Technology Priority Maps

About the Technology Priority Maps

The primary goal of the Technology Priority Maps (TPMs) is to provide a framework to help California's Emerging Technologies Program (ETP) identify high priority areas and reduce duplication of effort across utility service areas. They capture the emerging technology needs of the Rolling Portfolio and help drive project ideation for ETP implementers who will seek to identify, evaluate, and recommend a comprehensive set of suitable technology options for consideration by resource program designers and implementers.

The TPMs are living documents to allow responsiveness to changing technology, regulatory, and energy landscapes. They can assist communication with resource program designers, Commission staff, and the emerging technologies community. They will be reviewed periodically and updated in order to stay current with technological advances and accommodate changes in priorities or newly defined needs, such as shifts in the marketplace or evolving state policies. The TPMs are an important tool for Program Administrators' quality assurance needs but are not prescriptive, and are not research plans, checklists, nor the only sources for ETP ideas.

TPM Summary

This section describes the TPM structure and a description of areas of focus for the Emerging Technologies Program. It identifies linkages with codes and standards, demand flexibility, and non-energy decarbonization opportunities, and helps practitioners identify areas of overlap within the ETP. There is a TPM for each of the following **six Technology Categories**:

1. Heating Ventilation and Air Conditioning
2. Plug Loads and Appliances
3. Process Loads (Commercial, Industrial, Agriculture and Water)
4. Lighting
5. Water Heating
6. Whole Buildings

Each Technology Category contains multiple Technology Families with Subgroups.

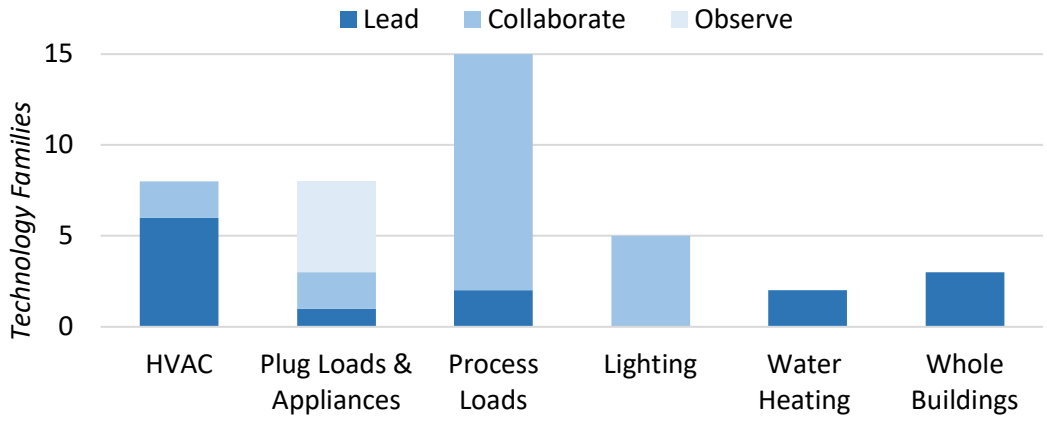
- **41 Technology Families** include technology types (transportation refrigeration units), sectors with unique needs (water treatment), or broad categories (commercial water heating). Integrated controls are important in almost all Technologies Families.
- **Over 200 Technology Subgroups** describe types of equipment within a Technology Family (e.g., "Sterilizers" are a Subgroup within "hospitals" Technology Family).
- Two approaches were used to address technologies that crossover between Categories. Technologies that require integration (for example, combination systems that integrate water heating and space conditioning) are included in the Whole Buildings Category. Alternatively, controls and pump systems are repeated in multiple Technology Families - for example, efficient pump systems are a part of water use control systems, pool systems, variable refrigerant flow HVAC systems and more. Because these pump systems are a part of the technology itself, they are included in each relevant Subgroup.

This TPM summary is followed by Technology Category Pages that contain more detail about unique ETP opportunities and barriers and related utility priorities.

The TPM Workbook is contains descriptions of each Technology Family, unique opportunities and barriers, and additional detail on the energy savings potential and other attributes. It is available as an appendix to this document.

Emerging Technologies Program Role

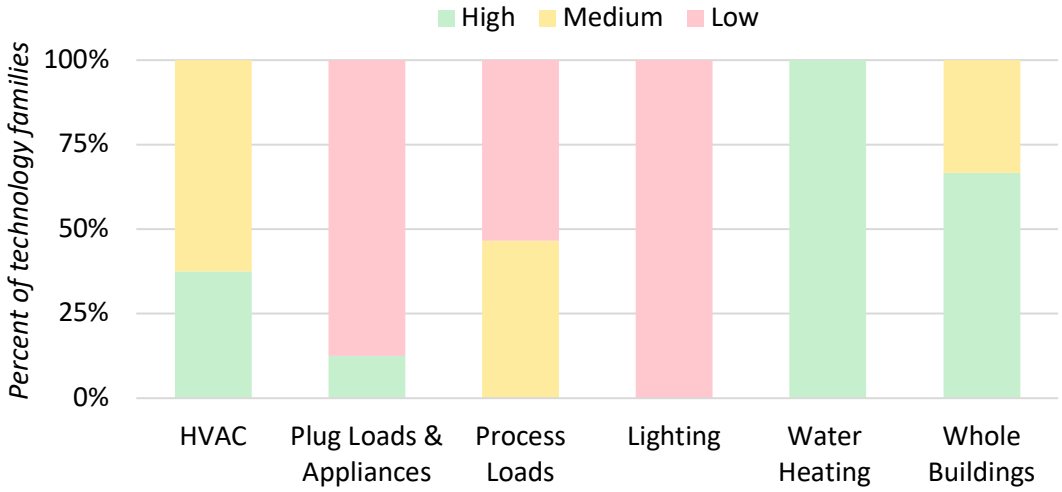
The ETP Role indicates the general level of engagement recommended by technology and program subject matter experts for ETP implementers, taking into account whether other organizations or entities are also conducting work in these areas. The figure below shows each Technology Category with the level of engagement recommended for different Technology Families in each Technology Category.



