Foodservice Water Heating Systems

Market Transformation Advancement Plan

CalMTA is a program of the California Public Utilities Commission (CPUC)
and is administered by Resource Innovations

Contents

List of Abbreviations

Abbreviation	Definition
AHRI	Air-Conditioning, Heating, and Refrigeration Institute
AQMD	Air Quality Management District
BAAQMD	Bay Area Air Quality Management District
BMA	Baseline Market Adoption
CARB	California Air Resources Board
CalMTA	California Market Transformation Administrator
CBO	Community-based Organization
CCDEH	California Conference of Directors of Environmental Health
CE	Cost-Effectiveness
CEC	California Energy Commission
CET	Cost-Effectiveness Tool
CPUC	California Public Utilities Commission
DOE	Department of Energy
EIA CBECS	Energy Information Agency's Commercial Buildings Energy Consumption Survey
ESG	Environmental, Social, and Governance
ESJ	Environmental and Social Justice
EUL	Effective Useful Life
FSTC	Foodservice Technology Center
GHG	Greenhouse Gas
HPWH	Heat Pump Water Heaters
HVAC	Heating, Ventilation, and Air Conditioning
IMC	Incremental Measure Cost
MR	Market Research
MT	Market Transformation
MTAB	Market Transformation Advisory Board
MTI	Market Transformation Initiative
NEB	Non-energy Benefit
NREL	National Renewable Energy Laboratory
PAC	Program Administrator Cost
PG&E	Pacific Gas & Electric
PNNL	Pacific Northwest National Laboratory
ROI	Return on Investment
RFI	Request for Ideas
SCE	Southern California Edison
SDG&E	San Diego Gas & Electric
SME	Subject Matter Expert
TA	Technology Assessment
TCO	Total Cost Ownership

TOU	Time of Use
TSB	Total System Benefit
TMA	Total Market Adoption
TRC	Total Resource Cost
TRM	Technical Reference Model
UEI	Unit Energy Impacts
WE&T	Workforce Education and Training

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1 Purpose

This Advancement Plan summarizes available information and essential research activities for the proposed Market Transformation Initiative (MTI) that CalMTA recommends advancing from Phase I: Concept Development into Phase II: Program Development. It represents the stage gate deliverable illustrated in Figure 1 that describes the scope of work for research, testing, and stakeholder engagement that will be needed during Phase II to develop a full MTI Plan for approval by the California Public Utilities Commission (CPUC) for Phase III: Market Deployment. The initial research efforts outlined in this Advancement Plan will inform the long-term potential of this technology before CalMTA recommends whether to advance this MTI further. All MTI Advancement Plans are reviewed by the Market Transformation Advisory Board (MTAB) and the public before they are finalized by CalMTA. This draft Advancement Plan contains:

1. Key characteristics of the Market Transformation (MT) idea (e.g., description, target market, initial MT theory, etc.).
2. Identified gaps in knowledge that need to be filled before an MTI Plan could be written for CPUC approval.
3. Estimated costs and workplan for activities in Phase II that will fill the knowledge gaps.

Figure 1: MTI development documents by phase

Note. Feedback received by MTAB indicated uncertainty about the size of the opportunity in café style foodservice. Prior to launching the research identified in this Advancement Plan, CalMTA staff will conduct a preliminary analysis of the café market segment size and natural gas usage. Once completed, Staff will bring those initial findings back to the CPUC and a subset of interested MTAB members for discussion prior to launching remaining research activities.

Additional information on CalMTA and the MTI development process can be found at https://calmta.org.

2 Executive summary

This section summarizes the Market Transformation concept opportunity, the problem it is trying to solve, strategies that are likely to drive market change, and the sustained change in the market we are expecting to see.

Foodservice buildings rank among the most energy-intensive property type in the commercial sector.[1] They can consume up to five times more energy than other commercial building types with up to 20% of the total energy use attributed to water heating. [1] [2] Despite the high energy use and associated operating costs, foodservice water heating systems generally do not receive adequate attention or investment by owners. This results in inefficient systems that place additional burden on owners and operators in an already low-margin industry. If California is to meet its ambitious decarbonization goals, more efficient technologies and optimal systems design are critical for the foodservice sector.

CalMTA has identified a strategic opportunity to support and accelerate the adoption of efficient electric water heating systems and will consider all major components that support heat pump water heater (HPWH) installations including water heater(s), controls (including load management), storage tanks, recirculation pumps, piping distribution, and hot water end uses.

This MT idea will require navigation of several technological and societal barriers that will be further researched and refined during Phase II. These barriers include:

- HPWHs for foodservice applications are less mature in their product development than their residential counterparts.
- The foodservice industry's low margins can deter establishments from investing in high efficiency equipment due to the upfront and operating costs.
- HPWH systems have more complex design and installation requirements than their gas counterparts.
- Water heating sizing guidelines are outdated and prevent foodservice facilities from adopting HPWHs.[2]
- Additional space required for equipment

Potential strategies to overcome these barriers and accelerate market adoption include:

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[1] Energy Information Administration. Commercial buildings energy consumption survey (CBECS). 2018.
[2] Market potential for heat pump assisted hot water systems in foodservice facilities: Final report. ET22SWE0019. CalNEXT. April 23, 2023. https://calnext.com/wp-content/uploads/2023/07/ET22SWE0019_Final_Report.pdf

- Working with industry leaders and regulatory bodies to update water heating sizing guidelines to ensure they reflect modern water fixture efficiencies and allow for use of HPWHs.
- Engaging with leading manufacturers, supply chains, and key market partners to develop and specify affordable heat pump water heater products tailored to the foodservice industry's needs in the California market. In parallel, partnering with national restaurant chains to influence their purchasing practices and promoting the adoption of efficient water heating system-level design approaches.
- Demonstrating non-energy benefits, such as space cooling, and working with industry associations to showcase the customer value proposition.
- Leveraging existing foodservice research and pilot programs to better understand optimal system design and configuration.
- Exploring various financing options and partnerships with statewide utility incentive programs to create bundled solutions that lower initial expenses.

Ensuring equitable access to efficient water heating system technologies for small independent businesses and foodservice establishments in environmental and social justice (ESJ) communities is crucial to this MT idea. Additional approaches for integrating equity include incorporating ESJ community voices in research and identifying workforce development and job creation opportunities when the market is ready.

CalMTA acknowledges the existing and ongoing work of other state and national foodservice-related programs, specifically regarding the water heating sizing guidelines. Existing program coordination and alignment is a priority for this proposed initiative so that the impact is amplified but work is not duplicated. Specific needs will be determined with input from industry experts during Phase II and detailed in the full MTI Plan prior to approval and implementation. CalMTA seeks to fill knowledge gaps to better understand the decision-making process regarding water heating for both small independent and larger chain restaurants, the baseline market, the policy landscape, and the technical feasibility of HPWH-based systems in foodservice facilities.

Through strategies informed by the Phase II research described in this Advancement Plan, CalMTA will aim to transform the foodservice water heating market, making efficient electric systems the preferred choice by 2045 while also identifying near-term solutions. This will not only help meet California's decarbonization goals but also lay the groundwork for broader full kitchen decarbonization strategies, ultimately delivering long-lasting energy savings and emissions reductions for foodservice establishments and their stakeholders. A preliminary analysis finds that this MT idea has an estimated Total System Benefit (TSB) of $216 million over the 20-year lifecycle of the initiative.

3 Product, service, or practice definition

This section describes the preliminary understanding of the initiative's technology, service, or practice, its benefits, and any existing codes, standards, or policies that govern it. Some parts of this definition may not be fully known at this point and will be solidified through further research and studies outlined in the following sections.

If advanced to a full MTI, this effort would focus on increasing energy efficiency and decarbonizing water heating systems in California's foodservice establishments by increasing the adoption of HPWHs as the primary hot water source. While HPWHs are central to this initiative, a system-level approach is essential for optimizing their performance and cost-effectiveness.

Simply replacing gas water heaters with HPWHs on a one-for-one basis does not address the complexities of the entire hot water system and how the system impacts the size and performance of the HPWH. Therefore, this initiative will adopt a system-level perspective, considering all major components that support HPWH installations including water heater(s), controls, storage tanks, recirculation pumps, piping distribution, and hot water end uses. The research under this Advancement Plan focuses on the following elements and strategies for efficient, decarbonized water heating systems:

1) **HPWHs:** Electric HPWHs designed for commercial applications, with features to minimize electrical demand during system peak hours (e.g. 4:00-9:00 pm) which are typically high-use periods in commercial kitchens.
2) **Combined heat pump systems**: Systems that improve overall heating, ventilation, and air conditioning (HVAC) and water heating efficiency by providing simultaneous space cooling and water heating.
3) **Hot water distribution system:** Optimized pipe sizing and layout methods to minimize heat loss during distribution. This could include integration of decentralized (point of use) water heaters, and eliminating/reducing reliance on recirculation pumps.
4) **End-use equipment:** Water-using equipment that reduces overall hot water demand, potentially including low-temperature or ventless dish machines.

Defining a single decarbonized water heating system specification for this initiative is challenging due to the substantial diversity within California's foodservice industry. Different types of restaurants have unique hot water usage patterns influenced by their menus, dishwashing needs, and space availability, all of which impact the choice of system components. The research planned for the next phase will help us better understand the impact of system components and identify the most efficient and cost-effective solutions for wide market adoption.

Despite the complexity of system specification, the key success criterion for this MTI – if it is moved into implementation in Phase III – will be the adoption of HPWH-based water heating systems in California's foodservice establishments. While other system components can contribute to overall efficiency, their primary role is to support the successful adoption of HPWHs.

4 Market Transformation theory and opportunity

4.1 Market opportunity

This section describes the market context, Market Transformation concept, and opportunity.

California's statewide decarbonization goals and regulatory focus, such as the zero-emission space and water heater standards being considered by the California Air Resources Board (CARB), will likely drive higher acceptance for decarbonization measures including efficiency in the coming years. The foodservice sector has the highest energy intensity of all commercial building types, consuming up to five times more energy per square foot than other types of commercial buildings.[3] This significant energy use presents both a need and an opportunity to establish a cohesive pathway for accelerating market transformation in foodservice efficiency and decarbonization.

The CalMTA team believes that starting with foodservice water heating systems decarbonization is a strategic entry point into this market shift for two key reasons:

First, unlike cooking equipment, water heating systems do not evoke a strong emotional attachment among chefs and decision makers. As long as these systems function well and meet practical kitchen demands and regulations, they are not a focal point and will face less resistance in a market shift. This makes water heating systems a practical starting point for initiating change. Additionally, the potential savings from upgrading water heating systems are significant.

Second, Pacific Gas & Electric's (PG&E) Foodservice Technology Center (FSTC) has estimated that commercial foodservice water heating represents 16% of all commercial gas usage in California.[4] This substantial share of energy consumption highlights the significant impact that improvements in water heating efficiency can have on reducing overall energy use and emissions in the foodservice sector.

By targeting water heating systems, the initiative can make meaningful strides toward achieving California's decarbonization goals. This focused approach will not only contribute to significant energy savings but also set a precedent for further advancements in other areas of the foodservice industry and pave the way for long-term strategic engagement towards full kitchen decarbonization.

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[3] US energy use intensity by property type. Energy Star Portfolio Manager: Technical Reference. August 2023.
https://portfoliomanager.energystar.gov/pdf/reference/US%20National%20Median%20Table.pdf

[4] Delagah, A. and Fisher, D. (2013) Energy efficiency potential of gas-fired commercial water heating equipment in foodservice facilities. Report prepared by FNI for the CEC, CEC-500-2013-050.

4.2 Target market

This section defines the sector(s) this product, service or practice is intended for. The target market may be adjusted based on the results of the research conducted in Phase II of the initiative.

This MT idea could target both existing establishments and the new construction market for full-service, quick-service, and café sectors across California. Most of these establishments currently rely on gas as their primary fuel source for heating water. We are defining full-service, quick service, and café as follows:

Full-service restaurants: These establishments provide foodservices where customers order and are served while seated (waiter/waitress service) and pay after eating. They may also offer alcoholic beverages, carryout services, or live non-theatrical entertainment.

Quick-service restaurants: These establishments provide foodservices where customers order or select items and pay before eating. Food and drinks may be consumed on-site, taken out, or delivered. Some may also sell alcoholic beverages. These are also known to as "limited service" restaurants.

