, highlighting the importance of considering different building types' specific characteristics and requirements when analyzing water heater data (Table 7).

Table 7: Building types and data sources.

<table>
<tr><th></th><th>California Electronic Technical Reference Manual (eTRM)</th><th>CBECS 2018</th><th>ASHRAE Chapter 51</th><th>ComStock</th></tr>
<tr><td rowspan="5">Education</td><td>Primary school</td><td rowspan="5">N/A</td><td>Elementary schools</td><td>Primary school</td></tr>
<tr><td>Secondary school</td><td>Junior and senior high schools</td><td>Secondary schools</td></tr>
<tr><td>Community college</td><td rowspan="3">N/A</td><td rowspan="3">N/A</td></tr>
<tr><td>University</td></tr>
<tr><td>Relocatable classroom</td></tr>
<tr><td>Grocery</td><td>Grocery</td><td>Food sales</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Restaurants</td><td>Sit-down restaurant</td><td>N/A</td><td>Full meal restaurants</td><td>Full service restaurants</td></tr>
</table>

<table>
<tr><th></th><th>California Electronic Technical Reference Manual (eTRM)</th><th>CBECS 2018</th><th>ASHRAE Chapter 51</th><th>ComStock</th></tr>
<tr><td></td><td>Fast-food restaurant</td><td></td><td>Drive-ins, grills, luncheonettes</td><td>Quick service restaurants</td></tr>
<tr><td>Healthcare</td><td>Hospital</td><td>Healthcare (inpatient)</td><td>N/A</td><td>Hospital</td></tr>
<tr><td rowspan="8">Lodging</td><td>Hotel</td><td rowspan="8">N/A</td><td rowspan="3">N/A</td><td>Small hotel</td></tr>
<tr><td>Hotel</td><td>Large hotel</td></tr>
<tr><td>Hotel guest room</td><td rowspan="6">N/A</td></tr>
<tr><td>Motel</td><td>Motel</td></tr>
<tr><td>Motel</td><td>Motel</td></tr>
<tr><td>Motel</td><td>Motel</td></tr>
<tr><td>University dormitory</td><td>N/A</td></tr>
<tr><td>Nursing home</td><td>Nursing home</td></tr>
<tr><td rowspan="3">Retail</td><td>Small retail</td><td rowspan="2">N/A</td><td rowspan="3">N/A</td><td rowspan="3">N/A</td></tr>
<tr><td>Retail – single story large</td></tr>
<tr><td>Retail – multistory large</td><td>Mercantile</td></tr>
<tr><td rowspan="2">Office</td><td>Large office</td><td rowspan="2">N/A</td><td rowspan="2">N/A</td><td>Large office</td></tr>
<tr><td>Small office</td><td>Small office</td></tr>
<tr><td>Public buildings</td><td>Assembly</td><td>Public assembly</td><td>N/A</td><td>N/A</td></tr>
<tr><td>Warehouse</td><td>Refrigerated warehouse</td><td>N/A</td><td>N/A</td><td>N/A</td></tr>
</table>

	California Electronic Technical Reference Manual (eTRM)	CBECS 2018	ASHRAE Chapter 51	ComStock
	Conditioned storage			
Manufacturing	Biotech manufacturing	N/A	N/A	N/A
	Light industrial manufacturing			

Using the data gathered from these sources, the team analyzed annual daily usage of water heaters by building type. By analyzing the performance metrics and specifications provided, the team derived insights into the typical daily water usage across various building types—listed above—and sectors. This approach allowed the team to understand water heater usage patterns and potential compatibility with light-duty HPWHs.

TARGET MARKET

To identify the most promising opportunities for commercial HPWH deployment, the team conducted a multi-step analysis of the California commercial building stock using NREL's ComStock metadata. This process involved filtering the dataset to isolate buildings that are the best candidates for HPWH installations, then evaluating those buildings across three key dimensions: the number of potential installations, electricity savings potential, and natural gas savings potential. The following section presents the results of this analysis, highlighting which building types offer the greatest opportunity for impact—through scale, energy savings, or both.

Table 8, below, summarizes the filtering steps applied to the ComStock dataset, along with key outcomes and observations for each.

Table 8: Filters applied to ComStock data.

Filter	Outcome	Observation	Question for Further Study
Fuel type (electricity and gas)	Buildings using other fuels excluded	Electricity and gas are most relevant for utility efficiency programs and compatible with HPWHs	How might the exclusion of buildings using other fuels (e.g., propane, fuel oil, district heating) limit opportunities for decarbonization in rural or underserved markets?

Filter	Outcome	Observation	Question for Further Study
Single tank	The following building types were completely excluded: full-service restaurant, hospital, large hotel, primary school, secondary school	These buildings typically require multiple water heaters due to high or distributed demand, making simple, single-tank HPWH retrofits infeasible.	What design or system innovations could enable HPWH adoption in high-demand, multi-heater buildings without compromising performance or cost-effectiveness?
No recirculation	Standalone retail and warehouses lose ~50% of their building count.	Recirculation, which could be required due to long pipe runs, implies higher energy losses and complexity, significantly reducing HPWH suitability and performance.	Can HPWH systems be adapted or paired with controls to efficiently serve buildings with recirculation systems?
24-hour draw threshold	Large offices nearly eliminated; medium offices and outpatient reduced	High daily demand exceeds HPWH capacity, making standard units infeasible.	Could integrating thermal storage or staggered heating cycles make HPWHs viable in high-demand commercial buildings?
Six-hour performance threshold	Minimal additional exclusions	Remaining buildings generally have demand within HPWH capacity.	Does mid-range demand (e.g., six-hour usage) better predict real-world HPWH performance than total daily consumption?
Second-hour performance threshold	No further exclusions	Remaining buildings already meet short-term demand limits.	How does short-term peak demand influence user satisfaction and system longevity in HPWH deployments?

With the target market refined, the team then evaluated the remaining building types based on three key metrics: the number of potential installations, electricity savings potential, and natural gas savings potential. Figure 1 and Table 9 below present these results, offering a comprehensive view of which building types stand out in terms of both scale and energy impact. For illustration about how the sequence of filters impacted the shaping of the target market, refer to Appendix A: Target Market Supplemental Information

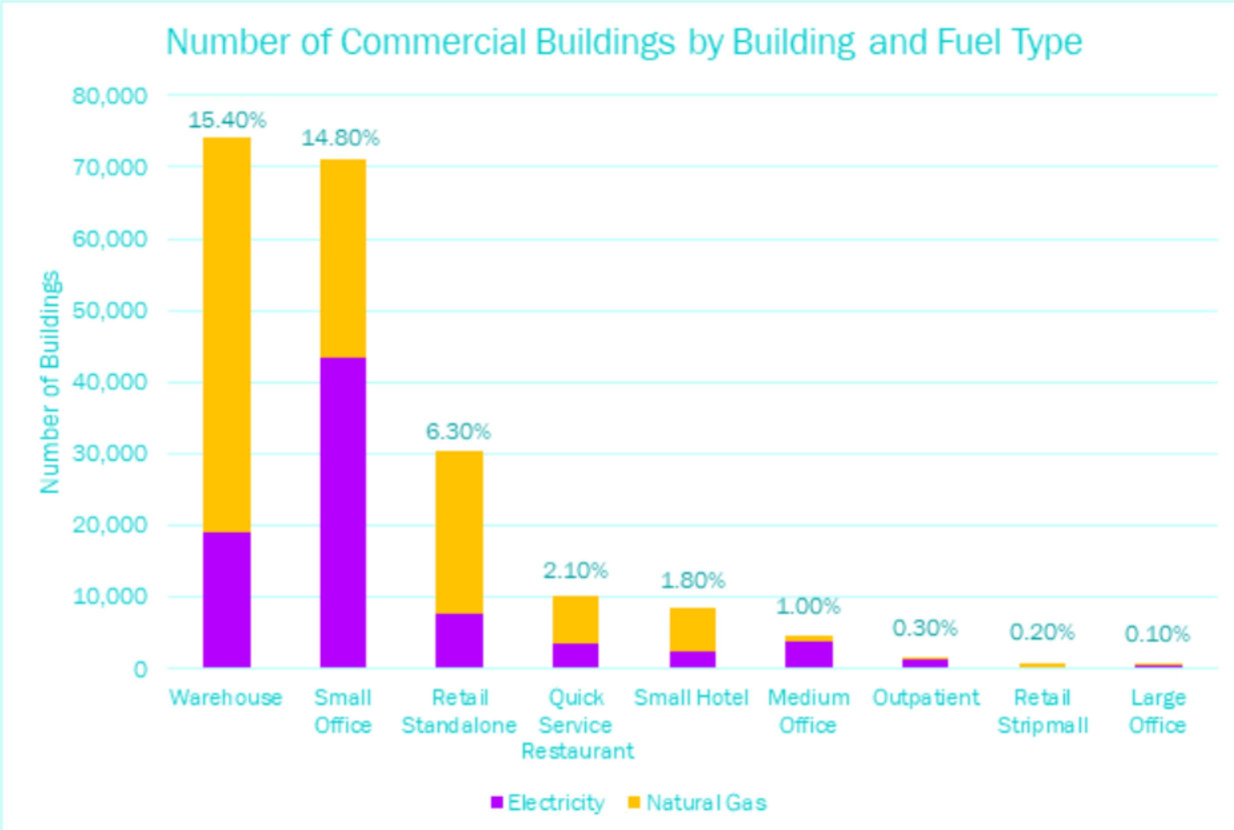

Figure 1: Market opportunity for light-duty HPWHs in commercial buildings by building and fuel type.

Table 9: Energy impact of light-duty HPWHs for buildings with electric and natural gas water heating.

Building Type	Total Buildings	Electric Water Heaters	Gas Water Heaters	Electric Savings Potential (MWh)	Gas Savings Potential (Therms)	Electric Load Growth (MWh)
Warehouse	74,087	19,067	55,020	41,537	1,414,422	6,982
Small office	70,952	43,285	27,667	72,428	2,353,108	11,615
Retail standalone	30,264	7,572	22,692	15,850	807,480	3,986
Quick service restaurant	10,103	3,622	6,482	24,496	2,739,996	13,525
Small hotel	8,436	2,339	6,097	8,547	1,165,975	5,755

Building Type	Total Buildings	Electric Water Heaters	Gas Water Heaters	Electric Savings Potential (MWh)	Gas Savings Potential (Therms)	Electric Load Growth (MWh)
Medium office	4,570	3,838	732	52,177	753,297	3,718
Outpatient	1,471	1,399	72	13,663	66,287	327
Retail strip Mall	754	159	595	1,022	111,391	550
Large office	610	575	35	5,315	32,363	160
Grand total	**201,246**	**81,854**	**119,392**	**235,035**	**9,444,319**	**46,618**

Based on the combined analysis of installation volume, electricity savings, and natural gas savings, a few building types clearly emerge as strong candidates for early adoption of commercial HPWHs. Small offices stand out across all three categories—they have the highest number of buildings, the greatest electricity savings potential, and substantial gas savings, making them an ideal target for both scale and energy impact. Warehouses also stand out, with the largest overall building count and significant energy savings in both electricity and gas categories. Quick service restaurants, while smaller in number, show exceptional potential for gas savings, making them a compelling choice for programs focused on reducing fossil fuel use. Other building types like medium offices and retail standalone show moderate promise.

