

Code Readiness Subprogram Strategic Roadmap

Version 1.0

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EXECUTIVE SUMMARY

The Code Readiness Subprogram team conducts applied research to close data gaps on energy-efficient technologies across the residential, nonresidential, industrial, and transportation sectors. Along with research results, the Code Readiness team provides actionable insights to inform effective Codes and Standards (C&S) updates that promote Code Readiness' ideals of energy efficiency, decarbonization, and grid resilience. The regulatory objectives—defined as updates or additions to codes or standards that further climate and energy goals—that Code Readiness supports may include updates to statewide building codes, state and federal appliance standards, national model codes, and other related codes, standards, or requirements.

The Code Readiness team created this Strategic Roadmap in 2025 to achieve the following goals:

1. Stage research projects over the next five to ten years to optimize project selection and timing to maximize impact on upcoming rulemakings and proceedings
2. Ensure that the Code Readiness budget is distributed to adequately support a balanced portfolio of research that aligns with near- and long-term needs
3. Allow Code Readiness to easily share ready-to-go research ideas with other teams

The Strategic Roadmap includes a list of over 100 regulatory objectives (ROs) that the Code Readiness Subprogram may support over the next five to ten years. The Code Readiness team worked with subject matter experts (SMEs) and key industry stakeholders to develop and prioritize the ROs based on criteria including energy savings potential, cost-effectiveness, and market feasibility. The highest-priority ROs are shown below. Table 1 includes the top building codes objectives and the Title 24 code cycles the Code Readiness team targets for implementation. Table 2 shows the top appliance standards objectives and timing estimates for supporting research.

Table 1. Code Readiness Top Regulatory Objectives: Building Codes

Technology Area	Regulatory Body	Objective	Target code cycle (Title 24)
Water Heating	CEC (Title 24)	Tighten water heating loss requirements in multifamily buildings	2031
Demand Flexibility, Transportation	CEC (Title 24)	Require energy storage in residential and nonresidential new construction to supply a defined percentage of the building's peak load	2031
Covered processes	CEC (Title 24)	Eliminate the practice of dilution ventilation in wineries and require CO2 to be vented directly outside	2031
Refrigeration, Ind. Cold Side, Demand Flexibility	CEC (Title 24)	Require thermal mass load management in select cold storage applications	2031
Covered Processes	CEC (Title 24)	Establish minimum efficiency requirements for laboratory equipment and supporting infrastructure	2031, 2034
Industrial, Mechanical	CEC (Title 24)	Require steam systems to use thermal vapor recompression (TVR) or mechanical vapor recompression (MVR)	2034

Demand Flexibility	CEC (Title 24), ASHRAE 90.1, IECC	Standardize building automation system (BAS) interoperability requirements, establish minimum performance criteria for integrated control systems, develop modeling methods, ACM rules, and adjustment factors for load flexibility in residential and nonresidential buildings that specify control strategies and timing for load shifting, and establish a compliance pathway for grid-interactive buildings	2031, 2034
HVAC, Water Heating, Demand Flexibility	CEC (Title 24)	Require nonresidential air-to-water heat pump installations to include thermal energy storage systems	2034
Industrial, Mechanical	CEC (Title 24)	Require heat recovery for industrial waste heat	2034

Table 2. Code Readiness Top Regulatory Objectives: Appliance Standards

Technology Area	Regulatory Body	Objective	Proposed Research Timing
Industrial	CEC (Title 20)	Establish standards for air dryer efficiency	2024-2027
Water Heating	AHRI, DOE, ENERGY STAR, CEC (Title 24)	Update DOE TP and standard for commercial HPWHs, including defrost best practices and simulation tools	2024-2026
Consumer Electronics	CEC (Title 20)	Establish standards for computer active mode energy consumption	2025-2027
C&I Refrigeration	DOE	Update additional CRE equipment test procedures, standards, and equipment efficiency options	2025-2028
Industrial	DOE	Establish standards for condensing-level gas storage water heaters	2025-2026

