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2025 Portfolio Enhancements TPM

DRAFT VERSION

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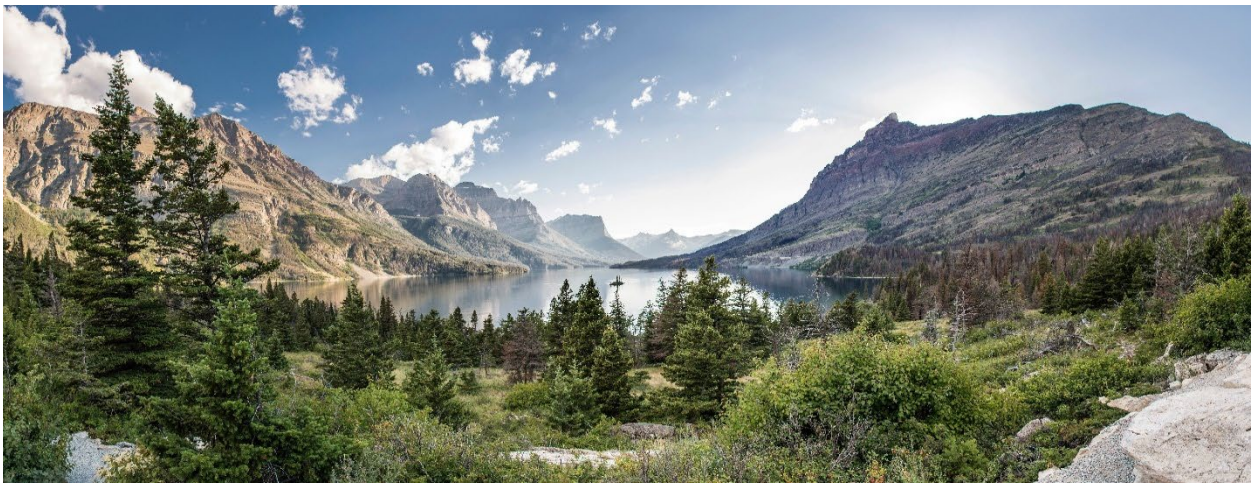

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Table of Contents

Tables

Abbreviations, Acronyms, and Glossary of Terms

Acronym	Meaning
ACA	American Cement Association
AEC	Architect, Engineering and Construction
ALD	Automated leak detection
CARB	California Air Resources Board
CPUC	California Public Utilities Commission
DAC	Disadvantaged communities
DER	Distributed energy resources
EE	Energy efficiency
ET	Emerging technology
ETP	Emerging Technology Program
GHG	Greenhouse gas emissions
GWP	Global warming potential
HTR	Hard-to-reach
HVAC	Heating, ventilation, and air conditioning
IOU	investor-owned utility
LRM	Lifecycle Refrigerant Management
NAPA	National Asphalt Pavement Association
NMEC	Normalized metered energy consumption

Acronym	Meaning
NRMCA	National Ready Mixed Concrete Association
NSSGA	National Stone Sand & Gravel Association
SCE	Southern California Edison
SMB	Small and medium businesses
SME	Subject matter expert
TPM	Technology Priority Map
TSB	Total System Benefit

Glossary Term	Meaning
Technology Category	One of six broad technology categories: whole buildings, HVAC, water heating, lighting, plug loads and appliances, process loads, and portfolio enhancements.
Technology Family	Functional grouping that provides description of program role, opportunities, and barriers.
Research Initiatives	New initiative in place of both subgroups and knowledge indices.
Research Initiatives Key	Visual aid explaining if each research initiative is at a level of high understanding, ranked on a low, medium, or high scale.
Rankings	**Future Needs:** Covers items that are not yet ready for consideration or due to having high needs in validation and market analysis. Programs should not be discouraged from submitting proposals for research initiatives with a "Future Needs" classification but instead focus on making a strong argument for how the project outcomes can help fill in the missing gaps for validation or market analysis. **Low**: Covers items that have lower industry interest and/or impacts for Total System Benefit due to having an existing expansive data set or information readily available or not being pertinent to the research initiative. **Medium:** Covers items that are an evolution of or offer promise to existing and common technologies for TSB or other emerging policy and/or research topics. This can be in the form of needs that may exist but are not critical to the objectives of meeting TSB metrics or the identified technology family research scope. **High:** Covers items that have high industry interest and high impacts for TSB and/or emerging technology/policy research scope.
Definitions	Narrative to provide additional clarification on the research family scope.
Opportunities	Description of potential impacts and potential research areas.
Barriers	Description of key 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.

