CalNEXT Projects for California Measure Development and Updates

Memorandum

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Executive Summary

The California Emerging Technology Program (CalNEXT) plays a critical role in advancing California's energy efficiency portfolio by identifying, testing, and validating emerging technologies, and translating findings into actionable measure development and program enhancements. CalNEXT seeks to support the evolution of California's electronic Technical Reference Manual and broader program design by generating data, methodologies, calculators and other savings tools, along with portfolio recommendations that directly inform deemed and custom measure design, adoption, improvement, and maintenance.

This memo summarizes the California measure impacts resulting from CalNEXT projects across five key categories:

1. New Deemed Measures
2. Deemed Measure Updates
3. Custom Measures and Tools
4. Measure Studies and Recommendations
5. Active Projects with Future Measure Impacts

Collectively, CalNEXT projects serve as a foundational mechanism for continuous innovation and improvement in California's energy efficiency portfolio. By bridging emerging technology research to measure development, CalNEXT strives to accelerate the adoption of high-impact, energy-saving technologies.

Abbreviations and Acronyms

Acronym	Meaning
120V	120-volt
AC RTU	Packaged air conditioners
AMI	Advanced metering infrastructure
AMS	Air management system
AWHP	Air-to-water heat pump
Cal TF	California Technical Forum
CCBEM	California Commercial Building Energy Modeling
CCH	Crankcase heaters
CEA	Controlled environmental agriculture
CFS	Commercial foodservice
COP	Coefficient of performance
CZ	Climate zone
DAC	Disadvantaged communities
DEER	Database for Energy Efficiency Resources
DWHC	Database for Energy Efficiency Resources Water Heater Calculator
DLI	Daily light integral
DOAS	Dedicated outdoor air system
DOE	US Department of Energy
ER	Electric resistance

Acronym	Meaning
ESMH	ENERGY STAR® for Manufactured Homes
ET	Emerging technology
eTRM	Electronic Technical Reference Manual
FLE	Full-load efficiency
GWP	Global warming potential
HECU	High-efficiency condenser unit
HEEU	High-efficiency evaporator unit
HP	Heat pump
HP RTU	Heat pump rooftop units
HPWH	Heat pump water heater
HRC	Heat recovery chiller
HTR	Hard-to-reach
HUD	Housing and urban development
HVAC	Heating, ventilation, and air conditioning
IEER	Integrated Energy Efficiency Ratio
IOU	Investor-owned utility
IPLV	Integrated part-load value
ISP	Industry standard practice
kWh	Kilowatt-hour
LGE	Lab-grade equipment
MP	Measure package

Acronym	Meaning
NEEM	Northwest Energy-Efficient Manufactured Housing
PCM	Phase change materials
PEI	Pump Energy Index
PG&E	Pacific Gas & Electric Company
PLE	Part-load efficiency
PY	Program Year
SCE	Southern California Edison
SDG&E	San Diego Gas & Electric
TESS	Thermal energy storage system
TSB	Total System Benefit
UEF	Uniform energy factor
ULT	Ultra-low temperature
VEIC	Vermont Energy Investment Corporation
VFD	Variable frequency drive
VRF	Variable refrigerant flow
WAHP	Water-to-air heat pumps
WCC	Water-cooled chillers
WWHRC	Water-to-water heat recovery chiller
ZERH MH	Zero Energy Ready Homes for Manufactured Housing

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New Deemed Measures

Residential High-Performance Windows Measure Package Development

Project Number	ET23SWE0043
Final Report Date	January 2, 2024
Link to Final Report	ET23SWE0043 - Residential High-Performance Windows_Final Report
Technology Area	Whole Buildings
Authors	Kyle Booth, Yang Li, Alamelu Brooks (Energy Solutions)

Summary of Recommendations

For this project, the project team developed a measure package for residential high-efficiency windows, following the standards of the California Public Utilities Commission (CPUC) requirements for measure packages. The measure package, including all major characterization sections and supporting energy modeling files and outputs, is ready for submission to the California Technical Forum (Cal TF) for review and approval. The team used the Database for Energy Efficiency Resources (DEER) Residential Building Prototypes to build an energy modeling simulation and to determine energy savings. The measure package uses eligibility criteria specified in the ENERGY STAR® Program Requirements for Residential Windows, Doors, and Skylights, Version 7.0, and provides two measure offerings: new construction and retrofit high-efficiency residential windows.

The project team's objective was to develop a California deemed energy savings measure package for residential high-efficiency windows. The California Decision 23-04-035 outlined a path for eliminating gas incentives; windows are considered a "gas exempt" measure because windows provide gas savings without incentivizing a gas appliance. The California investor-owned utilities (IOUs) have been asked by the CPUC to prioritize gas exempt measures, such as high-efficiency windows, which are connected to existing energy efficiency programs. These programs can use a completed measure package once it is developed. This proposed measure package will also play a large role in supporting California IOU equity programs. For example, this measure has been identified as a need from Southern California Edison's (SCE) Deemed QA/QC group for their residential equity programs.

This project led to another CalNEXT project, ET24SWE0004 - Residential High-Efficiency Windows Measure Package Completion, which saw the development of a new deemed measure package.

Residential High-Efficiency Windows Measure Package Completion

Project Number	ET24SWE0004
Published Date	September 18, 2024
Measure Package Active Date	April 1, 2026
KWh Savings as of April 8, 2026	0 kWh
Link to Final Report	ET24SWE0004_Residential High Efficiency Windows Measure Package Completion_Final Report
Technology Area	Whole Buildings
Authors	Kyle Booth, Rawad Abi Saab, Alamelu Brooks (Energy Solutions)

Summary of Recommendations

Residential windows can be a significant source of heat gain and loss. Research estimates windows account for 30 percent to 45 percent of envelope heat transfer. High-efficiency windows are a fuel-neutral measure, which is reflected in both electric and gas savings for customers and utilities. Highly efficient windows with a reduced U-factor and summer heat gain coefficient have not been widely adopted in the residential market. The low market adoption may be due to several factors, including high incremental measure cost, limited awareness of the technology, and low frequency of window retrofits. The market is resolving some of these barriers through reduced window costs and the new ENERGY STAR V7.0 Residential Windows specification. The results from installing highly efficient windows can provide meaningful savings for consumers and have reasonable incremental payback periods.

Project ET23SWE0043 - Residential High-Performance Windows Measure Package Development, completed through CalNEXT, developed a draft measure package for residential high-efficiency windows. This Residential High-Efficiency Windows Measure Package Completion project was a continuation of findings from ET23SWE0043; this project moved the drafted measure toward technology transfer completion by submitting it to the CPUC for measure review and affirmation.

The goal of both ET23SWE0043 and this project (ET24SWE0004) was to produce a measure package ready for CPUC approval and subsequent use in California. This project provided measure package development support to Cal TF and led to its submission to the CPUC. CalNEXT supported by reviewing and editing the measure package, communicating with Cal TF, and communicating with the California IOUs.

IMPACTS

The CPUC approved the new measure package, High-Efficiency Window, Residential (SWBE011-01), which was adopted into the California Electronic Technical Resource Manual (eTRM) on March 31, 2026. There are no Total System Benefit (TSB) or kilowatt-hour (kWh) savings as of the date of this memo.

Commercial Windows Market Study and Measure Package Development

Project Number	ET23SWE0018
Published Date	May 28, 2024
Link to Final Report	ET23SWE0018 - Commercial Windows Market Study and Measure Package Development_Final Report
Technology Area	Whole Buildings
Authors	Julie Birchfield, Kyle Booth, Jesse Zucker, Simpson Tanner, Scott Honegger, Nancy Metayer Bowen (Energy Solutions)

Summary of Recommendations

The Commercial Windows Market Study and Measure Package Development project seeks to characterize the California commercial windows market, understand the barriers to the widespread use of high-performance windows in commercial buildings, and draft a deemed savings measure package for California's eTRM. The study includes primary research through market interviews and analyses of secondary sources to generate actionable recommendations for increasing the number of high-efficiency window projects in California's IOU service area. In addition, this market study models savings potential for California's 16 climate zones (CZ) and addresses commercial barriers for new construction, retrofits, and secondary window projects.

There are currently no incentivized deemed savings measure packages for high-performance windows in commercial buildings in California; the first step toward assessing the potential for such a measure is to understand its market potential. The market study portion of this project seeks to develop a deeper understanding of the commercial buildings market for high-efficiency window products and illuminate the reasons for the low adoption levels of high-performance windows in the commercial sector. The published Final Report provides an estimated total market size and percentage of market sales for each type of commercial window measure, as well as an economic analysis of window measures available to each commercial building participant in all California IOU service areas. Lastly, the Final Report details a draft measure package to be submitted to Cal TF, along with an overview of Energy Solutions' considerations for a commercial windows incentive program design—including educational components, as well as considerations for hard-to-reach (HTR) customers and disadvantaged communities (DAC).

This project led to CalNEXT project, ET24SWE0005 - Commercial High-Efficiency Windows Measure Package Completion, which saw the development of a new deemed measure package.

Commercial High-Efficiency Windows Measure Package Completion

Project Number	ET24SWE0005
Published Date	December 27, 2024
Link to Final Report	ET24SWE0005_Commercial High-Efficiency Windows Measure Package Completion_Final Report
Technology Area	Whole Buildings
Authors	Kyle Booth, Rawad Abi Saab, Alamelu Brooks (Energy Solutions)

Summary of Recommendations

The Commercial High-Efficiency Windows Measure Package Completion project will continue the measure package development process that began under the completed CalNEXT project, ET23SWE0018. The goal of both ET23SWE0018 and this project (ET24SWE0005) is to submit the measure for CPUC approval and subsequent implementation in California. This project provides measure package development support to Cal TF, which will submit the measure package to the CPUC. The project team responded to initial Cal TF feedback on the draft measure packet, tracked ModelKit updates relevant to the project, and joined Cal TF modeling meetings.

IMPACTS

The new measure package—**High-Efficiency Window, Commercial (SWBE012-01-8)**—is currently in the final stages of CPUC review.

Commercial Cooktop Fuel Substitution

Project Number	ET24SWE0024
Published Date	December 4, 2024
Measure Package Active Date	December 19, 2025
Link to Final Report	ET24SWE0024_Commercial Cooktop Fuel Substitution_Final Report
Technology Area	Process Loads
Authors	Scott Honegger, Paul Kuck (Energy Solutions)

Summary of Recommendations

The Commercial Cooktop Fuel Substitution project is developing a new measure package for the California eTRM, which is designed to show the benefits of using electric induction cooktops in place of natural-gas-fired cooktops in a commercial environment. The project team used the existing measure package for commercial electric and gas cooktops, SWFS026, to develop the new measure. Commercial cooktop fuel substitution will support California's decarbonization goals by introducing a

new fuel-substitution measure for the commercial foodservice industry. Natural gas is the most used fuel in commercial cooking, and cooktops are one of the most used commercial kitchen appliances. As electric induction cooktops continue to gain acceptance, the introduction of a new fuel-substitution measure will help increase market share of the appliances and promote electrification of the foodservice industry by enabling deemed savings and incentives for commercial cooktop fuel substitution.