The figure above shows that the highest level of engagement is recommended for HVAC, water heating, and whole buildings technologies. “Lead” means that subject matter experts have suggested that the ETP should be ready to take on most of the work and cost burden. The Process Load category, for example, has two Technology Families for which the “Lead” role is recommended, all related to refrigeration where significant ETP work is needed to meet California requirements for low global warming potential (GWP) refrigerants.

Emerging Technologies Program TPM Priority

The Statewide ETP TPM Priority is intended to reflect the statewide priority and is informed by a weighted score that incorporates the following four factors for each Technology Family: Energy Savings Potential, (non-energy) Decarbonization Potential, Codes and Standards Alignment, and Demand Flexibility Potential. Current ETP TPM Priority is shown below, followed by a description of the four prioritization factors.



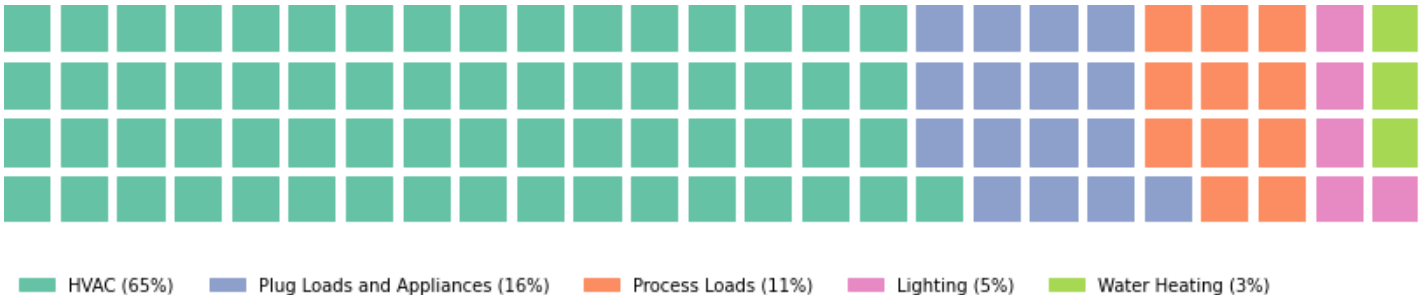
The figure above shows that HVAC, Water Heating, and Whole Buildings Technology Categories are prioritized more highly than others. Water heating ranks highly, for example, because it provides significant (non-energy) decarbonization and demand flexibility potential.

The TPM Workbook provides the option for users to enter different weights for each factor in order to apply different "lenses" on ETP TPM priority. For example, if (non-energy) decarbonization potential is a greater priority for a TPM user than energy savings potential, the relative weighting of these prioritization factors can be changed accordingly.[1]

Energy Savings Potential

The energy savings technical potential reflects the estimated amount of energy savings that would be possible if the highest level of efficiency for all technically applicable opportunities to improve energy efficiency were taken regardless of cost. To estimate energy savings potential, subject matter experts (SMEs) first considered Technology Subgroup estimates from the 2017 TPMs. SMEs took into account information from applicable studies and professional judgement, and when possible, aligned estimates with values in the CPUC's *2019 Potential and Goals Study*.[2] Consistent with this study, technical potential reflects energy savings that would be possible if the highest level of efficiency for all technically applicable opportunities to improve energy efficiency were taken regardless of cost. Savings potential estimates represent an estimate of the combined potential of all of the Technology Subgroups within the Technology Family.

Relative Electricity Savings Potential – Annual Incremental Savings in 2030



The figure above indicates relative electricity saving potential for Technology Categories.[3] Note that the Whole Buildings Category is not included in the above percentages. Savings in this cross-cutting category are important for additional energy savings and load management benefits (for example combining water heating and space conditioning). Because this is the Electric TPM, it focuses on electricity savings; a chart showing combined electricity and gas savings would look quite different. For example, water heating would have a higher relative role if fuel substitution were considered.

Decarbonization Potential

The Buildings sector in California has experienced an overall decrease in emissions since 2000, due largely to California's successful energy efficiency efforts. Further increasing energy efficiency in buildings is one important way to contribute to decarbonization. However, there are numerous technologies that offer pathways to decarbonization beyond those associated with decreasing energy use.

To capture those opportunities, the TPM Workbook now includes an estimate of the degree to which a technology family might contribute to decarbonization, beyond emissions reductions from increasing energy efficiency. These decarbonization pathways include switching fuel, shifting time of use (due to varied hourly carbon intensity of the

[1] Current weighting of prioritization factors: Energy Savings Technical Potential=5, Decarbonization Potential=2, C&S Alignment=3, Demand Flexibility Potential=3.

[2] ftp://ftp.cpuc.ca.gov/gopher-data/energy_division/EnergyEfficiency/DAWG/2019%20PG%20Study%20Report_Final%20Public_PDFA.pdf

[3] The graph illustrates the proportion of electric energy in 2030. Each square represents about 3,000 GWh/year.

generating mix), and reducing the release of high-GWP refrigerants by using low-GWP refrigerants and minimizing refrigerant leakage.

