2023 Plug Loads TPM

Final Report

ET23SWE0008

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Abbreviations, Acronyms, and Glossary Terms

Acronym	Meaning
AC	Alternating Current
ACEEE	American Council for an Energy-Efficient Economy
ADLD	Automatic and Dynamic Load Detection
CA	California
CARB	California Air Resources Board
CASE	Codes and Standards Enhancement
CEC	California Energy Commission
CEC-EPIC	California Energy Commission - Electric Program Investment Charge
CDC	Center for Disease Control
CPAP	Continuous Positive Airway Pressure
CPUC	California Public Utilities Commission
DC	Direct Current
DOE	Department of Energy
EE	Energy Efficiency
EPA	Environmental Protection Agency
ET	Emerging Technology
ETCC	Emerging Technology Coordinating Council
eTRM	Electronic Technical Reference Manual
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
FDAS	Flexible Demand Appliance Standards
GHG	Greenhouse Gas

Acronym	Meaning
GSA	General Services Administration
HVAC	Heating Ventilation and Air Conditioning
IEPR	Integrated Energy Policy Report
IOU	Investor-Owned Utility
kWh	Kilowatt-hour
LBNL	Lawrence Berkely National Lab
LEED	Leadership in Energy and Environmental Design
NEEA	Northwest Energy Efficiency Alliance
NEEP	Northeast Energy Efficiency Partnerships
NOx	Nitrogen Oxide
NREL	National Renewable Energy Lab
NYSERDA	New York State Energy Research and Development Authority
PA	Program Administrator
PPLs	Plug and Process Loads
RASS	Residential Appliance Saturation Study
SME	Subject Matter Expert
SPUR	San Francisco Bay Area Planning and Urban Research Association
TPM	Technology Priority Map
TSB	Total System Benefit
TWh	Terawatt Hour
U.S.	United States
VS	Variable Speed

Glossary	Meaning
Technology Category	One of six broad technology categories (e.g., Whole Building, HVAC, Water Heating (WH), Plug Loads, Lighting, Process Loads).
Technology Family	Functional grouping that provides description of program role, opportunities, barriers.
Subgroups	Common examples to further describe each technology family.
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 Role	Describes general level of engagement by California's Statewide Emerging Technologies Program (CalNEXT) SMEs. *Note: Roles will change as research is completed.*
Lead	"Lead" - CalNEXT expects to take on most or all of the work and cost burden.
Collaborate	"Collaborate" – CalNEXT is interested in collaborating and co-funding projects.
Observe	"Observe" – CalNEXT will track progress but encourage external programs to take lead in unlocking these opportunities.
CalNEXT Priority	Communicates expected level of focus by CalNEXT SMEs. *Note: Priorities will change as research is completed.*
High	"High" - CalNEXT SME team has highlighted this technology family as having high impacts within the Technology Category.
Medium	"Medium" - CalNEXT SME team determined this technology family has moderate overall impacts within the Technology Category.
Low	"Low" - CalNEXT SME team has highlighted this technology family as having low relative impacts within the Technology Category.
Impact Factor	One of four broad impact areas (energy savings potential, demand flexibility potential, decarbonization potential, and other GHG impacts).
Impact Factor Ratings	A qualitative rating (High-Medium-Low) by the CalNEXT SME team on impact potential if technological advancements are made in key subgroups.
Knowledge Index	One of three types of knowledge areas (technical performance, market understanding, and program intervention) used to assess types of barriers studies necessary to obtain the stated impact potential.

Glossary	Meaning
Knowledge Index Rating	A qualitative rating (High-Medium-Low) by the CalNEXT SME team on the relative knowledge of most subgroups within a technology family. A higher rating means that the topic is well understood.

Introduction

The Technology Priority Maps (TPMs) provide the CalNEXT Program a framework to externally communicate priorities of the program, clearly define the central focus areas of the program, and assist with project screening. They document the impact potential, programmatic research needs, and market readiness of all technology families across each of the end-use technology areas, driving product ideation, informing project selection, and determining eligibility for future focused pilot efforts. For the TPMs to provide this guidance, they require regular updates to reflect specific changes to technology, market, and policy. This Final Report covers the development of the 2023 Plug Loads and Appliances TPM.

Background

The TPMs were originally developed by Southern California Edison's Emerging Technologies program in 2017. They have been incorporated as a key element of the CalNEXT program to provide clarity to the program on our priorities. They require frequent updates to reflect the technical advancement, policy changes, and market developments in order to maintain their relevance. In 2022, the CalNEXT team did a thorough revision to the TPMs and published them to our website at: https://calnext.com/resources/plug-loads-appliances/.

