Technology Priority Map Workbook

Technology Category	Technology Family	Technology Subgroups	Definition	Opportunities	Barriers	ETP Role	ETP Priority	Energy Savings Technical Potential	Decarbonization Potential	C&S Alignment	Demand Flexibility Potential	Technical Performance KI	Market Knowledge Index (KI)	Program Intervention KI
HVAC	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 exchanger	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 use of lower-energy HVAC systems for space conditioning that use more neutral temperatures for comfort conditioning as compared to traditional HVAC systems (e.g. natural gas furnace or VAV with reheat). There is also potential for more efficient heat recovery ventilators, which provide ventilation air conditioning in a decoupled system, through emerging technologies in controls and equipment design.	With relatively few manufacturers, there is an opportunity to help introduce consistency and standardization in the CA market. This could entail: Quantify value and benefits for decoupled HVAC systems in a way that can be easily shared with manufacturers and trade allies. Document case studies and compare real data of these systems vs. real data of non-decoupled systems to demonstrate superior energy performance, occupant comfort, electrical load profiles. There may be a window of opportunity to help develop design guidelines and implementation practices for trade allies, and to collaborate with WE&T.	Advanced HRV controls with modulating heat recovery bypass controls are only offered by <3 manufacturers (as of early 2020) and other manufacturers offer partial versions. Advanced HRV controls with IAQ sensors for demand control ventilation are not offered by manufacturers now but is technically feasible. Research being performed by groups such as UCB Center for the Built Environment. Requires all building exhaust air to return to the unit, including class 2 air, which is a cost barrier and potential user concern.	1-Lead	2-Medium	1-High	2-Medium	1-High	2-Medium	2-Medium	3-Low	3-Low
HVAC	Variable speed compressor systems (commercial)	Variable refrigerant flow (VRF); Variable speed RTU's, chillers, fan coils, or VRF); Advanced HRV controls: modulating heat recovery bypass control and IAQ sensors for DCV; Advanced HRV design: counterflow heat exchanger	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.	Variable speed compressor systems are widely available fro all of these products. Existing RTUs, chillers, PTACS, and WSHP can be replaced with variable-speed equipment of like size. VRF has gained wide acceptance in CA.	The price premium is the largest barrier. All these systems have single-speed versions and many choose not to pay the premium. Though large chillers are the exception. If low-GWP refrigerants are required, VRF will become uncompetitive due to the requirement for a refrigerant leak detator with each coil.	1-Lead	1-High	1-High	1-High	1-High	1-High	2-Medium	2-Medium	3-Low
HVAC	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.	There are now many offerings in the market for all types of systems. Traditional systems are likely to be more cost effective, especially if CA requires low GWP refrigerants. This is because a refrigerant leak detector will be required with each coil. Water-source heat pumps are a good opportunity for multi-family and are growing in popularity.	The cost premium can be hard to economically justify in mild climates. Due to sophisticated controls, validation of field performance is essential.	1-Lead	1-High	1-High	1-High	1-High	1-High	2-Medium	2-Medium	2-Medium
HVAC	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 (natural gas furnaces, small boilers, fans, etc.); Large Commercial Buildings - HVAC equipment (chiller plants, large boilers, pumps, etc.); Residential Buildings - HVAC equipment (e.g. heat pumps, etc.)	Functionality that detects and diagnoses problems that lead to degraded performance of HVAC systems (energy efficiency, capacity, increased maintenance, or shortened equipment life), as well as operators responding to those issues.	There may still be an opportunity to drive standardization of information provided by FDDs, in collaboration with standards-setting bodies. There may also be a need for more studies on customer barriers to using FDD information and alerts.	Barriers = non-standardization of faults identified and diagnosis information provided; effectiveness of FDDs on getting action from operators to fix issues.	2-Collaborate	2-Medium	1-High	3-Low	2-Medium	4-None	2-Medium	3-Low	3-Low
