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EMERGING TECHNOLOGIES PROGRAM ADOPTION DRIVER STUDY

PREPARED FOR CALIFORNIA PUBLIC UTILITIES COMMISSION

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INTRODUCTION

This report presents the findings of the Emerging Technology (ET) Adoption Driver Study. The purpose of this Study is to understand the characteristics and market adoption practices that drive the success or failure of technologies that recently emerged from California's Emerging Technology Program (ETP) and entered the portfolio of Investor-Owned Utilities (IOUs) resource acquisition programs. This study focuses on 11 ETP-sourced technologies that were introduced into the energy efficiency (EE) portfolio of resource acquisition programs in 2016 and 2017, and the performance of those technologies over the period 2016-2021.

BACKGROUND

The California Public Utilities Commission (CPUC) authorizes the IOUs to fund a portfolio of resource acquisition programs that encourage the adoption of energy-efficient technologies. The resource acquisition programs offer rebates and incentives to customers who adopt high-efficiency technologies (referred to as "measures"). However, technologies that were considered high efficiency a decade ago are increasingly becoming standard practice in today's marketplace; arguably, these technologies no longer need incentives, and thus, some are "retired" or "sunset" from programs because they have become the new minimum code or standard. To identify new technologies, each IOU administered an ETP to serve as a pipeline for new measures in the programs.

Historically, ETP has been administered and implemented by IOU staff independently. However, in 2020, ETP became a statewide program designed to be delivered uniformly throughout the four large IOU service territories by a single lead program implementer under contract to a single lead program administrator (PA). As of this writing the statewide lead PA for electric emerging technologies[1] is Southern California Edison (SCE), and the lead PA for gas emerging technologies[2] is Southern California Gas (SCG). Each of these utilities' contracts with a separate third-party implementer.

RESEARCH APPROACH

This evaluation focused on adoption drivers for a select cohort of emerging technologies, which were introduced into the EE portfolio in the 2016/2017 period. While this time frame is prior to California shifting to the statewide ETP model as noted, our findings and case studies provide insights into both time periods (e.g., 2016/2017 and present day). In other words, what were the conditions that existed in the 2016/2017 period as they relate to vetting new technologies and what are the conditions that exist today in the emerging technology ecosystem? Looking relatively far backwards to 2016/2017 also ensures that the then emerging technologies which have since "graduated" into the resource acquisition programs had enough time to mature for us to observe their ultimate success or shortcomings in the market. The evaluation included 11 different ETP technologies, selected out of a possible 21 technologies and prioritized for this study. Technologies covered in this report were selected using a decision framework which ranked technologies on attributes such as electric or gas savings, measures installed, benefit/cost ratio, and savings contribution to the portfolio as described in Section 2.1. Technologies that fell on the extreme ends (high or low) on this ranking framework were selected for inclusion.

This study explores the following research objectives:

[1] Program name is Statewide Electric Emerging Technologies (SWEETP), and the selected vendor is Energy Solutions, with a contract end date of 12/31/2027.

[2] Program name is Innovative Gas Emerging Technology (IGET) Program, and the selected vendor is ICF, with a contract end date of 8/24/2024.

- Identify characteristics of ETP technologies that are highly successful or under-performing in resource programs.
- Explore the barriers and opportunities to technology market adoption as defined by EE (and ETP) program staff.
- Determine what programmatic, technological, or market elements lead to success or failure of ETP-originated measures in incentive programs.

The key findings and recommendations are drawn from a case study analysis of each of the 11 technologies informed through the following research activities blending qualitative methods and analysis of secondary sources:

- In-depth interviews with 23 IOU staff, including 10 staff members from the "Emerging Technology Team" and 13 staff members from the "Program/Resource team" (See Appendix A for interview guide).
- Secondary research or data sources to support the development of each case study.

FINDINGS

There are many stakeholders involved in the process of emerging technologies being identified, vetted, and assessed prior to being incorporated into existing (or new) programs and ultimately adopted by customers. Some of the key findings from this study are as follows:

- **Finding 1**: Prior to the statewide lead/third-party model, about half of the interviewees were not aware of the origination of ETP technologies. In today's landscape, most of the program staff are aware of the new technologies the third-party implementers are working on and considering for measure package development.
- **Finding 2:** Regarding internal collaboration between the ETP and program/resource team, prior to the statewide lead/third-party model, most staff shared there was some form of collaboration between the two teams. In today's landscape, most of the program staff do not collaborate with third party implementers, with some exception, primarily related to the review processes.
- **Finding 3:** Marketing efforts are aligned with the specific characteristics and delivery channels of each technology. Across the 11 technologies the marketing and promotional strategies are quite varied. In today's landscape, third party implementers execute a large portion of the marketing efforts and in some cases IOU staff play a review and advisory role.
- **Finding 4**: The key market barriers across most of the 11 technologies are upfront costs, a lack of customer understanding of how a product operates and lack of general awareness of a particular product (See the Market Adoption Barriers & Drivers for more details).
- **Finding 5:** A few key market drivers include state and federal policy, leveraging trade allies in providing educational marketing and product understanding to customers, and providing flexible financing options to address costs.
- **Finding 6:** Programmatic elements are defined as those associated with how energy efficiency programs are designed and delivered to customers. We have identified three programmatic elements correlated with the success of emerging technologies: market and customer research to inform program design, clear educational marketing on product uses cases and benefits, and leveraging trade allies as applicable.
- **Finding 7:** Technological elements are associated with how a product is designed. Two elements correlated with the success of emerging technologies: comprehensive field testing[3] of the product itself and a clear understanding and articulation of how the product operates and saves energy, both items of which would primarily fall on the ETP.

[3] Comprehensive field testing, in this context, would consist of not only the most essential components of focus when conducting field testing, such as how the product operates and performs in their intended environment, but also to assess how customers interact with the product or technology, facilitated through more extensive customer surveys to measure potential appeal and value propositions.

- **Finding 8:** Market elements are defined as those associated with key market dynamics impacting a particular product. We have identified three elements correlated with the success of emerging technologies: leveraging market actor marketing efforts as applicable, addressing variation in customer preferences through product differentiation, and clearly setting market actor expectations on program process.

RECOMMENDATIONS

Based on the evaluation activities conducted as part of this study, we provide the following recommendations to improve the ETP process and develop the conditions under which programs established based on ETs can achieve success. While we recognize that the technologies under study in this evaluation came into view in 2016/2017, during a time prior to the statewide model, we offer these recommendations to those involved in this new landscape for consideration as that model progresses and evolves.

- **Recommendation 1: It's important for utility and third-party implementer staff to set clear expectations for manufacturers with regard to product claims.** IOU and third-party implementer staff should set expectations for and work with manufacturers to ensure that the entities that provide these products have a mutual understanding of energy saving capabilities. Accurate and consistent product testing results can help to mitigate risks associated with measure development early in the process. In some cases, this may require more transparency on the part of manufacturers to reveal and provide details associated with product design and product testing. Ultimately, execution of specific agreements between utilities and manufacturers may be needed to ensure that any product testing results they provide are conducted under rigorous protocols which ensure energy savings claims are verified and consistent.
- **Recommendation 2: There is an opportunity to better incorporate more extensive customer acceptance evaluations within field testing studies.** While field testing studies may not be conducted for all assessed technologies, throughout the course of this evaluation it was evident that in some cases, the lack of information collected in these field testing studies related to customer acceptance contributed to a lack of success. Customer acceptance evaluations, which seek to understand how individuals interact with technology, might also provide an early indication on whether additional investment by ETP is an emerging technology should be halted due to insurmountable customer acceptance issues.
- **Recommendation 3: Adoption of technologies is bolstered by the presence and execution of comprehensive marketing plans, characterized by a sophisticated segmented approach that leverages key market actors and trade allies While anecdotal, one finding indicated that** the success of some evaluated technologies was associated with a comprehensive marketing approach that effectively leveraged existing marketing efforts by manufacturers[4], established close coordination with the most influential distributors, retailers & contractors, and provide technical assistance and educational marketing these actors could cascade to end-users to influence adoption. This approach should be patterned across other technologies where applicable, and where the supply chain is concentrated within midstream delivery channels[5].

[4] One clear example of this was in the case of smart thermostats, which involved extensive marketing efforts by manufacturers that raised awareness and amplified utility program marketing efforts

[5] In energy efficiency industry language, midstream delivery channels are terms which describe how programs can leverage these actors (e.g., distributors, retailers, and contractors) by providing incentives directly to these entities to influence product stocking or influencing end-users to implement higher efficiency measures.

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I. INTRODUCTION

I.I BACKGROUND

The California Public Utilities Commission (CPUC) authorizes the investor-owned utilities (IOUs) to fund a portfolio of customer programs that encourage the adoption of energy-efficient technologies. A central element of the IOU portfolio is incentive programs that offer rebates and incentives to customers who adopt high-efficiency technologies (referred to as measures). However, technologies that were considered high efficiency a decade ago are increasingly becoming standard practice in today's marketplace or even incorporated into required minimum building energy codes or equipment standards; arguably, these technologies no longer need incentives, and thus, some are "retired" or "sunset" from incentive programs.

Incentive programs are continually seeking new, emerging technologies (ETs) that can provide new opportunities for energy savings to replace sunset measures and continue to support California's aggressive energy and demand savings targets. To identify new technologies, the IOUs administer Emerging Technologies Programs (ETPs) to serve as a pipeline to identify and deliver ETs to energy efficiency (EE) incentive programs. A key function of an ETP is to conduct the research required to have high confidence in a technology's energy savings potential and then to pass vetted technologies to resource (incentive) or Codes and Standards (C&S) programs.

Historically, ETPs have been administered and implemented by IOU staff independently. In 2020, however, ETP became a statewide program designed and implemented by a third-party on behalf of the IOUs, based on Decision 16-08-019.[1] Based upon the terms established by that ruling, and for the purposes of establishing state-level programs, statewide was defined as "a program or subprogram that is designed to be delivered uniformly throughout the four large Investor-Owned Utility service territories by a single lead program implementer under contract to a single lead program administrator," As of writing, the statewide lead program administrator (PA) for electric ETs is Southern California Edison (SCE),[2] and the lead PA for gas ETs is Southern California Gas (SCG).[3] Each of these utilities contracts with third-party implementers.

This report should be considered in the context of previous reporting related to ET and the "handoff" process. These reports include:

- Emerging Technologies Program Handoff Process Evaluation, CALMAC Study ID CPU0201.01, Published October 29, 2020. This research study evaluated the handoff process of ETs across California's greater ET market, the ETP, and the IOU programs. Research activities included a series of primary and secondary data collection activities: reviewing process documents, interviewing ETP, incentive program, and C&S staff, technology developers, and technology development actors, and conducting a review of similar ET programs in other regions. Recommendations provided in the report sought to improve the process of handing off ETs along its lifecycle.
- Emerging Technologies Program Technology to Portfolio Evaluation, CALMAC Study ID CPU0231.01, Published May 11, 2021. This research examined the effects of the ETP from 2009 to 2017, at a time when each of the four California IOUs administered an ETP. In that timeframe, the ETP studied numerous technologies or novel applications of technologies, resulting in some being recommended for consideration in the California EE Portfolio and some being ruled out. Research activities included evaluation of the market uptake and achieved savings of all technologies that moved from the ETP to the Portfolio (or directly to C&S) from 2009 to 2017, estimates of lifetime savings, recommendations for database specifications or tracking mechanisms to improve the ETP savings reporting, and baselines for the ETP measures codified in IOU business plans.

[1] Decision 16-08-019, Issued August 25, 2016. See Decision 16-08-019.

[2] Program name is Statewide Electric Emerging Technologies (SWEETP), and the selected vendor is Energy Solutions, with a contract end date of 12/31/2027.

[3] Program name is Innovative Gas Emerging Technology (IGET) Program, and the selected vendor is ICF, with a contract end date of 8/24/2024.

This study aims to further our understanding of successful and unsuccessful ETs. The research will identify the key technology characteristics and market adoption practices that can drive high rates of adoption and improve market penetration. Specifically, the study will focus on technologies introduced to the portfolio in 2016 and 2017 and their performance from 2016 to 2021. One of the primary objectives of this effort is to explore end-user adoption drivers for ETP-associated technologies.

1.2 EVALUATION OBJECTIVES

California's SB350 establishes ambitious energy savings and greenhouse gas (GHG) reduction goals by 2030, which the CPUC and IOUs can address using a wide range of strategies. The ETP is one specific avenue that can be leveraged to achieve these goals based on the promotion and adoption of innovative, energy-saving technologies. Within an ETP, there are multiple factors, stakeholders, and stages that can influence and contribute to either program success or failure of ETs. This research effort focused on multiple technologies across IOUs, representing both residential and non-residential measures and a mix of use cases.

The main goal of this evaluation is to understand the market adoption and program strategies for each technology across all four IOUs in California. This effort focuses on those "adoption drivers" that can explain why a particular technology is successful in a resource program or not. The primary research objectives are as follows:

- Identify the relevant characteristics of ETP-originated technologies that are currently highly successful or under-performing in resource programs.
- Explore the barriers to and opportunities for technology market adoption as defined by EE (and ETP) program staff.
- Determine what programmatic, technological, or market elements lead to the success or failure of ETP-originated measures in incentive programs.

2. METHODOLOGY AND APPROACH

The evaluation team conducted an evaluation on adoption drivers for a select cohort of ETs that were introduced into the EE portfolio in the 2016–2017 period. This time frame is prior to California shifting to the statewide ETP model, though the context of the subsequent findings and case studies will include both timelines (e.g., 2016–2017 and present day).

The evaluation methodology established to review specific technologies and execute the research covered in this report involved the completion of four distinct phases:

- Phase I: Prioritize Technologies for Case Study Selection
- Phase II: Conduct In-Depth Interviews
- Phase III: Development of Technology Case Studies
- Phase IV: Reporting

Efforts associated with Phases I and II are described in Sections 2.1 and 2.2. Case studies (Phase III) developed for each of the 11 technologies covered in this report are provided in Technology Case Studies Phase IV is represented by this final report.

2.1 SELECTION OF CASE STUDY TECHNOLOGIES

The following section provides an overview of how we identified technologies for the purposes of developing case studies. We began with the creation of a dataset of ETP technologies that were introduced in 2016–2017. Leveraging CEDARS (California Energy Data and Reporting System) and each IOU's program database, these data were merged into

one dataset consisting of all variables for each ETP technology (defined by measure code), including energy savings (kWh, therms), demand (kW) savings, total resource cost (TRC), measure counts, measure categories, IOU territory, and any additional variables identified as relevant in the context of characterizing performance. This dataset ("ETP/CEDARS Dataset") provided the basis for the selection of technologies.

2.1.1 INITIAL SELECTION PROCESS

Out of all technologies introduced in ETP in the 2016–2017 timeframe, only 21 were subsequently adopted by an IOU resource program and contributed savings to an IOU portfolio of EE programs[4]. The ETP/CEDARS Dataset represented 53 discrete measure codes in use across all four major IOUs, which were mapped to a broader set of 21 technologies.

To assess and prioritize within this initial list of 21 technologies, we segmented each technology according to where it fell (by percentile) on nine separate primary components (1–9 below) and two secondary components (10-11):

1. First-Year Net kWh Savings
2. First-Year Net kW Savings
3. First-Year Net Therm Savings
4. Lifecycle Net kWh Savings
5. Lifecycle Net kW Savings
6. Lifecycle Net Therm Savings
7. Number of Units
8. Benefit/Cost Ratio (Cost-Effectiveness)
9. Contribution to Portfolio (ETP Savings Relative to Portfolio Savings)
10. Ratio of Lifecycle Net kWh to Technical Potential (kWh)
11. Adoption Curve

Within each of the components, each of the 21 technologies was scored as low, medium, or high depending on where each technology fell within the distribution of all 21 technologies being scored.[5] A total score for each technology was determined based on a summation across the nine primary components scored.[6] The result was a list of all 21 technologies and their final scores. The following tables provide the overall initial scoring results by technology. Tables have been separated by measures associated primarily with the residential sector and those associated with the non-residential sector. The total score is based on the summation of columns one through five (Benefit-to-Cost Ratio score through Contribution to Portfolio score). First Year and Lifecycle Savings Scores are aggregated across kWh, kW, and Therms. Score values for Benefit-to-Cost Ratio and Contribution to Portfolio correspond to low (1), medium (3), and high (5). The total possible score is 45.

[4] Note: There were 203 projects reviewed for the purposes of this study, 42 of which were either adopted or recommended for adoption. These 42 projects represented 53 measure codes which were grouped into the broad set of 21 technologies. This group of technologies was further assessed as described in this section to arrive at the 11 technologies profiled in this report.

[5] Low, medium, and high definitions were based on the 33rd and 66th percentiles, with low below the 33rd percentile, medium between the 33rd and 66th percentile, and high above the 66th percentile. Note that T8 LED Lamps are included in both residential and non-residential tables.

[6] Adoption Curve and Ratio of Lifecycle Net kWh to Technical Potential (kWh) information was not available for all technologies, so this assessment was more qualitative in nature and not included in the calculation of final scores.

Table 1: Selected Technologies, Residential Sector

Technology	Benefit to Cost Ratio[7] Score	First-Year Savings Score	Lifecycle Savings Score	Number of Units Score	Contribution to Portfolio[8] Score	Ratio Lifecycle to Tech Potential††	Total Score
Smart Communicating Thermostat†	5	13	12	4.5	5	38%	39.5
Thermostat (Non-Communicating)	5	12.3	12.3	4.7	5	22%	39.3
Smart/Connected Tier 2 Power Strip Lighting	5	15	13	3	3		39
Duct Sealing	3	15	13	3	3		37
Efficient Heat Pump Water Heater	3	15	10.3	2.3	5	2%	35.6
T8 LED Lamps	3	11	11	5	5	11%	35
Faucet Aerator	5	12.2	9.8	4.2	3		34.2
Small Storage Heat Pump Water Heater	5	15	8	2	3	1%	33
Smart Thermostat Heat Pump	1	13	9	3	3		29
Tier 2 Advanced Power Strip	1	11	9	3	3		27
Home Office Power Strip Lighting	1	9	7	3	1		21
Tub Spout/Thermostatic Shut-Off Showerhead	1	9	7.5	1.5	1		20

† Utility Recommendation †† Defined as the Lifecycle Net kWh Savings relative to Technical Potential of the technology.

Table 2: Selected Technologies, Non-Residential Sector

Technology	Benefit to Cost Ratio Score	First-Year Savings Score	Lifecycle Savings Score	Number of Units Score	Contribution to Portfolio[9] Score	Ratio Lifecycle to Tech Potential††	Total Score
Refrigeration Controls†	5	15	15	1	3		39
Exterior LED Fixtures	3	13	11	5	5	>100%	37
HVAC Chillers†	3	15	13	3	3		37
T8 LED Lamps†	3	12	10.5	5	5	>100%	35.5
Central Plant Consolidation	3	15	11	5	1	0%	35
Absorption Chiller†	3	13	11	1	3	2%	31
High Efficiency Ultra Low Temperature Freezer	5	11	7.7	1.2	5	97%	29.9
Ag Ventilation Fan Variable Speed Drive†	1	11	8	3	3		26
Commercial Water Heating	5	11	7	1	1	0%	25

[7] Benefit-to-Cost ratio is based on calculating aggregating benefits and costs at the detailed technology level based on measures within each detailed technology.

[8] Based on lifecycle net kWh relative to the total lifecycle net kWh for the residential sector based on portfolio totals (2016–2021).

[9] Based on lifecycle net kWh relative to the total lifecycle net kWh for the non-residential sector based on portfolio totals (2016-2021).

Plug Load Occupancy Sensor Control Lighting	1	9	7	1	1		19

† Utility Recommendation †† Defined as the Lifecycle Net kWh Savings relative to Technical Potential of the technology.

2.1.2 FINAL SELECTION PROCESS

In the final step of the selection process, we focused the sample on technologies that were either highly successful (as defined by the 11 components) or unsuccessful. In practice, this meant sorting the list of 21 technologies and prioritizing those that were ranked at the top of the list and those at the bottom of the list. In addition to this general selection strategy, we also prioritized specific technologies based on utility recommendations (five technologies). This resulted in reducing the 21 technologies discussed above to the 11 technologies identified in Table 3.

Table 3 provides an overview of the 11 ETs evaluated, including the month/year the initial measure package was approved, whether the technology is still active in a program, and the program name.

We included Commercial Water Heating and Refrigeration Controls in this research even though both technologies are not associated with any utility resource program energy savings claims. This is due to an internal assessment at the IOU involved, which revealed that in both cases, the savings claims made did not actually include measures associated with these technologies, and for all intents and purposes, these technologies were never *transferred* to an existing program.[10] We have, nevertheless, decided to include these technologies as they provide an additional view of technologies that were considered for resource programs but did not go through the same trajectory as the other nine technologies presented in Table 3.

Table 3 Overview of Emerging Technologies Selected for Case Studies

Technology	Month/Year Measure Package Approved	Current Status	Program Name
Smart Communicating Thermostat	November 2016	Active	Statewide Plug Load & Appliance
Commercial Water Heating	N/A	N/A	N/A
High Efficiency Ultra Low Temperature Freezer	September 2017	Active	Advanced Energy Program
Refrigeration Controls	N/A	N/A	N/A
Smart/Connected Tier Power Strip	October 2020	Discontinued	N/A
Tier 2 Advanced Power Strip	June 2018	Discontinued	N/A
T8 LED Lamps	January 2021	Discontinued	N/A
Exterior LED Fixtures	June 2017	Discontinued	N/A
Tub Spout / Thermostatic Shut-Off Showerhead	May 2016	Active	Energy Savings Assistance Program
Ag Ventilation Fan Variable Speed Drive	December 2017	Active	Agriculture Energy Savings Action Plan
Heat Pump Water Heater	December 2017	Active	Statewide Plug Load & Appliance

2.2 IN-DEPTH INTERVIEW APPROACH AND PROCESS

We sent a data request to the California IOUs in March 2023 to identify staff associated with each of the 11 technologies and the associated measure codes. The evaluation team targeted both ETP staff and resource program staff for each technology, ensuring at least one individual from both functional areas was interviewed. IOUs were also asked to provide the evaluation team with relevant research, reports, and impact evaluation results on the selected technologies. The evaluation team reviewed the materials to identify key information on the technologies that would

[1010] Note: These measures are custom measures so to the extent a customer wishes to utilize them, they have that prerogative.

help inform the case studies. Where applicable, the evaluation team leveraged existing secondary research cited in each case study (Technology Case Studies).