Cafés: These establishments primarily serve coffee and other non-alcoholic beverages, along with light snacks and pastries. This definition also includes doughnut shops.[5]

We will approach this market in two steps:

1) **Initial target market:** There are approximately 10,000 facilities in California, primarily cafés and quick-service restaurants, that currently use electric water heaters and have relatively low hot water demand. For establishments without space constraints, this presents a potential opportunity for straightforward one-to-one replacements with electric heat pump water heaters (HPWHs). While energy savings in smaller cafés may be modest, targeting larger quick-service chains and café chains with centralized decision-makingoffers a promising leverage point. These chains typically make purchasing decisions at the corporate level, providing an opportunity to influence adoption across multiple locations. By engaging with these chains, we can gain valuable insights into corporate decision-making processes, both for existing and newly constructed establishments, which can be applied to other segments as well. Focusing on chains that prioritize standardization and have the capacity for more engineering considerations will help drive faster adoption of HPWH technology, while also addressing initial barriers.

   In Phase II research, we will further characterize the market, exploring the various barriers and opportunities across these segments to identify the most impactful entry points.

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[5] North American Industry Classification System (NAICS) is the standard used by Federal statistical agencies to define these sectors.

2) **Ultimate target market:** Our ultimate goal is to transform all segments of existing café, quick-service, and full-service foodservice establishments to efficient electric water heating solutions regardless of their current water heating system complexity or their hot water demand. As we engage with the market and start overcoming initial barriers we will gain valuable experience and insights into addressing the more complex challenges. This will enable us to eventually transform the broader market.

4.3 Key market barriers

This section captures a high-level overview of perceived barriers which limit adoption of the technology in this market. These barriers will be verified, during Phase II, through the work defined in Section 6 of this document.

The foodservice water heating market and the technology face significant barriers that will be further researched during Phase II to verify and refine our understanding (see Section 6). These potential barriers include:

Outdated California Conference of Directors of Environmental Health (CCDEH) Water Heater Sizing Guidelines: The CCDEH water heater sizing guidelines are enforced by California county health departments. The guidelines were established prior to 1995, at which point natural gas and electric resistance storage water heaters dominated the market, and the guidelines included sizing only for those two technologies. In recent years, HPWHs have grown in popularity and are recognized as a leading pathway to decarbonize water heating systems, but the current CCDEH sizing guidelines do not support sizing for heat pump technologies. The guidelines require users to calculate total hourly hot water demand (in gallons per hour) based on demand assumptions, developed prior to 1995, which have not been updated to reflect present-day water fixture efficiencies and practices. Then the guidelines require the use of default electric resistance thermal efficiency for electric systems, effectively excluding the use of heat pump efficiency, discounting HPWH performance benefits. Additionally, the input rate calculation does not consider hot water storage capacity. As a result, the guidelines often lead to requirements for HPWH systems that are 2-4 times oversized, making them cost-prohibitive for many restaurant types.[6]

Upfront cost: The upfront cost of investing in a high-efficiency electric water heating system is a significant barrier for the low-margin foodservice industry. This challenge is compounded by the high risk of restaurants going out of business, making long payback periods less justifiable. Beyond the initial purchase and installation expenses, there may also be additional costs associated with upgrading electric panels to accommodate the electrification of water heating systems.

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[6] Market potential for heat pump assisted hot water systems in foodservice facilities: Final report. ET22SWE0019. CalNEXT. April 23, 2023. https://calnext.com/wp-content/uploads/2023/07/ET22SWE0019 Final Report.pdf

Space: In foodservice establishments, space constraints may present a significant barrier to implementing high-efficiency water heating systems like HPWHs. These systems often require more physical space compared to compact or tankless gas water heaters. The need for additional space can hinder adoption, particularly in the foodservice industry, where operating on tight margins makes it challenging to justify the costs of accommodating larger equipment or giving up valuable sitting space.

Product maturity/system complexity: Despite recent advancements in higher-capacity integrated HPWHs, replacing gas systems with equivalent heat pump systems in the foodservice industry remains challenging, particularly for operations with high hot water demands. The complexity lies in the fact that HPWH capacity and first cost is more sensitive to inefficiencies in the rest of the water heating system. In contrast, gas water heating is relatively inexpensive per unit of output, leading to less emphasis on understanding and addressing inefficiencies elsewhere in the system. By reducing demand and enhancing efficiency in other parts of the hot water system, designers can optimize the size and cost of the water heater itself. However, without a holistic approach to system design, there is a risk of oversizing or misalignment of HPWH capacity, resulting in increased upfront costs or operational inefficiencies.

Customer value proposition and awareness: Foodservice is often a low-margin business, so water heater upgrades in this sector are not a top priority for owners. Competing priorities often deter decision-makers from considering early water heater replacements, leading most replacements to occur during emergencies when quick decisions are needed, leaving little time to learn about the benefits of efficient electric water heating systems. High-efficiency HPWHs may offer benefits such as space cooling and load shifting due to the thermal capacity of the water heater tank, potentially working as a thermal battery when coupled with Time of Use (TOU) rates for bill savings.[7] However, CalMTA does not yet understand the full value of these non-energy benefits for business owners and needs to research and better articulate them for decision-makers. Additionally, despite the high efficiency of HPWHs, concerns about potential increases in operating cost including energy bills due to the relatively high cost of electricity compared to natural gas may further complicate the value proposition for business owners.

Contractor knowledge: Contractors lack familiarity with efficient electric water heaters such as HPWHs, the system-level complexities involved in water heating systems, and transitioning from gas to electric systems. Gas water heaters are less sensitive to output increases and can be oversized without significant energy penalty, make them easier to design. In contrast, HPWHs are more costly to scale up and require careful design to optimize efficiency, particularly regarding water temperature and demand.

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[7]Market potential for heat pump assisted hot water systems in foodservice facilities: Final report. ET22SWE0019. CalNEXT. April 23, 2023. https://calnext.com/wp-content/uploads/2023/07/ET22SWE0019_Final_Report.pdf

Contractor Business Case: Contractors and contracting firms do not see a compelling business case for changing their business model to focus on efficient electric systems. The traditional approach of replacing gas water heaters is simpler and more straightforward. Moreover, customers and restaurant decision makers are not demanding HPWHs or more efficient water heating systems. We need to further understand this barrier and what would motivate contractors to take advantage of the opportunity to decarbonize restaurants.

Despite these perceived barriers, the timing may be right for intervening to transform the foodservice water heating market. Some of the key leverage points and potential intervention strategies are outlined in the next section.

4.4 Possible points of leverage and strategy interventions

The section describes the points of leverage and strategic interventions that are envisioned at this early stage that could be utilized to achieve the transformed market end state. The next research phase of this MT idea will help the team test and refine assumptions.

The MT idea could employ multiple market leverage points through the following intervention strategies to transform the foodservice water heating market. The key strategies highlighted here could effectively drive market transformation, though they do not encompass all potential interventions. It is important to note that these strategies will be further examined and refined in the next phase of research, which will also provide more specific details on each approach. The possible strategies identified are:

- **Work with industry leaders to adjust the CCDEH water heating sizing guidelines:** The current outdated CCDEH guidelines are a key barrier to adoption of HPWHs in the foodservice sector. The initiative will leverage and potentially add to the existing and ongoing work that FSTC, CalNEXT foodservice project teams, and other industry leaders who have begun to build the case for water heating sizing adjustment. The initiative will then collaborate with these groups to present the case to CCDEH and work towards making the relevant statewide guideline updates.

- **Align initiative work with California codes and regulations:** To advance California's decarbonization goals, the CalMTA team will coordinate initiative strategies with the state's zero-emission appliance regulations, including those adopted by Bay Area Air Quality Management District and under consideration by CARB. Based on CARB's proposal heat pumps and/or electric resistance technology could be considered zero-emission.[8] By aligning our work with these regulations, we aim to prepare the market

[8] Zero-emission space and water heaters - frequently asked questions (FAQs). CARB. Mary 30, 2023. https://ww2.arb.ca.gov/our-work/programs/building-decarbonization/zero-emission-space-and-water-heater-standards/faq

for the adoption of efficient water heating systems that are based on heat pump technology in the foodservice sector. The initiative will focus on identifying and removing barriers to heat pump water heater adoption, ensuring the market is adequately prepared to meet the new standards. This approach will help minimize the risk of non-compliance and implementation delays for CARB. In parallel, our efforts will augment and support efforts underway in California's codes and standards, including Title 20 and Title 24, to ensure that water and electric-efficient appliances and design approaches become the standard in California's foodservice industry.

- **Engage with leading manufacturers, the supply chains, and key active market partners to ensure the right products are available in the California market:** Engage with industry partners and organizations to ensure the development and specification of HPWH products with a holistic system view. This will support the adoption of a system-level approach to water heating in the foodservice industry. In parallel, work with manufacturers and the supply chain to ensure that more affordable and electric HPWHs, with features tailored to the sector's needs, are available in the California market.

- **Engage national restaurant chains:** Capitalize on the movement toward setting and meeting environmental, social, and governance (ESG) goals adopted by some national restaurant chains. Form partnerships with manufacturers who have strong relationships with these restaurant chains to influence their purchasing practices and restaurant design specifications to consider system-level approaches that enable adoption of HPWHs. We assume that influencing the corporate practices of these restaurant chains could accelerate the conversion to electric HPWHs across their locations in California. Additionally, there is an opportunity to help restaurant chains meet air quality regulations, such as CARB's zero NOx. While maintaining our focus on water heating systems within the scope of this initiative, as we engage with national restaurant chains, we also aim to understand barriers to full kitchen decarbonization and explore where key strategic market interventions can support those outcomes.

- **Promote the value proposition of efficient water heating systems by leveraging restaurant association partnerships:** Showcasing the benefits of efficient water heating systems through case studies and demonstration projects is crucial for gaining buy-in amongst the decision makers. Additionally, promoting access to green financing, leasing options, and ways to reduce upfront costs can facilitate adoption by addressing financial barriers, making the transition more accessible for businesses. Engaging with associations such as the California Restaurant Association and Latino Restaurant Association can provide a pathway to amplify these efforts, and leverage the industry networks to spread awareness, share success stories, and build a broader coalition of support for the technology ultimately driving further momentum toward full kitchen decarbonization.

- **Partner for installer training:** Collaborate with manufacturers, supply chain partners, and local workforce development organizations and institutions to incorporate specific water heating system training in the existing installer training programs to equip installers with the knowledge and skills needed for HPWHs and water heating systems in foodservices.

4.5 Environmental & social justice

This section describes the initiative's targeted equity outcomes and summarizes the initiative's potential intervention strategies to advance equity, benefit environmental and social justice communities and develop workforce education and training (WE&T).

CalMTA is committed to prioritizing equity, reaching ESJ communities, and advancing workforce education and training (WE&T) to align with the needs of the ESJ communities in California. An initiative targeting the foodservice market would aim to ensure small independent businesses and foodservices businesses in the ESJ communities enjoy the benefits of efficient electric water heaters. Some possible approaches for integrating equity and supporting ESJ communities that we will explore in Phase II include:

- **Incorporation of ESJ community voices in research:** CalMTA will ensure ESJ community voices are incorporated into our market research, field demonstrations, and strategy pilots. This includes engaging Community Based Organizations (CBO's) and independent restaurant associations to understand the decision-making process for purchasing new or replacement water heaters, identifying unique barriers and opportunities for small, independent restaurants and those in ESJ communities, creating tools and resources to increase awareness among business owners, and identifying pathways for job creation in water heating installations for ESJ communities.
- **Equitable access to water heating solutions:** Identify financing mechanisms and bundling options that reduce the upfront cost of efficient electric water heating systems. Explore partnerships with electric panel upgrade programs to reduce or eliminate panel upgrade costs. Identify and promote affordable financing options such as green financing or on-bill financing or leasing mechanisms to spread the cost over time, making these solutions financially viable for restaurant owners.
- **Workforce development and job creation:** When the market is ready and enough demand exists, collaboration between manufacturers, vocational schools, and community colleges to influence workforce development initiatives could empower ESJ communities to engage in high-quality jobs in this market.
- **Monitoring and continuous improvement:** Track the effectiveness of ESJ and WE&T strategies and adjust them to maximize impact.

4.6 Market vision/end-state

The section describes the vision of the end state for what the transformed market will look like because of the initiative's work.

By 2045 efficient electric water heating systems capable of minimizing peak demand are the water heating system of choice in both new construction and existing foodservice facilities. Positive experiences with hot water electrification also leads to increasing the sector's acceptance of full kitchen electrification.

4.7 Key market assumptions

The section describes key market assumptions for the State of California that are assumed when determining the market vision/end state.

Key market assumptions include:

- California will continue to push for and invest in decarbonization including decarbonization of the foodservice sector.
- State energy codes can support the advancement of energy and water efficient electric equipment.
- National restaurant chains will continue to report ESG and decarbonization goals, driving demand for sustainable practices and equipment in foodservice.

