2026 Lighting, Plug Loads & Appliances Technology Priority Map

Final Report

ET26SWE0004

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August 20, 2026

Program paid for by ratepayers

Acknowledgements

This Lighting, Plug Loads, and Appliances Technology Priority Map (TPM) was developed by the Lighting, Plug Loads, and Appliances Subject Matter Expert (SME) team of the CalNEXT Program, which is responsible for the production of this document, background research, stakeholder engagement of the Technical Advisory Committee, and management of the TPM development process. We thank the Lighting, Plug Loads, and Appliances SME team members, and our facilitation team for their contributions in this process:

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Abbreviations and Acronyms and Glossary of Terms

Acronym	Meaning
CalMTA	California Market Transformation Administrator
CalTF	California Technical Forum
CPAP	Continuous positive airway pressure
CPUC	California Public Utilities Commission
DAC	Disadvantaged communities
DC	Direct current
DER	Distributed energy resources
DME	Durable medical equipment
EV	Electric vehicle
EVSE	Electric vehicle supply equipment
FDA	Food and Drug Administration
HP	Heat pump
HTR	Hard-to-reach
HVAC	Heating, ventilation, and air conditioning
IOU	Investor-owned utility
MRI	Magnetic resonance imaging
NOx	Nitrogen oxide
PG&E	Pacific Gas & Electric
SCE	Southern California Edison

Acronym	Meaning
SME	Subject matter expert
TPM	Technology Priority Map
TSB	Total System Benefit
TWh	Terawatt hour
ULT	Ultra-low temperature
VEIC	Vermont Energy Investment Corporation

Glossary Term	Meaning
Technology Category	One of six broad technology categories (Whole Buildings; Heating, Ventilation, and Air Conditioning (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	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 due to having high needs in validation, market analysis, measure development, or program development. 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 energy efficiency 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 energy efficiency. This can be in the form of needs that are currently being addressed with existing projects or needs that may exist but are not critical to the objectives of meeting efficiency metrics. High: covers items that have high industry interest and high impacts for energy efficiency.
Definitions	Narrative to provide additional clarification on the technology family scope.
Opportunities	Description of potential impacts and potential research areas.
Barriers	Description of key barriers and potential barriers research.
CalNEXT Priority	Communicates expected level of focus by CalNEXT SMEs. *Note: Priorities will change as research is completed.*

Glossary Term	Meaning
High	**High:** CalNEXT has highlighted this technology family as having high energy savings with any known barriers surmountable through targeted interventions within the Technology Category and will prioritize funding projects under this technology family.
Medium	**Medium:** CalNEXT has highlighted this technology family as having moderate to high overall energy savings with known barriers to entry that may be more challenging to address within the Technology Category and will consider funding projects under this technology family.
Low	**Low:** CalNEXT has highlighted this technology family as having moderate to high overall savings but faces difficult or unknown barriers to adoption within the Technology Category and will not prioritize funding projects under this technology family.

Introduction

Technology Priority Maps 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 document the impact potential, programmatic research needs, and market readiness of all technology families across each of the end-use technology areas, and drive product ideation and inform project selection. This Final Report covers the revision process for the 2026 Lighting, Plug Loads, and Appliances TPM.

2026 TPM Key Changes

The Lighting, Plug Loads, and Appliances category has seen significant changes over the years, relative to that of other technology areas. Notable recent drivers for these changes include the passage of the One Big Beautiful Bill (OBBBA) Act in 2025[1], which repealed many tax credits and funding for state-administered incentive programs targeting the market originally signed into law under the Inflation Reduction Act (IRA) of 2022. In addition, research conducted by California's investor-owned utility (IOU) Codes and Standards Enhancement (CASE) Team related to multiple technology families has impacted the state of knowledge to varying degrees.

As for the 2026 TPM update, the CalNEXT Program Team established a robust process for this initial phase of the TPM development and revisions. Similar to last year, the project team is incorporating a stronger push to gather feedback directly from Lighting, Plug Loads, and Appliances subject-matter experts at the beginning of the revision process. This year, the process began with the reformation of the Lighting, Plug Loads, and Appliances TPM SME Team, with representatives from each of the program team partners: Franklin Energy, Energy Solutions, TRC, UC Davis, and Vermont Energy Investment Corporation (VEIC), with the Ortiz Group providing feedback at the stakeholder outreach stage during the Draft Report. The Lighting, Plug Loads, and Appliances SME Team includes members who support an array of energy efficiency programs using technologies covered by the Lighting, Plug Loads, and Appliances TPM, as well as members who support the California IOUs' Codes and Standards (C&S) program. These emerging technology products are then contextualized into priority maps through the lens of markets and solutions.