The evaluation team received contact information for over 60 IOU staff associated with the 11 technologies in response to the data request, with representation across all four major IOUs. Given that the research plan budgeted for up to 30 one-hour interviews, the research team developed a process to prioritize interview subjects, typically utilizing the first interviews with staff to gather additional information on other personnel identified in the data request to maximize the value of subsequent interviews, for instance, identifying those with greater tenure or the most experience associated with a particular technology.

Another challenge we encountered was that staff at the smaller IOUs were often associated with multiple technologies, but the research team wanted to avoid overly burdening IOU staff. In these instances, the interview process was modified slightly to capture multiple technologies, and we conducted a maximum of two interviews per individual staff member. For each of the 11 selected technologies, we interviewed at least one staff member from the program team and one from the ETP team. Some technologies that were represented across multiple IOUs involved more than two individuals.[11]

The evaluation team interviewed 23 IOU staff members from April to June 2023, utilizing the in-depth interview guide provided in Interview Guide for IOU Staff. The interviews lasted approximately 60 minutes. Given that some IOUs have staff who cover three to five selected technologies, those interviews were approximately two hours in total (often spanning multiple conversations to avoid interviewee fatigue). These interviews combined equate to 35 individual conversations about a specific technology. Once the interviews were completed, the evaluation team proceeded to review the interview notes and analyze the findings across all the interviews. The evaluation team followed up with some interviewees to seek clarification or elaboration on what was shared as we proceeded with Phase III and developed the case studies. Table 4 provides a breakdown of the number of interviews in total and by program or ET function.

Table 4: IOU Staff Interview Breakdown by Program/ETP Function

Breakdown Structure	Total Number	Time Frame
Technology conversations covered through interviews	35	April 2023 – June 2023
IOU Staff on the “Program/Resource” team	13	
IOU Staff on the “Emerging Technology” team	10	

3. KEY FINDINGS

This section provides our key overall findings as a culmination of our analysis of ETP/CEDARS data and the entirety of staff interviews with the four primary IOUs operating in California. This section is organized into topical subsections containing findings from across ET types. We provide detailed case studies for each of the 11 technologies covered in this report in Technology Case Studies. Each of the following subsections represents the topical areas covered in our IOU staff interviews.

- Origination of ETP Technologies
- Collaboration Efforts
  - Internal Collaboration Efforts
  - External Collaboration Efforts
- Process and Program Strategy

[11] This included High Efficiency Ultra-Low Temperature Freezers, Smart Communicating Thermostats, and T8 LED Lamps.

- Market Characterization Studies
- Promotional Efforts
- Data Collection

- Market Adoption Barriers and Drivers
  - Barriers
  - Drivers
- Awareness and Role of Market Transformation Administrator
- Key Elements Associated with Success or Failure
  - ETP Technologies Characteristics
  - Programmatic Elements
  - Technological Elements
  - Market Elements

3.1 ORIGINATION OF ETP TECHNOLOGIES

This section pertains to whether IOU program management staff have a clear understanding of which technologies originate from the ETP[12]. To the extent possible, interviews with staff attempted to assess this during the period under which the technologies covered in this report were identified as ETs, generally during the 2016–2017 timeframe.

Prior to the statewide lead/third-party model, about half of the interviewees who were performing a relevant role in 2016–2017 were not aware the selected technologies originated from the ETP. Program managers that we spoke to who were aware the technologies originated from ETP were generally aware due to one of three reasons: the ETP team would notify them towards the middle/end of the process (during the ETP to program handoff), they would have meetings on an ad hoc basis that would cover such technologies (and where they stood in the pipeline), or (in a few cases) there was close collaboration between the program team and the ETP team.[13] Most of the communication between ETP and the program team was informal, and no one indicated that a formal or regular, standard process of communication was in place.

Since the introduction of the statewide lead/third-party model, interviews revealed that most IOU program staff (9 of 13) are aware of the new technologies the third-party implementers are working on. Those that were not aware expressed that it would be helpful to know about these technologies early in the process.

3.2 COLLABORATION EFFORTS

IOU staff were asked about the extent to which staff collaborated with other parties, either internally between program management or ET staff, as well as externally with other California PAs. We further separated findings between those relevant to the time prior to the establishment of the statewide program lead and third-party model and the present

[12] As indicated in response to the comment period for this publication, SDG&E clarified that the energy savings claim table in the CEDARS database now has a field that indicates when the "claim measure development was supported by specific technology evaluation(s) conducted by the electric or gas Emerging Technologies Program." SDG&E further indicated that the field was included for better visibility and to generate a simpler way to track savings for the program staff. Prior to that, the program staff were kept informed of the ET projects, but once completed, they don't necessarily follow the measure approval process. This outcome is generally consistent with what we heard in our staff interviews, that program staff were involved in early-stage assessments but do not closely monitor the measure approval process.

[13] This was typically characterized by two individuals (one from ETP and the other from resource programs) engaging in informal or tacit communication, not necessarily involving formal, recurring meetings.

day. In Technology Case Studies, there are additional details on collaboration efforts specific to some individual technologies, where relevant.

3.2.1 INTERNAL COLLABORATION EFFORTS

These findings are associated with collaboration efforts within IOU organizations between EE program managers/staff and ET staff.

Prior to the statewide lead/third-party model, most of the ETP and program teams would collaborate to some extent on program strategy. The collaboration consisted of the following activities: monthly meetings; instances where engineers associated with ETP would provide program staff with advance notice regarding workpaper specifics (generally towards the middle/end of their process); activities associated with formal groups such as Innovation Now (SCG) and New Product Development and Launch Group (SCE); or, the ETP team would present to the program team on an ad hoc basis. Based on interviews with four IOU staff, there was no collaboration between the ETP and the program teams. At one IOU, the ETP team expected the program team to know about the status of workpapers even if the reality was the program team had limited visibility into the process. Once the technology was handed off to the program team, communication would usually conclude between the teams.

In today's landscape (since the statewide lead/third-party model), most of the program staff do not collaborate with third-party implementers. There is one exception: two program staff shared they do review marketing materials and/or have weekly meetings with the implementer to discuss current actions and progress. IOU staff shared that they are usually unfamiliar with what is going on with the third-party implementers and expressed in interviews that they used to have more engagement between (ETP and program teams) prior to the introduction of the statewide lead/third-party model.

3.2.2 EXTERNAL COLLABORATION EFFORTS

These findings are associated with collaboration efforts between IOUs or other California PAs.

Prior to the statewide lead/third-party model, IOU staff would collaborate with other California PAs. Collaboration would consist of monthly meetings, roundtables, and periodic email check-ins. Discussion topics raised during these engagements would include rebates, new technologies, updates on workpapers (measure packages), and share-outs associated with what is and is not working regarding programs. Except for monthly meetings, communications and other engagements were typically informal. Based on interviews with staff and review of documentation associated with California Technical Forum (CalTF) engagements,[14] there was also inter-utility collaboration about study methodologies, data collection, and specific areas to address based on CalTF feedback.

With some exceptions, in present-day, IOU staff typically only collaborate with other California PAs on statewide programs. Some ETP staff members indicated in interviews that they engage in monthly calls with other (outside) IOU staff. Generally, ETP staff shared that they are more involved with ongoing discussions regarding ETs and feasibility vis-à-vis efficiency programs. These individuals indicated they do engage and are familiar with the Emerging Technologies Coordinating Council (ETCC) and have attended and presented at ETCC meetings on various topics and/or have host events with the ETCC.[15] Some staff did express that they have not engaged with the ETCC in "some time."

[14] California Technical Forum. The CalTF was formed in 2014 by a broad group of stakeholders and is funded by participating program administrators. For the purposes of this report, the role of the CalTF is to peer review methodologies, data, assumptions, and values. See WHAT WE DO — Cal TF

[15] The Emerging Technologies Coordinating Council was created by the California Energy Commission (CEC) to "facilitate collaborations on emerging technologies projects." The leadership team includes all four major IOUs operating in the state as well as the CEC and municipally owned

3.3 PROCESS AND PROGRAM STRATEGY

The following sections pertain to findings associated with process and program strategy, including the extent to which IOUs develop market characterization studies to inform program design and/or strategy associated with emerging technology measures, marketing and promotional efforts executed by IOU staff, and data collection. Data collection, in the context of this report, refers to two specific areas: collection conducted to inform the development of workpapers or measure packages and data collection conducted to inform program design or implementation.

3.3.1 MARKET CHARACTERIZATION STUDIES

IOU staff were asked about the extent to which each utility conducts its own research to inform market characterization associated with specific ETs. One key aspect of this research is to assess potential barriers or drivers that may impede or influence market adoption of technologies.

Three individual staff members indicated that their respective utility had conducted their own study at the time technologies were being assessed in 2016/2017.[16] In some cases, research was conducted because the existing research available was either inconclusive and/or contradictory. The scope and complexity of these studies conducted by IOUs varied widely, from large-scale market characterization studies replete with primary research conducted with multiple actors/segments (for instance, to assess supply chain dynamics) to something simpler in nature – customer surveys or reviewing feedback from customers (for instance, based on call center logs).

In instances where the IOU did not conduct a market characterization study or similar effort, IOU staff typically relied on other available resources to gather market barrier or driver information. These resources include the following: information supplied by manufacturers or contractors, published EM&V studies (either inside or outside California), industry reports from applicable entities, workpapers, and, in some cases, through the provision of data from out-of-state utilities. One IOU shared that the ETP team does utilize Industry Standard Practice (ISP), which can typically be used to address market barriers for custom and deemed measures, though they did add that lately, some of that information was not particularly constructive.[17]

3.3.2 PROMOTIONAL EFFORTS

Interviews with IOU staff also covered common strategies to promote ETs, both in general and (where applicable) specific to a particular technology. In addition, we attempted to gather information on whether the utility believed these strategies were successful.

Marketing and promotional strategies across the 11 technologies were quite varied. It should also be noted that these efforts changed significantly after the transition to a statewide lead/third-party implementation model. For instance, IOU staff indicated that in the present day, the third-party implementation contractors typically execute all the marketing, and some IOU staff were not cognizant of their specific marketing strategies. In some instances, IOU staff collaborate

utilities Los Angeles Department of Water and Power (LADWP) and Sacramento Municipal Utility District (SMUD). All collaborations, partnerships, and ETCC operating costs are funded directly by ETCC members; the ETCC does not have a budget and does not fund or conduct emerging technologies projects. See About the ETCC | ETCC (etcc-ca.com)

[16] Care should be taken in interpreting this finding, as a number of staff at IOUs who were involved in the emerging technologies during the period they were being assessed (2016/2017) were no longer employed by the utility, and while this question was asked consistently even of those who had shorter tenures, in many cases these individuals were not aware or did not recall specific studies being conducted.

[17] Industry Standard Practice (ISP), the use of which was established based on CPUC Decision 12-05-015, represents the typical equipment, or commonly used current practice absent the energy efficiency program. It also provides information on current trends related to purchase, installation or practice associated with a measure/technology applicable to a specific portion of the end-user market. The use of ISP in the context of measure development is most relevant in cases where there is no regulation, code or standard that applies, which would typically inform the measure baseline, a critical piece in measure package development.

with the implementers on marketing efforts and even have scheduled touchpoints. All the IOUs indicated that they do review marketing materials to ensure they follow the utility's own marketing protocols.

Based on the results of our interviews, marketing efforts are very much aligned with the specific characteristics of each technology in terms of its specific use case and the primary audience that is targeted. For instance, in the case of the Ag Ventilation Fan Variable Speed Drive, staff indicated that a one-on-one, face-to-face marketing approach was employed, as farmers (the primary target market) prefer in-person interaction. By contrast, IOU staff noted mass-market approaches were used for smart communicating thermostats, such as published articles/content, email marketing campaigns, and digital ad campaigns. Manufacturers also contributed significantly to the promotion of this technology, with cross-promotional efforts being a key factor in its success. These efforts helped to increase awareness of smart communicating thermostats among consumers.

Technologies served through midstream delivery channels, such as T8 LED Lamps, employed marketing strategies that leveraged trade ally networks, whereby the IOUs would provide marketing collateral or program-related information to these actors, who would then cascade those details to their respective customers. For T8 LED Lamps, in particular, efforts were primarily focused on educating the market about the technology and its value propositions, in addition to educating distributors and other trade allies. Marketing strategies for T8 LED Lamps were comprehensive and included online channels—the education and marketing efforts were noted as factors contributing to the success of that technology. Exterior LED Fixtures also received extensive online marketing, and one IOU even leveraged an online portal, which provided updated program information to interested parties. As the case study for exterior LED fixtures indicates, however, that technology's success was hampered somewhat by Title 24 compliance obligations. See Technology Case Studies for more detailed information.

Finally, for measures and technologies where the incremental cost of the efficient measure over the standard measure was high, marketing efforts focused primarily on the incentive. This was true, for example, in the case of Heat Pump Water Heaters, where incremental costs can be substantial. This was also true in the case of High Efficiency Ultra Low Temperature Freezers, although to a lesser extent, where one interviewee indicated a "kicker" (or additional) incentive was offered for a time to address the significant incremental cost of this technology. Admittedly, that interviewee further indicated that the campaign resulted in only "a handful of claims," speculating that the additional amount may not have been high enough or may not have been marketed effectively.

3.3.3 DATA COLLECTION

Data collection, in the context of this report, can refer to one of two areas: data collection processes related to measure package development (previously known as workpaper) and data collection as it relates to program implementation.[18] In general, the specific context is a function of who was interviewed; for instance, staff associated with ET functions typically spoke of data collection from the standpoint of measure package development, while program staff typically referred to data collection as processes that informed program design and implementation.

Questions related to data collection focused on the extent to which data collection was sufficient, either in terms of meeting the program design needs (e.g., information on barriers, market characterization, optimal delivery) or measure development (e.g., baseline development, effective useful life, savings calculations). In addition, this section of the interview also focused on the extent to which there were specific collaboration efforts between ETP staff and program staff to guide data collection efforts (in this case, mainly to inform program design).

Challenges associated with data collection were typically related to the specific measure/technology being discussed. For instance, in the case of T8 LED Lamps, data collection requirements related to end-user information were a

[18] Resolution E-5152, Approval of the Database for Energy-Efficiency Resources updates for Program Year 2023 and revised for Program Years 2022 and 2021, Issued August 5, 2021. See 387465216.PDF (ca.gov)

challenge for IOU staff, implementers, and distributors. This barrier is common in midstream programs, as some of this information is difficult to obtain given the delivery channel.

Information obtained from staff related to data collection informing measure package development was generally limited. This is mainly because utility staff employed in 2016–2017 were no longer with the company or had trouble recalling an old workpaper.

Other pertinent issues raised where staff could provide information included general challenges with establishing a proper baseline across nearly all the technologies. This was a particularly difficult issue to resolve in the case of smart communicating thermostats. Staff further shared that calculation of the TRC is also a challenge generally, particularly if the data needed to inform that value are not available. This point also speaks directly to the need to provide sufficient base data that can inform some of the key inputs into the TRC equation. One example of such base data might be the Residential Appliance Saturation Study (RASS). Other challenges include instances where there is only manufacturer data available and/or the data available are not California-specific.

3.4 MARKET ADOPTION BARRIERS & DRIVERS

When measuring the success of ET measures, market adoption is a primary, if not the primary, metric. The following sections provide findings across all the technologies covered in this report, organized by barriers to adoption and drivers that contribute to market adoption.

3.4.1 BARRIERS

This section focuses on barriers to market adoption, while other barriers (such as those related to program implementation or regulatory policy) are covered in Section 3.6.2.

Not surprisingly, upfront cost was cited as a key barrier for several technologies (e.g., Heat Pump Water Heater, High Efficiency Ultra-Low Temperature Freezer, Ag Ventilation Variable Speed Drive, and to a lesser extent, Tier 2 Advanced Power Strips [APS]). Interviewees noted both the incremental cost of the heat pump water heaters (relative to standard electric-resistance water heaters), as well as the installation and labor costs (particularly in the event the electrical capacity of the residence required upgrading), were barriers to adoption. In the case of the Ag Ventilation Variable Speed Drive, cost was cited as a particular concern based on the required upfront costs and the disproportionate impact this has on dairy farmers, a segment that has been "struggling financially for some time," according to staff. To address this barrier, staff noted the development of a financing option to allow customers to obtain a loan and explained that this has helped to overcome this barrier.[19]

A lack of customer understanding of how a product operates, in addition to general awareness about a particular energy-efficient product, was another barrier that was cited in interviews with staff across several technologies. Most notably, this included Heat Pump Water Heaters, Exterior LED Fixtures, Tub Spout and Thermostatic Shut-Off Showerheads, and to a lesser extent, Smart Communicating Thermostats. Typically, the barrier of general awareness of a more efficient alternative and how those measures operate is addressed based on providing additional information through marketing channels about the device and clearly illustrating how the device can save energy (and money). Another activity employed to address this barrier is engaging with the contractor and distributor communities that exist around these products. For instance, this method is apparent in the case of Heat Pump Water Heaters, where information is provided to the contractor community to raise awareness about the technology and its energy-saving properties. The staff interviewed did mention that initiatives taking place outside of utility programs, such as the

[19] Financing options available under the Agriculture Energy Savings Action Plan (AESAP), which provides qualifying agribusiness owners with technical assistance, rebates, and financing for energy-saving products, including high efficiency fans, as well as custom projects. Financing mechanisms include on-bill financing, on-bill repayment, and GoGreen financing, administered by the State of California

Technology for Clean Heating (TECH) initiative (focused on Heat Pump Water Heaters), provide a positive impact on raising awareness of these technologies. Leveraging the trade ally community was also evident based on comments associated with Exterior LED Fixtures, as trade professionals played a key role in IOU-directed marketing efforts, with events held to provide training opportunities and present information on the key benefits. Staff members suggested that a lack of customer understanding of how Tub Spout and Thermostatic Shut-Off Showerheads work may have been a factor in limiting their adoption. However, no primary research was conducted to investigate this issue. The barrier of limited customer knowledge also affected Smart Communicating Thermostats, especially among individuals who are less familiar with these technologies.

Other less-often mentioned barriers included manufacturer limitations on exactly how the product could be marketed, split incentives, increasing proliferation of product varieties (which drives the need for additional customer education), and the extent to which existing codes & standards may render a product untenable. IOU staff associated with Tub Spout and Thermostatic Shut-Off Showerheads indicated that manufacturer insistence and inflexibility on how the product would be marketed in the retail space contributed to retailers deciding not to move forward with product promotion. Staff also indicated this product was limited in the delivery channels, which perhaps exacerbated this outcome. Smart Communicating Thermostats, which have experienced a proliferation of new market entries over the past few years, have contributed to a need for customers to be able to discern specific features between offerings to maximize benefits, compelling the need to explain the variety of products and effectively communicate benefits. Finally, our case study on Commercial Water Heating noted that both new standards established by the Department of Energy as well as existing California Title 24 compliance regulations presented major challenges for the manufacturer to address through product design. Ultimately, this led to this technology being discontinued, though it is likely this was also attributable to there being only one manufacturer of the specific technology at that time (during the 2016–2017 time period).

3.4.2 DRIVERS

The success of ETPs is impacted not only by barriers but also by drivers—contributing factors that drive the market adoption of energy-efficient technologies. As is the case with many nascent products, there are typically more barriers than drivers influencing their adoption. Even still, there were a few specific drivers mentioned in staff interviews that assisted in driving adoption.

- Staff cited the role that both state and federal policy can have in providing an impetus in the market to drive the adoption of specific products. This was cited in the context of Heat Pump Water Heaters, as the combination of decarbonization policies and a continuing focus on electrification efforts in California have driven and will continue to drive growth in this and similar products moving forward.
- Leveraging trade allies—particularly in the case of T8 LED Lamps—was also cited as a key driver that has led to a fundamental shift in LED adoption over the past several years. Trade allies, in the context of that measure, played a significant role in providing education to their respective customers on the benefits of LED adoption.
- Providing flexibility around financing options, or how incentives can be customized currently based on customer need, was also cited as a key driver contributing to adoption, particularly in the case of Ag Ventilation Variable Speed Drive.

3.5 AWARENESS AND ROLE OF MARKET TRANSFORMATION ADMINISTRATOR

In January 2023, the CPUC announced the introduction of California's first-ever Market Transformation Administrator (CalMTA) to “advance groundbreaking energy efficiency transformation initiatives that will bring sustainable, cost-effective market changes to California.” When we discussed the CalMTA during our interviews with IOU staff, we found most interviewees were not familiar with this initiative in any substantive detail. As time progressed during our interview process, more interviewees were at least aware of the CalMTA (interviews were conducted between April and June

2023). Staff within the ET function were more likely to be aware of this initiative than were those within the program/resource function.

3.6 KEY ELEMENTS ASSOCIATED WITH SUCCESS OR FAILURE

One of the primary objectives of this effort is to assess key elements observed during this research that can predict or forecast the success level of an ET within a resource program. In this section, we provide an analysis of the interviews conducted to identify insights into these elements based on a comprehensive review of our results across all 11 technologies assessed. We have separated findings according to programmatic, technological, and market elements, beginning with specific technology characteristics that may influence success or failure.

3.6.1 ETP TECHNOLOGIES CHARACTERISTICS

This section focuses on identifying specific characteristics of technologies and the extent to which these characteristics explain success or lack thereof regarding the 11 technologies covered in this report. Based on a qualitative assessment comparing outcomes across all 11 technologies, we established the following lists of successful and not so successful.