Glossary Term	Meaning
	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 subject matter experts. *Note: Priorities will change as research is completed.*
High Medium Low	**High**: CalNEXT SME team has highlighted this research family as having high impacts within the technology category. **Medium**: CalNEXT SME team determined this research family has moderate overall impacts within the technology category. **Low:** CalNEXT SME team has highlighted this research family as having low relative impacts within the technology category.

Introduction

The Technology Priority Maps (TPMs) provide the CalNEXT Program with 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, as well as drive product ideation and inform project selection. This Final Report covers the revision process for the 2025 Portfolio Enhancements TPM.

2025 Key TPM Changes

The Portfolio Enhancements TPM is a revision to address issues which span individual end-use technologies and represent new emerging policies, market, or product trends. In interviews with emerging technology stakeholders about CalNEXT's research and pathway into the portfolio for promising emerging technologies, stakeholders report significant barriers unrelated to a particular technology or end-use, such as electrification and fuel substitution. Rather, these barriers arise from the overall parameters of energy efficiency (EE) programs that the California Public Utilities Commission (CPUC) funds.

To address these portfolio needs, this TPM gathers a targeted list of portfolio barriers into one document for consideration by the larger community of EE stakeholders and provides actionable suggestions on the types of portfolio-related research CalNEXT has interest in conducting. Additionally, the Portfolio Enhancements TPM aims to further clarify potential areas of study and offers definition, opportunities, and barriers for a sect of research families.

Notable drivers include:

- The need for broader decarbonization solutions to meet California's Senate Bill 32 climate goals to reduce statewide greenhouse gas emissions (GHG) by 40 percent below 1990 levels by 2030; achieve carbon neutrality by 2045; and meet net neutrality thereafter, as described in Assembly Bill 1279.
- California requirements for funding to disadvantaged communities (DAC), as described in Senate Bill 535.
- The fundamental parameters of the California EE Portfolio, including metrics and rules such as Total System Benefit (TSB), Total Resource Cost (TRC), the Normalized Metered Energy Consumption Rulebook, fuel substitution technical guidance, and the Refrigerant Emissions Avoided Cost Calculator.

For the 2025 Portfolio Enhancements TPM with additional 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, Carbon Leadership Forum, EC building material industry groups (ACA, NAPA, NRMCA, NSSGA), 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; these emerging products are then contextualized into the priority maps through a markets and solutions lens.

The SME team worked through several visual changes at the start of this revision process, which are available below in the narratives of the Final Report. These visual changes allow submitters and viewers to get a clear, simplified view of what topics are of most interest in each research family and what is most important to progress within the portfolio. Additionally, the new icons and their accompanying descriptions will help a reader understand what projects are the most in need and the remaining research they require.

The simplified icon view in the Research Initiatives table describes the three to five most important research areas 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: Rankings and their meanings.

Icon	Meaning
Future Needs	Covers items that are not yet ready for consideration due to having high needs in validation and market analysis. Programs should not be discouraged from submitting proposals for research initiatives with a "Future Needs" classification but instead focus on making a strong argument for how the project outcomes can help fill in the missing gaps for validation or market analysis.
Low	Covers items that have lower industry interest and/or uncertain impacts for TSB due to having an expansive data set or information readily available or not being pertinent to the research initiative.
Medium	Covers items that are an evolution or offer promise to existing and common technologies for TSB or other emerging policy and/or research topics. This can be in the form of needs that may exist but are not critical to the objectives of meeting TSB metrics or the identified technology family research scope.
High	Covers items that have high industry interest and high impacts for TSB and/or emerging technology/policy research scope.

Some major additions in this Portfolio Enhancements TPM include consideration of the implemented Total System Benefit (TSB) metric, its role in emerging technology (ET), and CalNEXT's ability to

support understanding of the metric in the EE landscape. The team developed the structure of the TPM Research Initiatives table to ensure strong coordination among CalNEXT activities.