4.8 Diffusion and "lastingness" mechanism

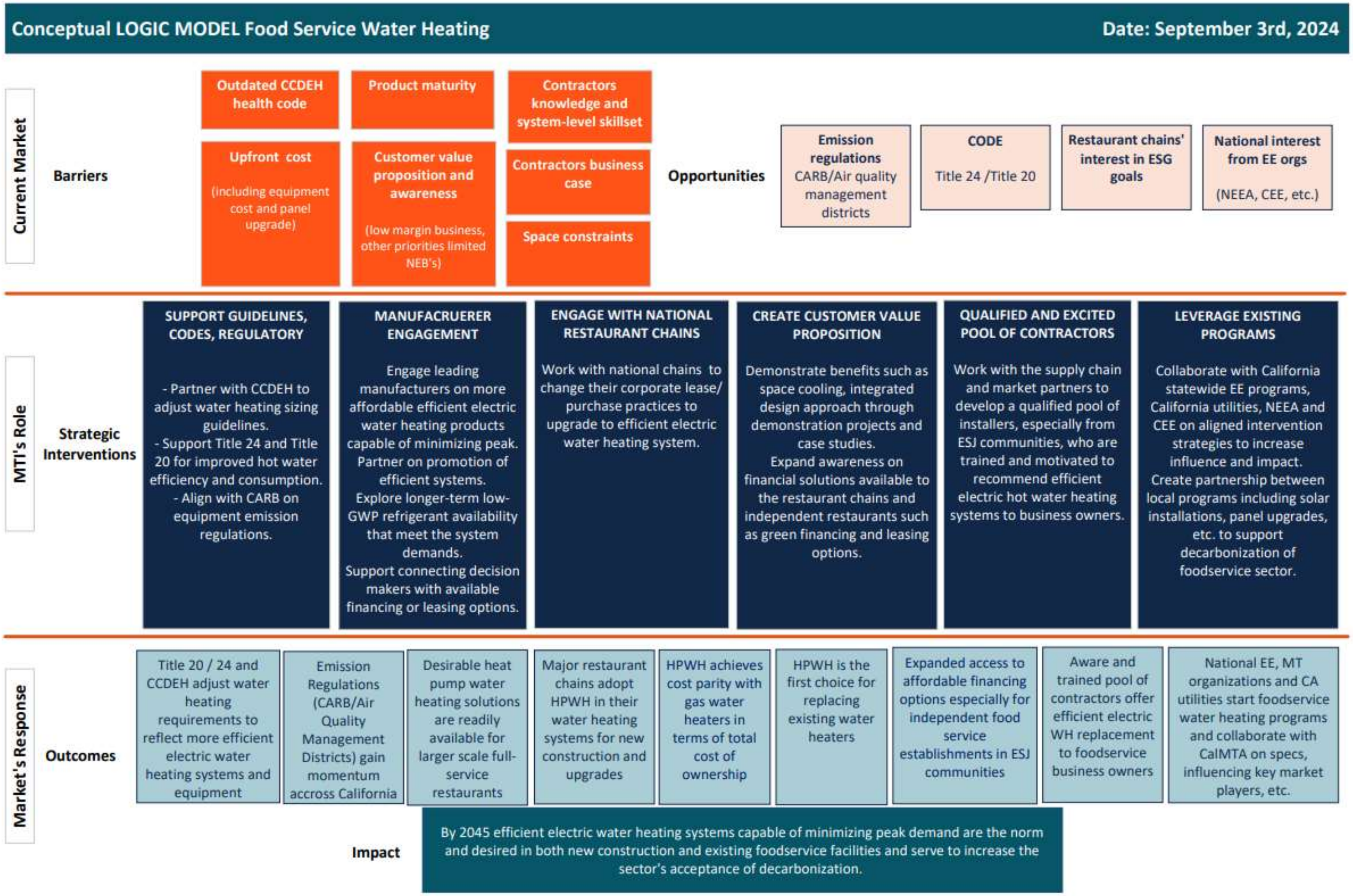
At some point, the market will continue to transform, even when the initiative's investments have ended. This section describes the market mechanism that will continue to move the technologies' transformation forward, after CalMTA's exit, to achieve the end state described above.

Market drivers such as equipment emissions limits set by air quality regulators, California's decarbonization policies and updated code requirements, and market awareness and availability of efficient electric water heating systems will drive the foodservice market to adopt efficient electric water heaters over gas or less efficient electric resistance water heaters.

4.9 Conceptual Logic Model

Conceptual logic models include high-level barriers and opportunities that inform the draft interventions, as well as expected outcomes and long-term impacts. The proposed market characterization, product assessment, and pilots conducted in Phase II will verify this logic model's assumptions and draft interventions. Once this work is completed in Phase II, CalMTA will develop a more refined and formal logic model for Phase III: Market Deployment.

Figure 1. Draft Phase I Conceptual MTI Logic Model



4.10 Measuring market outcomes

This section identifies a few preliminary market progress indicators (MPIs) for the initiative. A more comprehensive set of MPIs and equity metrics will be established during the development of a more refined and formal logic model for Phase III: Market Deployment.

Table 1. Possible MTI market progress indicators and data sources

Preliminary outcome*	Possible market progress indicator	Possible data sources
Title 20, Title 24, and CCDEH adjust water heating requirements to reflect more efficient electric water heating systems and equipment	CCDEH code revised to accommodate efficient water heating systems Title 20/24 modified to require electric water heaters in new construction	Review of CCDEH / Title 20 / Title 24 code
Emissions regulations (CARB/Air Quality Management Districts) gain momentum across California	Existing regulations strengthened to require emissions levels for commercial water heaters that are equivalent to those achieved by HPWHs New regulations introduced targeting emissions from commercial water heaters, with standards set at levels equivalent to those achieved by HPWHs	Review of CARB / AQMDs regulations
Foodservice owners are aware and benefit from available financing options	Percentage of foodservice establishments demonstrating awareness of at least one financing option for water heater upgrades Percentage of foodservice establishments that have utilized financing options for energy-efficient water heater upgrades	Survey of restaurant owners
HPWH achieves cost parity with gas water heaters in terms of total cost of ownership	Ratio of total cost of ownership of HPWH to that of gas water heater Installed cost of HPWH over time	Manufacturer websites/ interviews Survey of restaurant owners Data sharing agreement with manufacturers, distributors, and installers
HPWH is the first choice for replacing existing water heaters	Saturation and Annual Market Share of HPWH in water heater replacements by restaurants Percentage of contractors who recommend HPWH when replacing existing water heaters	Commercial water heater sales data (include data from manufacturer, distributors & AHRI industry sales data)

Preliminary outcome*	Possible market progress indicator	Possible data sources
		Survey of restaurants and contractors
Major restaurant chains adopt HPWHs in their new construction and upgrades	Number of major restaurant chains installing efficient water heating systems Percentage of replacements or installations within a chain that are efficient water heating systems	Survey and interviews of major restaurant chains
Desirable HPWH solutions are readily available for larger scale full-service restaurants	Number of HPWH models designed for full-service restaurants	Manufacturer websites/ interviews Interview of commercial equipment distributors
National energy efficiency and MT organizations start foodservice water heating programs and collaborate with CalMTA on specs, influencing key market players, etc.	Number of national energy efficiency and MT organizations that launch foodservice water heating programs Number of meetings or workshops held between CalMTA and national organizations focused on transformation of foodservice water heating market Number of documented instances where other organizations' foodservice water heating programs are modeled after CalMTA's program	CalMTA Salesforce Tool Websites of other MT organizations/interviews of other Program Administrators
Aware and trained pool of contractors offer efficient electric water heating replacement to foodservice business owners	Number of contractors offering HPWH installation in the commercial foodservice sector and demonstrating profitability Percentage of contractors specializing in commercial foodservice sector who offer HPWH installation services Customer satisfaction ratings for HPWH installations by foodservice businesses Number of personnel trained/certified to install HPWH in commercial establishments Number of contractors who participate in workshops, webinars, or other informational sessions about HPWHs for commercial applications	Survey of restaurant associations and owners Survey of installers/ contractors

*See Figure 1. Draft Phase I Conceptual MTI Logic Model

Table 2. Possible MTI equity metrics and data sources

For the purposes of the Advancement Plan, we focus on independently owned foodservice establishments located in ESJ communities.

Preliminary outcome*	Possible equity metric	Possible data sources
Achieve parity in HPWHs adoption rates between independent foodservice establishments in ESJ communities and those in non-ESJ communities	Adoption rate of HPWHs by independent foodservice establishments in ESJ communities compared to those in non-ESJ communities	Survey of restaurant owners
Expanded access to affordable financing options, for independent foodservice establishments in ESJ communities	Percentage of applicants from ESJ communities for both green financing and on-bill loan programs	Interview/survey of restaurant owners, SMEs, financing/leasing entities
Increase in employment and training opportunities for members of underserved communities in the field of hot water systems installations in the foodservice establishments	Number of trainees from underserved communities/ESJ communities who are trained/certified and employed to install HPWH in commercial establishments	Survey of contractors collaboration with training establishments

*See Figure 1. Draft Phase I Conceptual MTI Logic Model

5 Gap Analysis

This section describes the most critical data/information needs to be gathered through Phase II to make sure the MTI is viable and to create the full MTI Plan. Section 6 will provide more information on how we are going to gather this data.

As described in Section 2, the primary purpose of this Advancement Plan is to describe the research and testing that will be conducted starting late-2024 that would inform development of a full MTI Plan (the stage gate to move to Phase III). In this context, CalMTA has identified critical knowledge gaps surrounding the adoption of efficient water heater systems by the foodservice industry. These gaps are crucial for informing the development of a successful MTI Plan to drive increased utilization of these energy-saving technologies. These gaps will be addressed through targeted data collection and analysis efforts in Phase II and discussed further in Section 6. To better determine the market entry point, we will first prioritize understanding the size of the café market through secondary research. We will assess the natural gas and electric load and estimate the water heating load compared to the rest of the market. Answering these key questions will help us focus on an impactful entry point and filling the most critical knowledge gaps for the remainder of the Phase II research.

1) **Assessing decision-making processes in efficient water heating adoption for California's restaurants:**

There is a need to understand the decision-making process among restaurant owners regarding the adoption of efficient water heating systems. We hypothesize that restaurant size and ownership structure influence these decisions. National restaurant chains, with their centralized decision-making and greater internal resources, are more adept at navigating the complexities of adopting efficient water heating systems and tend to consider a systems view, including the water heater, end-use appliances, and the HVAC system, for overall energy efficiency.

Comparatively, independent restaurants are likely to rely on contractors and may adopt a localized view that focuses on individual components, such as water heaters and dish machines. Another gap in our understanding involves the decision-making process for water systems across different operational types – full service, quick service, and cafes – particularly considering that variations in water use volume and patterns may influence the factors these establishments prioritize.

We want to understand how these dynamics differ for independent foodservice establishments operating in low-income and disadvantaged communities (ESJ communities) compared to national chains operating in similar ESJ communities, and independent chains operating in non-ESJ communities.

There are other dimensions of decision-making we aim to understand in Phase II. These include:

- Understanding whether upgrade decisions are triggered by equipment failures or other factors like potential operating cost reductions.
- How foodservice approaches funding and acquisition. Do restaurants typically purchase equipment outright, or are leasing options a common practice?
- Identifying which components of the water heating system (water heaters, end-use appliances) are typically leased versus purchased, and what factors influence the buy-versus-lease decision, such as upfront costs and long-term budget constraints.
- Exploring the landscape of the financing or leasing industry specifically for restaurant equipment to provide information on how these entities may influence decision-making, including system sizing and design.
- Investigating the robustness of the second-hand market for water heating systems in the restaurant industry can reveal valuable insights into cost-saving opportunities and potential barriers for some establishments.

We believe that some of the challenges faced by independent foodservice establishments operating in low-income and disadvantaged communities may be higher in magnitude, such as access to finance and access to expertise for installation and maintenance. Understanding these dynamics is crucial for fully identifying market barriers and informing intervention to promote energy efficiency in California's restaurant industry.

2) **Uncertainty in characterizing the baseline market**

Our understanding of the baseline market for water heating systems in California restaurants is hindered by uncertainty in the characterization of the total number of establishments. National surveys used for appliance ownership, fuel consumption, and emission modeling provide a lower estimate compared to other sources listed in the next paragraph. For instance, NREL COMSTOCK estimates around 22,000 full-service and quick-service restaurants in California for 2018, while the Energy Information Agency's 2018 Commercial Buildings Energy Consumption Survey (EIA CBECS) reports around 38,000 restaurants in the entire Pacific Census Division (California accounts for around three-fourths this number based on relative population as well as gross domestic product).[9]

Compared to EIA CBECS and NREL COMSTOCK, the US Census County Business Patterns data, which focuses on employment and economic metrics, paints a considerably different picture. This source estimates a higher number of restaurants in California, with around 75,000 establishments in 2021 (compared to 65,000 in 2012). These figures align more closely with a 2009 CEC-sponsored study by Amin and Fisher, which estimated approximately 68,000 restaurants across the various service categories.[10] Unfortunately, the US Census data lacks information on energy appliance ownership, water usage, and fuel consumption, limiting its usefulness for our specific research goals. While the upcoming release of the California Commercial End Use Survey 2022 data might offer a more accurate picture of restaurant numbers, its limitations in providing individual survey records (as possible in EIA CBECS) may restrict the depth of analysis possible.