HVAC	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.	Replace or supplement existing boilers. Replace a chiller with a reversible heat pump, keep boiler for high load only.	There are few barriers. Lack of designer and sales chain knowledge is the issue. Quantifying savings is still a challenge.	1-Lead	2-Medium	2-Medium	1-High	2-Medium	2-Medium	2-Medium	2-Medium	3-Low
HVAC	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 (passive, ambient loops, etc.)	HVAC systems that do not rely on refrigerant-based vapor compression cycle	Lab and field test available products for performance and interoperability and analyze control and management functions, in order to provide data to support modeling of promising system-level holistic solutions. Familiarize architecture/engineering/contractor teams with compressor-less technologies as part of a holistic design that incorporates a suite of design strategies to enable compressorless cooling (e.g. building envelope features such as orientation, glazing type and location, operable windows, overhangs, etc), as well as utilizing advanced comfort models, and systems more cost effectively suited for compressorless space conditioning.	Cost effectiveness and not yet fully commercialized technologies. A majority of non-compressor based HVAC only do cooling and heating. Addition of heating is a challenge or adds substantial cost.	2-Collaborate	2-Medium	2-Medium	2-Medium	2-Medium	2-Medium	1-High	3-Low	3-Low
HVAC	Low-GWP refrigerants in HVAC	Low global warming potential (GWP) refrigerants, applies to room AC and dehumidifiers, pack-aged systms, VRF, etc.	Refrigerants used in vapor compression systems that have lower global warming impacts than legacy refrigerants.	State and Federal phase-out plans for legacy refrigerants will drive large stock turnover. identify remaining research needs and explore possible support or coordination with EPA's SNAP evaluation. In particular, consider whether EPA is providing sufficient consideration of CA-specific needs; gap would be ETP opportunities.	Not widely available. Safety issues. Performance and compatibility need to be verified, though EPA's Significant New Alternative Program (SNAP) is currently evaluating. Building code safety standards are not in place for residential.	1-Lead	2-Medium	3-Low	1-High	1-High	3-Low	3-Low	3-Low	2-Medium
HVAC	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.	Training of building operators to maintain and use controls as intended in design.	Multiple vendors. Not plug and play. Built on proprietary standards and platforms. Installers not familiar with technologies. Multiple trades are involved. Not integrated by end-use. Lack of translation of design-intent to implementing contractor to building operator.	1-Lead	1-High	1-High	2-Medium	1-High	1-High	2-Medium	3-Low	3-Low
Plug Loads and Appliances	Electric vehicle supply equipment	Electric vehicle supply equipment (EVSE)	"EVSE" means the conduction, 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.	California (and other states) may consider future Title 20 appliance standards for EVSE. ETP may consider strategies to align program efforts with future standards development. There is already an ENERGY STAR test procedure for Level 1 and Level 2 chargers but the federal battery charger test procedure, which explicitly does not cover EVSE, would need to be adapted to address DC fast chargers. Rapid commercialization of wide band-gap power electronics presents both opportunity and challenge. ETP may also consider opportunities to increase managed charging adoption.	Split incentive issues. EV rate design alignment. This is a nascent market, and programs and standards need to guide, not impede, the evolution of the EVSE market. There are a growing number of manufacturers and little data on comparative efficiencies.	1-Lead	1-High	1-High	2-Medium	1-High	1-High	2-Medium	2-Medium	2-Medium
Plug Loads and Appliances	White goods	Refrigerator, Washer, Dryer, Dishwasher, induction cook tops, ranges	Major appliances in a home or some commercial spaces, that are used for routine housekeeping tasks such as cooking, washing and drying laundry, cleaning dishes, and food preservation. Includes but is not limited to connected white good appliances.		For induction cooktops: lack of consumer demand and/or lack of value proposition compared to gas cooktops. Further, its lack of education and demonstration; once consumer is shown the EE and NON EE benefits, they show interest. Lack of rebate as well; can't move market without rebate and infrastructure incentive (retrofit. For connected appliances: Cost, proprietary products, lack of consumer demand (lack of value proposition) until household aggregation or other DR implementation infrastructure addresses consumer value proposition adequately.	2-Collaborate	3-Low	3-Low	2-Medium	2-Medium	2-Medium	2-Medium	2-Medium	1-High