The proposed project supports CPUC Decision 23-04-035 by developing a fuel-substitution measure package for customers switching from natural gas to electric. The project aims to deliver a comprehensive measure package, fully developed and ready for approval by the CPUC, which will be submitted to the Cal TF measure screening committee. It will encompass the creation of a draft measure packet within the California eTRM, along with all necessary review and editing tasks for Cal TF affirmation.

IMPACTS

The team leveraged this research to develop a new measure: Cooktop, Commercial, Fuel Substitution (SWFS034-01).

Commercial Duct Sealing Market Characterization

Project Number	ET24SWE0041
Published Date	December 20, 2024
Link to Final Report	ET24SWE0041_Commercial Building Duct Sealing Market Characterization_Final Report
Technology Area	Whole Buildings
Authors	• JoeDon Breda, Mostafa Tahmasebi, Rupam Singla, Harry Gao, Lake Casco (TRC) • Jingjuan (Dove) Feng, Lake Casco, Marc Fountain (formerly TRC)

Summary of Recommendations

This study produced an analysis of the current duct sealing technology market.

Table 1 summarizes the comparison and evaluation of the four major duct sealing technologies: manual taping, mechanical fastening, mastic, and aerosol sealant spray. Each technology has its strengths and weaknesses and can be the best option in certain situations; for example, aerosol sealant spray is a good fit for applications where the leak openings are smaller and difficult to locate, or the ductwork is not accessible. This is common in existing ductwork with unsealed joints, seams, or penetrations. If the leaks are easy to locate and the ductwork is accessible, then mastic—or mechanical fastening combined with mastic—may be a good application. A durable duct-sealing-duty tape, such as butyl tape, may be considered for leaks that cannot feasibly be repaired with other methods.

Findings from this study will help inform a measure to incentivize customers to test and seal existing ductwork. Historically, weak duct leakage testing and sealing requirements yield a large market with duct leakage rates of 10 to 20 percent or higher. Any duct system that has not been previously required to pass a duct leakage test presents an opportunity. Conditioned supply air leaking from ductwork has significant energy impacts in existing buildings, in that fan energy, cooling energy, and heating energy are all wasted. Exhaust air leakage into ductwork impacts fan energy and leads to excess infiltration, in which the conditioned supply air equipment must work harder to overcome the unintended infiltration of warm air in the summer and cold air in the winter.

Such a measure has huge savings potential, as studies have demonstrated that efforts to seal existing ductwork leakage have yielded annual HVAC energy savings of 15 to 30 percent. It is noteworthy that ductwork leakage is a problem that persists during all hours that HVAC equipment is operating, unlike other HVAC challenges that may be isolated to seasonal conditions, i.e., economizer or heating inefficiencies.

Table 1: Commercial building duct sealing energy savings and cost analysis.

	Good Applications	Training/ Expertise Required	Cost	Effectiveness	Risks
Manual Taping	Leaks are easy to locate and ductwork is accessible.	No specialized training.	Low	Low	Safety risk when working at elevated heights. Poor long-term performance.
Mechanical Fastening	Leaks are easy to locate and ductwork is accessible. Leaks with openings greater than 1/4-inch. Round duct common in small buildings.	Requires specialized training.	High	Low when alone. High when combined with mastic or aerosol sealant.	Safety risk when working at elevated heights.
Mastic	Leaks are easy to locate and ductwork is accessible.	Requires specialized training.	High	Medium	Safety risk when working at elevated heights. Environmental impacts with some mastics.

	Good Applications	Training/ Expertise Required	Cost	Effectiveness	Risks
Aerosol Sealant Spray	Leaks with smaller openings. Ineffective or unsealed duct joints, seams, penetrations.	Requires significant specialized training.	High	High when openings are smaller.	Sensitive equipment needs to be protected (coils, smoke dampers). Aerosol can leak out into building if large holes remain, and precautions are not taken.

This project led to ET24SWE0048 - **Commercial Building Duct Sealing Energy Savings and Cost Analysis**, which contributed toward the development of a new measure.

Commercial Building Duct Sealing Energy Savings and Cost Analysis

Project Number	ET24SWE0048
Published Date	August 1, 2025
Link to Final Report	**ET24SWE0048_Commercial Building Duct Sealing Energy Savings and Cost Analysis_Final Report**
Technology Area	Whole Buildings
Authors	Mostafa Tahmasebi, Afshin Faramarzi, Lake Casco (TRC)

Summary of Recommendations

The project team set out to quantify the energy savings potential and cost analysis of duct sealing technologies in small commercial buildings across California, and that analysis showed substantial opportunities for energy savings in most California CZ. HVAC energy savings were notably higher in leakage-to-outside scenarios, especially for some systems—such as direct expansion systems combined with gas furnaces—and in CZ characterized by more extreme temperature conditions. The findings highlight that duct sealing is not only technically effective but also economically advantageous in most California climates. The cost-effectiveness analysis demonstrates relatively short payback periods for aerosol sealing methods, making it a viable option for targeted incentive programs. These insights provide a robust basis for utilities and policymakers to prioritize duct sealing in efficiency programs, particularly leveraging performance-based incentives and preliminary diagnostic evaluations to optimize energy savings and reduce operational costs in small commercial buildings.

IMPACTS

The new measure—**Duct Seal, Commercial (SWSV017-01-2**)—is currently under development, undergoing CPUC review.

Lab Grade Refrigerators and Freezers Measure Package Development

Project Number	ET24SWE0034
Published Date	December 23, 2024
Link to Final Report	ET24SWE0034_Lab Grade Refrigerators and Freezers Measure Package Development_Final Report
Technology Area	Process Loads
Authors	Lisa Riker, Ted Jones, Paul Kuck (Energy Solutions)

Summary of Recommendations

The Lab Grade Refrigerators and Freezers Measure Package Development project aims to establish a new California eTRM measure package for the high-performance subset of the equipment. defined by ENERGY STAR's Laboratory Grade Refrigerators and Freezers Specification, Version 2.0. The project included capturing baseline energy consumption data through onsite field equipment metering, conducting a market assessment, developing incremental measure cost values for the measure package, and submitting a measure package to Cal TF for affirmation.

- Data shared with the project team showed there is an aging population of lab-grade equipment (LGE) still plugged into the grid. Although this falls outside the scope of this project, this inventory offers an opportunity to analyze the equipment lifecycle, the existing market inventory, and the potential of an early retirement program.
- LGE presents a unique opportunity, as many units are currently connected to monitoring systems that collect energy use, temperature, and other data points. The IOUs should leverage data from stakeholders' connected monitoring systems to conduct additional and long-term research on LGE energy use, expected useful life, and deterioration of efficiency.
- The complexity and sensitivity of life sciences stakeholders require that project engagement provide long lead times to coordinate and work within the bandwidth of their facilities and research teams. At least nine months should be planned for stakeholder outreach and engagement, followed by an additional nine months for project implementation in collaboration with stakeholders.

IMPACTS

A draft measure package plan has been developed and preliminarily socialized with Pacific Gas & Electric Company (PG&E). The next steps are to formally pursue the development of this new measure.

High-Speed Oven Energy Use Field Monitoring for the Commercial Foodservice Industry

Project Number	ET24SWE0057
Published Date	December 19, 2025
Link to Final Report	ET24SWE0057_High-Speed Oven Energy Use Field Monitoring for the Commercial Foodservice Industry_Final Report
Technology Area	Process Loads
Authors	Edward Ruan, Richard Young III (Frontier Energy)

Summary of Recommendations

The primary objective of this study was to characterize the savings opportunities associated with high-speed ovens and create a measure package that can effectively leverage those opportunities to guide efficient market use of the technology. High-speed ovens are a rapidly growing appliance category, but there is a significant lack of data to properly characterize high-speed oven current market usage—and prospective energy savings potential when optimally integrated into a foodservice operation. To fill this gap and develop a comprehensive outlook on the high-speed oven market in California, Frontier Energy generated data throughout this study with a mixture of market analysis and field data acquisition.

Through stakeholder interviews, Frontier estimated a current inventory of about 23,000 high-speed ovens in the state of California, with projections for the market continuing to grow 10 percent to 20 percent over the next two years.

Frontier replaced the existing appliances at three sites, upgrading the gas oven and two existing high-speed ovens to the newest generation of energy efficient electric high-speed ovens. Frontier developed an energy model from the culmination of laboratory testing data and the real-world operational field site data collected from this project, which allowed for the estimate of overall potential for high-speed ovens within California. Using the operational hours from the evaluated sites and the laboratory test results from standardized testing of high-speed ovens under the ASTM International F2238 Standard Test Method for Performance of Rapid Cook Ovens (ASTM International 2020), Frontier estimated 28 percent energy savings when converting from a standard high-speed oven to an energy efficient high-speed oven, equivalent to 2,354 kWh per replaced unit. With a current inventory of about 23,000 high-speed ovens in California, Frontier estimates that the statewide energy savings potential for high-speed ovens may be around 5.4 terawatt-hours per year, assuming 10 percent of the existing high-speed oven inventory are older units ready for replacement.

Frontier also reviewed market pricing data to estimate an incremental measure cost of $2,979 for upgrading from a baseline high-speed oven to an efficient one. Efficient high-speed ovens were defined as ovens tested via ASTM F2238-20 that have a cooking efficiency greater than or equal to 39 percent and an idle rate of less than or equal to 1 kW, with all other ovens that do not meet that criteria—or have not been tested at all—assumed to be baseline. With a calculated 2,354 kWh per

year of savings per high-speed oven, and assuming an average commercial cost of electricity in California of 30 cents per kilowatt-hour, Frontier estimates a return on investment of 4.2 years for a high-speed oven replacement at this time.

IMPACTS

The team combined the lab, field, and market data into a draft measure package for submission to Cal TF.

HVAC Thermal Energy Storage System (TESS) Field Evaluation

Project Number	ET23SWE0022
Published Date	December 12, 2024
Link to Final Report	ET23SWE0022_HVAC Thermal Energy Storage System (TESS) Field Evaluation_Final Report
Technology Area	HVAC
Authors	• Akane Karasawa (ASK Energy) • Daniela Grassi, Derick Baroi (AESC)

Summary of Recommendations

This project evaluated the performance of a thermal energy storage system (TESS) that uses phase change material (PCM) as a medium. The TESS studied is comprised of a module made of PCM-filled panels and a controller; this technology can be added to any HVAC system with a new or existing supply duct. The retrofit does not require any alteration to be made to the existing system and therefore, it does not require a permit or structural analysis, unlike most other HVAC retrofits.