Alongside conducting primary research, the Code Readiness team carries out additional initiatives to support the program's goals on an ongoing basis, including:

- Testing compliance software to ensure it accurately represents real-world outcomes and recommending specific updates based on real-world data.
- Recommending compliance and enforcement improvements and opportunities to streamline and simplify code language.
- Identifying opportunities for greater market adoption of newer technologies, such as through utility programs or consumer education.
- Coordinating with the California Statewide Utility Codes and Standards Enhancement (CASE) Team, CalNEXT, CalMTA, and National Codes and Standards Advocacy (NCSA) teams to align research activities and strengthen the transition between Code Readiness research findings and advocacy efforts.
- Addressing ad-hoc analysis, reporting, presentation, or technical needs as needed.

These initiatives may be addressed as part of each research project or as separate workstreams from individual project teams.

CODE READINESS SUBPROGRAM OVERVIEW

INTRODUCTION

The Code Readiness Subprogram plays a pivotal role in advancing California’s energy efficiency and decarbonization goals by using applied research to close critical data gaps to enable effective C&S development. Positioned between early-stage technology pilots and formal regulatory adoption, Code Readiness translates emerging ideas into actionable insights that support policymakers, regulators, and program implementers in making informed decisions. The Subprogram works closely with emerging technology research initiatives, market transformation programs, and new construction programs to identify and evaluate promising, market-ready technologies and design practices. This collaboration allows for robust field data collection and testing in real-world and laboratory conditions, helping to refine technology performance metrics, assess cost-effectiveness, and reduce uncertainties around enforceability.

Importantly, not all Code Readiness research is immediately suited for inclusion in state or federal codes. In such cases, these insights can still create value by informing PG&E’s incentive programs. For example, when a measure or technology is not yet ready for codification due to market adoption or technology maturity, Code Readiness findings can help PG&E staff with incentive design, customer targeting, and implementation strategies to support early market adoption. These interim applications also help accelerate learning and uptake, ultimately improving the viability of future code proposals.

Figure 1 provides an overview of the broader C&S Program structure, illustrating how the Code Readiness Subprogram serves as a bridge between research, market adoption, and regulatory action.