Plug Loads and Appliances	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		Proprietary products and communications. Limited integration but starting to happen. Limited data on usage profiles, still difficult for average customer to install and maintain. Low-energy potential per device, but high market potential.	2-Collaborate	3-Low	3-Low	3-Low	2-Medium	3-Low	2-Medium	2-Medium	2-Medium
Plug Loads and Appliances	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 consistent and steady air pressure to sleeping users. Devices that allow for movement--stationary (elevators) and mobile (scooters). The mobile devices typically require charging.		Insufficient understanding of product stock and end user behavior associated with these technologies.	3-Observe	3-Low	3-Low	3-Low	4-None	3-Low	3-Low	3-Low	3-Low
Plug Loads and Appliances	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.		Energy impacts are not well researched or understood.	3-Observe	3-Low	3-Low	3-Low	4-None	3-Low	3-Low	3-Low	3-Low
Plug Loads and Appliances	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.	Industry is motivated to maximize battery life (equipment efficiency) but stand by charging loads may be improved. Efficiency of wireless charging devices can be improved.	No Energy Star for products besides laptops. Not all devices support wireless charging and there are still several different USB standards and connectors.	3-Observe	3-Low	3-Low	3-Low	2-Medium	3-Low	2-Medium	2-Medium	2-Medium
Plug Loads and Appliances	Miscellaneous Plug Load (residential)	Power tool charging/standby, advanced power strips, Coffee makers , lawn equipment, robotics (e.g., vacuums), residential 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.		Not enough information on use profiles and savings potential is available.	3-Observe	3-Low	3-Low	3-Low	2-Medium	3-Low	2-Medium	2-Medium	2-Medium
Plug Loads and Appliances	Miscellaneous Plug Load (commercial)	Commercial networking and computing, advance power strips, Robotics, Mixed reality devices, water coolers, lawn equipment, affordability stations	Includes a variety of plug in tools and devices not accounted for in other rows and that serve a primarily commercial market segment.		Not enough information on use profiles and savings potential is available.	3-Observe	3-Low	3-Low	3-Low	2-Medium	3-Low	2-Medium	2-Medium	2-Medium
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 cafeterias.	Continue collaborative effort with BPA, Southern Company, and others. EPA and California Air Resources Board (CARB) sales will limit common refrigerants, driving a turnover of equipment stock. Understand performance, safety, and toxicity of alternative refrigerants.	Challenge of moving markets toward electrification of the historically gas fueled products, high costs, and performance uncertainty with new refrigerants. Difficulty of replacing refrigerants which require new equipment designs and performance uncertainty.	2-Collaborate	2-Medium	2-Medium	1-High	2-Medium	2-Medium	1-High	2-Medium	2-Medium
Process Loads (Commercial, Industrial, Water and Ag)	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.	Address customer barriers, possibly through case studies. This may include: Develop industry standards, develop and enhance test protocols, expand electrification of heating functions. Provide data to help customers understand benefits and costs of using of advanced refrigerants. Document good practices for equipment specification and process system integration, including variable elements that yield energy efficiency and DR opportunities.	Unique and complex built up systems requiring custom designs. Perceived risks to core business from changing equipment and system approaches.	2-Collaborate	3-Low	3-Low	1-High	3-Low	2-Medium	2-Medium	3-Low	3-Low
