2024 Portfolio Enhancements TPM

Final Report

ET24SWE0050

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California Energy Commission
California Market Transformation Administrator
California Public Utilities Commission
California Technical Forum
Commonwealth Edison Company
National Renewable Energy Laboratory
Northwest Energy Efficiency Alliance
Pacific Gas and Electric
Pacific Northwest National Laboratory
San Diego Gas & Electric
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Abbreviations, Acronyms, and Glossary of Terms

Acronym	Meaning
AC	alternating current
ADLD	Automatic and dynamic load detection
ASHRAE	American Society of Heating, Refrigeration, and Air-Conditioning Engineers
CA	California
CARB	California Air Resources Board
CEC	California Energy Commission
CEH	Controlled Environment Horticulture
CDC	Center for Disease Control
CPAP	continuous positive airway pressure
CPUC	California Public Utilities Commission
DAC	disadvantaged communities
DER	distributed energy resources
DERMS	distributed energy resource management system
DH&C	district heating and cooling
DOE	Department of Energy
EE	energy efficiency
ET	emerging technology
EV	electric vehicle
EVSE	electric vehicle supply equipment

Acronym	Meaning
FDAS	Flexible Demand Appliance Standards
GHG	greenhouse gas emissions
HP	heat pump
HTR	hard-to-reach
HVAC	heating, ventilation, and air conditioning
IEPR	Integrated Energy Policy Report
IOU	investor-owned utility
LBNL	Lawrence Berkely National Laboratory
NOx	nitrogen oxide
NREL	National Renewable Energy Lab
PPLs	plug and process loads
RASS	Residential Appliance Saturation Study
SCE	Southern California Edison
SME	subject matter expert
SPUR	San Francisco Bay Area Planning and Urban Research Association
TPM	Technology Priority Map
TSB	Total System Benefit
TWh	terawatt hour
VRF	variable refrigerant flow
WH	water heating

Glossary	Meaning
Technology Category	One of six broad technology categories: Whole Buildings, HVAC, Water Heating (WH), Lighting, Plug Loads and Appliances, Process Loads.
Technology Family	Functional grouping that provides description of program role, opportunities, barriers.
Research Initiatives	New initiative in place of both subgroups and knowledge indices
Research Initiatives Key	Visual aid explaining whether a research initiative is at a high level of understanding, is research in progress, has immediate needs, or demonstrates future research needs.
High Understanding	Projects have run in this technology category, overall, the market is comfortable with this technology category, and it is well known.
Research In Progress	CalNEXT projects are currently running regarding this technology category.
Immediate Needs	There is a need to learn about this technology, and there may not be any CalNEXT projects taking place at this time.
Future Research Needs	If the technology is not on the immediate horizon and requires further understanding and research before being fully developed.
Definitions	Narrative to provide additional clarification on the technology family scope.
Opportunities	Description of potential impacts and potential research areas.
Barriers	Description of barriers and potential barriers research.
CalNEXT Role	Describes general level of engagement by CalNEXT SMEs. Note: Roles will change as research is completed.
Lead Collaborate Observe	"Lead" — CalNEXT expects to take on most or all of the work and cost burden. "Collaborate" — CalNEXT is interested in collaborating and co-funding projects. "Observe" — CalNEXT will track progress but encourage external programs to take lead in unlocking these opportunities.
CalNEXT Priority	Communicates expected level of focus by CalNEXT SMEs. Note: Priorities will change as research is completed.
High Medium Low	"High" — CalNEXT SME team has highlighted this technology family as having high impacts within the Technology Category. "Medium" — CalNEXT SME team determined this technology family has moderate overall impacts within the Technology Category. "Low" — CalNEXT SME team has highlighted this technology family as having low relative impacts within the Technology Category.

Introduction

The Technology Priority Maps (TPMs) provide the CalNEXT Program a framework to externally communicate priorities of the program, clearly define the central focus areas of the program, and assist with project screening. They will document the impact potential, programmatic research needs, and market readiness of all technology families across each of the end-use topic areas. The TPMs will drive product ideation and inform project selection. This Final Report covers the revision process for the 2024 Portfolio Enhancements TPM.

Methodology

The Portfolio Enhancements TPM is a TPM revision that will address the portfolio issues that are not specific to an end-use technology, but rather impact emerging technologies across the portfolio. The origins of this TPM are in conversations with energy efficiency (EE) portfolio stakeholders. When these stakeholders were asked about CalNEXT research and the path into the portfolio for emerging technologies demonstrating technical promise, they would report significant barriers not based in a particular technology or single end-use but relating to the overall parameters of CPUC-funded programs. This TPM gathers these barriers into one document for consideration by the larger community of EE stakeholders and provides actionable suggestions on the type of research that CalNEXT has interest in working in, that also fits into the overall portfolio. The Portfolio Enhancements TPM aims to further clarify potential areas of study and offers definitions, opportunities, and barriers for a set of technology families. Notable drivers include:

- The need for broader decarbonization solutions to meet California's climate goals to reduce statewide greenhouse gas emissions (GHG) by 40 percent below 1990 levels by 2030 (SB 32), achieve carbon neutrality by 2045, and meet net neutrality thereafter (AB 1279).
- California requirements for funding to Disadvantaged Communities (SB 535).
- The fundamental parameters of the California EE Portfolio, including metrics and rules such as Total System Benefit (TSB), Total Resource Cost (TRC), Normalized Metered Energy Consumption Rulebook, Fuel Substitution technical guidance, and Refrigerant Emissions avoided cost calculation.