In particular, the key to reducing emissions from energy use in buildings will likely involve electrification of space and water heating with highly efficient technologies, coupled with strategies to intelligently shift electricity consumption in time. These strategies may also encourage the use of refrigerants with low-GWP and otherwise reduce greenhouse gas emissions associated with refrigerants. Addressing refrigerant emissions will become increasingly important as building energy systems rely more on heat pump technologies rather than fossil fuels to meet heating demands. As noted above, water heating is a compelling decarbonization opportunity due to high efficiency technology, fuel switching, and ability to shift the time of consumption.

Codes and Standards Alignment

Emerging technology activities are most often focused on supporting the development of new measures for Program Administrators' programs. In a number of cases, the Codes and Standards (C&S) programs are working on objectives that align with ET opportunities. Thus, the C&S program may also be able to leverage work conducted by the ETP and its implementers. Note, however, that C&S and ETP's distinct objectives drive different data collection outcomes. Whereas ETP is driven predominantly by new technology opportunities as they relate to incentive programs, C&S technical priorities are set directly by code setting bodies or presumed regulatory updates several years hence. The C&S alignment column was added to the TPM to identify where technology family opportunities appear likely to align with current and future C&S Program efforts.

Demand Flexibility

Demand flexibility associated with control and use of some technologies is another key opportunity in California. As with decarbonization, the TPM Workbook identifies technologies with demand flexibility potential. Many of the technology family opportunities reflect the increasing prevalence of communication and control technologies that can respond to grid needs. Variable speed pumping and compressor systems, whole building controls, battery charging systems, and smart appliances are all examples of emerging technologies that appear to offer significant demand flexibility opportunities relative to their energy use.

Knowledge Indexes (KI)

Technical Performance KI - Market KI - Program Intervention KI

The TPM introduces the concept[4] of "Knowledge Indexes" to characterize the state of knowledge along three key dimensions for each technology: Technical Performance Knowledge, Market Knowledge, and Program Intervention Knowledge. The assessments are rough, characterized only as "high", "medium", and "low". These Knowledge Indexes can be used by ETP implementers and resource programs to understand the level of confidence with which ETP would recommend these technologies for new program measures at this time. For example, a technology with a medium or high Technical Performance Knowledge Index may be ready for further market barrier studies. Once a technology has a medium or high Market Knowledge Index, it may be ready for pilot testing of interventions and for Emerging Technologies Focused Pilots (ETFPs), intended to be conducted in coordination with other relevant programs. Due to the variability of confidence in knowledge of individual technologies, preliminary Knowledge Index assessments at the technology family level should be refined through subsequent ETP activities as specific technologies and practices are addressed.

[4] These Knowledge Indexes are based upon the Northwest Energy Efficiency Alliance Readiness Levels. However, ETP does not attempt to rate "readiness". The determination of when a technology is "ready" is up to individual programs: A program with low risk tolerance may not decide a technology is "ready" until there is high confidence in knowledge of all three dimensions, whereas a program with higher risk tolerance may choose to offer a technology with a high Technical Performance Knowledge Index, but only a medium or low Market Knowledge Index.

HVAC

Technology Families

- Decoupled HVAC systems
- Variable capacity systems (commercial)
- Variable capacity systems (residential)
- Automated fault detection and diagnostics
- Air-to-water heat pumps for space heating and cooling
- Non-compressor-based HVAC
- Low-GWP refrigerants in HVAC
- HVAC controls

Technology Area

Decoupled ventilation and heating/cooling systems incorporating low energy technologies with advanced design and controls features—including heat recovery ventilators, variable refrigerant flow systems, chilled beams, and radiant systems—are leading the movement for greater efficiency gains. Advanced controls, system integration, and fault detection are gaining importance in advancing building energy efficiency and occupant comfort. Non-compressor and variable capacity compressor technologies, and sustainable refrigerants are also emerging areas of interest.

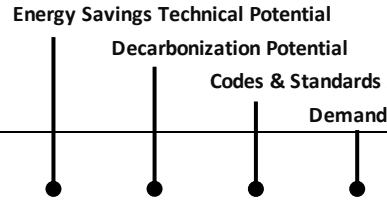
Unique Opportunities and Barriers

The emphasis on low-energy systems and decarbonization has the potential to lower energy use, while utilizing refrigerants that have low global warming potential or avoiding refrigerants altogether. Adopting cost-effective, climate-appropriate technologies for the hot, dry service territory of Southern California is important.

Highlighted Priority Areas

Tech Family	*Tech Subgroups*	*Definition*	*Priority*
Variable Speed Compressor Systems (commercial)	Variable refrigerant flow (VRF); Variable speed RTU's, chillers, water-source heat pumps, and PTACS.	A reversible heat pump or cooling-only system that uses a variable-speed compressor to modulate refrigerant flow to optimize energy consumption. VRF, PTAC, and WSHP are almost always reversible heat pumps, RTUs and chillers are nearly always cooling-only, but are available in reversible models.	High
Variable Speed Compressor Systems (residential)	Mini- and multi-split systems (non-ducted & ducted) and traditional central split systems; usally air source but can be water-source or geothermal	A reversible heat pump or cooling-only system that uses a variable-speed compressor to modulate refrigerant flow to optimize energy consumption. Mini- and multi-splits sold in the USA are nearly all reversible heat pumps. Traditional splits are available in both configurations.	High
HVAC Controls	Building Automation System/Energy Management Information System (commercial); communicating thermostat (residential)	Controls, monitors, and manages the building's HVAC energy use and component functionality. Allows interaction of devices, systems, controls, automated response to predetermined settings. Understands the operation of building systems to improve performance.	High