Additionally, the current data sources do not provide a clear breakdown between national chains and independent restaurants. Understanding this segmentation is crucial for analyzing current appliance ownership patterns and potential differences between chain and independent establishments.

3) **Uncertainty in the policy and regulatory landscape**

A deeper understanding of the relevant federal and state policy and regulatory landscape is necessary to effectively evaluate the leverage points and assess impact. One of the relevant state policies is the California Health and Safety Code, which when enforced on the county level includes the CCDEH Water Heater Sizing Guidelines, which has a direct impact on what water heaters can be installed in foodservice facilities in California. Currently, there is limited understanding of the CCDEH guideline amendment process, including the specific steps and

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[9] 2018 Commercial Buildings Energy Consumption Survey final results. https://www.eia.gov/consumption/commercial/#:~:text=Based%20on%20the%202018%20Commercial,were%20the%20main%20energy%20sources

[10] Delagah, A. and Fisher, D. (2013) Energy Efficiency Potential of Gas-Fired Commercial Water Heating Equipment in Foodservice Facilities. Report prepared by FNI for the CEC, CEC-500-2013-050.

timelines involved, the role of stakeholders, the criteria used for evaluating proposed changes, and the mechanisms for approval.

Additionally, it's important to understand how other regulations, such as California's Title 24 Building Energy Standards and Title 20 Appliance Efficiency Regulations, might influence the adoption of HPWHs in the foodservice sector. Potential overlaps or conflicts with these regulations need to be addressed. There is also a lack of clarity regarding the policies and regulations being developed by both CARB as well as the various Air Quality Management Districts (AQMD) that might influence the adoption of efficient water heating systems in the foodservice sector.

The research under this Advancement Plan would gain understanding of applicable codes, standards, and guidelines that impact foodservice hot water system design, and documenting existing and anticipated changes to minimum energy efficiency requirements or other code changes. Additionally, we would identify specific permitting challenges or delays, including those related to limited panel capacity, associated with installing HPWHs in foodservice establishments.

4) **Technical feasibility and potential configurations of heat pump-based water heating**

A critical knowledge gap exists in the technical feasibility and best practices for deploying HPWHs in restaurants. While direct one-to-one replacements for gas water heaters may work in some smaller facilities, there is much less certainty about how to design, size, and configure larger and more complex heat-pump based hot water systems. Unlike gas water heaters, which rely solely on a burner, HPWHs are inherently more complex, typically including both a heat pump and resistance heating, along with control logic to determine the appropriate heating source at any given time.

In terms of energy consumption, this means that heat pump-based systems are more sensitive to design flaws than gas systems. When coupled with relatively high unit-for-unit cost of electricity, poor system design, sizing, and controls can significantly increase operating cost, underscoring the need to identify and specify best practices.[11]

FSTC and others have extensively studied the efficiency of gas water heating systems, but far less lab testing and research on designing efficient heat pump-based systems foodservice applications has been conducted. As such, more research is needed to identify best practices for heat-pump based system designs and improvements to existing HPWH products.

Also, although various heat pump water heating products (both integrated and split) can be used in foodservice facilities, to date these systems have only been broadly deployed in single and multi-family residential settings, leaving limited field data on their performance in foodservice applications.

[11] https://caenergywise.com/design-guides/Technical_Design_Guide.pdf

Furthermore, we lack comprehensive data on hot water demand profiles across various restaurant types, which we believe are quite different from residential applications. This foodservice-specific data is essential for modeling and determining optimal HPWH configurations that can meet decarbonization goals without increasing operating costs.

Finally, several technical barriers could limit the practicality of HPWHs in restaurants, such as limitations in electrical panel capacity, spatial constraints to accommodate the equipment, the impact of recirculation and other design variables on HPWH performance, and the range of HPWH products currently available. However, it is unclear how widespread these barriers are, and what they might cost to overcome at any given site.

Phase II research objectives to address the knowledge gaps described above are described in Section 6.1 below.

5) **Technical feasibility and specifications for high efficiency dish machines**

Since dish machines can account for a large proportion of the hot water use in full-service restaurants, dish washing equipment that uses less hot water can significantly reduce cost and increase feasibility of replacing gas water heaters with HPWHs. Two such products include ventless heat-recovery dish machines, which use cold water instead of hot, and low-temperature dish machines with chemical sanitizer. However, despite the availability of products in the US market, both types of dish machines currently have very limited adoption in the foodservice market and there is limited understanding of the reasons for such low adoption.

To address this knowledge gap, further investigation is required in several areas. First, the market needs to be characterized to determine which foodservice facilities would benefit most from ventless heat-recovery and low-temperature dish machines, particularly in terms of reducing water heating loads and supporting the decarbonization of foodservice water heating (FSWH). Second, there are gaps in our understanding of the engineering and economic aspects. While replacing conventional dishwashers with these alternatives can reduce water heating capacity requirements, a thorough analysis is needed to estimate the impact on the total cost of ownership, considering cost savings from a reduced water heater size versus the potentially higher cost of the dishwashers. Finally, a comprehensive review of existing technologies is necessary. This review should cover the range of ventless and low-temperature dish machines available in the US market, their operating temperatures, and how these options meet the needs of different foodservice market segments.

6) **Lifecycle costs, HPWH product design improvements, rate structures, and non-energy impacts**

There are limited insights on the total cost of ownership (TCO) for HPWHs compared to traditional gas water heaters in restaurants. While HPWHs are efficient, concerns about higher operating costs due to California's high electricity prices persist. However, HPWHs with sufficient storage capacity, controlled to minimize peak period electricity use, and paired with aggressive TOU rates, may cost less to operate than gas water heaters.

A recent CalNEXT study found increased operating costs for HPWHs using conservative assumptions but acknowledged that using flat rates per kWh does not reflect current TOU rates. The study suggested that with load flexibility and TOU rates, HPWHs could generate cost savings. The same report highlighted scheduling and demand-response capability as methods to increase feasibility but indicated uncertainty about the necessary electricity rate structure to achieve cost parity or savings compared to gas water heaters.[12]

A comprehensive assessment is needed to quantify TCO for different types of restaurants, including equipment installation, maintenance, operational expenses including energy costs/savings, and electricity costs. This assessment will also consider the impact of HPWHs on peak electricity demand, lifespan, and maintenance compared to gas water heaters. Addressing these knowledge gaps will provide a complete picture of TCO, informing investment decisions for HPWH adoption in the restaurant industry. Additionally, there is limited understanding of non-energy impacts of HPWHs and hybrid systems, such as worker comfort, noise, and safety, which this assessment will address.

6 Research and program development plan

6.1 Technology assessment

This section describes any assessment that might be needed to prove the viability of the technology, service, or practice the initiative is targeting. Table 3 summarizes what and why the information is needed to complete the planning phase of the initiative and how the information will be collected. Table 4 summarizes the estimated cost per task and the time it will take to complete the task by the research team.

Technical assessment objectives

This section describes the planned activities for Phase II, which will start in late-2024 based on the current gaps in knowledge highlighted in Section 5.

The CalMTA team will conduct technology assessments (TA) to address critical knowledge gaps and inform MT strategies. These assessments will help validate and refine assumptions about technology adoption, expected impacts, and any technical limitations that would need to be addressed in a potential MTI.

Below are the key technical assessment objectives that are important to achieve:

TA 1. Assess technical feasibility and challenges

a. Identify optimal water heating system configurations for decarbonizing water heating in each foodservice facility type.

[12] Market Potential for Heat Pump Assisted How Water Systems in Foodservice Facilities. CalNEXT. April 2023. https://calnext.com/wp-content/uploads/2023/07/ET22SWE0019_Final_Report.pdf

b. Define hot water demand profiles for different types of foodservice facilities, including effects of system design such as heat recovery, heat pump assist, and efficient water use.
c. Identify technical barriers to the installation of all-electric water heating equipment such as electric panel capacity, space constraints, and product limitations.[13]
d. Characterize foodservice equipment design features including pre-rinse spray valves, faucets, heat recovery dish machines, and distribution piping. Identify design strategies to reduce hot water demand.
e. Determine if hybrid hot water systems (e.g. heat pump assist) are a practical and successful bridge to all-electric hot water system design.

TA 2. Quantify energy benefits

a. Calculate the energy and GHG impacts of optimized all-electric and hybrid water heating systems versus incumbent gas water heater technologies. Include estimated space cooling savings.
b. Determine the energy savings of implementing water pre-heat with a heat/energy recovery heat exchanger.

TA 3. Identify the non-energy benefits (NEBs)

a. Estimate impacts on indoor air quality, worker comfort, and noise levels in restaurant environments in switching from gas water heater to heat pump water heater.

TA 4. Quantify peak electrical load impacts

a. Estimate the increased peak electric demand of various water heating equipment configurations. Identify peak electric load management strategies such as hot water storage and advanced controls to mitigate demand increases and/or associated costs.

TA 5. Evaluate product performance and durability

a. Assess the reliability (instances of failure and durability) and useful life of available high-efficient electric water heater equipment.

TA 6. Investigate financial and cost factors

a. Quantify lifecycle costs including those from equipment installation, maintenance, operation (including TOU impact).
b. Assess relationship between current utility rate structures, demand charges, and hybrid HPWH operation. Identify and recommend revised rate structures that could support cost-effective operation of hybrid HPWHs.

TA 7. Identify technical barriers and opportunities related to regulations and policy

a. Identify applicable codes, standards, and guidelines that impact foodservice hot water system design. Document existing and anticipated changes to the minimum energy efficiency requirements or other code changes.

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[13] These can be considered both technical and market barriers. Since they will be investigated through site visits and audits they are described in this section rather than the Market Assessment section.

b. Determine the specific permitting challenges or delays, including those related to limited panel capacity, associated with installing HPWHs in foodservice establishments.

Technology assessment methods: The research team proposes a multi-prong approach to address the data and knowledge gaps: (1) Literature, Data Review & Dataset Analysis, (2) Expert Engagement (3) Energy Modeling and Economic Analysis, (4) Energy and Water Audit Site Visits, and (5) Lab Study.

The team will review existing literature and data sets and engage technical experts to estimate the technical feasibility of HPWHs and high-efficiency dish machines. For a select number of foodservice establishments, the team plans to conduct energy and water site audits to better understand existing configurations and infrastructure. Each of these assessment methods will support a comprehensive energy modeling analysis to determine the energy and peak demand impact of the optimized water heating system configurations for each foodservice facility type. The team will also complete an economic analysis to determine the financial and cost impact.

Lastly, the team plans to leverage existing lab testing conducted by the Code Readiness Program for smaller HPWHs and undertake additional lab testing of water heaters and larger heat pump-based water heating system equipment tested under foodservice conditions to determine product performance, end-use impact, and optimal configurations. The team will also analyze site data (such as space constraints, panel capacity, fixture counts, and incremental costs) and leverage ongoing work by CalNEXT to evaluate the practicality of hybrid water heating systems and evaluate its potential as a transitional solution towards all-electric hot water system design.

Table 3. Summary of technology assessment activities

Technology Assessment (TA) research objective	Phase II research task					Deliverable(s) informed by research	Related market research
	Literature & Existing Data Review	Ongoing Expert Engagement	Energy Modeling & Engineering Calculations	Laboratory Testing	Site Visits/ Audits		
TA.1: Assess technical feasibility and challenges	X	X	X	X	X	Product Assessment; Product Plan	MR.1 MR.2
TA.2: Quantify energy benefits	X		X			Product Assessment Impact and Cost Effectiveness Forecast; Product Plan	MR.1 MR.5
TA.3: Identify the NEBs	X	X			X	Product Assessment; Product Plan	MR.2
TA.4: Quantify peak electrical load impacts	X		X			Product Plan; MTI Plan	MR.1
TA.5: Evaluate product performance & durability	X	X		X		Product Specifications; Product Plan	MR.2
TA.6: Investigate financial & cost factors		X	X		X	Product Assessment; Impact and Cost Effectiveness Forecast; Product Plan	MR. 1 MR. 2 MR. 3
TA.7: Identify technical barriers & opportunities related to regulations & policy	X	X				Product Assessment; Product Plan	MR.4

Table 4. Summary of technology assessment needs, cost, and estimated timeline

Assessment task	Schedule (estimated weeks)	Estimated cost	Deliverables informed by this task
(1) Literature, Data Review, & Dataset Analysis	Weeks 1-20	$60,000	MTI Plan
(2) Expert Engagement: Policy SME, Technical SME, Site Operators & Owners, Contractors	Weeks 3-20	$60,000	MTI Plan
(3) Energy Modeling, Engineering Calculations, & Economic Analysis	Weeks 8-38	$85,000	MTI Plan
(4) Site Visits/Energy and Water audits*	Weeks 12-48	$100,000	MTI Plan
(5) Laboratory Testing	Weeks 16-52	$220,000	MTI Plan
Total estimate:		**$525,000**	

*This task will be conducted in coordination with the market research interviews. The timeline and cost for this task takes that coordination into consideration.