In 2026, the research initiatives were revised as needed based on market changes that had occurred since the 2025 Lighting, Plug Loads, and Appliances TPM revision. The research initiatives tables describe the two to five most important technology areas, with the current version providing a simplified ranking view of where the Lighting, Plug Loads, and Appliances portfolio stands for easier use and external understanding. Research initiatives are presented at a higher level than project- or proposal-specific details. The intent of these is to provide guidance for project submitters, rather than providing specific examples. The end goal of these visual summaries is to have a clear representation of where the technology family stands in the portfolio and what remaining research is needed.

[1] To read the One Big Beautiful Bill Act, see: https://www.congress.gov/bill/119th-congress/house-bill/1/text.

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, market analysis, measure development, or program development. 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 energy efficiency 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 energy efficiency. This can be in the form of needs that are currently being addressed with existing projects or needs that may exist but are not critical to the objectives of meeting efficiency metrics.
High	Covers items that have high industry interest and high impacts for energy efficiency.

In 2026, Lighting, Plug Loads, and Appliances SME team focused on revising and cleaning up the technology families based on energy efficiency and affordability standards, among annual revisions considering market changes and CalNEXT program priorities.

Overall, the changes made in this 2026 Technology Priority Map aim to focus on increased technology transfer broadly across the portfolio, allowing the CalNEXT team to define new measures of interest and illustrate its efforts to bring them into the portfolio. These changes should improve shorter-term technology transfer, such as measure packages for expansion of the existing Resource Acquisition programs. Even for longer-term investments, the visual format will provide more tactical guidance to what type of research is needed to better progress different technologies to the goal of portfolio savings.

Stakeholder Feedback

TPM Advisory Committee Outreach

The TPM Advisory Committee outreach began in June 2026. The team requested stakeholder feedback via email, through survey questions targeted for the Lighting, Plug Loads, and Appliances TPM, which resulted in updates to the Word document of the technology family narratives based on that feedback. The stakeholders that provided feedback are listed below in Table 2.

Table 2: Advisory committee outreach.

Organization
California Public Utilities Commission (CPUC)
California Technical Forum (CalTF)
California Market Transformation Administrator (CalMTA)
Pacific Gas & Electric (PG&E)
Southern California Edison (SCE)
TECH Clean California

This outreach allowed advisory committee members to provide candidly written comments and suggestions. Suggestions were reviewed by the TPM coordinator and the 2026 Lighting, Plug Loads and Appliances TPM SME team and incorporated into the Revised 2026 Lighting, Plug Loads and Appliances TPM sections below. A detailed table of changes can be found in Appendix A, the Advisory Committee Feedback & Resolution Matrix.

Electric Vehicle Supply Equipment (EVSE)

CalNEXT Priority: High

Definition

Electric vehicle supply equipment (EVSE) is defined as the conductors, connectors, related equipment, and control software that deliver energy to an electric vehicle (EV). Electrified transportation is expected to be the major driver of load growth within California, and EVSE is a key enabling technology to unlock decarbonization of this sector. The California Energy Commission's latest Integrated Energy Policy Report[2] projects that by 2030, electrical consumption from transportation will make up more than 20 terawatt hours (TWh), or 6.7% of all electrical consumption. This technology family has strong overlaps with the electrical infrastructure technology family within the Whole Buildings TPM.

Research Initiatives

Table 3: Electric vehicle supply equipment (EVSE) research initiatives.

Research Initiative	Performance Validation Needs	Market Analysis Needs	Measure Development Needs	Program Development Needs
EVSE Load Management for Panel Loads	!	!	!	!
Panel Upsizing Alternatives to Support Electrification Efforts	!	!	!	!
Level 2 EVSE Load Management for Multifamily and Commercial Installations	!	!	!	!
Bi-Directional EVSE to Support Electrification Efforts	!	!	!	!

KEY ! High Needs ! Medium Needs ! Low Needs ! Future Needs

[2] https://www.energy.ca.gov/data-reports/reports/integrated-energy-policy-report-iepr/2026-integrated-energy-policy-report

Opportunities

Given the rapid deployment in progress, it is crucial for state energy goals to ensure that EVSE is functioning with energy efficiency, load management, and demand flexibility in mind. To that end, some highlighted opportunities are as follows:

- Limiting standby energy usage, charger losses
- Incorporation of demand flexibility
- Load management at the panel level
- Load management for multi-family installations
- Tariff eligibility and program design to improve affordability for multifamily customers and tenants
- Smart charging (V1G) and vehicle-to-grid (V2G) functionality

Barriers

While EVSEs are relatively new, their technical performance is well understood, especially for Level 1 and Level 2 equipment. Market understanding is growing, although as EVs reach mass market end-users, there is a need for both broad and specialized consumer education to help end-users navigate the following barriers:

- Lack of understanding of load management and flexible demand programs
- No ability to claim benefits related to load shifting
- Limited panel upgrade space for existing buildings
- Infrastructure challenges (such as panels being located too far from the parking spaces).