The technology uses biobased PCM and is safe for human comfort applications. The PCM has a solidification temperature of 62 degrees Fahrenheit (°F). Thus, the PCM is solidified as the cold supply air—typically 50°F to 55°F—passes through the TESS module in the supply duct. The PCM remains solidified until the TESS's controller limits compressor operations and reduces runtime, allowing the PCM to thaw and absorb heat from a warmer supply air.

The TESS assembly has been fire tested with a plenum rating per ASTM E84/UL 723, with zero flame or smoke. The TESS controls compressor operations to shift load and reduce peak demand by solidifying PCM during lower energy demand periods (off-peak) and thawing during the high energy demand periods (peak). In this field test, the TESS was installed in the supply duct of four packaged rooftop air conditioning units, used to condition a fitness building located in California's CZ 10.

The field test demonstrated that the PCM-based TESS reduced the energy use of packaged rooftop air conditioners during a four-hour peak period between 4:00 p.m. and 8:00 p.m. by shifting cooling load from the peak to off-peak. When the team compared two similar weather days, the TESS installed on a 15-ton rooftop unit (RTU) reduced its energy usage by 36 percent during the four-hour peak period. The energy reduction varied from unit to unit, with the most observed for AC5 at 68 percent. The large energy reduction observed for AC5 is likely attributed to the added duct insulation,

reduced leakage, and improved airflow, resulting from the duct replacement performed during the TESS installation. Collectively, the TESS reduced the energy usage of four RTUs by 48 percent during the four-hour peak on the two similar weather days.

A regression model was developed for each unit using the data collected from the field test. A regression model was use to annualize the energy reduction during the four-hour peak period and the energy savings resulting from shifting load and operating compressors more efficiently during off-peak. The typical weather file, CZ2022 for California CZ 7, was used for this exercise. When the post-installation performance was compared to the baseline model, the TESS installed on the four RTUs shifted 46 percent of HVAC energy to off peak and saved 11 percent annual energy.

The sequencing test showed that the technology could further reduce peak demand by sequencing the operation of four retrofitted units. The sequencing test demonstrated a 32-percent reduction in peak demand on a relatively cool day, with the potential for even greater savings at the height of summer when more units are operating simultaneously.

Based on the significant peak energy and demand reduction TESS attained during the field test, it should be considered for a potential load flexibility program. Additionally, the technology may fit with several other programs, such as a demand response program, a quality installation and maintenance program, or a permanent load shift program when one becomes available. The technology will most benefit from programs that use TSB because it saves demand and energy during high value hours, i.e., time with high energy demand. However, this field testing alone did not provide sufficient information to be directly incorporated into an incentive program. Subsequent work, such as modeling simulations, may therefore be required to validate the consistency of technology performance with different peak durations, RTU sizes, CZ, and building load types.

IMPACTS

SDG&E is currently working with the CPUC and RMS Energy Consulting on a deemed measure development pathway, with consideration of a custom measure route.

Nonresidential Heat Recovery Chiller and Air-to-Water Heat Pump Measure Package Development

Project Number	ET24SWE0036
Published Date	December 9, 2024
Link to Final Report	ET24SWE0036_Nonresidential Heat-Recovery Chiller and Air-to-Water Heat Pump Measure Package Development_Final Report
Technology Area	HVAC
Authors	• Shaojie Wang, Bryan Boyce, Samantha Putlak (Energy Solutions) • Pradeep Bansal (formerly Energy Solutions)

Summary of Recommendations

To fulfill California's ambitious goal of decarbonizing the built environment by midcentury, Energy Solutions has partnered with the California IOUs (Pacific Gas & Electric, Southern California Edison, and San Diego Gas & Electric) to expand the eTRM by adding measure packages that focus on hydronic air-to-water heat pump (AWHP) and heat-recovery chiller (HRC) technologies. These technologies are commercially available, being leveraged by designers, and ready for addition to the utility portfolio to boost visibility and market share.

In summary, for the measure package modeling task, the next steps are as follows:

- **Phase I, Short-Term:** Integrate the AWHP, water-to-air heat pumps (WAHP), and water-to-water heat recovery chiller (WWHRC) technologies into the DEER prototypes environment. As of the Final Report, the DEER prototypes lack an AWHP model, so this integration is crucial for ensuring accurate assessments and program design.
- **Phase II, Medium-Term:** Evaluate and implement the WAHP, AWHP, and WWHRC models within the DEER prototype, ensuring that it aligns with existing data and performance metrics. This will involve testing and validation to confirm the model's accuracy and reliability. Conduct the necessary parametric simulations to generate the impacts for a measure package.
- **Phase III, Long-Term (i.e., activities that could occur after version one of the measure package is finalized):** Consider further data collection and development of modeling approaches for HRCs. This will involve researching and gathering performance data for HRCs and developing robust modeling techniques to accurately reflect their efficiency and operational characteristics. This step will help expand the scope of energy efficiency measures and improve program effectiveness. From there, the project team will consider implementing a follow-up project.

The team has engaged SDG&E for feedback at key stages of the project's development, and the same team has planned a subsequent project to begin measure package development under SDG&E's guidance.

IMPACTS

The results of this study are being leveraged in follow-up efforts to further study nonresidential heat recovery chiller and air-to-water heat pump technologies, as well as to continue developing a measure package plan.

Deemed Measure Updates

Advanced Motors Channel Partner Support and Measure Package Development

Project Number	ET23SWE0068
Published Date	January 2, 2025
Link to Final Report	ET23SWE0068_Advanced Motors Channel Partner Support and Measure Package Development_Final Report
Technology Area	Process Loads
Authors	• Julie Birchfield, Kyle Booth, Jim Hanna, Ted Jones, Amanda Shorin, Jesse Zucker (Energy Solutions) • Sarabeth Erdman, Asa Parker, Cole Shea, Kelly Shin, Jonathan Thibeault (VEIC)

Summary of Recommendations

In the Advanced Motors Channel Partner Support and Measure Package Development Focused Pilot, the project team sought to overcome key barriers to the widespread adoption of advanced motors. Primary barriers include limited manufacturing, limited technical knowledge (from customers, contractors, and distributors), stocking, market awareness, and a lack of deemed energy savings methodologies needed to incentivize advanced motors. To help overcome these obstacles, the project team conducted a market characterization study, designed educational and outreach materials aimed at increasing market awareness, implemented an on-site monitoring program, and gathered data needed to develop a deemed measure package proposal for submission to Cal TF.

- Energy savings witnessed through the field trials support that, when using the nominal efficiency limits, the advanced motor efficiency gains equal and often exceed the expected efficiency gains. This confirms the importance of continuing work to increase market adoption of advanced motors.
- For advanced motors requiring a variable-frequency drive (VFD), future motor measure packages and utility programs should focus on motor installations where a VFD will provide cost-effective savings. Ultimately, the VFD needs to prove cost effective on its own, with the advanced motor bringing benefits at an incremental price.

IMPACTS

Energy Solutions proposed new offerings to the following measures:

- VFD for Glycol Pump Motor (SWPR002-03)
- VSD for Ventilation Fan, Agricultural (SWPR006-03)

These measure updates were originally recommended in the project team's Final Report for inclusion in the California eTRM; however, funding constraints around measure package updates have halted their progress.

Supply-Chain Engagement for Increasing Packaged Unitary Heat Pump System Adoption

Project Number	ET23SWE0073
Published Date	April 28, 2025
Link to Final Report	ET23SWE0073_Supply-Chain Engagement for Increasing Packaged Unitary Heat Pump System Adoption_Final Report
Technology Area	HVAC
Authors	• Caitlyn Fosberg, Carey Oster, Jim Hanna, Grace Bennett (Energy Solutions) • Jenna Lusczynski, Amruta Khanolkar, Noel Stevens, Mostafa Tahmasebi (TRC)

Summary of Recommendations

The Supply-Chain Engagement for Increasing Packaged Unitary Heat Pump System Adoption Focused Pilot aimed to understand the barriers limiting greater adoption of commercial heat pump rooftop units (HP RTUs) in California and overcome them through a midstream incentive approach. According to the US Energy Information Administration Commercial Building Energy Consumption Survey results, approximately 64 percent of all commercial buildings in the Pacific region of the United States used packaged air conditioners (AC RTUs) to provide space conditioning. Compared with conventional packaged RTUs with natural gas heating, HP RTUs are estimated to reduce greenhouse gas emissions and energy costs by up to 50 percent (US Department of Energy. n.d.). However, despite the prevalence of replacement-ready AC RTUs, HP RTUs have not reached widespread adoption in the commercial sector.

This project provides a market characterization of the commercial heat pump market to identify challenges and opportunities to transform the commercial RTU market in favor of HP RTUs. To complete this market characterization, the project team engaged with market actors across the supply chain to gain insights into barriers to the sales, design, and installation of HP RTUs, and to explore potential interventions to mitigate these obstacles. The team also researched HP RTU technologies available in the market, their technical specifications, California code requirements, and eTRM requirements; additionally, we researched the Comfortably California incentive structure to better understand the current program challenges and develop technical requirements that will help with program adoption. This market research helped guide the development of the focused midstream pilot offered in support of this project.

Results from interviews about the supply chain demonstrate that these are best suited for single-zone applications. It will take years, if not decades, for HP RTU manufacturers to update their systems to be manufactured for these use cases. However, other commercial heat pump technologies—such as dedicated outdoor air systems (DOAS) and variable refrigerant flow (VRF)—show potential for significant impacts on the multizone commercial HVAC market. To increase building efficiency for applications that often exclude HP RTUs, the project team recommends developing a measure package for both VRF and DOAS RTUs.

Based on the culmination of distributor interviews, market research, and an investigation of barriers to HP RTU adoption, the project team recommends:

- **Adding VRF to the California measure offering (California eTRM):** Multizone building applications currently screen out the commercial heat pump RTU measure. To reach California's climate goals, we recommend adding VRF to supplement current commercial fuel substitution efforts.

IMPACTS

The Packaged Heat Pump Air Conditioner Commercial, Fuel Substitution (SWHC046-06) measure was updated to add VRF as an equipment class.

Large Ultra-Low Temperature Freezer Measure Offering

Project Number	ET24SWE0016
Published Date	December 23, 2024
ETRM active date	November 7, 2025
Link to Final Report	ET24SWE0016_Large Ultra-Low Temperature Freezer Measure Offering_Final Report
Technology Area	Process Loads
Authors	Lisa Riker, Phil Pipitone, Paul Kuck (Energy Solutions)

Summary of Recommendations

The Large Ultra-Low Temperature (ULT) Freezer Measure Offering project will update the existing eTRM Measure Package SWCR017, aligning the measure offering size categories with the new ENERGY STAR Laboratory Grade Refrigerators and Freezers Specification V2.0. The measure will remove the upper and lower limits of the existing 15-cubic-foot to 29-cubic-foot size categories and modify the HVAC interactivity methodology, which will align the measure with current market purchasing trends and help reach the state's energy efficiency goals by expanding the model offerings to include energy efficiency programs. The project included capturing baseline energy consumption data, a market assessment, updating the eligible building types and incremental measure cost updates for the measure package.