Objectives

The Plug Loads & Appliances category has only seen minor changes since the last update. There is a continued need for programs to transition to Total System Benefit (TSB) from the previous cost effectiveness metrics, with implications particularly for demand flexibility and fuel substitution impacts. A greater weighting of these impacts is reflected in the TPM itself. New research and policies continue to develop around emerging efficient electric household appliance technologies to replace gas-fired products, and the TPM continues to consider these developments.

Methodology

The 2023 Plug Loads TPM revision begins with multiple meetings of the CalNEXT Plug Loads SMEs to review the existing 2022 Plug Loads TPM and identify key changes expected based on technology, market, and policy for different technology families. Common sources of research include published research papers or publicly available information from various California-based sources including the Emerging Technology Coordinating Council (ETCC), California's Investor-Owned Utilities (CA IOU) Codes and Standards Enhancement (CASE) Team, California's Electronic Technical Reference Manual (eTRM), IOU program evaluations, California Energy Commission (CEC) rulemakings, California Public Utilities Commission (CPUC) decisions, California Air Resources Board (CARB) rulemakings, and recently passed state legislation. The team also leverages outside resources from other emerging technologies programs, national building codes and standards bodies, and voluntary programs. Following this research, the SME team then drafts changes to the narratives, definitions,

opportunities, and barriers which is then presented in the Preliminary Findings Report (submitted on March 28, 2023).

Following the development of the Preliminary Findings Report, the Plug Loads SME team are given digital ballots to provide guidance on potential changes to the program role and program priority, key factors, and knowledge indices through an online balloting platform. Concurrent to this activity, the initial narratives were presented to the Technical Advisory Committee (presented April 19, 2023) as well as supplemental feedback from the CalNEXT equity specialist (Ortiz Group). Feedback on the preliminary findings report is documented and incorporated into the Draft Report submitted on May 10, 2023.

The SME Team then refined the Plug Loads TPM based on stakeholder feedback for this Draft Report. Following external review, it will be finalized before distributing to the public. Note: any technology families that show potential for a Focused Pilot will be identified for further development under that effort.

Draft Report Feedback

Following submission of the Preliminary Findings Report, the CalNEXT program team solicited additional feedback from our equity-focused partner (Ortiz Group) to inform updates to equity topics as well as the SME team, both of which are documented in Table 1 and incorporated into this Final Report. The TPM Advisory Committee meeting was held on April 19, 2023, via the Microsoft Teams platform.

Table 1: Additional Draft Report Feedback & Resolution

Technology Family	Section	Suggestion or Comment	Action Taken & Justification
Electric Vehicle Supply Equipment (EVSE)	Key Factors	From an equity perspective, controllability of load management is a key priority. Also, general uncertainty of about what impacts are included for this family: the impact of an electric vehicle replacing a gas vehicle, or the impact of a better, controllable electric vehicle (EV) charger.	Adjusted Key Factors to highlight demand flexibility impact as preeminent among impacts, and the major decarbonization potential of replacing gasoline vehicles with electric vehicles is not included in this family's energy efficiency impacts from a California investor-owned utility (IOU) perspective.
EVSE	Subgroups	Add utility pricing signals for EVSE.	Suggestion accepted.
EVSE	Definition	Add This technology family has strong overlaps with the Electrical Infrastructure technology family within the Whole Building TPM.	Suggestion accepted. Electrical panel upgrades come up frequently for this TPM, Water Heating, and other TPMs, and need to be considered holistically.
EVSE	Opportunities	Remove Load management will also be an area of rising importance,	Suggestion accepted. General comment more than specific opportunity.