HVAC at a Glance



Technology Family	Technology Subgroups	Definition	ETP Role	ETP Priority	Technical Performance KI	Market Knowledge Index (KI)	Program Intervention KI
Decoupled HVAC systems	Decoupled HVAC systems (e.g. HRV/DOAS + chilled beams, radiant, fan coils, or VRF); Advanced HRV controls: modulating heat recovery bypass control and IAQ sensors for DCV; Advanced HRV design: counterflow heat	Decoupled HVAC systems separate ventilation airflow/loads from space comfort conditioning to provide lower HVAC system energy overall through the reduction in reheat and allowing for the	**1-Lead**	2-Medium	2-Medium	3-Low	3-Low
Variable speed compressor systems (commercial)	Variable refrigerant flow (VRF); Variable speed RTU's, chillers, water-source heat pumps, and Package Terminal Air Conditioner Systems (PTACS).	A reversible heat pump or cooling-only system that uses a variable-speed compressor to modulate refrigerant flow to optimize energy consumption. VRF, PTAC, and WSHP are almost always	**1-Lead**	1-High	2-Medium	2-Medium	3-Low
Variable speed compressor systems (residential)	Mini- and multi-split systems (non-ducted & ducted) and traditional central split systems; usally air source but can be water-source or geothermal	A reversible heat pump or cooling-only system that uses a variable-speed compressor to modulate refrigerant flow to optimize energy consumption. Mini- and multi-splits sold in the USA are	**1-Lead**	1-High	2-Medium	2-Medium	2-Medium
Automated fault detection and diagnostics	Small/Medium Commercial Buildings - FDD reporting format; Large Commercial Buildings - FDD reporting format; Residential Buildings - FDD reporting format; Small/Medium Commercial Buildings - HVAC equipment	Functionality that detects and diagnoses problems that lead to degraded performance of HVAC systems (energy efficiency, capacity, increased maintenance, or shortened equipment	2-Collaborate	2-Medium	2-Medium	3-Low	3-Low
Air-to-water heat pumps for space heating and cooling	Air-to-water heat pumps for space heating; air-to-water reversible heat pumps for space heating and cooling.	Heat pumps that use ambient air as a heat source to add heat to a space heating hydronic system. Reversible units can also chill the water for cooling.	**1-Lead**	2-Medium	2-Medium	2-Medium	3-Low
Non-compressor based HVAC	Sub wet-bulb systems, High-performance evaporative systems, Natural ventilation systems, Radiant systems, Solid state (thermoelectric, magnetocaloric), Systems designed for compressorless heating/cooling	HVAC systems that do not rely on refrigerant-based vapor compression cycle	2-Collaborate	2-Medium	1-High	3-Low	3-Low
Low-GWP refrigerants in HVAC	Low global warming potential (GWP) refrigerants, applies to room AC and dehumidifiers, packaged systms, VRF, etc.	Refrigerants used in vapor compression systems that have lower global warming impacts than legacy refrigerants.	**1-Lead**	2-Medium	3-Low	3-Low	2-Medium
HVAC controls	Building Automation System/Energy Management Information System (commercial); communicating thermostat (residential)	Controls, monitors, and manages the building's HVAC energy use and component functionality. Allows interaction of devices, systems, controls, automated response to predetermined	**1-Lead**	1-High	2-Medium	3-Low	3-Low

Plug Loads and Appliances

Technology Families

- Electric vehicle supply equipment
- White goods
- Home entertainment, networking, office, and security equipment
- Medical equipment (residential and assisted living)
- Medical equipment (health care facilities and clinics)
- Mobile charging devices
- Miscellaneous Plug Load (residential)
- Miscellaneous Plug Load (commercial)

Technology Area

Plug loads and appliances is a broad category that includes electric vehicle supply equipment (EVSE), white good appliances, home entertainment and office equipment, medical equipment, and miscellaneous plug loads.

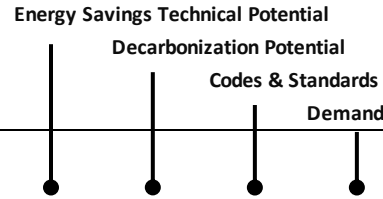
Unique Opportunities and Barriers

The EVSE end-use category is growing due to increasing electric vehicle adoption and there are a range of energy efficiency and demand flexibility opportunities. Efficiency gains for white good appliances still exist as do increased demand flexibility opportunities. Increasing induction range market acceptance and demand is an important strategy for building decarbonization. Plug loads remain a challenging area because of the large number of diffuse and diverse items that use relatively low amounts of power. Some appliances and electronics with connectivity and advanced intelligence features hold some new promise for both energy efficiency and demand flexibility.

Highlighted Priority Areas

Tech Family	*Tech Subgroups*	*Definition*	*Priority*
Electric vehicle supply equipment	Electric vehicle supply equipment (EVSE)	"EVSE" means the conductors, including the ungrounded, grounded, and equipment grounding conductors, the electric vehicle connectors, attachment plugs, and all other fittings, devices, power outlets, or apparatuses installed specifically for the purpose of delivering energy from the premises wiring to the electric vehicle. Charging cords with NEMA 5-15P and NEMA 5-20P attachment plugs are considered electric vehicle supply equipment. Excludes conductors, connectors, and fittings that are part of a vehicle. EVSE products are included with EVs by manufacturers, sold online, and sold through commercial channels.	High