The California eTRM measure package, SWCR017-04 Ultra-Low Temperature Freezer, has included ULT freezers in two size categories: 15 cubic feet to less than 24 cubic feet, and 24 cubic feet to 29 cubic feet. These categories were based on market availability and energy efficiency benchmarks when the measure was developed in 2017. They did not include high-efficiency units larger than 29 cubic feet, inadvertently excluding the energy savings these models can provide.

While the COVID-19 pandemic increased the visibility of ENERGY-STAR-certified ULTs as an energy-saving measure, many factors continue to expand the market, including an increasing population that needs healthcare, the ever-present research needs, and growing biotech manufacturing and biobanking industries. New technologies—such as advanced compressors and hydrocarbon refrigerants—have enabled large storage capacity models to be as energy efficient as their smaller counterparts, while better insulation and thoughtful design allow these larger units to occupy the same footprint as smaller size models, thus increasing demand for units with volumes larger than 29 cubic feet.

- Adjust the existing measure package to use the ULT size categories and efficiency qualifications defined in ENERGY STAR's Laboratory Grade Refrigerators and Freezers Specification v2.0. MDEC Requirements (kWh per day per cubic foot) for ENERGY-STAR-Certified Ultra-Low Temperature Freezers: -75 degrees Celsius (°C) $0 < V < 20 \leq 0.46$ $20 \leq V \leq 0.35$.
- Capture increased energy savings and drive program participation in new industries by adding all feasible CPUC building types to the eligibility list.
- Update the HVAC interactivity method to use previous study results on ULT and HVAC interactivity effects.
- ULTs present a unique opportunity in that many units are currently connected to monitoring systems that collect data points such as energy use and temperature, among others. The IOUs should leverage data from stakeholders' connected monitoring systems to conduct additional and long-term research on ULT energy use, expected useful life and deterioration of efficiency.

IMPACTS

The CPUC approved the measure package update to Ultra-Low Temperature Freezer (SWCR017-06) on November 7, 2025.

Plug-in 120V HPWH Measure Package Updates to eTRM

Project Number	ET23SWE0074
Published Date	December 12, 2024
Link to Final Report	ET23SWE0074_Plug-in 120V Heat Pump Water Heater_Final Report
Technology Area	HVAC
Authors	Lysandra Meda; Justin DeBlois, PE; Lake Casco, PE; Jenna Lusczynski; Ritesh Nayyar, PE; Amruta Khanolkar (TRC)

Summary of Recommendations

Plug-in 120-volt (120V) heat pump water heaters (HPWHs) are market-ready and have proven to be an important new offering. It is estimated that 90 percent of water heater replacements occur on an emergency basis. Without an easy, fast, and affordable replacement option, homeowners are likely to opt for replacement with natural gas water heaters to match their current water heater fuel type. The 120V low-power HPWH design can plug into existing wall outlets without the expensive electrical panel upgrades or home rewiring often required for gas water heater replacements. A recent California-wide field study reported an average monthly energy-consumption savings of approximately 85 percent in comparison to the pre-existing natural gas water heater, when normalized to kilowatt-hour.

The proposed new residential water heating electrification offerings described below will allow space and power-constrained households to decarbonize and help California meet its goal of installing 6 million heat pumps by 2030. Currently, 93 percent of California's water heating stock is gas and propane water heaters. 120V HPWHs can help utilities, cities, and states meet decarbonization goals by targeting the retrofit market and emergency replacements. Because the 120V plug-in technology does not always contain an inefficient electric resistance element, the energy savings could be substantial, and the technology is expected to meet cost-effectiveness requirements. Current measure packages for fuel substitution already promote "traditional" 240V HPWH systems. This project is aimed at developing measure package research for 120V HPWHs, which would help existing homeowners electrify water heating without major electrical upgrades while receiving incentives from the state.

The current HPWHs in the California eTRM have uniform energy factor (UEF) requirements for eligibility. Since 120V HPWHs have smaller compressor sizes, the UEF for most of the tank sizes are lower than the eTRM eligibility criteria. However, since they do not have an inefficient electric resistance element (or have a smaller size element), 120V units are expected to save more energy.

The following outlines recommendations for updating deemed measures **Heat Pump Water Heater, Residential, Fuel Substitution (SWWH025)** and **Heat Pump Water Heater, Residential (SWWH014),** aiming to support the successful inclusion of 120V plug-in HPWHs in the measure package update to ensure product offerings are cost effective and feasible.

- **Measure offerings:** The 120V HPWH systems should be included as a distinct product category due to their unique market potential and installation ease: plug-in 120V heat pump water heater measure package updates to California eTRM, which are particularly suitable for retrofit applications where minimal electrical upgrades are required. Their distinct feasibility and cost-effectiveness impacts are well suited for measure offerings that are separate from the existing heat pump water heater offerings.
- **Electric resistance:** To ensure easier implementation, electric resistance (ER) and non-ER HPWH offerings should remain separate. This is driven by significant differences in savings and cost-effectiveness based on the cost-effectiveness tool results. Segregating these offerings will allow for better tracking and clearer eligibility criteria for customers and will facilitate smoother program implementation.
- **Measure application types**: Due to their reduced electric upgrade costs, 120V HPWH measures should target existing homes. Therefore, the team recommends adding these

offerings under the normal replacement and accelerated replacement measure application types. Furthermore, following feedback from SCE and SDGE, the team suggest 120V HPWH measure offerings be excluded from new construction measure application type in the SWWH025 and SWWH014 packages, due to code requirements for new construction that mandate 240V HPHW systems in buildings that need to comply with California Energy Code Title 24, Part 6. This exclusion will not significantly impact the fuel-substitution strategy, as these measures primarily target existing buildings and retrofits.

- **Tank size**: Although some tank sizes performed better than others, the project team recommends that all 120V HPWH tank sizes be offered in the measure package. This will provide maximum flexibility to installers and end users to select the appropriate tank sizes for their application. This is particularly important for 120V HPWHs that will have a lower heating output than existing gas systems and will need to upsize their storage capacities in order to provide similar first-hour ratings to meet existing loads. We also recommend that 65- and 80-gallon electric baseline equipment not be offered, since they require heat pump baselines and confer negative or no savings.
- **Building type**: 120V HPWH systems are most advantageous for homes with electrical constraints, as these buildings can benefit most from the plug-and-play nature of 120V systems. This situation can pertain to any home or building type, and the project team recommends that all building types be offered in the measure package. Of note are multifamily dwelling units, which may have infrastructure constraints due to many homes in a single building, and mobile home buildings in parks with constrained infrastructure.
- **Market type**: The focus for 120V HPWH measures should be on retrofit and FS markets, specifically targeting homes transitioning from natural gas to electric water heating systems.
- **Installation standards**: The unique characteristics of 120V HPWHs should be reflected in installation standards that emphasize plug-and-play deployment and retrofit flexibility. This includes incentivizing installers to adopt best practices for replacing existing gas systems without requiring panel upgrades or extensive electrical modifications. The installation location should prioritize areas where free heat can be recovered, such as laundry rooms or other areas with waste heat. While there may be limited flexibility in changing locations for retrofit scenarios, the water heater may need to be relocated in cases where the storage tank size needs to be increased due to the upgrade. In these situations, any new location should provide adequate space for ventilation and comply with manufacturer guidelines regarding air volume requirements.

IMPACTS

The 120V HPWHs were integrated into the 2026 versions of **Heat Pump Water Heater, Residential (SWWH014-08)** and **Heat Pump Water Heater, Residential, Fuel Substitution (SWWH025-10)** measure packages for 2026.

Water and Wastewater Pump Replacement Industry Standard Practice and Measure Package Update

Project Number	ET24SWE0038
Published Date	January 14, 2026
Link to Final Report	ET24SWE0038_Water and Wastewater Pump Replacement Industry Standard Practice & Measure Package Update_Final Report
Technology Area	Process Loads
Authors	Cristalle Mauleon (Lincus, Inc.)

Summary of Recommendations

The SWWP004-03 Measure Package applied only to pumps used for clean water applications, even though similar pump types are also used in wastewater applications. The reason wastewater pumps were not initially considered is that the baseline Pump Energy Index (PEI) criteria used in the measure package is from the DOE-developed Energy Conservation Standards, which only apply to their definition of "clean water pumps."

Wastewater pumping of water treated to secondary treatment standards or better meets the DOE definition, but is not necessarily subject to the standard. Additionally, any wastewater pumps cleared of rags, grit, and other solids that cannot pass through a bar screen are of similar design to wastewater pumps located in subsequent treatment processes at a wastewater treatment plant. Therefore, non-solids handling wastewater pumps also go through the same PEI testing as clean water pumps. This creates a critical need for a comparable measure package for wastewater pumps, to encourage the adoption of high-efficiency pumps in the wastewater market segment. A previous CalNEXT Emerging Technologies (ET) study — ET23SWE0039: Wastewater Pump Measure Development — also identified this gap, recommending the development of a deemed measure package for wastewater pumps. One purpose of this market study was to establish the industry standard practice (ISP) baseline PEI rating for both clean water and wastewater pumps for future measure package updates. The second purpose was to use the ISP findings to update the existing SWWP004 measure package.

It is recommended to use the recent DOE Pump Compliance Certification Database to update the baseline PEI values in the SWWP004 measure package for clean water and wastewater pumps. We also recommend establishing the baseline PEI values at the 25th percentile of the DOE database for each pump size range and control strategy. This approach balances the survey results—which indicated that customers are largely unaware of PEIs and do not consider PEI in their purchasing decisions—with the PEI ratings of all pumps in the DOE database that exceeded the minimum DOE standards.

IMPACTS

The Water Pump Upgrade (SWWP004-04) existing measure was updated to include wastewater pumping, per project recommendations.

Water-Cooled Chillers Market Assessment & Performance Evaluation

Project Number	ET23SWE0025
Published Date	November 30, 2023
Link to Final Report	ET23SWE0025 - Water-Cooled Chillers Market Assessment & Performance Evaluation_Final Report
Technology Area	HVAC
Authors	• Shaojie Wang, Bryan Boyce, Samantha Putlak (Energy Solutions) • Pradeep Bansal (formerly Energy Solutions)

Summary of Recommendations

This report addresses the shortcomings of the current Water-Cooled Chiller (WCC) measure package (SWHC005-03) in the Cal TF eTRM, where WCC Tiers of CPUC's Database for Energy Efficiency Resources (DEER) do not match market conditions. The Tier 1 full-load efficiency (FLE)—measured in kW per ton—of the 10 percent/10 percent requirement contrasts with the Tier 2 part-load efficiency (PLE) requirement of 15 percent /15 percent. WCCs modeled in DEER are based on the same performance curves. This project aimed to add more granularity to the performance maps so that part-load performance is better correlated to the unit integrated part-load value (IPLV) ratings for systems with variable speed compressors.