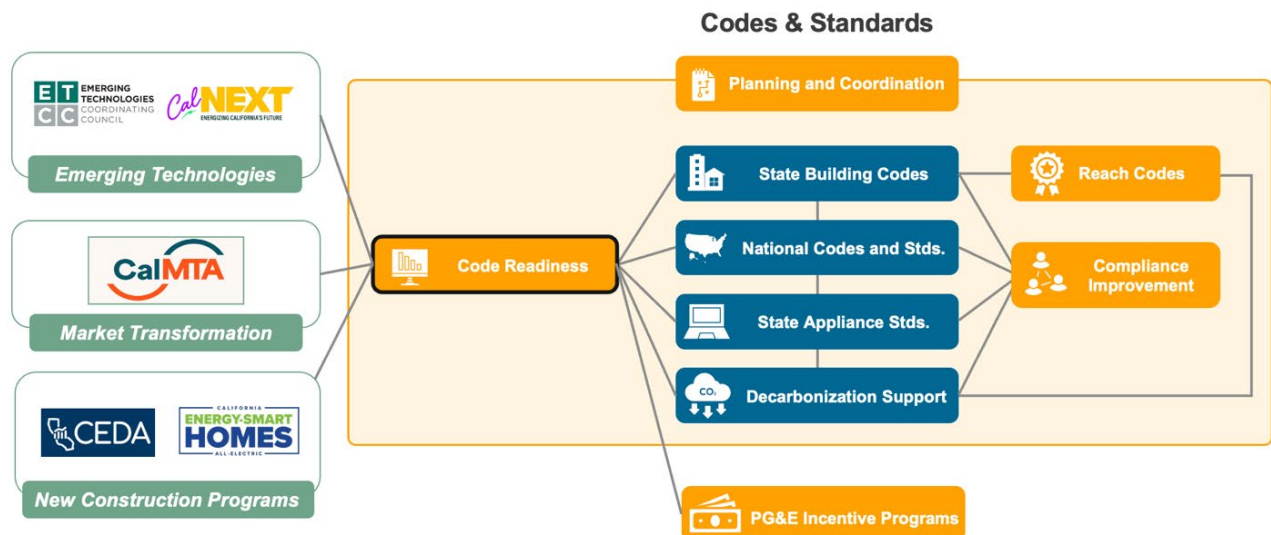


Figure 1. Codes & Standards Program Structure

PURPOSE & OBJECTIVES

The Code Readiness Subprogram serves as a critical bridge between innovative research and future state and federal rulemakings. It supports a wide range of organizations, including the California Energy Commission (CEC), U.S. Department of Energy (DOE), American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), International Energy Conservation Code (IECC), and ENERGY STAR®. This coordinated approach ensures that Code Readiness activities produce timely, applicable research that directly supports energy policy development and implementation. These efforts span residential, nonresidential, and industrial sectors, as well as crosscutting strategies such as transportation and demand flexibility.

To support this goal, the Code Readiness Subprogram focuses on three key objectives:

Data-Driven Research & Field Testing

- Identify promising and market-ready technologies with the potential to impact energy efficiency, decarbonization, and grid resilience.
- Collaborate with industry leaders, utilities, and research institutions to collect real-world performance data on market-ready technologies.
- Conduct rigorous field studies and laboratory testing to validate energy savings, operational efficiency, and cost-effectiveness.
- Leverage partnerships with statewide New Construction programs to amplify data collection efforts.

Strategic Partnerships & Collaboration

- Collaborate with stakeholders like CalMTA, CalNEXT, and other industry groups to align research objectives and maximize impact.
- Foster partnerships with building owners, contractors, and manufacturers to address barriers to the research and adoption of market-ready technologies and strategies.
- Enhance collaboration with regulatory agencies and advocacy groups to streamline the transition from research to policy implementation and ensure that data-driven insights effectively inform code updates.
- Where codifying a measure is not viable, leverage research findings to inform utility incentive programs and voluntary initiatives that accelerate adoption and drive early energy savings.

Informing Codes & Standards

- Use research findings to inform state and national code-setting bodies, including CEC, DOE, ASHRAE, and IECC.
- Support regulatory objectives by providing data to justify the improvement and adoption of energy efficiency and electrification measures.
- Engage stakeholders to help navigate research challenges and expand the scope of covered products.
- Support compliance and enforcement improvements, including streamlining code language to improve readability and navigability.

Together, these strategies ensure that Code Readiness research delivers actionable insights, accelerates technology adoption, and lays the groundwork for timely, impactful updates to energy codes and standards.

STRATEGIC PLANNING

This Code Readiness Strategic Roadmap informs short- and long-term planning for the Code Readiness Subprogram and complements the broader Long-Term Tactical Plan (LTTP).¹ While the LTTP sets overarching strategies and investment priorities across the entire Codes and Standards (C&S) Program portfolio, this Roadmap focuses specifically on Code Readiness research and project timing. It translates statewide goals into a sequence of actionable research priorities that support the development and adoption of building codes and appliance standards.

Figure 2 illustrates the framework used to guide the development of the Code Readiness Strategic Roadmap and activities. This process links high-level statewide policy goals to specific, actionable research efforts by tracing a clear path through market transformation, regulatory opportunities, and data needs. By following this sequence, the Code Readiness Subprogram ensures that its research portfolio aligns with long-term objectives such as reducing energy use and greenhouse gas emissions while also supporting timely and effective code updates.