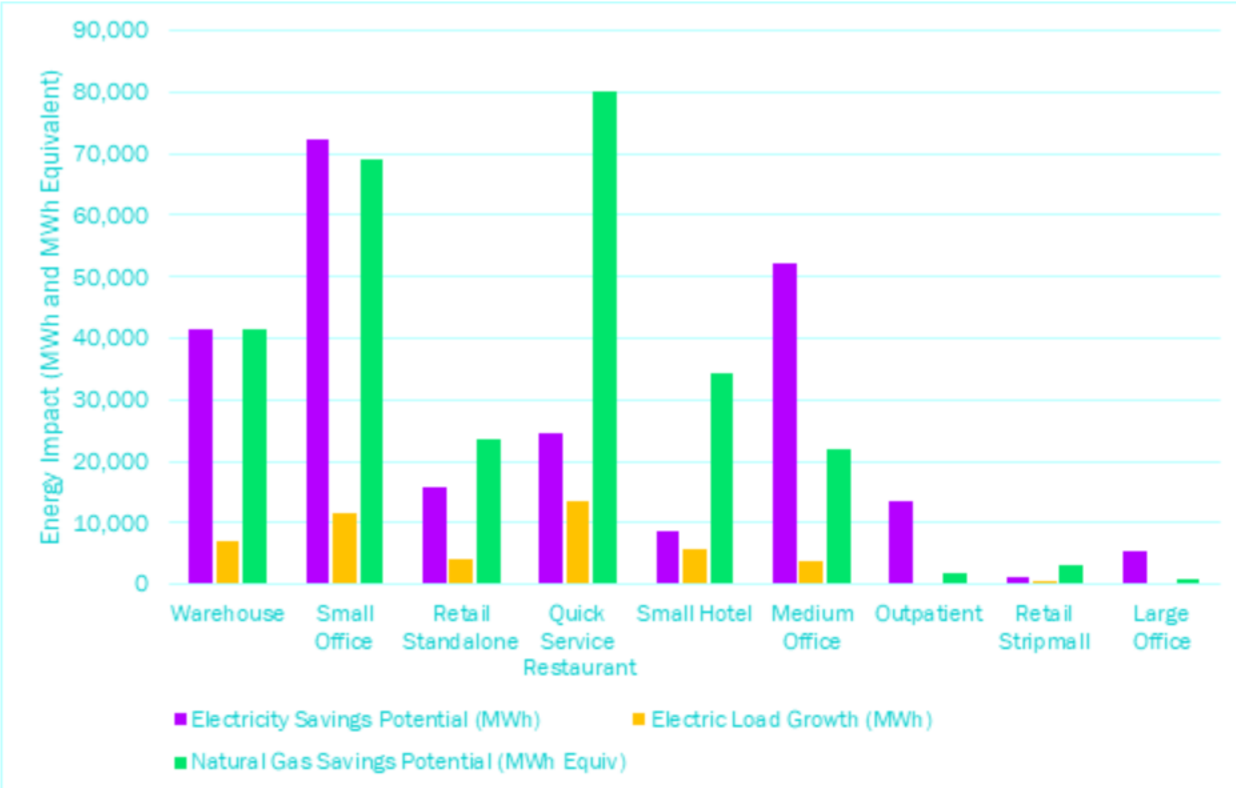

Figure 2: Estimated energy impact of light-duty HPWHs on commercial buildings.

While the target market analysis highlights building types with strong technical and energy-saving potential for HPWH deployment, it's important to recognize that market suitability goes beyond system compatibility and energy metrics. A major barrier to adoption—especially in the commercial sector—is the split incentive problem, where the benefits of energy upgrades are misaligned between those who pay for them and those who reap the rewards. This issue is well-known in residential energy efficiency, but it's even more pronounced in commercial buildings, where leasing is common and lease structures are often complex. In California, it is estimated that 70 percent of business establishments operate in leased spaces, meaning decisions about capital improvements like HPWHs often fall into a gray area. For example, in triple net leases, tenants pay for utilities but may not have authority to upgrade building systems. In gross leases, landlords cover utilities but may lack motivation to invest if tenants benefit from the savings. Modified gross leases vary widely, often leaving ambiguity around who bears the cost of improvements. These dynamics can stall HPWH adoption, even when the technology is cost-effective over its lifetime. Addressing this challenge will be critical to unlocking the full potential of the target market identified in this analysis.

DRAW PROFILES

An important aspect of defining water usage is understanding how different building types use water throughout the day, hour by hour. Draw profiles or hourly flow profiles are used to visualize this differing use by building type, often over a 24-hour period, depicting water usage patterns and needs on a more detailed level than daily or annual water usage numbers, for example. The 2023 ASHRAE Handbook, Chapter 51: Service Water Heating, includes draw profiles for 11 building types, including dormitories, schools, and food service establishments. Shown below are the profiles for maximum hourly flow, maximum daily flow, and average flow of the office buildings, measured in gallons per hour per person, and food service: type A, with flow measured in gallons per hour per maximum meals per hour (Figure 3). Please note, food service: type A includes full-meal restaurants and cafeterias, but exclude drive-ins, and sandwich and fast-food service establishments.

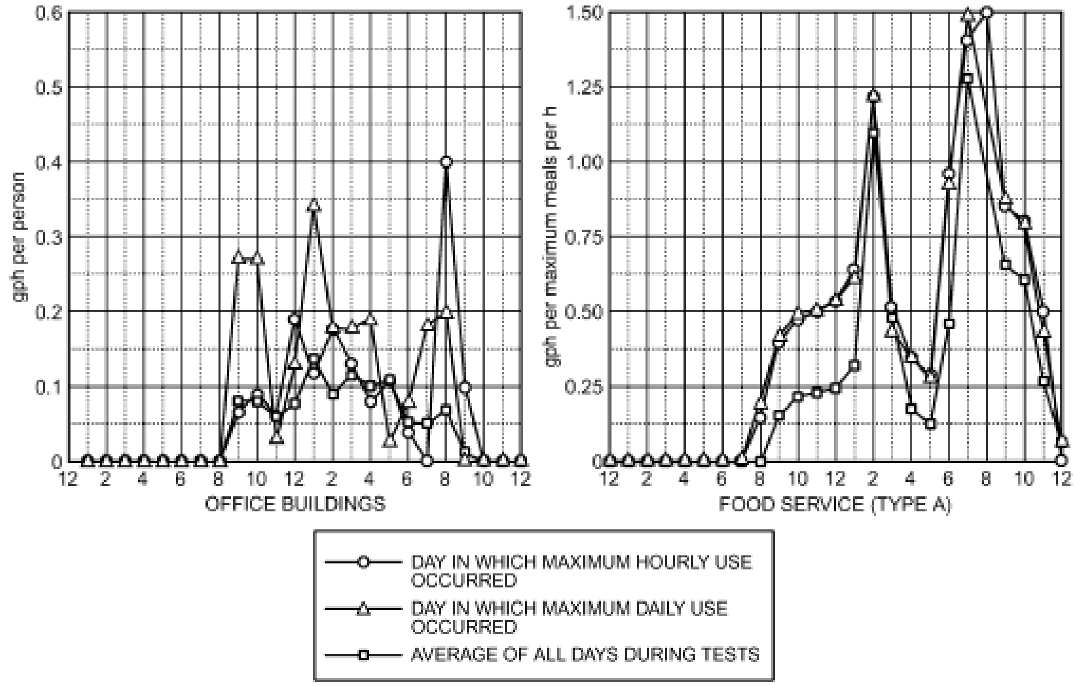

Figure 3: Hourly flow profiles for various building types.

These profiles show variations in how and when different buildings use water. For example, peak water usage in food service: type A occurs between 6:00 and 9:00 p.m., at an average of about 1.5 gallons per hour per meal, during and after the dinner service. Use remains relatively flat throughout the rest of the day, except for the lunch service, at an average of about 0.5 gallons per hour per meal.

There is an important distinction between the draw profile of a typical residence and commercial building types. Residential water use peaks in the morning, shows a small peak in the evening, and remains within a relatively narrow band during working hours, between four and eight gallons of use per hour (Figure 4). Draw profiles of commercial buildings are more irregular, with more prominent use peaks. These peaks can be high enough to require larger or higher-output water heaters.

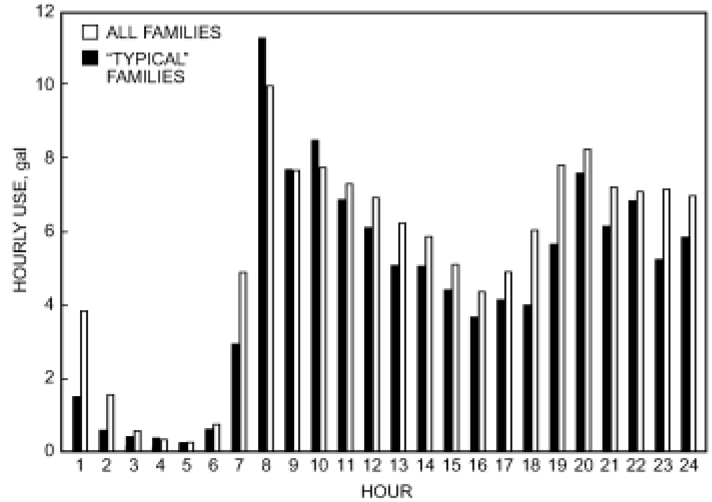

Figure 4: Residential hourly hot water use.

As mentioned earlier, this variation highlights the importance of considering different building types of specific characteristics and requirements when analyzing water heater data. Water heating systems must be able to supply these peak use times.

DRAW PATTERNS

As established by federal regulations, in order to determine efficiency (UEF), the water heater is tested using one of four possible draw patterns: very small, low, medium, or high. The draw patterns vary in the length of draws, timing, and flow rates. The current federal test procedure for consumer water heaters incorporates draw patterns to represent an average period of use for the products subject to the test procedure. Federal regulations state that residential and residential-duty commercial water heaters must be tested under a draw profile that is dependent upon either the tested first-hour rating (storage units), or the tested maximum gallons per minute (GPM) (instantaneous, for tankless units). The volume of hot water drawn during the applicable draw pattern relates to the efficiency of the water heater (UEF). Depending on the water heater type and sector, commercial or residential, data are available in various product lists, including the AHRI Certification List, DOE Instantaneous Water Heaters, and the ENERGY STAR Residential QPL.

HOT WATER CONSUMPTION BY BUILDING TYPE

To determine water consumption by building type, the team used values from the eTRM to calculate annual water usage in gallons per square foot, as illustrated in Figure 5.

In buildings like sit-down restaurants, hot water usage is exceptionally high, reaching 117.75 gallons per square foot per year. This is likely due to extensive cooking, cleaning, and sanitation needs. Consequently, sit-down restaurants have been removed as an outlier.

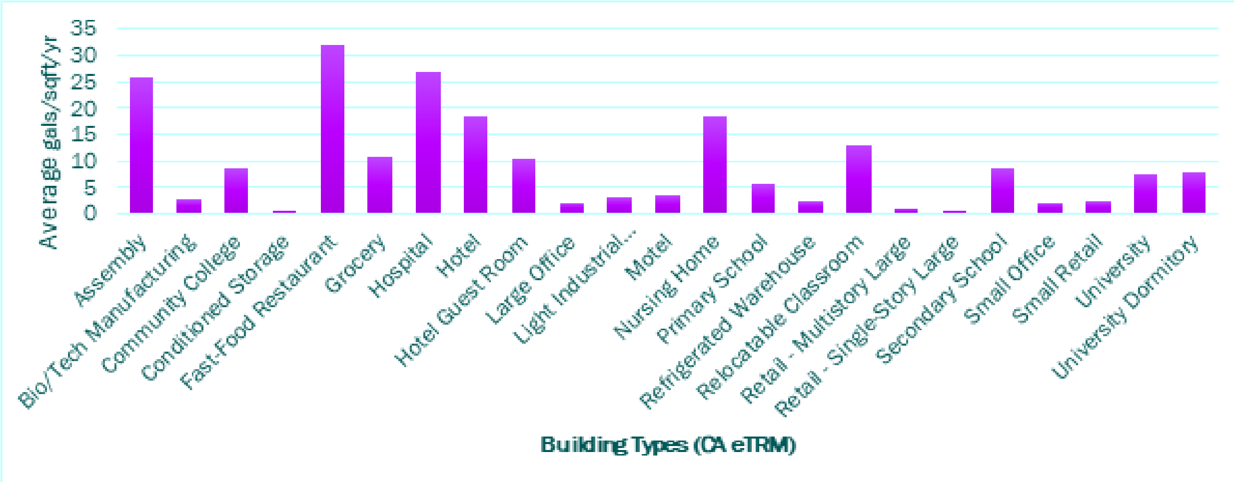

Figure 5: Defined eTRM building types and associated average annual hot water consumption.

Note: Figure shows water consumption in gallons per square foot with outliers removed.

As end-use facilities with higher hot water demands, fast food restaurants use 32.08 gallons per square foot per year due to continuous operations that demand significant hot water for cooking and sanitation. Hospitals and assembly buildings also consume significant amounts of hot water, at 26.99 and 25.6 gallons per square foot per year, respectively. Hospitals require hot water for patient care, sterilization, and laundry services. Assembly buildings, including theaters and convention centers, need hot water for large-scale sanitation and catering services.

Nursing homes consume substantial amounts of hot water, at 18.4 gallons per square foot per year, as these facilities need hot water for patient care, sterilization, and laundry services. Hotels and hotel guest rooms have varying usage, at 18.3 and 10.46 gallons per square foot per year, reflecting the extensive water needs for guest services and amenities.

Educational institutions, such as primary schools, secondary schools, community colleges, and universities, use moderate amounts of hot water, ranging from 5.74 to 8.69 gallons per square foot per year. This reflects the need for hot water in cafeterias, restrooms, and laboratories. Grocery stores use 10.6 gallons per square foot per year for cleaning and food preparation.

Motels and university dormitories use less hot water, at 3.35 and 7.93 gallons per square foot per year, respectively, due to their simpler facilities and fewer amenities than those found in hotels. Small retail spaces and large and small offices show minimal hot water usage, ranging from 0.45 to 2.16 gallons per square foot per year. Refrigerated warehouses and light industrial manufacturing facilities also fall into the low-usage category. These buildings typically use hot water for basic needs like restrooms and small kitchen areas, resulting in usage figures ranging from 1.98 to 3.08 gallons per square foot per year.