While a reasonable percentage of equipment can meet CPUC DEER Tier 1 (10 percent/10 percent) above California Energy Code Title 24, Part 6, it is very rare for equipment to meet DEER Tier 2 15 percent /15 percent efficiency levels. FLE and PLE improvements should at the very least be "decoupled" or even better, change to an "inverse" relationship—meaning that as PLE requirements increase from Tier 1 to Tier 2, FLE requirements could decrease slightly. Therefore, having accurate technical performance in the existing measure is crucial to seeing any energy savings in this measure; WCCs modeled in DEER are based on the same performance curves. However, this project aims to add more granularity to the performance maps so that part-load performance is better correlated to the unit IPLV ratings for systems with variable speed compressors.

This effort was started in 2019 and data was presented to the CPUC, resulting in the less restrictive FLE requirements in Section D3 of CPUC Resolution E-5152 of the DEER in 2023.

Between 2019 and 2023, two major trends emerged within the product category of WCCs:

1. Upcoming California Air Resources Board and US Environmental Protection Agency regulations requiring low-global warming potential (GWP) refrigerants.
2. The emergence of waste HRCs to offset or replace natural gas boiler usage. The 2019 vintage dataset was collected mainly for high-GWP refrigerant equipment and did not include any data for HRCs.

The team used EnergyPlus to model low-GWP refrigerant R1233zd data in water cooler chillers and generated performance curves. We then developed a measure package plan to update the measure package WCC (SWHC005-03) in the eTRM. Additionally, the team collected data on low-GWP refrigerants R513A, R454B, and R1233zd in HRC from chiller distributors, and used EnergyPlus to generate performance maps.

The CalNEXT program is currently considering the initiation of follow-up projects intended to address and build upon the HRC findings from this report, with the ultimate goal of measure development.

IMPACTS

The CPUC approved the measure update to **Water-Cooled Chiller (SWHC005-03)** to incorporate requirements around refrigerant usage. However, this update (SWHC005-04) was put in suspension by measure developers and CPUC staff in order to develop a process to troubleshoot the parameterization of the chiller water plant system assumptions that govern the current water-cooler model. Recent parametric modeling attempts have only identified chiller system performance output issues, such as capacity oversizing, high coefficient of performance (COP), and high part-load operating hours.

Custom Measures and Tools

Standardized HVAC Control Sequence Savings Estimation Calculator

Project Number	ET22SWE0043
Published Date	February 27, 2024
Link to Final Report	ET22SWE0043_Standardized-HVAC-Control-Sequence-Savings-Calculator_Final-Report.pdf
Technology Area	HVAC
Authors	Justin DeBlois, Rupam Singla, Tharanga Jayarathne, Bilsay Varcin (TRC)

Resources:

- ASHRAE G36 Savings Estimation Calculator

Summary of Recommendations

This project demonstrated the feasibility of packaging highly complex controls measures into a simplified calculator while retaining both a degree of flexibility for different buildings and a quantifiable level of accuracy.

Based on conversations with stakeholders, the project team recommends that the calculator framework be used to improve program deployment, streamline measure implementation and increase customer satisfaction so controls and RCx measures become more widely adopted. These conversations resulted in recommendations that the framework be further developed to match the specific needs of energy efficiency programs trying to cost-effectively comply with the CPUC's NMEC rulebook and the Energy Trust of Oregon's coordinated research process. This project provides a customizable framework for future implementations to build from. As the calculator becomes specialized for program use, important considerations include the implementation of utility rate structures, agreement on the uncertainty limits, and defining the scope of the building parameters and measures to be considered. In coordination with efficiency programs, the scope of the calculator can be both narrowed to target building type(s) and measures and expanded to include a wider range of existing building conditions. This will allow for more robust automated calibration, and applicability to buildings of different vintages in different states of repair. It will allow program administrators to target buildings that present the greatest opportunity in their portfolio.

Based on the results of the research project, several next steps were determined for general development of the dashboard. During the development process, the team chose to run a lightweight machine learning algorithm, allowing extensive dynamic uncertainty calculations in the back end but at the expense of reduced accuracy in the algorithm's results. Further research can reduce the level of uncertainty by adjusting the machine learning approach as well as the number of parametric simulations used. This will improve the results of data validation, reducing CV(RMSE), NMBE and the error in the savings calculations. In addition, developing custom controls algorithms in EnergyPlus could improve the energy savings estimates for the measures by aligning more closely with G36.

Finally, several methods for calculating uncertainty were assessed through the development of this project. In order to reduce the uncertainty range created by default inputs, more data is needed to define the distribution of each optional parameter in the existing building stock. An approach to uncertainty that dynamically combines each source of error can then be used, reducing risk for the calculator's adopters.

The project team is currently pursuing recommendation to add tool to eTRM Custom Tool Library.

AMI Intelligence Connected Building Energy Modeling

Project Number	ET23SWE0040
Published Date	December 30, 2022
Link to Final Report	ET23SWE0040_AMI Intelligence Connected Building Energy Modeling_Final Report
Technology Area	Whole Buildings
Authors	Benjamin Staub, Keith Downes, Josh Talbert, Matt Deslauriers (VEIC)

Resources:
California Commercial Building Energy Modeling Tool (.zip file)

Summary of Recommendations

The Vermont Energy Investment Corporation (VEIC) developed and refined a building simulation modeling tool, the California Commercial Building Energy Modeling (CCBEM) tool, that uses advanced metering infrastructure (AMI) data and regression methods to identify customer specifics about their facility. The outputs the model generates are efficiency measure suggestions customized to the customer's specific building situation. VEIC demonstrated this technology in K-12 schools, pharmacies, and health clinics; it can also be applied to medium-sized commercial buildings. The ease of use and customized savings analysis of the tools can be a catalyst for users to continually make efficiency enhancements beyond the original suggested control-based strategies.

There are three primary components of the new CCBEM tool: the user interface, the output details and reporting metrics, and the database housing configuration.

User Interface: The project team designed CCBEM user interface with simplicity in mind, aiming to demonstrate the effectiveness of an energy modelling tool that can be used by utility engineers and public end-users alike.

The user interface is divided into three tabs:

1. **Job information:** Contains the name of the building, location information, temperature and electricity unit measurements, and a field to upload AMI data.

2. **Configuration:** Contains qualitative characteristics: the age of the site's HVAC, lighting, and plug systems. Additionally, it contains fields for square footage, ratios of room types to the total square footage, floor height, and window-to-wall ratio.
3. **Measures:** Presents the opportunity for the user to experiment with measure changes.

Output Details and Reporting Metrics: The project team developed CCBEM so that it can be adapted to any time-period measurement a building's utility uses. Once the data is entered in the user input fields and the program runs, the model uses regression methods to identify customer specifics about when and how they use their facility. Then, the CCBEM displays the results of the regression analysis.

Database Housing Configuration: While this project will not result in a permanently hosted tool that utilities and others can access, the optimized tool that results from this project will have its source code made available to utilities for them to modify and host themselves or provide to third-party program administrators; encryption is included in the business fees associated with those hosting services. In preparation for this, the project team developed the tool with Amazon Web Services server-hosting in mind.

The project team will deliver source code for a Streamlit application, along with instructions for running it locally on a Windows computer. The Streamlit application could also be run on a server to allow multiple users to access it via a browser. If public website hosting is desired, a stakeholder could either link to the URL for Streamlit application or add on a user interface to integrate it with their website.

Manufactured Housing Electrification Measure Development Support

Project Number	ET23SWE0031
Published Date	June 20, 2024
Link to Final Report	ET23SWE0031_Manufactured Housing Electrification Measure Development Support_Final Report
Technology Area	Whole Buildings
Authors	Ritesh Nayyar, PE; Yiyi Chu; Angel Moreno; Mostafa Tahmasebi; Laura RuffAgard; Lake Casco, PE (TRC)

Summary of Recommendations

In California, escalating housing costs have driven a greater reliance on affordable manufactured housing, particularly in wildfire-prone areas. However, these homes have historically been excluded from California efficiency rebate programs. While the California Energy Code Title 24, Part 6 building code does not apply to manufactured housing, the industry operates under Housing and Urban Development (HUD) code standards that do not emphasize resilience or efficiency. Despite federal preemption preventing stringent energy efficiency standards, homeowners and mobile home parks can opt for higher efficiency levels through national programs like ENERGY STAR® for Manufactured Homes (ESMH) and Zero Energy Ready Homes for Manufactured Housing (ZERH MH).

These programs offer options for energy-efficient features, along with significant utility bill savings. Additionally, the Northwest Energy-Efficient Manufactured Housing (NEEM) program works to exceed ENERGY STAR standards, driving adoption among manufacturers and retailers. However, upfront costs have hindered the adoption of heat pumps, leading to reliance on energy-intensive electric resistance heaters—and contributing to higher homeownership costs.

This project aimed to foster the development of an eTRM measure package for electrifying newly built manufactured housing in California. This initiative aligned with complementary efforts—like the CalNEXT Mobile and Manufactured Housing Market Characterization Study—to holistically enhance the energy efficiency of the manufactured housing sector. Our approach involved detailed energy savings and cost analysis, along with insights from manufacturer and stakeholder interviews, ensuring a comprehensive understanding of the market's needs and barriers. By establishing baseline and measure case assumptions, we meticulously modeled energy savings for various improvements, including HVAC, domestic hot water systems, and induction cooktops, leveraging programs like ESMH and NEEM.

The findings underline the potential for significant energy savings through envelope upgrades and the adoption of high-efficiency HVAC, domestic hot water, and cooking equipment in newly manufactured homes. Incremental cost analyses revealed the economic implications of transitioning to more efficient systems, while stakeholder insights emphasized the importance of market readiness, educational efforts, and incentive structures for encouraging the adoption of heat pumps and other energy-efficient technologies.

IMPACTS

PG&E has granted approval to proceed with energy modeling analysis to estimate projected savings. The measure is currently in the package plan phase; the team held a preliminary meeting with the CPUC to discuss the plan, and the process will now advance to the Cal TF screening and measure package plan stages, which must be completed prior to the full measure development phase.