Process Loads (Commercial, Industrial, Water and Ag)	Refrigeration (industrial)	Walk-ins; Warehouses	Food storage, low and medium temperature, for industrial applications	Work to reduce high global warming potential (GWP) refrigerants and drive equipment upgrades, pursuant to Senate Bills 1383 - short lived climate pollutants. Explore need for future lab and field assessments for a various market segments and execute evaluation projects to establish benchmarks for high performance levels in terms of low-GWP, energy efficiency, and DR capacity for each technology.	Legacy HCFCs, HFCs, and pumped ammonia refrigerants are still ubiquitous with low adoption of advanced refrigerants. This is current a high priority activity for ARB. Availability of smaller packaged refrigeration systems has been a barrier, but changing.	2-Collaborate	3-Low	3-Low	1-High	2-Medium	3-Low	2-Medium	2-Medium	3-Low
Process Loads (Commercial, Industrial, Water and Ag)	Refrigeration (commercial)	Self contained; central systems, walk-ins	Food storage, low and medium temperature. Commercial and institutional food preparation.	Work to reduce high global warming potential (GWP) refrigerants and drive equipment upgrades, pursuant to Senate Bills 1383 - short lived climate pollutants.Pursue laboratory and field assessments to verify systems' improved energy performance and water usage reduction to established benchmarks for high performance levels in terms of low-GWP, energy efficiency, and DR capacity for each technology.	HCFC, HFC, and pumped glycol refrigerants are still ubiquitous and refrigerant conversion cost is often high. Low adoption of advanced refrigerants. Building and safety code updates are needed for A2L and B2 refrigerants (which are used in Europe but not in the US).	1-Lead	2-Medium	2-Medium	1-High	1-High	3-Low	2-Medium	1-High	2-Medium
Process Loads (Commercial, Industrial, Water and Ag)	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.	Normalize server loads and profiles based on data collected regarding locations of closets, NAICS, and building size. Assess products specifically made for server closets and server aisles. Potential use of adjacent space transfer return air for cooling. Compare to current method of using standard A/C equipment for the application (in some cases, VRF type systems are used). Non-HVAC opportunities include efficient UPS, efficient servers, and server utilization monitoring.	Off the shelf HFC refrigerant-based AC systems are the norm. New equipment has high cost. Difficult to get traction with HVAC, uninterruptible power systems (UPS) and servers because facility managers aren't focused on energy (they see a risk of compromising performance).	2-Collaborate	3-Low	2-Medium	3-Low	2-Medium	3-Low	2-Medium	2-Medium	3-Low
Process Loads (Commercial, Industrial, Water and Ag)	Laboratories	Fume hoods; ultra low temp freezers, medium temp freezers, refrigerators, other lab plug load equipment (e.g., mass spectrometers, incubators, etc.), process water heating systems, purified water systems, compressed dry air systems, vacuum systems	Laboratories contained in academic, life science research (LSR), hospital, and non-profit research facilities, and for the purposes of this study, a laboratory was defined as any space equipped to conduct experiments, tests, and investigations, or to manufacture chemicals, medicines, etc.	Work to reduce high global warming potential (GWP) refrigerants and drive equipment upgrades, pursuant to Senate Bills 1383 - short lived climate pollutants. Opportunity to work with EPRI for national market level transformation, but cannot depend on this.	High costs and low penetration of Energy Star models. Users typically not interested in learning about operation of fume hood controls. Many equipment manufacturers and specialized equipment; energy efficiency not historically a priority	2-Collaborate	3-Low	2-Medium	2-Medium	3-Low	3-Low	2-Medium	2-Medium	2-Medium
Process Loads (Commercial, Industrial, Water and Ag)	Supermarket Systems	Central refrigeration rack systems, etc.	Includes heat recovery, closed loop cooling, controls	Work to reduce high global warming potential (GWP) refrigerants and drive equipment upgrades, pursuant to Senate Bills 1383 - short lived climate pollutants. Pursue laboratory and field assessments to verify systems' improved energy performance to established benchmarks for high performance levels. Assess potential for integration of HVAC and water heating with rack refrigeration systems. Research opportunities for existing equipment and/or faster replacements recognizing that customers cannot afford downtime to upgrade a system.	Replacement costs, conservatism regarding new technology deployment due to centrality of refrigeration performance to business model, and down time for replacing systems. Retrofit options are limited and most supermarkets projects are retrofit.	1-Lead	2-Medium	2-Medium	1-High	2-Medium	3-Low	2-Medium	2-Medium	2-Medium