For the 2024 Portfolio Enhancements TPM with much new content, the CalNEXT Program Team established a robust process for this TPM development and revisions. This year, the project team is incorporating a stronger outreach push to ensure that feedback directly targets potential deemed measure stakeholders from the CPUC, Program Administrators, implementers, research laboratories, and technology companies. The project team is comprised of representatives from each of the Program Team partners: VEIC, AESC, TRC, UC Davis, and Energy Solutions. The Portfolio Enhancements SME team represents members that collectively support an array of EE programs using technologies covered by the various TPM domains, and these emerging products are then contextualized into the priority maps through a markets and solutions lens. The team met four times between August and September of 2024.

The SME team worked through a number of visual changes at the start of this revision process that can be seen below in the narratives of the Final Report. These visual changes will serve for

submitters and viewers to see what topics are of most interest in a given technology family and what is most important to progress within the portfolio, with an end goal of a simplified view. For example, the table in the Time of Use and Value of Load Flexibility technology family has an initiative named "Research and creation of additional load shapes for EE Measures." The first two criteria, Performance Validation and Market Analysis are technology-driven, while the next two, Measure Development and Program Development are market driven. When a submitter views the table, the icons and their accompanying descriptions will help depict what projects are the most in need. The changes provide a visual summary of the topics of most interest within a given technology family and to record the current state of progress. The end goal of these visual summaries is to have a clear representation of where the technology family stands in the portfolio and identify the remaining research required. The simplified icon view in the Research Initiatives table describes the three to five most important technology areas that the team can prioritize for subsequent versions. The intent was to demonstrate more clearly how the SME Team assessed each research initiative's maturity level.

Table 1: Icons and their Meanings

Icon	Meaning
	High Understanding
	Research In Progress
	Immediate Needs
	Future Research Need

Some major additions in this Portfolio Enhancements TPM include consideration of the newly implemented Total System Benefit (TSB) metric, its role in emerging technology (ET), and CalNEXT's ability to support understanding of the metric in the energy efficiency (EE) landscape. The structure of the TPM Research Initiatives table was developed to ensure strong coordination among CalNEXT activities. Overall, the changes made in this 2024 TPM aim to increase technology transfer broadly across our portfolio, allowing the CalNEXT team to define new measures of interest and illustrate our efforts to bring them to the portfolio. These changes should put greater focus on shorter-term activities like measure packages to support the expansion of the existing Resource Acquisition programs. Even for longer-term investments, the new visual format will provide more tactical guidance as to the research needed to advance different technologies to the ultimate goal of portfolio savings.

Stakeholder Feedback

TPM Advisory Committee Outreach

The TPM Advisory Committee outreach began in October 2024, when stakeholders' feedback was requested via email, which resulted in this Word document of the technology family narratives. The TPM Advisory Committee members are listed below in Table 2.

Table 2: Advisory Committee Outreach

Organization
American Council for an Energy-Efficient Economy (ACEEE)
California Air Resources Board (CARB)
California Technical Forum (CalTF)
California Market Transformation Administrator (CalMTA)
California Energy Commission (CEC)
California Public Utilities Commission (CPUC)
Pacific Gas & Electric (PG&E)
Pacific Northwest National Laboratory (PNNL)
Southern California Edison (SCE)
San Diego Gas & Electric (SDG&E)

This outreach conducted allowed advisory committee members to provide candid feedback in written comments and suggestions. The resulting written comments and suggestions were reviewed by the TPM coordinator, the 2024 Portfolio Enhancements SME team, and incorporated into the Revised 2024 Portfolio Enhancements TPM section below. A detailed table of the changes made can be found in the Advisory Committee Feedback and Resolution Matrix in Table 9 in Appendix A. For any outstanding questions, the project team will hold an optional question and answer session that stakeholders can choose to attend to ask for clarifications regarding the 2024 Portfolio Enhancements TPM revisions.

Electrification and Fuel Substitution

ETP Role: Lead | ETP Priority: High

Definition

This technology family is focused on supporting electrification, fuel substitution from regulated fuels, and fuel switching from nonregulated fuels, as well as identifying critical barriers and developing consistent and effective solutions. Beneficial electrification involves use of the most efficient conversion or fuel substitution strategies, switching from a carbon intensive fossil fuel source in buildings and transportation end-uses to electricity generated from a clean renewable energy source. Electrification is commonly achieved with individual end-uses, but often requires a broader assessment of impact on the building, community, or utility infrastructure. Associated impacts can include necessary upgrades to a building and utility electrical infrastructure to accommodate the higher electric demand associated with increased electrification of building energy, transportation, and process loads in California homes and businesses as well as the incorporation of onsite renewable energy and energy storage.

Research Initiatives

The goal of the research initiatives for California's decarbonization strategies described below is to identify both common and unique electrification and fuel substitution or switch pain points and support the development and demonstration of innovative and scalable solutions. The focus areas of this portfolio enhancement will be on policy, program, and multiple end-use control solutions to support scaled electrification for both buildings and communities to avoid expensive electrical infrastructure upgrades.