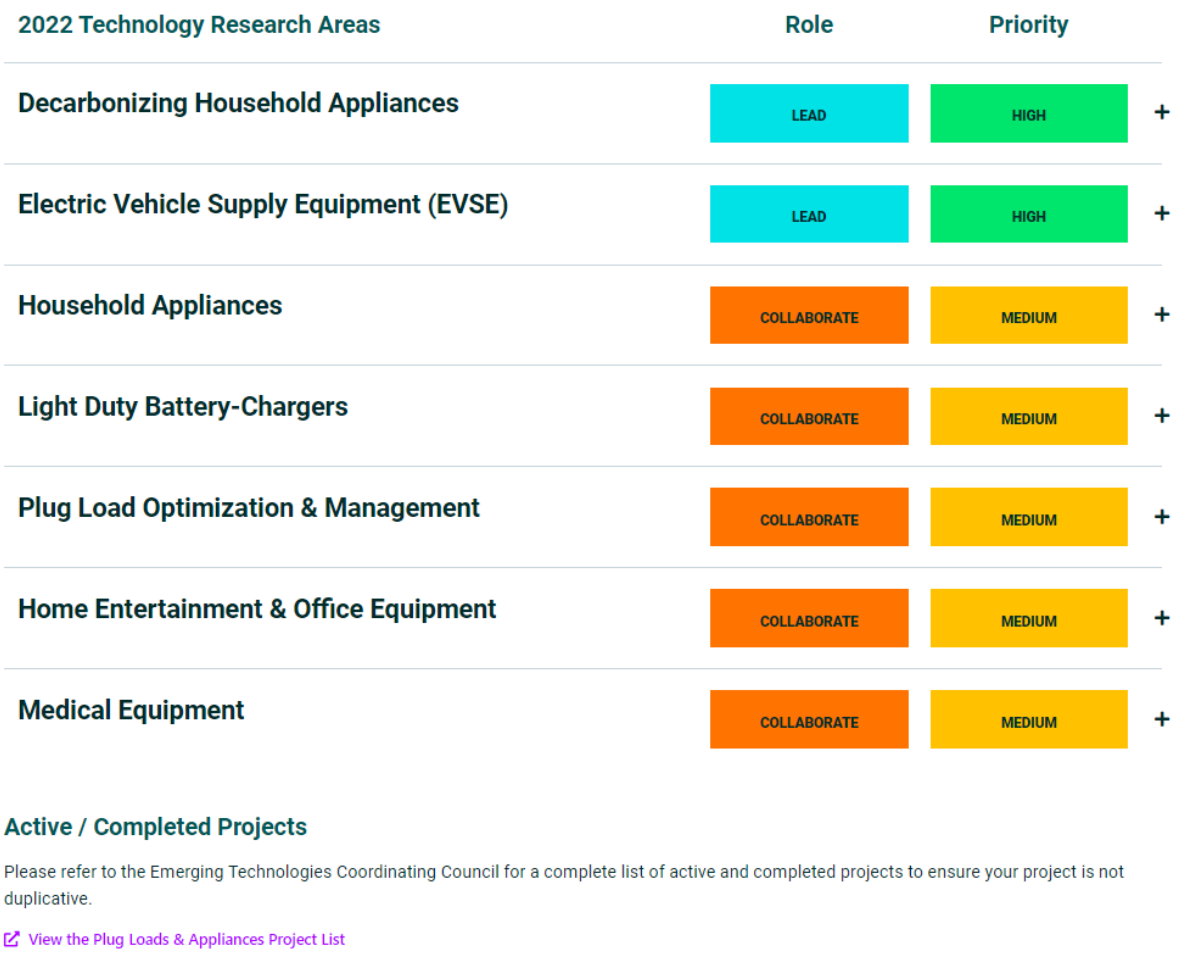
Technology Family	Section	Suggestion or Comment	Action Taken & Justification
		whether as a strategy to decarbonize plug loads without the need for electric panel upgrades or to deliver monetary benefits such as savings from time of use rates or by limiting monthly demand charges.	
Household Appliances	Subgroups	Add commercial clothes dryers.	Suggestion accepted.
Household Appliances	Opportunities	Add text describing opportunities from current Department of Energy (DOE) ratings activities for air cleaners and commercial clothes washers and dryers.	Suggestion accepted.
Household Appliances	Barriers	Add text describing barriers for commercial clothes washers.	Suggestion accepted. Accompanies opportunities modified above.
Decarbonizing Household Appliances	Subgroups	Removed residential kitchen hoods; and commercial clothes dryers; added low-voltage modifier to heat pump clothes dryers	Suggestion accepted. Remaining subgroups are more oriented toward replacement of gas appliances.
Decarbonizing Household Appliances	Opportunities	Add context on Nitrogen Oxide (NOx) emissions and benefits of electrification, and highlight need for study of impacts on	Suggestion accepted.