6.2 Market research

This section describes the market research needed to inform the MTI planning. The objective of the proposed research, the methods by which the research is conducted and how the results of the research will be use are shown in Table 5. Table 6 summarizes the estimated cost per task. The estimated costs do not include staff time.

Market research objectives: This market research (MR) aims to understand the barriers to adopting efficient water heating systems (such as HPWHs) and dish machines within California's foodservice industry. We will investigate both restaurant owners (demand side) and the supply chain (manufacturers, contractors) to identify key challenges and opportunities.

To address these goals, the CalMTA team will delve into the following five key research areas to gain a comprehensive understanding of the challenges and opportunities for efficient water heating system adoption in California restaurants and inform the MTI strategy:

MR 1. Market landscape and baseline market conditions

a. Refining estimates of the number of restaurants: Develop a more accurate and reliable estimate of the total market size disaggregated by type of restaurant (full service, quick service and cafés) and ownership structure (national restaurant chain and independent).
b. Equipment ownership and market size: Estimate the current saturation of water heating and dishwashing systems by technology, restaurant type, age, and ownership structure (owned vs. leased).
c. Replacement plans and future outlook: Identify the number of restaurants planning water heating and dishwasher replacements within the forecast period, including those with no replacement plans yet.

d. Current status of HPWH-based systems adoption in foodservice: Estimate the current saturation and market share of heat pump-based water heating systems disaggregated by type of restaurant.

MR 2. Restaurant owners' perspectives on barriers and opportunities

a. Needs and decision-making: Assess restaurant owner awareness of efficient water heating technologies, their approach to energy and cost reduction strategies, and their decision-making process for equipment upgrades. This includes exploring the level of owner involvement compared to contractor involvement, with a specific focus on discrepancies between independent and national restaurant chains.
b. Challenges and opportunities: Explore pain points with traditional systems, analyze decarbonization trends (including electric water heater adoption), and identify national trends influencing sustainable practices in restaurants. How do concerns about potential power outages or grid capacity limitations influence restaurant owners' decisions regarding electric water heater adoption, particularly in low-income and disadvantaged communities?
c. Technology adoption and investment: Investigate restaurant owners' concerns regarding maintenance of HPWHs compared to traditional systems and analyze the frequency and drivers behind water heating and dishwasher upgrades, considering factors like equipment age, efficiency improvements, regulations, and sustainability goals.
d. Leasing versus purchasing: How common are leasing options for water heating systems compared to purchasing outright? Which components (water heaters, end-use appliances) are typically leased vs. purchased? What factors influence the buy-versus-lease decision for restaurant owners (e.g., upfront costs, budget constraints)? Who are the key players in the leasing market for water heater systems? What are the alternate financing options available? Do California IOUs offer financing programs for energy-efficient equipment upgrades in the foodservice industry? If so, what are the program details regarding transferability upon ownership change and eligibility restrictions?
e. Consumer influence on sustainable choices: Evaluate the potential for diners to influence restaurants' sustainability practices, and assess the effectiveness of labeling, certifications, and incentive programs in driving consumer behavior towards patronizing energy-efficient restaurants.
f. Independent versus national restaurant chains: We will compare the perspectives on above topics of independent owners to that of national restaurant chains. Further, we will compare the perspectives of independent owners operating in ESJ communities with the responses from independent owners operating in non-ESJ communities. With the responses from independent owners in non-ESJ communities, our goal is to understand potential differences in their decision-making processes, challenges, and technology adoption considerations.

MR 3. Supply-side perspective questions

a. Water heater system design and installation: Identify the key players involved in designing and installing water heating systems for restaurants (engineers, architects, installers)? What factors influence design decisions for water heating and dishwashing solutions in new restaurants (roles of various stakeholders)? What incentivizes contractors to recommend and install efficient systems?
b. Installer qualifications: Assess the key skills, certifications, and experience levels required for contractors to become qualified installers of water heating. systems? What are the current training programs and certification processes?
c. Market adoption barriers: What are the key challenges within the supply chain that hinder the adoption of efficient water heating and dishwashing systems in restaurants (e.g., potential risks, collaboration issues)? What challenges and opportunities exist for manufacturers to scale production as demand for these technologies increases?
d. Cost analysis: How do the capital and operating costs of HPWH systems compare to traditional water heaters?

MR 4. Policy and regulatory landscape

a. Review existing policies and programs implemented by the CARB and AQMDs influencing equipment emissions standards for foodservice equipment, particularly water heaters and dishwashers.
b. Review existing policies and programs mandating or supporting decarbonization in the foodservice industry in California and other states.
c. Review the influence of CCDEH code on selection of water heating solutions. Also review existing policies and programs influencing equipment emissions standards.

MR5. Develop Baseline Market Adoption forecasts

a. Baseline forecasts for full and quick service restaurants and cafés.
b. Baseline forecasts for national/regional chains.

Market research methods: This research will utilize a multi-method approach to comprehensively assess the market potential for efficient water heating systems within California restaurants. We'll leverage existing data and reports (secondary data analysis) to establish a foundation on the industry, water heating trends, and relevant policies. In-depth interviews with key stakeholders - restaurant owners, manufacturers, architects/installers, program managers with experience in foodservice electrification, and financing/leasing entities - will explore their awareness, decision-making processes, supply chain dynamics, design/installation considerations, and existing electrification efforts. We will complement these interviews with a Delphi panel of industry experts and a comprehensive survey of restaurant owners to gather broader industry data on equipment ownership, replacement plans, and attitudes towards efficient technologies.

This combination of methods will provide a rich perspective on the market potential and challenges for efficient water heating solutions in California restaurants.

Table 5. Market research objectives, tasks, and deliverables

Market Research (MR) objective	Phase II research task						Deliverable(s) informed by research
	Secondary Research	Interview – FS Owners	Interview – Manufacturers, Architects and Installers	Interview – SMEs and Financing/ Leasing Entities	Delphi Panel	Survey of FS Owners	
MR.1: Characterize market landscape and baseline market conditions	X	X				X	Market Characterization, Baseline Market Forecast
MR.1a: Estimate current adoption of heat pump-based water heating systems	X					X	Market Characterization
MR.2: Assess restaurant owners' perspectives & decision-making process on efficient water heating systems	X	X		X		X	MTI Plan, Evaluation and Data Collection Plans, Market Characterization, Baseline Market Forecast, Impact and Cost Effectiveness Forecast
MR.3: Assess perspectives of manufacturers, installers, design professionals on barriers and opportunities	X	X	X	X		X	MTI Plan, Evaluation and Data Collection Plans, Market Characterization, Baseline Market Forecast, Impact and Cost Effectiveness Forecast
MR.4: Policy and regulatory landscape	X					X	MTI Plan, Market Characterization
MR.5: Develop Baseline Market Adoption forecasts	X				X	X	Baseline Market Forecast

Table 6. Market research task, estimated cost, and estimated timeline

Research task	Schedule (estimated weeks)	Estimated cost	Deliverables informed by this task
(1) Secondary research / sales data analysis	Weeks 1-20	$62,000	Market Characterization, MTI Plan
(2) Interview – restaurant owners and associations	Weeks 8-26	$80,000	Market Characterization and MTI Plan
(3) Interviews - manufacturer (HPWH & dishwashers), architect and contractor/installer	Weeks 10-32	$70,000	Market Characterization and MTI Plan
(4) Interviews – SMEs and financing/leasing entities	Weeks 10-32	$45,000	Market Characterization and MTI Plan
(5) Survey of restaurant owners	Weeks 24-42	$182,000	Market Characterization and MTI Plan
(6) Delphi Panel	Weeks 32-48	$74,000	Baseline Market Adoption (BMA) Forecast
Total Estimate:		**$513,000**	

The market research activities will conclude with an estimation of base year saturation and market share of the MTI technology.

The technology and market research activities described in this plan will inform an updated forecast of market adoption and development of Phase II TSB and cost-effectiveness estimates. These revised estimates will be developed upon the completion of the market characterization and will be submitted as part of the full MTI Plan.

6.3 Strategy Pilots

This section describes any potential intervention strategies that need to be tested during the Phase II development of this initiative and how conducting the pilot can inform the MTI's business case.

The CalMTA foodservice team has determined that this MTI requires further research before pilot programs can be thoroughly planned. Any potential pilot and its research objectives will be shaped by the outcomes of our outlined market research and, if deemed necessary, the initiative team will present a comprehensive Strategy Pilot Test Plan to MTAB and the CPUC.

7 External program review and stakeholder engagement

This section identifies a few key program stakeholders CalMTA needs to coordinate with as we determine the MT idea viability and develop the full MTI Plan. This list is a subset of a larger list and more stakeholders will be identified to coordinate with during Phase II.

As is standard practice in Phase I of our MTI development process, CalMTA conducted initial analysis to identify areas for alignment and opportunities for collaboration between this potential MT idea and existing programs or organizations focused on this market segment. While incentive programs like the Statewide Midstream Water Heating Program and other IOU offerings may be an important point of leverage during the MTI's implementation, CalMTA will prioritize coordination with the following stakeholder groups as we conduct the activities identified in this Advancement Plan.

Table 8. Summary of key external stakeholders

Program – Organization/ Stakeholder Segment	Coordination Approach
Statewide Codes & Standards Advocacy Programs	Continue ongoing series of coordination meetings to understand partners' current work and/or upcoming activities related to this technology and market segment Provide relevant information and insight to support the standardization of product performance and efficiency metrics
CalNEXT	Review existing research findings and conduct 1:1 outreach to the team's SMEs to understand questions and areas of future research Maintain regular cadence of meetings to share research plans and explore for overlap and cost-sharing opportunities
California Energy Wise (statewide foodservice instant rebates program)	Leverage market knowledge and established industry relationships to inform the design of planned research activities and interventions If applicable, coordinate on identification of strategy pilot sites
California Energy Design Assistance (CEDA)	Leverage and promote this resource to decisions-makers for complimentary custom energy modeling for new construction or major remodeling
IOU Foodservice Technology Centers	Leverage market knowledge and established industry relationships to inform the design of planned research activities and interventions Explore opportunities to collaborate on lab/product testing

Program – Organization/ Stakeholder Segment	Coordination Approach
	Leverage their relationships for potential pilot recruitments
Industry associations (e.g., the National Restaurant Association, Green Restaurant Association, California Restaurant Association, Latino Restaurant Association)	Collaborate on targeted educational efforts and recommendations for practices and equipment

As the MTI moves into Phase II: Program Development, CalMTA will define an approach for ongoing coordination with critical program teams to avoid duplication of efforts, facilitate mutually beneficial information/data-sharing, and identify key leverage opportunities to enhance each other's work in this market segment.

8 Potential risks & mitigation

Table 9 describes potential risks, their assumed severity, and how we plan to track and mitigate the risks if needed.

Table 9. Hypothesized MTI risk review

Initiative Risk	Severity	Mitigation Approach
CCDEH code does not get updated, which will continue to prohibit HPWHs in restaurants	High	Conduct market research to better understand the code amendment process; develop an approach based on research and learnings Align and collaborate with MTI stakeholders to increase awareness and pressure around code update needs
Electricity costs relative to gas rise, making the value proposition for decarbonization even more challenging	High	Projection of bill impacts as electricity and gas rates change over time Better understanding of and ability to quantify NEBs of HPWHs and efficient water heating systems in foodservice establishments Identify financial solutions, rate structure and time-of-use adjustments
Market is not prepared for and rejects California codes, standards and/or legislative efforts aimed at moving the market to heat pump technology	High	Leverage market relationships to understand response pre and post legislation and closely monitor how the market is responding in real time

Initiative Risk	Severity	Mitigation Approach
		Work with supply chain partners to pivot tactics/strategies to address barriers prior to legislation taking place Explore and advocate for cost neutralization approaches targeting parody in price for installation and operation Create and or leverage existing statewide sales data collection mechanism to track sales and monitor "work arounds" Work closely with regulatory organizations to understand monitoring and enforcement mechanism. Leverage market size of California to encourage market actors to partner on cost neutralization and training efforts, specifically targeting necessary pivots to installer business models and sales tactics
Product quality and performance issues arise when replacing gas water heaters with efficient water heating systems	Medium	Remain highly engaged with manufacturers to ensure open communication on quality and performance; ensure manufacturers have emergency replacement plans Monitor performance to adjust specs and quality testing requirements as needed
Foodservice establishments in ESJ communities experience negative, unintended consequences of electrification and decarbonization	Medium	Intentionally engage independent foodservice facilities (i.e. small family-owned restaurants or local chains) and ESJ stakeholders Develop tools/resources to increase awareness and establish communication channels with ESJ communities Identify financial solutions and resources
Market risks due to potential setbacks in federal, state, and local appliance standards and uncertain decarbonization policies	Medium	Engage with CARB and federal appliance standard setting bodies to influence/inform policies

Initiative Risk	Severity	Mitigation Approach
In efforts to decarbonize, restaurant owners may prioritize other opportunities over water heating (e.g. HVAC, kitchen ventilation)	Medium	Leverage codes and regulations to influence decision making and prioritization of water heaters Strengthening the business case for HPWHs and efficient water heating systems by better understanding and quantifying the NEBs
Large, national food chains and trade associations resist decarbonization	Low	Leverage relationships with manufacturers as an entry point to national food chains Target foodservice chains with active ESG goals and decarbonization commitments

9 Estimated cost, timing, and expected results

Table 10 summarizes the estimated costs to complete the technology assessment, market research, and strategy pilots described in Section 6.