Additionally, upgrading electric panels to accommodate new electric equipment can be costly, especially for older homes, which are prevalent in DAC and hard-to-reach (HTR) communities. This poses a barrier to installing EVSE and promoting access to EVs.

CalNEXT Related Projects

- ET22SWE0026 – Advanced Multifamily Electric Vehicle Load Management System
- ET24SWE0025 – Performance Evaluation of DC EVSE
- ET24SWE0011 – DAC HTR Statewide Single-Family Housing Characteristics Study

Gas and Electric Household Appliances

CalNEXT Priority: High

Definition

This technology family focuses on household appliances, known as white goods, that commonly operate with multiple fuel sources. Measure case products may be used for the replacement of gas appliances or improving upon existing electric powered offerings. Products include cooking ranges, cooktops, battery equipped 120-volt induction cooktops, on-battery equipped 120-volt induction cooktops, ovens, clothes dryers, and combination washer-dryers.

Note: This technology family has strong overlaps with the electrical infrastructure technology family within the Whole Buildings TPM.

Research Initiatives

Table 4: Gas and electric household appliances research initiatives.

Research Initiative	Performance Validation Needs	Market Analysis Needs	Measure Development Needs	Program Development Needs
120V Induction Stoves	●●●	●●●	●○○	○○○
120V Heat Pump (HP) Dryer	●●●	●○○	●●●	○○○
Commercial HP Dryers in Multifamily	●●●	○○○	○○○	○○○
Smart Controlled Appliances	●●●	●○○	○○○	○○○
Residential HP/Hybrid[3] (HP + Resistance Heat) Dryers	●●●	●○○	●○○	●○○

KEY ●●● High Needs ●○○ Medium Needs ○○○ Low Needs ○○○ Future Needs

Opportunities

In California, most households use gas-powered white goods for cooking and clothes drying, creating a huge opportunity for electrification, while those households with electrical appliances have the opportunity to further improve their products' energy efficiency without compromising performance.[4]

[3] Hybrid heat pump dryers incorporate a resistance heater when faster drying is needed for heavier loads or time-sensitive cycles, offering a compelling middle ground that can help change the narrative around heat pump dryers for being too slow.

[4] Percentage of white goods that are gas-powered for different end uses, based on the 2019 California Statewide Residential Appliance Saturation Study (RASS). https://www.energy.ca.gov/publications/2021/2019-california-residential-appliance-saturation-study-rass

- **Energy efficiency**: Electric and induction technologies offer substantial energy savings,[5] supporting household decarbonization efforts.[6] Heat pump clothes dryers represent a significant savings over all other dryer technologies.
- **Health benefits**: A report by San Francisco Bay Area Planning and Urban Research Association determined that gas appliances emit four times more nitrogen oxide (NOx)—harmful pollutants linked to respiratory issues—than gas power plants, and about two-thirds as much NOx as all passenger cars in California. A more recent study measuring indoor NOx exposure nationally by zip code further confirmed the severity of excessive NOx exposure among gas stove users in California[7]. Transitioning to electric appliances can significantly reduce NOx emissions.
- **Help achieve policy goals**: The California Air Resources Board (CARB) plans to enact zero emission space and water heater standards that could ban the sale of new gas space and water heaters by 2030,[8] but other gas appliances—e.g., stoves and dryers—are not yet widely targeted. There is potential for accelerated regulation of gas-powered appliances beyond space and water heating. The percentages of white good products that are still gas powered in California are as follows:
    - Residential clothes dryers: 58 percent
    - Commercial clothes dryers: 82 percent
    - Cooktops: 54 percent
- **Environmental benefits**: Recent research shows gas stoves emit pollutants even when turned off, highlighting ongoing indoor air quality risks. Transitioning to electric appliances can effectively improve indoor air quality. While heat pumps are highly energy efficient and support decarbonization, the type of refrigerant used can either enhance or undermine their climate benefits.
- **Achieve higher savings through artificial intelligence (AI) and sensor driven optimization**: Smart laundry products use AI and sensor driven feedback to unlock higher energy savings potentials, including:
    - Energy optimization through the sensing of load size, fabric type, and moisture levels.
    - Coordinating with the electric grid, running during times of low energy prices.
    - Detecting and preventing energy-wasting issues like clogged filters and ensuring the machines are operating at peak performance.
    - Providing energy consumption feedback and recommendations on the best cycle choice.
- Evaluating, improving, and defining cost-effective use cases for 120V powered appliances.