- **Successful (5):** Smart Communicating Thermostats, T8 LED Lamps, Ag Ventilation Fan Variable Speed Drive, High Efficiency Ultra-Low Temperature Freezer, and Heat Pump Water Heaters
- **Not Successful (6):** Smart/Connected Tier 2 Power Strips, Tier 2 APS, Tubspout/Thermostatic Shut-Off Showerhead, Refrigeration Controls, Exterior LED Fixtures, and Commercial Water Heating

With some exceptions, measures that did not perform well in the market had a couple of commonalities:

- Issues associated with the design or performance of the measure/product
- Lack of suppliers (manufacturers) or misalignment between manufacturers regarding the energy savings properties of the device

For example, the Tier 2 advanced power strip (APS) encountered an issue with product performance. Specifically, the device would reset itself, which caused the resident to reconfigure the system settings. In response to this performance issue, 15%–20% of households that had received a Tier 2 APS uninstalled the device. While this problem wasn't present in all the devices, it resulted in low customer satisfaction with the technology. Furthermore, it posed a challenge to estimating the expected lifespan of the device.

The second commonality was also highlighted with Tier 2 APS devices. The product manufacturers did not align on the energy-saving features of the device, which created difficulties for the utility in measure development. Other technologies impacted included commercial water heating equipment and thermostatic shut-off for tub spouts and showerheads.

It was observed that measures and technologies that were considered successful, such as T8 LED lamps and smart communicating thermostats, were aided by other market actors assisting in expanding awareness and understanding of the product understanding. The key factor contributing to their success was a general adequate understanding of the product's use case and how it operates.

In the case of smart communicating thermostats, the device manufacturers played a significant role in educating consumers about the device's benefits, which substantially aided adoption by "priming the pump" or creating a favorable market condition.[20] Similarly, program staff attributed the success of T8 LED Lamps to the contribution of

[20] There are a few caveats to this outcome as indicated in the case study found in Technology Case Studies. A small but significant part of the market, primarily older individuals and those less familiar with technology were noted by staff as typically not understanding how the device

trade allies and distributors by program staff, who acted as a crucial link between the utility and the end-user. They provided clear and credible information to the prospective adopters, explaining the retrofitting process and the related energy savings. Overall, trade allies played a critical role in increasing the market adoption of several technologies covered in this report by providing valuable information to consumers.

3.6.2 PROGRAMMATIC ELEMENTS

Programmatic elements are those associated with how energy efficiency programs are designed and delivered to customers. Below are our key findings associated with those programmatic elements that, based on the entirety of research conducted in this evaluation, correlate with the ETs' success covered in this report.

- **Market and Customer Research is Imperative**. The relative success of a particular ET is the result of considerable market research and the identification of target customer segments. Understanding the market actors associated with a specific technology and the most appropriate ways to engage them are critical building blocks that can contribute substantially to the success of any potential measure.
- **Clear Educational Marketing on Product Use Cases & Benefits**. Whether technologies were successful or not, clarity of education marketing was crucial. The successes typically resulted from clear educational marketing to prospective end-users (either directly by the IOU or through trade allies). In contrast, technologies that staff indicated were less than successful typically lacked clear educational marketing regarding their operation, energy-saving benefits, or both.
- **Leverage Trade Allies as Applicable**. Some energy-efficient technologies are delivered primarily through downstream channels (i.e., directly to consumers) instead of midstream channels. In the case of technologies where a midstream channel is the most relevant, the successful technologies covered in this report typically included program components that sought to educate and leverage trade allies to build awareness among their customer base and influence market adoption.

3.6.3 TECHNOLOGICAL ELEMENTS

Technological elements are associated with product design. Below are our key findings associated with those technological elements we believe are correlated with the success of the ETs covered in this report.

- **Field Testing Must be Comprehensive**. The Tier 2 APS devices were the most notable example of a technology where product design issues hindered success. Customers were dissatisfied when connected devices reset to system defaults and uninstalled them, making it difficult for the evaluation team to assess the devices' effective useful life. There are other examples of technologies where product design issues moderated success as well. Field testing should also include customer research, and a robust assessment of customer acceptance, as part of their evaluation plans.
- **Product Design Should Focus on Ability to Self-Install Measures**. To a lesser extent, the experience associated with the Tub spout/Thermostatic Shut-Off Showerhead also points out product design features that may limit the adoption of energy efficient technologies. As indicated in that case study, the possible need to cut the existing supply pipe connected to the tub spout appears to have tempered adoption (given skills/knowledge required) and influenced decisions to only offer this measure through direct installs.

worked or how it would assist in saving energy (for instance, some individuals use the smart communicating thermostat manually, which eliminates many of the energy saving properties of the device).

3.6.4 MARKET ELEMENTS

Market elements are defined as those associated with key market dynamics impacting a particular product, the extent to which customer acceptance of the product is high, and how market characterization can impact adoption. Below are our key findings associated with those market elements we believe are correlated with the success of the ETs covered in this report.

- **Leverage Market Actor Marketing as Applicable**. One of the more successful technologies covered here, Smart Communicating Thermostats, was substantially assisted by manufacturers' extensive efforts to educate their customers on the use of their products. While this outcome may not always be relevant for a product, utilities should seek to engage manufacturers (and retailers) early on in product development and identify opportunities for cross-promotional efforts to raise the likelihood of market adoption.
- **Customer Choice can Expand Adoption**. Although utilities have minimal influence on it, the extent to which energy-efficient technologies proliferate can have a positive impact on adoption. Product differentiation may appeal to latent customer segments with specific preferences addressed by newer product variations, often new features that are added to existing technologies.
- **Set Market Actor Expectations.** To some degree, utilities looking to expand the adoption of a particular technology are providing a captive market for manufacturers (upstream) and distributors (midstream). In a few of the technologies reviewed in this report, disagreements between manufacturers about energy-saving capabilities or marketing inflexibility had adverse impacts on program success. In instances where there appeared to be clear expectations and alignment across market actors, these technologies were more successful.
- **Depth of Supply Chain can Impact Success**. Most of the technologies covered in this report are produced by more than one or two manufacturers, meaning the success of the measure is not wholly contingent upon the success or failure of its manufacturers. A few of the technologies covered here (most notably, Commercial Water Heating) were not necessarily eliminated by factors under utility control but rather because only one manufacturer existed. Technologies in measure development should take this into account.

4. RECOMMENDATIONS AND CONSIDERATIONS

4.1 RECOMMENDATIONS

Based on the evaluation activities conducted as part of this study, we provide the following recommendations to improve the ETP process and develop the conditions under which programs established based on ETs can achieve success.

- **Recommendation 1: It's important for utility and third-party implementer staff to set clear expectations for manufacturers with regard to product claims.** IOU and third-party implementer staff should coordinate and work with manufacturers to ensure that the entities that provide these products have a mutual understanding of energy saving capabilities. Accurate and consistent product testing results can help to mitigate risks associated with measure development early in the process. In some cases, this may require more transparency on the part of manufacturers to reveal and provide details associated with product design and product testing. Ultimately, execution of specific agreements between utilities and manufacturers may be needed to ensure that any product testing results they provide are conducted under rigorous protocols which ensure energy savings claims are verified and consistent.
- **Recommendation 2: There is an opportunity to better incorporate more extensive customer acceptance evaluations within field testing studies.** While field testing studies may not be conducted for all assessed technologies, throughout the course of this evaluation it was evident that in some cases, the lack of information

collected in these field-testing studies related to customer acceptance contributed to a lack of success[21]. Customer acceptance evaluations, which seek to understand how individuals interact with technology, might also provide an early indication on whether additional investment by ETP in an emerging technology should be halted due to insurmountable customer acceptance issues.

- **Recommendation 3: Adoption of technologies is bolstered by the presence and execution of comprehensive marketing plans, characterized by a sophisticated segmented approach that leverages key market actors and trade allies.** While anecdotal, one finding indicated that the success of some evaluated technologies was associated with a comprehensive marketing approach that effectively leveraged existing marketing efforts by manufacturers[22], established close coordination with the most influential distributors, retailers & contractors, and provided technical assistance and educational marketing these actors could cascade to end-users to influence adoption. This approach should be patterned across other technologies where applicable, and where the supply chain is concentrated within midstream delivery channels.[23]

4.2 CONSIDERATIONS

The following considerations are based on the results of interviews with IOU staff as well as reflection among the evaluation team. These considerations are not technology-specific but broadly applicable to the technologies that were evaluated.

Consideration 1: Measure packages should incorporate a more holistic approach to strike a balance between cost-effectiveness and customer appeal. Multiple IOU staff members mentioned this consideration and how it might serve to assist in meeting California's electrification goals. One staff member shared, "Energy efficiency is about things that make sense from all different aspects, not just economic but also a big emphasis on environmental and sustainable aspects." As primary metric development moves from total resource cost (TRC) to total system benefit (TSB), the energy efficiency ecosystem in California should assess the extent to which these metrics impact ETs.

- ETP projects should incorporate a more holistic approach during the portfolio stages. Staff should take into consideration technology infrastructure cost, early adopter rates, and the required steps for customers to use the technology. Projects should consider environmental, sustainability, and climate change potential.
- While cost-effectiveness is, and should be, a primary metric for comparing measures and technologies and ensuring a fiduciary use of funds, staff did indicate that, in some cases, reliance on cost-effectiveness may lead to the exclusion of beneficial technologies from the program.
- IOU staff recommend that measure packages address new California needs, for example, electrification requirements. There is a substantial amount of new ET that can be incorporated into the program, even if they are non-traditional to energy efficiency.

Consideration 2: IOU staff presented opportunities to improve the measure package process, from review timelines to the modification of measure package criteria. The scope of this effort did not necessarily include an assessment of the current measure package process, though comments from staff across multiple technologies were captured during interviews. Many of the suggestions provided by staff are peripheral to the established measure review process and are

[21] In response to this report's draft, SDG&E indicated that these field studies are typically done at a handful of willing customer sites, and that the acceptance evaluation is therefore not extensive or representative of the targeted customer base. The authors acknowledge this clarification and understand that in some cases, the feasibility of conducting more large-scale and targeted customer acceptance evaluations may be a challenge. Entities conducting these field studies should discern for each technology the potential benefit of conducting a larger scale effort, particularly for those technologies with large savings potential and high investment needs.

[22] One clear example of this was in the case of smart thermostats, which involved extensive marketing efforts by manufacturers that raised awareness and amplified utility program marketing efforts.

[23] In energy efficiency industry language, midstream delivery channels are terms which describe how programs can leverage these actors (e.g., distributors, retailers, and contractors) by providing incentives directly to these entities to influence product stocking or influencing end-users to implement higher efficiency measures.

primarily items that should be considered moving forward. The evaluation team believes that the currently established measure review process, including roles for CalTF and CPUC, is adequate.

- IOU staff would like to have more transparency associated with CPUC review, including a set timeline for how long reviews will take and established criteria and scoring used to evaluate measure packages. The review and approval process should be streamlined to the extent possible to keep up with the speed of the market.
- A consideration should be made to allow flexibility around faster timelines for specific technologies. Some technologies can move faster in the market than regulatory processes. Despite this "fast path," IOU resource programs still have value to add and can contribute to accelerating adoption.
- Consider simplifying the process of adding more items to measure packages without the need to complete the entire review process.[24] Simplifying the process of adaptions that do not materially impact results substantially should be considered.
- Another consideration is to integrate the measure packages that have different components of a technology into one single measure package (e.g., three or four measures associated with one single technology). Such an approach, it was argued, would save time and financial resources if such an approach were considered.

Consideration 3: IOU staff indicated an opportunity to share knowledge with the IOUs following the establishment of CalMTA. There could be a process in place where information and ideas can be streamlined between all stakeholders and take a more holistic approach to incorporating all the key components of the energy efficiency ecosystem, including resource acquisition, emerging technology, market transformation, and codes & standards. Resource Innovations, the current MTA, appears to agree with this assessment, viewing all these components as "being part of the set of tools that can be used during development of the logic model to create long-term change."[25] Resource Innovations did clarify that work and coordination efforts will nevertheless be exclusively focused on specific markets where an approved market transformation initiative (MTI) Plan is deployed.[26]

[24] This item was raised specifically in the case of Ag Ventilation Variable Speed Drive, where the inclusion of a larger fan size, that, according to staff, did not materially impact the results of the measure package, was not granted short of initiating the entire measure review process again.
[25] Decision 19-12-021. Issued December 5, 2019. Resource Innovations continues by indicating that "the role of the MTA and the MTI (Market Transformation Initiatives) to coordinate with the organizations and budgets supporting each of [ecosystem activities], adding the missing pieces that will allow the MTI to change the market in the long term."
[26] During the comment period associated with this report's draft, CalMTA indicated that "the work and coordination efforts of CalMTA will be focused on specific markets where CalMTA is deploying an approved market transformation initiative (MTI) Plan and will not encompass the entire energy efficiency market or ecosystem. The approach and process for collaboration with codes and standards, energy efficiency program administrators, implementers, and stakeholders will be specified in our MTI Plans and will be customized based on the barriers and opportunities identified in each MTI logic model to transform the target markets."

APPENDIX A. INTERVIEW GUIDE FOR IOU STAFF

OVERVIEW

This interview guide identifies key research questions to inform the overall study goals of this research effort, entitled Emerging Technology to Portfolio Study – Adoption Driver Examination. The backdrop for this effort includes the passage of California SB 350, which established ambitious energy savings and greenhouse gas (GHG) reduction goals by 2030. The California Statewide Emerging Technologies Program (ETP) is one area whereby ratepayer-funded programs attempt to address these goals through the promotion and development of innovative energy-saving technologies.

This current effort is grounded in the context of previous evaluative efforts. For instance, the Emerging Technologies Program Handoff Process Evaluation (November 2021) suggests that the ETP provides value to EE portfolio programs. That research focused on reviewing the hand-off process as opposed to diving deeper into the technology characteristics.

The goal of this research effort is to understand the characteristics and market adoption practices that can inform and provide synergies between ETP and EE programs and what steps can be taken to improve alignment to provide for increased handoff of ETP measures to EE programs, resulting in high market adoption.

OPENING SCRIPT

Read the following to interviewees at the beginning of the interview.

"Guidehouse has been engaged by CPUC to understand the characteristics and market adoptions practices that can inform and provide synergies between ETP and EE programs. Specifically, what can be done to improve the adoptions of ETP technologies and increase the amount being handed off to EE programs. We have selected a sample of former ETP technologies that are now in rebate programs for case studies. Some of our questions will be specifically about this technology's performance in programs.

We are conducting these interviews with IOU staff to collect feedback with the goal of identifying characteristics of emerging technologies that are either successful or under-performing in resource programs, explore barriers and opportunities to market adoption of technologies, and identify those elements of ETP-originated measures that lead to success. We would like to hear about your experience working with ETP measures, so that we can better understand any successes and challenges. Our ultimate objective is to identify any opportunities to improve the program and effectively increase the rate at which emerging technologies enter the market.

On behalf of CPUC, we thank you for agreeing to spend this time with us. Your feedback will remain anonymous. Before we get started do you have any questions for us?"

INTRODUCTION

First, we would like to discuss the role you and your department have in relation to the emerging technology program.

1. Can you describe your role, your department, and if you aren't part of ETP how do you interact with ETP? [Context dependent upon exact individual being interviewed.]
    a. How long have you been in this role, and has it evolved during your experience?
    b. If so, what factors have contributed to that evolution?

PROGRAM STRATEGY

The next set of questions are related to **[UTILITY]'s** general strategy around the Emerging Technologies Program (ETP).

3. What are some common challenges that an emerging technology faces during its inclusion into the portfolio of incentive programs?
    a. Probe: Are there any challenges you can point to that are specific to **[TECHNOLOGY]?**
    b. Probe: What are some strategies, techniques or tactics that **[UTILITY/ORGANIZATION]** has employed to try and address these challenges?
    c. What can be done to ensure that an emerging technology can move through the process smoothly? Is there anything the CPUC can do to make this happen? [Probe for specifics]
4. Does the **[UTILITY EE PM]** know which technologies originated from ETP?
    a. **[IF YES]** How do you know?
    b. **[If YES]** How does this change your tactics, if at all?
    c. **[IF NO]** Would it be helpful to know this information?

MARKET ADOPTION

Let's talk about the market adoption drivers or barriers for technologies in general at first, and then we'll talk more specifically about these factors for **[TECHNOLOGY]**.

5. Has **[UTILITY PM]** experienced any barriers associated with increasing the adoption of **[TECHNOLOGY]**? [Probe for specific areas contributing to barriers: lack of information or awareness, cost, quality of measure, etc.]
6. What drivers has **[UTILITY PM]** experienced that led to the **[TECHNOLOGY]** to be successful (i.e., awareness of technology, ease of use, cost effectiveness)?
7. How have economic trends, demographics trends, and available substitutes (if any) impacted **[TECHNOLOGY]**?
    a. Probe: Do you project any substantial changes in these trends moving forward (next 5-10 years) that would make it more (less) likely this technology will increase (decrease) its adoption?

COLLABORATION

We want to understand how all the different teams work towards the success of **[TECHNOLOGY]** from its inclusion as an emerging technology measure to a resource (incentive) program.

8. Have you collaborated with **[EE and/or ETP MANAGERS]** to develop strategies to promote **[TECHNOLOGY]**? (Probe for in general)
    a. **[IF YES]** What does that process look like?
    b. **[IF NO]** What role, if any, do you have in identifying or selecting potential emerging technologies to develop in the ETP program?
9. Has **[INTERVIEWEE]** collaborated with other CA Utility PAs, the ETCC (Emerging Technologies Coordinating Council) staff, or other stakeholders to develop strategies to promote **[TECHNOLOGY]**?
    a. **[IF YES ON STAKEHOLDERS]** Can you identify who those stakeholders are?
    b. **[IF YES]** What did that process look like and what is beneficial?
    c. **[IF NO]** What are some of the reasons that **[INTERVIEWEE]** has not collaborated with other CA Utility PAs or the ETCC? [Probe for specifics]

MARKETING AND OUTREACH

Let's discuss what marketing efforts **[UTILITY/ORGANIZATION]** has in place for emerging technology programs generally, and for **[TECHNOLOGY]**, specifically**.**

10. What strategies does **[UTILITY/ORGANIZATION]** use to promote emerging technologies?
    a. Probe: Does it vary by program type? (e.g., direct install, mid-stream, hard-to-reach segments)
    b. Probe: Does it vary by technology class? (i.e., LEDs, HVAC, Water Heating, etc.)

c. Probe: Does it vary by any specific level? In other words, is the promotion of certain technologies more relevant at the measure level or more broadly, and what factors inform the level at which technologies are promoted?
d. In your opinion have these strategies been successful generally?
e. What is your assessment of the success of **[TECHNOLOGY]**, specifically, within the context of marketing and outreach?

11. Generally, what information does **[UTILITY/ORGANIZATION]** rely on to understand **[TECHNOLOGY]'s** market barriers?
    a. Does the **[UTILITY/ORGANIZATION]** conduct any research on their own to understand **[TECHNOLOGY]'s** market barriers? (e.g., publicly available information/desk research, other utility experiences, syndicated research, etc.)?
    b. **[IF YES]** Does **[UTILITY/ORGANIZATION]** utilize this research to inform promotional strategies?
    c. **[IF NO]** What does **[UTILITY/ORGANIZATION]** typically rely on when considering barriers to adoption for any technologies?
        i. Probe: Specific information gathered for **[TECHNOLOGY]**.
        ii. Probe: General sources consulted in the process of program design, marketing strategies, or assessing market barriers.
        iii. Probe: What did you know about this **[TECHNOLOGY]** prior to its inclusion into the portfolio of resource programs?
        iv. Probe: Do they emulate other programs (inside/outside California)?
    d. What studies (if any) do you think would help you better market **[TECHNOLOGY]** that are not currently available? (Probe: Any specific information you think would have been helpful regarding **[TECHNOLOGY]**.

DATA COLLECTION

We want to discuss the data collection process of the Emerging Technology Program (ETP), and data in the context of informing program design for resource (incentive) programs.

12. **[FOR NON-ETP STAFF ONLY]** Was the data you received from ETP about **[TECHNOLOGY]** suitable and sufficient to meet the program's needs and/or measure development?
    a. Probe: Was the data useful in terms of informing resource program design?
    b. Probe: Are there data sources or elements that you can identify, specific to **[TECHNOLOGY]**, that you did not have that would have been useful for program design?
13. How do you collaborate with **[ETP/EE PM]** to guide the ETP project data collection?

PROGRAM FEEDBACK

In the next few questions, we would like to talk about any changes or updates you think could help improve the Emerging Technology program.

14. What technology attributes should ETP be focused on in the future (e.g., decent TRC, high kW savings, high potential, low market penetration)?

ROLE OF MARKET TRANSFORMATION ADMINISTRATOR

Finally, we wanted to ask a few broad questions relevant to a new initiative being undertaken by the CPUC, in addition to any specific feedback related to program and measure development. In January of this year, the CPUC announced the introduction of the state's first-ever Market Transformation Administrator (CalMTA) to "…advance groundbreaking energy efficiency transformation initiatives that will bring sustainable, cost-effective market changes to California."

15. First, when it comes to program and measure development broadly speaking, what has the **[UTILITY/ORGANIZATION]** identified as a missing component to program success, if any?

a. Are there any recurring frustrations related to the entire process of technology selection and program development that **[UTILITY/ORGANIZATION]** would like to address?

16. Second, and recognizing that this new initiative and is expected to be an eight-year effort, how do you envision the role of CalMTA and TFPs (Technology Focused Pilots) as they relate to either emerging technology programs or energy efficiency incentive (resource) programs?
    a. Will these initiatives address any of the gaps identified in previous questions? Will they conflict with any existing processes?

Those are all the questions I have for you. Is there anything we haven't covered that you would like to share or anything else that you think would be helpful in meeting our objective to understand what strategies should be deployed around diffusion of innovation or how EE programs can better leverage ETP technologies?

a. [Probe: Specifics associated with actionable things that can be done to improve processes or try to facilitate the success of emerging technology programs that move from ETP to EE portfolios.]

ADD-ON QUESTIONS FOR SPECIFIC TECHNOLOGIES

Heat Pump Water Heater

17. Have the various other programs (outside the utility ecosystem) that incentivize heat pump water heaters in the state negatively or positively impacted **[UTILITY's]** program participation for these measures?
    a. **[IF NEGATIVE]** What do you feel can be done to improve this process? What would make it easier to potentially co-exist with these other programs?
    b. **[IF POSITIVE]** What is working well? [Probe for specifics] Is there something you wouldn't want to change?