Stakeholder Feedback

TPM Advisory Committee Outreach

The TPM Advisory Committee outreach began in July 2025, when stakeholders' feedback was requested via email, which resulted in additions to this Word document of the research family narratives. The TPM Advisory Committee members are listed below in Table 2.

Table 2: Advisory committee outreach.

Organization
California Air Resources Board (CARB)
California Department of Housing and Community Development (HCD)
California Technical Forum (CalTF)
California Market Transformation Administrator (CalMTA)
California Public Utilities Commission (CPUC)
Effecterra
Northwest Energy Efficiency Alliance (NEEA)
North American Sustainable Refrigeration Council (NASRC)
Pacific Gas & Electric (PG&E)
Pacific Northwest National Laboratory (PNNL)
Southern California Edison (SCE)

Organization
San Diego Gas & Electric (SDG&E)

The team's outreach allowed advisory committee members to provide candid feedback in written comments and suggestions, which were then reviewed by the TPM coordinator and the 2025 Portfolio Enhancements SME Team, and incorporated into the Revised 2025 Portfolio Enhancements TPM section in Appendix A.

Electrification and Fuel Substitution

ETP Role: Lead | ETP Priority: High

Definition

This research family[1] 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.

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). In addition, South Coast and the Bay Area air quality management districts have passed new rules regulating emissions from space and water heating appliances, which will be a significant driver of electrification. 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 other rebates that encourage higher-efficiency products and electrical upgrades

Research Initiatives

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

[1] The CalNEXT team uses the label "research families," since it covers both technologies and topics, whereas "topic families" feels a bit more cursory. For example, the term "topical" conveys a high level understanding. "Research families" also aligns with the nomenclature of "research initiatives" as the next level-cut down. This is specific to the Portfolio Enhancements TPM.

Table 43: Electrification and fuel substitution research initiatives.

Research Initiatives	Performance Validation Needs	Market Analysis Needs	Measure Development Needs	Program Development Needs
Scaled and targeted cost-effective electrification, load flexibility, and control strategies				
Commercial, industrial, and agricultural market sector electrification research and tools				
Beneficial electrification policy and program strategy alignment				
Technology gaps for all market sectors and application electrification				

KEY High Needs Medium Needs Low Needs Future Needs

Opportunities

A higher-level market assessment is 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. The team identified the following opportunities:

- Assess the cost, barriers, benefits, and effectiveness of technology solutions and load flexibility controls comprehensively at the individual end-use, building, and utility level.
- Targeted high-priority electrification areas—like heating, ventilation, and air conditioning (HVAC) and water heating—have competing solutions. These solutions prioritize benefits to the customer, either in improved performance or reduced installed or operational costs; alternatively, these benefits may go to the utility for mitigating the impact to the grid. These solutions are often achieved with different degrees of complexity, cost, and required market and contractor engagement.

    - Historically lagging market sectors, like small and medium businesses (SMB), 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.
    - Identify, research, and analyze the most cost-effective way of scaling electrification, e.g., zonal electrification.

- Insights on appliance controls—distributed energy resources (DER) versus demand response (DR) versus home management—will provide programs with different control strategies and inform the level of compatibility of the various load flexibility solutions.
- Partner with and capture insights from utility pilot electrification programs to inform new technology and programmatic research needs to accelerate electrification.

Barriers

The 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 potentially replacing expensive electrical panels and utility service upgrades in homes and businesses to accommodate new electrical loads. In addition to cost escalation, increased permitting and complexity of electrification projects can overly burden small contractors and homeowners.
- 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.
- The diversity of water and space heating needs, complexity of owner and tenant decision making, and spilt cost and benefits in small and medium businesses can limit rates of adoption of electrification.

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, which include financial constraints, lack of program awareness, language isolation, and substandard housing. The objective of this research family is to identify barriers requiring new portfolio solutions and policies, as well as propose tailored strategies that ensure equitable access to emerging technologies,[2] energy efficiency, electrification, and decarbonization programs. Addressing the unique energy burdens and challenges of DACs and HTRs face when integrating electrification technologies and real-time load management strategies is critical—both for energy savings and establishing the grid stability needed to advance California's decarbonization goals.