[5] https://www.leafscore.com/eco-friendly-kitchen-products/which-is-more-energy-efficient-gas-electric-or-induction/

[6] https://sustainablewestchester.org/stovetop-cook-off-how-induction-stoves-are-healthier-faster-and-more-energy-efficient/

[7] Yannai Kashtan, Chenghao Wang, Kari C Nadeau, Robert B Jackson, Integrating indoor and outdoor nitrogen dioxide exposures in US homes nationally by ZIP code, *PNAS Nexus*, Volume 4, Issue 12, December 2025, pgaf341, https://doi.org/10.1093/pnasnexus/pgaf341

[8] https://ww2.arb.ca.gov/our-work/programs/building-decarbonization/clean-space-and-water-heater-standards/faq

Barriers

- Despite the large savings and decarbonization opportunities, there are significant deployment barriers, from basic consumer understanding of induction cooking to performance concerns around low-voltage combination washer/heat pump dryer models.
- Marketing challenges for electric cooktops include:
    - Consumer habits and preferences: emotional attachment to gas, fear of change.
    - Cost barriers: higher upfront costs, cookware compatibility, and electrical upgrade costs.
    - Knowledge gaps: low awareness and misinformation.
    - Market constraints: gas-favoring real estate and builder incentives.
    - Mixed policy signals: In regions without strong electrification mandates or incentives, gas appliances are still being installed in new homes.
- Marketing challenges for heat pump clothes dryers include:
    - Maintenance: These dryers often require additional filter cleaning and other maintenance considerations compared to non-heat pump dryers.
    - Cost barriers: higher upfront costs.
    - Performance: Heat pumps generally operate at lower temperatures resulting in longer cycle times and lower customer perceived dryness and concerns in multi-family and commercial settings when operated as coin laundry regarding how long drying cycles take to sufficiently dry clothing.
    - New technology: Non-vented dryers are novel in the U.S. market, consumers adopting multiple technology changes is difficult (vented to ventless, traditional heating to heat pump).
- A lack of energy efficiency performance-based standards and test procedures make evaluating technological improvements challenging, such as with standalone ovens or commercial clothes dryers.
- Electrical panel constraints can limit the ability of a building to easily electrify. This is especially prominent in low-income and multifamily buildings, which have more challenges with electric panel upgrades.
- Generally, with decarbonization efforts driving increased electrification, uncertainties exist around operating costs, and how electric rates or tariffs might compare to gas rates or tariffs over the long term.[9]
- The single biggest concern among DACs and HTR communities for electrification is the potential for bill increases. A close second is losing power in a blackout. Fuel-switching household gas appliances need to address these concerns when looking at the viability of decarbonization in this market segment and any potential solution options.[10]
- Lack of 120V ENERGY STAR® Induction Cooktops.

[9] https://docs.nlr.gov/docs/fy18osti/71500.pdf

[10] https://calnext.com/wp-content/uploads/2025/02/ET24SWE0011_DAC-HTR-Statewide-Single-Family-Housing-Characteristics-Study_Final-Report.pdf

- Strong cultural biases and beliefs exist within the DAC and HTR market segment in relation to traditional, gas-cooking methods.[11]

CalNEXT Related Projects

- ET22SWE0022 – Residential Housing Characteristics Study
- ET22SWE0057 – Market Study of Household Electric Infrastructure Upgrade Alternatives for Electrification
- ET23SWE0064 – 120V Induction Stoves with Battery Back-Up
- ET24SWE0011 – DAC HTR Statewide SF Housing Characteristics Study
- ET24SWE0023 – Field Demonstration of Electric Clothes Dryer Controller
- ET25SWE0009 – Market and Technical Evaluation of Combination Washer-Dryer Units for Multifamily Buildings

[11] According to the DAC HTR Statewide SF Housing Characteristics Study, of the 300 participants surveyed, 40 percent believe you cannot cook a proper, traditional meal on an electric stove, while 32 percent believe that food cooked on electric cooking appliances doesn't taste as good.

Advanced Capabilities and Technologies in Lighting and Plug Load Controls and Integration

CalNEXT Priority: High

Definition

This cross-cutting technology family included components, platforms, control algorithms, advanced diagnostics and analytics, and communication protocols, with the ability to communicate, coordinate, and reduce energy use of electric loads in a residential or commercial building. Devices and systems within this technology family are expected to enable lighting and plug load appliances to operate at lower power modes based on either automated control or behavior-modifying features.

Technologies in this family may also serve as a platform for controlling additional building systems and appliances to maximize energy savings, enhance occupant comfort and wellness, or provide environmental data to building systems, including shading, HVAC, and other energy information systems.

Research Initiatives

Table 5: Advanced capabilities and technologies in lighting and plug load controls and integration research initiatives.

Research Initiative	Performance Validation Needs	Market Analysis Needs	Measure Development Needs	Program Development Needs
Networked Lighting and/or Plug Load Control System as the Integration Platform with Other End-Use Systems for Small and Medium Buildings	!	!	!	!
Coordinated Load Management of Lighting and Plug Loads	!	!	▯	▯

KEY ! High Needs ! Medium Needs ! Low Needs ▯ Future Needs

Opportunities

Emerging technologies within this technology family have the potential to yield significant energy savings, demand flexibility, and broad decarbonization benefits by managing lighting, plug loads, and other end-use operations, enabling communication across devices and minimizing consumption when not in use. Specific opportunities include:

- Largely untapped energy savings potential in small and medium buildings, where there is no central building management or control system.