APPENDIX B. TECHNOLOGY CASE STUDIES

HEAT PUMP WATER HEATER

Technology Background

Conventional electric-resistance water heaters operate by bringing cold water into a tank and heating the water with an electric heating element. The water then rises to the top portion of the tank, where hot water is drawn for consumption. Efficient Heat Pump Water Heaters (HPWH) use a direct expansion (DX) heat pump to transfer heat to the water, utilizing electricity to move heat, taking heat from the surrounding air and transferring it to water in its enclosed tank (Figure 1). [1] These heat pumps can include a control panel that offers unique operating modes (e.g., efficiency mode, auto mode, vacation mode).[2] Information provided in the measure package indicates that the uniform energy factor (UEF) for an HPWH ranges from 3.50 to 3.75 (depending on capacity).[3] Efficient HPWHs are forecasted to grow at a 6.8% compound annual growth rate from 2022–2032 in the global market.[4]

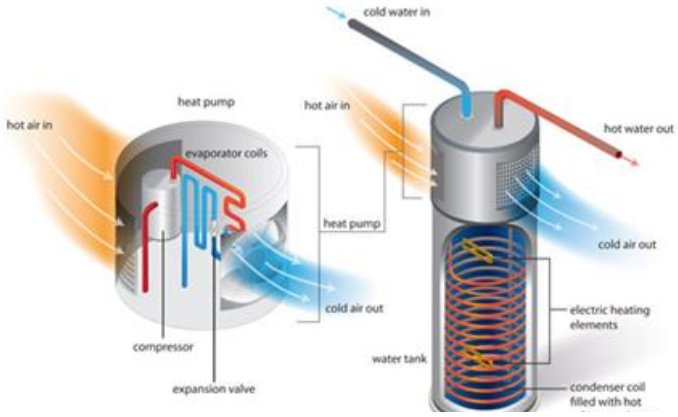

Figure 1: Hybrid Heat Pump Water Heater Diagram[1]

This technology is a part of the statewide Plug Load & Appliance program; SDG&E is the Program Administrator (PA) Lead, and CLEAResult is the implementer. This technology is made available and supported through a point-of-sale program implemented with a range of vendors, who administer these programs through a network of distributors and contractors, determining strategies and stocking habits to impact adoption.[5] Interviews with IOU staff reveal that the impact of marketing efforts is tempered by the lack of knowledge about HPWHs among both consumers and contractors.

When the HPWH measure package was first introduced, CPUC policy only allowed for the technology to replace electric water heaters. In 2019, the CPUC changed this policy due to electrification goals,[6] and now HPWHs are eligible to replace both electric resistance and gas-fired water heaters. The latest information on the distribution of homes by fuel source from 2019 indicated that 11% of the market relied on electric water heating (compared to only 6% in 2009).[7] Most homes in California (77%) rely on natural gas to fuel their water heaters. In a recent report focused on the market characterization of the heat pump market, the growth potential of both electric water heating and HPWHs was anticipated "given California's focus on decarbonization."[8] In interviews with trade allies, several indicated the primary reason for the growth in HPWHs is attributable to the state's emphasis on electrification. Despite this push, interviews with contractors revealed

[1] eTRM. Measure Characterization: Heat Pump Water Heater, Residential. Version SWWH014-04. See https://www.caetrm.com/measure/SWWH014/04/

[2] https://www.energystar.gov/products/water_heaters/high_efficiency_electric_storage_water_heaters/how_it_works

[3] Note: Uniform Energy Factor (UEF) is a metric developed by the US Department of Energy to communicate the relative efficiency of energy consuming products (including water heaters); the higher the UEF, the more efficient the product.

[4] https://www.contractormag.com/iot/article/21252427/heat-pump-water-heater-market-to-double-by-2032

[5] Based on a response to a CPUC Data request in March 2023

[6] Based on CA SB 1477; while electrification is not in the bill's title, the direction to provide incentives for near-zero-emission building technologies would involve the adoption of electric-consuming measures.

[7] Based on 2019 California Residential Appliance Saturation Study (RASS). DNV GL Energy Insights USA, Inc. July 2021. See 2019 California Residential Appliance Saturation Study (RASS) | California Energy Commission. Data on heat pump water heater penetration was not collected in 2019.

[8] Opinion Dynamics Corporation. California Heat Pump Residential Market Characterization and Baseline Study, published May 17, 2022. See OD-CPUC-Heat-Pump-Market-Study-Report-5-17-2022.pdf (calmac.org)

that they typically recommend a gas water heater if the existing fuel type is gas, given the cost involved in fuel switching.[9] As upfront cost was the most mentioned concern among contractors interviewed, it is perhaps likely that this will serve to temper any proliferation of fuel switching.[10]

Key Findings

1. Consumers and contractors lack awareness of efficient HPWHs and the benefits they provide. This continues to impact the adoption of this technology, as this was true when the measure was emerging as it is today.
2. The combination of decarbonization policies in California, environmentally conscious early adopters, and a comprehensive marketing plan all contributed to the uptake of HPWHs over the past 6–7 years; observers suggest the continuing focus on electrification in California will drive growth over the next decade.
3. Marketing efforts have focused primarily on the incentive, though it is unclear what type of an overall impact this is having, given the high incremental cost and the typical purchase behavior being replacement on failure; this, coupled with stocking practices that favor cheaper, more inefficient water heaters, has tempered adoption.

Process and Program Strategy

IOU staff interviewed for this report indicated that the other IOUs (PG&E & SCE) conducted some market characterization studies for HPWHs, and SDG&E used this to inform potential program design and strategy. For instance, when HPWHs were emerging as a measure (2016–2017), there was a significant base of research and opinions published regarding the technology. The IOU staff found some of this research included conflicting information. For this reason, the IOU staff needed to conduct their own independent research to identify what was legitimate and credible. Once the technology moved to a statewide program, the responsibility of market characterization studies fell to CLEAResult, the designated implementation contractor. IOU staff did share that CLEAResult engages with all market actors, and they share this information with the IOUs, as they meet regularly to develop the best approaches and ensure they are compliant with their contract and program guidelines.

Regarding whether the data collected during the ET phase was sufficient and suitable, IOU program staff indicated they had minimal input into this process. In the case of HPWHs, IOU staff simply used the water heater calculator to calculate savings.[11] Early in the program, there was an issue with the data collection process. The implementation contractor was required to collect specific data associated with existing baseline information, which was usually not known by the customer when they replaced their gas water heater with an HPWH. The CPUC lifted this requirement in 2019; therefore, the issue has been resolved.

The marketing strategies evolved for HPWHs as the technology became a part of a statewide program. Early in the program, marketing focused on customers who had existing electric-resistance water heaters. This marketing strategy did not lead to substantial uptake because of the limited market size (few customers had electric resistance water heaters).[12] The early marketing channels included email campaigns, direct mailers, and social media campaigns. The general strategy was to focus on the incentives and a high-level accounting of the benefits, with the goal of driving customers to the program website. Once CLEAResult began to administer the program, they conducted multiple social media campaigns, along with ads on social media and the internet. They also promote the program by offering customers a coupon, which requires customers to enter their email address, resulting in the development of a distribution list administered by CLEAResult. Since CLEAResult took over marketing efforts, the IOUs are unable to measure the success of the marketing strategies independently.

[9] Opinion Dynamics Corporation. Op. Cit., page 84.
[10] Ibid., page 86.
[11] Based on the context that this statement is attributable to staff describing their process at the time that this measure was in the ET phase, this water heater calculator would be the one established initially through the Database of Energy Efficiency Resources (DEER) in 2015 and updated subsequently. For more information, see the latest documentation: DEER Water Heater Calculator v4.1 (sound-data.com)
[12] According to the 2019 California Residential Appliance Saturation Study (RASS), gas-fueled water heating is more common, ranging from a low incidence of 45% within apartments/condominium structures with 5+ units, to a high incidence of 86% within single-family structures.

IOU staff shared that other programs outside of utility-funded efforts that incentivize HPWHs, such as the Technology for Clean Heating (TECH) initiative, positively impact program participation. Since the programs have the same goal of promoting and stimulating development and raising adoption, the IOU staff expressed that the more resources, the better. The only concern is ensuring that the program is not double-dipping on savings, typically addressed by verification of the program source of each HPWH installed.

Market Adoption

HPWH adoption has increased in the market within the US since 2016, as national sales of ENERGY STAR®-certified HPWHs increased by 52,000 units from 2016–2020, with projections for California suggesting some degree of growth over the next five or ten years, driven by the state's focus on decarbonization.[13] One reason IOU staff shared, which is corroborated by market reports, was that early adopters are contributing to this trend and are typically environmentally conscious or more aware that this technology exists. The heightened focus on safety, reliability, and resilience to address climate change is likely to stimulate technologies that benefit clean energy, micro-grid, electrical grid security, and modernization. California's electrification goals and policies have stimulated the development of this technology and are likely to continue to drive adoption into the future.

There are two primary barriers to adoption: upfront cost and market awareness for both end-users and contractors. The following items describe each of these barriers in more detail.

- **Upfront cost** is a barrier that can contribute to a lower adoption rate as lower-cost (though less efficient) options are available to the customers. According to ENERGY STAR, replacing a standard electric resistance water heater with an HPWH can cost around $1,500–$3,000 for the unit, with an additional $1,000–$3,000 for installation and material costs.[2] In the scenario where a gas-fired water heater is replaced with an HPWH, there is a greater likelihood that electrical upgrades (such as panel amperage) would be required and increase the upfront cost. IOU staff shared that the midstream Plug Load Appliance program is trying to offer a higher incentive that is above the current incremental cost, and this may help to decrease the burden of high upfront costs. Staff did note that the marketing strategies focus on the provision of the incentive first to mitigate this barrier.
- Finally, a lack of **market awareness** about this technology among end-use customers and contractors is an additional barrier to HPWH adoption. According to the measure package documentation,[14] only 8% of consumers consider higher efficiency when looking to replace their existing water heater. Based on information provided by staff, contractors may have some knowledge of the technology but may not fully understand the benefits; if contractors understand the technology better, it may serve to drive down the installation cost. Since the replacement of a water heater is typically due to emergency replacement, ensuring more efficient units are available among contractors at the time of service calls could impact adoption.

Considerations

The following considerations are based on interviews with IOU staff associated with HPWHs specifically and areas where they believe improvements could be made to increase adoption or clarify savings.

- Continue to focus on educational marketing campaigns to expand awareness of this technology and its benefits; expand the focus on educational marketing for contractors, as this segment is a critical piece in making more efficient water heaters available for emergency replacement.

[13] US sales of heat pump water heaters doubled during 2016-2020, driven by a push for greater adoption by manufacturers, utilities, and governments (See U.S. International Trade Commission, Executive Briefings on Trade: Residential Heat Pump (Hybrid) Water Heater Market, Production, and Trade: Residential Heat Pump (Hybrid) Water Heater Market, Production, and Trade (usitc.gov), Accessed 14 Aug 2023). State of California information based on Opinion Dynamics, California Heat Pump Residential Market Characterization and Baseline Study, Published May 17, 2022; See OD-CPUC-Heat-Pump-Market-Study-Report-5-17-2022.pdf (calmac.org), Accessed 14 Aug 2023.

[14] eTRM. Measure Characterization: Heat Pump Water Heater, Residential. Version SWWH014-04, See https://www.caetrm.com/measure/SWWH014/04/

- Consideration should be placed on improving the existing measure package for HPWHs by including demand response benefits and the operation of this technology when replacing a gas-fired water heater to ensure savings are captured properly.
- Measure packages should try to strike a better balance between being cost-effective and appealing to the potential customer for this measure to be more successful. The measure package associated with HPWHs has a maximum incentive that can be offered at incremental cost, which may not cover the specific costs borne by someone adopting this technology. While it is true that the current measure package does allow incentives to go over the incremental cost, these instances need to be justified by PAs or third-party implementation contractors on a case-by-case basis. For technologies with a significant upside corresponding to increased adoption, perhaps greater flexibility on incentive amounts (with controls) could be considered. We note a similar recommendation made in the most recent impact evaluation report for HPWHs, indicating that increasing incentives could encourage mass market adoption of high-efficiency water heaters in single-family homes.[15]

[15] DNV GL Energy Insights USA, Inc. Impact Evaluation of Water Heating Measures – Residential Sector – Program Year 2019, June 16, 2021. See 2019 Water Heating Evaluation (calmac.org)

EXTERIOR LED FIXTURES

Technology Background

Exterior LED Fixtures represent one of many LED technologies that have grown in adoption over the years. Also called LED Exterior Wall Packs, these fixtures (Figure 2) are commonly used in walkways, parking areas, building facades, garages, and other outdoor spaces[16]. They have photocell control and operate from dusk to dawn.[17] Measures associated with this technology include LED fixtures that are meant to replace metal halide lamps, high-pressure sodium, and compact fluorescent lighting. According to the final workpaper (authored by SCE) associated with this technology, the measures were made available through the Multifamily Energy Efficiency Rebate's Direct Install and Commercial Direct Install Programs. Associated delivery mechanisms included downstream incentives, direct install, and midstream incentives. Energy savings information provided in the workpaper indicates that these measures use anywhere from 27% to 87% of the energy consumption of a metal halide, high-pressure sodium, or compact fluorescent fixture.

Key Findings

1. Trade allies played a key role in educating themselves about the technology and effectively marketing the technology to their customers.

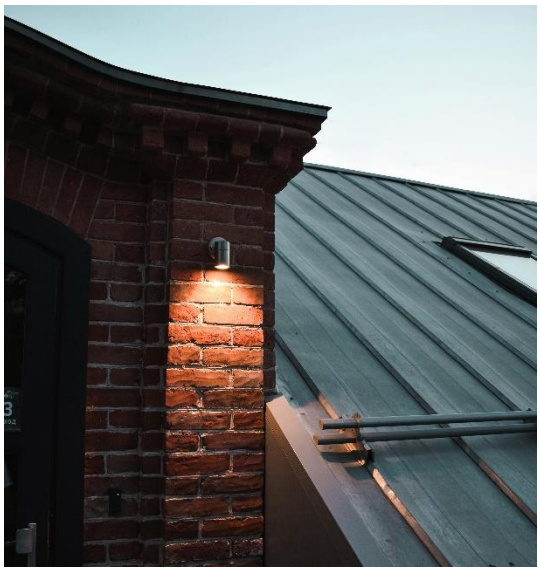

Figure 2: Exterior LED [16]

2. Data collection requirements associated with program documentation were a challenge, particularly in cases where the product came through distributors, as this information was required from the end user and was typically difficult to obtain.

3. The decrease in the price of exterior LED fixtures was a driver; however, this created an uptake challenge for the program, as customers may not contend with program requirements to receive an incentive.

Process and Program Strategy

Based on interviews with relevant staff, one staff member held a different role during the ET phase and was not able to speak to market characterization work that may have been conducted at that time. Another staff member, speaking on the topic of market characterization work more broadly, indicated that staff typically engages with contractors (who are customer-facing) for insights around the viability of a specific technology. Staff also indicated that during the ET phase (2016–2017), they reviewed relevant studies on trends, engaged with market actors, or reviewed the experiences of other states. Staff further indicated that they do not currently engage in these activities much anymore, as these processes are expected to be undertaken by the third-party implementation contractor. The IOU does have visibility on these items and does provide feedback to the implementation contractor in the event they wish to propose an idea for measure packages, but they do not directly engage.

As indicated in the workpaper, no relevant studies related to market potential were reviewed. A review of the ETCC web portal reveals only two studies associated with exterior LED lighting: one developed by PG&E in 2007 that assessed LED low-bay garage lighting and a report produced for SCE that assessed occupancy sensors coupled with LED lighting for cold cases and exterior lots.

[16] Image Credit to денис-нагайцев, Pexels 4

[17] Based on Workpaper SCE13LG108, See CEDARS Measure Package

Staff indicated that program data collection requirements can be burdensome, particularly the requirements to ensure customers are compliant with California Title 24. Title 24 includes multiple requirements for outdoor wall-mounted lighting luminaires, such as the requirement that "all installed outdoor lighting…shall be controlled with automatic lighting controls" that must meet several requirements. These include motion sensors or other lighting control systems capable of automatically reducing the lighting power of each luminaire over the range of 40%–80%. Other requirements include employing an auto-on functionality when the area becomes occupied, and no more than 1500 watts of lighting power should be controlled together. In terms of the data collection process related to ensuring program design and management considers these types of requirements, one interviewee (on the program side of the organization) did indicate they worked closely with the engineering team to understand the requirements and to inform program-related processes.

Staff interviews indicated that marketing efforts related to this technology during its ET and handoff phase sought to leverage both internal and external marketing efforts to drive awareness about this technology and its energy-saving features. The IOU internal customer business division would reach out directly to customers to provide educational marketing, organized around campaigns for new products (in addition to Exterior LED Fixtures) and marketing initiatives. As was the case with other lighting initiatives, the trade professional community played a key role in the marketing plans of the utility. Annual hosted kickoff events took place where the IOU staff could train the trade allies on the newest technology and provide breakdowns of the benefits. The IOU also established an online portal to provide updated information to interested parties. Based on information provided by staff, the online portal was primarily for non-residential programs; it consisted of program updates and announcements as well as changes to program processes. One example might be an announcement that indicates a workpaper would expire, with information about the anticipated expiration date and application deadline. Staff also indicated that online marketing was used heavily to promote this product.

Market Adoption

Market adoption of LED products has certainly grown in recent years—particularly during the ET period under study in this report (2016–2017). The latest data provided by the Department of Energy indicates that the outdoor lighting market has seen greater penetration of all LEDs (51.4%) than indoor lighting (29.8%), though total LED installations are higher for indoor applications, which would stand to reason given the concentration of fixtures in indoor areas.[18]

The barriers to adoption can be broken down into two categories: those involving barriers to adoption among customers and those that we can characterize as regulatory barriers or barriers that may hinder program or utility operations.

Barriers related to customer adoption include:

- As is generally the case with energy-efficient measures requiring a large capital outlay, the **cost of upgrades** can be a limiting factor for measures like exterior LED fixtures. This is particularly true if there is a substantial portion of a company's geographic footprint requiring exterior lighting, for example, a university campus, health care complex, office building, or a portfolio of buildings with substantial garage space.
- A **lack of understanding about the technology** is a barrier also cited by staff, as in many instances, it is important for the customer to have a good understanding of how the technology functions and its benefits. To some extent, this barrier was being addressed based on the program through educational marketing and distributor trainings, which they could then cascade to their customers. As indicated earlier, this technology also adds an extra layer of complexity as installations must be compliant with Title 24. Staff noted this regulatory hurdle could be a major challenge since, in many cases, it may be difficult to precisely assess whether a location (and the lighting design) will comply with Title 24 requirements.

[18] U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy. Adoption of Light-Emitting Diodes in Common Lighting Applications, August 2020. See Adoption of Light-Emitting Diodes in Common Lighting Applications (energy.gov).

Regulatory barriers include:

- **LEDs are becoming standard practice in the industry**, and some utility staff indicated this presents a challenge since, ideally, programs should focus on products that need some assistance to increase adoption. This barrier is not specific to LED fixtures but could be a barrier (from a program perspective) for any technology that has increased in adoption—to some extent, the low-hanging fruit has been harvested.
- An additional barrier from a regulatory or program perspective involves **data collection challenges**, particularly if the program design involves a midstream or upstream delivery channel, as the amount of data required to be collected from the end user may introduce difficulties. While this technology (exterior LED fixtures) would not be the only technology impacted by this barrier, given the design of many of these programs to work with trade allies, this is a barrier that might disproportionately impact this technology.
- Another challenge is related to **qualification under the Design Lights Consortium (DLC)**. This organization provides performance standards associated with lighting products; under this system, manufacturers need to submit their proposed products to the DLC, which would have to meet certain requirements to be listed on DLC, a requirement of program qualification (according to staff). If a product met performance specifications but was not listed on the DLC, it would not qualify.

One additional item related to regulatory barriers mentioned by staff includes additional requirements that have been layered onto measure approval processes, lengthening the time for even submitting a measure package; for instance, requiring PAs to submit a measure package plan (MPP) prior to drafting and submitting a measure package.[19]

Staff noted a few key adoption drivers that came to their mind when discussing this technology. For instance, the delivery channel, despite some of the barriers noted above, was a key driver in expanding the adoption of this technology. The reduction in product pricing for this technology over the past several years has led more firms to institute changeovers of existing lighting to exterior LEDs (in addition to interior). Utility personnel noted this dynamic as a key contributor to large amounts of energy savings, though given the trends in market adoption, outcomes such as these are declining. One staff member noted that, as the flip side of the same coin, the drop in price can also be a barrier from the perspective of a utility program. At a low enough price, the customer may forego the time and effort required to ensure they meet all program-related requirements and simply end up conducting a lighting changeover without utility-provided incentives. While this is a positive outcome from the standpoint of the market increasing its adoption of energy-efficient technologies, it has ramifications for utility programs.

Considerations

- Based on the experiences associated with the increased adoption of this technology, considerations should be made (where applicable) to coordinate and collaborate efforts among product distributors, as these actors can influence product purchase decisions on a wider and more direct scale. To the extent possible, these types of collaborative efforts in driving an understanding of emerging technologies and their specific benefits should be leveraged. Examples of collaborative efforts would include joint events between market actors and implementation contractors, webinars to explain how products operate and how they save energy, an online portal to serve as a repository of key information, and training sessions or online training videos leveraged across multiple channels.
- One challenge noted by staff during interviews focused on the amount of time it takes to conduct an ex-ante review. While this situation has improved recently due to additional staff, one consideration, particularly for custom measures, would be to update the industry standard practice (ISP) document in a more expeditious and streamlined manner.