Technology Family	Section	Suggestion or Comment	Action Taken & Justification
		disadvantaged communities.	
Networking, Office, Home Entertainment, & Office Equipment	Tech Family Name and Subgroups	Partner Team SME suggestion to reorder to add emphasis on Networking and Entertainment subgroups which are significant users within this family, and name audio equipment, monitors, plug-in smart home devices specifically.	Suggestion accepted
Networking, Office, Home Entertainment, & Office Equipment	Definition	Expand to clarify overall applicability to both home and office settings.	Suggestion accepted.
Medical Equipment	Opportunities	Add context for expected proliferation of these devices and need to utilize controls and efficient design.	Suggestion accepted.
Light Duty Battery Chargers	Opportunities	Add details on consumer electronics, Flexible Demand Appliance Standards, and add context on the expected changes in charging profiles as these devices proliferate.	Suggestion accepted.
Plug Load Optimization & Management Technologies	Definition	Clarify focus on enabling devices to operate at lower power modes	Suggestion accepted.

Technology Family	Section	Suggestion or Comment	Action Taken & Justification
		based on either automated control or behavior modifying features.	

CalNEXT Website TPM Mock-up (2022 Plug Loads sample below)

The 2023 Plug Loads TPM website update will be in the same format as the 2022 Plug Loads TPM website update that can be seen below here, the 2023 final report link will appear in the top right corner with the option to download.



Revised 2023 Plug Loads and Appliances TPM

Plug Loads Category Overview

Plug Loads and Appliances is a broad category centered on consumer or light-commercial appliances and other miscellaneous plug loads which includes the EVSE, common household appliances, medical equipment, and light-duty battery-powered equipment.

Unique Opportunities and Barriers

EVSEs continue to be a focus of the ET program due to the enormity of expected load growth in the coming years. As EVSEs have matured, CalNEXT is focused on how to best limit idling power use of these devices, how best navigate electrical infrastructure barriers related to EVSE and other electrified options, and how to leverage technology and/or program designs to educate, navigate, and funnel end-users into demand response programs. As decarbonization has taken a more prominent role, CalNEXT is also interested in how to effectively deploy efficient electric cooktops and clothes dryers in a market that is dominated by gas-fired products.

Highlighted Priority Areas

Technology Family	Definition	ETP Role	ETP Priority
Electric Vehicle Supply Equipment (EVSE)	Electric Vehicle Supply Equipment (EVSE) is defined as the conductors, connectors, related equipment, and control software that deliver energy to an electric vehicle (EV). *Note: A number of mobile battery charging applications exist outside of traditional passenger vehicles and are covered in separate technology families within the Plug Load and Process Loads TPMs. These include applications such as e-bikes, motorized wheelchairs, forklifts, and golf carts.*	**1-Lead**	1-High
Decarbonizing Household Appliances	This technology family focuses on the replacement of gas-powered appliances used in housekeeping tasks (white goods) such as cooking and clothes drying with electric ones. Products include cooking ranges, cooktops, ovens, and clothes dryers.	**1-Lead**	1-High

Technology Family (1): Electric Vehicle Supply Equipment (EVSE)

(ETP Role: Lead, ETP Priority: High)

Key Factors

Energy Savings Potential: Low (decreased)
Decarbonization Potential: Low (decreased)
Demand Flexibility Potential: High (increased)
Other Emissions Impacts Potential: Low (decreased)

Knowledge Index

Technical Performance: High
Market Understanding: Medium
Program Intervention: Medium

Subgroups

AC Level 1 chargers; AC Level 2 chargers; DC chargers; bi-directional chargers; local load management technologies; chargers with integral communication functions; utility pricing signals for EVSE; charging connector standardization.

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). This technology family has strong overlaps with the Electrical Infrastructure technology family within the Whole Building TPM.

Note: A number of mobile battery charging applications exist outside of traditional passenger vehicles and are covered in separate technology families within the Plug Load and Process Loads TPMs. These include applications such as e-bikes, motorized wheelchairs, forklifts, and golf carts.

Opportunities

Electrified transportation is expected to be the major driver of load growth within California and EVSE are a key enabling technology to unlock decarbonization of this end use. California Energy Commission's (CEC's) latest Integrated Energy Policy Report (IEPR) projects that by 2030 electrical consumption from transportation will make up more than 20 Terawatt hours (TWh) or 6.7% of all electrical consumption. Given the rapid deployment in progress, it is crucial for state energy goals to ensure that EVSE are functioning with energy efficiency and demand flexibility in mind. To that end, products must limit standby energy usage and ensure that demand flexibility is incorporated into EVSE. While there currently are no energy efficiency standards for EVSE, ENERGY STAR® has been taking a lead role in developing voluntary standards for the critical features that are immediately needed such as idle power mode limits, criteria for grid-connected functionality, and communication with the EV itself.