- Deeper energy savings made possible with embedded intelligence, including behavior learning algorithms that manage usage based on learned occupant behavior, and automatic and dynamic load detection capability that identifies devices as they are plugged into a building.
- Open-source communication protocols are becoming more prevalent with extended application profiles to enable sustainable and scalable control layers across multiple building systems.
- Research findings could support and drive standard development organizations, such as the Connectivity Standards Alliance, DALI Alliance, Bluetooth SIG, etc., to develop standardized application-layer communication protocols or control profiles.

Barriers

Technology and market barriers must be overcome to actualize and scale this technology family to the broader market. Key barriers include:

- Lack of familiarity and availability of simple, affordable, and effective control integration solutions for small and medium-sized buildings that don't have any building or energy management systems and/or dedicated building operation personnel.
- Standardized communication protocols have yet to be deployed to or adopted by different product and end-use types to easily allow data sharing, which would facilitate more holistic, sophisticated controls and analytics.
- Insufficient understanding of the scope, availability, and cost of the technologies, as well as the viability of embedding intelligence into the products.
- Slow adoption due to the lack of understanding of customer experience in interacting with these technologies and potential data privacy concerns.

CalNEXT Related Projects

- ET22SWE0044 – Lab Evaluation of Integrated Controls for Commercial Buildings

Resources and Links

- Luminaire Level Lighting Controls with HVAC Control, in NEEA Emerging Technology Quarterly Newsletter 2026 Q1.
- Renner, Rita and Wolgamott, Chris, "Demonstrating Interoperability and HVAC Integrations: Exploring Open Standards in Action with Wireless LLLC." Education seminar presentation at 2025 LEDucation and LightFair. https://leducation.org/wireless-lllc/,
- Slupik, Szymon, "Bluetooth® NLC now supports HVAC integration, enabling smarter systems and better energy efficiency." Bluetooth SIG, July 2025. https://www.bluetooth.com/blog/bluetooth-nlc-now-supports-hvac-integration-enabling-smarter-systems-and-better-energy-efficiency/

Advanced Approaches to Exterior Lighting

CalNEXT Priority: Medium

Definition

This technology family encompasses products, design strategies, and components that improve the efficiency, and adaptability of exterior lighting in commercial and public sectors while also considering best practices for the nighttime lighting environment, including human health, visual comfort, public safety, and environmental impacts. This category has the opportunity to produce a large change both visually and in terms of energy consumption if changes are made in design approach and technology deployment.

Research Initiatives

Table 6: Advanced approaches to exterior lighting research initiatives.

Research Initiative	Performance Validation Needs	Market Analysis Needs	Measure Development Needs	Program Development Needs
Distributed Energy Resources (DERs)-Integrated (Hybrid Solar Outdoor Lighting and Controls)				
Advanced Outdoor Lighting Controls Applications and Technologies				
Adaptive Outdoor Lighting Design Standards				

KEY  High Needs  Medium Needs  Low Needs  Future Needs

Opportunities

There are significant energy savings benefits if the exterior lighting stock is transformed by this technology family. Streetlights managed by the public sector stakeholders and area lighting managed by commercial sector stakeholders are the primary focus. The key opportunities are described below.

- As increased daytime solar energy is produced, reducing nighttime loads through energy storage integrated into the light points significantly reduces exterior lighting energy use, compared to regular LED outdoor lighting. Under most operating conditions, the energy consumption from the grid may be reduced to almost zero.

- With the peak demand on the California grid moving toward the early evening hours, this technology family could shift and reduce a significant portion of exterior lighting demand while also delivering meaningful energy savings.
- As utility tariffs continue to evolve, advanced network controls and DERs integration for exterior lighting will become more cost-effective, and increased adoption should drive additional innovation. DERs-integrated exterior lighting also has the potential to serve as part of the essential infrastructure in locations with a high likelihood of power outage, such as areas impacted by the Public Safety Power Shutoff events.
- Advanced motion-sensing technologies that enable deep savings for installations where the dimensions or other site-specific conditions, such as vegetation or weather, prohibit the deployment of existing motion sensing technologies.

Barriers

- Exterior lighting consists of a wide array of applications—such as roadway, hardscape or other area, façade, landscaping, and more—and it is a significant barrier to justifying programs for technologies covered under this family.
- Workforce training related to installation and commissioning, and adoption/acceptance by operations and maintenance staff remain a significant barrier to the adoption and deployment of advanced approaches to exterior lighting.
- The conventional exterior lighting design practice of providing minimum required illuminance and uniformity for nighttime visibility and public safety, regardless of the presence of pedestrians and traffic, significantly limits the wide adoption of motion sensor control technology.
- The cost-effectiveness of motion sensor integration in exterior lighting systems is increasingly constrained by the rising luminous efficacy of LEDs and the persistently high cost of outdoor motion sensor technologies. This combination reduces the marginal energy savings achievable through motion-based control, thereby diminishing the overall return on investment. However, rising electricity costs are driving the market to maximize energy savings from every watt consumed by LED exterior lighting systems.