[19] In the resolution introducing a measure package plan, specific timelines are indicated under which CPUC provides a review, the maximum of which is 70 days (though could be longer if additional information is required in multiple instances). See Resolution E-5152. Approval of the Database for Energy-Efficiency Resources updates for Program Year 2023 and revised for Program years 2022 and 2021. See 387465216.PDF (ca.gov)

TIER 2 ADVANCED POWER STRIP

Technology Background

Tier 2 Advanced Power Strips (APS), illustrated in Figure 3[20], are activity monitoring power strips that manage both standby and active power consumption.[21] The manner in which a Tier 2 APS operates is to shut off all items plugged into the controlled outlets after a period of user absence or inactivity; energy savings result by removing power to devices that would otherwise be drawing full power when not actively being used.[21] Tier 2 APS are differentiated from Tier 1 APS based on the following contrasts. Tier 1 APS primarily target passive standby or "vampire load," determines the "master" device state (controlled outlets) through sensing current consumption, and disables power to controlled devices when the master is switched off. A Tier 2 APS utilizes intelligent algorithms to monitor the power of all controlled devices. They use infrared sensing and root mean squared power sensing (as opposed to current sensing) and deliver energy savings by shutting off connected devices after one hour of inactivity.[22] It should be noted that this technology is differentiated from another case study, Smart/Connected Tier 2 Power Strip. That technology uses Tier 2 APS plus wireless communication-enabled features that allow households to monitor plug-load connected devices via a smartphone app, as well as providing energy management tools.

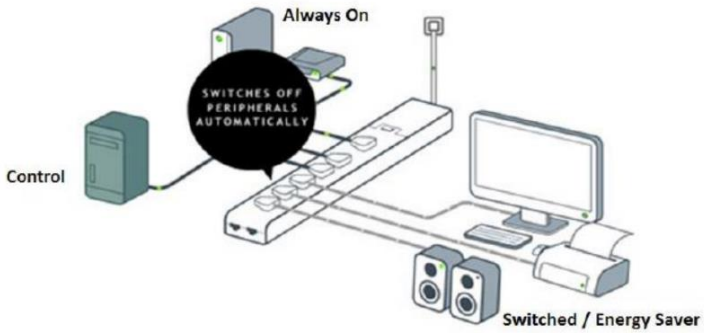

Figure 3: Tier 2 APS Diagram[20]

The field research that informed this measure's workpaper included two studies: one associated with CalPlug baseline data collection and the other associated with SDG&E baseline data collection.[23] The studies included a total of 53 and 47 households, respectively. Study data provided in the workpaper indicate that, on average, these devices used approximately 50% less energy than a standard power strip,[24] consistent with other field testing studies. Data collection included second-by-second metered data of multiple indicators, including main power level (voltage), connected equipment current consumption, power use (watts), and energy saved and energy used (cumulative watt hours and instantaneous watt seconds). An original workpaper was drafted in January 2015 by RMS Energy Consulting, LLC, and discussed by the CalTF in that same month, with a follow-up presentation in February 2015, which addressed initial comments from the CalTF membership. These comments included assessing the statistical confidence of the field-testing study results in California, combining California-specific studies,[25] estimating the cost of collecting baseline usage data, including the use of Nielsen and RASS data to cross-validate baseline usage data,[26] and estimating saving potential.

[20] SDG&E Technology Assessment Report, Tier 2 Advanced Power Strips in Residential and Commercial Application, April 2015

[21] Northeast Energy Efficiency Partnerships. Case Study: Tier 2 Advanced Power Strips and Efficiency Programs, published April 2015. See NEEP Tier 2 APS Case Study

[22] Comparison based on CalTF, Meeting Materials, January 22, 2015. See Tier 2 Advanced Power Strip Presentation (Slide 4)

[23] California Plug Load Research Center.

[24] As indicated in the workpaper, the assumed base case is a standard power strip. Work Paper WPSDGEREHE004-0. San Diego Gas & Electric, Energy Efficiency Engineering. Tier 2 Advanced Power Strips, January 9, 2015.

[25] This action combined the California-based site of three studies associated with the CalPlug effort (included sites in Australia, South Africa and Santa Cruz, CA) with SDG&E residential study.

[26] Residential Appliance Saturation Study. The most recent study was conducted in 2019; see 2019 Residential Appliance Saturation Study (ca.gov).

A subsequent meeting with the CalTF took place in January 2016. After discussing the results of the field testing studies, the CalTF recommended a longer duration of field monitoring to assist in accurately estimating the persistence of these devices within residential homes. A subsequent workpaper was submitted in August 2015 and approved. The measure was retired by SDG&E in 2018, primarily due to issues with the device performing a factory reset, according to information provided by IOU staff.

Similar to the case study on Tier 2 Smart Connected Power Strips, there was some resistance to these devices by consumers, as indicated in follow-up results one month after install presented to CalTF.[27] This follow-up study revealed that devices had been removed after installation in 17% of households (in some cases less than two weeks after installation) due to issues with their televisions shutting down while in use, difficulty using the device, and other issues. Due to some of the complexity issues and cost, the ET report recommended that a direct install program would be most appropriate. The price of Tier 2 APS were dependent on the market segment, incentives, and distribution channels, but the average cost was around $60 to $100.[27] aboveA Puget Sound Energy survey found 43% of respondents stated they wouldn't pay more than $20 for Tier 2 APS.[21] Tier 2 APS were distributed through a direct install program until the measure was retired in 2018.

Key Findings

1. Field testing for this product cost a substantial amount of money, and the savings were not large enough to justify the costs, contributing to the decision to retire this measure.
2. The Tier 2 APS could not support the shift to TV streaming services and Smart TVs, and there were technological issues with factory resetting customer products that were plugged into the device, further contributing to the decision to retire this measure.
3. General customer dissatisfaction led to customers unplugging the device, which made it difficult for the utility to verify savings unless utility staff were physically checking each household; this also resulted in issues with accurately measuring the effective useful life (EUL), leading to a low EUL assigned by the CPUC.

Process and Program Strategy

Relatively little information was available on efforts SDG&E (the primary IOU associated with this measure) executed to inform the market characterization or customer-based research as individuals involved in this technology during its ET phase were no longer employed by SDG&E. That said, research was conducted and "designed to explore customers' experiences with the APS devices and factors that could affect persistence." Customers participating in field trials were contacted approximately six to eight weeks following installation among three zip codes in SDG&E's service territory (1,100 total installs). Researchers received approximately 200 responses to survey invitations associated with two primary models installed and provided information on their age cohort, whether children were present in the household, and levels of satisfaction. Results revealed that retirees and customers 65 years of age and older were less satisfied with the APS and were less likely to recommend to a friend or purchase additional units; households with children, by contrast, were significantly more likely to show interest in these devices, and more accepting of the technology than were households without children present.

Based on the information we were able to receive from staff interviews with SDG&E personnel, the data collection process associated with evaluating the ET was challenging. This was related to two key factors. First, there were only two manufacturers of this product, and there were reported disagreements among the manufacturers regarding the energy savings properties between the two products. Second, and related to the customer resistance issues noted above, installations that were disabled or removed by participants in the field-testing studies made it challenging to assess an accurate EUL of the product. For this reason, a low EUL was assigned by the CPUC to reflect the low persistence. In other comments provided by staff, it was indicated that each time a new power strip model was introduced by a manufacturer, it had to be tested through an independent lab with UC Irvine per field-testing requirements. Testing costs were high and

[27] CalTF. Tier 2 Advanced Power Strip (APS) Presentation. See http://www.caltf.org/s/2016-01-25-Tier-2-Residential-APS-Cal-TF-Workpaper-Presentation-DRAFT-no-Appendicies-n7w9.pptx

difficult to justify, given the level of savings the device offered. As one interviewee shared, "In retrospect, given the cost, time and effort required to manage the study, the [Tier 2 Advanced Power Strip] was not able to deliver the necessary savings to be cost-effective as a direct install measure." The interviewee went on to indicate that the proliferation of online content and growing adoption of "Smart TVs" have made the Tier 2 Advanced Power Strip obsolete.

As noted above, no information was available associated with marketing efforts related to the ET time period under study (2016–2017), either because staff were no longer employed or those who were interviewed could not speak to this question with any authority. Staff did note that, under the third-party implementer model currently in place, the implementers conduct marketing and outreach in collaboration and with the review of the IOU, in coordination with the internal (IOU) marketing team.

Market Adoption

One clear barrier to market adoption of this technology, as indicated above, was the lack of acceptance among consumers, as revealed in the field-testing study follow-up primary research. Based on comments received from staff, there were several additional barriers that impacted this technology, including:

- A barrier to adoption was the **technological shift** consumers experienced during this period. Many consumers were transitioning to streaming services (e.g., Netflix, Amazon Prime), and as a result, decreased their use of plug-in devices such as DVD players that the Tier 2 APS targeted.[28] Based on staff interviews, consumers are also using their phones a lot more for entertainment or using tablets and similar devices, which has obviated the need for this type of technology to some extent.
- The **inability to accommodate smart TVs and gaming consoles** was another barrier, which was unappealing for consumers as those devices were also gaining a foothold in the marketplace.[28]
- **Issues with the technology itself** also contributed to barriers to adoption. For instance, if a TV wasn't actively on, the Tier 2 APS would turn it off and, in some cases, perform a factory reset on the TVs, which contributed to consumer dissatisfaction with the device and (per the research provided above) resulted in them removing the device.

There were also challenges from a program perspective. It was challenging for the IOU to validate savings because they weren't sure if consumers had the Tier 2 APS plugged in or not unless they physically checked and validated. In addition, as indicated above, the IOU was managing two manufacturers who generally were not aligned with regard to the energy-saving capabilities of these devices, which created challenges for the IOU regarding the data collection process associated with measure development.

Considerations

- It is important to engage with manufacturers and, if possible, ensure a mutual understanding of the energy-saving capabilities of Tier 2 APS, as this was indicated as something that impacted measure development.
- While it is true that field testing studies were conducted for this technology, it is also true that there were significant issues related to how these devices were operating in situ and that these issues ultimately contributed to measure retirement. Participant process evaluations should be a common component within field testing studies (as applicable) to ensure issues such as these are addressed before additional investments are made into a particular technology.
- All four major IOUs operating in California have an ET program that involves the assessment and evaluation of potential energy-saving technologies. All of them have core components related to market assessment and a broader consideration of the industry context. To the extent each of these programs has a stage-gate process that would consider technologies at each stage of development, consideration should be made to establish clear

[28] Provided by SDG&E in responses to the CPUC data request in March 2023.

criteria associated with passing each stage of development. Based on the reflection of staff, perhaps this technology might have been retired sooner—a clear stage-gate process with metrics informing a go/no-go decision would have been beneficial in this context.

SMART/CONNECTED TIER 2 POWER STRIP

Technology Background

The Tier 2 Advanced Smart Connected Power Strip ("Advanced Connected Power Strip"), shown in Figure 4, is an example of a plug-load technology that seeks to address a growing problem contributed to by the proliferation of electronic devices. Specifically, the problem is the power consumed by an electronic device in *standby* or *OFF* mode, also referred to in the literature as "vampire load." Standby power represents electricity that is consumed by devices when they are turned off or not performing their primary functions. According to research provided by Lawrence Berkely National Laboratory, estimates of the contribution of this component of plug-load devices range from 5% to 10% of residential electricity use.[29] While this consumption is not isolated to residential settings (most office environments also contend with this issue), the specific measure described here is only eligible within residential buildings.

Figure 4. An image of the Tier 2 Advanced Smart Connected Power Strips[30]

This measure is differentiated from a "Tier 1" advanced power strip as the Tier 2 model includes either an infrared or motion sensor that detects if electronics are not being used, and the power strip turns the device it is controlling off. The measure also has a wireless communication feature that customers can leverage to better understand and manage energy use, in addition to providing several consumer and utility program implementation benefits compared to a non-communicating Tier 2 advanced power strip.[30] In the initial workpaper covering this technology developed by Southern California Edison, these benefits included validating device installations wirelessly (relevant to direct install program strategies); collecting device power, energy usage and savings data (approved through opt-in); providing households with energy data on commonly used household electronic equipment; and engaging households through two-way direct messaging via the smart device application, in order to recommend energy-efficient monitoring products and service solutions. Given these products are essentially identical to the Tier 2 APS covered in another case study, the energy-savings reduction is the same, approximately 50% less than the standard efficiency model (or base case).

Key Findings

1. The factory reset experience customers faced, as described in the Tier 2 APS case study,[31] negatively impacted the potential success of this device. Additionally, customers had privacy concerns associated with the communication functionality.
2. The cost of the device was high relative to common power strips, and it was a challenge for customers to feel inclined to purchase them without significant value propositions.
3. Further exacerbating these negative impacts, the total resource cost (TRC) test result for this measure was well below 1.0, leading to the decision to discontinue this measure.

[29] Standby Power, see Home | Standby Power (lbl.gov)
[30] eTRM. Measure Characterization: Smart Connected Power Strip. Version SWAP010-01. See Smart Connected Power Strip | ETRM (caetrm.com).
[31] Related to instances where the power strip powered off and caused the equivalent of a factory reset of connected televisions.

Process and Program Strategy

Interviewed IOU staff mentioned only one study specific to this technology, which was an ET report involving a field evaluation.[32] While the primary goal of that study was to determine the energy savings and demand reduction in situ, the report did speak to market characterization of this technology and potential barriers to adoption. The report noted that these devices are "well suited to many environments," essentially anywhere A/V or PC systems are installed.[33] This includes residential settings where home entertainment systems are found or in-home office settings, while commercial office buildings, schools, dormitories, or hotels would represent commercial opportunities. The report goes on to note that the market for this technology is large, and viable settings would include single-family residences, multi-family residences, and small commercial operations. IOU staff did indicate that they do typically receive customer feedback (as a result of field-testing studies or from active participants) and use this information to identify opportunities for improvement.

The delivery channel employed was direct install. The primary strategy associated with marketing as deployed by implementers included door-to-door canvassing, identifying homes by climate zone with the greatest energy-savings potential, and notices (door hangers) left behind at residences where no one was present. Implementer vehicles were co-branded with utility markings, raising awareness in the neighborhood and increasing word-of-mouth advertising, according to staff interviewed.

Market Adoption

As indicated in the ET report previously cited, while these devices are matured technologies present in global locations, the market penetration remains small, and IOU staff mentioned a number of barriers, some of which were specific to the field testing conducted when this technology was in its ET phase. A few barriers that staff mentioned, which are general to the technology overall, include the following:

- The **cost** of the product was relatively high for customers, at over $100 per unit compared to $20 for a regular power strip.[34] According to staff, customers were not willing to adopt the technology if the incentive provided was not enough to offset the cost more significantly.
- **Customer resistance** to these devices was indicated in the ET report, as the use of a typical power strip (devoid of sensing or communicating technologies) is a more common, engrained practice difficult to dislodge without significant value propositions for the typical resident.
- The extent to which this technology **may impede the normal use of connected devices** such as entertainment centers or PCs is also identified as a barrier to adoption. The field evaluation revealed that when the power strip turned off, it would perform the equivalent of a factory reset, leading some customers to disconnect the power strip entirely. This situation impacted customer satisfaction and contributed to uncertainty regarding persistence point that also underlined the specific use of these devices during field evaluation. This issue impacted the viability of this measure along with the previous measure related to Tier 2 APS (non-communicating).

Other comments provided by staff that characterized their experience with this technology also indicated that cost-effectiveness was an issue and contributed to the decision to discontinue the measure. The exact TRC for this item was well below 1.0, which was not offset by significant savings.

Considerations

[32] San Diego Gas & Electric, Emerging Technologies Program, Technology Assessment Report, Project IDs ET14SDG8021 & ET14SDG8031. Prepared by M M Valmiki and Antonio Corradini, PE, Alternative Energy Systems Consulting, Inc. Published April 2015. See Tier 2 Advanced Power Strips in Residential and Commercial Applications (caetrm.com).

[33] A/V stands for Audio/Video, in general referring to a residential entertainment system.

[34] Current pricing indicates an average of approximately $80, less than the $100 cited by IOU staff, but still high relative to a common-use power strip.

- Considerations associated with this technology would be identical to those provided above for Tier 2 APS, including the identification of these customer experience issues early in the process to either address or decide to discontinue sooner.
- While cost-effectiveness is and should be, a primary metric by which to compare measures/technologies and ensure a fiduciary use of funds, staff did indicate that, in some cases, reliance on cost-effectiveness may preclude the inclusion of technologies that might still benefit the program.

TUB SPOUT/THERMOSTATIC SHUT-OFF SHOWERHEAD

Technology Background

In addition to most technologies covered in this report, which focus on energy savings (either therms or kilowatt-hours), the technology covered in this case study is a water-saving measure that also contributes to energy savings. More commonly known in California as" embedded energy savings," this concept revolves around the fact that energy is required to extract, pump, and deliver water for domestic uses and to treat wastewater so it can be safely returned to the environment.[35] The measure/technology covered here, officially termed Diverting Tub Spout with Thermostatic Shutoff Valve (TSV), Residential, is a replacement for tub spouts and showerheads in residential dwellings with a shower-bathtub combination.[36]

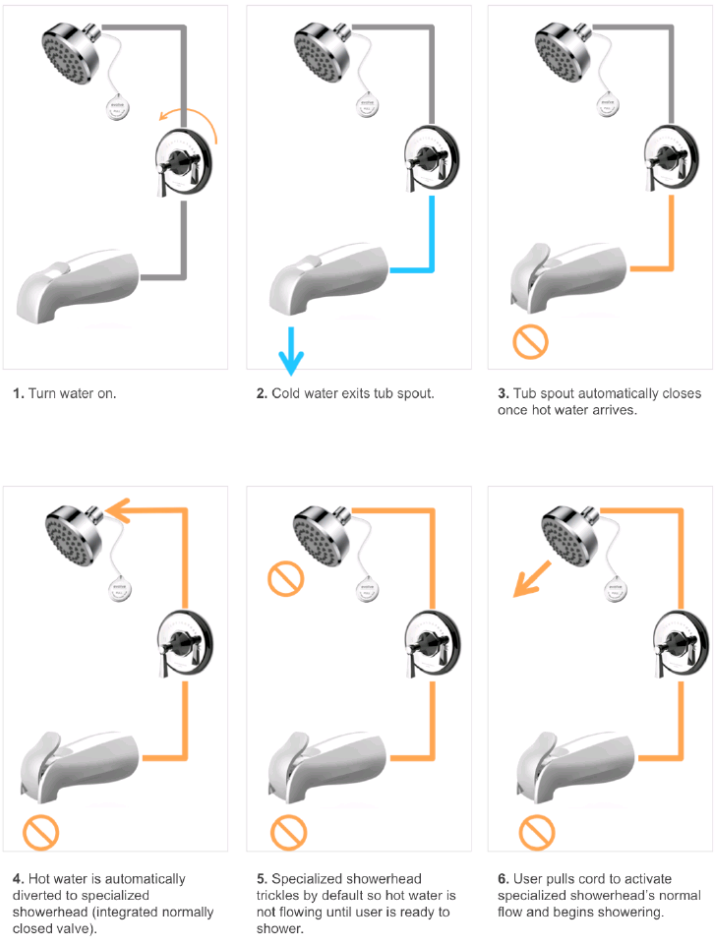

Figure 6. Diverting Tub Spout with TSV, Residential[36]

The energy-saving functionality of this measure uses an automatic thermostatic shutoff when the water reaches a certain temperature so that it can cut off water flow to save water and, by extension, energy by not allowing unused hot water to go down the drain (Figure 6). It is applicable in instances where there is a showerhead/bathtub combination unit but not applicable for bathtubs or standalone showers. The technology has been on the market since 2017.[37]

The Southern California Gas Company (SCG) funded the ET study ET16SCG0011 in 2016 to establish and evaluate the energy and cost savings associated with this technology. The initial measure approval date was January 1, 2020 (under version SWWH023-01). According to interviews with IOU staff, both measures (including the tub spout *and* showerhead) are still active measures in the residential measure mix. However, both of these measures are not being promoted as no major retail outlets (e.g., Home Depot, Lowe's) offer these units at the time of publication of this report. Additionally, staff indicates that several years ago, these measures were offered via Marketplace and that they are deliberating to offer these via the Marketplace platform administered by Enervee moving forward.[38] Staff did confirm that these measures are still active.

Key Findings

1. IOU staff indicated that the energy savings claims provided by the manufacturer could not be independently verified, and no specific reports were offered to provide evidence of energy savings; in addition to quality issues, this caused delays in the measure development phase.

[35] SBW Consulting, Inc. Prepared for California Public Utility Commission. Water-Energy Calculator 2.0 Project Report, Published February 22, 2022. See Water-Energy Calculator 2.0 Project Report.

[36] eTRM. Measure Characterization: Diverting Tub Spout with TSV, Residential. Version SWWH023-02. See https://www.caetrm.com/measure/SWWH023/02/

[37] Based on a response to a CPUC Data request in March 2023.

[38] See Enervee's Marketplace for Utilities.

2. Manufacturer limitations have been placed on exactly how the measure could be marketed; such inflexibility appears to have had a deleterious effect on the success of this measure.
3. A primary barrier mentioned by staff that limited the success of this technology is a lack of customer understanding of exactly how this measure operates. While staff did not conduct any primary research to investigate this barrier, they believed the inability to clearly explain the functionality may have contributed to limiting adoption.

Process and Program Strategy

IOU staff who were involved in the development of workpapers (now measure packages) at the time this technology was part of ETP indicated through interviews that the IOU does conduct market research to inform their program planning and strategy, but this is not product-specific. Typically, staff rely on information provided by the manufacturer as these entities tend to be more integrated into the market and can provide insights into customer behavior and preferences that can assist program planning. The IOU staff interviewed for this report did indicate that they utilize and assess customer feedback from their call center to better understand customer preferences as they relate to program delivery.

Regarding the data collection process associated with workpaper development at the time this measure was in the ET phase, IOU staff indicated that there were some differences between what the measure was expected to save, based on information provided by the manufacturer, and what was established in the development of the measure package. There were some manufacturing quality issues revealed in field testing that were subsequently addressed. The manufacturer did not provide any "quality studies" to corroborate their energy savings claims. To address this, SCG performed on-site field measurements of the hot water set point, actual flow, and the actual duration until the valve activated. According to the measure package, data collection requirements include information such as the manufacturer and model number, flow rate (gpm), building location, building type, and water heater fuel type.