Buildings such as conditioned storage and large retail spaces use minimal hot water, with conditioned storage using only 0.23 gallons per square foot per year. This is understandable, as these spaces are primarily used for storing goods and do not have significant water needs. Single-story and multistory retail spaces also show low usage, at 0.45 and 0.78 gallons per square foot per year, respectively.

The data highlight how a building's function and operations significantly influence its water usage, and this extreme variation from building to building is a significant barrier to commercial HPWH adoption. Contractors are less familiar with HPWH performance compared to existing electric resistance and gas systems, leading to hesitancy in recommending HPWHs when loads can vary drastically.

Determining Commercial Light-Duty HPWH Water Requirements

WATER HEATER STANDARDS AND SPECIFICATIONS

Several current standards and specifications across the industry impact water heater efficiency and performance:

- Baseline Residential Water Heater – Federal Standard
    - DOE EERE Federal Standards for Consumer Water Heaters, 10 CFR 430.32(d)
- Baseline Commercial Water Heaters – Federal Standard
    - DOE EERE Federal Standards for Commercial Water Heating Equipment, 10 CFR 431.110
- Efficient Commercial Water Heating Specifications
    - ENERGY STAR Commercial Water Heaters Requirements V2.0
    - NEEA's Advanced Water Heating Specification, V8.1

While ENERGY STAR has an Efficient Central HPWH Specification under development, those standards have not currently been finalized as of late 2025.

WATER HEATER APPLICATIONS

To define light-duty conventional water heaters and efficient HPWH technologies and performance metrics, the team gathered water heater data from across the industry, including all sectors (residential and commercial). This included the following:

- AHRI Certified Residential Water Heaters Product List
- ENERGY STAR Certified Commercial Water Heaters Product List
- ENERGY STAR Certified (Residential) Heat Pump Water Heaters Product List
- DOE EERE Compliance Certification Database for Water Heaters and Boilers
- NEEA Commercial/Multifamily HPWH Systems QPL
- Database of Energy Efficient Resources (DEER) Water Heater Calculator Tool Version 5.1 supporting data and assumptions

This comprehensive data collection enabled the team to examine baseline and efficient products across various sizes and performance capabilities and to provide a clearer understanding of how water heaters serve different sectors. The following fields were included in most of the above product lists:

- Water heater types: instantaneous storage, heat pump, tankless
- Energy source(s): electric, natural gas, natural/propane gas, propane gas, and oil

- Heat pump system types: 120V, 240V, and split system
- Storage volume (gallons)
- First-hour rating in GPH (FHR)
- Draw pattern usage: very small, low, medium, and high

Available performance metrics varied depending on water heater type and energy source.

The DEER Water Heater Calculator provided annual water consumption and flow assumptions, tied to both building type and characteristics (square footage), and groundwater temperatures by climate zone, as shown in Table 10.

Table 10: Average groundwater temperature by climate zone.

Climate Zone #	Example City or Town	Average °F
1	Eureka	51.4
2	Napa	57.7
3	Watsonville	57.8
4	Milpitas	61.6
5	Santa Maria	57.9
6	Westminster	63.9
7	San Diego	64.1
8	Norwalk	65.9
9	Los Angeles	65.3
10	Fontana	65.5
11	Roseville	64.1
12	Bay Point	61.6
13	Bakersfield	66
14	Hesperia	63.7
15	Indio	76.2
16	San Bernadino	52.6

The California Public Utilities Commission (CPUC) recommended using Climate Zone 7 as the statewide average for locations, therefore establishing 64.1°F as the groundwater temperature. The groundwater temperature affects the supply water temperature, thus affecting the performance of the water heater. The maximum temperature was found in Climate Zone 15, and Indio represents a city within that zone. The minimum average temperature was found in Climate Zone 1, with Eureka representing.

TEST PROCEDURES AND ASSUMED CONDITIONS

While reviewing the water-heating technology across the industry and supporting testing procedures and assumptions for reported values, we found slight differences across the measures and standards. Table 11 summarizes the assumed temperature rise and the associated testing specifications.

Table 11: Temperature rise and testing procedure.

Assumed Test Condition Temperature Rise (°F)	Unit Type	Source	Name
100	HPWH	eTRM	DEER Water Heater Calculator
80	Storage water heater	eTRM	DEER Water Heater Calculator
67		Federal Standards	10 CFR Part 430 Subpart B Appendix E[55]
77		AHRI	Max GPM Test, section B 3.7
70		AHRI	FHR Test, section B 4.3.2.4

There is some variance in temperature rise assumptions across the industry; for the purposes of this pilot, we assumed a 90°F rise.

MAXIMUM HOT WATER DELIVERY

The team compared various A.O. Smith residential and commercial models to better understand how different tank sizes can support small light-duty commercial applications, since they are a recognized brand with a good recovery rate. The A.O. Smith CAHP-120 commercial water heater is designed with a 119-gallon storage tank and features a heat pump and dual 6 kW electric elements. This water heater offers three distinct modes of operation: electric element only, heat pump heater only, and hybrid mode. The CAHP-120 can deliver 49 gallons per hour in the electric element-only mode for a 100°F temperature rise. Operating in heat pump heater-only mode provides 50 gallons per hour for the same temperature rise. In hybrid mode, where both the electric elements and the heat pump work together, the capacity increases significantly to 99 gallons per hour.

The A.O. Smith HPTS-80 HPWH comes with an 80-gallon storage tank and is equipped with a heat pump and dual 4.5 kW electric elements. This model is designed to efficiently meet the hot water needs of various commercial applications, leveraging the heat pump technology to maximize energy savings while ensuring a reliable hot water supply.

Both models are engineered to cater to different commercial water heating requirements, offering flexibility in operation modes to optimize performance and energy efficiency. The CAHP 120, with its larger tank and higher capacity in hybrid mode, is suitable for applications with higher hot water demands, while the HPTS-80 provides a more compact solution with efficient heat pump technology.

Table 12: Recovery capacities (recovery rate in gallons per hour).

Mode of Operation	Output		Temperature Rise °F												
	BTU/h	kW	F	30	40	50	60	70	80	90	100	110	120	130	140
			C	17	22	28	33	39	45	50	56	61	67	72	78
Efficiency	41,669	12.2	GPH	169	126	101	84	72	63	56	50	46	-	-	-
			LPH	638	478	382	318	272	238	211	190	173	-	-	-
Hybrid	82,615	24.2	GPH	334	250	200	167	143	125	111	99	91	-	-	-
			LPH	1265	948	757	630	540	472	419	377	343	-	-	-
Electric	40,946	12	GPH	166	124	99	83	71	62	55	49	45	41	38	35
			LPH	627	470	375	312	267	234	208	187	170	156	144	134
			Density (lb/gal)	8.24	8.25	8.26	8.27	8.28	8.29	8.30	8.30	8.30	8.29	8.28	8.27
			Stored Energy (BTU)	23,531	31,416	39,318	47,237	55,171	63,119	71,079	79,073	86,875	94,679	102,460	110,219
			Inlet (F)	110	100	90	80	70	60	50	40	40	40	40	40
			Outlet (F)	140	140	140	140	140	140	140	140	150	160	170	180

The A.O. Smith water heater's hybrid mode has double the capacity of the electric-only and heat pump-only modes (Table 12), showcasing its enhanced power. Interestingly, the efficiency mode (heat pump heater only) does not outperform the electric-only mode in capacity, which might be surprising given the expectation of higher efficiency. Additionally, there are noticeable data gaps when comparing residential units with commercial applications, indicating a need for more comprehensive data to understand performance across different settings fully.

RESIDENTIAL VS. COMMERCIAL HPWH PERFORMANCE

To better understand how residential and commercial HPWHs can serve the smaller commercial building sector, the team compared various A.O. Smith models to determine the maximum hot water each model can provide. Table 13 highlights the performance metrics of different A.O. Smith water heater models across various modes, focusing on their storage volume, recovery rate, and overall water delivery capacity. The team intends to expand this list to include other major manufacturers as the study progresses.

Table 13: Comparing A.O. Smith residential and commercial HPWHS to determine maximum hot water outputs.

Mode	Brand	Model #	FHR (gal)	Storage Volume (gal)	Recovery Rate at 90°F rise (GPH)	GPD Delivery at 90°F rise	Max Gallons Per Year	Peak GP2H
Dual (hybrid)	A.O. Smith	CAHP-80	95	81	28	753	274,845	137
Heat pump only	A.O. Smith	CAHP-120		119	56	1,463	533,995	231
Dual (hybrid)	A.O. Smith	CAHP-120		119	111	2,783	1,015,795	341
All electric	A.O. Smith	CAHP-120		119	55	1,439	525,235	229

Note: This data compares FHR, storage volume, recovery rate, gallons per day, and gallons per year to determine the maximum amount of hot water each HPWH can provide.

Depending on the amount of hot water needed for smaller commercial establishments, one or two light-duty HPWHs may provide the necessary amount of hot water for a building to serve its function. Table 14 shows the maximum hot water demand for different building types. The team assessed whether one or two 80-gallon HPWHs can meet the hot water needs or if a 120-gallon unit is required. For this analysis, the team assumed 50,000 square feet for each building type and multiplied the hot water usage from the eTRM to provide the maximum hot water consumption.

Table 14: Maximum hot water demand by building type.

Building Type (eTRM)	Hot Water Consumption (gallon/y)	Max. Square Feet Served (80-gallon HPWH)	Max. Square Feet served (2x 80-gallon HPWH)	Max. Square Feet served (120-gallon HPWH)
Assembly	1,280,000	10,736	21,472	39,679
Community college	434,500	31,628	63,255	116,892
Conditioned storage	11,500	1,194,978	2,389,957	4,416,500
Fast food restaurant	1,604,000	8,567	17,135	31,664
Grocery	530,000	25,929	51,858	95,830

Building Type (eTRM)	Hot Water Consumption (gallon/y)	Max. Square Feet Served (80-gallon HPWH)	Max. Square Feet served (2x 80-gallon HPWH)	Max. Square Feet served (120-gallon HPWH)
Hospital	1,349,500	10,183	20,366	37,636
Hotel	915,000	15,019	30,038	55,508
Hotel guest room[59]	523,000	26,276	52,552	97,112
Large office	108,000	127,243	254,486	470,275
Motel	167,500	82,043	164,087	303,222
Nursing home	920,000	14,937	29,874	55,206
Primary school	287,000	47,882	95,765	176,968
Refrigerated warehouse	112,000	122,699	245,397	453,480
Relocatable classroom	647,500	21,224	42,447	78,440
Retail - multistory large	39,000	352,365	704,731	1,302,301
Retail - single-story large	22,500	610,767	1,221,533	2,257,322
Secondary school	426,500	32,221	64,442	119,085
Small office	99,000	138,811	277,621	513,028
Small retail	126,500	108,634	217,269	401,500
University	368,000	37,343	74,686	138,016
University dormitory	396,500	34,659	69,318	128,095

Note: This table assesses the maximum hot water demand for different building types to determine whether an 80-gallon or 120-gallon HPWH can adequately meet the building's hot water needs.

Educational Institutions
Primary schools have an annual hot water consumption of 287,000 gallons, allowing a single 80-gallon HPWH to serve up to 47,882 square feet. This capacity doubles with two 80-gallon HPWHs and significantly increases with a 120-gallon HPWH. Secondary schools and community colleges have higher hot water consumption (426,500 and 434,500 gallons/year, respectively), resulting in lower maximum square footage served per HPWH capacity. Universities, with slightly lower hot water consumption (368,000 gallons/year), can serve more square footage with a single 80-gallon HPWH compared to secondary schools and community colleges.

Commercial and Hospitality
Grocery stores have moderate hot water consumption of 530,000 gallons/year, with a single 80-gallon HPWH serving 25,929 square feet. With the highest hot water consumption (1,604,000 gallons/year), fast food restaurants have the lowest maximum square footage served per HPWH capacity. Hotels, with a hot water consumption of 915,000 gallons/year, and motels, with significantly lower consumption (167,500 gallons/year), show that motels can serve a much larger square footage per HPWH capacity.

Healthcare and Residential
Hospitals, with high hot water consumption of 1,349,500 gallons/year, have a low maximum square footage served per HPWH capacity. Nursing homes, with hot water consumption of 920,000 gallons/year, have similar maximum square footage served per HPWH capacity as hotels. University dormitories, with hot water consumption of 396,500 gallons/year, allow a single 80-gallon HPWH to serve 34,659 square feet.

Retail and Office Spaces
Small retail spaces and offices, with relatively low hot water consumption (126,500 and 99,000 gallons/year, respectively), can serve a large square footage per HPWH capacity. Large single-story and multistory retail spaces, with very low hot water consumption (22,500 and 39,000 gallons/year, respectively), yield the highest maximum square footage served per HPWH capacity.

Specialized Facilities
Refrigerated warehouses and conditioned storage facilities, with low hot water consumption (112,000 and 11,500 gallons/year, respectively), can serve extremely large square footage per HPWH capacity.