CalNEXT Related Projects

- ET24SWE0055 – New Toolkit for Outdoor Lighting Baseline Updates
- ET25SWE0059 – Outdoor Lighting Toolkit Validation

Medical Equipment

CalNEXT Priority: Medium

Definition

This category includes both FDA-regulated and non-regulated mains-connected medical equipment in two key categories:

- Labs and Hospitals
- Residential and Assisted Living

This category includes equipment where primary function or operational constraints are driven by clinical performance, patient safety, or regulatory/quality requirements, which may materially influence energy use, operating schedules, or efficiency upgrade feasibility.

Labs and hospitals are one of the highest energy consuming sectors due to their energy-intensive activities and stringent health and safety requirements. A 2015 market assessment conducted by the California IOUs estimated that just 12 types of lab and hospital equipment were likely responsible for between 0.8 and 3.2 TWh per year. Despite this large opportunity, only lab grade freezers, refrigerators, and ultra-low temperature freezers had significant development—all three now have ENERGY STAR specifications.

The aging demographics of the US suggests growing opportunities in medical devices. Current data suggests there are 61 million adults with disabilities in the country, and 13.7 percent with a disability that impacts walking and climbing stairs. In addition, a 2021 study by Lawrence Berkeley National Lab estimates there are 2.74 million oxygen concentrators and 2.2 million continuous positive airway pressure (CPAP) ventilators.

Research Initiatives

Table 7: Medical equipment research initiatives.

Research Initiative	Performance Validation Needs	Market Analysis Needs	Measure Development Needs	Program Development Needs
Characterization of Energy Consumption, Load Shapes, and Standby Losses of Medical Equipment	❗	❗	❗	❗

Research Initiative	Performance Validation Needs	Market Analysis Needs	Measure Development Needs	Program Development Needs
Power Management Strategies for Reducing Peak and Idle Energy Use	!	!	!	!
Standard Development of Test Methods and Efficiency Metrics	!	!	!	!

KEY ! High Needs ! Medium Needs ! Low Needs ! Future Needs

Opportunities

Hospital/lab: In 2023, the EPA began working more within this sector as ENERGY STAR looks to develop product specifications for magnetic resonance imaging (MRI). The key opportunity areas include:

- Creating a baseline industry standard for lab and hospital equipment.
- Promoting energy efficiency to original equipment manufacturers as a priority in product development to unlock higher energy savings potential.
- Creating best practice guidelines for labs and hospitals and their medical devices.
- Accessing untapped savings in biotechnology and pharmaceutical laboratories with specific utility energy efficiency program offerings.

Residential/assisted living: The key opportunities in this area include:

- Reducing parasitic load in residential/assisted living medical equipment.
- Energy savings opportunities from home based medical equipment usage with priority to high-power durable medical equipment (DME).

According to the Medical Device Market Characterization Study, there are also opportunities to build demand flexibility into device energy efficiency standards, such as reducing standby loads in magnetic resonance imaging equipment as part of the proposed ENERGY STAR standard, or in standardizing the variance of power demand across residential medical devices of the same type.

Barriers

As noted in the Medical Device Market Characterization Study, a general acceptance that medical safety and effectiveness are primary objectives for regulation or standards means that additional objectives such as energy performance or efficiency will necessarily be deprioritized.

Additionally, the potential variety or uniqueness of product functions and limited approved models for certain product categories also pose challenges for establishing energy performance standards or data collection/test procedures.

Hospital/lab: With the few exceptions mentioned above, there is limited technical understanding about many of the types of more energy-intensive equipment of interest, including:

- Limited understanding of the variety of energy-intensive equipment in hospitals, their usage, and the magnitude of savings potentials.
- The lack of national energy efficiency standards for most lab equipment (except for ultra-low temperature freezers and fume hoods).

Residential/assisted living: Information about medical equipment for residential and assisted living sectors is not well understood, and there are no efficiency programs currently in place for this market. The key barriers include:

- Technical performance and load shape are not well understood for residential/assisted living medical equipment.
- Equipment has not been evaluated from an appliance standards perspective but only from the perspective of health outcomes.
- Cost analysis is challenging due to much of these expenditures being reimbursed by health insurance.

CalNEXT Related Projects

- ET24SWE0008 – Medical Devices Market Characterization Study

Electronics and Electrical Appliances

CalNEXT Priority: Medium

Definition

The Residential and Commercial Electronics and Electrical Appliances technology family is defined as electrically powered appliances and electronics found within commercial and residential environments, including devices that can be operated untethered via battery. Example products include clothes washers, refrigerators, dishwashers, air purifiers, televisions, and computer monitors.