Research Initiatives

Table 4: DAC and HTR research initiatives.

Research Initiatives	Performance Validation Needs	Market Analysis Needs	Measure Development Needs	Program Development Needs
Identify and quantify DAC/HTR program participation barriers	❗	❗	❕	❗
Assess EE program co-benefits in DAC/HTR communities	❗	❗	❕	❗
Evaluate retrofit challenges for DAC/HTR older housing	❗	❗	❕	❗

KEY ❗ High Needs ❗ Medium Needs ❗ Low Needs ❕ Future Needs

Opportunities

DAC and HTR communities present significant opportunities for impactful energy efficiency, electrification, and decarbonization initiatives. By prioritizing direct installation programs, real-time

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

load management, and culturally tailored outreach, positive impacts can be maximized in these underserved areas—addressing barriers such as lack of awareness, language, and financial hurdles. Below are some examples, although this is not an exhaustive or exclusive list:

- **Direct Install Programs:** Promote easy adoption of energy-efficient technologies through installation support.
- **Real-Time Load Management:** Implement simple and durable control strategies to shift the largest loads during peak periods, stabilize the grid, and lower operating costs.
- **Culturally Relevant Outreach:** Develop targeted communication strategies to overcome language and awareness barriers.
- **Energy Cost Reductions:** Lower utility bills for households facing disproportionate energy burdens.
- **Improved Indoor Air Quality**: Enhance health outcomes by upgrading inefficient systems.
- **Local Job Creation and Skilled Workforce:** Generate economic opportunities through energy efficiency and electrification job growth together with a skilled workforce able to meet local DAC and HTR community electrification needs.
- **Increased Climate Resilience:** Boost community resilience against climate impacts via efficient, electrified, and decarbonized homes.
- **Urban-Rural Equity:** Bridge energy efficiency gaps between urban and rural low-income households.
- **Smart Technologies Adoption:** Engage households with demand response, time-of-use rates, and smart home tools to promote energy savings and resilience.

Barriers

While DAC and HTR communities offer meaningful potential for energy efficiency, electrification, and decarbonization, several persistent barriers continue to limit their widespread participation. Financial, technical, structural, and awareness challenges, as well as issues related to workforce and housing dynamics, hinder the adoption and effectiveness of these programs. Some examples include:

- **Financial Constraints:** Limited ability to invest in energy efficient technologies due to high upfront costs.
- **Substandard and Older Housing:** Structural issues and outdated buildings increase costs and complexity of energy upgrades.
- **Rental Housing and Split Incentives:** Landlords pay for improvements, but tenants typically benefit from cost savings, reducing owners' willingness to invest.
- **Shortage of Skilled Workforce:** Insufficient numbers of qualified contractors and need for culturally competent training limit deployment at scale.
- **Low Program Awareness:** Limited understanding of real-time pricing, demand response, and load-shifting opportunities hampers engagement, as does limited capacity to actively engage with load-shifting opportunities on an ongoing basis.
- **Technology Access Barriers:** High initial costs for smart devices and lack of access to technologies like smart thermostats obstruct participation in advanced programs.

- **Inadequate Grid Infrastructure**: In some areas—e.g. PG&E's Yolo County, which includes Davis, Woodland, West Sacramento—the absence of advanced metering infrastructure prevents effective participation in real-time load management programs.

Lifecycle Refrigerant Management and Emissions Reductions

ETP Role: Collaborate| ETP Priority: High

Definition

This research 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 low and ultra-low alternatives.
- Aligning refrigerant emissions reductions calculations within the Total System Benefit (TSB) metric with current practices in the field.

Reducing leaks in existing refrigerant systems will complement the approaches within the HVAC, Water Heating, and Process TPMs, which will also drive active recovery, reclamation, and destruction of high-GWP refrigerants. This framework also emphasizes the need to expand consideration of disruptive innovations, such as non-vapor compression systems that avoid refrigerants entirely, eliminating the risk of leakage and the need for refrigerant management. It will also be important to more clearly define Lifecycle Refrigerant Management (LRM) within the California EE portfolio and incentive structures, which will create more cost-effective, impactful incentives and program interventions.