Table 10. MTI Advancement Plan estimated cost summary

Section	Estimated Cost $
Technology Assessment	
(1) Literature, data review & dataset analysis (Weeks 1-20)	$60,000
(2) Expert engagement: policy SME, technical SME, site operators & owners, contractors (Weeks 3-20)	$60,000
(3) Energy modeling, engineering calculations, & economic analysis (Weeks 8-38)	$85,000
(4) Site visits/energy and water audits (Weeks 12-48)	$100,000
(5) Laboratory testing (Weeks 16-52)	$220,000
Market Research	
(1) Secondary research/sales data analysis (Weeks 1-20)	$62,000
(2) Interview – restaurant owners and associations (Weeks 8-26)	$80,000
(3) Interviews - manufacturer (HPWH & Dishwashers), architect and contractor/installer (Weeks 10-32)	$70,000
(4) Interviews – SMEs and financing/leasing entities (Weeks 10-32)	$45,000
(5) Survey of restaurant owners (Weeks 24-42)	$182,000
(6) Delphi Panel (Weeks 32-48)	$74,000
Total	**$1,038,000**

Figure 2 in this section shows a rough timeline of this phase's activities to develop the full MTI Plan.

Figure 2. Overall timeline/schedule of activities

Activity	Duration (Weeks)	Timeline (Months)													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
Technology Assessment															
(1) Literature, data review & dataset analysis	1 - 20														
(2) Expert engagement: policy SME, technical SME, site operators & owners, contractors	3 - 20														
(3) Energy modeling, engineering calculations, & economic analysis	8 - 38														
(4) Site visits/energy and water audits	12 - 48														
(5) Laboratory testing	16 - 52														
Market Research															
(1) Secondary research/sales data analysis	1 - 20														
(2) Interview – restaurant owners and associations	8 - 26														
(3) Manufacturer (HPWH & dishwashers), architect and contractor/installer interviews	10 - 32														
(4) SME interviews	10 - 32														
(5) Survey of restaurant owners	24 - 42														
(6) Delphi Panel	32 - 48														

Table 11 shows a rough estimate of the initiative should it advance to the Market Deployment phase and what the high-level estimates initiative results would be.

Table 11. Initiative market deployment estimated cost & expected results

Initiative Cost ($)	>25 million	A sizeable investment will be required to transition the foodservice sector from gas to electric and heat pump-based systems
Initiative Timeline (Years)	> 10 years	Due to the complexity and variability of foodservice water heating systems, transforming the market will take time
Expected Results	TSB: $216 million TSB Energy: $7 million TSB Grid: -$79 million TSB GHG: $288 million	Given the high energy intensity of foodservice water heating systems, this MTI could result in significant GHG and peak demand reduction benefits

About CalMTA

CalMTA is a program of the California Public Utilities Commission and is administered by Resource Innovations. We work to deliver cost-effective energy efficiency and decarbonization benefits to Californians through a unique approach called market transformation. Market transformation is the strategic process of intervening in a market to create lasting change by removing market barriers or exploiting opportunities, accelerating the adoption of identified technologies or practices. CalMTA-developed market transformation initiatives also aim to advance state goals on demand flexibility, workforce development and equity. Learn more at www.calmta.org.

Appendix A: Market Forecasting & Cost-Effectiveness Modeling Approach

FOODSERVICE WATER HEATING SYSTEMS

The information provided in this appendix summarizes the approach and methodologies used for the preliminary estimation of market adoption, total system benefit (TSB), and cost-effectiveness during stage 2 scoring. The target markets, product definition, or other criteria may have shifted during the development of the advancement plan. The information contained in this appendix will be updated at the end of Phase II as part of the MTI Plan development to ensure the estimates better reflect the most current MTI design.

Market transformation initiatives (MTIs) generate energy savings and related benefits by accelerating and increasing market adoption of energy-efficient technologies and practices. Estimating the energy impacts and cost-effectiveness of MTIs requires developing a market forecasting model that uses a set of inputs based on well-documented sources, methods, and assumptions.

This appendix provides an overview of the technology and market characteristics of the MT idea involving the decarbonization of foodservice water heating, as adopted in Stage 2 of the MTI lifecycle. The document summarizes the inputs, sources, and methods used for the preliminary estimation of market adoption, total system benefit (TSB), and cost-effectiveness. The summary of model outputs covers the estimates of the benefits and cost-effectiveness of the MTI. As we learn more about the market through additional research in Phase II of the MTI lifecycle, we will refine and update our approach and this document.

MTI overview

The MT idea consists of electrifying water heating in foodservice establishments.[14] Table A1 summarizes the Foodservice Water Heating Systems MT idea's product definition and market characteristics adopted in Stage 2 of the MTI lifecycle. MTIs typically evolve over time based on market research and experience.

Table A1. MT idea product definition and market characteristics

MTI Phase	Stage 2
Product definition	Water electrification focuses on HPWHs
Addressable market segments	Full-service restaurants and quick-service restaurants[15]. The MTI covers both existing and new foodservice establishments

[14] We use the terms "foodservice establishments" and "restaurants" interchangeably. Unless specified, the terms refer to both full-service and quick-service (or limited-service) restaurants.

[15] In Phase II, the addressable market segment will be expanded to include Cafés.

MTI Phase	Stage 2
Baseline installation conditions	Water heaters: gas fueled water heater[16]

Adoption forecasting model

This section outlines the team's approach to forecasting the adoption of HPWHs by foodservice establishments from 2025 to 2045 in the addressable market segments. To begin, we projected the baseline market adoption (BMA) of the technology, which considers current and expected market trends, technological advancements, and regulatory factors, assuming no intervention by CalMTA. Next, we forecasted the total market adoption (TMA), which assumes interventions by CalMTA to transform the market. Finally, the team calculated incremental adoption (TMA minus BMA) and used it as an input to estimate cost-effectiveness and TSB.

Inputs

Table A2 lists the key assumptions used to forecast the adoption of efficient electric water heaters by foodservice establishments in California.

Table A2. Assumptions used in forecasting model

Category	Variable	Assumptions	Notes
Forecasts of units of MTI technology – heat pump water heater	Number of units of HPWH per restaurant (ω)	2020: 2 2045: 2	
	Effective Useful Life (EUL)	10 Years	California Electronic Technical Reference Manual (eTRM)
Timing of MTI initiation, rollout, and impact realization	Start year for initiation of CalMTA MTI	2025	
	Number of years for design and finalization of CalMTA initiatives	2	
Forecasts of new restaurants	Number of restaurants per 1000 residents	2023: 1.9 2045: 1.9	Based on estimates from EIA CBECS 2018

Note: The team will review and update assumptions in Phase II to reflect recent research.

The following sections discuss the sources and methods used to estimate product saturation, market size, and market growth (with and without the MTI).

Base-year estimate of foodservice establishments

[16] For simplicity, we only considered gas water heaters as the baseline assumption for the preliminary Stage 2 analysis. Per EIA CBECS 2018, around 75% of foodservice establishments in California depend upon gas for water heating. In Phase II, we will consider other technologies including electric water heating.

The team used EIA CBECS 2018 (EIA 2022) to develop estimates of the number of foodservice establishments in California. CBECS is a national sample survey that collects information on the stock of US commercial buildings, including their energy-related building characteristics and energy usage data (consumption and expenditures). EIA CBECS 2018 collected information in two stages: first, the Buildings Survey, where building-specific information was collected directly from building owners, managers, or tenants, and subsequently, the Energy Suppliers Survey, which collected information from energy suppliers of buildings covered in the first stage.

While analyzing CBECS 2018 data, CalMTA considered establishments with principal building activity listed as foodservice, food sales, lodging, and strip shopping centers and with non-zero cooking energy use in 2018. Per the CBECS 2018, these establishments jointly accounted for around two-thirds of cooking energy consumed by the commercial sector in 2018. The CBECS 2018 provides data for the Pacific Census Division instead of California.[17] The team estimated the number of establishments in California based on the relative share of California's gross domestic product (GDP) compared to the GDP of other states in the Pacific Census Division.[18]

Table A3. EIA CBECS 2018 estimated number of foodservice establishments in California

Description	Pacific Census Division	Estimated for California
Number foodservice establishments	100,779	74,577[19]

Note: The team only considered establishments that reported consuming fuel for cooking in 2018.

For Stage 2 preliminary forecasts, we assumed that the number of establishments remained unchanged from 2018 to 2023. In Phase II, we will revisit this assumption to account for physical closures of restaurants (as opposed to ownership or management changes).

Forecast of foodservice establishments

The team forecasted growth in the number of foodservice establishments based on population forecasts from the California Department of Finance. To forecast growth, we assumed that the number of restaurants per 1,000 residents remains at the same level as in the base year of 2023, which is 1.91 establishments per 1,000 residents.

Current *electrification of water heaters*

Table A4 provides an estimated distribution of foodservice establishments in California, segmented by the primary type of fuel used for water heating. It categorizes the proportion of restaurants that exclusively use natural gas and/or propane, as opposed to those that incorporate electricity for some or all of their water heating energy requirements. To estimate this distribution,

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[17] Pacific Census Division includes the states of California, Washington, Oregon, Alaska and Hawaii.

[18] State GDP is estimated by US Department of Commerce https://www.bea.gov/data/gdp/gdp-state

[19] The estimates from EIA CBECS 2018 differ from estimates elsewhere in the literature. For example, the CalNEXT 2022 report on foodservice decarbonization estimated around 70,000 Quick Service and Full Service establishments. The US Census' County Business Patterns 2021 estimated around 63,000 Full Service and Limited Service restaurants. In Phase-2, we will refine our estimates for number of foodservice establishments.

we considered the CBECS's estimate of energy consumption for water heating disaggregated by fuel type for each foodservice establishment identified in Table A3 above. To provide a trend in the distribution, we also analyzed the CBECS 2012 published in 2016.

Table A4. Distribution of foodservice establishments in California by fuel used for water heating (2012 and 2018)

Fuel used for cooking	Percentage distribution by given year of survey	
	2012	**2018**
Natural Gas and/or Propane only	52%	62%
Electricity (Fully or Partially)	48%	38%

Source: EIA CBECS 2018 and 2012

The table shows that 62% of foodservice establishments did not use any electricity for water heating in 2018. This proportion of natural gas consuming foodservice establishments in California increased from 52% in 2012 to 62% in 2018, highlighting the increase in adoption of natural gas during that time period.

Methodology

To develop the preliminary Stage 2 forecast of the electrification of water heating equipment, CalMTA made assumptions about the proportion of existing restaurants that will transition partially or fully from natural gas to electricity. For new restaurants, CalMTA assumed the proportion of new restaurants with HPWHs in any given year. Subsequently, we made assumptions about the number of HPWH per restaurant.

Baseline Market Adoption forecast

For the Phase I forecasting model, the following equation summarizes the team's approach to forecast the number of existing restaurants that transitioned to electricity for water heating in BMA:

$$y_t^{Existing} = Restaurants^{2023} \times (P_t^{BMA} - P_{t-1}^{BMA}) \times \omega^{WH}$$

Where:

$y_t^{Existing}$ = annual adoption of HPWH in year t by existing foodservice establishments

$Restaurants^{2023}$ = number of foodservice establishments in year 2023

P_t^{BMA} = Proportion of foodservice establishments that electrified water heating in year t in BMA (Cumulative proportion)

P_{t-1}^{BMA} = As above, but for year $t-1$

ω^{WH} = number of water heaters per restaurant (assumed to be 2)

For new foodservice establishments, we adopted the following approach:

$$y_t^{NC} = Restaurants_t \times \rho_t^{BMA} \times \omega^{WH}$$

Where:

y_t^{NC} = annual adoption of HPWH in year t by new foodservice establishments

$Restaurants_t$ = number of new foodservice establishments established in year t

ρ_t^{BMA} = Share of foodservice establishments established in year t who adopt HPWH (Annual share)

Electrification of water heating equipment

CalMTA made the following assumption of the trend in the proportion of restaurants that adopt efficient electric water heaters (Table A5). The team anticipates a shift away from historical trends for this analysis, with a growing number of restaurants choosing electric water heating. This assumption is supported by the overall trend towards electrification in California, driven by regulations like stricter California Air Resources Board Appliance Standards, local air quality measures targeting nitrogen oxide emissions, and utility programs incentivizing electrification. Additionally, the California Energy Commission's forecast of a steeper price rise for natural gas compared to electricity (2.5% versus 0.5% annually) strengthens the economic case for HPWH.[20] However, we expected the rate of electrification to be low given various barriers including relative cost of HPWH and gas-fueled water heaters.