Plug Loads and Appliances at a Glance



Technology Family	Technology Subgroups	Definition	ETP Role	ETP Priority	Technical Performance KI	Market Knowledge Index (KI)	Program Intervention KI
Electric vehicle supply equipment	Electric vehicle supply equipment (EVSE)	"EVSE" means the conductors, including the ungrounded, grounded, and equipment grounding conductors, the electric vehicle connectors, attachment plugs, and all other fittings, devices,	**1-Lead**	1-High	2-Medium	2-Medium	2-Medium
White goods	Refrigerator, Washer, Dryer, Dishwasher, induction cook tops, ranges	Major appliances in a home or some commercial spaces, that are used for routine housekeepings tasks such as cooking, washing and drying laundry, cleaning dishes, and food preservation.	2-Collaborate	3-Low	2-Medium	2-Medium	1-High
Home entertainment, networking, office, and security equipment	Televisions, Automation, security equipment, set-top boxes, home entertainment equipment, gaming consoles and computers, computers and peripherals, home networking equipment	Devices used for home entertainment, networking, office, and security	2-Collaborate	3-Low	2-Medium	2-Medium	2-Medium
Medical equipment (residential and assisted living)	Breathing machines, mobility devices	Oxygen Generators and Continuous positive airway pressure (CPAP) therapy is a small machine that supplies a constant and steady air pressure to sleeping users. Devices that allow for	3-Observe	3-Low	3-Low	3-Low	3-Low
Medical equipment (health care facilities and clinics)	Centrifuges, autoclaves, imaging equipment (also included in hospitals family)	Medical office plug loads. May not have high operation hours but do have high energy draw when they are being used.	3-Observe	3-Low	3-Low	3-Low	3-Low
Mobile charging devices	Laptops, tablets, mobile phones, portable rechargeable batteries, USB outlets, wireless charging devices	Computing devices of which an individual may have several. Due to the mobile nature, the use profile would be a mix of charging and concurrent use while charging.	3-Observe	3-Low	2-Medium	2-Medium	2-Medium
Miscellaneous Plug Load (residential)	Power tool charging/standby, advanced power strips, Coffee makers , lawn equipment, robotics (e.g., vacuums), pool pumps, electric pool heaters, other	Includes a variety of plug in tools and devices not accounted for in other rows and that serve a primarily residential market segment	3-Observe	3-Low	2-Medium	2-Medium	2-Medium
Miscellaneous Plug Load (commercial)	Commercial networking and computing, advance power strips, Robotics, Mixed reality devices, water coolers, lawn equipment, eMobility stations	Includes a variety of plug in tools and devices not accounted for in other rows and that serve a primarily commercial market segment	3-Observe	3-Low	2-Medium	2-Medium	2-Medium

Process Loads
(Commercial, Industrial, Agriculture and Water)

Technology Families

- Food service equipment
- Food processing
- Refrigeration (industrial)
- Refrigeration (commercial)
- Data rooms and data closets
- Laboratories
- Supermarket systems
- Pools (non-residential)
- Transport refrigeration units
- Off-road fleet charging
- Hospitals
- Agricultural water conveyance
- Wastewater treatment and water treatment
- Water use controls
- Industrial water process management

Technology Area

Process Loads is a broad sector. Advanced controls, variable speed compressors and fans, and hybrid condensing units provide flexibility and load management opportunities that have not previously been available. Employing sensors to gather data and leveraging existing data collection sources with advanced data analytics will provide cost-effective opportunities for efficiency improvements in wastewater and water treatment, water delivery, and water use processes. New applications of heat recovery technologies in the food processing industry have the potential to reduce energy and water consumption.

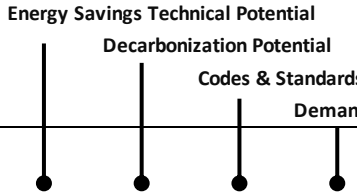
Unique Opportunities and Barriers

The Statewide ETP is pioneering research in low-GWP refrigerants by working with local refrigerant startups and expert groups and undertaking pilots. There is a significant opportunity for more widespread transfer of technologies that had previously only been available within a narrower subset of commercial applications. Agricultural, water and wastewater systems and equipment are geographically remote, making sensor data collection historically difficult and costly to employ. Advances in communication technologies have lowered these barriers, resulting in new operational data that has yet to be fully exploited for system efficiency opportunities. Industrial process systems are designed to have long lifetimes, making equipment replacement with new, higher efficiency equipment difficult. Equipment demonstrations and pilot projects will be needed to convince industry decision makers to adopt new, unproven technologies over incumbent and proven technologies.

Highlighted Priority Areas

Tech Family	*Tech Subgroups*	*Definition*	*Priority*
Refrigeration (commercial)	Self contained; central systems, walk-ins	Food storage, low and medium temperature. Commercial and institutional food preparation.	Medium
Supermarket Systems	Central refrigeration rack systems, etc.	Includes heat recovery, closed loop cooling, controls	Medium