Barriers

While EVSEs are relatively new, understanding of 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 need for both broad and specialized consumer education to help end-users navigate the complexities of: (1) installing efficient EVSE, (2) limiting need for expensive panel upgrades, and (3) enrolling and educating users in flexible demand programs.

Prospective CalNEXT research should look at innovative program designs to address these multi-pronged barriers.

Technology Family (2): Decarbonizing Household Appliances

(ETP Role: Lead, ETP Priority: High)

Key Factors

Energy Savings Potential: Medium
Decarbonization Potential: High
Demand Flexibility Potential: Medium
Other Emissions Impacts Potential: Medium

Knowledge Index

Technical Performance: Medium
Market Understanding: Low
Program Intervention: Low

Subgroups

Induction cooktops (residential); all-electric ranges & ovens (residential); low-voltage clothes dryers (residential).

Definition

This technology family focuses on the replacement of gas-powered appliances used in housekeeping tasks (white goods) such as cooking and clothes drying with electric ones. Products include cooking ranges, cooktops, ovens, and clothes dryers. This technology family has strong overlaps with the Electrical Infrastructure technology family within the Whole Buildings TPM.

Opportunities

In California, most households use gas-powered white goods for cooking and clothes drying, creating a huge opportunity for electrification.[1]

A report by San Francisco Bay Area Planning and Urban Research Association (SPUR) determined that, “Gas appliances in California homes and buildings generate four times as much lung-damaging nitrogen oxide (NOx) pollution as the state’s gas power plants, and roughly two thirds as much NOx as all of the state’s passenger cars.”[2] While the California Air Resources Board (CARB) has moved to ban the sale of new gas space and water heaters by 2030, gas-powered white goods are not yet being phased out on a large scale. A recent study on gas stoves found that even when they are off,

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[1] Percentage of white goods that are gas-powered for different end uses based on the 2019 California Statewide Residential Appliance Saturation Study (RASS).

Table 2: Percent of White Goods Products that are Gas-Powered

White Good Product	Percent Gas-Powered in California
Residential Clothes Dryers	58%
Commercial Clothes Dryers	82%
Cooktop	54%
Oven	55%

[2] https://www.spur.org/publications/policy-brief/2022-09-20/gas-appliances-and-smog-californias-hidden-air-pollution

they are emitting dangerous air pollutants.[3] There is an opportunity to accelerate the decarbonization of household appliances and prime the market for future regulation. Aside from the decarbonization benefits from fuel switching, both dryers and cooktops have significant energy savings opportunities. ENERGY STAR® estimates that conventional gas cooktops are approximately 32% efficient compared to 75-80% for electric resistance and 85% for induction.[4]

Prospective research should focus on behavioral interventions and technologies to break down fuel-switching barriers. These include the marketing challenges for electric cooktops, avoiding the need for electrical upgrades through the deployment of 110V clothes dryer products and combination washer/dryers, and other solutions to reduce barriers to electrification. Research should also focus on the unique challenges and opportunities in low income and multifamily buildings, where commercial laundry is used, apartments often have limited electrical capacity, and high-end electrical appliances such as induction cooktops and heat pump dryers may not be the most suitable option.

Barriers

Despite the status as a mature product area, knowledge of technical performance lags other large household appliances. As of January 2023, neither ovens nor commercial clothes dryers have national standards nor approved test procedures. ENERGY STAR® has only recently taken action to establish voluntary standards for electric cooktops and DOE is in the process of setting performance standards for electric and gas cooktops.

Despite the large savings opportunities, significant deployment barriers exist from basic consumer understanding of induction cooking as well as quality concerns around heat pump dryers. Existing electric panel constraints are also a potentially large barrier where these products compete with other electrification opportunities. This is particularly stark in multifamily buildings. Given the significant barriers, CalNEXT research should focus on additional program interventions that can help consumers effectively navigate decarbonization efforts.