LRM broadly refers to the full lifecycle of refrigerants—from system selection and installation to refrigerant leak prevention, detection, and repair—during the operational life of equipment, as well as refrigerant recovery and reclamation or destruction at equipment end of life. LRM's goal is to eliminate the GHG impact from refrigerant emissions, given these are primarily gases with global warming potential (GWP) values thousands of times higher than CO_2.

Research Initiatives

Table 65: Lifecycle Refrigerant Management and Emissions Reductions Research Initiatives

Research Initiatives	Performance Validation Needs	Market Analysis Needs	Measure Development Needs	Program Development Needs
Improve refrigerant recovery rates, including targeted incentives for end-of-life refrigerant recovery.	!	!	!	!
Automated Leak Detection (ALD), and alternative monitoring options.	!	!	!	!

Research Initiatives	Performance Validation Needs	Market Analysis Needs	Measure Development Needs	Program Development Needs
Equipment selection and installation practices including natural refrigerant systems and lower system leak rates.				
Data collection and analysis on refrigerant charge size, leak and recovery rates to inform TSB assumptions.				
Evaluate non-vapor compression technologies for HVAC and Refrigeration.				

KEY High Needs Medium Needs Low Needs Future Needs

Opportunities

The following are some examples of opportunities in Lifecycle Refrigerant Management and Emissions Reductions:

- The TSB metric recognizes GHG benefits from mitigating refrigerant leak emissions
- Despite some progress, further work is needed regarding how EE portfolios handle refrigerants to meet utility regulatory requirements and state emissions reduction goals.
- Utility efficiency programs, traditionally valued for energy savings, can also serve as cost-effective platforms for refrigerant emissions reduction.
- Refrigerant emission reductions often result in energy savings, allowing:
    - Seamless integration of LRM efforts into existing programs.
    - Delivery of both direct energy savings and indirect cost/emissions savings across sectors.
    - Promotion of ultra-low GWP refrigerant-based systems.
- Transitioning to an LRM-based approach for calculating refrigerant emission impacts will:
    - Enable more accurate measurement of lifetime carbon dioxide equivalent savings.
    - Enhance program effectiveness.
- A comprehensive approach to LRM includes equipment selection, installation best practices, leak monitoring and repair, and proper disposal of refrigerants at equipment end-of-life.

- Commercial and industrial refrigeration's largest opportunity is to replace existing systems with high GWP refrigerants, while residential and small commercial HVAC's largest opportunity is recovery of refrigerant at decommissioning
- Accelerating the adoption of emerging non-vapor compression technologies will help California meet key climate policy deadlines while also delivering significant cost savings across multiple sectors.

Barriers

The following barriers should be considered:

- Though substantial progress with natural refrigerants has been made in commercial refrigeration, the HVAC sector faces several challenges:
    - Lack of harmonization between US national codes and international safety standards for natural refrigerants.
    - Misuse of Environmental Protection Agency Significant New Alternatives Policy guidance for hydrofluorocarbon alternatives.
    - Misaligned efficiency and emissions metrics.
    - Limited project data, leading to perceived technology viability issues.
- A shortage of skilled HVAC and refrigeration technicians.
- Low rates of refrigerant recovery due to:
    - Added time and cost to achieve compliance.
    - Lack of financial incentives and low enforcement rates.
- Concern by utilities that recognizing current conditions with LRM may erode existing savings.
- Lack of ultra-low GWP products for many product categories, e.g. mini-splits.

Policies for Energy Efficiency Success

ETP Role: Collaborate | ETP Priority: High

Definition

This research family is focused on increasing awareness and understanding of the market and policy constraints created by dual use of TRC and TSB as EE portfolio metrics, as well as the opportunities to consider new metrics for measure selection. While California has a rich and diverse set of delivery approaches to measures, including deemed, custom, and normalized metered energy consumption (NMEC)—in addition to 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. Shedding light on some of these barriers, research needs, and tools can enhance awareness and uptake for TSB, NMEC, and other methods, which will also support and validate a more robust EE portfolio.

Research Initiatives

Table 76: Measure and portfolio research initiatives.