Measure Studies and Recommendations

Residential Water Heater Sizing Measure Package Support

Project Number	ET22SWE0036
Published Date	December 30, 2022
Link to Final Report	ET22SWE0036_Residential-Water-Heater-Sizing-Measure-Package-Support_Final-Report.pdf
Technology Area	Water Heating
Authors	• Lake Casco, Ritesh Nayyar (TRC) • Marc Fountain (Formerly TRC)

Summary of Recommendations

This project provides updates to the DEER Water Heater Calculator (DWHC) V 5.1 (California Public Utilities Commission, n.d.), which result in savings values representative of replacing an existing gas water heater with a larger storage HPWH. A statewide measure package that includes these measure savings would enable incentives for these types of upsizing replacements. As shown in the survey results and example installation projects from the California Energy Smart Homes Program, it is increasingly more common in the market to expand HPWH storage capacity. Using the updated tool, the following types of replacements would now be available for efficient HPWHs:

- Replacing an existing 40- or 50-gallon natural gas water heater with a 65-gallon HPWH.
- Replacing two existing 40- or 50-gallon natural gas water heaters with one 80-gallon HPWH.

The current offerings for SWWH025-05 assume a “like-for-like” replacement based on the storage capacity of the existing natural gas water heater and the new HPWH. This update creates new measure offerings that reflect the upsizing of storage capacity and alignment of first-hour rating values when replacing natural gas water heaters with HPWH; however, no specific tank size is recommended because the correct tank size varies by project. Factors that affect upsizing include the location of the water heater, the first-hour rating, the number of people in the house, and overall costs—all of which inform the contractor’s decision about tank size, and which mean there is no standard “oversizing” recommendation.

The current offerings for SWWH025-05 include combinations of heat pump water heaters replacing existing storage or tankless water heaters. However, the workpaper assumes like-for-like replacement based on the storage capacity of existing gas water heaters. For example, Measure Offering K is for installing an HPWH between 55 gallons and 75 gallons, replacing a 60-gallon natural gas water heater; furthermore, Measure K only includes an HPWH with one uniform energy factor (UEF) rating (3.33). This project expands the possible replacements by modeling permutations of UEF ratings and HPWH tank sizes. In all cases, both the base and measure technologies for the new offerings already exist in the DWHC as TechIDs. Therefore, the updates to the tool include creating

new measure offerings using different combinations of existing DEER TechIDs to reflect different combinations and upsizing of HPWH storage tank.

IMPACTS

In 2022, the CPUC updated the DWHC to version 5.1 and included report recommendations.

Impacted Measures:

The following measure package versions adopted the report recommendations:

- Heat Pump Water Heater, Residential (SWWH014-04)
- Heat Pump Water Heater, Residential, Fuel Substitution (SWWH025-06)
- Heat Pump Water Heater, Commercial, Fuel Substitution (SWWH027-03)
- Heat Pump Water Heater, Commercial (SWWH031-02)

Table 2: Measure savings to date.

Measure	Total TSB Claimed
SWWH014*	$510,641
SWWH025	$14,111,707
SWWH027*	$8,295,318
SWWH031*	$1,229,726

*Savings listed for measures SWWH014, SWWH027, and SWWH031 cannot be reported as direct impacts from this project at this time. Values reported reflect all savings for these measures since the addition of measure updates resulting from this project (California Technical Forum [CalTF], n.d.).

Foodservice Refrigeration: High-Efficiency Condenser and Evaporator Units Focused Pilot

Project Number	ET22SWE0054
Published Date	September 24, 2024
Link to Final Report	ET22SWE0054_Foodservice HECU HEEU Focused Pilot_Final Report
Authors	• Amanda Shorin, Kyle Booth, Paul Kuck, Rocco Sucato (Energy Solutions) • Christine White, Gregory Pauza, Jake Ahrens, Melissa Stewart, Nicole Duquette (VEIC) • Angelo Karas, Russell Hedrick (Frontier Energy) • Irina Krishpinovich, Vanya Krishpinovich (Ortiz Group) • Andrew Leishman, Marian Goebes, Yiyi Chu, Rupam Singla, Jose Rosado (TRC) • Derick Baroi, Christopher Rogers (AESC)

Summary of Recommendations

The market characterization study involved dynamic market research on high-efficiency condenser units (HECUs) and high-efficiency evaporator units (HEEUs) in the California commercial refrigeration market. Research methods involved comparison to other state programs, as well as interviews with program administrators, manufacturers, distributors, and trade ally managers. For measure application and potential, the study investigated the supply chain and demand drivers of HECUs and HEEUs. The project team also characterized constraints on the market, which include government regulations and energy efficiency standards, market barriers (such as high initial costs and lack of awareness from contractors), and competitive positioning of various manufacturers and suppliers. This led to an analysis of key market barriers and recommendations on how to overcome them.

This study also examined current market trends, adoption rates for high-efficiency commercial refrigeration products, and the technical potential of a market-integrated midstream program for HECUs and HEEUs in California, and it surfaced growth opportunities and highlighted challenges and key market gaps for participants, such as coordination with supply chain manufacturers, distributors, and contractors.

Overall, results from this focused pilot determined that both an active measure package and a statewide midstream point-of-sale incentive program—along with ongoing partnerships with distributors, manufacturers, and contractors—can help transform the market and overcome barriers to HECU and HEEU adoption while simultaneously reducing ratepayer operating costs, energy demand, energy use, and in some cases, the use of high-GWP refrigerants.

The data prepared in this report has provided the basis for developing a measure package in the California eTRM. Additional analysis may be required to validate and aggregate the data into an

eTRM-friendly format, but the project has provided the foundational data needed to develop measure packages for high-efficiency condensers and evaporators.

The data from the project—including the original metered interval data, analysis spreadsheet, and supporting data—will be packaged for ease of use and future analysis. Measure developers will have access to all data required to fully draft a measure and identify any future measure development needs.

Measure development will require the team to submit a measure package proposal to Cal TF, as well as draft the measure characterization—including the methodologies and formulas used to calculate the savings, development of the measure package content in the eTRM, review from Cal TF, final submittal of a measure package plan, and CPUC review.

IMPACTS

The Energy Solutions team is in the early stages of developing measures as recommended by this study.

Compressed Air End-Use Air Management System

Project Number	ET22SWE0045
Published Date	December 8, 2025
Link to Final Report	ET22SWE0045_Compressed Air End-Use Management_Final Report
Technology Area	Process Loads, Whole Buildings
Authors	• M M Valmiki (ASK Energy) • David Moell (AESC)

Summary of Recommendations

Compressed air energy systems operate in 82 percent of industrial facilities and account for about 10 percent of all manufacturing electrical energy use. This ubiquity—and the inherent inefficient use of energy in compressed air systems—makes them a high-value target for new efficiency measures and program support. Compressed air systems convert high-value electrical energy into usable motive energy at pneumatic end-uses, with an efficiency of only 10 percent to 20 percent. Many opportunities for improvement and energy savings remain, especially in the controls, management, and monitoring of these systems. Despite the large energy footprint of compressed air systems, leaks, artificial loads, and inappropriate uses remain a persistent source of energy waste. One particularly unaddressed opportunity is control and monitoring of loads for large end-use machinery. Manufacturers and vendors in the compressed air industry have acknowledged this market need and new technologies are becoming available.

One such new product is a monitoring-and-control technology known as an air management system (AMS), which can be installed conveniently in both new and retrofit applications. AMSes augment or replace existing filter-regulator-lubricator assemblies, which are nearly always installed upstream of

large pneumatic end uses. These large end-use machines often have internal air leaks, losses, inefficiencies, and unproductive loads, whether production is active or not, and remedying these losses is oftentimes prohibited or too costly if the interiors of these machines are difficult to access.

The new AMS technology can address this issue; its thoughtful design includes features that can be commissioned to reduce supply pressure and completely cut off airflow to these machines when they are idle and unproductive. These control features will generate dependable, reliable energy savings by reducing the load on the air compressors. Additionally, monitoring at these machines can give facility staff insights into their plant and machine health that would otherwise be unavailable.

New plug-and-play widget technologies rarely come to market, especially in the industrial sector, but the emerging technology's calculated savings and impacts set the stage for further opportunities, such as workpaper development. In parallel with such an effort, AMSes could be further validated in a laboratory or additional field demonstration setting, if necessary. The product has a wide training and technical support network for early adopters, and installation is generally straightforward for any typical industrial facility with knowledgeable maintenance staff. The findings suggest that this emerging technology is broadly applicable across the industrial sector and is well-suited for rebate program support that could benefit both utilities and their customers.

Workpaper development would likely need to identify a single set of representative idle flow and idle time per machine size. The project team suggests 25 percent idle time as an assumed, representative idle time, but some confirmation through additional market surveying may be warranted. The effective useful life of the AMS would also need to be defined; the team suggests drawing on approved lifespan of controls measures since the electronics and mechanical valving system is equivalent in terms of longevity.

The workpaper should also make note that there are various manufacturers of pneumatic end-use monitoring systems and off-the-shelf valving but, thus far, only one offers the measure as a packaged, plug-and-play product with flow controls. If included in rebate programs, the inspection process would also be relatively straightforward, as observation of the product's standby and isolation functionality can be conducted during a site visit or in exported data. Control parameters can also be exported or captured from the AMS control portal to further validate measure implementation, if necessary. No permitting is necessary for the measure.

To address the added complexity that AMS presents over incumbent, analog filter-regulator-lubricator products, there is comprehensive training and manual documentation for plant staff to refer to. After the initial learning curve for the first installation, subsequent units will be much easier. Distributors and manufacturer representatives are also widely available to provide support for both the physical and controls installation process. Incentive and rebate programs—such as Industrial Incentive Solutions in Southern California Edison territory—can market the new measure and provide materials and information to both gain market traction and ease the learning curve for early adopters. Potential workpaper limits around eligible conditions can also ensure that customers realize the energy efficiency benefits of the product, thereby avoiding the lower-value applications that could potentially slow the adoption curve. All this combined suggests that the AMS is a rare and valuable opportunity for a new, deemed energy efficiency measure that will be broadly applicable across the industrial sector.

eTRM Heat Pump Baseline Systems Assessment

Project Number	ET23SWE0024
Published Date	December 15, 2023
Link to Final Report	ET23SWE0024_eTRM Heat Pump Baseline Systems_Final Report
Technology Area	HVAC
Authors	Lysandra Medal, Ritesh Nayyar, PE, Lake Casco, PE, Angel Moreno, Abhijeet Pande (TRC)

Summary of Recommendations

The project team identified gaps in the current measure packages and recommends six base case systems to be further analyzed in subsequent studies—or to be considered by IOUs or measure package developers for measure package updates, as shown in Table 3 below.