KEY TAKEAWAYS
Educational institutions typically have higher hot water consumption, which results in a lower maximum square footage served per HPWH capacity. With the greatest hot water consumption, fast food restaurants and hospitals also have the lowest maximum square footage served per HPWH capacity. In contrast, retail and office spaces, especially larger buildings, have the lowest hot water consumption, allowing them to serve the largest square footage per HPWH capacity. Specialized facilities, such as refrigerated warehouses and conditioned storage, can serve the greatest square footage due to their minimal hot water consumption. These trends highlight the varying demands for hot water across different building types and the corresponding capacity requirements for HPWHs to meet these needs efficiently.

While residential HPWHs can meet the needs of smaller commercial establishments, the second-hour performance is a crucial factor. This rating measures the amount of hot water a heater can deliver in the second hour of operation, after the initial supply has been depleted. It provides a reliable measure of a water heater's performance during extended use, making it essential for planning and sizing hot water needs in smaller commercial settings.

Analysis of Water Heater Performance

The first-hour rating (FHR) gives insight into hot water performance across different building types and is an evaluation criterion to ensure that an HPWH can meet the needs of the building type. The FHR takes into consideration the tank capacity of the water heater as well as the recovery rate, which indicates how quickly the water in the tank heats up. This metric is crucial for determining whether the water heater can meet the peak demands of a specific building type.

Table 15: Count of water heater types.

Heater Type	Water Heater Type	Unit Count	Percentage	Avg. UEF	Min. UEF	Max. UEF
Instantaneous	Electric resistance	328	26.4%	0.94	0.82	0.98
Instantaneous	Gas/propane	915	73.6%	0.91	0.81	0.98
Storage	120V heat pump	68	1.8%	3.10	2.80	3.46
Storage	240V heat pump	495	13.0%	3.73	3.34	4.07
Storage	Electric resistance	993	26.1%	0.92	0.81	0.95
Storage	Gas/propane	2,242	29.0%	0.65	0.54	0.93

Table 15 provides a look at data gathered from AHRI on heater types, their unit counts, and average UEF. As expected, counts of 120V or 240V HPWHs are lower than those of electric resistance (ER) or gas/propane water heaters, but HPWHs' UEFs are approximately four times higher. A higher UEF means that the technology performs with higher energy efficiency, indicating why a switch from electric resistance or gas water heaters would be beneficial.

FIRST-HOUR RATING PERFORMANCE METRIC

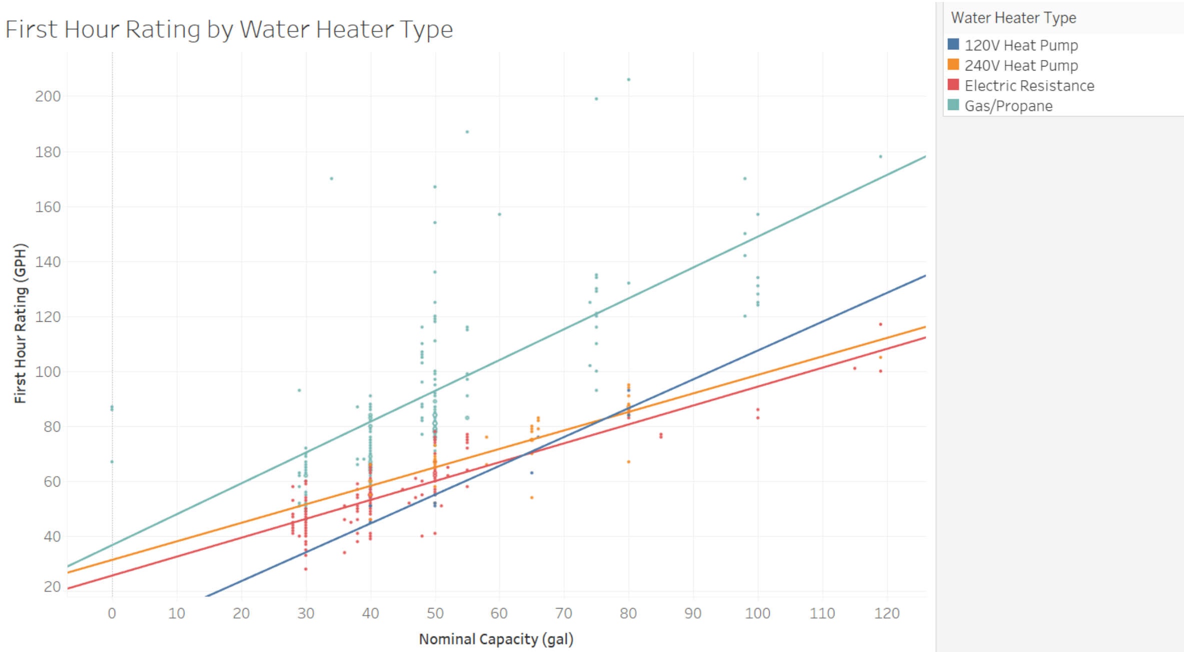

Figure 6: First-hour rating performance metric.

Storage water heater types perform differently, with the storage capacity of the water heater being one of the main variables. For instance, as seen in Figure 6 above, gas water heaters have the highest FHR at any capacity. 120V HPWHs have the lowest FHR until nominal capacity exceeds 70 gallons; then they start to perform comparably with the 240V counterparts and electric resistance water heaters, but not the gas water heaters. The average FHR for a 50-gallon gas water heater is 88 GPH, and if that water heater were to be replaced, that would require at least an 80-gallon HPWH and possibly a 119-gallon unit if water usage is on the higher side. Upsizing is required if an HPWH needs to meet the same standards as a lower-capacity gas water heater. Replacing electric resistance water heaters, however, should not require upsizing; a 240V HPWH is almost always a good replacement for electric resistance water heaters at any capacity.

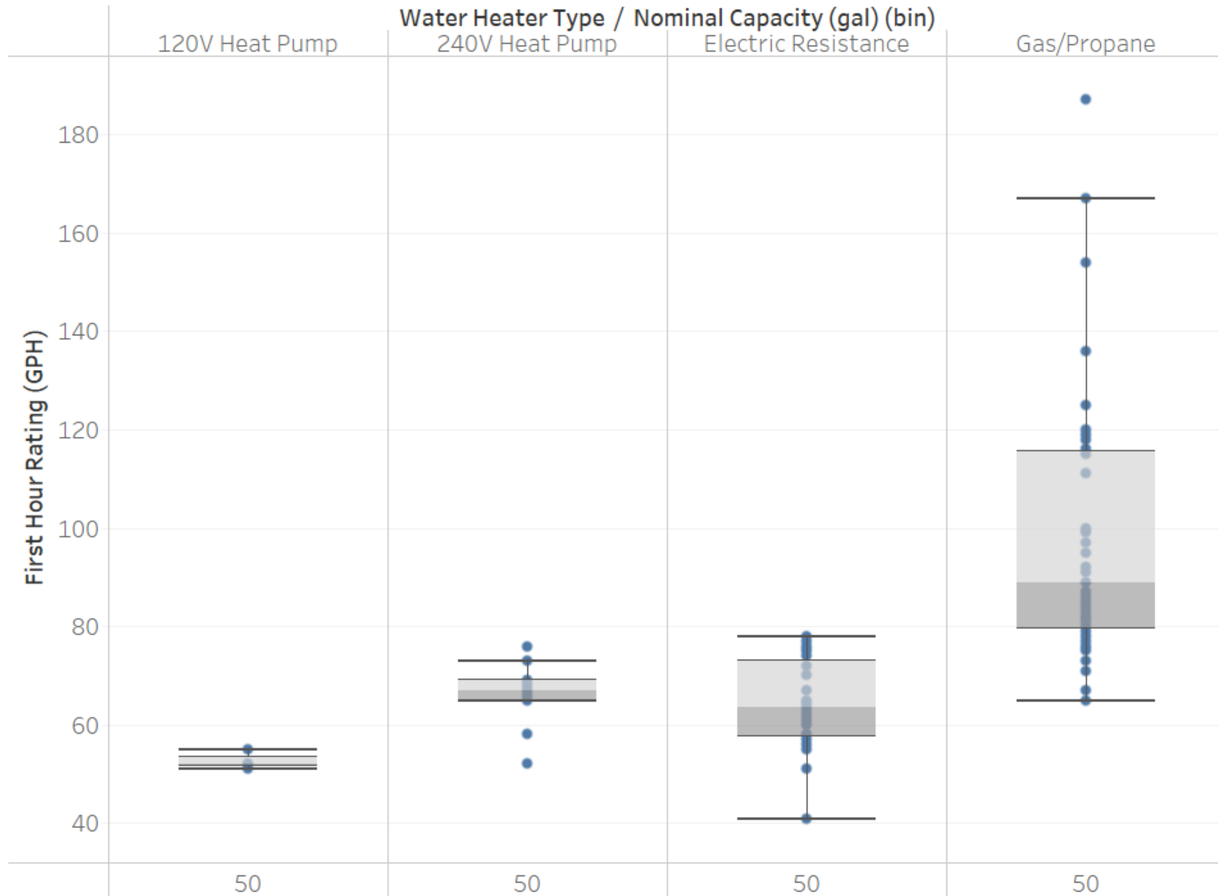

Figure 7: First-hour rating by water heater type.

Note: This figure is broken down by 50-gallon 120V heat pump, 240V heat pump, electric resistance, and gas water heater.

Figure 7 above considers only 50-gallon storage water heaters and compares the FHR across water heater types. This data illustrates the range of performance of 50-gallon water heaters. The electric resistance water heaters and HPWHs perform in a relatively narrow range, but the gas units have a much wider range of performance. The gas types have a huge range of first-hour ratings, from 65 GPH to 187 GPH. Over 75 percent of the gas units can provide more hot water during the first hour of operation than all of the rated 50-gallon water heaters powered by electricity. The gas input rate of these gas units plays a major role in how large their FHR is. As the input rate increases, so does the FHR of these units, as more gas corresponds to more hot water.

TWO-HOUR PEAK

The two-hour peak is crucial for determining hot water performance in commercial buildings because it represents the maximum hot water demand the system must handle within a short period. This metric is essential for several reasons.

Firstly, the two-hour peak significantly impacts capacity planning. It helps to appropriately size the water heating system to ensure it can meet the highest demand periods without running out of hot water. This is particularly important in commercial settings where hot water usage, such as restaurants, hotels, or gyms, where can be intense and concentrated.

Secondly, understanding peak demand allows contractors to recommend a system that would meet these building characteristics. This can prevent oversizing, which leads to higher initial costs and reduced efficiency during regular operation. By accurately sizing the system, engineers can ensure it runs optimally, balancing cost and performance.

User satisfaction is another critical aspect influenced by the two-hour peak. Ensuring the system can meet peak demand helps maintain user satisfaction by providing a consistent hot water supply, even during the busiest times. This is important in commercial buildings where a lack of hot water can disrupt operations and negatively impact customer experience.

Lastly, accurate peak demand data allows for better energy management. It can help implement energy-saving measures, such as load shifting or more efficient heating technologies during peak times. This can save energy and reduce operational costs, making the system more sustainable and cost-effective.

To fully understand the commercial market potential for light-duty HPWHs, the team developed an initial comparison of data from ComStock and the eTRM to determine the two-hour peak.

Table 16 presents values extracted from ComStock and the eTRM. The team evaluated the square footage of buildings from both datasets to assess their comparability. Since the eTRM provides an average square footage for each building type, it can be challenging to determine the smaller square footage for each type. For instance, a refrigerated warehouse with 100,000 square feet is unlikely to be served by a commercial HPWH, whereas a 23,444-square-foot warehouse falls within the potential range for an HPWH. Similarly, a large office of 175,000 square feet is likely impossible for a light-duty HPWH, whereas a 19,532-square-foot office is. The team explored these two datasets to calculate two-hour peaks and determine the potential HPWH commercial market opportunity.

Table 16: Two-hour peak values from ComStock and the California eTRM.

eTRM Building Types[2]	eTRM[3]	eTRM Average Square Footage	eTRM Peak GPH[4]	ComStock Building Types Stock	Building Size (ft^2)
Secondary school	1542	149,859	771	Secondary school	24,831
Hotel	458	78,931	229	Large hotel	26,810
Primary school	334	48,240	167	Primary school	33,056
Large office	315	175,000	158	Large office	19,532
Sit down restaurant	190	2,000	95	Full-service restaurant	9,517
Motel	130	59,973	65	Small hotel	22,715
Fast food restaurant	110	4,000	55	Quick service restaurant	3,247
Refrigerated warehouse	83	100,000	42	Warehouse	23,444
Department store	68	120,000	34	Retail strip mall	20,901
Big box retail	38	130,502	19		
Small office	18	10,000	9	Small office	8,402
Small retail	16	8,000	8	Retail standalone	21,355

From the ComStock data, we calculated the average two-hour water heating energy against the maximum two-hour water heating energy to determine a ratio of intensity between the average and the maximum requirements for each building type. We used this assumption with the eTRM building data, including size and average and peak water demand, to calculate the system's maximum water heating energy required.