Marketing strategies associated with this technology were primarily driven by raising awareness when the technology was initially offered as a "giveaway" item back in 2010. This strategy was employed simply to drive awareness about the technology. IOU staff indicated that the promotion of the technology beyond 2010 on customer bill inserts and the IOU webpage were effective strategies. Other effective channels indicated by staff included the provision of instant rebates through point-of-sale at big box stores, mail-in rebates, and direct installs. Adoption uptake, according to staff interviews, was driven by the availability of this product through Costco, which contributed to the successful promotion of the technology during the 2017–2018 timeframe. Once Costco stopped offering the technology, staff indicated adoption and uptake of the measure "fizzed out." Since 2020, the measure has not been actively promoted on the retail side, and if the IOU wanted to promote the measure, they would likely need to promote the measure as a new product. One barrier mentioned that tempered promotion of the tub spout (as a separate component) is the fact that the existing supply pipe connected to the tub spout may need to be cut,[39] which explains why the technology is only offered through direct installs.

Market Adoption

In interviews with relevant staff associated with this technology, they indicated that there were a few drivers and some significant barriers that contributed to the (lack of) adoption of this measure. In terms of drivers, which may not offset the barriers, staff mentioned the placement of this product within point-of-sale locations such as Home Depot or Lowe's increased the accessibility of the product. Also, establishing the measure deployment through a direct install program increased the adoption based on customer eligibility.

That said, staff also indicated some significant barriers to adoption that tempered the success of this measure. As indicated above, and perhaps a less significant barrier, the potential need for cutting the supply line to a particular size

[39] Evolve Technologies, LLC. See EV3746 User Guide - WDTS +TSV3 (thdstatic.com).

for fitting the tub spout component was also mentioned as a potential barrier. The following describes the more significant barriers in more detail:

- **Customer understanding** of the product was one area mentioned by staff that made the adoption and uptake of this technology more difficult. For adoption to take place, the customer needs to understand exactly how the technology works; it was unclear to staff the extent to which the functionality of the technology was explained in clear terms to customers.
- **Manufacturer limitations** also appear to have contributed to limiting the adoption of the measure, and this was primarily due to the manufacturer prescribing how the product would be marketed within the retailer space. This inflexibility, according to staff, contributed to retailers deciding not to move forward with the promotion of this product. To a lesser extent, the IOU staff interviewed also indicated that they were limited in the delivery channels to use, and this was cited as a barrier as well.

Considerations

- Leverage utility expectations with manufacturers in an attempt to collaborate and coordinate marketing efforts, as the inflexibility of the manufacturer appears to have contributed to the lack of success of this measure (at least in terms of availability through retail channels). If utility personnel can clarify the benefit of inclusion in EE programs to manufacturers, it might lead them to compromise. Consider, in potentially re-launching this measure, expanding customer education efforts through the use of short descriptions (ideally, with visual elements) and/or videos to illustrate live how the technology works or ensure the operation of the device and its benefits are explained at the point of installation.
- In developing emerging technologies, particularly with regard to early-stage product designs, an area of focus should be on the ability of a customer to “self-install” energy-efficient measures, while a less significant barrier, attempting to arrive at a product design that would eliminate the need to cut the supply line would contribute to higher rates of adoption.

AG VENTILATION FAN VARIABLE SPEED DRIVE

Technology Background

The Agricultural Ventilation Fan Variable Speed Drive ("Ag VSD") is a relatively new technology, the use case of which is centered on agricultural operations, specifically within dairy farms.[40] Dairy farms require barn ventilation fans (Figure 7) to keep livestock cool to relieve conditions of heat stress, typically used in tandem with water sprayers to enhance evaporative cooling. Given airflow demand in these instances is variable and highly dependent on outside air temperature, the condition of fan speed running at 100% is not always required, opening the opportunity to save energy using a variable speed drive (VSD). A VSD allows the fan to operate at a reduced speed to match the demand. Usually, there are outdoor mounted temperature sensors in the system that send control signals to the VSD. This technology has been successful, as it is one of the more popular measures in the Agriculture Energy Savings Action Plan program.

Figure 7. Agricultural Fans with VSD

According to the most recent measure package associated with this technology, "The VSD saves energy due to the cubic nature of the fan affinity laws.[41] In an ideal system, fan power is proportional to the cube of the fan speed, e.g., operating at half speed theoretically requires only one-eighth of the power draw than operating at full speed." VSD applications will modulate the fan speed from 25% to 100% in a linear fashion, from 68°F to 90°F, at which point the fan speed will operate continuously at 100%, as indicated graphically in Figure 8.[42] The initial work associated with evaluating the energy and cost savings was based on an ET report funded by Pacific Gas & Electric.[43] Interviews with relevant staff members revealed that this measure was generally successful, though a number noted the cost hurdles that customers face in adopting this technology.

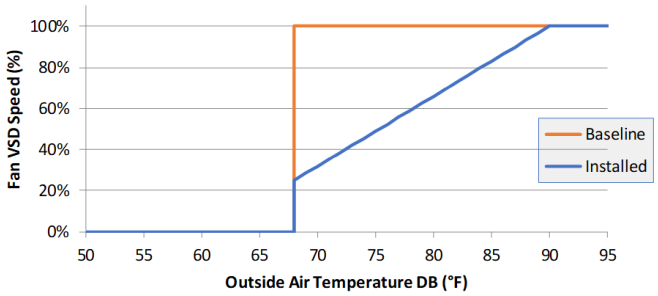

Figure 8. Livestock Barn Fan VSD Profile[40]

Key Findings

1. The Ag VSD Fan is one of the more popular measures in the Agriculture Energy Savings Action Plan Program. As the climate changes and temperatures continue to rise, demand for this product may increase in the future.
2. The IOU and the implementer's marketing approach focus on a one-on-one approach with customers, as farmers prefer in-person interaction, and other marketing channels haven't been effective.

[40] Technology summary based on eTRM. Measure Characterization: VSD for Ventilation Fan, Agricultural. Version SWPR006-02. See VSD for Ventilation Fan, Agricultural | ETRM (caetrm.com).

[41] Generally referred to as a set of three laws that represent a group of equations for determining the effects of a change in the speed, the diameter of the fan and the density of air in the system; in short, they are used to express the relationship between fan performance and power. See Understanding the Basic Fan Laws | Axair Fans UK (axair-fans.co.uk).

[42] Source: eTRM. Op. cit.,

[43] Emerging Technology Project ET17PGE8181

3. The high upfront cost of Ag VSD was a barrier to customer adoption. The IOU implemented financing options and customized incentives to increase adoption among customers.

Process and Program Strategy

Research into market characterization relevant to this technology was relatively limited based on information provided by staff, at least in terms of primary research with those overseeing agricultural operations and potential barriers to adoption. PG&E, the IOU most involved in this effort, conducted secondary research and developed impact evaluation results that certainly informed the level of knowledge about the customer segment and the potential value propositions of this technology, according to one interviewee. A fair amount of data that informed the development of the workpaper (and subsequent measure package) are based on twelve custom projects involving this technology.[44] The utility did conduct surveys with customers within this segment, which are reviewed monthly, though this is a process that is conducted across all technologies and was not specific to this particular measure.

In terms of data collection undertaken at the time this measure was in workpaper development, IOU program staff indicated they had relatively little input into this process. One staff member did indicate that, at times, the lack of information on market size or when no available information is available (through desk research) can create challenges for workpaper or measure development, and a modicum of "base data" made available to program administrators that CPUC might address would be a positive development.

The main marketing strategy for Ag VSD is in-person interaction with this customer segment. The IOU found that this was the best way to market and communicate with these customers, primarily via email, as this is the customer segment's preferred means of communication. There are account managers out in the field who directly interact with these customers to promote the program, armed with program pamphlets that help to raise general awareness. Another marketing method is the IOU's articles that discuss the Ag program and highlight popular technologies, including the Ag VSD. Word of mouth within this customer segment is a key component of this offering and has also helped increase awareness of this technology. Today, the implementer does most of the marketing, and the IOU shared that, based on interviews with staff, their methods have been successful.

Collaboration Efforts

Prior to the statewide model, there was limited collaboration and no formal communication between the ETP and the program team. One exception is when the ETP team wants to make a change to a measure package, and they do advise the program staff. For this technology specifically, the ETP team had the most collaboration with the IOU's business and customer-facing roles, especially to secure data from customers and information on current operations.

Currently, there is moderate collaboration between the implementer and the IOU staff. The implementer will attend weekly meetings with the IOU to propose new technology. The implementer will run it by the appropriate staff, and they also fill out a template that the IOU engineering staff reviews, which can assist in facilitating and expediting the review process. It was also noted that there are joint meetings (focused across technologies) between program staff, ET staff, and relevant sales staff. Topics of discussion in these meetings include how programs are performing, sales and participation objectives, updates on measure packages, and any action items needed from the ET team.

Market Adoption

The biggest barrier this technology faces is upfront costs;[45] it is especially challenging in the dairy sector because these farmers have been struggling financially for some time, according to interviews with utility staff. The IOU developed a

[44] Key data associated with these twelve projects provided as part of the measure package available via download through eTRM at VSD for Ventilation Fan, Agricultural | ETRM (caetrm.com).

[45] According to one of the reference files provided in the measure package (reference-documents-swpr006-02_calc_summary_by_cz_8-31-22), the range in costs of the equipment was between $4,500 and $46,200 (rounded) based on the 12 projects that informed much of the measure package. On a per horsepower basis, the cost analysis indicated a material cost of $276.32 and a labor cost of $144.06.

financing option to allow customers to take out a loan to pay for this technology. It has helped overcome the barrier of high upfront costs and increased uptake. In the present-day statewide model, implementers can now customize incentives based on the customer's needs; this addresses the barrier of high cost and has been helping customers.

The warming climate will have a significant impact on dairy farms and increase the need for these fans. As one interviewee put it, [the warming climate] has had a large impact on the cows, as unhealthy cows are less likely to produce milk or produce less quality milk. At some point, adoption may eventually hit saturation in the market, and this technology has been a popular measure. The Ag program's detailed and sophisticated marketing approach has increased awareness of this technology to the customer segment, according to staff interviews.

The unique marketing approach might be combined with additional operational components of this effort to explain increasing adoption and why this item is one of the more popular ones within the Agricultural offering, according to comments from IOU staff. In addition to the detailed and sophisticated marketing approach, collateral for this program is collaborated upon between multiple functions (program, marketing, implementation contractor); for instance, work occurs on a periodic basis to develop materials for raising awareness and educating customers. Articles are developed by the utility to present the Agricultural program offerings and highlight popular technologies. Case study pamphlets on specific technologies are developed and provided to account managers for distribution in the field during in-person interactions, which the utility indicated is the preferred means of interactions among customers.

Considerations

- IOU staff recommend that measure packages address new California needs, for example, electrification requirements. There is a substantial amount of new existing ET that can be incorporated into the program, even if they are non-traditional to energy efficiency. IOU staff also indicated the critical need to have an emphasis on environmental and sustainable measures. This emphasis can help California meet its goals.
- One takeaway from our research into this specific technology is the positive impacts that the marketing approach has had on the apparent success of this technology; the consideration is not about the technology itself but rather the specific approach to marketing. Based on conversations with staff, this approach was informed through a data-driven process that indicated in-person interactions would be most preferred by customers, with the distribution of educational marketing leveraging this approach and contributing to the success of this measure.
- One item to consider based on information gathered for this case study involves simplifying the process of adding additional items to the measure package without the need to go through the whole process. For instance, comments provided by staff indicated that there was a decision made to add a larger fan size, and faced with going through the entire measure development process for this, ultimately tabled that decision. Simplifying the process for variations or adaptions of measures that do not impact results substantially (which would trigger a new measure) should be considered.
- Another recommendation is to integrate the measure packages that have different components of a technology into one single measure package. For example, there can be three to four measures for one single type of technology, such as one measure for the motor and another measure for the control. Many deem measures focus on one single element of a technology instead of the entire system of the product. It would save time and financial resources if these components of a technology could be combined into one measure package.

HIGH EFFICIENCY ULTRA LOW TEMPERATURE FREEZER

Technology Background

Ultra-Low Temperature Freezers (ULT Freezers), as shown in Figure 9[46], have a typical temperature setpoint of approximately -80°C, which explains why many of these freezers are commonly referred to as "minus eighties." They are used in a wide range of life science research applications to maintain the integrity of samples and reagents for long periods of time.[47] The COVID-19 pandemic recently focused attention on ULT Freezers, as the COVID-19 vaccines produced by Pfizer-BioNTech and Moderna both require cold storage at a temperature between -60°C and -80°C (with some exceptions).

Figure 9. Ultra-Low Temperature Freezer[46]

According to the technology summary of the latest version measure package, ULT Freezers were introduced to the market in the 1970s, with two more recent advances in the technology occurring since 2010. Prior to 2010, the most common technology was referred to as a cascade compressor, which utilizes two compressors in a cascading arrangement with two stages. One compressor cooling loop operates between ambient and intermediate temperature, and the second operates between the intermediate temperature and the freezer cabinet.[48] Stirling Ultracold, a key market supplier, introduced a new technological innovation, developing a freezer that used no compressors; rather, the cooling system at the center of this technology is a combination of an electrically driven free-piston Stirling engine, which provides the cooling, and a thermosiphon transporting energy from the interior of the freezer to the Stirling engine.[49] In 2016, Thermo Fisher Scientific introduced a freezer technology called the "V-drive," which allows the compressor and condenser fans to run at variable speeds in response to the varying cooling load.[50]

As an ET endeavor, ULT freezers were offered by the three primary IOUs in California, and rebates are still offered. In the ET report that accompanies the latest measure package, it was reported that "energy-efficient ULT freezers exhibited temperature performance that was comparable to, and in some cases better than, their standard efficiency peers, while consuming at least 25%, and in some cases up to 70%, less energy."[51] According to information provided in the latest measure package assessing the direct energy unit savings of high-efficiency units compared to standard efficiency units, the average kWh/ft^2/day was 0.45 and 0.84, respectively, nearly double in the case of standard efficiency units. ENERGY STAR standards were published in May 2017,[52] and according to the latest measure package (approved in 2022), this standard is based on the same data presented in the ET study.[51] The incremental cost of an energy-efficient

[46] PG&E's Emerging Technologies Program, Ultra-Low Temperature Freezers: Opening the Door to Energy Savings in Laboratories Report, August 31, 2016

[47] eTRM. Measure Characterization: Ultra-Low Temperature Freezer. Version SWCR017-03. See Ultra-Low Temperature Freezer | ETRM (caetrm.com). Eligible building types include Universities, Hospitals, and Pharmaceutical and Biotech facilities.

[48] Stirling Ultracold. Ultra-Low Temperature Free-Piston Stirling Engine Freezers, October 11, 2013. See Lane_2013_10354-GLOBAL-whitepaper-apr13-vF-web.pdf (caetrm.com), page 2.

[49] Simply put, a thermosiphon (also referred to as thermosyphon) is a passive method of heat transfer.

[50] eTRM. Op.cit.

[51] Center for Energy Efficient Laboratories (CEEL). Ultra-Low Temperature Freezers: Opening the Door to Energy Savings in Laboratories. Issued August 31, 2016. See PGE Emerging Technologies (caetrm.com), page 18.

[52] ENERGY STAR Program Requirements for Laboratory Grade Refrigerators and Freezers. Eligibility Criteria Version 1.1. Effective on December 21, 2016. See ENERGY STAR V1.1 Lab Grade Refrigerator and Freezer Program Requirements (caetrm.com).

model, according to a previous study, ranges from $1,000 to $3,000 more than a standard model. Current rebate amounts range from $300 (for 15–24 cubic feet) to $600 (for 24–29 cubic feet).[53]

Key Findings

1. The relative success of this technology, with some exceptions, is the result of considerable research into the customer segment and customer preferences coupled with a comprehensive marketing approach that leveraged in-person interaction, educational marketing, and sales staff having a deep understanding of the technological features and energy-saving properties.
2. Academic institutions and laboratories are the primary customer segments, resulting in a niche market where account executives play a large role in developing customer relations and promoting the product.
3. The primary barrier associated with this measure is the cost, as these can range from $12,000 to $18,000.

Process and Program Strategy

There were two key reports that informed the development of the original ULT Freezer workpaper, which focused on establishing the market characterization and assessment. This includes the previously cited report "Ultra-Low Temperature Freezers: Opening the Door to Energy Savings in the Laboratories" (published in August 2016) and a broader market assessment report entitled "Market Assessment of Energy Efficiency Opportunities in Laboratories" (published in March 2015). This latter report was part of a larger effort to establish the statewide Center of Energy Efficient Laboratories (CEEL), with the stated goal "to benefit the Investor-Owned Utilities, their customers with laboratories, laboratory equipment manufacturers, and those industry stakeholders involved with laboratory efficiency projects and program."[54] Both reports provided a wealth of information related to market characterization as well as identifying the most significant savings opportunities for IOUs.

The original workpaper established for this technology references both reports in the market assessment section,[55] incorporating information associated with the product distribution of this technology within California, reasons for purchase (replacement or expansion), key data on product testing, and willingness to pay premiums for more efficient equipment. As indicated in the market assessment report and corroborated through staff interviews,[56] one of the primary challenges early in the process involved a proper establishment of the baseline:

> *"Laboratory end-users and equipment manufacturers have overwhelmingly acknowledged the need for baseline studies, third-party testing to objectively measure equipment performance against that baseline, financial incentives, and technical support to motivate a paradigm shift to greater energy efficiency in labs."*

The ET report compared this situation with other household appliances in that some energy certification (such as ENERGY STAR) or other energy efficiency program will "take the guesswork out of these calculations and allow buyers to make thoughtful justifications of more expensive purchases in the name of well-defined and predictable future savings."[57] Developing such an energy-efficient certification does appear to influence the decision to purchase energy-efficient products, as 65% of academic labs in California indicated they consider energy efficiency when purchasing a new ULT freezer. Non-academic labs indicated a lower percentage associated with considering energy efficiency (53%), and a high percentage (20%) indicated they did not know or were not involved in purchase decisions, as purchases in

[53] Esource. "Refrigerating COVID-19 vaccines with ultralow temperature freezers", March 1, 2021. See Refrigerating COVID-19 vaccines with ultralow temperature freezers (esource.com).
[54] Center for Energy Efficient Laboratories, My Green Lab. Market Assessment of Energy Efficient Opportunities in Laboratories. Issued March 12, 2015. See Market Assessment of Energy Efficiency Opportunities in Laboratories (etcc-ca.com).
[55] Work Paper PGECOREF130 ULT Freezers, Revision #0, Pacific Gas & Electric Company (Measure Codes RF006 and RF007), Published August 7, 2017. Corresponding workpapers established by other IOUs include SCE17RN029-R0 and WPSDGENRRN0016-R0.
[56] Center for Energy Efficient Laboratories, My Green Lab. Market Assessment of Energy Efficient Opportunities in Laboratories. Op. Cit., page 2.
[57] Center for Energy Efficient Laboratories (CEEL). Ultra-Low Temperature Freezers: Opening the Door to Energy Savings in Laboratories. Op. Cit., page 106.

those settings are more centralized. According to staff who could speak to this prior research, they believed it was sufficient to inform the program and process strategy.

Marketing efforts in 2016–2017 associated with this technology were focused on direct customer contact through key account managers, as the initial delivery mechanism was a downstream rebate. Specific marketing activities included face-to-face interaction with purchase decision-makers, webinars executed with account representatives to provide key details about the technology and tactics to raise awareness, and information disseminated to trade professionals. The marketing approach also required a good understanding of manufacturers and their specific products, as there was a variety of technological features and energy savings properties. In the present day, to the extent staff could speak to this, there was less clarity around the exact marketing strategies being employed by the third-party implementer.

Collaboration Efforts

In the context of the 2016–2017 period, interviews with IOU staff at one utility indicated that the ETP team would work closely with the account managers related to this technology, particularly because it was a downstream measure. One IOU indicated they did not have much inter-utility collaboration as this was a local measure at that time. It is clear, based on the publication of both the ET report and the supplemental market study, that all three primary electric IOUs were involved and the most relevant audiences for these reports. More generally, outside of this technology, staff indicated that there was consistent collaboration associated with ET. Project managers (program side) would often reach out to the ETP to discuss extending existing measures, though the program team would only be informed about early-stage upcoming technologies once the workpaper was completed and readied for transfer (hand-off).

In the present day, with some exceptions, the primary response from IOU staff was that many of the actions associated with the ET process are now under the purview of the third-party implementer. Comments from staff indicate that while there is collaboration with the implementers (one indicated meeting with the implementer weekly), staff believes these entities have subject matter experts and "a good grasp" on the market. This would suggest a positive outcome in that third-party experts may be in a better position to successfully inform strategies based on a deeper understanding of market characterization and customer preferences. That said, a challenge with the transition to the third-party implementer model, according to one interviewee, is the transition of legacy programs, particularly since internal subject matter experts at an IOU may have retired, representing the loss of institutional knowledge, and may jeopardize the continuity of these legacy programs.

Market Adoption

According to the current measure package, there are an estimated 58,000 ULT freezers in California that consume an estimated 400 million kWh/year. It appears this is the most recent estimate established, which is based on the previously cited report published in 2015. According to interviews with IOU staff, there are two primary barriers associated with increasing market adoption:

- Rebates provided by the utilities may not have been enticing enough to customers as the **incremental cost** of these units does not offset the cost of the freezers. Recent research suggests these units can range between $12,000 and $18,000,[58] with the ET study indicating an incremental cost between $1,000 and $3,000. National data presented in the ET report indicated that, among potential purchasers of this equipment, price was universally acknowledged as the most important factor considered, making this barrier particularly important.[59] According to one interviewee, a "kicker" (or additional) incentive was offered at one point to address the high cost,

[58] Esource. Op. Cit.

[59] Center for Energy Efficient Laboratories (CEEL). Ultra-Low Temperatgure Freezers: Opening the Door to Energy Savings in Laboratories. Op. Cit., page 135. Other considerations following prices (among all responses nationally) include capacity, temperature range, legacy/brand reputation, and energy efficient properties, rounding out the top 5.

but only a "handful of claims" resulted, and this individual speculated that either the additional amount was not enough or may not have been marketed effectively.

- Another barrier mentioned during staff interviews referenced the challenges with **split incentives**. Split incentives occur when two parties have opposing interests, and, according to the interviewee, this was most relevant within academic settings. Within this specific context, the individual researcher has an incentive to purchase the least expensive freezer possible to preserve research dollars for other items. However, they do not pay directly for the operational costs of the unit (as these are managed by the university). The university, on the other hand, would prefer to minimize operational costs but may not have control over the specific freezer model chosen. Split incentives are more often cited among instances in owner/tenant agreements, though this situation within academic labs indicates a similar outcome and resultant challenge. The interviewee went on to indicate that overcoming this can sometimes include the sharing of an efficiency incentive and working with large customers/accounts to develop minimum efficiency guidance.