Process Loads (Commercial, Industrial, Water and Ag)	Pools (non-residential)	Pool pumps, pool heaters	Includes pumping systems and pool heating systems in public and commercial pools		Increased costs, increasing complexity, resistance to new technologies and approaches	2-Collaborate	2-Medium	3-Low	2-Medium	3-Low	1-High	2-Medium	2-Medium	2-Medium
Process Loads (Commercial, Industrial, Water and Ag)	Transport refrigeration units	Transport refrigeration units	Transport refrigeration units (TRUs)	Diesel to electric and refrigerant change out opportunity. Stationary resources are needed at both ends (as well as truck stops/DCs/etc). The cost savings to the owner/operators would drive adoption as connection infrastructure becomes available	Lack of available sites to connect	2-Collaborate	2-Medium	2-Medium	1-High	1-High	3-Low	2-Medium	3-Low	3-Low
Process Loads (Commercial, Industrial, Water and Ag)	Off-road fleet charging	Fork lifts, golf carts, ground support equipment	Work to maximize charging for fleet vehicles to minimize GHG impacts.	Potential for under 10k lb capacity for Forklift to switch from diesel or propane and then move them to smart/on demand charging system.		2-Collaborate	2-Medium	3-Low	1-High	1-High	1-High	2-Medium	3-Low	3-Low
Process Loads (Commercial, Industrial, Water and Ag)	Hospitals	HVAC systems providing a large amount of reheat, MRI machines, other imaging equipment, sterilizers, autoclaves	Hospitals provide multiple uses in one: hotel, clean room, commissary, office, and laboratory. Warm water return heat recovery can provide reheating and reduce chiller loads	Warm water return heat recovery: a portion of warm return water to the chillers detours through a heat pump. The reduction of chiller load will be attractive to facilities managers.	For HVAC in hospitals: space requirements in crowed mechanical rooms and installation cost are barriers. Not a large barrier for new construction, but could be a problem for retrofit. Operators also have to accomodate high airchange requirements.	2-Collaborate	3-Low	3-Low	3-Low	2-Medium	4-None	1-High	1-High	3-Low
Process Loads (Commercial, Industrial, Water and Ag)	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 integration.		Standard energy efficiency technologies may not apply to the varied processes used at farms and agricultural facilities	2-Collaborate	3-Low	2-Medium	3-Low	4-None	2-Medium	1-High	2-Medium	2-Medium
Process Loads (Commercial, Industrial, Water and Ag)	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 control of aeration process resulting in better load management and energy efficient operations.		Challenging to estimate savings. Technologies exist but individual systems are specific.	2-Collaborate	2-Medium	2-Medium	2-Medium	4-None	1-High	2-Medium	2-Medium	3-Low
Process Loads (Commercial, Industrial, Water and Ag)	Water use controls	Pressure management controls, pump system optimization, data analytics for water/energy (e.g., AMI/AMR), for efficiency and demand side management	Better use of data to optimize pumping energy use, better manage pressure in the system, and minimize water loss. SCADA water energy management systems with integrated control devices, input monitoring and recovery systems to reduce water-energy consumption			2-Collaborate	3-Low	2-Medium	3-Low	4-None	2-Medium	2-Medium	2-Medium	3-Low
Process Loads (Commercial, Industrial, Water and Ag)	Industrial water process management	Process water reuse and heat recovery, process heating (e.g., low temp steam generation), cooling tower water, chemical management	Localized waste water treatment for on-site reuse for consumption, washing, irrigation, etc.; Cooling tower water-usage reduction strategies and technologies		The Energy Division has not identified measures that can qualify as Water Energy Nexus.	2-Collaborate	3-Low	3-Low	3-Low	4-None	2-Medium	2-Medium	3-Low	3-Low
Lighting	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.		Cost, installation complexity, operational complexity, connectivity range (what else can it connect to?), lack of established training and certification programs for installers, limited interoperability of integrated controls, and questions on how savings can be claimed through incentive programs.	2-Collaborate	3-Low	2-Medium	3-Low	2-Medium	3-Low	2-Medium	2-Medium	2-Medium
Lighting	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).		Cost, nascent technologies with uncertain performance outcomes (including energy efficiency impacts) proprietary communications protocols, dearth of data on customer acceptance and usage behavior	2-Collaborate	3-Low	2-Medium	3-Low	2-Medium	3-Low	2-Medium	2-Medium	3-Low