[3] https://pubs.acs.org/doi/10.1021/acs.est.2c02581

[4] https://www.energystar.gov/about/2021_residential_induction_cooking_tops

Technology Family (3): Household Appliances

(ETP Role: Collaborate, ETP Priority: Medium)

Key Factors

Energy Savings Potential: Medium
Decarbonization Potential: Low
Demand Flexibility Potential: Medium
Other Emissions Impacts Potential: Low

Knowledge Index

Technical Performance: High
Market Understanding: High
Program Intervention: Low

Subgroups

Refrigerators and freezers; beverage coolers; residential and commercial clothes washers; dishwashers; air cleaners; counter-top cooking appliances (microwaves, coffee makers, air fryers, etc.), heat pump clothes dryers, residential kitchen hoods, commercial clothes dryers.

Definition

Large and small appliances that aid in routine home keeping and housework that are powered exclusively by electricity and without a battery. They can be located within the home, in multi-family buildings, or light commercial settings.

Note: products that commonly use gas such as clothes dryers, ovens, cooktops, and ranges are covered in a separate plug load technology family to focus on the unique challenges for decarbonization.

Opportunities

These products are technologically mature with effective energy and water standards implemented at a national level for products including refrigerators, beverage coolers, residential clothes washers, and dishwashers. As such there are limited impacts, with the exception of dishwashers where access has lagged, and traditional handwashing is significantly more energy- and water-intensive. In the latest California Statewide Residential Appliance Saturation Study (RASS) homeowners reported high penetration rates at 81% while only 51% of renters reported having a dishwasher. Of those who do own a dishwasher, 21% of homeowners and 34% renters respectively report not using their appliance.

Outside of products with national standards, research to develop representative test procedures or demonstrate novel technologies in support of deployment of new standards remains an opportunity for energy savings impacts for products such as large commercial clothes washers, where DOE could increase the capacity limit to 8.0 cubic feet to match the residential limit. In 2022 DOE determined that air cleaners qualify as a covered product and estimated average household energy use at greater than 100 annual kilowatt-hour (kWh). Commercial clothes dryers are an unregulated product with significant market potential and are one of the last “big” white goods products left to regulate. Regulating commercial clothes dryers will generate natural gas and electricity savings, greenhouse gas (GHG) mitigation and downstream impacts for low income and disadvantaged communities.

Barriers

Technical understanding of products in this family is well known and while market knowledge around consumer purchasing behavior is known, the actual use of these products is not well understood. The utilities codes & standards teams have been active in regulatory rulemakings to push higher

standards, but innovative program designs focused on consumer education for household appliances may provide significant savings of energy and water. Increasing the DOE capacity limit for commercial clothes washers will require working closely with manufacturers as the test burden would increase but should not require new test equipment or lab facilities.

Technology Family (4): Networking, Office, Home Entertainment, & Security Equipment

(ETP Role: Collaborate, ETP Priority: Medium)

Key Factors

Energy Savings Potential: Medium
Decarbonization Potential: Low
Demand Flexibility Potential: Low
Other Emissions Impacts Potential: Low

Knowledge Index

Technical Performance: Medium
Market Understanding: Low
Program Intervention: Low

Subgroups

Home entertainment equipment; Televisions; set-top boxes; gaming consoles; audio equipment; office equipment; computers; monitors; networking equipment; imaging equipment; security equipment; cameras; servers; home and facility automation; plug-in smart home devices.

Definition

Devices used within homes and offices to provide and access local and wide area networks, allow computing, establish security networks, and provide entertainment.

Opportunities

Energy consumption for many of these products has been addressed by appliance standards (televisions, computers), voluntary certifications (computers, monitors, televisions, imaging equipment, audio equipment) and industry voluntary agreements (set-top boxes, small network equipment). Energy efficiency savings may be limited to either new technological innovations such as advances for televisions and monitors, or energy savings from inactive modes, which have become more significant as many of these devices are never fully off. Emerging technology (ET) projects on inactive power can leverage and contribute data to the CEC's ongoing proceeding on Low Power Modes.

Barriers

In aggregate these devices consume significant power, but the savings per individual device are low, as is consumer awareness. Energy efficiency does not drive purchasing behavior, and efficiency programs largely ignore these devices. Customer engagement is low for features such as automatic brightness control and automatic power down that can determine power consumption. Furthermore, a number of subgroups within this technology family have short life expectancy due to new technological advancements within the subgroup, making them difficult to regulate without limiting overall performance. Energy consumption trends have been driven by customer expectations for network connectivity and availability of video and audio, and network connection often defaults to basic Wi-Fi even when data rate and latency needs allow for more efficient technologies.