Process Loads at a Glance



Technology Family	Technology Subgroups	Definition	ETP Role	ETP Priority	Technical Performance KI	Market Knowledge Index (KI)	Program Intervention KI
Food service equipment	Food preparation (cooking, baking, product storage, etc.); Water heating/dish washing; Food service-specific refrigeration	Equipment typical of commercial and institutional restaurant facilities, including fast food, sit down, hospitality, and	2-Collaborate	2-Medium	1-High	2-Medium	2-Medium
Food processing	Roasting, washing, dehumidifier, process cooling and process heating systems, etc.	Equipment used to transform agricultural products into food, or of one form of food into other foods.	2-Collaborate	3-Low	2-Medium	3-Low	3-Low
Refrigeration (industrial)	Walk-ins; Warehouses	Food storage, low and medium temperature, for industrial applications	2-Collaborate	3-Low	2-Medium	2-Medium	3-Low
Refrigeration (commercial)	Self contained; central systems, walk-ins	Food storage, low and medium temperature. Commercial and institutional food preparation.	**1-Lead**	2-Medium	2-Medium	1-High	2-Medium
Data rooms and data closets	Data rooms and data closets	Server rooms embedded in smaller facilities who serve a specific, narrow need for a single business.	2-Collaborate	3-Low	2-Medium	2-Medium	3-Low
Laboratories	Fume hoods; ultra low temp freezers, medium temp freezers, refrigerators, other lab plug load equipment (e.g., mass spectrometers,	Laboratories contained in academic, life science research (LSR), hospital, and non-profit research facilities, and for the	2-Collaborate	3-Low	2-Medium	2-Medium	2-Medium
Supermarket Systems	Central refrigeration rack systems, etc.	Includes heat recovery, closed loop cooling, controls	**1-Lead**	2-Medium	2-Medium	2-Medium	2-Medium
Pools (non-residential)	Pool pumps, pool heaters	Includes pumping systems and pool heating systems in public and commercial pools	2-Collaborate	2-Medium	2-Medium	2-Medium	2-Medium
Transport refrigeration units	Transport refrigeration units	Transport refrigeration units (TRUs)	2-Collaborate	2-Medium	2-Medium	3-Low	3-Low
Off-road fleet charging	Fork lifts, golf carts, ground support equipment	Work to maximize charging for fleet vehicles to minimize GHG impacts.	2-Collaborate	2-Medium	2-Medium	3-Low	3-Low
Hospitals	HVAC systems providing a large amount of reheat, MRI machines and other imaging equipment, sterilizers, autoclaves	Hospitals provide multiple uses in one: hotel, clean room, commissary, office, and laboratory.Warm water return heat	2-Collaborate	3-Low	1-High	1-High	3-Low
Agricultural water conveyance	Irrigation and delivery, pump system optimization, water reuse, leak reduction.	Applying automated communication systems, scheduling, sensors, and other telemetric systems. Applying VFDs and	2-Collaborate	3-Low	1-High	2-Medium	2-Medium
Wastewater treatment and water treatment	Oxygen process optimization, water treatment facility design, reverse osmosis	Achieving energy efficiency through enhanced reuse, water pressure monitoring and management. Precise	2-Collaborate	2-Medium	2-Medium	2-Medium	3-Low
Water use controls	Pressure management controls, pump system optimization, data analytics for water/energy (e.g., AMI/AMR), for efficiency and demand	Better use of data to optimize pumping energy use, better manage pressure in the system, and minimize water loss.	2-Collaborate	3-Low	2-Medium	2-Medium	3-Low
Industrial water process management	Process water reuse and heat recovery, process heating (e.g., low temp steam generation), cooling tower water, chemical	Localized waste water treatment for on-site reuse for consumption, washing, irrigation, etc.; Cooling tower water	2-Collaborate	3-Low	2-Medium	3-Low	3-Low

Lighting

Technology Families

- Integrated controls
- Advanced lamps
- Centralized DC power conversion systems
- Daylighting
- Signage

Technology Area

LEDs and related controls continue to mature, having demonstrated their ability to achieve high efficacies and connectivity between lighting, window shades, and other building systems. New research into the role lighting plays on physical well-being of occupants may push specifiers to increase total installed lighting power, making continued development in easily installed, programmed, and tested lighting controls imperative to prevent achieved lighting demand reductions from backsliding. OLED hardware remains an immature but advancing technology. LEDs and connected lighting controls continue to draw consumer and operator interest for their non-energy benefits. Signage and indoor agricultural lighting have emerged as practical energy-saving opportunities.

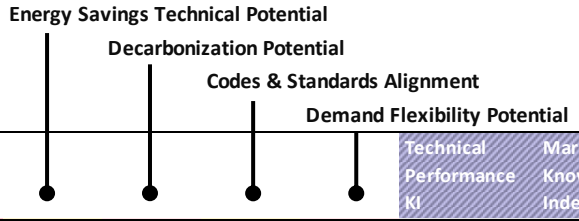
Unique Opportunities and Barriers

This sector continues to evolve with less utility ET intervention than some other sectors. However, though gains in efficiency and advanced features continue, there has been some backsliding on product quality. ETP will monitor this and intervene as appropriate to ensure maximum efficiency and quality. ETP will conduct this work with partners that include California Lighting Technology Center, other California utilities, and other lighting industry stakeholders and laboratories.

Highlighted Priority Areas

The "Highlighted Priority Area" tables list ETP priority = high or medium and ETP Role = Lead.
As described above, none of the Lighting Technology Families meet this requirement.

Lighting at a Glance



Technology Family	Technology Subgroups	Definition	ETP Role	ETP Priority	Technical Performance KI	Market Knowledge Index (KI)	Program Intervention KI
Integrated controls	Residential indoor/outdoor (home automation), lighting EMS	Overlays multiple functionalities of lighting, including on/off, color tuning, dimming, scheduling, and DR enabling. Uses many types of components: motion or occupancy sensing, BMS connections, etc. Also can have behavioral component.	2-Collaborate	3-Low	2-Medium	2-Medium	2-Medium
Advanced lamps	Residential and commercial indoor/outdoor connected lamps	Lamps that screw, snap, or plug into an existing socket (includes screw base, pin base, etc.) and are connected (has ability to communicate its status and be controlled via separate control system).	2-Collaborate	3-Low	2-Medium	2-Medium	3-Low
Centralized DC power conversion systems	24-48 volt DC internal grid using single transformation to power lighting systems. Higher voltage internal DC grid.	Moving from AC to DC or down-stepping DC to DC	2-Collaborate	3-Low	2-Medium	3-Low	3-Low
Daylighting	High performance passive daylighting, active daylighting (e.g., electrochromic), and fenestration accessories	Includes skylighting and side lighting, whether it is the glass panels or other fenestration-related technologies. Includes shading, blinds, light shelves, etc.	2-Collaborate	3-Low	1-High	2-Medium	2-Medium
Signage	Interior and exterior LED/LCD displays	LED billboards, message centers, menu boards and other LED or LCD displays	2-Collaborate	3-Low	2-Medium	2-Medium	3-Low