Research Initiatives	Performance Validation Needs	Market Analysis Needs	Measure Development Needs	Program Development Needs
What measure-level impacts might follow from adoption of a new cost-effectiveness test?	!	!	○	○
Are there additional potential value streams for EE Portfolio to consider enhancing TSB value?[3]	!	!	○	○
What are the barriers and untapped opportunities to increase NMEC solutions and market participation?	!	!	!	○

[3] Are market participants (customers, implementers, supply chain actors) adequately compensated to support emerging needs such as load shift, grid resiliency, and climate change impacts?

KEY High Needs Medium Needs Low Needs Future Needs

Opportunities

Rethinking how we measure success by looking at EE through the lens of TSB and TRC creates some natural opportunities to promote the awareness, use, and benefits of these metrics:

- Increasing awareness of TSB and TRC as primary metrics of the EE Portfolio

Initial feedback from stakeholder interviews and research indicates a limited understanding for the drivers of TSB and TRC, as well as their interactive effects.

- Addressing potential gaps in the EE portfolio, such as identifying potential co-benefits or non-energy benefits.

Some potential non-energy benefits include health and safety comfort from fuel sub measures, job creation, and waste heat recovery, as well as implications for departing loads. Identifying potential gaps, such as opportunities to incentivize market activities for demand management, load flexibility, and other system benefits in TSB.

Barriers

Current discussions with EE stakeholders revealed the following barriers:

- A limited understanding of how to optimize TSB despite increasing awareness of TSB as an operating metric.

There is a general need for broader awareness for the drivers of TSB, such as long-lived measures (long, effective, useful lives) and their potential trade-offs with market uptake if these measures typically require higher capital investment, which may impact market participation. There is a limited understanding for the interaction between TSB and TRC. TSB replaced kilowatt-hours (kWh) and kilowatts (kW) as a primary goal but did not replace TRC for cost-effectiveness. Some stakeholders have mistaken TSB as a replacement cost-effectiveness metric for TRC.

There is also an increased interest in but limited understanding for the flexibility around TRC.

- Some stakeholders have noted that while TRC captures all participant and program costs, it does not capture all participant benefits, such as health and safety benefits associated with fuel-substitution measures. Also, cost-effectiveness is currently addressed in multiple regulatory proceedings—e.g., R.22-11-013 for DER Program Cost-Effectiveness, Data Access and Use, and Equipment Performance Standards, as well as in the new EE proceeding, R25-04-010.
- Certain infrastructure-heavy electrification measures could be much more successful by incentivizing above current deemed incremental measure cost values due to inherent system benefits, despite the resulting TRC value.
- Some 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.

A recent State of California Auditor's Report of Energy Efficiency programs highlighted that the current TRC calculation does not include certain non-energy related benefits—as accounted for by other states—despite including participant costs. This result could discourage utilities from implementing certain EE programs or not achieving cost-effective program portfolios[4].
Existing EE policy restricts some NMEC opportunities, such as limiting NMEC to strategic energy management programs in the industrial sector, or cases where site-specific NMEC resembles large commercial buildings. EE policy also restricts fuel switching from non-regulated fuels, e.g., wood or propane, to regulated fuels, e.g., electricity or natural gas. Recently, strategic energy management has expanded in California beyond the industrial sector; however, further study of additional untapped markets could yield new program pathways for the EE portfolio.

[4] For more information, visit: https://www.auditor.ca.gov/reports/2023-127/

Time-of-Use and the Value of Load Flexibility

ETP Role: Collaborate | ETP Priority: Medium

Definition

This research family is focused on adaptation in the EE portfolio to maximize decarbonization and TSB 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, and load shifting, demand management, and demand response have been excluded from EE measures. Because TSB is now the primary metric for EE programs, there is a framework for including demand management in EE program benefits. This also means EE savings and costs are more dependent than ever on the time-of-day and month-of-year energy impacts.

This research family will investigate 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 87: Time-of-use and load flexibility research initiatives.