Table 3: Electrification and Fuel Substitution Research Initiatives

Research Initiatives	Performance Validation	Market Analysis	Measure Development	Program Development
Cost-effective electrification, load flexibility, and control strategies	⚠	⚠	☝	☝
Lagging market sector electrification research and tools	⚠	⚠	☝	☝
Beneficial electrification policy and program strategy alignment	⚠	⚠	☝	☝
Technology gaps for all market sector and application electrification	⚠	⚠	☝	☝

KEY High Understanding | Research In Progress | Immediate Needs | Future Research Need

Opportunities

Electrification of the California's buildings, end-uses and transportation will be essential to meet California goals to be carbon neutral by 2045, reducing carbon emissions by 85 percent from 1990 levels (AB 1279, statutes of 2022), and requiring 100 percent of electricity by 2045 to be from renewable energy and zero-carbon resources (SB 100, statutes of 2018). California is making significant investments in building electrification through statewide and regional efficiency programs, large heat pump market transformation efforts such as TECH Clean California, and the Inflation Reduction Act (IRA) tax credits and rebates that encourage higher-efficiency products and electrical upgrades. However, additional innovation and market assessments are needed to improve policies, program strategies, tools, and technology solutions to maximize the overall impact of funding investments and reduce the financial burden of electrification of buildings on owners and tenants.

For broader scale electrification it is imperative to assess the cost, barriers, benefits, and effectiveness of technology solutions and load flexibility controls comprehensively at the individual end use, building, and utility level. For example, targeted high priority electrification areas like HVAC and water heating have competing solutions that prioritize benefits to the customer either in improved performance, reduced installed or operational costs, or alternatively to the utility for mitigating the impact to the grid; all of which are often achieved with different degrees of complexity, cost, and required market and contractor engagement.

Additionally, historically lagging market sectors like small and medium businesses require targeted research and tools to support successful electrification strategies. In addition, identifying specific technology gaps and appropriate solutions is necessary to achieve comprehensive electrification in California.

Another area of importance is zonal electrification, where the most cost-effective way of scaling will need to be researched and analyzed. Insights on appliance controls, distributed energy resources (DER) vs demand response (DR) vs home management, will provide programs with different control strategies and inform the level of compatibility of the various load flexibility solutions.

Barriers

Primary barriers to building electrification are the complexity, cost and time associated with the replacement of existing fossil fuel end uses with electrical solutions. Gaps in availability of simplified electrification solutions and increased burden of building code, permitting, and program requirements significantly impact scaled electrification.

Unplanned building electrification can also lead to the potential need to replace expensive electrical panels and utility service upgrades in homes and businesses to accommodate new electrical loads.

Increasing peak electric demand also leads to increased grid infrastructure requirements, such as replacement of transformers, distribution wires, and additional generation, increasing future costs for all ratepayers. The cost of electrical upgrades, especially for lower income households and small businesses, can pose a significant barrier to scaling electrification in California.

DAC and HTR Program Needs

ETP Role: Collaborate | ETP Priority: High

Definition

Disadvantaged communities (DAC) and hard-to-reach (HTR) communities often face multiple barriers to accessing energy efficiency (EE) and decarbonization programs. These barriers include financial constraints, lack of program awareness, language isolation, and substandard housing. The objective of this technology family is to identify barriers requiring new portfolio solutions and policies and proposing tailored strategies that ensure equitable access to emerging technologies[1], energy efficiency, and electrification programs. Addressing the unique energy burdens and challenges of DACs and HTRs in integrating electrification technologies and real-time load management strategies is critical to both the energy savings and the grid stability needed to advance California's decarbonization goals.

Research Initiatives

Table 4: DAC and HTR Research Initiatives

Research Initiatives	Performance Validation	Market Analysis	Measure Development	Program Development
Evaluate DAC and HTR barriers to energy efficiency and electrification program participation. The goal is to identify, classify, and quantify obstacles such as financial constraints, limited program awareness, language isolation, and property ownership complexities, e.g., the challenges faced by renters versus property owners.				
Assess financial and nonfinancial co-benefits of EE programs, electrification, and load flexibility programs in DACs and HTR communities				

[1] Emerging technology risks could include unknowns from lack of proven performance, costs, and other barriers such as community mistrust of programs

Research Initiatives	Performance Validation	Market Analysis	Measure Development	Program Development
Investigate the costs, feasibility, and technical challenges of retrofitting substandard housing in DAC and HTR communities preventing installation of advanced energy efficiency and electrification measures in older buildings.	⚠	⚠	☝	⚠

KEY High Understanding | Research In Progress | ⚠ Immediate Needs | ☝ Future Research Need

Opportunities

DAC and HTR communities offer significant opportunities for targeted energy efficiency and electrification initiatives. Focusing on direct install programs, real-time load management, and culturally relevant outreach can maximize the positive impacts in these underserved areas. DAC and HTR communities are disproportionately affected by energy inefficiency and face barriers such as lack of program awareness, language obstacles, and financial constraints. Addressing these issues through dedicated programs will not only improve energy efficiency but also reduce energy costs, improve indoor air quality, and generate local job opportunities.

Programs focused on DAC and HTR households offer the potential for significant co-benefits, including health outcomes from improved indoor environments, increased resilience to climate impacts, and economic opportunities through local job creation in energy efficiency and electrification efforts. These efforts can also help bridge the gap between urban and rural communities and address the unique energy burdens that affect low-income households.

By integrating real-time load management technologies into DAC and HTR programs, these communities can reduce energy consumption during peak hours, stabilizing the grid while offering the best chance at cutting operating costs and providing long-term affordability. Programs that combine demand response, time-of-use rates, and smart home technologies provide immediate opportunities for households to engage with their energy use. These strategies also enhance resilience during peak demand periods.