Technology Family (5): Medical Equipment (residential and assisted living)

(ETP Role: Collaborate, ETP Priority: Medium)

Key Factors

Energy Savings Potential: Medium
Decarbonization Potential: Low
Demand Flexibility Potential: N/A
Other Emissions Impacts Potential: N/A

Knowledge Index

Technical Performance: Low
Market Understanding: Low
Program Intervention: Low

Subgroups

Oxygen concentrators; continuous positive airway pressure ventilators (CPAP); power wheelchairs; personal vertical transport; automated reclining chairs; circulation pumps for beds; precision heaters; emergency back-up power for medical equipment.

Definition

This category includes the specialty medical equipment intended for elderly and people with disabilities for personal mobility or medical treatment in residential and assisted living facilities.

Note that this technology family excludes hospital-specific equipment, such as imaging equipment (CT scans, MRI, X-ray), medical-grade cold storage, and biosafety cabinets which are covered under the Process Loads TPM.

Opportunities

Medical devices in the U.S. are a growing fixture in households. The U.S. Center for Disease Control (CDC) estimates that there are 61 million adults with disabilities and 13.7 percent with a disability that impacts walking and climbing stairs. In addition, a 2021 study by Lawrence Berkeley National Lab (LBNL) estimates there are 2.74 million oxygen concentrators and 2.2 million CPAP ventilators. Despite the prevalence of these products, data on energy usage of medical equipment is sparse, so overall energy savings opportunities remain unclear. Many of these devices are used continuously (oxygen concentrators) while others have the potential to have high parasitic loads (such as vertical lifts), so efficiency improvements are likely to save significant amounts of energy (and be cost-effective). Demand flexibility, while technically feasible, is unlikely to have significant uptake due to concerns for safety and health impacts.

As the population ages and costs of care rise, home-based, medical equipment is likely to proliferate, including diagnostic sensors and in-home "lab tests" that to replace commercial laboratory testing and specially equipped bathrooms and automated hygiene assistance. These technologies are likely to increase energy consumption, so the goals should be to ensure efficiency and controls to switch off components when nobody is present.

Barriers

Significant barriers exist for this technology family. Technical performance is not well understood as there is limited data on actual energy use of this equipment and despite the maturity of this sector, these products have been historically exempted from appliance standards. Market signals are misaligned as equipment purchasers are reimbursed by health insurance for the capital expense and end-users pay a lower electricity rate under the utility-run medical baseline program. Prospective ET studies should address (1) fundamental lack of knowledge in the technical performance in this

sector followed by (2) research to improve viability of different market interventions (e.g., federal standards, state standards, voluntary standards, adjustments to the medical baseline program or other programs).

Technology Family (6): Light Duty Battery-Chargers

(ETP Role: Collaborate, ETP Priority: Medium)

Key Factors

Energy Savings Potential: Medium
Decarbonization Potential: Low
Demand Flexibility Potential: Medium
Other Emissions Impacts Potential: Low

Knowledge Index

Technical Performance: High
Market Understanding: Low
Program Intervention: Low

Subgroups

Mobile devices (laptops, tablets, phones); non-medical mobility devices (e-bikes, scooters); battery-powered yard equipment (mowers, chainsaws, leaf blowers); miscellaneous battery-powered equipment (power tools, vacuums, drones); stand-alone rechargeable batteries; wireless charging devices.

Definition

Electronic devices with onboard batteries that may be operated while plugged in but largely operated untethered via battery. Building energy use occurs while charging battery or during concurrent usage.

Note: this technology family excludes medical mobility devices which are covered under a separate technology family within the Plug Load TPM.

Opportunities

Battery-chargers are mature technology that have become ubiquitous in our society, charging everything from billions of small devices like smartphones and electric toothbrushes to a growing number of larger devices like electric bicycles and lawn equipment. This growth is expected to continue, especially among larger battery equipment, as the CARB has recently required the use of zero-emissions landscaping equipment starting in 2024. Across all battery sizes, national efficiency standards for battery chargers have already been codified at the national level covering active mode and standby mode for all non-automotive applications and DOE has an active rulemaking to revise these standards. Meanwhile, the State of California is beginning to set flexible demand appliance standards (FDAS) under SB-49 (Skinner) which may have significant opportunities for certain applications of large battery chargers.

Wireless charging technologies have seen widespread growth in consumer electronics, however, efficiency standards for wireless charging efficiency have only recently become mandatory for wireless product testing, which represents an opportunity to research efficiency performance in this growing area. Understanding the efficiency losses of wireless charging platforms will become increasingly important as this technology expands beyond low-capacity products such as cell phones and toothbrushes to laptops and other devices. Power losses from wireless charging can increase energy consumption by 50%, so efforts should lay groundwork for efficiency standards in wireless charging.