The project team recommends further studies and energy modeling to inform the potential updates to the measure packages. The proposed potential next steps are as follows:

- **Program Year (PY) 2026 Updates**: These recommended systems could potentially be included in the PY 2026 updates, contingent upon the interest of IOUs and the availability of program resources. The project team acknowledges that bandwidth may be a constraint due to multiple models being run statewide.
- **Midcycle Implementation**: In the event that these recommendations are not incorporated into the PY 2026 updates, they could potentially be implemented as midcycle updates. These can go live as soon as they are approved by the CPUC, which offers a flexible and timely eTRM Heat Pump Baseline Systems Assessment 19 approach to updating the measure packages. The approval process for midcycle updates is managed by the CPUC and IOUs responsible for measure development. Although midcycle updates can be proposed for various reasons, such as adding new offerings, they are typically aligned with specific program years. While the stakeholders see values in these recommendations, the project team also acknowledges the limited statewide bandwidth to accommodate such updates, as well as the regulatory obligations to first complete PY 2026 updates before considering additional offerings in the midcycle updates.

Table 3: Recommended new baseline cases for heat pump measure offerings.

Baseline Case	Central Ducted HP, Measure Case *(Number of TECH Participants)*	Central Mini-Split or Multi-Split HP, Measure Case *(Number of TECH Participants)*	% TECH Program Participation
Central Forced Air Electric Furnace Only	**Recommended 1** *(24)*	**Recommended 2** *(45)*	0.6%
Central Forced Air Gas Furnace Only	SWHC045 *(3,420)*	-	28%
Floor or Wall Gas Furnace Only	-	SWHC044 *(2,295)*	19%
Central AC + Central Forced Air Electric Furnace	**Recommended 3** *(40)*	**Recommended 4** *(11)*	0.4%
Central AC + Central Forced Air Gas Furnace	SWHC045 *(5,190)*	-	42%
Central AC + Floor or Wall Gas Furnace	-	**Recommended 5** *(1,002)*	8%
Window Room AC + Central Forced Air Electric Furnace	-	Not Recommended *(21)*	0.2%
Window Room AC + Central Forced Air Gas Furnace	**Recommended 6** *(53)*	-	0.4%
Window Room AC + Floor or Wall Gas Furnace	-	SWHC044 *(139)*	1%
Central Mini-Split or Multi-Split HP	-	SWHC050 *(0)*	0%
Central Ducted HP	SWHC049 *(0)*	-	0%

Commercial Heat Pump Water Heater Focused Pilot

Project Number	ET24SWE0062
Published Date	December 18, 2025
Link to Final Report	ET24SWE0062_Light-Duty Commercial Heat Pump Water Heater Focused Pilot_Final Report
Technology Area	Water Heating
Authors	• Kurtis Deschamp, Carey Oster, Adam Popp, Grace Bennett (Energy Solutions) • Chris Badger, Katey Beaton, Matt Bourke, Tom Chase, Deirdre Collins, Nathan Mascolino, Asa Parker, Benjamin Staub (VEIC)

Summary of Recommendations

The primary objective of the Light-Duty Commercial Heat Pump Water Heater Focused Pilot is to identify and address barriers to greater adoption of light-duty HPWHs in California's commercial buildings.

As one component of this Focused Pilot, the team reviewed existing measure packages for commercial HPWHs to identify limits on equipment eligibility and recommend updates to the measure packages to expand program eligibility for current commercial water heating programs in California; the team expected to find existing gaps. They then proposed new commercial scenarios to Cal TF, intended as additions to the measure packages. Finally, to determine how to make commercial sales more feasible, demonstration projects were not subject to tank-size-change limitations.

The team recommends the following measure package updates:

SWWH031-05: Heat Pump Water Heater, Commercial

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

- The minimum UEF requirement of 3.3 is higher than the UEF rating of 120V HPWHs. To accommodate 120V HPWHs, the team recommends expanding measures to include lower UEF ratings.

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

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

- Use first-hour ratings to compare hot water volume usage characteristics between gas water heaters and HPWHs. The current measures assume hot water volume usage is primarily based on tank capacity.
- Provide each gas base capacity with their own allowed range of HPWH replacements.
- Expand the allowed HPWH capacities above their current limitations; to have similar performance characteristics to gas units, HPWHs need larger capacities (e.g., 40-gallon gas water heater to 80-gallon HPWH).

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

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

Heat Pump Crankcase Heat Management

Project Number	ET23SWE0029
Published Date	December 15, 2023
Link to Final Report	ET23SWE0029 - Heat Pump Crankcase Heat Management_Final Report
Technology Area	HVAC
Authors	Angel Moreno; Lysandra Medal; Lake Casco, PE; Ritesh Nayyar, PE; Abhijeet Pande (TRC)

Summary of Recommendations

The need for this project arises from field studies that indicate crankcase heaters (CCHs) and other auxiliary loads may use almost half the total energy of HPs installed in California. There is a particular concern that CCHs sometimes operate unnecessarily, so the objective of this study is to evaluate potential solutions to the CCH energy consumption issue and quantify potential savings from identified solutions.

Based on this study, the project team proposed recommendations as follows:

- Update the existing heat pump measure packages to include a requirement for CCH controls. There was a limited window between 2023 and 2026 when energy efficiency programs could incorporate CCH control requirements in the existing heat pump measure packages. Offering a rebate for HP projects that provide documentation showing compliance with CCH control requirements will ease the transition for market actors as they prepare for upcoming code changes.
    - If the lead IOUs—SCE and SDG&E—are interested and have capacity to act quickly after the Final Report comes out, it may be possible for them to implement the CCH control requirement update to current measure packages in time for Program Year 2024

updates. This update might require energy modeling to determine savings but could be turned around more quickly without conducting modeling if the savings from the proposed 2025 California Energy Code Title 24, Part 6 changes are applied.
    - Incorporating the requirement as a short-term program offering could support market actors as they prepare to transition for this to become code in 2026.

- Conduct further research to investigate the prevalence and savings potential of unnecessary CCH operation. This could lead to the potential development of a new retro-commissioning measure for optimizing CCH operation.
- Develop new measure offerings specifically for heat pumps without CCHs.
- Conduct further research at commercial sites to better understand if the modeled savings are representative of field conditions across all program applications.

High-Efficiency Rooftop Unit (HE RTU) Focus Pilot

Project Number	ET24SWE0066
Published Date	December 11, 2025
Link to Final Report	ET24SWE0066_High-Efficiency Rooftop Unit (HE RTU) Focused Pilot_Final Report
Technology Area	HVAC
Authors	• Caitlyn Fosberg, Carey Oster, Jim Hanna, Grace Bennett (Energy Solutions) • Jenna Lusczynski, Mostafa Tahmasebi, Chris Battisti (TRC) • Curtis Harrington (UC Davis)

Summary of Recommendations

According to the 2024 California Commercial End-Use Survey, packaged air conditioner rooftop units (AC RTUs) with gas or electric resistance heating are installed in 64.5 percent of California's commercial buildings. Additionally, 63 percent of commercial building floor space is supported by gas heat (California Commercial End-Use Survey, 2022). As AC RTUs age and need to be replaced, they present a significant decarbonization opportunity through installation of heat pump rooftop units (HP RTUs).

This focused pilot aimed to:

- Determine and define high-efficiency product characteristics for heat pump RTUs and dedicated outdoor air systems (DOAS).
- Establish advanced measure criteria and incentive levels for heat pump RTUs, as well as initial measure criteria and incentives for DOAS.
- Test and assess the effectiveness of measure criteria and incentive levels through a midstream incentive pilot and participant feedback.

- Provide information on incremental costs for high-efficiency HP RTUs and DOAS.
- Deliver recommendations for light commercial HVAC measures to guide future program design.

Measure Package Recommendations

Across nearly all commercial HVAC incentive programs the project team reviewed, cooling and heating performance metrics—such as Integrated Energy Efficiency Ratio (IEER) and COP—remain the primary benchmarks for defining RTU efficiency. These metrics capture standardized part-load and full-load behavior and form the basis of federal code compliance and original equipment manufacturer product differentiation. Considering this industry consensus, the project team's tiered incentive framework anchors each level to progressively higher IEER thresholds. However, given California's unique CZ and energy priorities, the team also identifies a series of state-specific high-efficiency features that address performance gaps IEER does not capture alone, and offers additional savings in California conditions.

The efficiency tiers outlined in the final report are intended to accelerate the adoption of high-performance HP RTUs and encourage installations without electric resistance (ER) heat, addressing peak energy use and adoption barriers. Replacing a traditional RTU with an HP RTU that includes ER heating can double the power requirements of the new system. This would often require upgrading the RTU's electrical service to support the added load and could potentially trigger a full panel upgrade, which can be time-consuming, costly, and complex—all critical heat pump RTU barriers. Furthermore, since HP and ER heating can operate simultaneously, removing electric heaters can also reduce the peak power use of the HP RTU by a factor of two. ER heaters can also add significant energy use by overuse of electric heating, but in many cases, this can be avoided by proper commissioning.

New Commercial Foodservice Measure Prioritization

Project Number	ET24SWE0032
Published Date	December 11, 2025
Link to Final Report	ET24SWE0032_New Commercial Foodservice Measure Prioritization_Final Report
Technology Area	Process Loads
Authors	Paul Kuck, Grant Kelley (Energy Solutions)

Resources in Final Report
Prioritized Measure List

Summary of Recommendations

The existing commercial foodservice (CFS) measures offered in California incentive programs are the most common pieces of equipment for this industry. Many of the most impactful measures in the energy efficiency programs will be considered for appliance code standards in the coming years, or

removed from programs due to the CPUC's gas incentive phase-out Decision 23-04-035 (California Public Utilities Commission, 2023). This will leave the foodservice market—which has the highest energy use intensity in the commercial sector—with fewer opportunities to push savings, despite a wide selection of energy-intensive products used in this market. Currently, there is limited aggregated data to determine which measures would provide the largest impact on the IOU energy-efficiency portfolio.

This project developed a database of criteria for potential new electric CFS measures to help prioritize measure development, which would replace the measures that will be phased out from the IOU energy efficiency programs.

The project aimed to thoroughly assess non-incentivized CFS equipment by developing preliminary savings estimates, estimating measure costs and sales volumes, identifying equipment testing needs and fuel-substitution potential, and engaging with market actors to understand market trends and efficiency efforts. The collective data helped facilitate the prioritization of electric CFS measure development and led to the discovery of the most impactful and cost-effective measures for development for energy efficiency programs.

Table 4 below presents the 10 measures that ranked the highest in the scoring methodology. These measures scored highest in the five ranked categories, but because factors such as measure development complexity and implementation feasibility were factored into the scoring system, they do not necessarily offer the highest savings opportunities for the energy efficiency programs. For example, the sales data for hot dog grills/rollers—which are used extensively in convenience stores—show potential for large annual sales and indicates they could offer significant savings opportunities to the energy efficiency portfolio, but they do not have a test methodology and have no test data available. The lower score for this measure factors in the additional time to implement and the lack of data available to accurately confirm savings estimates.