Barriers

Despite the significant opportunities in DAC and HTR communities, barriers continue to hinder widespread participation in energy efficiency and electrification programs.

Many DAC and HTR customers face financial constraints that prevent them from investing in energy-efficient technologies or participating in programs requiring upfront costs. Substandard housing and older buildings in these communities often prevent the successful implementation of energy efficiency measures, making upgrades more costly or technically challenging.

In DAC and HTR communities, where renting is common, split incentives between tenants and landlords discourage energy efficiency and electrification upgrades. Landlords often bear the costs of retrofits, but tenants reap the cost savings, leading to reluctance among property owners to invest in improvements.

In many HTR areas, a lack of skilled contractors and workforce limits the ability to deliver electrification and EE measures at scale. There is also a need for training a culturally competent workforce to better serve diverse communities.

Awareness and understanding of real-time pricing, demand response programs, and load-shifting opportunities are often low in DAC and HTR communities, limiting participation. Many DAC and HTR households lack access to smart technologies that enable real-time load management. High upfront costs for smart devices, such as smart thermostats and home energy management systems, can prevent participation in grid-responsive programs. Some DAC and HTR areas may lack the necessary grid infrastructure, such as advanced metering infrastructure (AMI), required to fully participate in real-time load management programs.

Lifecycle Refrigerant Management and Emissions Reductions

ETP Role: Collaborate| ETP Priority: High

Definition

This technology family focuses on technology strategy and policy frameworks that could impact multiple end uses. The objectives include:

- Creating an actionable framework for reducing refrigerant emissions across end uses.
- Examining barriers to replacing refrigerants with lower-GWP alternatives.
- Aligning refrigerant emissions reductions calculations within the Total System Benefit (TSB) metric with current practices in the field.

It will complement the approaches within the HVAC, Water Heating, and Process TPMs to reduce leaks in existing refrigerant systems and drive active recovery, reclamation, and destruction of high-GWP refrigerants. The framework also emphasizes the need for clearer definitions for Lifecycle Refrigerant Management (LRM) within the California EE portfolio and incentive structures, which are needed for more cost-effective, impactful incentives and program interventions. LRM broadly refers to refrigerant leak prevention, detection, and repair during the operational life of equipment and refrigerant recovery and reclamation or destruction at equipment end of life, all with the goal of eliminating refrigerant emissions, given these are primarily gases with GWP values thousands of times higher than CO_2.

Research Initiatives

Table 5: Lifecycle Refrigerant Management and Emissions Reductions Research Initiatives

Research Initiatives	Performance Validation	Market Analysis	Measure Development	Program Development
Market study of industry strategies to improve refrigerant reclamation rates, including targeted incentives for certified end of life refrigerant recovery.	⚠	🎯	⚠	⏳
Market study and performance validation of scalable ALD, and analytical, predictive alternative monitoring options.	⚠	🎯	⚠	⏳

Research Initiatives	Performance Validation	Market Analysis	Measure Development	Program Development
Market study of California contractors' existing equipment installation practices and characterization impact of technician certification and training on quality installs, including zero-leak fitting and joining as a low-cost simple DI program solution and O&M requirement under California's eTRM to ensure safe handling of A2Ls/A3s as required by state code.				
Revise and recommend updates to TSB assumptions and equipment categories to more accurately reflect refrigerant charge size, leak rates, reclamation rates.				

KEY High Understanding Research In Progress Immediate Needs Future Research Need

Opportunities

The California energy efficiency portfolio programs have taken a big step toward recognizing the GHG benefits of mitigating refrigerant leaks in 2024 with the adoption of the Total System Benefit (TSB) metric, but many aspects of how the EE portfolio considers and handles refrigerants can be further optimized to achieve the state's emissions reductions goals. Utility efficiency programs are traditionally valued for their energy savings, but they also offer a cost-effective platform to expand services focused on emissions reduction. With established customer relationships, administrative systems, and technical expertise, utilities are well-positioned to promote the adoption of ultra-low or zero GWP refrigerant options and accelerating market awareness and importance of effective refrigerant management. Since refrigerant emission reductions often align with energy savings, LRM efforts collectively can seamlessly integrate into existing programs, and deliver both direct energy savings and indirect cost and emissions savings benefits to customer across all sectors. Utilities will need to prioritize refrigerant management in the wake of new federal regulations under subsection (h) of the AIM Act. As part of this prioritization exercise, utilities must take a more comprehensive approach to integrating LRM strategies that support the transition to lower-GWP refrigerants. A transition to an LRM approach to calculating the refrigerant emission impacts will enable programs to more accurately measure lifetime CO_2e savings, and in so doing, enhance the effectiveness of their efforts.

Barriers

While market awareness and adoption of natural refrigerants in commercial refrigeration have grown significantly across the California market in recent years — driven by SB 1206 and 1383, CAFRIP and programs like EPA's SNAP — in contrast the HVAC sector has faced notable challenges. A primary obstacle has been the lack of harmonization between US national codes and international safety standard regarding natural refrigerants. Additionally, misaligned efficiency and emissions metrics, misuse of EPA SNAP guidance for HFC alternatives, and limited project data have contributed to perceived barriers around the viability of available technologies. Compounding these issues is a persistent shortage of skilled HVAC technicians and the lack of supportive infrastructure to recover refrigerants cost-effectively given the lack of financial incentive and low enforcement rates. Both barriers hamper the effective implementation of utility programs designed to promote innovative technology adoption and ensure refrigerant management compliance. With significant numbers of HVAC field technicians lacking formal training, there may be significant gaps between portfolio assumptions and current practices in system sealing and refrigerant reclamation.