Table A5. Assumptions for proportion of foodservice establishments with electric water heating equipment for BMA forecast

	Vintage of foodservice establishment	
Year	**Existing ($P_t^{BMA} - P_{t-1}^{BMA}$) ***	**New ρ_t^{BMA} ****
2022	38%	38%
2035	50%	50%
2045	55%	67%

Notes: (*) The percentages represent the assumed proportions of establishments using electricity by the respective year (i.e., saturation). (**) The percentages are assumed annual market share of electrified establishments.

During the preliminary Stage 2 analysis, when applying the above assumptions for share of HPWHs, CalMTA considered the overall share of electricity for water heating but did not differentiate between HPWHs and less efficient electric resistance heaters. In Phase II, we will focus specifically on adoption of HPWH within the broader electrification decision. We will revisit assumptions for adoption trends based on inputs from subject matter experts and stakeholders and re-develop the forecasts.

Total Market Adoption forecast

This section focuses on the Stage 2 adoption forecast for the MTI in California with targeted interventions to address market barriers and opportunities. While the specifics of these interventions remain undetermined, we considered the potential increase in adoption resulting

[20] California Energy Commission. Accessed April 2024. California Energy Demand, 2023-2040. https://www.energy.ca.gov/data-reports/reports/integrated-energy-policy-report/2023-integrated-energy-policy-report/2023-1

from them. The forecasting methodology for TMA was consistent with the methodology used by the team to forecast BMA, and adoption in year t is written as follows:

$$y_t^{Existing} = Restaurants^{2023} \times (P_t^{TMA} - P_{t-1}^{TMA}) \times \omega^{WH}$$

Where:

P_t^{TMA}	=	Proportion of foodservice establishment which electrified cooking in year t in TMA (Cumulative proportion)
P_{t-1}^{TMA}	=	As above, but for year $t-1$
ω^{WH}	=	Number of WH per restaurant

For new foodservice establishments, we adopted the following approach:

$$y_t^{NC} = Restaurants_t \times \rho_t^{TMA} \times \omega^{WH}$$

Where:

ρ_t^{TMA}	=	Share of foodservice establishments established in year t who adopt electrical water heaters (Annual share)

Other terms are as defined in the prior equation for BMA.

To forecast TMA, the team applied estimates of annual sales and assumptions similar to those used for the BMA forecast. However, inputs for the TMA forecast differed from BMA in one specific way: the team assumed more accelerated electrification of existing restaurants (i.e. $(P_t^{TMA} - P_{t-1}^{TMA})$); and faster growth in market share of electrical water heating equipment for new restaurants (i.e. ρ_t^{TMA}).

Electrification of water heating equipment

CalMTA made the following assumptions about the trend in the proportion of restaurants that adopt efficient electric water heaters (Table A6). Compared to the BMA, the TMA anticipates a faster transition to HPWH in restaurants. This is driven by factors such as reduced market barriers leading to lower upfront costs, easier installations and streamlined permitting and technical support processes, and potential advancements in HPWH technology leading to lower capital costs.

Table A6. Assumptions for proportion of foodservice establishments with electric water heating equipment for forecast with MTI interventions

	Vintage of foodservice establishment	
Year	Existing $(P_t^{TMA} - P_{t-1}^{TMA})$ *	New ρ_t^{TMA} **
2022	38%	38%
2035	67%	67%
2045	75%	75%

Notes: (*) The percentages represent the assumed proportions of establishments using electricity by the respective year (i.e., saturation). (**) The percentages are assumed annual market share of electrified establishments.

Similar to the BMA forecast, in Phase II, we will revisit these assumptions based on Phase II research and re-develop the market adoption forecast.

Incremental Market Adoption (TMA – BMA)

Incremental market adoption in any given year is the difference between the number of total market adoption units and the number of baseline market adoption units, as described in the following equation:

$$y_t^{Incremental,Existing} = y_t^{TMA,Existing} - y_t^{BMA,Existing}$$

$$y_t^{Incremental,NC} = y_t^{TMA,NC} - y_t^{BMA,NC}$$

Where:

$y_t^{Incremental}$ = Incremental annual adoption in time t. The superscripts $Existing$ and NC refer to forecasts of incremental electrification among existing and new foodservice establishments, respectively.

Outputs

In this section, we summarize the preliminary BMA and TMA forecasts for efficient water heaters in the foodservice industry. We used outputs developed applying the following formulas to calculate the cumulative adoption units:

$$\sum_{t=2025}^{2045} y_t^{BMA,Existing}, \sum_{t=2025}^{2045} y_t^{BMA,NC}, \sum_{t=2025}^{2045} y_t^{TMA,Existing} \text{ and } \sum_{t=2025}^{2045} y_t^{BMA,NC}$$

Baseline Market Adoption forecast

We forecasted a cumulative adoption of HPWH units by around 12,000 existing and 1,000 new foodservice establishments over the forecast horizon in the absence of CalMTA interventions. Given our assumption of 2 water heaters per restaurant, this amounts to approximately 26,000 over the forecast horizon.

Total Market Adoption forecast

We forecasted a cumulative adoption of efficient electric water heaters by around 27,000 existing and 1,200 new foodservice establishments over the forecast horizon in the absence of CalMTA interventions. This amounts to approximately 56,000 efficient electric water heaters over the forecast horizon.

Incremental adoption

We calculated incremental market adoption, in terms of difference between TMA and BMA, of approximately 30,400 efficient electrical water heaters as shown in Table A7.

Table A7. Stage 2 HPWH – incremental adoption

Segment	Technology	Baseline condition	Incremental market adoption (units of MTI technology)
Existing restaurants	Efficient Electric Water Heater	Gas water heater	~ 30K
New restaurants			~0.4K

Cost-effectiveness model

Evaluating cost-effectiveness and determining the net benefit for an MTI requires the appropriate application of outputs from the market forecasting model, initiative costs, incremental measure cost (IMC), avoided cost, load shape, and unit energy impacts (UEI). This application of inputs considers the baseline installation conditions, baseline and efficient technologies, fuel types, target sector, and costs incurred by all stakeholders in the MTI implementation. Moreover, both the costs and benefits change over time, due to factors such as EUL, regulatory policy, electricity and gas rates, and initiative funding.

Currently, CEDARS' Cost-Effectiveness Tool (CET) is the official publicly available tool to evaluate energy efficiency programs in California. The CET can be used to evaluate programs from all utilities and climate zones, using approved 8,760 load shapes and defined avoided costs. However, since analysis for this MTI involved 8,760 load shapes not currently supported by CET, the team developed an in-house Excel-based cost-effectiveness tool versatile enough to handle all the MTIs for CalMTA.

Inputs

The cost-effectiveness model uses the following inputs to assess cost-effectiveness and develop TSB estimates. TSB is a representation, in dollars on an annual basis, of the consumption of energy, ancillary services, generation capacity, transmission and distribution capacity, and greenhouse gas (GHG) benefits of the market transformation initiative during the life of the measure. We applied the inputs according to the formulas listed in the *Methodology* section below. The inputs for the Foodservice Water Heating System cost-effectiveness analysis are detailed below.

Incremental adoption

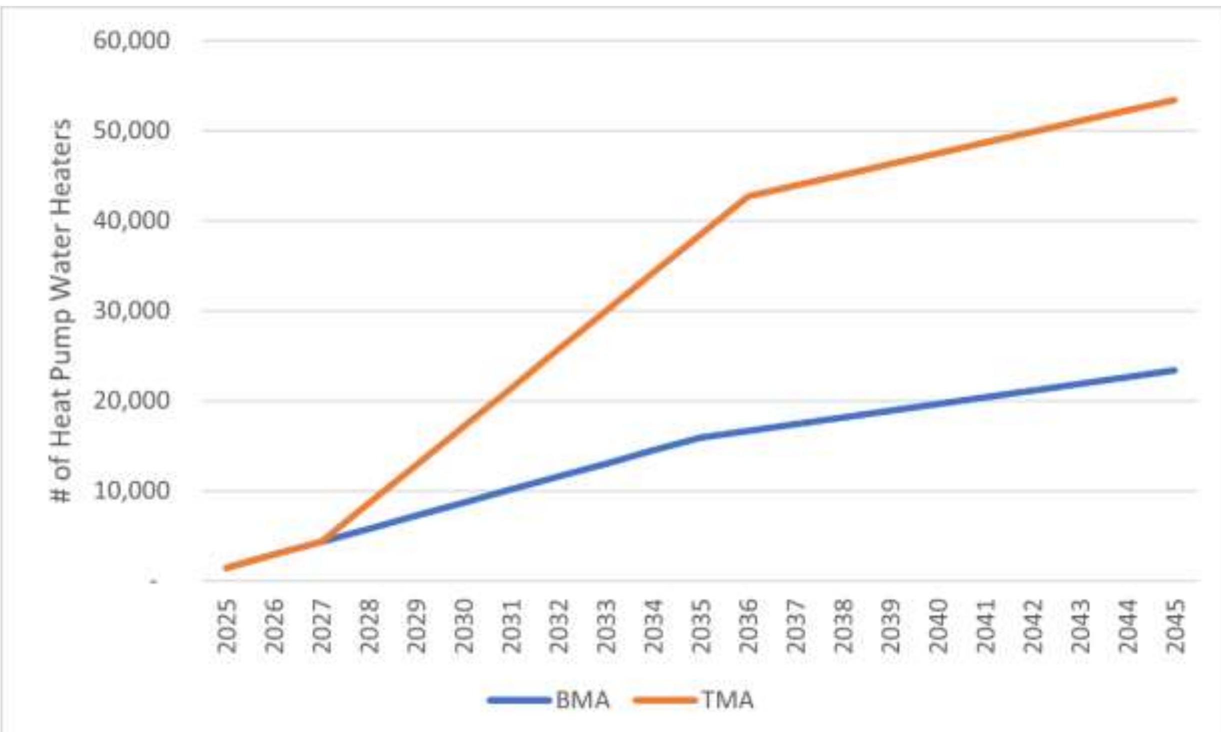
The team developed incremental market adoption of HPWHs for establishments projected to replace their existing gas water heaters with HPWHs from 2025 to 2045. The MTI considered the installation conditions as shown in Table A8.

Table A8. Installation conditions

Sector	**Decision** type	**Baseline** equipment	**Efficient equipment**
Commercial (restaurants)	Accelerated Replacement (AR), Normal Replacement (NR), and New Construction (NC)	Gas water heater	HPWH

The team applied incremental adoption for the duration of the EUL for HPWHs in foodservice establishments. For example, if 80,000 units of HPWHs were projected to be installed in 2027, these units would contribute to the model for 10 years (EUL for HPWHs), combined with HPWHs introduced in the following years. Figure A1 illustrates cumulative market adoption of Foodservice Water Heating Systems by year.[21]

Figure A1. Cumulative adoption of Foodservice Water Heating Systems by year



Initiative costs

Initiative costs are related to the implementation of the MTI. This includes flow-down incentives (FDI) and non-incentive costs, such as administration, research and evaluation, marketing, and other related costs. Initiative costs are applied over the length of the MTI from 2025 to 2045.[22] Initiative costs are used to determine the Total Resource Cost (TRC) test and Program

[21] For Phase II research, we will incorporate any updates to the EUL values.

[22] Flow down incentives refer to incentives that flow down to the customer and reduce customer costs.

Administrator Cost (PAC) test. In the PAC test, all initiative costs are included. For the TRC, incentive costs are excluded. Initiative costs are discounted to determine the net present value of the initiative.

Incremental Measure Cost

The team conducted secondary research to develop estimates of incremental costs. We researched currently available products for gas water heaters and HPWHs in stores like Home Depot in their California locations.

In the first year of the MTI, for the installation of efficient HPWH to replace the baseline gas water heating, the team determined an Incremental Measure Cost (IMC) of $3,288 for Normal Replacement and Accelerated Replacement. For New Construction, we determined an IMC of $2,658.