Research Initiatives	Performance Validation Needs	Market Analysis Needs	Measure Development Needs	Program Development Needs
Research and creation of additional load shapes for measures.	!	!	☐	☐
Evaluate TSB and cost-effectiveness of current measures versus policy alternatives that incorporate more load shift and demand flexibility.[5]	!	☐	☐	☐

[5] Evaluate policy pathways for CalNEXT research to inform technical potential studies to enhance TSB recognized value in EE goals.

Research Initiatives	Performance Validation Needs	Market Analysis Needs	Measure Development Needs	Program Development Needs
Measure characterization and market study of measures with added demand flexibility costs and benefits.				
Cost-effective and future-proof program implementations for various degrees of connectivity.				

KEY High Needs Medium Needs Low Needs Future Needs

Opportunities

In 2024, TSB replaced kWh as the primary metric for savings accounting in the EE portfolio, which created the following opportunities:

- There is potential to evaluate and identify new benefits, such as load flexibility and demand management.
- Matching measures and creating more accurate load shapes and load shape variations based on peak-avoidance, load-shifting, and demand management strategies.
- Studies for potential measures to address system needs, such as demand flexibility measures, time-of-use benefits to customer, and grid resilience.
- Researching new technologies and applications, such as upsizing thermal energy storage, passive demand flexibility, and connected demand flexibility.
- As recent CPUC policy also encourages NMEC measures in the EE portfolio, these and other meter-based 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 California, may also provide useful user data for analysis.
- Since the adoption of the California eTRM, a significant number of EE measures have been removed due to a lack of cost-effectiveness. With the hourly and monthly valuations now a default, sunsetted measures—as well as creative new decarbonization measures—may benefit the EE portfolio.

Barriers

The team identified the following barriers for using time-of-use and load flexibility:

- 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 more 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 and schedule relative to the Database for Energy Efficiency Resources updates, and what is necessary in EE measure development to capture changing peak values.

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 time-of-use 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."[6] This research family is focused on determining pathways to integrate embodied carbon metrics within the EE portfolio and with building decarbonization programs while simultaneously identifying opportunities to reduce costs, energy use, and lifecycle emissions for identified low embodied carbon (EC) building materials.

Research Initiatives

Table 98: Embodied carbon research initiatives.

Research Initiatives	Performance Validation Needs	Market Analysis Needs	Measure Development Needs	Program Development Needs
Identify opportunities in the production and supply of low EC building materials.	❗	❗	❕	❕
Identify opportunities for low EC building materials via demand-side programs.	❗	❗	❕	❕
Identify ways to harmonize EC with EE and/or building decarbonization programs and policies.	❗	❗	❕	❕
Increase EC market awareness.	❕	❕	❕	❕

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

Research Initiatives	Performance Validation Needs	Market Analysis Needs	Measure Development Needs	Program Development Needs
Increase adoption of adaptive reuse and circular economy approaches.	❗	❗	❗	❗

KEY ❗ High Needs ❗ Medium Needs ❗ Low Needs ❗ Future Needs

Opportunities

This research family includes, but is not limited to, the following opportunities for study:

- Exploring upstream incentives to promote the manufacture of lower-carbon building materials, such as concrete; cement; steel; insulation; glass and glazing; finished materials; and mechanical, electrical, and plumbing materials.
- Identifying market mechanisms to encourage the adoption of low-embodied carbon in cement and concrete sectors, e.g. Assembly Bill 2109 for industrial process heat recovery, CARB's recent workshops on embodied carbon, Caltrans' research on newer low-embodied carbon materials, and/or low-embodied carbon building material selection in new construction projects.
- Researching opportunities to stimulate market demand among market actors for low-embodied carbon building materials, similar to Buy Clean California by the California Department of General Services.
- Integrating EC with EE programs:

Increasing the awareness of EC in the design of buildings could dramatically reduce EC while also achieving EE benefits. Existing EE programs, like the California Energy Design Assistance new construction program, could provide additional education to architects, builders, and structural engineers about EC and existing EE design practices.

Increasing embodied carbon market awareness. It is necessary to develop a broader suite of Environmental Product Declaration forms and conduct Whole Building Life Cycle Analyses 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 will be a crucial first step.

Future research should consider examining potential synergies between embodied carbon and existing EE programs, such as the creation of an Embodied Carbon Avoided Cost Calculator—similar to how the Refrigerant Avoided Cost Calculator unlocked GHG potential for low-GWP HVAC refrigerants.