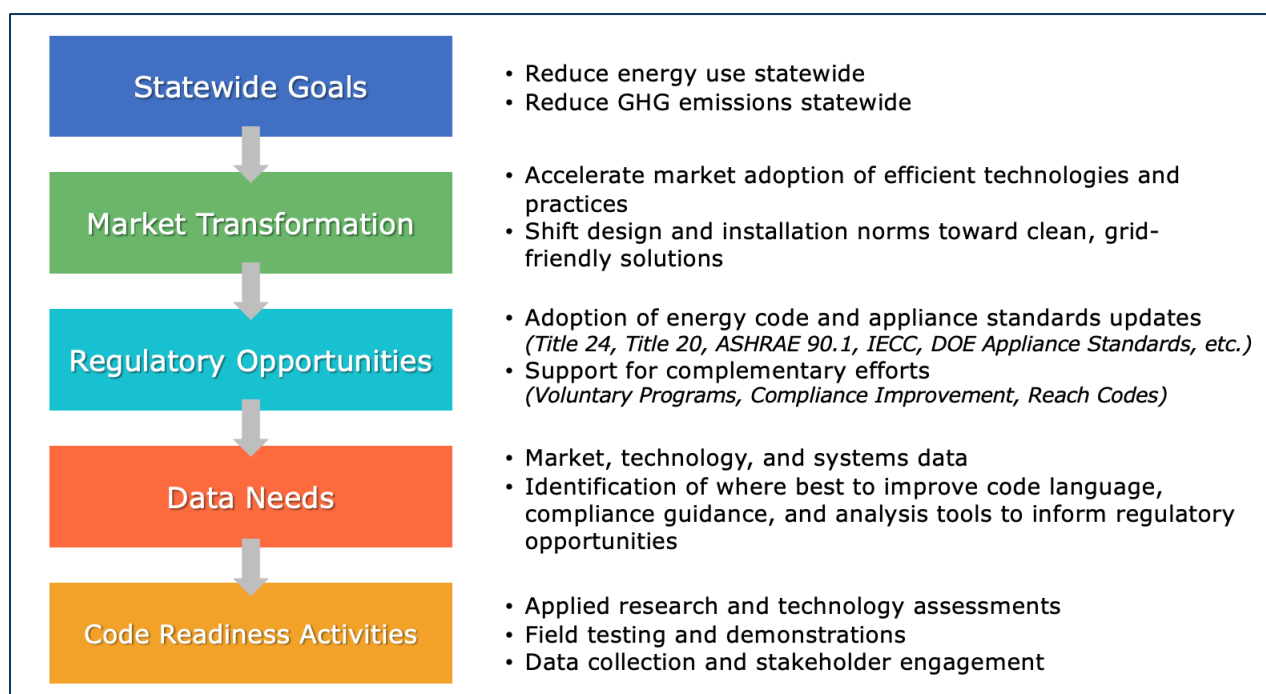


Figure 2. Framework used to Guide the Development of Code Readiness Strategic Roadmap & Activities

¹ The LTTP is available on the [Code Readiness External SharePoint](#) as a companion document to this Strategic Roadmap.

The Code Readiness Strategic Roadmap serves the following purposes:

- **Stage Research Priorities:** Provide a comprehensive plan that articulates research priorities over the next five to 10 years, considering anticipated rulemaking and data collection schedules. This plan will inform future project selection and timing to maximize the program’s impact on upcoming state, federal, and regulatory proceedings and statewide energy savings.
- **Optimize Budget Allocation:** Ensure that the Code Readiness budget is distributed to support a balanced portfolio of research addressing both near- and long-term needs.
- **Facilitate Seamless Collaboration:** Provide other C&S teams with well-timed, policy-aligned research ideas and outcomes that support upcoming rulemakings and standards development.

The Strategic Roadmap serves as the foundation for a Code Readiness Master Measure/Project List, which acts as a living tool to inform project scoping and align research activities with evolving market and policy needs. This list will be updated annually to optimize planning and prioritization. This Master Measure/Project List is accessible in Appendix A.