Rethinking Energy Efficiency Success for the Measure and the Portfolio

ETP Role: Collaborate | ETP Priority: Medium

Definition

This technology family is focused on increasing awareness and understanding of the market and policy constraints and opportunities created by use of Total Resource Cost (TRC) and Total System Benefit (TSB) as EE portfolio metrics to select and implement measures. While California has a rich and diverse set of delivery approaches to measures, including deemed, custom, and normalized metered energy consumption (NMEC), as well as recent policy changes that encourage innovation under the TSB metric and NMEC solutions, overall measure utilization remains low. Some measures have inherent barriers to adoption and implementation. By shedding light on some of the barriers, research needs, and tools to enhance awareness and uptake for TSB, NMEC, and other methods, this topic will support and validate a more robust energy efficiency (EE) portfolio.

Research Initiatives

Table 6: Measure and Portfolio Research Initiatives

Research Initiatives	Performance Validation	Market Analysis	Measure Development	Program Development
How does TSB impact measure prioritization, selection and implementation?	⚠	⚠	☝	☝
How TSB and TRC create dual hurdles for EE measures?	⚠	⚠	☝	☝
What are the barriers and untapped opportunities to increase NMEC solutions and program participation?	⚠	⚠	⚠	☝
What are the barriers to increasing use of unused or underused EE measures in the EE Portfolio?	☝	⚠	⚠	☝
What are the barriers and opportunities for addressing waste heat and departing loads?	⚠	☝	☝	☝

Research Initiatives	Performance Validation	Market Analysis	Measure Development	Program Development
Simplifying Measure Permutations: are there ways to hybridize measures and optimize the balance of assumptions vs. program data collection?				

KEY High Understanding | Research In Progress | Immediate Needs | Future Research Need

Opportunities

The adoption of TSB as a primary EE metric creates a natural opportunity to promote awareness of its use, benefits, and constraints. Collected information from interviews with targeted EE stakeholders, available secondary information on TSB and an understanding of implementers and administrators' awareness of TSB may yield insight on opportunities to address gaps in the EE Portfolio. Additionally, TSB is currently captured as utility benefits, and increasingly to contractors as well, but has offered limited direct benefits to customers due to lack of awareness and customer education on TSB, its definition and use as an operating metric.

Identifying potential co-benefits, e.g., non-energy benefits or other benefits such as job creation and training, as well as waste heat recovery and the implications for utilities of departing loads could also inform this work. This research could include the barriers, costs, and action steps needed to incorporate these co-benefits as part of TSB or their impacts on EE program delivery as well as the incremental costs of measurement and verification.

Barriers

Current discussions with EE stakeholders suggest a limited understanding of how to optimize TSB despite increasing awareness of TSB as an operating metric. Stakeholders have highlighted the interaction between benefit metrics like TSB and cost-benefit ratios, currently in California the TRC (Total Resource Cost), with a poor value in either causing a measure to be dropped. Stakeholders have suggested more interest in flexibility around TRC, for example where certain infrastructure-heavy electrification measures could be much more successful by incentivizing above current deemed Incremental Measure Cost (IMC) values, despite the resulting TRC value. Stakeholders suggest that other cost-benefit metrics should be explored for use in California.

EE policies left over from years or decades past may no longer be serving California's decarbonization goals well: for example, limitation of NMEC in the industrial sector to only Strategic Energy Management may hinder program participation by customers interested in site-specific NMEC opportunities. Likewise, EE policies that limit fuel switching incentives for wood or propane to electricity hinder interventions against these emitting fuels. Changes may be needed to achieve state policy goals and realize increasing program participation, especially in light of diminished EE program participation in important sectors.

Time of Use and the Value of Load Flexibility

ETP Role: Collaborate | ETP Priority: Medium

Definition

This technology family is focused on adaptation in the EE portfolio to maximize decarbonization benefits by properly considering the time-dependence of energy consumption within the day and year. Currently EE savings are attributed based on a limited set of load shapes. Load shifting, demand management, and demand response have been excluded from EE measures. With TSB now the primary metric for EE programs, there is a framework for including demand management in EE program benefits, and EE savings and costs are more dependent than ever on the time of day and month of year energy impact. This technology family will research ways to incorporate demand flexibility, demand management, and load-shifting attributes in EE measures along with the necessary policy updates critical to support successful decarbonization programs. In this category, we will research ways to incorporate demand response and load shifting benefits from EE measures and identify and evaluate cost-effective ways to improve TSB benefits of measures with load shifting capabilities.

Research Initiatives

Table 7: Time of Use and Load Flexibility Research Initiatives

Research Initiatives	Performance Validation	Market Analysis	Measure Development	Program Development
Research and creation of additional load shapes for EE Measures	⚠	⚠	☝	☝
Evaluate network enabled load flexing functionality of heat pumps, thermal storage, and thermal upsizing for impact on TSB	☝	☝	☝	☝
Measure characterization and Market Study of EE measures with added demand flexibility costs and benefits	☝	☝	☝	☝
Examining policies separating Demand Response, Grid Resiliency, and Energy Efficiency Measures, and balancing benefits for customer, utilities and society.	☝	☝	☝	☝

Research Initiatives	Performance Validation	Market Analysis	Measure Development	Program Development
Cost-effective and future-proof program implementations for various degrees of connectivity				

KEY High Understanding | Research In Progress | Immediate Needs | Future Research Need

Opportunities

The 2024 transition from kWh to TSB as the primary metric for savings accounting in the EE Portfolio creates enormous opportunity to identify new benefits from load flexibility and demand management, and to set new policy direction to realize these benefits. A measure-by-measure analysis of the eTRM has been published, but more work needs to be done to match measures to more accurate load shapes and publish additional load shape variations based on peak-avoidance, load-shifting, and demand management strategies. There is a menu of possible demand measures to be considered for each measure, including passive demand flexibility, connected demand flexibility, and new specification opportunities like upsizing thermal storage.