Other ET activities should support CARBs efforts in decarbonizing lawn equipment & other similar fossil-fuel powered mobile energy products as well as efforts to embed demand-flexible capabilities into battery chargers in support of FDAS. Some battery chargers may warrant new research to inform potential applicability in evolving FDAS standards, such as large home lawn appliances with systems approaches to charging.

As battery technologies evolve, so will charging profiles and new research will be needed to ensure that the chargers are maintaining optimal battery performance while maintaining low power modes once battery charging is complete, especially for seasonal devices with larger battery storage capacity such as lawn equipment (in certain regions of the state).

Barriers

The technical understanding of battery chargers is mature, with the exception of the emerging wireless charging platforms. Market incentives are not well aligned because consumer purchasing decisions are not driven by battery chargers themselves but rather by the products to be charged. The California utility programs have had limited activity in this area, with incentive activity for all-electric landscaping equipment funded by some regional air quality districts.

Technology Family (7): Plug Load Optimization & Management Technologies

(ETP Role: Collaborate, ETP Priority: Medium)

Key Factors

Energy Savings Potential: Medium
Decarbonization Potential: Low
Demand Flexibility Potential: Medium
Other Emissions Impacts Potential: Low

Knowledge Index

Technical Performance: Medium
Market Understanding: Low
Program Intervention: Low

Subgroups

Smart Receptacles; advanced power strips; plug load management devices; product-embedded plug load management.

Definition

Components, platforms, and foundational communications protocols with the ability to communicate, coordinate, and reduce energy use of plug-in electric loads in a residential or commercial building. Devices in this cross-cutting technology family are expected to enable plug load appliances to operate at lower power modes based on either automated control or behavior modifying features.

Opportunities

Emerging technologies in the Plug Load Management Technology Family have the potential to result in significant energy savings and decarbonization benefits. According to the National Renewable Energy Laboratory (NREL), "Plug and process loads (PPLs) account for 47% of U.S. commercial building energy consumption" and are expected to continue steady growth. Managing plug load operations to communicate across devices and minimize consumption when not in use may result in significant energy savings and have broad decarbonization benefits, as fossil-fuel power has contributed to just over 40% of California's total power mix in 2021.

Prospective research should focus on: (1) deepening understanding of the energy savings potential associated with optimized plug load management; (2) demonstrating energy savings potential for learning behavior algorithms which can manage usage based on learned occupant behavior and automatic & dynamic load detection (ADLD) which identifies devices as they are plugged into a building (3) assessing the market to understand scope, availability, and cost for technologies as well as the viability to embed intelligence into the products themselves; (4) understanding consumer appetite to adopt and interact with these types of technologies, with a particular focus on the customer experience, and potential data privacy concerns.

Barriers

Significant barriers must be overcome to actualize and scale plug loads management to the broader market. Technical demonstrations have been done to prove viability of certain product types, but broader opportunity will come if standardized communication protocols across different product types can be developed to allow manufacturers to embed communications and controls intelligence into their products. Until these technical and market challenges are addressed, it is unlikely traditional utility programs will be able to identify cost-effective savings outside of a couple specialized products (e.g., refrigerated vending machines & water coolers).

Next Steps

In preparation for finalizing the Plug Loads and Appliances TPM, the Program Team will do the following:

1. Update CalNEXT website with new 2023 Plug Load and Appliances TPM.
2. Launch email announcement through email outreach.
3. Develop and submit Distribution Report.

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

Table 3: Advisory Committee Feedback & Resolution Matrix

Technology Family	Section	Suggestion or Comment	Action Taken & Justification
All	Key Factor / Knowledge Index Ratings	Request Indication on how ratings changed vs. prior year.	Noted as “increased” or “decreased” throughout document.
EVSE	Key Factor / Knowledge Index Ratings	Why is decarbonization set as low? Should it be higher?	No changes made. Key factors are viewed through the lens of building energy use and do not include transportation electrification impacts.
EVSE	Opportunities	Controllable load management (load management controllability) is a key priority.	Incorporated change within the narrative.
Decarbonizing Household Appliances	Subgroups	Why not have electric panel capacity as a separate research area since it can be a major barrier for decarbonizing household appliances, EVSE’s, and other electrification projects?	Incorporated note on overlap with Electrical Infrastructure technology family.