Additional barriers mentioned during staff interviews also included the fact that, at a very early stage of operation, there was no ENERGY STAR certification. Certification for certain units did become effective in late 2016, though it is not entirely clear whether products certified at that time also satisfied local California eligibility requirements. Minor barriers would include the fact that the market for this product is fairly limited, based on the very specific use cases, in addition to the difficulty of locating and interacting directly with those at institutions who make purchase decisions.

Based on staff interviews, drivers indicated are less likely to offset some of the key barriers listed above, particularly the cost (both gross and incremental) of this technology. Energy savings was typically mentioned as a driver. As indicated in this case study, these could range from 25% to 70% in comparison with the base case (standard efficiency). An additional driver is the high level of consumer choice due to the variety of manufacturers. That said, as indicated in the ET report, three of the manufacturer offerings encompassed more than 70% of ULT freezers.[60] Finally, staff did indicate that adoption of these more efficient freezers has been "steady," and they did not see the technology being discontinued. As indicated at the outset of this case study, while the COVID-19 pandemic drove demand for ULT freezers, there is no evidence to suggest this demand impacted high-efficiency units disproportionately; furthermore, supply chain issues also influenced by the pandemic seemed to offset this driver.

Considerations

- Based on comments provided by staff, there should be some consideration on reviewing the rules associated with the application of net-to-gross (NTG) values to ET measures. Currently, per the Statewide Deemed Workpaper Rulebook, after an ET measure has been offered in the marketplace by any program for more than two years, it is no longer an ET measure and can no longer be claimed as 0.85 [NTG Ratio] by anyone.[61]
- When developing products for a niche market or a smaller market size, considerations should be made in assessing whether enough savings claims would be potentially forthcoming to determine if the investment in time, effort, and resources is justified.
- Marketing efforts should assume a long timeline for decisions by sites where this technology could be used since the typical outlays for this equipment are quite large, and adoption may be impacted by engaging with customers early and often to intervene strategically in these timelines and increase the likelihood of adoption.

[60] Center for Energy Efficient Laboratories (CEEL). Ultra-Low Temperature Freezers: Opening the Door to Energy Savings in Laboratories. Op. Cit., page 258.

[61] See Statewide Deemed Workpaper Rulebook, Version 4.0. See Statewide Deemed Workpaper Rulebook (squarespace.com)

PHASE CHANGE MATERIALS FOR REFRIGERATION

Technology Background

Phase Change Materials for Refrigeration,[62] as described in this case study, involve two key components in an energy management strategy for commercial refrigeration and cold storage. The first component includes an ET entitled Phase Change Material (PCM) used in a refrigeration application (Figure 10)[63]. The second component of this technology includes a control component—a separate system that provides real-time monitoring capabilities to optimize the use of PCMs. This technology was recommended for inclusion in the resource program portfolio at SDG&E, but as this case study will attest, a variety of obstacles precluded its full incorporation.

Figure 10: Phase Change Material [63]

As indicated in the ET report corresponding to this measure,[64] this technology "uses Thermal Storage Cells (TSC) filled with a substance that has a melting point equivalent to the desired [refrigeration] temperature in order to store or release latent heat to achieve that temperature." PCMs are substances that change from one phase (solid, liquid, or gas) to another. When a PCM changes from a solid to a liquid, it absorbs and stores thermal energy from the surrounding space; when it changes from a liquid to a solid, it releases that energy back into the air. The primary benefit of this technology, from an energy efficiency perspective, is to reduce or shift the cooling load while maintaining a consistent temperature for commercial end-use operations.[65] PCMs can provide energy cost savings to the customer, improve the efficiency of the refrigeration system, extend equipment life, and reduce maintenance costs, according to a 2010 study that assessed such technology.[66]

The ET report commissioned by SDG&E provided results of the demonstration project, which evaluated the energy saving and potential demand response applications of the PCM and control system across two different walk-in freezers in SDG&E service territory.[67] This includes a mess hall located at Camp Pendleton (with a 301-square-foot walk-in freezer in a cafeteria kitchen) and the San Diego Food Bank, which has a large walk-in freezer warehouse of 3,419 square feet. Summary results of this study indicated that the annual kWh savings associated with both sites totaled approximately 59,000 kWh, with a demand response simulation exercise (at the Camp Pendleton site only) indicating a 1.89 kW load shed over a two-hour duration and a 1.72 kW load shed over a four-hour duration.[68] Financial analysis

[62] Referenced as Refrigeration Controls in CEDARS.

[63] Image of phase change material courtesy of Viking Cold Solutions, Inc., Houston, Texas, USA www.vikingcold.com ©2023

[64] Emerging Technology Project ET16SDG1061 and DR15SDGE0003. Phase Change Materials and Controls Study, Prepared for Emerging Technologies Program, SDG&E, Prepared by ASWB Engineering. Published October 20, 2016. Available through Emerging Technologies Coordinating Council (ETCC), see Phase Change Material and Controls Study for Low Temp Refrigeration Applications | ETCC (etcc-ca.com)

[65] Efficiency Vermont. Phase Change Materials in Refrigeration. Efficiency Vermont Research & Development Report. March 29, 2021. See Phase Change Materials in Refrigeration (efficiencyvermont.com).

[66] Tulapurkar, Chetan, Pradip Radhakrishnan Subramaniam, G. Thagamani, and Ramasamy Thiyagarajan, 2010. "Phase Change Materials for Domestic Refrigerators to Improve Food Quality and Prolong Compressor Off Time". Presented at the International Refrigeration and Air Conditioning Conference, Purdue University. See Phase Change Materials For Domestic Refrigerators To Improve Food Quality And Prolong Compressor Off Time (core.ac.uk).

[67] Emerging Technology Project ET16SDG1061 and DR15SDGE0003. Op. cit., page i.

[68] A 7-hour duration demand response test indicated that the refrigeration system was unable to remain offline for the full period as the freezer temperature rose too high and the controls overrode the DR signal to maintain temperature.

revealed a simple payback of 24.1 years for the Camp Pendleton site and 5.8 years at the San Diego Food Bank site. The study authors developed a projected simple payback under the assumption that costs for this equipment were to decline substantially, indicating a forecasted simple payback of 5.1 years and 2.0 years for Camp Pendleton and the food bank site, respectively. The report provides detailed results for both sites and concludes with its recommendation that the PCM (and controller technology facilitating demand response) be adopted into the EE program.

Despite that recommendation, and according to information provided in staff interviews, this technology was never incorporated into the resource portfolio, primarily due to reservations among IOU staff that the energy savings would be "claimable," in addition to the fact that the cost incurred by the IOU was capped at a certain amount, and approaching that cap influenced the decision to discontinue the effort. An additional reason was that implementing this technology required some disruption to the operational routines of the refrigerated warehouse and required the addition of management controls that reduced the appeal. Additional factors are described in the Market Adoption section below.

Key Findings

1. There was hesitation among stakeholders about whether refrigeration controls would have claimable energy savings, as it could not stand alone as an energy efficiency measure but was seen as more viable if combined with a demand response program; lack of statewide measure data also contributed to these challenges.
2. While the technology was in ETP, the IOU had already incurred immense time and financial resources to keep the technology in the process and move forward, which also contributed to this measure never being incorporated into the IOU portfolio.
3. Cost and customer acceptance are two market barriers that were known going into the development of the measure package.

Process and Program Strategy

Process and program strategy associated with this technology is less relevant in this case, given the fact that the technology never materialized as a measure available through any resource program. In terms of prior primary research that might inform program strategy, none were mentioned in interviews with IOU staff. Given the primary objective of the ET report was to evaluate the energy savings and demand response benefit, no information was collected by operational staff at the two sites to potentially inform how this technology might be incorporated into operational processes.

The report does state clearly that "there are no known major potential market barriers that may prevent the adoption of this technology."[69] Directly following this statement, the report notes two specific reasons that might decrease the appeal of this technology among end-user customers:[70]

- **Reluctance among some customers to try a new control strategy** if the types of products or materials being stored in their cold storage assets are expensive and temperature sensitive, which the report authors note was a barrier in recruiting test sites.
- **Reluctance associated with cost**, as corroborated by comments provided by IOU staff. The initial cost of this equipment is high (for instance, the implementation cost, net of any incentive, was $19,723 for the mess hall site and $47,039 for the food bank site).

Collaboration Efforts

Collaboration efforts associated with this technology were non-existent as a workpaper was never developed, and no plans were made to develop a program offering.

[69] Emerging Technology Project ET16SDG1061 and DR15SDGE0003. Op. cit., page 45.
[70] Ibid., page 45.

Market Adoption

Information related to market adoption as covered in these case studies, which typically involves information associated with market characterization efforts, data collection processes related to measure development or program strategy, and marketing efforts, was not relevant for this technology as the decision to table this opportunity obviated the need to execute any of those activities.

Considerations

- One component that would contribute to program success is having an ETP champion for the handoff between ETP and programs (in the present day, the IOU and the implementer). There is a need for a champion to step in once this technology is no longer an ET project to ensure the success of the technology. This champion would fully dedicate their time to the handoff/next phase of the ET project.
- Consider making an exception for instances in which statewide data are not available (or not feasible to collect). This was the case with this particular measure and is likely to be relevant with ET opportunities that are downstream and local.
- Field evaluations (ET report) should have a customer feedback component associated, as this would have revealed potential operational issues in accommodating this technology in target customer sites.

SMART COMMUNICATING THERMOSTAT

Technology Background

Regardless of the name used (e.g., smart, advanced, communicating), one technological trend that has experienced considerable growth over the past several years is the use of smart communicating thermostats (Figure 11). Smart thermostats, as opposed to traditional programmable thermostats, are Wi-Fi-enabled devices that help households maintain desired temperature levels by controlling the HVAC system from anywhere (typically using a smartphone app). These devices can also optimize the performance of the HVAC system through automatic setbacks based on occupancy sensing capabilities.[71] In addition, leveraging the wireless communication properties, smart thermostats also open the opportunity for customers to participate in utility-sponsored demand response programs. These programs are designed to reduce electric load during periods of high demand by either adjusting the temperature settings of smart thermostats (remotely by the utility) or shifting energy use from peak to off-peak time periods.

Figure 11: Smart Thermostat

Similar to a few other technologies profiled in this report, there was considerable research conducted during the ET phase, including an initial field evaluation pilot,[72] an evaluation of the first year and second year of study results,[73] and multiple presentations and workpaper discussions with CalTF,[74] that took place from May 2015 through February 2017. In proceedings with the CalTF in July 2015 discussing a potential workpaper and approach, all four major utilities were represented (PG&E, SDG&E, SCE, and SCG), with all conducting data analysis to inform workpaper development using some form of a quasi-experimental design. There were multiple iterations of the workpaper established for this measure, which were consolidated into a statewide draft, initially discussed by the CalTF as of September 2016 and submitted as a new workpaper in February 2017.

As of 2018, smart communicating thermostats were offered by all four major utilities in California across 18 different programs, including direct install and rebates/incentives.[75] Within these programs, smart thermostats were available through $50 to $75 rebates or as part of direct install channels that offered smart thermostats at low or no cost to consumers. In total, approximately 220,000 customers received smart thermostats in program year 2018 via the programs and delivery channels.

[71] See eTRM. Measure Characterization: Smart Thermostat, Residential. Version SWHC039-06. See Smart Thermostat, Residential | ETRM (caetrm.com), and DNV GL – ENERGY. Impact Evaluation of Smart Thermostats – Residential Sector – Program Year 2019, Issued June 16, 2021. See calmac.org/publications/CPUC_Group_A_Residential_PY2019_SCT_Final_Report_CALMAC.pdf.

[72] ET Project Number ET11PGE1072. Findings from the Alpha Test of the Opower/Honeywell Thermostat Pilot. Prepared by Freeman, Sullivan & Co., Issued April 13, 2012. This report predated the specific ET period under study (2016-2017), and was a pilot based on the installation of smart thermostat within PG&E employee residences but represents what may be one of the first pilot studies.

[73] Based on ET project ET13PGE1462, this represented results of a randomized encouragement design (RED) trial involving a few thousand homes randomly assigned and offered a free smart thermostat.

[74] California Technical Forum (CalTF). Per WHAT WE DO — Cal TF, *CalTF is a collaborative of experts who use independent professional judgment and a transparent, technically robust process to review and issue technical information related to California's integrated demand-side management portfolio.*

[75] DNV GL – ENERGY. Impact Evaluation of Smart Thermostats, Residential Sector – Program Year 2018, Issued April 16, 2020.

Key Findings

1. The variety of manufacturers that offer smart communicating thermostats has provided more customer choice, but each has its own limitations, and this has created some challenges for the IOUs.
2. There is an opportunity to increase customer education to facilitate a better understanding of the full capabilities of the technology and the benefits it offers.
3. Manufacturer marketing efforts led to the high uptake of smart communicating thermostats, and manufacturer efforts can help drive awareness for a technology; cross-promotional efforts were mentioned as contributing to the success of the measure.

Process and Program Strategy

Perhaps more so than any of the other technologies profiled for this report, a considerable amount of research related to smart communicating thermostats was executed prior to or concurrent with the ET phase (2016–2017). A pilot study conducted in 2012 by PG&E was one of the earlier studies that contributed to the body of knowledge associated with smart thermostats.[76] The utility also conducted a two-year pilot study among approximately 2,200 households, the results of which were published as part of the first-year and second-year findings cited above. Regarding workpaper and measure package development, all four major utilities conducted studies, discussed on two occasions with the CalTF, in May and July 2015.

Utility staff envisioned these studies would inform workpaper developments targeted to be completed between Q3 2015 and Q4 2016.[77] Two of the studies (PG&E and SCG) used a randomized control trial (RCT) as a central methodology, with the others using some form of billing/usage analysis. All the studies were designed to achieve a medium-to-high level of statistical confidence (ranging from 75% to 90%). One driver for conducting these studies was the various white papers published by manufacturers that reported savings claims were difficult to validate and tie to specific thermostat features.[78] This feedback was corroborated by interviews with IOU staff, who indicated that there was a wide variation in savings results, particularly those associated with gas savings. Other challenges associated with the data collection and research process based on staff interviews included the development of the baseline, or base case upon which gross savings can be calculated; establishing research results independent from manufacturer data;[79] the expected useful life of the measure or technology (as staff noted it was more behavioral); and, calculation of the total resource cost (TRC) associated with this measure. This last item was cited as a challenge in general, in that it is difficult to assess TRC if the data meant to inform that value is not available. This can lead to inefficiency since time and resources can be expended for a measure that may ultimately not be feasible because of a TRC that indicates a measure does not comply with cost-effectiveness thresholds (a benefit-cost ratio above 1.0).

Marketing efforts have evolved since utilities first made these devices available to utility customers. In the first impact evaluation report of PY 2018,[80] programs targeted different population segments, including general residential customers and customers in multifamily and manufactured home dwellings. According to staff interviews, there was considerable cross-promotion through third parties and the manufacturers, noting that one of the manufacturers was spending more than the utilities were on marketing efforts. As a general comment, one interviewee suggested that the uptake of these programs has been "pretty decent." In terms of marketing channels, staff indicated that the IOU website is the primary source for customers to learn more about the program and apply online. IOUs conducted both digital and traditional advertising campaigns, with the former leveraging Google Ads, as well as direct email marketing to customers. One IOU mentioned the use of an in-store point-of-purchase campaign through a vendor, with the IOU

[76] Includes two reports, Freeman, Sullivan & Co. (2012), op. cit., and Freeman, Sullivan & Co., Opower/Honeywell Thermostat Trial – Interim Findings, Issued December 12, 2012. The former report was an alpha test based on PG&E employees and the latter was based on a sample of 888 customers recruited through marketing events.

[77] IOUs other than SDG&E had established a timeframe for completing a workpaper; SDG&E, at the time this was discussed with CalTF (July 2015) were considering an EE program but had not identified a target date.

[78] CalTF, Meeting Notes, July 23, 2015: See Microsoft Word - July 23 Notes_v3.docx (squarespace.com).

[79] This topic arose frequently in CalTF discussions related to the workpaper development as well.

[80] DNV GL – ENERGY. Impact Evaluation of Smart Thermostats, Residential Sector – Program Year 2018, Issued April 16, 2020. Op. Cit., page 4.

creating in-store signage and marketing collateral (such as stickers), but such efforts became expensive. The combination and preponderance of marketing across multiple channels and entities was instrumental in expanding awareness, according to one interviewee.

Current marketing efforts are primarily driven through third-party implementation contractors, which oversee operations, with one IOU noting that they ensure all collateral still includes the IOU logo, and they remain the customer-facing entity. The IOU and the implementer coordinate closely on marketing efforts, including the use of a shared calendar to ensure touchpoints and marketing activities are well-planned and do not conflict or interfere with other IOU activities. Current marketing channels being leveraged include email marketing for the umbrella program covering smart thermostats, marketing copy included in the residential newsletter that is distributed to customers monthly, and marketing coordination among implementers to ensure advertising is going to homes with central AC.

Market Adoption

Smart communicating thermostats are now owned by 12.78 million households across the US, with an estimated 1.7 million households in California.[81] The source of this estimate, the Residential Energy Consumption Survey, which is conducted on a five-year basis and was last conducted in 2020, did not collect information in the prior study of 2015, so it's difficult to assess to what extent adoption has grown, but there is considerable anecdotal evidence that would suggest adoption continues to grow. Recent research released by Parks Associates, a Texas-based technology consulting company that conducts primary research, estimated that 15 million households nationwide have smart communicating thermostats, suggesting healthy growth since 2020.[82] This research also indicated that only 12% of new purchasers received their thermostat through their utility provider.

Interviews with IOU staff revealed multiple barriers to adoption, which can be segmented into barriers faced by customers and barriers that are outside of these issues that may preclude program continuity.

Barriers to adoption faced by customers include:

- An inability to leverage and optimize the benefits of smart communicating thermostats due to a **lack of customer education** associated with this technology. This includes not using the device as it was intended; for instance, staff indicated that in some cases, customers may functionally use these as a manual or programmable thermostat, eliminating the potential benefit of the "learning" features or advanced technologies.
- Related to this barrier is the **proliferation of device variety**, which is manifest in the multiple different versions available to customers. The manifestation of this barrier is that each device has specific features that customers must understand to maximize the benefits. This compels the need to drive customer awareness of the variety of products and effectively communicate the specific benefits that correspond to such a variety.
- There is also a barrier associated with **ineffective communication of benefits**, as staff noted that the value proposition of these devices is not always clear to customers, reducing the level of interest or appeal to purchase, particularly given the incremental cost associated with these products. In the context of direct install programs, staff noted that explaining the benefits clearly to customers is a critical step to ensure they understand the settings and scheduling component, which will assist in maximizing benefits.

Other barriers indicated that older-aged customer segments may lack familiarity with a "smart" device and may not be as technologically savvy. While this may be a perception, this seems to be corroborated based on the latest 2020

[81] U.S. Energy Information Administration, Residential Energy Consumption Survey, 2020. See Residential Energy Consumption Survey (RECS) - Energy Information Administration (eia.gov).

[82] Parks Associates. "27% of smart thermostat owners report owning a Nest thermostat", October 25, 2022. See 27% of smart thermostat owners report owning a Nest thermostat (parksassociates.com).

Residential Energy Consumption Survey data, as those aged under 45 are nearly twice as likely to own a smart thermostat.[83]

Barriers related to issues outside of those customer-related include the following:

- A few staff noted that smart communicating thermostats, *on their own*, are **not cost-effective** for residential direct install programs unless bundled with other measures endowed with greater cost-effectiveness – in some instances, it was mentioned that the smart communicating thermostat, as a trendier offering, allowed a greater uptake for other bundled measures that may not have resulted in a decision to participate. Somewhat related to this, one staff member indicated measures could become less cost-effective the longer they remain active, incentivized measures.[84]
- There are **internal limitations** that may put a constraint on the number of times an IOU can promote a "free" thermostat, related to a consideration on the number of times an IOU reaches out to customers regarding offerings, according to interviews.
- One comment from interviews referred to challenges associated with **varying manufacturer expectations**. Based on the impact evaluation report from PY 2018, which only indicates a few manufacturers,[85] staff noted in many instances, each company is different in terms of what is expected of the IOU and the range of control they have over their product. Staff noted one way to address the inconsistent limitations across manufacturers is to take these limitations into consideration when designing a program. Staff also noted that in the past, they would have more flexibility to do so, and the lack of flexibility now may hinder deployment.
- Either through a lack of understanding or a lack of clarity in communicating, it was noted that **unclear program eligibility and requirements** resulted in confusion among customers and rebate approval rejections. For instance, some customers were buying thermostats that mentioned "smart" in their marketing collateral but lacked the Wi-Fi connectivity component to be eligible for program rebates.
- The **duration of regulatory cycles** was mentioned by one staff member, indicating that the IOU would not have been able to offer smart communicating thermostats if they were not able to get approvals during special proceedings associated with summer reliability. The mention of this was more about the potential barrier longer duration cycles to gain approval might be creating, particularly about technologies that are fast-moving and may have steeper adoption curves.

In addition to barriers, staff interviews revealed a number of key drivers that are facilitating the growth in smart communicating thermostat adoption:

- **Effective promotion** by manufacturers was cited by staff, indicating that such promotion was instrumental in driving adoption rates of these technologies; in some cases, this included promotion by manufacturers outside of IOU involvement, reflecting the cross-promotional efforts noted previously in this case study.
- The **proliferation of distribution channels** was also mentioned as a key driver, as it helps to facilitate access to these devices by a wide range of customers.
- The **default installation in new construction** of smart communicating thermostats provides another driver of increased adoption (though it assumes the new owner/occupant does not remove the device).

[83] U.S. Energy Information Administration, Residential Energy Consumption Survey, 2020. Op. cit.

[84] The reason for this, according to the staff member who mentioned it, has to do with the fact that as measures are offered over time, evaluations conducted can establish a lower net-to-gross value (which also lowers the cost-effectiveness of the measure).