As recent CPUC policy also encourages NMEC measures in the EE portfolio, these and other TOU measurement activities may create a data source for the identification of specific measure opportunities and the creation of new load shapes. IOU Smart water heater programs and market transformation activities like TECH Clean CA may also provide useful user data for analysis.

Since the adoption of the California eTRM, a significant number of EE measures have sunset due to a lack of cost-effectiveness. With the hourly and monthly valuations now a default, sunset measures, as well as creative new decarbonization measures can restrengthen the EE portfolio.

Barriers

The existing eTRM load shapes are out of date and inadequate for calculating TSB value. With the adoption of TSB, load shifting for demand management and peak price avoidance are clearly incorporated into EE benefits. Updates to measures and program policies may be needed to address the overlap of demand management and EE. As the hourly cost of energy embedded in the TSB calculation is constantly shifting, it is unclear how the eTRM impacts shift, schedule relative to DEER updates, and what is necessary in EE measure development to capture changing peak values. In addition, a lack of definition related to the valuation of DERs in EE measures poses barriers to assessing the benefits of new technologies like 120V induction stoves with batteries and comparison of thermal and electric energy storage benefits.

Cost-effectiveness and valuation of load flexibility is significantly different at the utility, vendor, contractor, and customer level. Developing solutions and assessing their cost, complexity, and benefit is needed to strengthen the case for broader TOU and load flexibility adoption.

Embodied Carbon

ETP Role: Collaborate | ETP Priority: Medium

Definition

The materials used to construct and maintain buildings contribute significant GHG emissions over the lifetime of a building. This concept is referred to as *embodied carbon,* defined by the California Energy Commission as the greenhouse gas emissions "resulting from the extraction, manufacturing, transportation, installation, maintenance, and disposal of building materials."[2] This technology family is focused on determining pathways to integrate embodied carbon metrics within the EE portfolio while simultaneously identifying opportunities to reduce costs, energy use, and lifecycle emissions for identified building materials.

Research Initiatives

Table 8: Embodied Carbon Research Initiatives

Research Initiatives	Performance Validation	Market Analysis	Measure Development	Program Development
Building materials production: Identify opportunities to reduce Embodied Carbon in low EC building materials production	⚠	⚠	☝	☝
Building materials procurement: Identify opportunities to reduce Embodied Carbon via demand/procurement of low EC building materials	⚠	⚠	☝	☝
Integration with Energy Efficiency programs: Examine opportunities to align Embodied Carbon market activities with existing Energy Efficiency programs and/or utilize Energy Efficiency resources to support Embodied Carbon goals	⚠	⚠	☝	☝

[2] https://www.cpuc.ca.gov/about-cpuc/divisions/energy-division/building-decarbonization

Research Initiatives	Performance Validation	Market Analysis	Measure Development	Program Development
Increasing Embodied Carbon awareness: Identify general market awareness and needs for low EC building materials	⚠	⚠	☝	☝
Building system retrofit vs. replace: Conduct market studies to understand market actors approaches to mitigate Embodied Carbon emissions by considering the retrofit opportunities vs. replacement of existing buildings	⚠	⚠	☝	☝

KEY High Understanding | Research In Progress | Immediate Needs | Future Research Need

Opportunities

Embodied carbon is an area of increasing policy focus, especially from a total carbon reduction strategy perspective. However, it is currently underexplored as a source of mitigating GHG emissions by utilities and the EE industry. There is a significant opportunity for CalNEXT to bridge this gap by beginning to explore the implications of addressing embodied carbon and its potential future integration with the EE portfolio. Potential market activities to reduce embodied carbon include:

Building Materials Production: Opportunities exist to explore whether upstream incentives can lead to the manufacture of lower-carbon building materials such as concrete and cement, steel, insulation, glass and glazing, finished materials, and mechanical, electrical and plumbing (MEP) materials. There is growing interest to establish embodied carbon incentives for the cement and concrete sectors, e.g., AB 2109 for industrial process heat recovery, including CARB's recent workshops on embodied carbon as well as CalTrans research on newer, low-embodied carbon materials.

Building Materials Procurement: Current activities to create more demand for lower-carbon building materials include Buy Clean California (BCCA) by the California Department of General Services (DGS). However, there is little to no research on activities to stimulate market demand amongst private market actors, including through incentives. Opportunities exist on both the new construction and retrofit of buildings to reduce embodied carbon emissions without sacrificing cost or EE.

Integration with EE programs: Currently, embodied carbon is not included in Total Systems Benefit (TSB) and therefore, not considered in EE incentive programs due to its classification as a non-energy benefit. However, embodied carbon includes production energy used in the manufacture of building materials (lifestage A3), and changing the amount or type of production energy used through EE would directly reduce embodied carbon. Yet, similar treatment and barriers existed for low-Global

Warming Potential (low-GWP) refrigerants until a Refrigerant Avoided Cost Calculator (RACC) enabled these benefits to be captured among EE program activities. Likewise, existing EE programs like California Energy Design Assistance (CEDA) new construction program could be a viable means for educating architects, builders and structural engineers about total carbon reduction strategies with funding for midstream incentives. Future research should consider examining potential synergies between embodied carbon and existing EE programs.