- Increasing awareness about circularity principles, such as retrofitting buildings rather than replacing them. It is important to encourage building owners to consider the entire lifecycle carbon impacts of their buildings, not just the operational energy use impacts.

This includes education about replacing 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.

- There is increasing convergence of embodied carbon with wildfire mitigation and impact on low-income communities, as seen in recent CARB research focus—as well as potential convergence with advanced building design approaches, such as passive house.

Barriers

As a relatively underexplored topic with low general market awareness, there are several significant barriers to addressing the large amount of GHG emissions from embodied carbon, including:

- Limited market development policies to encourage adoption of low-embodied carbon building materials. Current policy mechanisms—Senate Bill 596, Assembly Bill 2446, and Assembly Bill 43—are under development and are primarily focused on supply chain solutions to reduce embodied carbon in the production of building materials rather than encouraging demand and adoption of low-embodied carbon building materials.
- 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 forms across product categories and a need for increased awareness of embodied carbon impacts via Whole Building Life Cycle Assessments.
- It is critical to increase 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 provided limited federal funding opportunities of $250 million for assistance with the development of Environmental Product Declarations, this funding has diminished under new administration changes, and virtually no funding exists for embodied carbon program designs or market interventions.

Next Steps

Following submittal of the 2025 Portfolio Enhancements TPM, the program team will:

- Update the CalNEXT website with new 2025 Portfolio Enhancements TPM and this final report.
- Launch an email announcement through email outreach.
- Develop and submit the distribution report.

Appendix A: Advisory Committee Feedback and Resolution Matrix

Table 39: Advisory committee feedback and resolution matrix.

Research Family	Section	Suggestion or Comment	Action Taken and Justification
Time of Use and the Value of Load Flexibility	General narrative	Will you address how to collaborate with IOUs' DR-ET programs and to avoid duplicative efforts?	The CalNEXT team will collaborate with IOUs' DR-ET programs to avoid duplicative efforts
Embodied Carbon	Opportunities	There's also Embedded Carbon studies under Codes & Standards Program, do you plan to collaborate the effort and integrate the results there?	The CalNEXT team will continue to collaborate with the Codes & Standards Program on committed Embodied Carbon projects to evaluate how research can be shared and/or integrated.
DAC and HTR Program Needs	Barriers	For barrier 7, can you provide examples where AMI is absent in IOU service territory	PG&E (Yolo County: Davis, Woodland, West Sacramento)
2024 Stakeholder Feedback[7]	N/A	N/A	N/A

[7] This is feedback we received in Q3 2024 during the 2024 Portfolio Enhancements TPM revision cycle.

Research 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.	The CalNEXT team will incorporate needed policy changes for characterizing load shapes.
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.	Added additional opportunity for partnering and gathering insights from pilot utility electrification programs.
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 CalNEXT team will evaluate these opportunities in light of existing/developing EE policies to see if there is relevant technical guidance to inform policy considerations.
Electrification and Fuel Substitution	Opportunities	Suggestion: add regulations such as SCAQMD's NOx rules that can spur electrification	Updated the definition to reference SCAQMD and BAAQMD rules.

Research Family	Section	Suggestion or Comment	Action Taken and Justification
Electrification and Fuel Substitution	Opportunities	Suggestion: Recommend adding a reason for SMB's lagging adoption	Added additional barrier to clarify reasons for lagging electrification adoption in SMB.
Lifecycle Refrigerant Management	Opportunities	Split HVAC and Refrigeration Priorities. Refrigeration highest priority: replacement of existing systems with ultra-low refrigerant equipment. HVAC refrigerant recovery at decommissioning.	Added bullet in Opportunities section identifying highest priorities by sector
Lifecycle Refrigerant Management	Research Initiatives	Include non-vapor compression technology exploration	Added language to definitions and opportunities to include NVC and new RI to reflect this addition.
Lifecycle Refrigerant Management	Research Initiatives	Add direct/indirect language to ALD RI	Determined that existing language is broad enough to prevent unwanted exclusion or appearance of favoring one approach over another. No change made.