[85] DNV GL – ENERGY. Impact Evaluation of Smart Thermostats – Residential Sector – Program Year 2019. Op. cit., page 14. Data from this report indicates that 2019 rebates were primarily associated with the three largest manufacturers in this space, Google Nest, EcoBee, and Honeywell, though comparisons with 2018 indicate a more dispersed distribution by brand and a growing "other" category.

Considerations

- Consideration should be made regarding measures and technologies that are fast-moving through the market, as staff indicated the duration of the regulatory cycle (citing the five-year duration) was a barrier, particularly in cases where the technology is moving rapidly, and there is a greater opportunity of capturing resource acquisition savings correlated with adoption.
- Based on comments provided by IOU staff, recommendations should include directing ET staff to calculate the total system benefit (TSB) multiple times at periodic intervals and circulate this information to other teams to ensure accuracy. This would bring awareness to all stakeholders earlier in the process if the technology is viable before resources are invested in the technology.
- As noted in other case studies, while manufacturers are key actors within this ecosystem, this case study also reveals that a variation of manufacturer expectations presented challenges to the IOU. While it may be difficult to extend consistent expectations across all manufacturers, establishing these expectations at the beginning of the process may pay dividends as the measure moves from development to introduction into utility portfolios.
- The technologies associated with smart communicating thermostats are sophisticated and evolving rapidly. Developing educational marketing materials that can be easily understood by wide segments of the population, for instance, through video snippets or visual illustrations, may address the lack of customer education associated with this measure. Educational information on exactly how to operate these devices would also address a common issue involving customers who essentially use these as programmable thermostats, effectively eliminating some of the energy-saving benefits these technologies present.

T8 LED LAMPS

Technology Background

Until recently, commercial buildings used linear fluorescent fixtures and tube lamps for indoor lighting. However, a more efficient alternative lighting technology is available in the form of light-emitting diodes (LEDs). The LED tube, which has a recognizable shape as shown in Figure 12, is a specific type of LED lighting that follows the UL Type A configuration. The DesignLights Consortium, a non-profit organization focused on improving energy efficiency for commercial lighting, defines the UL Type A as a four-foot or two-foot LED "tube" designed to replace a four-foot or two-foot fluorescent lamp, respectively.[86] For this reason, these lighting fixtures are commonly referred to as linear lamps. When this measure was in its ET phase (2016–2017) within California, approximately 80% of linear lamps were found in offices, schools, retail establishments, and miscellaneous businesses such as services, laboratories, and assembly spaces.[87] Products associated with this lighting category are designed to be "plug and play" to replace fluorescent lamps, eliminating the need to rewire or change the ballast.

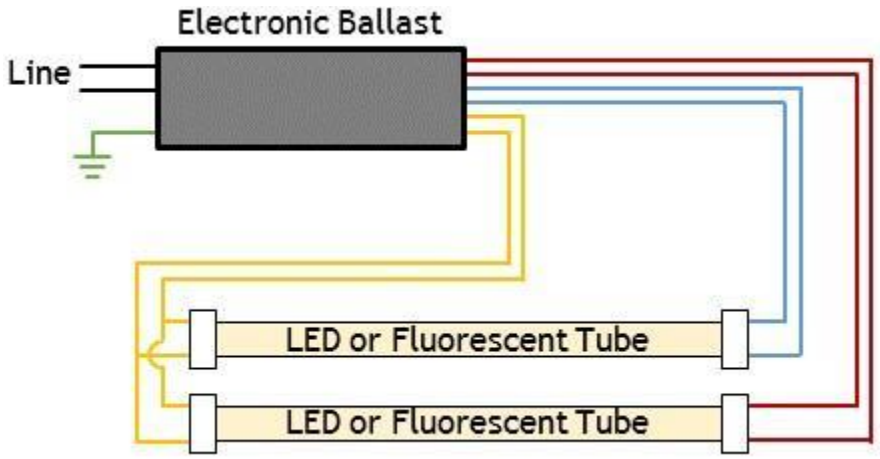

Figure 12: T8 LED Lamp, UL Type A Configuration[86]

The adoption of LED technologies has increased markedly over the past decade, corresponding to some extent to the ET phase associated with this measure. For instance, the latest adoption report produced by the Department of Energy indicated the following key findings:[88]

- From 2016 to 2018, installations of LED products increased in all applications, roughly doubling to 2.325 million units or 30% of all general illumination lighting.
- Type A lamps, as described above, represent nearly half of all LED lighting installations and have increased to an installed penetration of 32.9% in this application. Type B are referred to as Ballast Bypass as they do not require a ballast and Type C replace the ballast with an external driver.

LED technology is utilized in both residential and non-residential settings through various statewide programs. T8 LED Lamps (Type B and C) were measures incented through the CA Statewide Lighting Program. Branded as Illuminate California (Home - Illuminate California), this program was terminated in 2023. According to the home page of Illuminate California, the widespread adoption of LED lighting and increased base level efficiency, which lowered energy savings, were the primary reasons for the program's termination:

> *"Due to lower incentives and increased costs, TRC [Implementation Contractor] along with SCE, has determined that the financial viability of the Illuminate California program is unsustainable. Maintaining incentives at 2022 levels or increasing administrative costs would result in a program that would not be cost effective. Therefore, TRC has reached the difficult decision to close the program."*

[86] eTRM. Measure Characterization: LED, Tube. Version SWLG009-04. See LED, Tube | ETRM (caetrm.com)

[87] Pacific Gas & Electric, Linear LED Lamps: Application and Interoperability Evaluation, ET Project Number ET16PGE1951, August 29, 2017. Prepared by California Lighting Technology Center, University of California-Davis. See Linear LED Lamps: Application and Interoperability Evaluation | California Lighting Technology Center (ucdavis.edu).

[88] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, *Adoption of Light-Emitting Diodes in Common Lighting Applications*, August 2020.

During this measure's ET phase (2016–2017), it was administered through programs through two IOUs: SCE and Pacific Gas & Electric (PG&E). SCE administered several programs associated with this technology, including the Commercial Direct Install Program, the Multi-Family Energy Efficiency Rebate (MFEER) Program, and the Midstream Point of Purchase (MPOP) Program. The MPOP program counted LED T8 Type A tubes as one of the top measures installed in 2017.[89] In 2025, nearly a decade after the T8 LED Lamp's ET phase, the ban on the sale of all fluorescent bulbs (AB 2208, Kalra), including the linear tubes most often present in office buildings, will go into effect.

Key Findings

1. The marketing strategies for T8 LED Lamps were comprehensive, involving online activities and leveraging trade allies and the professional community; the focus was on educating the market about available and emerging products.
2. The cost of T8 LED Lamps decreased enough to increase adoption without customers needing financial incentives from IOUs; the market uptake (initially) contributed to scale and facilitated achieving cost-effectiveness requirements. Ultimately, the significant market uptake led to the decision to discontinue the wider lighting program Illuminate California.
3. A challenge noted for T8 LED Lamps was the data collection requirements, particularly within the midstream channel, and this created challenges for IOU staff, implementers, and distributors.

Process and Program Strategy

When this technology was emerging, IOU staff indicated that the program teams had a close relationship with lighting distributors, more so than with the ET teams. This relationship proved to be a key component in the program's success. The lighting distributors, along with the manufacturers, were typically a good source of information regarding the market. Other key sources of information that informed program strategy and customer preferences included the ETCC reports and other online resources. Based on interviews conducted with IOU staff, it appears there was little reliance on conducting independent research to assess market characterization and inform strategies.

Data collection requirements for measure development revolved around information associated with the ballast,[90] including the model number and manufacturer. Additional requirements, as indicated in the initial measure package approved and through staff interviews, included fluorescent lamp wattage, sampling requirements (at least 10% of the fixtures present), and information associated with manufacturer compatibility.

Marketing efforts focused on educating the market about the technology's benefits as well as the cost. Educational marketing efforts included classes, website education, and webinars to cover how the technology would be used, its benefits, and raising general awareness. In addition to external marketing, internal marketing efforts leveraged market-facing representatives who had good customer relationships and would promote rebates. The success of this measure and the sizable uptake of these technologies facilitated the ease of achieving the cost-effectiveness requirements.

Market Adoption

Adoption of T8 LED fixtures rose markedly over the period in which this measure moved from its ET phase to a resource program in California and the US. The percentage of commercial buildings that used LED lighting (of any type) increased from 9% in 2012 to 44% in 2018.[91] According to staff interviewed for this report, several drivers assisted in increasing this adoption. Drivers of T8 LED linear fixtures specifically, included:

- **Midstream point-of-sale programs proved to be quite successful** in establishing opportunities for customers to replace fluorescents with LED technology; this primarily resulted from distributors increasing the volume of

[89] CPUC Order R. 13-11-005, page 41. See 220593856.PDF (ca.gov).

[90] Electronic device that is mounted inside the T8 fixture; while ballasts are necessary for the safe and reliable operation of T8 fluorescent lamps, they may or may not be necessary for T8 LED lamps.

[91] U.S. Energy Information Administration, Commercial Building Energy Consumption Survey (CBECS), 2018. See PowerPoint Presentation (eia.gov)

throughput due to the large network of contractors who were instrumental in informing end users about rebates and efficiency opportunities.

- The **useful life of T8 LED fixtures** was also mentioned as a key driver; the useful life of these fixtures is typically five times that of fluorescent lighting, reducing lifetime replacement and maintenance costs (a non-energy benefit to building owners).
- The **level of incentives** helped consistently offset customer outlays for large lighting retrofits from fluorescents to LEDs. This scenario appears to have played out across multiple settings, driving the above mentioned adoption rates.

While all these drivers likely influenced the increase in the adoption of these technologies, interviews with IOU staff also identified some barriers that can be loosely organized to cover three specific areas (in no order):

- **Onerous requirements impacting implementer engagement,** primarily related to Title 24 regulations in California, were mentioned by a few interviewees. For instance, as indicated by IOU staff, one of the eligibility requirements is that lamps must operate from an electronic instant-start ballast. Utilities must validate this by ensuring the manufacturer's specification sheets indicate the ballasts are electronic start types and should be accompanied by photographic evidence of the ballast nameplate indicating electronic/instant start designation (in some form). As part of the documentation requirement, the implementer needed to collect several documents, including a copy of the invoice detailing the purchase of the lamps; manufacturer specification sheets; a screenshot or download of DLC Version 5.1;[92] a letter from the implementer identifying whether the existing lamps were disposed of in the standard method or recycled; a completed Preponderance of Evidence questionnaire; maintenance records (if available); lab certification on the ballast; and customer attestation (as applicable).
- Although these requirements helped the IOUs more accurately document and track savings, they introduced **data collection challenges** for the implementer due to the amount of documentation required to collect and provide for a single lamp/fixture installation. Depending on how many measures the implementer projected would be installed, the effort required to collect this information may have prevented the implementer from program participation. This was particularly true if the projected volume of installations was low, as the work required to generate the documentation does not offset the benefits to implementers.
- **Customer acceptance** was the least prominent topic in comments provided during interviews. When discussed, these comments primarily focused on the quality of light emanating from the fixtures and general acceptance of the technology.

Other comments from staff mentioned that data collection also involved the need to keep track of the installation locations. They noted that some distributors were unwilling to employ the effort required to collect and maintain that information.

Considerations

- The success of this technology was driven by a comprehensive marketing approach that effectively leveraged internal and external stakeholders, including close coordination with distributors and developing educational marketing these actors could cascade to their customers. This approach should be implemented across other technologies where the supply chain is concentrated within midstream delivery channels.
- ETP projects should incorporate a more holistic approach during the portfolio stages. Staff should consider the technology's infrastructure cost, early adopter rates, and the required steps for customers to use the technology.

[92] Refers to DesignLights Consortium (DLC) Technical Requirements V5.1. These requirements are designed to improve the quality and controllability of high performance, energy efficient commercial lighting products by establishing requirements and reporting standards of DLC listed products. For more information, see Technical Requirements V5.1 - DesignLights.

COMMERCIAL WATER HEATING

Technology Background

Most of the case studies in this report focus on technologies that began as ET candidates and were ultimately transferred fully into resource portfolios, where they were either highly successful or not so successful (and discontinued). In this case study, we profile an additional technology that never materialized as a deemed program for various reasons cited below. As a custom measure, this technology is still available to customers to the extent they want to pursue it.

Figure 13 Wasted Heat Recovery Unit[93]

When this measure was being investigated, it was titled *Waste Heat Recovery Rooftop Unit (RTU),* as shown in Figure 13[93]. The current generation of technology, by one of the primary manufacturers, Rheem, is called an Integrated Air and Water System, which includes three components: the Rooftop Unit (H_2AC), a storage tank, and a condensing tankless water heater.

As indicated in the ET report that evaluated a previous generation of this technology, the primary target market that could most utilize this technology includes restaurants, food processing operations, health clubs, hotels, and assisted living.[94] Ideally, sites utilizing this technology should consume at least 1,500 gallons per day (GPD).

As this measure is a custom measure, it is available in the San Diego Gas & Electric (SDG&E) measure catalog, though according to interviews with staff, uptake has been limited. To the best of their knowledge, there have been no savings claims linked to the installation of this specific technology between 2016 and 2021.

Key Findings

1. This technology is an example of an instance where factors outside of utility control can have a deleterious impact on the viability.
2. New regulations associated with standards and Title 24 compliance (related to the use of fans) created product design challenges that the (only) manufacturer could not accommodate, which ultimately led to this technology not moving into the resource portfolio.
3. The potential market size of this technology was small, driven by restriction to areas with specific climates conducive to the technology being cost-effective to the target businesses.

Process and Program Strategy

Interviews with IOU staff revealed that, apart from some general insights related to the target market and prospective sites where this technology might present energy-saving opportunities, no substantive research, such as a market characterization study, was conducted. According to staff, there were two projects conducted that involved this specific technology. One took place in a food service operation in Laguna Hills, CA, as referenced in the ET report.[95] A second

[93] Image used with permission of Rheem Manufacturing Company. © 2013, Rheem Manufacturing Company.
[94] Gas Technology Institute. Waste Heat Recovery RTU and Hot Water System Field Installation Report. Emerging Technology Project Number ET14SDG1091. Issued March 31, 2016. See Waste Heat Recovery RTU and Hot Water System Field Installation Report | ETCC (etcc-ca.com)
[95] Ibid.

project was identified and funded through the California Energy Commission (CEC) at a small industrial site, and it received no financial or technical support from SDG&E. The outcomes of both projects reveal factors that impact the feasibility and potential success of emerging technologies and, in this case, may be outside of utility control.

Market Adoption

The initial project with the food service operation produced results that were promising, as the report indicated "significant" natural gas savings, positive cost-effectiveness, a well-established manufacturer, and positive contractor/customer experience. It should be noted that project results did indicate an *increase* in electric consumption, primarily due to the waste heat recovery (WHR) cycle. As the condenser return water temperature increases, the load to the compressor increases, and the RTU consumes more electrical energy.[96] As noted by staff, the performance of this technology is typically higher with increasing hot water usage, and the site profiled in the field evaluation report used 1,200 GPD, 300 GPD less than the 1,500 GPD associated with the target market. As noted in the ET report, if the hot water usage is reduced to approximately 775 GPD, the product would "only begin to make economic sense in a hot-dry or marine climate when [natural] gas prices are higher."[97]

Additional factors that define the target market include sites with at least 4,700 square feet using a 15-ton system in a climate with 1,800+ cooling degree days (CDD). Within the State of California, this essentially restricts the market to areas south of Santa Barbara along the coast or parts of the central valley, as climates characterized as Hot-Dry / Mixed Dry (in California) would be prospective areas, as indicated in Figure 14.[98] As recounted by IOU staff, the food service operation project in Laguna Hills and its apparent success led to a second project at a small industrial site funded by the CEC.

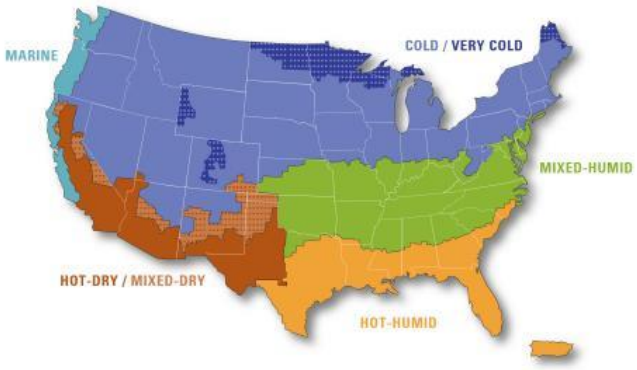

Figure 14: Climate Zone Map[98]

Details provided by IOU staff related to this second project revealed challenges and barriers associated with this technology (in California) that were unrelated to a misunderstanding of the target market or use case or customer awareness and education. The primary factor leading to the cancelation of this second project was related to codes and standards, as this ultimately made the technology untenable, based on the product line established at the time. New standards established by the Department of Energy, as well as specific compliance regulations associated with Title 24 in California related to fans, produced major challenges for the manufacturer. This ultimately required specific adjustments in the product design of this technology, which the manufacturer was not able to accommodate. As a result, the project was canceled by the CEC. At the time of this project, it was indicated that there was only one manufacturer of this product, further restricting the feasibility of this technology.

Considerations

- While it is difficult to predict potential challenges related to new standards being promulgated that may impact a specific technology, communication with manufacturers early on related to the specific product design may help in alerting staff to potential future pitfalls; developing measures based on technology provided by few manufacturers (or in this case, one) may introduce challenges.

[96] Ibid., See Figure 17.
[97] Ibid., page 28.
[98] U.S. Department of Energy Building America Program. (2010). "Guide to Determining Climate Region by County", Prepared by PNNL and ORNL, Report No. PNNL-17211.

- Technologies only relevant to a small or niche market should bring about a much greater focus on a better understanding of the customer segments that represent the best candidates based on economics and site characteristics.
- One primary lesson learned, as represented by this case study, is that factors outside of the control of any individual utility may contribute to a lack of success.

APPENDIX C. STAKEHOLDER COMMENTS ON DRAFT REPORT

CPUC published a draft version of this report on 02/26/2024 followed by a stakeholder workshop held on 03/04/2024. Comments on the draft report were accepted through 3/11/2024. This appendix provides a summary of comments received prior to the comment deadline as well as the study team's responses to those comments. This final report incorporates updates to the draft report informed by the comments below.

RESPONSES TO COMMENTS

Affiliation	Subject	Comment	Response
CalMTA	Cal MTA	CalMTA is supportive of the idea of increasing coordination to share knowledge with resource acquisition, emerging technology, market transformation, and codes & standards programs. In fact, in the markets where we are considering and researching the potential for Market Transformation Initiatives (MTIs), we have initiated regular coordination meetings and have plans to expand coordination in 2024 and beyond as we continue to advance more MTI ideas through our stage gate process. We would like to clarify, however, that the work and coordination efforts of CalMTA will be focused on specific markets where CalMTA is deploying an approved MTI Plan and will not encompass the entire energy efficiency market or ecosystem. The approach and process for collaboration with codes & standards, energy efficiency program administrators, implementers, and stakeholders will be specified in our MTI Plans and will be customized based on the barriers and opportunities identified in each MTI logic model to transform the target markets. CalMTA would like to offer the opportunity for the evaluator to interview our team for this study or any future studies that wish to gain our insights into the role and responsibilities of CalMTA.	Thank you for the information. We have included this information in the report in footnote 26 on page 25.
SDG&E	Heat Pump Water Heater background	In Appendix B. Technology case studies under the Heat Pump Water Heater Technology Background section, the authors write that the technology is part of the statewide Plug Load & Appliance program for which SCE is the program administrator. This is incorrect. San Diego Gas & Electric is the Program Implementer for the statewide PLA program.	Thank you for your comment, the report now reflects SDG&E as the program implementer for the statewide PLA program.
SDG&E	Commercial Water Heating background	In Appendix B. Technology case studies under the Commercial Water Heating Technology Background Section, the third paragraph appears to describe a different image than what is pictured at the left of the text. It stats 'Error! Reference source not found" and describes an overview of a mechanical process, whereas the photo to the left is an exterior shot of a waste heat recovery unit.	Thank you for your comment, the reference error has been updated in the report.
SDG&E	Customer acceptance evaluations	Recommendation 2 states "There is an opportunity to better incorporate more extensive customer acceptance evaluations within field testing studies." ETP field study are typically done at a handful of willing customer sites. The customer acceptance evaluation is therefore not extensive or representative of the targeted customer base.	Thank you for the information. We have included this information in the report in footnote 21 on page 24.
SDG&E	Formatting	In a couple of instances throughout the document, "Cedars Dataset" is listed when CEDARS is an acronym and each letter should be capitalized.	Thank you for your comment, CEDARS has been capitalized throughout the report.
SDG&E	Technology origination	This section of the study indicates "...whether the IOU program management staff have a clear understanding of which technologies originate from the ETP." A binary field was added to CEDARS to indicted if a measure originated from ET. This field was included for better visibility and to generate a simpler way to track savings for the program staff. Prior to that, the program staff were kept informed of the ET projects, but once	Thank you for the information. We have included this information in the report in footnote 12 on page 15.

Affiliation	Subject	Comment	Response
		completed, they don't necessary follow the measure approval process.	
SDG&E	Technology origination	In section 3.1, the report states "prior to the statewide lead/third-party model, about half of the interviewees who were performing a relevant role in 2016 -2017 were not aware the selected technologies originated from the ETP." In section 3.2.1, the report states "IOU staff shared that they are usually unfamiliar with what is going on with the third part implementers and expressed in interviews that they used to have more engagement between (ETP and program teams) prior to the introduction of the statewide lead/third-party model." SDG&E seeks clarification as these two statements appear to contradict each other. The earlier statement says the program staff were less aware of ET measures prior to the third-party model, but the later statement says the staff were more engaged with the ETP and program teams prior to third-party model.	While these two statements may appear to contradict each other, one involves the extent to which program staff were aware of technologies originating out of ETP, while the other involves the level of engagement between program staff and ETP. These are different concepts based on different questions being asked of staff. The primary takeaway is that there is less engagement now between third parties (implementation contractors) and the IOU than there was between IOU program and ETP teams prior to the introduction of the third-party lead model.

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