Approximately 80 percent of the Code Readiness program’s annual research budget supports planned research activities identified in this roadmap. The remaining 20 percent is reserved for emerging data needs identified over the course of the Code Readiness Subprogram implementation. This balance allows the program to remain responsive to immediate regulatory timelines while staying focused on long-term strategic goals. The Strategic Roadmap prioritizes research for both state and federal rulemakings through 2035.

ROADMAP FRAMEWORK & DEVELOPMENT

STRATEGIC ROADMAP FRAMEWORK

The Code Readiness team used a robust framework to identify and evaluate the measures and regulatory objectives needed to achieve California’s decarbonization and electrification goals. These goals include—but are not limited to—reducing greenhouse gas emissions to 40% below 1990 levels (SB 32), doubling the energy efficiency of existing buildings (SB 100, 350), establishing appliance standards that support the deployment of flexible demand technology (SB 49), and reaching 100% zero-emission vehicle (ZEV) new car sales by 2035 (EO N-79-20).² The Code Readiness team identified the following key policy drivers for the subprogram to support in service of the statewide goals:

- Decarbonization (Electrification)
- Energy Efficiency
- Load Flexibility
- Emissions Reduction
- Resiliency, Equity, and Community Wellbeing

For each policy driver, the Code Readiness team identified long-term goals focusing on broad outcomes like reducing emissions, advancing electrification, improving efficiency, and enhancing resiliency for specific building types or technologies. Each of these goals contributes to energy savings, GHG emissions reduction, decarbonization, or improved IAQ

² Additional details on the state’s climate and energy goals are provided in Appendix C.

in the state of California, and may be furthered via activity from one of the regulatory vehicles that Code Readiness supports, including:

- Title 24, Part 6 (Building Energy Efficiency Standards)
- Title 24, Part 11 (CALGreen)
- Title 20 and SB 49 Appliance Standards
- DOE/ENERGY STAR Appliance Standards
- National Energy Model Code Development (i.e., IECC/ASHRAE)
- California Air Resources Board (CARB)

Figure 3 shows the long-term goals for Code Readiness Building Code and Appliance Standards research targeted through 2035.

Figure 3: Policy Drivers and Long-Term Goals for Code Readiness Research

STRATEGIC ROADMAP DEVELOPMENT

The Code Readiness Strategic Roadmap was developed through a collaborative, multi-step process that engaged a range of stakeholders, subject matter experts, and regulatory partners to ensure that the roadmap reflects current programmatic efforts and future needs.

Building Codes: Regulatory Objective Identification

The Code Readiness team initially gathered existing research ideas from the LTTP and from a list of Code Readiness project ideas generated in June 2024 by the Subprogram implementation teams. The Code Readiness team combined or modified the ideas to create a singular list and determined what regulatory objectives (ROs) the research ideas would support. The team then organized the objectives into four main sectors:

- Residential
- Non-Residential
- Industrial, Agricultural, and Covered Processes
- Transportation and Demand Flexibility

In December 2024, the team held a series of virtual workshops to discuss the draft list of ROs for Code Readiness research to support over the next five to ten years within each sector. The purpose of the workshops was to gather subject matter experts (SMEs) to review the initial list of draft ROs, discuss outstanding questions or data needs, and identify where additions, modifications, or removal were needed.

The Code Readiness team used that feedback to refine the ROs and ensure they each were associated with a regulatory body, could lead to energy savings or other climate-related benefits, and had defined research needs. The team aligned the ROs with California's climate goals and Policy Drivers (Decarbonization, Energy Efficiency, Load Flexibility, Emissions Reduction, and Resiliency, Equity, and Community Wellbeing) to improve navigation and ensure all key policy drivers were addressed. In addition, the team reviewed the measures proposed for the 2028 Title 24 selection process and added measures that were removed from the 2028 measure selection process due to existing data gaps as of June 2025.