LIGHT-DUTY HPWH RECOVERY RATES

Table 17Obtaining detailed and reliable sources for water heater performance is important to support contractors in comparing and selecting a properly sized water heating solution for commercial buildings. Recovery rate is one of the most critical performance metrics that

[2] The eTRM reports average building values in the documentation.
[3] Peak gallons over two hours
[4] Peak gallons over one hour

manufacturers can provide, which can allow a contractor to not only understand the maximum capacity the water heater can supply in the first hour, but also for more extended continuous use—such as over two-, six- and twenty-four-hour periods.

Depending on available manufacturer data,[6] two approaches may be used to calculate the extended water heater performance.

Recovery rate is typically reported as the number of gallons of water the heater can raise to the desired hot-water temperature in one hour, starting from cold water. If the recovery rate is available, as it was for the models evaluated in Table Table 13, then the extended performance can be estimated with the following calculation:

Extended performance: First-hour rating (FHR) + recovery rate x extended period in hours.

If not reported, a water heater's recovery rate can be calculated by multiplying the maximum heat input by its efficiency transferring heat into the water, divided by the amount of energy needed to heat a gallon of water to a standard temperature rise. However, there are significant gaps in the consistency of water heater performance metrics based on required reporting for different federal standards, test procedures and regional specifications. Examples of these inconsistencies and necessary water heater performance metrics for calculating recovery rates and extended performance are highlighted in Table 17.

AHRI and EPA ENERGY STAR residential water heater product lists and DOE commercial gas and oil-fired storage water heater product lists represent the most comprehensive source for reporting water heater performance for calculating recovery rates. However, requirements for reporting certain performance metrics vary based on sector (residential vs. commercial) and water heater type. Alternatively, NEEA reports performance based on the water heater configuration and system efficiency (SysCOP). NEEA provides the SysCOP for different climate zones, which is useful for evaluating performance in specific applications.

Table 17: Data sources and inputs for calculating second-hour performance.

Data Source	Volume	First-Hour Rating	Input (kW or Btu/hour)	Recovery Efficiency %
AHRI Residential Water Heater Certified Product List	X	X	X	X
NEEA Commercial/Multifamily HPWH Systems Qualified Products List				
ENERGY STAR Certified Heat Pump Water Heaters Product List	X	X	X	X
ENERGY STAR Certified Commercial Water Heaters Product List	X		X	
Commercial Instantaneous Water Heaters and Hot Water Supply Boilers	X		X	X
Commercial Electric Storage Water Heaters	X			
Commercial Gas and Oil-Fired Storage Water Heaters	X	X	X	X

While volume (gallons) is typically available across the industry product lists, NEEA only presents the configuration of the unit and system efficiency (SysCOP). However, NEEA does provide the SysCOP by climate zone, so this data is very useful in certain applications. Regarding performance metrics, the remainder of the product lists vary in the values presented, as this is often tied to sector (residential vs. commercial) and water heater type. AHRI appears to have the most complete list of performance metrics published for their certified models.

Summary

The Engineering Analysis sought to gather information on the general market for HPWHs by defining suitable commercial buildings, determining their commercial requirements, and understanding water heater performance across fuel types.

Using a subset of the NREL ComStock metadata, the team evaluated the building types based on their number of potential installations, hot water consumption, electricity savings potential, and natural gas savings potential. With all of those metrics in mind, small offices, warehouses and quick service restaurants stand out as potential targets for conversion to light-duty HPWHs.

By comparing water heater models from leading manufacturers, the team was able to determine that light-duty HPWHs can serve smaller commercial buildings. Establishments with high hot water consumption (e.g. educational institutions, fast food restaurants, and hospitals) are better served by larger unitary or split system HPWH designs. Those with lower hot water consumption (e.g. retail and office spaces) would fare better as targets for light-duty HPWHs.

To get a better depiction of what HPWHs can effectively replace existing water heaters, the project team analyzed the recovery rates and first hour ratings of several types of water heaters. This analysis showed that even with their high UEF ratings, light- duty HPWHs cannot provide the same performance as gas water heaters without tank upsizing. In the case of replacing an existing electric resistance water heater, light-duty HPWHs can replace ER water heaters without any tank size increases.

Market Characterization

Site Interactions

The team recruited sites through:

- Outreach to contractors
- Outreach to CBOs
- Collaboration with TECH Clean California
- Word of mouth

OUTREACH TO CONTRACTORS

The project team used The Switch Is On website to collect 84 TECH Clean California–qualified contractors from across California for outreach. These contractors were emailed an overview of the pilot, benefits to participating, and a call to action to sign up to participate in the pilot. Of 84 contractors contacted, 18 filled out the form to indicate their interest in participation. Multiple follow-up emails were sent to the remaining 66 contractors, but participation did not increase. Each of the 18 contractors was sent an interview request, and the project team scheduled sessions with 4 of them. Those who were able to meet seemed enthusiastic about the pilot and its offerings and, through them, we have identified CBOs in need of an HPWH installation.

The contractors were asked a couple of questions when signing up for the pilot. With the 18 that signed up, it was indicated that, in total, 59 percent of the work that they do is in the residential sector. This is close to showing an even split but indicates that a preference for residential work. It may also show that there are gaps in commercial understanding that allow for residential preference. Our intervention of working with contractors to promote participation proved mostly unsuccessful. Although some contractors were interested in the pilot and looked for eligible sites, many opted out if they weren't provided directly with project leads.

OUTREACH TO COMMUNITY-BASED ORGANIZATIONS

In partnership with the Tech Clean California team, the Focused Pilot team reached out to CBOs that have participated in the TECH program. The project team contacted 15 CBOs to make them aware of the pilot and the incentive offering. Of the 15, 7 replied showing interest in the pilot. However, there are currently no proposed sites from these CBOs.

A portion of those contacted could not go further with the pilot unless the entire project was paid for, even though the HPWHs we were offering would have been sufficient to replace their existing water heater. As it turns out, CBOs typically do not place electrification as a priority unless they have dedicated teams. It is likely that CBOs uninterested in electrification are not conducting their own research either. However, our intervention with conducting outreach to CBOs was successful because we found churches interested in electrification work.

TECH CLEAN CALIFORNIA COLLABORATION

The TECH Clean California team offers non-residential HPWH incentives, and we reached out specifically to contractors participating in that aspect of the TECH Clean California program. Because the TECH Clean California program is not a resource program, their incentives could stack with the Focused Pilot incentives. The Focused Pilot has not identified any sites through this channel yet.

WORD OF MOUTH

Word of mouth has been an unexpected but strong communication pathway for prospective sites. Once the Focused Pilot team or one of our engaged contractors spoke to a site, we observed multiple instances of those CBOs knowing other CBOs in their community that could benefit from the offering. This spread of information led to three other sites reaching out to request more information about the pilot. None of them have signed a participation agreement yet, but they have shown major interest in taking part in the pilot. The project team conducted a call with one of the CBOs that indicated they would like to install two HPWHs. They did not have any contractors within their network, so to ensure their participation, we gave them contractor contacts within their area. This CBO also made us aware they intended to let others in their network know of this opportunity, hopefully resulting in more participation.

Site Installations

HPWHs were installations at two CBO sites; each site was a church community campus consisting of multiple buildings beside the church. Both sites wanted two of their water heaters replaced, leading to four HPWH installations. Both churches had an electrification team that worked with their contractor to identify which HPWHs should replace their existing gas water heaters. Two contractors that installed the units at both sites.

CBO SITE #1, EQUIPMENT #1

The first church had its HPWH installation on September 17, replacing a 40-gallon gas water heater with a 50-gallon HPWH. The location of the original WH was in a small basement under one of the buildings of the church's campus. Prior to the installation, the electric panel for the building was upgraded to have the appropriate capacity to sustain the new technology. The doorway leading to the basement was too small to have the HPWH fit through it, so the door jambs were removed prior to installation. Once inside, the space was sufficient to fit the new HPWH, but the location had to be adjusted about 10 feet to fit the height of the HPWH given it was taller than the original gas water heater.

The potential savings from this installation were:

- Electric: –12,900 kWh
- Gas: 1,450 MBtu/h
- Total Resource Cost (TRC): $11,629.61
- Total System Benefit (TSB): $16,541.49

CBO SITE #1, EQUIPMENT #2

Within the campus of the same church, another building needed to have its water heater replaced. A 199,900 BTU outdoor vent tankless gas water heater was replaced with an 83-gallon HPWH on

September 25. This building also required electrical panel upgrades to have the capacity for the HPWH. The old water heater was located outside the building it provided hot water to. The new unit is a split system that has a component placed on the wall and it's tank placed on a concrete pad.

This installation consists of an ineligible HPWH due to measure package limitations and therefore could not have its potential savings calculated. This topic is covered in the Measure Package Review section below.

CBO SITE #2, EQUIPMENT #1

The second church was informed of the pilot because they were in the network of the prior church. They had their first HPWH installation take place on September 23, replacing a 40-gallon natural gas water heater with a 50-gallon HPWH. Electrical panel upgrades were made prior to the church participating in the program due to them already preparing for electrification. The previous panel upgrade meant that only a 30-amp 240V circuit needed to be installed in the utility room sub-panel for the HPWH installation. Outside but still connected to the church's kitchen, there is a small utility room that housed their old water heater. The space provided enough room for the replacement HPWH, but an old furnace had to be removed from the room.

The potential savings for this installation are:

- Electric: –12,900 kWh
- Gas: 1,450 MBtu/h
- TRC: $11,629.61
- TSB: $16,541.49

CBO SITE #2, EQUIPMENT #2

This church also needed to upgrade the water heater that served their bathrooms. On September 29, the contractor replaced a 30-gallon gas water heater from 1977 that was already broken with a 40-gallon 240V HPWH. Prior to the installation, a 30-amp 240V circuit was installed in the utility closet between the bathrooms. There was enough space within the room that housed the old water heater for the HPWH to be installed.

The potential savings for this installation are:

- Electric: –12,900 kWh
- Gas: 1,460 MBtu/h
- TRC: $11,708.38
- TSB: $16,726.54

SUMMARY

These four HPWH installations were accomplished due to the network of church CBOs the project team identified. A common theme among all the installations is that there had to be some electrical upgrades done to support the HPWHs. Both churches installed low-GWP HPWHs to align with their climate goals. There were some space constraints, but those problems were relatively minor. It is worth noting that all four of these installations layered incentives with the TECH Clean California program. Both CBOs were heavily reliant on the incentives provided by the programs because of the high cost of everything included in the project, such as equipment, upgrades, and associated labor.

Contractor Interactions

Contractors who were interested in the pilot completed a form prior to participating. In this form, their familiarity with commercial HPWHs was surveyed. Out of the 16 contractors who signed up for the pilot, 59 percent of the work they do is in the residential sector. While not towering over the percentage of commercial work, this suggests a preference for residential opportunities and therefore preference for residential HPWH knowledge.

INITIAL INTERVIEW

While coordinating with participating contractors, we requested interviews prior to having them install the HPWHs. This was done to determine a baseline of their HPWH knowledge and to get an understanding of their experience with this technology prior to participating in the pilot. The project team has conducted interviews with contractors and followed up with these contractors to evaluate whether participating in this pilot has helped increase their knowledge on HPWH installations, replacements, and applications.

CONTRACTOR PROCESS FOR HPWH INSTALLATION

During the interview, contractors were asked how they evaluate a site for an HPWH installation. They made the following points:

- Some contractors match their suggested water heater solutions based on business needs by using flow meters to document their water usage.
- Contractors may also check the customers' energy bills and use the middle of summer as a gauge, given they are not likely to use gas for heating the home or business at that time.
- Current water heater storage capacity is also a factor in determining what size water heater to install.

EXPERIENCE INSTALLING HPWHS IN A COMMERCIAL SETTING

While many contractors had little to no experience installing HPWHs commercially, one contractor was well-versed and a strong advocate for the technology in those spaces. Only one of the contractors interviewed had little to no knowledge of HPWH installations, commercially or residentially. This was due to a language barrier that limited overall familiarity with the technology.

CONTRACTORS WITH EXPERIENCE IN THE LAST 12 MONTHS

Contractors stated that the installations themselves typically take a couple of hours, but more complex commercial jobs can take longer. The contractors also stated that any units under 85 gallons were considered “small commercial.”

COMMON BARRIERS TO INSTALLATION

During the interview, contractors pointed out additional barriers to HPWH installation:

- Some meters don’t have the existing power to handle the appropriate size of HPWH that needs to be installed.
- If pulling a permit is required, that can be another obstacle for the installing contractor, given permitting can take up to six to eight months in select California areas.
- Timing is the driving force behind common hurdles for HPWH installations.
- Business operation hours of commercial areas can greatly affect the timeline of the project because the availability of contractors might conflict with those hours.

- Physical space constraints and distance between the equipment and the breaker/electrical panel all account for typical barriers, which cause contractors to be wary of replacing existing gas water heaters with an electric HPWH.