Increasing embodied carbon awareness: Limited general awareness exists about embodied carbon. There is a need for developing a broader suite of Environmental Product Declaration (EPD) forms and conducting Whole Building Life Cycle Analyses (WBLCAs) to inform builders, contractors, and customers about total carbon footprint of buildings. Educating stakeholders, including utilities and implementers, on how they can begin to voluntarily incorporate embodied carbon into their messaging is a crucial first step.

Building System Retrofit or Replace: There is a need to encourage building owners to consider the entire lifecycle carbon impacts of their buildings, not just operational energy use. This includes the replacement of existing systems, appliances, and equipment as well as demolishing and reconstructing new buildings, which will add to the entire carbon footprint of the city or local community. Education and improved measurement tools would provide a needed service to building owners interested in addressing their carbon footprint.

Barriers

As a relatively underexplored topic with low market awareness, there are a significant number of barriers to addressing the large amount of GHG emissions from embodied carbon. Barriers include:

- Limited policy mechanisms beyond SB 596, AB 2246, and AB 43, which are primarily focused on distribution chain solutions to reduce embodied carbon in the manufacturing of building materials. However, virtually no policy mechanisms exist for the creation of market development activities, such as how AB 1477 provided funding for BUILD and TECH to launch the state's new construction and retrofit decarbonization programs.
- Limited market knowledge and awareness of the urgency for addressing total building carbon emissions as well as understanding the embodied carbon building materials costs and cost-effectiveness relative to other carbon mitigation solutions.
- Gaps in the availability of Environmental Product Declaration (EPD) forms across product categories and a need for increased awareness of embodied carbon impacts via Whole Building Life Cycle Analyses (WBLCAs).
- There is a need for increasing general embodied carbon awareness among mainstream architectural firms, builders, and engineers, especially those in larger firms with a clientele that are likely more knowledgeable about embodied carbon practices and are focused on sustainability principles.
- Limited funding mechanisms to support market interventions for embodied carbon within or outside of EE programs. Although the Inflation Reduction Act (IRA) provides limited federal funding opportunities ($250 million) for assistance with the development of EPDs, virtually no funding exists for embodied carbon program designs or market interventions.

Discussion

Following submittal of the 2024 Portfolio Enhancements TPM, the Program Team will do the following:

- Update CalNEXT website with new 2024 Portfolio Enhancements TPM and this Final Report.
- Launch email announcement through email outreach.
- Develop and submit the Distribution Report.

Appendix A: Advisory Committee Feedback and Resolution Matrix (Incorporated in the Draft and Final Report)

Table 9: Advisory Committee Feedback and Resolution Matrix

Technology Family	Section	Suggestion or Comment	Action Taken and Justification
Time of Use and the Value of Load Flexibility	Main Narrative	There needs to be some policy changes considered in this section. DNV has started a new method for characterizing load shapes. This must be incorporated into the avoided cost combos used in the CET. Collecting information on load shapes would also be useful.	This feedback will be addressed in the 2025 Portfolio Enhancements revision process.
DAC & HTR Program Needs	Barriers	Renters/Tenant vs Property Owners poses a barrier in these communities as well I don't think that was explicitly called out in this section but wanted to make sure it was mentioned. I think better understanding tenant vs owner concerns would benefit program design.	Feedback received and considered.
DAC & HTR Program Needs	Barriers – Workforce Challenges	Related to skilled workforce, is this exacerbated in rural communities, where lack of skilled workforce can drive up the cost to install measures?	Yes, feedback received and considered.
Electrification and Fuel Substitution	Main Narrative	PG&E is leading new 3P electrification programs so suggest to flag to PG&E or get their input and lessons learned. All electrification programs are pilot programs, so they are set up to gain lessons learned too.	This feedback will be addressed in the 2025 Portfolio Enhancements revision process.
Electrification and Fuel Substitution	Barriers	Could lack of a large enough/ properly educated and trained workforce to support this work also pose a barrier here?	It could. Hence, the project team thinks workforce training and awareness building efforts are needed for the workforce which making a big switch in their business model going from gas appliances to electric appliances.
Lifecycle Refrigerant Management and Emissions Reductions	Main Narrative	The efficiency of equipment with different refrigerants is also important. Coordinate with what IOUs are researching. (See SDG&E.)	Agreed, that is tied into the research initiatives under TSB alignment.