Water Heating

Technology Families

- Residential
- Commercial and large multi-family

Technology Area

Water heating electrification using heat pump water heater (HPWH) technologies represents one of the major strategies to achieve deep greenhouse gas emission reductions from buildings. Driven by this strategic goal, there are active research and development efforts underway to advance HPWH equipment, grid-interactive load control technologies, and system integration solutions.

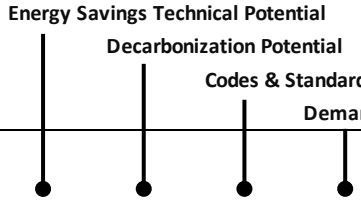
Unique Opportunities and Barriers

Wide adoption of HPWHs in existing single-family homes requires 110V-based models to avoid expansive electric system upgrade. Supporting market development and adoption for retrofit-ready HPWHs (e.g., 110V) presents an ETP opportunity. Central HPWH systems applications require design solutions and guidelines supported by extensive field installation examples. HPWH load controls for single family homes require enhanced field validation. Central HPWH load control solutions are yet to be developed and demonstrated. Most HPWHs use high-GWP refrigerants and availability of products based on low-GWP refrigerants needs to be improved.

Highlighted Priority Areas

Tech Family	*Tech Subgroups*	*Definition*	*Priority*
Residential	High-performance packaged heat pump water heaters and load control technologies for single family and individual multi-family dwelling units.	Electrify water heating by using high-performance HPWHs with low GWP refrigerants; achieve load flexibility to further reduce building GHG emissions and support grid operation.	High
Commercial and large multi-family	Central heat pump water heater systems and load control technologies for multifamily, hotel/motel, and commercial buildings.	Electrify water heating by using high-performance HPWH equipment and central HPWH system designs; achieve load flexibility to further reduce building GHG emissions and support grid operation.	High

Water Heating at a Glance



Technology Family	Technology Subgroups	Definition	ETP Role	ETP Priority	Technical Performance KI	Market Knowledge Index (KI)	Program Intervention KI
Residential	High-performance packaged heat pump water heaters and load control technologies for single family and individual multi-family dwelling units.	Electrify water heating by using high-performance HPWHs with low GWP refrigerants; achieve load flexibility to further reduce building GHG emissions and support grid operation.	**1-Lead**	1-High	1-High	1-High	1-High
Commercial and large multi-family	Central heat pump water heater systems and load control technologies for multifamily, hotel/motel, and commercial buildings.	Electrify water heating by using high-performance HPWH equipment and central HPWH system designs; achieve load flexibility to further reduce building GHG emissions and support grid operation.	**1-Lead**	1-High	1-High	2-Medium	1-High

Whole Buildings

Technology Families

- Whole buildings (residential)
- Whole buildings (non-residential)
- Distributed energy resources to reduce greenhouse gas emissions

Technology Area

In California, legislative initiatives including AB 802 and SB 350 along with residential and commercial ZNE mandates and decarbonization goals are some of the largest drivers of energy efficiency. The continued proliferation of energy storage and other distributed energy resources (DERs), and emergence of building demand flexibility as an important design attribute, are major supporting elements of these initiatives. Maintaining building performance and integrating systems to achieve ongoing energy management information systems.

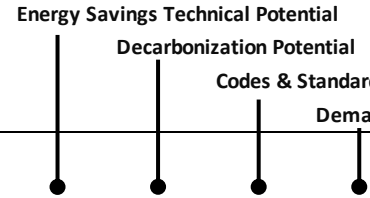
Unique Opportunities and Barriers

Integration of energy efficiency and DERs in buildings supports the clean energy economy of the future and allows for greater customer choice. ETP is working on integration of whole building solutions by coordinating research and implementation activities with stakeholders and demonstrating those strategies and solutions.

Highlighted Priority Areas

Tech Family	*Tech Subgroups*	*Definition*	*Priority*
Whole buildings (residential)	Decarbonization (including efficient electric water and space heating, and induction cooking), Efficient HVAC, High EE performance (including energy modeling), Integrated controls, Enclosures (includes building envelope and fenestration), Combination systems (water heating + space conditioning)	High-performance buildings with holistic designs (including envelope, electrified HVAC and DHW, and lighting), integrated controls (that communicate for demand flexibility and load management), and energy storage, resulting in lower operating cost and a smaller enviornmental footprint.	High
Whole Buildings (non-res)	Decarbonization (including efficient electric water and space heating, and induction cooking where applicable), Efficient HVAC, High EE performance (including energy modeling), Integrated controls, EMIS (Energy Management Information Systems), Enclosures (includes building envelope and fenestration), Managed charging (vehicle to building), DC power systems (opportunistic for lighting, etc), Combination systems (water heating + space conditioning)	High-performance buildings with holistic designs (including envelope, electrified HVAC and DHW, and lighting), integrated controls (that communicate for demand flexibility and load management), EMIS, and energy storage, resulting in lower operating cost and a smaller enviornmental footprint.	High