PILOT PARTICIPATION

Both contractors who participated in the pilot provide service to the East Bay area and, prior to the pilot, had completed a combined total of five HPWH installations in the residential sector. Their participation showed that small, residentially focused plumbing contractors are interested in expanding to small commercial customers. Coming out of the installations, both contractors stated their level of comfort with HPWHs grew, and they were open to pursuing more small commercial projects.

The contractors projected that the main barrier they would experience pushing for HPWHs in the market would be the initial cost of the equipment. For example, one of the HPWHs installed during this pilot had a total cost of $14,000, whereas its gas counterpart would have been $3,000 to $5,000. End users who need a water heater are going to be less inclined to electrify if first costs are too high. Both participating CBOs said they were only able to go through with upgrading at this time due to the CalNEXT incentive. If the cost of the HPWH had not been covered, the installations would not have occurred.

Overall, the contractor feedback regarding their experience with the pilot was positive. They appreciated the opportunity to increase their understanding of small commercial HPWH applications and are interested in training opportunities that would provide more hands-on experience with these installations.

Manufacturer Interviews

To better understand the market for HPWH in California, we conducted interviews with two manufacturers and one engineering firm as well as a hot water control and recirculation systems specialist, all with extensive portfolios of business in California. The companies interviewed represent prominent actors in the water heating industry in our target market and provided valuable insights for this pilot research.

Several themes emerged across the interviews we conducted:

ELECTRIC RESISTANCE TO HPWH CONVERSIONS IS EASIER THAN GAS TO HPWH CONVERSIONS

This is largely due to not needing electric service upgrades, which add cost and create more logistical challenges for contractors. One interviewee noted tankless water heaters as a particularly promising fit for HPWH conversions.

SPACE AND AIRFLOW REQUIREMENTS FOR HPWH CAN MAKE RETROFITS CHALLENGING

Even when a smaller commercial building is otherwise well-suited for an HPWH, the location of existing water heaters can make HPWH replacements difficult. If rooms where existing water heaters are located are too small or far away from power outlets to work well for HPWH, the HPWH may need to be installed in a new location, which often increases project complexity and cost.

120V HPWH ARE NOT A PREFERRED SOLUTION IN COMMERCIAL BUILDINGS

While a 120V HPWH can be a promising application in many settings, interviewees noted that recovery times for these systems are generally too long to reliably serve the needs of commercial buildings and businesses.

NEW LIGHT COMMERCIAL HPWH PRODUCT OFFERINGS ARE IN DEVELOPMENT

The current assortment of light-duty HPWHs are effectively residential models labeled for commercial use. These models use the same heat pump across multiple tank sizes, limiting the recovery rates necessary for some commercial buildings and business applications. Manufacturers indicated that new HPWH products are currently in development to meet this need. These new products may change the existing market landscape and provide better options for small commercial buildings.

RECIRCULATION WITH AN HPWH CAN BE COMPLICATED AND MAY NOT ALWAYS BE A GOOD SOLUTION FOR MAINTAINING TEMPERATURE

Interviewees added that flow rates and mixing valves often do not match up for HPWH, that different recirculation strategies can be needed depending on the application, and recirculation can lead to the HPWH running more often than is needed.

FAILED HEALTH DEPARTMENT INSPECTIONS FOR HPWH

Interviewees recounted multiple instances where local health departments failed inspections at businesses because HPWH did not produce adequately high water temperatures or because local codes do not recognize HPWHs as a source of hot water in commercial applications, and HPWH units were subsequently replaced. Additionally, this was noted as a problem in permitting offices as well, and there is no current standardized process across all jurisdictions.

CORRECT SYSTEM SIZING IS CRITICAL TO HPWH INSTALLATIONS, ESPECIALLY WHEN CONVERTING FROM GAS WATER HEATING

Interviewees noted that most gas water heaters are well-oversized, and installers need to ask the right questions to calculate the correct system size. According to one interviewee, 120 percent of peak demand is a good rule of thumb to account for unusual usage, and "nobody complains about having too much hot water." In general, manufacturers noted that teaching proper installations is critical and remains an ongoing challenge to wider HPWH adoption.

Measure Package Review

The review of the SWWH027-06 measure package showed the limitations in tank upsizing. It is assumed that 30- to 50-gallon gas water heaters could all be replaced by an HPWH between 45 and 55 gallons. As seen in Table 17, the engineering analysis shows that HPWH capacities need to be much larger to compare with base case gas FHR. Not only do these base cases have separate ranges, the average HPWH replacement for both cases is outside the ranges listed within the measure packages.

Table 17: Measure package vs. engineering analysis findings.

Base Case Capacity (gal)	Allowed Measure Case Capacity (gal)	Engineering Analysis Findings 120V (gal)	Engineering Analysis Findings 240V (gal)
30	≥ 45 to ≤ 55	65	60
40	≥ 45 to ≤ 55	80	80
50	≥ 45 to ≤ 55	N/A	90
60	> 55 to ≤ 75	N/A	110
75	> 75	N/A	>120

The SWWH028-07 measure package does something similar. Table 18 shows that for its minimum UEF rating, the range for HPWHs is 75 ≤ to < 100 gallons. The project team found in the AHRI and ENERGY STAR QPLs that there are UEF-rated HPWHs available in the market that go up to 120 gallons. The current measure package excludes HPWHs that are over 100 gallons, limiting the potential participation of a subsection of the market.

This analysis of the current measure packages proves the barrier they pose to commercial HPWH adoption. The current measure packages do not provide the necessary upsizing required to sufficiently replace gas water heaters. Under the current measure packages, one of the four projects' HPWHs would not have been applicable to be installed. The 199,900 Btu outdoor vent tankless gas water heater could not be replaced with the SANCO2 83-gallon HPWH. This would have affected the participation, making it so that the required number of installations would not have been met.

Recommendations

Measure Package Update

SWWH031-05: Heat Pump Water Heater, Commercial

The project team's engineering analysis indicates that this measure package could be updated in the following ways:

- Minimum UEF requirement of 3.3 is higher than the UEF rating of 120V HPWHs. We recommend expanding measures to include lower UEF ratings to accommodate 120V HPWHs.

SWWH027-06: Heat Pump Water Heater, Commercial, Fuel Substitution

The project team's engineering analysis indicates that this measure package could be updated in the following ways:

- Use FHR to compare hot water volume usage characteristics between gas and HPWHs. The current measures assume hot water volume usage is primarily based on tank capacity.
- Minimum UEF requirement of 3.3 is higher than the UEF rating of 120V HPWHs. We recommend expanding measures to include lower UEF ratings to accommodate 120V HPWHs.
- Provide each gas base capacity with their own allowed range of HPWH replacements.
- Expand the allowed HPWH capacities above their current limitations because, to have similar performance characteristics to gas units, HPWHs need larger capacities.
    - E.g., 40-gallon gas water heater to 80-gallon HPWH.

SWWH028-07: Large Heat Pump Water Heater, Commercial and Multifamily, Fuel Substitution

The current allowed capacities for UEF-rated HPWHs are 75 ≤ to < 100 gallons. To align with market availability of the HPWHs, this measure package should include HPWHs up to 120 gallons, given they also meet the minimum efficiency requirements.

Contractor Education and Outreach

To ensure contractors step into the market prepared for complications that may arise, the project team will be providing resources and recommendations based on their findings. The recommendations include:

- Providing materials in multiple languages.
- Understanding appropriate HPWH replacements for existing electric resistance and gas water heaters.

Through our pilot intervention of working with contractors and CBOs, we learned that commercial contractors were busy and reluctant to change their sales processes, even with an incentivized unit. It took the pilot team working directly with CBOs to develop our projects, and these CBOs were actively pursuing electrification. These interactions might help us understand the limited commercial HPWH uptake in the statewide water heating program, which focuses on working through distribution. The midstream distributor program has proven successful for well-established technologies like HVAC rooftop units and food service equipment and plays a role in keeping commercial HPWH equipment in stock. Willdan's rapid rebates program works directly with end users and has seen more commercial HPWH uptake than the midstream program. HPWHs in a commercial setting are less established and appear to need contractor and end-user engagement to increase uptake. Once contractors are more familiar with the technology in commercial settings and are actively recommending it to customers who don't already know about it, programs focusing on distribution work may see increased participation.

Incentives

We recommend continued analysis of market sizing and incentive impact on naturally occurring market adoption (NOMAD) curve supported by Delphi Panel. Future incentive recommendations require additional data for sizing the market and projecting NOMAD. Quantifying historical market uptake and modeling NOMAD-estimated baseline data will require populating key parameters of start year, maximum penetration, a coefficient of growth, and a coefficient of imitation. An Initiative Review Committee should reference the following to establish an initial baseline projection over the life of the initiative: research and survey results from the pilot; research and review of published studies from industry associations, universities, and government publications; interviews with industry subject matter experts, distributors, or manufacturers; historical sales data from willing distributors and retailers; historical sales data from manufacturers; distributor and dealer surveys about the percentage of high-efficiency equipment sales, dealer stocking, and sales changes over time; and a formal Integrated System Planning Study. This could be measured over time through market actor surveys to document changes in stocking and sales of high-efficiency equipment.

See

Appendix C: NOMAD, Bass Diffusion Curve, and Delphi Panel Considerations for detailed recommendations on estimating NOMAD curve for HPWH, the formula and parameters to create a NOMAD baseline estimate, and recommendations for identifying industry experts for establishing a Delphi Panel.

A normal market adoption curve for commercial HPWHs would be informed by dozens of data inputs, including current technology adoption, installation and operating costs, consumer awareness, technology performance characteristics, utility program coverage, and fuel price forecasts. Many of our recommended data sources for these inputs informed the pilot report, including:

- California Energy Data and Reporting System (CEDARS) for data on HPWH incentive uptake
- Market research of previous HPWH studies to inform market barriers
- HPWH performance specifications (e.g. recovery rates) from HPWH manufacturers
- Interviews with market actors to inform consumer awareness and market barriers.
- California eTRM for average hot water consumption by building type
- NREL's ComStock database to inform the market opportunity by building type

Creating a NOMAD curve for commercial HPWHs would require these data sources and many more to properly inform the curve. However, we have identified existing data gaps that could make this process more difficult:

- Low number of baseline studies of HPWH in small commercial settings.
- Limited information on how the relationship between building owners and tenants impacts the suitability of HPWH in smaller commercial applications.
- Limited performance data for HPWH in commercial settings.

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Appendix A: Target Market Supplemental Information

The following tables show the progression of target market refinement as filters were applied to the dataset.

Filter 1: Fuel Type (Electricity and Gas)

The initial filter selected buildings that use electricity or natural gas for water heating, based on the primary service water heating fuel source. This ensured the dataset began with buildings to broadly align with most program interests.

Table 18: Filter 1: Fuel type (electricity and gas).

Building Type	Existing Electric Water Heating	Existing Natural Gas Water Heating	Grand Total
Full Service Restaurant	6,117	14,562	20,679
Hospital	149	1,684	1,833
Large Hotel	806	11,415	12,221
Large Office	1,932	1,734	3,666
Medium Office	6,738	5,460	12,198
Outpatient	3,296	3,623	6,919
Primary School	4,350	13,266	17,616
Quick Service Restaurant	4,275	7,328	11,603
Retail Standalone	33,782	22,692	56,474
Retail Strip mall	29,021	57,598	86,620
Secondary School	5,606	9,190	14,796
Small Hotel	2,370	6,195	8,565
Small Office	50,544	27,667	78,211
Warehouse	88,954	55,055	144,009
Grand Total	237,941	237,468	475,409

Filter 2: Single Tank Filter

Buildings with more than one water heater were excluded. This filter targeted simpler systems, assuming that single-tank configurations are most suitable for HPWH retrofits.

Table 19: Filter 2: Single tank.

Building Type	Existing Electric Water Heating	Existing Natural Gas Water Heating	Grand Total
Large Office	1,932	1,734	3,666
Medium Office	6,738	5,460	12,198
Outpatient	3,296	3,623	6,919
Quick Service Restaurant	4,275	7,328	11,603
Retail Standalone	33,782	22,692	56,474
Retail Strip mall	808	606	1,413
Small Hotel	2,370	6,195	8,565
Small Office	50,544	27,667	78,211
Warehouse	88,954	55,055	144,009
Grand Total	192,699	130,359	323,058

Filter 3: Recirculation Filter

Recirculation systems were identified using a derived metric: water heating intensity (kWh per cubic meter of water). Systems with intensity above 75 kWh/m³ were considered to have recirculation, indicating multiple heating cycles and higher energy losses. These buildings were removed to further focus on simpler systems.

Table 20: Filter 3: Recirculation filter.