Technology Family	Section	Suggestion or Comment	Action Taken and Justification
Lifecycle Refrigerant Management and Emissions Reductions	Opportunities	Suggest keep adoption of natural refrigerants entirely separate from LRM. As is outlined by the definition LRM is best understood as a way to eliminate refrigerant emissions. Keeping it separate from discussions around refrigerant choice helps to elevate its appeal and ultimate effectiveness, given that LRM otherwise isn't subject to the lingering barriers facing A3 adoption in many sectors.	Language has been edited to ensure description and research opportunities focus on LRM NOT new technology opportunities.
Lifecycle Refrigerant Management and Emissions Reductions	Research Initiative #1	This seems very broadly defined for something that is refrigerant oriented. Also note that CalMTA is doing work on ERTUs, which should be coordinated to avoid redundancy.	Refrigerants are by nature broad. What CalMTA is doing on ERTU is not LRM focused unless it is tied to CA R4 program which I do not believe it is.
Lifecycle Refrigerant Management and Emissions Reductions	Research Initiative #2	This seems like a great topic area.	Agreed. Understanding how to best target incentives to end of life /or early equipment retirement refrigerant recovery is critical to supporting the lifecycle accounting of an equipment's CO2e impact.
Lifecycle Refrigerant Management and Emissions Reductions	Research Initiative #5	Some work has been done in this area already. See Low-GWP Refrigerant Study done with DNV published June 2024. There are mobile apps that can assist in documentation of recovery. Also note that the RACC has baseline recovery rates-built in.	The DNV report is a valuable reference and understanding how smart aps that support not only refrigerant recovery efforts but also equipment maintenance should be evaluated as a stacked LRM incentive offer to help 1) validate RACC rates and 2) support attribution of lifetime CO2e relative to equipment refrigerant GWP.
Lifecycle Refrigerant Management and Emissions Reductions	Research Initiative #6	CEC has done a study in the last year or so focused on contractors. Contractor compliance rates are also reflected in the leakage and recovery rates built into the RACC, which originated with CARB.	This study will certainly provide important references to build from as it relates to addressing contractor comfort and readiness to handle A2L and A3s and the gap that needs to be addressed in incentivizing either training or purchase of tools. Equally, the most recent updates to the RACC are applaudable as they recognize not only the value of calculating leaks during use, but also end of life recover/save "documented recovery" vs. the one-dimensional unit of GWP. These elements will certainly help to support LRM integration and accounting practices for utility program consideration.

Technology Family	Section	Suggestion or Comment	Action Taken and Justification
Main Narrative	Methodology	Suggestion: Spell out first use of DAC and HTR	Included full name of Disadvantaged Communities and Hard To Reach markets
Main Narrative	Methodology	Suggestion: Remove repetitive text about by reviewing the submitted proposals the team was able to make strategic consolidations and determine which technology families would be appropriate (to consolidate)	Removed repetitive text.
Main Narrative	Methodology	Suggestion: Explain what was intended by the statement "Portfolio Enhancement portfolio stands for easier use and external understanding"	Added explanation that the icons were added to provide the Team's assessment of the research initiative's maturity level.
Main Narrative	Methodology	Suggestion: Estimating TSB for emerging tech is challenging given the limited data that would feed into the calculation. It's more easily estimated for higher TRL tech that is in limited but commercial use (even if proven, piloted) still lacks sufficient data.	The team will incorporate this feedback into the edits for the "Rethinking Energy Efficiency Success for the Measure and the Portfolio" section.
Rethinking Energy Efficiency Success for the Measure and the Portfolio	Definition	Suggestion: Expand abbreviation in first instance of NMEC	Provided expanded name for Normalized Metered Energy Consumption (NMEC).
Rethinking Energy Efficiency Success for the Measure and the Portfolio	Research Initiatives	Suggestion: Add two other lines of research: How EE funds could promote waste-heat reduction including: A. use of water by thermal networks/ district heat B. Use of waste heat by another utility customer The potential mismatch between CA's departing load penalties and decarbonization goals	The Project Team will be considering adding these extra lines in the 2025 revision cycle.
DAC & HTR Program Needs	Definition	Suggestion: Adjust reference to "emerging technologies" to include emerging technology risks (e.g., unknowns from lack of proven performance), costs, and other barriers (e.g., community mistrust of programs) should be carefully considered for DACs and HTR communities	Included footnote detailing these additional ET risks.

Technology Family	Section	Suggestion or Comment	Action Taken and Justification
DAC & HTR Program Needs	Research Initiatives	Comment: This would mean that DAC and HTR communities do not have to wait to access new tech until later timescales. Identifying barriers and mitigating them (e.g., cost subsidies etc) and running controlled pilots offer a way to improve conditions through EE sooner.	Prior text which included reference to the goal to ensure equitable access to EE and Decarb benefits while overcoming technical, financial and market barriers that limit participation in these communities was removed due to other reasons, so this text is no longer included.
Electrification and Fuel Substitution	Definition	Suggestion: to add the Industrial sector	Added reference to the Industrial sector.
Electrification and Fuel Substitution	Opportunities	Suggestion: add regulations such as SCAQMD's NOx rules that can spur electrification	This feedback has been received and is being considered for the 2025 revision cycle.
Electrification and Fuel Substitution	Opportunities	Suggestion: Recommend adding a reason for SMB's lagging adoption	This feedback will be addressed in the 2025 Portfolio Enhancements revision process.
Embodied Carbon	Opportunities	Suggestion: mention the building momentum towards embodied carbon initiatives from the cement/concrete sectors (e, g, AB 2109 industrial process heat recovery) and CARB's latest workshops on embodied carbon, as well as Caltrans research on newer, low-embodied-carbon materials	The Team included these points.
Embodied Carbon	Opportunities	Comment: Embodied carbon includes production energy used in the manufacture of materials (Lifestage A3). Changing the amount or type of production energy through energy efficiency would therefore reduce embodied carbon. It's tied to an energy benefit	The Team will consider including these points if not in 2024, then the 2025 revision cycle.
Embodied Carbon	Barriers	Comment: Although GHGs emitted anywhere have the same impact, ideally ratepayer funds would be prioritized for emissions reduction and economic benefits in the US.	The Team will consider including these points if not in 2024, then the 2025 revision cycle.