Note: Products that replace gas appliances, such as clothes dryers, ovens, cooktops, and ranges, are covered in the Gas and Electric Household Appliances technology family in this TPM to focus on the unique challenges of decarbonization.

Note: This technology family excludes medical mobility devices which are covered under the Medical Equipment technology family within this TPM.

Research Initiatives

Table 8: Electronics and electrical appliances research initiatives.

Research Initiative	Performance Validation Needs	Market Analysis Needs	Measure Development Needs	Program Development Needs
Inactive/Low Power Modes	Medium	Medium	Medium	Medium
User Behavior/ Interaction	Medium	Medium	High	High
Battery Integration Potential and Viability	High	High	Medium	Future
Update Energy Efficiency Test Procedures to Reflect Real-World Conditions	High	High	Medium	Medium

KEY High Needs | Medium Needs | Low Needs | Future Needs

Opportunities

A number of products in this category are generally technologically mature, and energy efficiency for many of these products has been addressed by appliance standards, voluntary certification programs, and industry voluntary agreements, many implemented at a national level. But there are still other opportunities to consider, including:

- New technological innovations, such as advances in televisions and monitors, or energy savings from inactive and low power modes.

- Understanding the motivation for consumer habits — especially those that may significantly affect energy or water consumption — and identifying effective interventions to help motivate consumers to choose the more energy- and water-efficient path.
- As battery technologies evolve and are integrated into more products, so will charging and appliance operating profiles. New research will be needed to ensure that the chargers maintain optimal battery and product performance while offering efficient charging profiles and low-power mode operation.
- The integration of new technologies—such as variable speed compressors, AI, and additional sensors—into long-standing appliances may change how the products themselves operate and how consumers interact with them. Updates to energy efficiency test procedures and associated metrics may be needed to ensure that new technologies are being properly evaluated and incentivized.
- Outside of products with existing standards, research to develop test procedures or demonstrate novel technologies in support of the deployment of new standards remains an opportunity for energy savings impacts.

Barriers

- Technical, market, and consumer use of these products has historically been known, but as these products have continued to mature and evolve, studies have not kept up with any potential changes.
- Consumer interaction with these products is frequently colored by past experiences and feelings, so it may prove difficult to sway how consumers operate the product or purchase something they're not already familiar with.
- Consumers often make their own purchasing decisions with limited expert insight, leading to an information gap that is challenging to overcome.
- For higher power density products, such as major home appliances, utilities codes and standards teams have been active in regulatory rulemakings to push higher efficiency standards; however, for lower power density devices, such as office equipment and televisions, energy efficiency does not drive purchasing behavior, and regulatory rulemaking largely ignores these devices.
- For a number of products, renters are in a unique split-incentive situation where the building owner is likely the decision maker in determining whether to install, repair, or replace an appliance or not, but it's the renter who would realize the benefits of lower energy and water use—when properly used—and time saved.

CalNEXT-Related Projects

- ET23SWE0044 – Benchtop Efficiency Measurements for Residential Mesh Networking Equipment

Discussion

Following approval of the 2026 Lighting, Plug Loads, and Appliances TPM, the program team will:

- Update the CalNEXT website with revised 2026 Lighting, Plug Loads, and Appliances TPM and this final report.
- Launch an email announcement through email outreach.
- Develop and submit the distribution report.
- Highlight any technology families to reinvestigate for the 2026 Focused Pilot TPM, which will support the 2027 Focused Pilot projects.

Appendix A: Lighting, Plug Loads & Appliances Advisory Committee Feedback & Resolution Matrix

Table 9: Advisory committee feedback and resolution matrix

Lighting, Plug Loads & Appliances TPM Technology Family	Section	Suggestion or Comment	Action Taken and Justification
General Narrative	General Narrative	Flagging that there seems to be a mistake on page 14, with the graphic showing "Medium, Low, High" instead of the graphic that represents those numbers.	Corrected.
Gas and Electric Household Appliances	General Narrative	Would be good to consider CalMTA feedback particularly for induction cooking as that is one of their major initiatives and how the research can be tailored for CalNEXT.	CalMTA feedback was captured and included, responses can be found below and throughout the narrative.
Gas and Electric Household Appliances	General Narrative	Ensure that any research and scope on 120V induction includes both battery and non-battery equipped products as different barriers, opportunities and use cases for these two very different products.	Added 120V induction cooktops both battery and non-battery enabled.
Gas and Electric Household Appliances	Definition	For Gas and Electric Household Appliances, widen scope of 120V product category to call out both battery and non-battery equipped. Two very different products with different barriers and opportunities, so I think making this distinction is important and non-battery enabled products come to market (like Summit's Wattspipper).	Added 120V Induction cooktops both battery and non-battery enabled.