Building Type	Existing Electric Water Heating	Existing Natural Gas Water Heating	Grand Total
Large Office	1,725	1,056	2,782
Medium Office	5,131	1,475	6,607
Outpatient	1,528	166	1,694
Quick Service Restaurant	4,275	7,328	11,603
Retail Standalone	7,574	22,692	30,266
Retail Strip mall	159	606	764
Small Hotel	2,370	6,195	8,565
Small Office	43,285	27,667	70,952
Warehouse	19,130	55,055	74,185
Grand Total	85,177	122,239	207,416

Filter 4: 24-Hour Draw Threshold Filter

ComStock timeseries data was used to analyze peak 24-hour hot water usage. Buildings with demand exceeding 740 gallons per day—beyond the capacity of a 65-gallon HPWH—were excluded. This ensured that selected buildings could be adequately served by standard HPWH units.

Table 21: Filter 4: 24-hour draw threshold filter.

Building Type	Existing Electric Water Heating	Existing Natural Gas Water Heating	Grand Total
Large Office	685	83	768
Medium Office	4,505	1,001	5,506
Outpatient	1,455	105	1,560
Quick Service Restaurant	4,269	7,328	11,597
Retail Standalone	7,574	22,692	30,266
Retail Strip mall	159	606	764
Small Hotel	2,355	6,150	8,505
Small Office	43,285	27,667	70,952
Warehouse	19,067	55,020	74,087
Grand Total	**83,353**	**120,651**	**204,004**

Filter 5: Six-Hour Performance Threshold Filter

A similar analysis was performed looking at a six-hour usage period. Buildings with demand above 236 gallons were filtered out, aligning HPWH capacity with usage patterns based on engineering analysis.

Table 22: Filter 5: Six-hour performance threshold filter.

Building Type	Existing Electric Water Heating	Existing Natural Gas Water Heating	Grand Total
Large Office	575	35	610
Medium Office	3,838	732	4,570
Outpatient	1,399	72	1,471
Quick Service Restaurant	3,622	6,482	10,103
Retail Standalone	7,572	22,692	30,264
Retail Strip mall	159	595	754
Small Hotel	2,339	6,097	8,436
Small Office	43,285	27,667	70,952
Warehouse	19,067	55,020	74,087
Grand Total	**81,854**	**119,392**	**201,246**

Filter 6: Second-Hour Performance Threshold Filter

Finally, buildings with peak two-hour usage above 124 gallons were excluded. This step confirmed short-term demand compatibility with HPWH performance, ensuring reliability during peak usage.

Table 23: Filter 6: Second-hour performance threshold filter.

Building Type	Existing Electric Water Heating	Existing Natural Gas Water Heating	Grand Total
Large Office	575	35	610
Medium Office	3,838	732	4,570
Outpatient	1,399	72	1,471
Quick Service Restaurant	3,622	6,482	10,103
Retail Standalone	7,572	22,692	30,264
Retail Strip mall	159	595	754
Small Hotel	2,339	6,097	8,436
Small Office	43,285	27,667	70,952
Warehouse	19,067	55,020	74,087
Grand Total	**81,854**	**119,392**	**201,246**

Table 24: Target market by building type and existing water heating fuel.

Building Type	Number of Small Commercial Buildings by Fuel Type		
	Electricity	Natural Gas	Total
Large Office	575	35	610
Medium Office	3,838	732	4,570
Outpatient	1,399	72	1,471
Quick Service Restaurant	3,622	6,482	10,103
Retail Standalone	7,572	22,692	30,264
Retail Strip mall	159	595	754
Small Hotel	2,339	6,097	8,436
Small Office	43,285	27,667	70,952
Warehouse	19,067	55,020	74,087
Total Buildings	**81,854**	**119,392**	**201,246**

Table 25: Target market by building type and existing water heating fuel, as percentage of total commercial building stock.

Building Type	Percentage of Small Commercial Buildings by Fuel Type		
	Electricity	Natural Gas	Total
Large Office	0.1%	0%	0.1%
Medium Office	0.8%	0.2%	1.0%
Outpatient	0.3%	0.0%	0.3%
Quick Service Restaurant	0.8%	1.3%	2.1%
Retail Standalone	1.6%	4.7%	6.3%
Retail Strip mall	0.0%	0.1%	0.2%
Small Hotel	0.5%	1.3%	1.8%
Small Office	9.0%	5.8%	14.8%
Warehouse	4.0%	11.5%	15.4%
% of Total Stock	**17.0%**	**24.9%**	**41.9%**

Table 26: Retrofit savings potential for buildings with existing electric water heating.

Building Type	Count of Buildings	Electricity Savings Potential (kWh)
Large Office	575	5,315,200
Medium Office	3,838	52,176,625
Outpatient	1,399	13,663,127
Quick Service Restaurant	3,622	24,495,859
Retail Standalone	7,572	15,850,399
Retail Strip mall	159	1,022,041
Small Hotel	2,339	8,546,830
Small Office	43,285	72,427,561
Warehouse	19,067	41,537,353
Grand Total	**81,854**	**235,034,995**

Appendix B: Marketing Materials

Contractor One-Pager

CalNEXT

Light Duty HPWH Pilot

Why are we offering this pilot?

Heat pump water heaters are being broadly adopted in the residential markets, but commercial adoption of the technology has not accelerated at a similar rate. This initiative addresses some barriers of commercial heat pump water heater adoption in the commercial market sector.

Through this pilot, contractors will have the opportunity to install up to three heat pump water heaters and gain experience with these units in a commercial setting. An engineering and market characterization study is simultaneously being conducted to provide contractors information on the best commercial buildings for light duty heat pump water heater installations.

Visit calnext.com/comm-hpwh or email apopp@energy-solution.com for more information about this pilot.

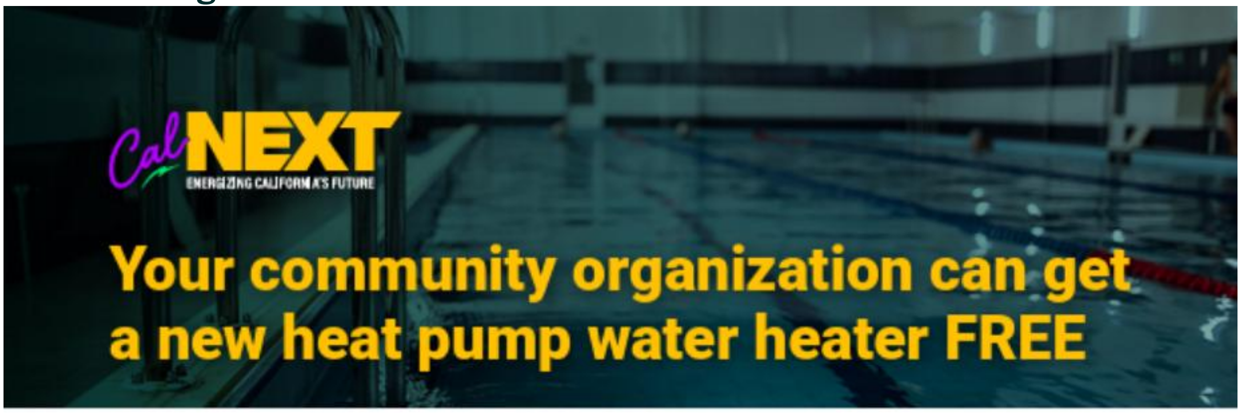
What you will need to do:

- ☑ Submit the enrollment form to tell us you want to participate.
- ☑ Identify commercial sites (community centers, cultural centers, places of worship, etc.) that would benefit from a light duty heat pump water heater.
- ☑ Confirm site eligibility with CalNEXT program team and make the connection with the sites.
- ☑ Work with the customer to sign program agreement document.
- ☑ Obtain approved equipment.
- ☑ Install prior to September 30, 2025.
- ☑ Provide program feedback before and after the demonstration.

About CalNEXT

CalNEXT's vision is to identify emerging technology trends and bring commercially available technologies to the energy efficiency program portfolio. The CalNEXT team brings decades of market development and technical expertise to provide support and resources for evaluating new technologies. We are dedicated to removing barriers to commercial heat pump water heater energy efficient technology adoption so all Californians can benefit from a cleaner and healthier environment. Through our initiative, we are seeking sites in environmentally impacted communities to demonstrate this technology and engage community members to gain insight into how to support equity and inclusion in delivering technologies to the market. For more information about CalNEXT visit calnext.com.

CBO One-Pager



Heat pump water heaters deliver big impacts to the market — they produce less pollution, are easy to install, and provide dehumidification in addition to heating water.

CalNEXT is looking for community-based organizations to promote the benefits of heat pump water heater technology in commercial settings. **Be one of 50 community organizations to receive a FREE light duty heat pump water heater by September 30, 2025.**

Light duty heat pump water heaters are listed by ENERGY STAR® as residential water heaters. These units are typically used in homes but are also installed commercially when large volumes of hot water are not needed.

Eligible Sites

We are looking for California-based commercial locations served by investor-owned utilities (PG&E, SDGE, SCE) that will benefit from this pilot:

Community centers

Cultural centers

Places of worship

YMCAs

Nonprofits

Limited to the first 50 who apply. The pilot will provide the heat pump water heater but will not cover the installation costs.

Enroll Today!

Reach out to apopp@energy-solution.com or gbennett@energy-solution.com for more information about this pilot.

Light Duty HPWH Pilot

Why are we offering this pilot?

Heat pump water heaters are being broadly adopted in the residential markets, but commercial adoption of the technology has not accelerated at a similar rate. This initiative addresses some barriers of commercial heat pump water heater adoption in the commercial market sector.

Through this pilot, contractors will have the opportunity to install up to three heat pump water heaters and gain experience with these units in a commercial setting. An engineering and market characterization study is simultaneously being conducted to provide information on the best commercial buildings for light duty heat pump water heater installations.

What you will need to do:

- Email CalNEXT program team (apopp@energy-solution.com or gbennett@energy-solution.com) to express your interest in the pilot.
- Confirm with CalNEXT program team that your site is eligible (community centers, cultural centers, places of worship, etc.) to benefit from a light duty heat pump water heater.
- Make the connection with a program contractor.
- Sign program agreement document.
- Obtain approved equipment.
- Install prior to September 30, 2025.
- Provide program feedback before and after the demonstration.
- Work with CalNEXT program team to promote the installation.

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Draft Contractor Marketing Flyer

The following language is the copy edit that is being developed by the marketing team to create a 2–4-page educational piece for contractors installing light-duty HPWHs in commercial settings.

Header:

- Help your small commercial customers make the switch to heat pump water heaters

Subhead:

- Using light-duty heat pump water heater technology in commercial settings.

Copy:

- Heat pump water heaters have big impacts on the market—they produce less pollution, are easy to install, and provide dehumidification in addition to heating water.
- CalNEXT piloted a program to install residential or "light duty" heat pump water heater technology in commercial settings. CalNEXT selected community-based organizations to highlight the benefits of "light duty" heat pump water heaters.

Why did we offer this pilot?

Heat pump water heaters are widely used in residential markets, but commercial adoption of the technology has not accelerated at a similar rate. CalNEXT piloted a program in 2025 to address barriers of commercial heat pump water heater adoption in the commercial market sector. Through this pilot, contractors had the opportunity to install heat pump water heaters to gain more familiarity with the equipment and a greater comfort level with the technology.

An engineering study and market characterization was conducted to provide contractors with information on ideal building types for light duty heat pump water heaters. The following are some of the findings.

What are heat pump water heaters?

Light duty heat pump water heaters are listed by ENERGY STAR® as Certified Heat Pump Water Heaters. These units are typically used in homes but are also installed commercially when large volumes of hot water are not needed. This is an opportunity for small commercial installations to use efficient equipment to reduce energy use.

Suggested Equipment Types:

- **Storage Capacity**
- **Power**

Fuel Conversion:

Gas Capacity (gal)	120v (gal)	240v (gal)
30	65	60
40	80	80
50	N/A	90
60	N/A	110
75	N/A	>120

Building Types

The following building types are generally well suited for light duty heat pump water heater installations. Based on installation volume, electrical and natural gas savings, these building types would benefit and represent key locations for heat pump water heater installations:

Building Type	Opportunity – market size	Electricity Savings	Gas Savings
Small offices	High	Highest	High
Warehouses	High	High	High
Quick service restaurants	Medium	Medium	Highest
Community Based Organizations (examples: community centers, cultural centers, places of worship, YMCAs, non-profits)	Medium		High

What makes a suitable location for heat pump water heater installation?

- Ventilation – ensure heat pump water heaters s will be installed at a location with adequate ventilation, following manufacturer requirements.
- Access to Electricity – Check panel capacity to confirm that the customer's electrical panel has sufficient amperage to support the proposed HPWH.
- Properly sized heat pump water heater that meets or exceeds the manufacturer's sizing recommendations.
- Are incentives available? Whether projects qualify for small business incentives is based on the equipment installed. Small business projects are those that install equipment that would otherwise qualify for residential incentives, but that are installed at a non-residential business or facility.

Customer Benefits

According to the California Air Resources Board, 85 percent of on-site building emissions come from space and water heating and cooling. Heat pump technologies are key to decarbonizing buildings and achieving California's zero-carbon goals.