Whole Buildings at a Glance



Technology Family	Technology Subgroups	Definition	ETP Role	ETP Priority	Technical Performance KI	Market Knowledge Index (KI)	Program Intervention KI
Whole buildings (residential)	Decarbonization (including efficient electric water and space heating, and induction cooking), Efficient HVAC, High EE performance (including energy modeling), Integrated controls, Enclosures (includes building envelope and fenestration), Combination systems (water heating + space conditioning)	High-performance buildings with holistic designs (including envelope, electrified HVAC and DHW, and lighting), integrated controls (that communicate for demand flexibility and load management), and energy storage, resulting in lower operating cost and a smaller enviornmental footprint.	**1-Lead**	1-High	2-Medium	3-Low	3-Low
Whole buildings (non-residential)	Decarbonization (including efficient electric water and space heating, and induction cooking where applicable), Efficient HVAC, High EE performance (including energy modeling), Integrated controls, EMIS (Energy Management Information Systems), Enclosures (includes building envelope and fenestration), Managed charging (vehicle to building), DC power systems (opportunistic for	High-performance buildings with holistic designs (including envelope, electrified HVAC and DHW, and lighting), integrated controls (that communicate for demand flexibility and load management), EMIS, and energy storage, resulting in lower operating cost and a smaller enviornmental footprint.	**1-Lead**	1-High	2-Medium	3-Low	3-Low
Distributed energy resources to reduce GHGs	PV and storage integration, DC controls, AC/DC networks, Microgrid for resiliency value, Interoperability, integration with building systems	Reduce conversion losses of AC>DC (grid sourced) or DC>AC>DC losses (on-site PV generation). Aim for flexibility to address high GHG intensity. Shifting load to manage energy efficiency. Examples include ways to operate storage and PV together; interoperability (e.g., software platforms and specifications).	**1-Lead**	2-Medium	3-Low	3-Low	3-Low

Emerging Technology Focused Pilot Candidates

About ETFPs

ETP has traditionally conducted pilot tests to gather data on the technical performance, market viability, and effective program delivery methods for emerging technologies. With Emerging Technology Focused Pilots (ETFPs), ETP will begin formally conducting coordinated pilot testing of program interventions. ETFPs will identify market barriers for a diverse range of high-impact technologies through studies, and subsequently pilot test interventions against these identified barriers via cooperative projects initiated in coordination with relevant IOU programs. ETP will assemble a TPM dedicated to ETFPs by extracting suitable technology candidates from the six TPM Technology Categories as well as non-TPM sources.

Screening for ETFP Candidates

Knowledge Indexes (KIs) in the TPMs characterize the state of knowledge along three dimensions of each Technology Category: technical performance knowledge, market knowledge, and program intervention knowledge. These indexes can be used for rapid assessment of ETFP candidates: suitable candidates should be products for which ETP has high confidence in technical performance and at least a medium knowledge of market barriers that are unique to the emerging technology. ETP implementers can have low confidence in understanding specific interventions but should have a sound theory of why a specific intervention would be successful against the ET market barrier. The preliminary KI assessments are rough and provide a range for the Technology Family. These KI assessments should be refined through subsequent ETP activities as specific technologies and practices are identified. Candidates may also be found in technologies not captured in the TPMs.

ETFP Screening Example

The following page shows an example scan of the TPM Workbook for ETFP candidates that meet the following filters:

- ETP Priority (which includes Energy Savings Potential, Decarbonization Potential, Codes and Standards Alignment, and Demand Flexibility Potential): high or medium
- Technical Performance Knowledge Index: high
- Market Knowledge Index: high or medium
- Program Intervention Knowledge Index: high, medium, or low

The screening process in this example identifies three technology categories in which there may be suitable products for ETFPs: Residential Water Heating, Commercial and Multi-family Water Heating, and Food Service Equipment. The ETFP filters are shown on the right. From this point, ETP can examine individual technologies that fall into these categories for specific opportunities. There may be suitable ETFP candidates at the individual technology level within low-priority Technology Families as well. Further ETP investigations are needed to develop data-driven estimates of the four prioritization factors at the product level, to identify specific technologies to pilot test. The TPM framework will be used to organize the product-level data collected by ETP.

Emerging Technology Focused Pilot

Candidate Example

Energy Savings Technical Potential
Decarbonization Potential
Codes & Standards Alignment
Demand Flexibility Potential

Technology Category	Technology Family	Technology Subgroups	Definition	ETP Role	ETP Priority	Technical Performance KI	Market Knowledge Index (KI)	Program Intervention KI
Process Loads (Commercial, Industrial, Water and Ag)	**Food service equipment**	Food preparation (cooking, baking, product storage, etc.); Water heating/dish washing; Food service-specific refrigeration	Equipment typical of commercial and institutional restaurant facilities, including fast food, sit down, hospitality, and	2-Collaborate	2-Medium	1-High	2-Medium	2-Medium
Water Heating	**Residential**	High-performance packaged heat pump water heaters and load control technologies for single family and individual multi-family dwelling units.	Electrify water heating by using high-performance HPWHs with low GWP refrigerants; achieve load flexibility to further reduce building GHG emissions and support grid operation.	**1-Lead**	1-High	1-High	1-High	1-High
Water Heating	**Commercial and large multi-family**	Central heat pump water heater systems and load control technologies for multifamily, hotel/motel, and commercial buildings.	Electrify water heating by using high-performance HPWH equipment and central HPWH system designs; achieve load flexibility to further reduce building GHG emissions and support grid operation.	**1-Lead**	1-High	1-High	2-Medium	1-High