Overall, each measure has market or measure development aspects beyond what can be ranked and scored; these should be considered when further evaluating measures for development. With this scoring system, the booster heater ranked just out of the top 10 because the measure package could be produced with no testing, significantly reducing the effort and time to implementation, but the savings opportunity is very low at 12,000 kWh per year. The HEEU and HECU measures offer significant savings opportunities, but they are sold outside the CFS sales channel, which could create program-delivery hurdles. Conveyor dishwashers offer significant gas and electric savings but could be included in Title 20 appliance standards, which would reduce or eliminate the savings opportunity.

As such, this information should be used as guidance for measure development rather than a strict sequential list. Additional opportunities in the list should be reviewed and considered for further testing and analysis to verify savings opportunities for the IOU energy efficiency programs.

Table 4: Top measures for development.

Measure	kWh Per Unit	Unit Count	Total Annual kWh
High-Efficiency Evaporator Unit (HEEU)	902	1,442	780,712
High-Efficiency Condensing Unit (HECU)	4,146	292	726,077
Rapid Cook Oven - Microwave	2,870	328	564,127
Conveyor Dishwasher	7,262	55	239,864
Synchronous Motor (open cases and walk-ins)	375	1,000	225,000
Pasta Cooker	7,704	9	42,526
Conveyor Impingement Oven	1,985	91	108,596
Conveyor Oven	2,100	40	50,094
Convection Oven: 1/4 Sized	546	338	110,496
Espresso Machine	1,991	113	135,109

Smart Controls for Data-Driven Indoor Agriculture Field Evaluation

Project Number	ET23SWE0067
Published Date	September 19, 2025
Link to Final Report	ET23SWE0067_Smart Controls for Data-Driven Indoor Agriculture Field Evaluation_Final Report
Technology Area	Process Loads
Authors	Gretchen Schimelpfenig, PE; Ethan Clifford, PE; Brad Watterud, PE (ERI)

Summary of Recommendations

The CalNEXT Smart Controls for Data-Driven Indoor Agriculture Field Evaluation project explored the market potential for and evaluated the impact of “smart controls” technologies on controlled environmental agriculture (CEA). This method of agriculture involves the cultivation and manufacturing of floriculture, food, and cannabis products; more greenhouses and indoor farms are being built in California to meet increasing demand for a consistent supply of these and other high-quality horticultural products. The study focused on automated, integrated, and intelligent environmental control technologies used in indoor and greenhouse CEA facilities in California, which

monitor, evaluate, and control energy consumption of a facility's HVAC, lighting, crop irrigation, and nutrient management systems. The project included a market assessment, field evaluations, and a technology roadmap (recommendations) to identify cost-effective energy efficiency and demand response measures for smart environmental controls in California's CEA sector.

From December 2024 to May 2025, the project team documented issues and resolutions to identify field demonstration deficiencies. The technology roadmap shares five program pathway recommendations, including ideas for two new energy efficiency measure packages. The results from the study yielded the following lessons learned:

- California cannabis, tomato, vegetable, herb, and strawberry growers are more likely to use smart HVAC controls than some floriculture growers due to higher profit margins and tighter plant-specific environmental requirements.
- CEA businesses are more likely to be hard-to-reach (HTR) customers and require unique outreach strategies.
- Automated greenhouse lighting controls and automated greenhouse ventilation fan controls can achieve significant energy savings for growers across California.
- The proposed changes to the 2028 version of the California Energy Code Title 24, Part 6 requirements for greenhouses may include a requirement for greenhouse lighting controls.

The project concluded that accelerating the adoption of integrated and intelligent control systems with energy monitoring at CEA businesses may be challenging because some CEA facilities are in areas that require a higher level of effort for program outreach. Similarly, small farms may not produce cost-effective energy savings for a smart CEA environmental controls energy efficiency program.

Currently, a greenhouse daily light integral (DLI) controls measure for supplemental lighting systems is not included in specialized daylighting measures for horticultural process lighting in the California eTRM. This measure reduces energy consumption by using automated, integrated, and/or Level 2 through Level 4 intelligent controls that modulate lighting power to meet a set DLI target.

Data from California commercial CEA businesses supports smart controls program design with actual energy consumption and demand data from multiple sites across the state. The impact of the field demonstrations' findings on the CEA market and key industry stakeholders (such as California IOUs) include:

1. Confirm the Level 0 to Level 4 baseline level of control for CEA lighting, HVAC, and irrigation controls, based on the results of this study's surveys, interviews, site visits, and field demonstrations. Document the IOU-specific baseline equipment by crop type, facility size, or other parameters using the operational details described in site visit and field demonstration reports to develop a standalone work paper.

2. Develop a deemed measure package for greenhouse supplemental lighting DLI controls. The proposed changes to the California Energy Code Title 24, Part 6 requirements for greenhouses may include a requirement for DLI controls; this gives IOUs three years to implement an energy efficiency program for DLI controls before the energy code requires this automation strategy. The recommended calculation methodology can be modified and used as the permutations for a new deemed measure based on CZ, crop type, or DLI target.

The team recommends sharing the measure idea with the Cal TF team to determine the next steps to launch a deemed rebate program for DLI controls.

3. Develop a deemed measure package for installing a variable frequency drive on agricultural circulation fans in greenhouses. The recommended calculation methodology can be modified and used as the permutations for a new deemed measure based on CZ, crop type, or DLI target. The team recommends sharing the measure idea with the Cal TF team to determine next steps for launching a deemed rebate program that could provide variable frequency drive (VFDs) for greenhouse ventilation fans.
4. Develop a unique outreach strategy for HTR CEA businesses in IOU territory. Many businesses active in the CEA market are more likely to be HTR customers because concentrations of cultivation facilities are in counties that satisfy the HTR geographic criteria. CEA businesses in these counties are considered HTR customers if they meet one other HTR criteria, and the study found that CEA businesses may meet several other HTR criteria more often. For example, these businesses may operate in leased buildings, their owners or operators may not speak English as a first language, and enterprises may be micro-businesses with less than 25 employees.
5. Leverage controls equipment manufacturers and distributors to encourage technology transfer and recruit CEA customers and contractors to participate in new CEA controls incentive programs and/or project marketplaces. Controls equipment manufacturers can help confirm the incremental cost of different levels of control for CEA lighting, HVAC, and irrigation controls for IOU territories. Consider implementing rebate programs upstream to accelerate adoption of smart CEA environmental controls.

Active CalNEXT Projects with Future Measure Impacts

Controllers for Inverter-Driven Compressors

Project Number	ET24SWE0012
Expected Date	Q3 2026
Technology Area	HVAC
Authors	AESC

Project Description

The proposed project will evaluate patent-pending compressor controller technology through a field demonstration. The field demonstration entails installing the technology onto an existing variable refrigerant flow (VRF) system with inverter-driven compressor to understand its potential energy savings. This commercially available technology increases the suction pressure of the compressor to optimize the inverter compressor operation when system demand reduction occurs. As a result, the optimization allows for an overall compressor lift decrease, which saves compressor energy while maintaining occupant comfort. To the team's knowledge, there are no known competing manufactures of this technology or an existing energy efficiency measure. This ongoing work will inform the framework for a new deemed or custom measure package.

Load Shape Planning Tool Development

Project Number	ET25SWE0041
Expected Date	Q3 2026
Technology Area	Portfolio Enhancements
Authors	TRC; Second Hand Energy, LLC

Project Description

The creation of new usage load shapes is planned to be completed before the PY 2028 program cycle. This project will identify usage load shapes for 10 strategically chosen deemed measure packages and examine the appropriate level of granularity to strike a balance between the costs and benefits of compiling, saving and using more data.

This project will examine five types of electric load shapes and their sensitivity to Total Resource Cost (TRC) and TSB, as compared to the other significant knobs for cost effectiveness. Recommendations for developing appropriate usage load shapes—along with guidance on how to incorporate this information into a development tool—will be created to support focused development of usage load shapes for the next deemed measures program.

Optimization of Deemed Data Collection Requirements

Project Number	ET25SWE0038
Expected Date	Q2 2026
Technology Area	Portfolio Enhancements
Authors	TRC; Second Hand Energy, LLC

Project Description

Deemed measures rely on competing goals of accuracy and volume to ensure that the gross claims are reasonable. However, making a single claim more accurate requires more documentation, which increases the cost of supporting each customer's claim; higher customer acquisition costs will decrease the volume of claims. This project proposes to quantify the tradeoffs of data collection requirements to minimize customer acquisition cost while still maintaining reasonable accuracy in the claimed savings. Five commonly implemented measures and two unused or rarely used measures from the California portfolio in 2023–2024 will be examined to inform more general recommendations for guiding the development of PY 2028 measure packages. Ideally, by driving down data collection costs, the volume of claims can increase—ultimately leading to broader participation and more energy savings achieved in the market.

Packaged Propane Refrigeration Market Analysis

Project Number	ET25SWE0011
Expected Date	Q2 2026
Technology Area	Process Loads
Authors	VEIC

Project Description

This project consists of market analysis and measure package development of strategies to promote packaged propane (R290) refrigeration systems for walk-in coolers and freezers in small-to-medium food retailers and food service establishments. These systems use a natural refrigerant, R290, which offers energy savings, easier installation, and reduced maintenance costs compared to traditional hydrofluorocarbon systems.

The project will quantify R290's potential to reduce California statewide greenhouse gas emissions, energy use, and operating costs. It addresses barriers to adopting R290 systems and develops utility program recommendations designed to support compliance with upcoming refrigerant regulations and benefit underserved businesses with higher operating costs. By collaborating with manufacturers, contractors, and regulators, the project promotes technology transfer and ensures a fair transition to sustainable refrigeration solutions.

PG&E HVAC Tool Validation, Phase 2

Project Number	ET25SWE0011
Expected Date	Q4 2026
Technology Area	HVAC
Authors	TRC

Project Description

Cal TF and PG&E requested that TRC implement recommendations from PG&E HVAC Tool Validation Study (ET23SWE0060) to comply with program requirements and strengthen tool accuracy and applicability. They also requested that the team examine temperature reset fan and pump penalties, as well as zone-level minimum variable air volume calculations.

To validate and build upon CalNEXT Project ET23SWE0060, TRC proposes to update airside, hot water, and chilled water system calculations. The airside updates include more recent fan curves, supply air reset calculations, and zone control; meanwhile, the hot water updates include boiler sequencing and reset, while the chilled water updates include the addition of air-cooled systems and reset calculation improvements.

The results of this work will maximize the effectiveness of the HVAC tool for users, developers, program administrators, and evaluators. They will also increase tool understanding and minimize uncertainty when using the tool to forecast and verify energy savings claims and incentives.

Resources in ET23SWE0060 - PG&E HVAC Tool Validation Final Report
PG&E HVAC Tool v2.2.03
PG&E HVAC Tool v2.2.03 Documentation
Support File: Minimum Air Flow Ratio
Support File: DAT Heating Load Fan Energy

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