Heat pump water heaters offer significant benefits to your customers, including:

- High energy efficiency and potential for lower utility bills. Participation in programs that shift water heating to off-peak hours can provide further bill savings and support a more stable electricity grid.
- Reduced emissions and carbon footprint.
- Often more durable than conventional models and can provide cooling and dehumidification to the surrounding area.

How can you help your customers claim incentives?

- Participate in the relevant incentive programs, such as TECH Clean California.
- Enroll in a time-of-use rate, demand response program, and a water heater rewards program (for TECH Clean California).
- Make sure the equipment is on the list of eligible models for the programs you are using.
- Submit the necessary paperwork to claim rebates.

HPWH Product warranty

Double check to ensure the residential warranties are covered for commercial installations. There are commercial warranties available depending on the HPWH installed.

CTA:

This is an exciting time to help your customers make the switch to a heat pump water heater. Make sure you are ready to help your customers through the process by learning more about heat pump water heaters.

Footer:

About CalNEXT:

CalNEXT's vision is to find emerging technology trends and bring commercially available technologies to the energy efficiency program portfolio. The CalNEXT team brings decades of market development and technical ability to provide support and resources for evaluating innovative technologies. We are dedicated to removing barriers to commercial heat pump water heater energy efficient technology adoption so all Californians can benefit from a cleaner and healthier environment. Through our initiative, we are seeking sites in environmentally impacted communities to show this technology and engage community members to gain insight into how to support equity and inclusion in delivering technologies to the market.

Appendix C: NOMAD, Bass Diffusion Curve, and Delphi Panel Considerations

Quantifying historical market uptake and modeling NOMAD estimated baseline data requires populating key parameters of start year, maximum penetration, a coefficient of growth, and a coefficient of imitation. Key parameters should consider data that incorporates all required minimum features identified in the TFP. Definitions of the key parameters and a Bass Diffusion Curve formula used to plot NOMAD are shown below in Equation 1 and Table 26.

Equation 1: Formula for estimating NOMAD.

$$\mathrm{F(t)}= \frac{1 - e^{-(p+q)t}}{1 + \frac{q}{p}\, e^{-(p+q)t}}$$

Where: p = coefficient of innovation (e.g., external influence or advertising effect)
q = coefficient of imitation (e.g., internal influence or word-of-mouth effect)
t = year (e.g., year zero, 1, 2, etc.)

Table 26: Description of inputs, data sources, and methodology for data collection to create NOMAD baseline estimates.

Parameter	Parameter-Specific Instructions	Effect on NOMAD Curve	Recommended Data Source	Methodology for Data Collection
Start year	Estimate the year in which the measure-case technology or efficiency level was first available on the market.	The curve intersects with the x-axis in the Start Year.	Manufacturers	Interviews or surveys requesting "when were HPWHs first made available for sale by your company?" and "when were HPWHs at the current standard for efficiency [to be specified in the survey] first made available for sale by your company?"

Historical market penetration	Estimate market adoption at specific dates since start year.	Reference data point. Used to refine coefficient of innovation and coefficient of imitation.	Manufacturers and/or distributors	Interviews or surveys requesting raw data such as: "What percent of historical sales have been HPWH compared to standard efficiency units for 1 year, 3 years, 5 year, 10 years, etc. after start year." Manufacturers prioritized would be those selling efficient systems into California, and results would be compared to ENERGY STAR unit shipment data.
Maximum penetration	Estimate the long-term maximum penetration of the measure case without a standard. Consider what persistent barriers would stand in the way of widespread adoption.	This sets the asymptote for the top of the S-curve; the curve will flatline as the curve approaches this value.	Distributors, contractors, ENERGY STAR unit shipment data	Additional modeling incorporating ENERGY STAR unit shipment data.
p ("Coefficient of innovation")	Typical values of p are in the range of 0.0001 to 0.2. Adjust p to match historical data and your estimate of NOMAD over the first measure case lifetime after the effective date.	This sets the base rate of linear growth over time. A higher p means the initial growth is faster	Calibrate coefficient of innovation to closely follow mean data points provided as Historical Market Penetration	See "Historical Market Penetration" above
q ("Coefficient of imitation")	Typical values of q are in the range of 0.05 to 1. Adjust q to match historical data and your estimate of NOMAD over the first measure case lifetime after the effective date.	This sets the rate of exponential growth fed by the current market share. A higher q means a steeper bend in the S-curve.	Calibrate coefficient of imitation to closely follow mean data points provided as Historical Market Penetration	See "Historical Market Penetration" above.

Additional Data Sources for Parameters Used in Calculating NOMAD

- NEEA (Northwest Energy Efficiency Alliance) (2022). Plug-In Heat Pump Water Heaters: An Early Look to 120-Volt Products. Northwest Energy Efficiency Alliance. Retrieved from https://neea.org/resource/plug-in-heat-pump-water-heaters-an-early-look-to-120-volt-products/

- NEEA (2021) Laboratory Assessment of Rheem Generation 5 Series Heat Pump Water Heaters. Northwest Energy Efficiency Alliance. Retrieved from https://neea.org/resources/laboratory-assessment-of-rheem-generation-5-series-heat-pump-water-heaters
- Opinion Dynamics (2022). California Heat Pump Residential Market Characterization and Baseline Study. CPUC TECH program. Retrieved from https://www.calmac.org/publications/OD-CPUC-Heat-Pump-Market-Study-Report-5-17-2022ES.pdf
- Opinion Dynamics (2022). Technology and Equipment for Clean Heating (TECH) Initiative Baseline Market Assessment. CPUC TECH program. Retrieved from https://pda.energydataweb.com/api/downloads/2658/TECH%20Baseline%20Market%20Assessment%20Report_Revised_Final.pdf
- Pacific Gas and Electric (PG&E) (2022). Midstream Heat Pump Water Heater (HPWH) Market Study and Field Test. Emerging Technologies Coordinating Council. Retrieved from https://etcc-ca.com/reports/midstream-heat-pump-water-heater-hpwh-market-study-and-field-test
- SCE (2022). ET21SCE0018 - Residential Water Heating Cost Comparison Tool/Calculator. Emerging Technologies Coordinating Council. More information at https://www.etcc-ca.com/reports/residential-water-heating-cost-comparison-toolcalculator
- SCE (Pending 2024). ET19SCE1100 - Grid Responsive Heat Pump Water Heater (WH) Study Emerging Technologies Coordinating Council. More information at https://www.etcc-ca.com/reports/grid-responsive-heat-pump-water-heater-wh-study
- SCE (2019). DR17.06 - Smart Water Heater Controller Study. Emerging Technologies Coordinating Council. Retrieved from https://www.etcc-ca.com/reports/smart-water-heater-controller-study
- ENERGY STAR Certified HPWH energy savings estimates. More information at https://www.energystar.gov/products/water_heaters/high_efficiency_electric_storage_water_heaters/benefits_savings
- NBI (2023). Pilot project in Seattle shows central heat pump water heaters can act as massive hot water batteries that help reduce carbon emissions. Retrieved from https://newbuildings.org/pilot-project-in-seattle-shows-central-heat-pump-water-heaters-can-act-as-massive-water-batteries-that-help-reduce-carbon-emissions/

In addition to the start year, one or more additional estimates of historical market penetration can be plotted on the NOMAD chart to assist in estimating the coefficients of growth and imitation. See sample historical adoption estimates in Table 27 and orange dots in Figure 8, for example.

Maximum penetration estimates will need to factor industry standard practices, high efficiency cost differences, estimated average payback periods, estimated effective useful life, and purchasing habits at the consumer and contractor levels. Maximum penetration may be limited by adoption practices that consumers, contractors, distributors, or manufacturers deem “efficient enough” but fall short of all minimum requirements for the TFP. Additionally, condensing units and evaporators may be indefinitely repaired on a part-by-part basis, further affecting maximum penetration estimates.

Table 27 and Figure 8 below show an example of the NOMAD chart, as well as how multiple data points, such as estimated historical HPWH saturation, can be backed into the NOMAD chart when refining the coefficients of innovation and imitation.

Table 27: Historical data and estimates to map to NOMAD curve.

Year	Historical Market Penetration (HPWH)	Historical Data and Estimates: Comments	Data Source
2008	<.1%	First year that standards for HPWH were included in the ENERGY STAR residential water heating specification.	NEEA documentation for Advanced Water Heater Specification 6.0
2009	<.1%	Estimated first date of ENERGY STAR qualified HPWH market availability from at least one of the three major HPWH manufacturers.	Rheem website
2014	1.08%	Date when 1.08% of residential electric storage water heaters shipped in the US were HPWHs meeting ENERGY STAR high-efficiency specifications. At this time, the active specification was ENERGY STAR v 3.0.	ENERGY STAR annual unit shipment data for HPWHs
2017	1.74%	Date when 1.74% of residential electric storage water heaters shipped in the US were HPWHs meeting ENERGY STAR high-efficiency specifications. At this time, the active specification was ENERGY STAR v 3.2.	ENERGY STAR annual unit shipment data for HPWHs
2019	2.00%	Date when 2.00% of residential electric storage water heaters shipped in the US were HPWHs meeting ENERGY STAR high-efficiency specifications. At this time, the active specification was ENERGY STAR v 3.3.	ENERGY STAR annual unit shipment data for HPWHs
2022	3.09%	Date when 3.09% of residential electric storage water heaters shipped in the US were HPWHs meeting ENERGY STAR high-efficiency specifications. At this time, the active specification was ENERGY STAR v 4.0.	ENERGY STAR annual unit shipment data for HPWHs

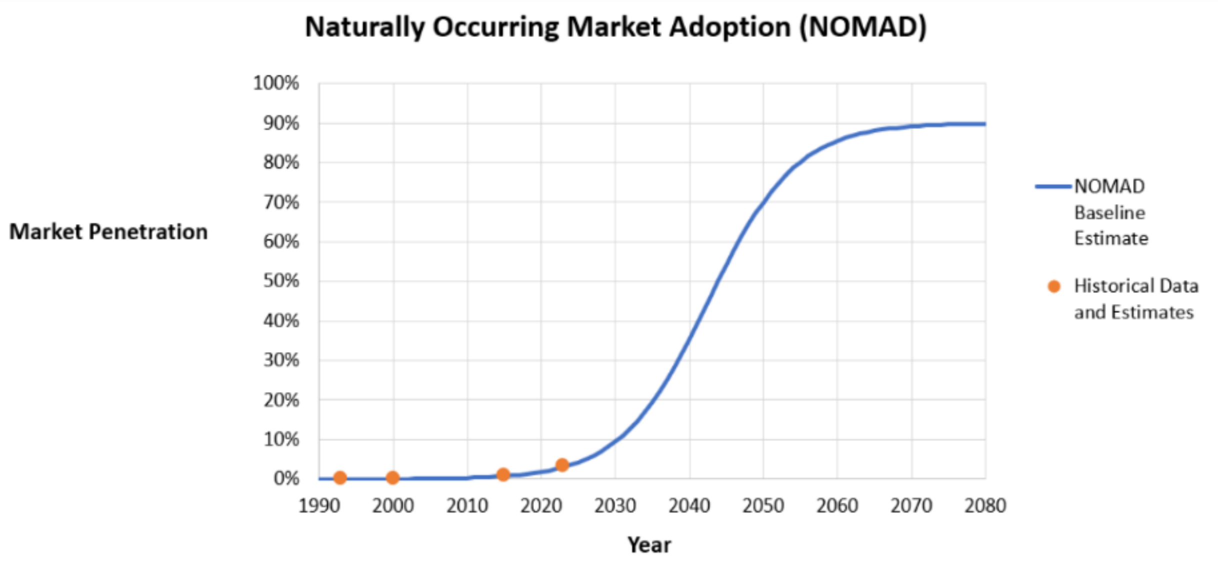

Figure 8: Example of NOMAD estimate.

Delphi Panel Use to Inform Inputs for the NOMAD Calculation

In areas where research alone provides inconclusive data, or when parameter data is not available, a Delphi Panel, consisting of industry representatives and experts, may validate data sources, estimates, and points prior to finalizing NOMAD calculations.

The Delphi Panel members themselves are not required to know the NOMAD formula or definitions of coefficients of innovation or imitation. Instead, the Delphi Panel serves to validate sources and data points to be later included in NOMAD calculations by SMEs conducting those estimates. Those SMEs should first curate the best available data from the sources above prior to utilizing the Delphi Panel, if needed at all. Parties recruiting and employing a Delphi Panel will likely provide compensation to its Delphi members for their participation.

For screening, Delphi members should be from within the industry supply chain and have first-hand knowledge of equipment and sales, as well as future trends within the industry, that will help inform key criteria. Sources of Delphi Panel members may include manufacturer and distributor representatives contacted and interviewed for the Market Characterization Study, as well as outside parties who can be qualified as SMEs. An SME with a focus on federal appliance standards for HPWHs would have additional knowledge and value outside of supply-chain members. A minimum of one manufacturing representative and one distributor representative is suggested.