Lighting, Plug Loads & Appliances TPM Technology Family	Section	Suggestion or Comment	Action Taken and Justification
Gas and Electric Household Appliances	Research Initiatives	Would recommend to increase need for "performance validation Needs" for 120V non-battery products to "high need". A lot has been done on 120V battery-enabled, but very little on non-battery. There is a lot of interest and momentum on these products that are hitting the market later this summer/ early fall, and questions remain on their ability to meet cooking needs and stay under the 1,800W threshold. Programs are very interested in this product, especially for MF and disadvantaged communities (DAC). We need research to show what the parameters are and best use cases for the non-battery product.	Increased performance validation to high need.
Gas and Electric Household Appliances	Research Initiative #4	Should these be referred to as smart controlled?	Changed to smart controlled.
Gas and Electric Household Appliances	Research Initiatives	Add 120V non-battery efficiency gains verses product limitations.	Added battery and non-battery 120V induction to the list of products covered. However, the SME team believes for conciseness, the best approach is to keep both in the same Research Initiative rather than adding the non-battery version as a separate research initiative.
Gas and Electric Household Appliances	Opportunities	In the section about health benefits, there was a study released by Standford that released data from gas stoves and IAQ: https://woods.stanford.edu/news/air-inside-your-home-more-dangerous-air-outside-it.	Added the citation of this source.

Lighting, Plug Loads & Appliances TPM Technology Family	Section	Suggestion or Comment	Action Taken and Justification
Gas and Electric Household Appliances	Barriers	An additional barrier in the Gas and Electric Household Appliances section is the lack of 120V ENERGY STAR Induction Cooktops	Added to barriers.
Gas and Electric Household Appliances	Barriers	Performance: Heat pumps generally operate at lower temperatures resulting in longer cycle times and lower customer perceived dryness. Concerns in MFM/commercial settings and operated as coin laundry and how long it takes.	Added commercial concerns to the performance bullet.
Advanced Approaches to Exterior Lighting	Research Initiative #2	Can you explain how different this is from the design standards initiative right below?	Lighting controls applications and technologies (Research Initiative #2) focus on "controlling" exterior lighting, i.e., reducing the light level when the lights do not provide any functional use due to the lack of motion, traffic, etc., in a predictable and reliable way under all circumstances, to increase energy savings. The design standards in Research Initiative #3 focus on allowing the light level to drop below the recommended levels when traffic activity is low or absent. The recommended illumination in the design standards has historically been based on the presence of traffic (as described in Barrier #3). Due to liability concerns, if the design standards remain unchanged, even though the technology (Research Initiative 2) is mature enough to reliably reduce lighting in the absence of traffic, there is no pathway for its adoption, as deviating from design standards may expose the owners and operators to lawsuits.

Lighting, Plug Loads & Appliances TPM Technology Family	Section	Suggestion or Comment	Action Taken and Justification
Electronics and Electrical Appliances	Opportunities	This section is disorganized/disjointed and lacks focus/a clear vision.	The opportunities are directly tied into the noted research initiatives. But it is a broad range of topics and if there are specific areas that feel disjointed, we can refresh to ensure the narrative and point of impact are clearly tied back to the technologies and research initiatives.
Electronics and Electrical Appliances	Opportunity #1	This has been in programs for some time and title 20 is working on it, what additional can we expect from this?	We haven't seen much engagement on this topic for CalNEXT submitted projects. But note that as of 2023, televisions in particular have a 1% ENERGY STAR unit shipment market penetration. In the past, a reason for this has been challenge with the test procedure, leading to little engagement from manufacturers. Figuring out a way to get engagement on participation for recognized energy reach standards (like ENERGY STAR) is a valuable endeavor. On the Title 20 front, we are not always engaged directly with the Title 20 team working on cross-over efforts. Our team is happy to engage and discuss support efforts to ensure we are complimentary and not duplicative.
Electronics and Electrical Appliances	Opportunity #3	What path will we use to enforce or to implement this?	This is a very valuable question but would note that it is a research question in itself. The TPM is not intended to answer this, but to encourage research that will help answer this question.

Lighting, Plug Loads & Appliances TPM Technology Family	Section	Suggestion or Comment	Action Taken and Justification
Electronics and Electrical Appliances	Opportunity #4	Is this near term? How much influence for the test procedure and which product?	It can be near or long-term depending on which technology is being researched. For example, variable speed compressors have been adopted into many refrigerators today, but the current test procedure is lacking in the value it provides to this technology. There have been past efforts to change the evaluation method, but those efforts have run into challenges, like how repeatable and reproducible is a more representative test procedure. Challenges that CalNEXT could help resolve. More long term, how do AI touted appliances actually operate? Are they learning and optimizing over time? Do they need burn in periods of operation for a test procedure to capture any potential savings the technology provides? Is it more buzz word than actual operational change? All questions that need research to understand.