After determining the average costs for products currently on the market, we extrapolated the costs into future years by subtracting 2% of the first-year incremental cost from each subsequent year in the MTI, to represent anticipated reduction in case costs relative to the baseline. We assumed in Stage 2 that IMC would decrease over time due to economies of scale (that is, the price of the efficient technology becomes cheaper over time, as production volume increases) and move closer to the price of the baseline technology. The Stage 2 analysis also assumes that inflation would equally impact both the base and proposed cases and therefore did not update IMC estimates for inflation. In Phase II, we will conduct additional analysis to refine incremental cost estimates for the forecasting period.

The team included IMCs in the TRC test, along with non-FDI costs for each year and installation condition. IMCs in the TRC test are discounted to determine the net present value of the initiative.

Avoided costs

Avoided costs are defined as the marginal costs that the state would avoid in any given hour through lower energy consumption. The electric avoided costs include cap and trade, GHG adder, GHG rebalancing, energy, generation capacity, transmission capacity, distribution capacity, ancillary services, losses, and methane leakage. The gas avoided costs include transmission and distribution, commodity, nitrogen oxides, carbon dioxide, and methane emissions.

The team developed avoided costs using the Avoided Cost Calculator (2022) for three utilities: Pacific Gas & Electric (PG&E), Southern California Edison (SCE), and San Diego Gas & Electric (SDG&E). We developed avoided costs based on Foodservice Water Heating Systems from 2025 to 2052 in each utility's territory. Avoided costs include energy, grid, and GHG benefits for electric and gas fuels. Because the MTI will result in market impacts outside the IOU service territories, we also estimated avoided costs for "other" non-IOU territories.[23]

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[23] Since the MTI is implemented for California as a whole, avoided costs for PG&E, SCE, and SDG&E only do not fully represent the entire state. For the Stage 2 (Phase I) analysis, we included a separate

The team used the avoided costs to determine the TSB, as well as TRC and PAC ratios. We applied avoided costs to the incremental adoption for PGE, SCE, SDGE, and other utilities for each installation condition in each year. We then summed and discounted these benefits to the first year of the MTI to determine the TSB. TSB is identical to the benefits used in TRC and PAC.

Load shape

Load shape is defined as the hourly probability of activity for HPWH for Foodservice Water Heating Systems and is based on a set of variables including equipment runtimes, operating characteristics, and other factors, such as occupancy patterns. The load shape was developed in CBECC using the quick-service restaurant prototype assuming a .65 UEF gas water heater baseline and a 2.8 UEF HPWH proposed tech. After determining a ratio between the baseline and proposed, that ratio was applied to the hourly HPWH hourly load output from CBECC.

Unit Energy Impacts

To estimate the savings from foodservice water heating, the team used CBECC-2022 to model the annual energy savings resulting from switching from a natural gas water heater to an HPWH for commercial kitchens. The small restaurant prototype model was run with a standard default Title 24 compliant natural gas water heater as the baseline, and a standard efficiency HPWH was modeled as the proposed replacement.

As shown in Table A9, the average annual electric use increases by 4,323 kWh per HPWH. Average annual gas savings were 635 therms, for an average of $1,912 in total avoided cost.

Table A9. Unit Energy Impacts

Installation Condition	Average Annual Increased Electric Usage	Average Annual Gas Savings
Commercial Gas Water Heater	4,322.69 kWh	635.37 therms

The team applied these UEIs to the load shape and avoided costs to determine the TSB generated by HPWH adopted because of the MTI.

Methodology

The team took a systematic approach to developing the cost-effectiveness model. It began by determining all the necessary model inputs and outputs for the MTI, further described below.

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category, "other," to represent the other utilities in California, developed through population proportions and utility territory maps. Specifically, we overlayed the utility territory maps with county boundaries and assigned an appropriate proportion of the county's population to the respective utility. We developed avoided costs for the "other" category by applying population-weighted average avoided costs for the three utilities. After discussion with the CPUC, we agreed to remove benefits estimated for non-IOU territories from the Phase II cost-effectiveness calculations.

Determine input values

MTI cost-effectiveness inputs are broken down into six inputs: market adoption, UEIs, initiative costs, load shape, avoided costs using the 2022 ACC, and IMCs. Each of these inputs is developed using product and market definitions documented by the MTI team and must have consistent units of analysis. For example, MTIs can be defined in terms of a single unit of equipment, household, whole building, or square feet. All inputs must be developed accordingly and converted into the same units.

UEI inputs for Stage 2 consist of the three largest California utilities: PG&E, SCE, and SDG&E, and the "other" category (representing other utilities in California). Therefore, each installation condition for any MTI has four sets of utility specific UEIs. The model pairs UEI inputs with an 8,760 hourly load shape appropriate for each MTI technology that estimates how likely an end user will use the equipment in any given hour of the year.

All inputs must also be applied on a yearly basis, constrained by the EUL and the MTI lifetime. These inputs will be reviewed during Phase II and updated as appropriate. The Phase I analysis includes these EUL and lifetime assumptions for foodservice decarbonization HPWH:

- MTI lifetime = 20 years (2025 to 2045)
- EUL = 10 years

For incremental market adoption and initiative costs over the course of the MTI, we used three assumptions:

- 2025 and 2026 are initiative design years. Thus, incremental adoption begins in 2027.
- Though there is no incremental adoption in 2025 and 2026, the MTI is still operating; therefore, we allocate non-incentive related initiative costs to 2025 and 2026.
- FDIs are components of initiative costs during the first five years of incremental adoption. Incentives are assumed for 25% of units adopted in 2027, ramping up to 50% of units adopted in 2031.

Determine required outputs

After developing the inputs, the team developed and reported the outputs needed for cost-effectiveness. To account for the time value of money, we applied a discount rate of 6% to discount outputs to the first year of the MTI in Stage 2. For the Phase II analysis, we will update this assumption and apply the discount rate based on the ACC. There are three outputs for reporting on the MTI: TSB, the TRC ratio, and the PAC. The team evaluated the TSB, TRC, and PAC for each of the two installation conditions for the MTI, determining the total for TSB, TRC, and PAC.

After collecting the required inputs and outputs, the team developed an Excel model that used all the inputs, operated an hourly (8,760) based analysis, and reported the discounted values of both installation conditions and MTI-level TSB, TRC, and PAC. Table A10 lists the terms (based on the CET) used by the Excel model to determine the TSB, TRC, and PAC.

Table A10. Cost-effectiveness model parameters

Terms	Description	Units
ElectricBenefits	Net Benefits generated through electric savings from ACC	Dollars/Kwh & Dollars/kW and associated GHG avoided costs
GasBenefits	Net Benefits generated through gas savings from ACC	Dollars/Therms and associated GHG avoided costs
OtherBenefits	Benefits generated through non-electric or gas savings. Stage 2 analysis incorporated refrigerant benefits only.	Dollars per unit
NumberOfUnits	Incremental adoption	HPWHs
Net kWh	Net to Gross Ratio of the measure used to standardize other benefits to Electric and Gas benefits	NTG Ratio (Assumed to be 1 for this analysis)
MarketEffectsBenefits	Measure benefits generated through market forces	Dollarized Market Effects (assumed to be 0)
RefrigerantBenefits	Measure benefits generated through refrigerant savings	Dollars/unit
ElectricSupplyCost	Costs incurred in the supply of electricity	Dollars/kWh & Dollars/kW
GasSupplyCost	Costs incurred in the supply of gas	Dollars/Therms
MarketEffectsCosts	Costs incurred through market forces	Dollarized Market Costs (where present)
UnitRefrigerantCosts	Costs incurred through refrigerant losses. Stage 2 analysis incorporated refrigerant costs only.	Dollars/Unit
TRCCost	Costs associated with the TRC test	Dollars (Initiative Admin/Marketing/Evaluation and Incremental Measure Costs)
PACCost	Costs associated with the PAC test	Dollars (Initiative Admin/Marketing/Evaluation and Initiative Incentive Costs

Total System Benefit

TSB is a function of the inputs described in earlier sections. For the Foodservice Water Heating Systems MTI, we disaggregated TSB into three components: energy, grid, and GHG benefits (categorized as refrigerant and non-refrigerant). We used the following CET-based formula to determine TSB:

$$(ElectricBenefits + GasBenefits$$

$$+ NumberOfUnits * (Net\ kWh + MarketEffectsBenefits) * RefrigerantBenefits)$$

$$- (ElectricSupplyCost + GasSupplyCost$$

$$+ NumberOfUnits * (Net\ kWh + MarketEffectsCosts) * UnitRefrigerantCosts)$$

Cost-effectiveness ratios

Total Resource Cost

The TRC test compares the lifecycle benefits that the MTI will deliver to the costs associated with achieving those benefits from the perspective of the MTI administrator and the participant combined. Net benefits, initiative costs (not including FDIs), and IMC were used to determine TRC. The non-FDI initiative costs are summed together with the IMC and discounted during the period of the MTI's implementation. The discounted net useful life benefits for each installation condition are divided by the sum of the respective discounted IMC and non-FDI Initiative costs to determine the TRC benefit-to-cost ratio. This installation condition-specific TRC is weighted by its respective adoption total and summed with the other installation condition-specific TRC to determine the MTI TRC. Below is the CET-based formula used by the tool to determine TRC.

$$(ElectricBenefits + GasBenefits + OtherBenefits) / TRCCost$$

Program Administrator Cost

The PAC test compares the lifecycle benefits that the MTI will deliver to the costs associated with achieving those benefits from the perspective of the MTI administrator. Net benefits, and Initiative costs (including FDIs) were used to determine PAC. The initiative costs are discounted to the first year of the MTI's implementation. The discounted net useful life benefits for each installation condition are divided by the sum of the initiative costs to determine PAC. This installation condition-specific PAC is weighted by their respective adoption totals and summed to determine the PAC. Below is the CET-based formula used by the tool to determine PAC.

$$(ElecBenefits + GasBenefits + OtherBenefits) / PACCost$$

Outputs

Total System Benefit (TSB)

Table A11 shows the preliminary TSB estimates disaggregated for energy, grid, and GHG impacts.

Table A11. Stage 2 Preliminary Lifetime TSB Estimate Foodservice Water Heating Systems

Idea Name	TSB ($M)	Energy ($M)	Grid ($M)	GHG Non-Refrigerant ($M)	GHG Refrigerant ($M)

Foodservice Decarbonization – Water Heating	216	7	-79	288	0

As shown in Table A11, the Phase I model estimates that this Foodservice Water Heating Systems MTI will generate approximately $216 million in lifetime TSB. The largest share of the benefit can be attributed to mitigated GHG emissions, with an estimated $288 million in TSB. The smallest share of the TSB is driven by negative grid benefits, with -$79 million in TSB due to increased electric usage. Finally, energy benefits driven by savings related to electricity and natural gas reductions generate nearly $7 million in lifetime TSB.

Cost-effectiveness ratios

The team developed preliminary TRC and PAC ratios of 2.04 and 3.45, respectively, for the MTI.

Phase II – refined TSB and cost-effectiveness estimates

The CalMTA team will conduct additional market and technology research on Foodservice Water Heating Systems during Phase II of the MTI, as described in the Advancement Plan. Based on that research, we will refine TSB and cost-effectiveness estimates for the MTI. These refined estimates and their detailed methodology and assumptions will be included as part of the MTI Plan required for MTI advancement to Phase III. The MTI Plan will also include an evaluation plan and a data collection plan to support ongoing evaluation.

References consulted for Appendix A

Source #1. US Department of Energy: Energy Information Administration. 2022. *Commercial Buildings Consumption Survey 2018 (CBECS 2018*).

Source #2. Energy Solutions 2022. *All-Electric Commercial Kitchen Electrical Requirements Study Final Report*. Prepared for the CalNEXT program. Report # ET22SWE0010.

Source #3. California Public Utilities Commission. October 2001. *California Standard Practice Manual: Economic Analysis of Demand-Side Programs and Projects*. https://www.cpuc.ca.gov/-/media/cpuc-website/files/uploadedfiles/cpuc_public_website/content/utilities_and_industries/energy_-_electricity_and_natural_gas/cpuc-standard-practice-manual.pdf

Source #4. California Public Utilities Commission. October 2001. *California Standard Practice Manual Economic Analysis of Demand-Side Programs and Projects.* https://www.cpuc.ca.gov/-/media/cpuc-website/files/uploadedfiles/cpuc_public_website/content/utilities_and_industries/energy_-_electricity_and_natural_gas/cpuc-standard-practice-manual.pdf

Source #5. California Public Utilities Commission. October 25, 2021b. *Total System Benefit Technical Guidance*. https://pda.energydataweb.com/api/view/2560/FINAL%20TSB%20Tech%20Guidance%20102521.pdf

Source #6. Energy+Environmental Economics. Avoided Cost Calculator for Distributed Energy Resources (DER). June 15, 2023. https://www.ethree.com/public_proceedings/energy-efficiency-calculator/