Lighting	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	With the objective of reducing AC to DC conversion losses, establish savings potential and feasibility as well as key test methods and industry standards through participation in standards committees and conducting research on savings/feasibility with LBNL and others.	Relevant products and practices are still in test phases. Need standards that address DC power distribution voltages, connectors, and protection schemes.	2-Collaborate	3-Low	2-Medium	3-Low	3-Low	3-Low	2-Medium	3-Low	3-Low
Lighting	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.	Firm up confidence in cost-effectiveness and sustained performance of daylighting solutions for designers and owners through more accurate and robust modeling tools. Undertake modeling tool usability studies and outreach to design community.	Lack accurate modeling tools/approaches that can support high confidence savings estimates during project design stages/value engineering processes. Usually only cost-effective in new constructions. Also technically difficult in existing constructions. Can significantly impact HVAC systems through heat gain.	2-Collaborate	3-Low	2-Medium	3-Low	2-Medium	4-None	1-High	2-Medium	2-Medium
Lighting	Signage	Interior and exterior LED/LCD displays	LED billboards, message centers, menu boards and other LED or LCD displays		Lack of well defined, integrated, automated light output controls to optimize efficiency and visibility in response to changing ambient lighting conditions, time of day, and demand management events.	2-Collaborate	3-Low	2-Medium	3-Low	2-Medium	3-Low	2-Medium	2-Medium	3-Low
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.	State policy goals and related legislations (e.g. AB 1477) and DOE's Grid-Interactive Efficient Buildings (GEB) initiative; HPWH load controls require further improvement, manufacturers begin to provide 110V HPWH models.	Gas water heaters are the preferred option, availability of products for easy installation in existing buildings and products using low-GWP refrigerants.	1-Lead	1-High	1-High	1-High	2-Medium	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.	State policy goals and related legislations (e.g. AB 1477) and DOE's Grid-Interactive Efficient Buildings (GEB) initiative; Load controls of central HPWH systems have not been tested, hybrid system designs represent a large retrofit opportunity for existing buildings.	Building industry not familiar with HPWH systems, lack of system design guidelines and tools, limited HPWH products, and limited availability of load control products for central systems.	1-Lead	1-High	1-High	1-High	2-Medium	1-High	1-High	2-Medium	1-High
Whole Buildings	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 environmental footprint.	In new construction, work with builders to incorporate decarbonization technologies at the onset. In existing building engage at the time of sale, at the time of replacement of appliances.	Existing buildings, infrastructure upgrade costs, technology adaption barriers. Initial cost barriers. Higher operating costs due to low natural gas rates.	1-Lead	1-High	1-High	1-High	1-High	1-High	2-Medium	3-Low	3-Low
Whole Buildings	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 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 environmental footprint.	Use of integrated design approach to make efficient early design decisions (e.g., building orientation, HVAC system options, design load assumptions). Office (large & small), retail, schools, hotels/motels, and hospitals are highest priority based on statewide building square footage (existing and new construction).	Limited PV production space in high-rise buildings. First cost barriers. Technology adaption barriers in existing buildings.	1-Lead	1-High	1-High	1-High	1-High	1-High	2-Medium	3-Low	3-Low
Whole Buildings	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 source)) 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).	Resiliency through microgrids; energy cost savings through dynamic load shapes tied to grid electricity costs.	Some technologies are available but the sector is not seamless. Integration with grid is in early stages. Limited PV production space on many buildings. Options for building systems' (appliances, lighting, HVAC) responsiveness to grid are somewhat limited. Benefits to grid are not quantified. Multiple stakeholders makes implementation challenging.	1-Lead	2-Medium	3-Low	2-Medium	3-Low	1-High	3-Low	3-Low	3-Low