Appliance Standards: Regulatory Objective and Project Development

The Code Readiness team engaged directly with appliance standards leads to establish the appliance standards ROs. Initially, the team reached out to the relevant technical and strategic leads by technology area to individually discuss long-term planning and research opportunities for Code Readiness. The team conducted initial calls with the leads to gather general research ideas and understand existing data gaps and long-term plans. Where a tactical plan already existed for a technology area, the Code Readiness team leveraged the plan directly. The team then held follow-up conversations to discuss high-priority ideas, aiming to get more detailed information on how Code Readiness research activities could close the data gaps and what objectives the research would support. The Code Readiness team then drew project ideas from the identified research needs, estimated the general level of potential impact each regulatory objective could have across all the technology areas, and used upcoming regulatory timelines to estimate research start dates. The team returned to the appliance standards leads to confirm the relative impact and general timeline.

Regulatory Objective Prioritization

The Code Readiness team assessed the ROs to identify high-impact research areas and determine the priority level each RO and associated research should have. The priority level

in turn informed the estimated code cycle or start date of the research activities. Prioritization criteria for the ROs included:

- Size of potential impact (saved or avoided energy use, GHG emissions reduction, improved indoor air quality)
- Alignment with regulatory bodies' priorities
- Cost-effectiveness
- Technical feasibility and market readiness
- Enforceability
- Complexity
- Applicability to anticipated rulemakings in the next 5-8 years

Figures 4, 5, and 6 show energy use by end use across the residential, nonresidential, and industrial sectors in California or the Western United States.

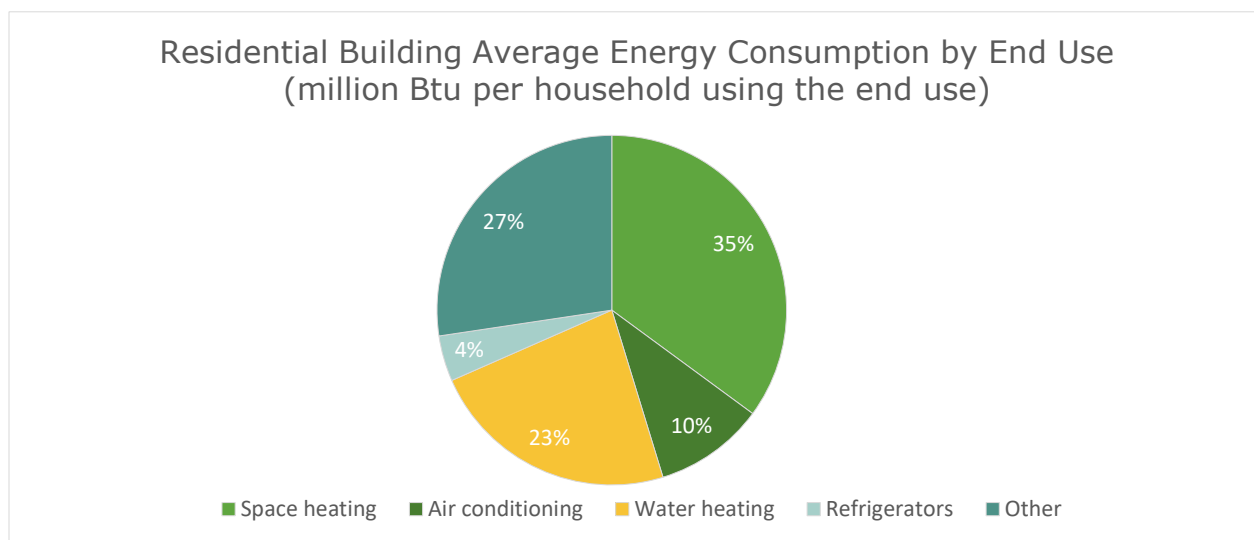


Figure 4. Average annual household site energy end-use consumption, West (2020 Residential Energy Consumption Survey data, EIA)³

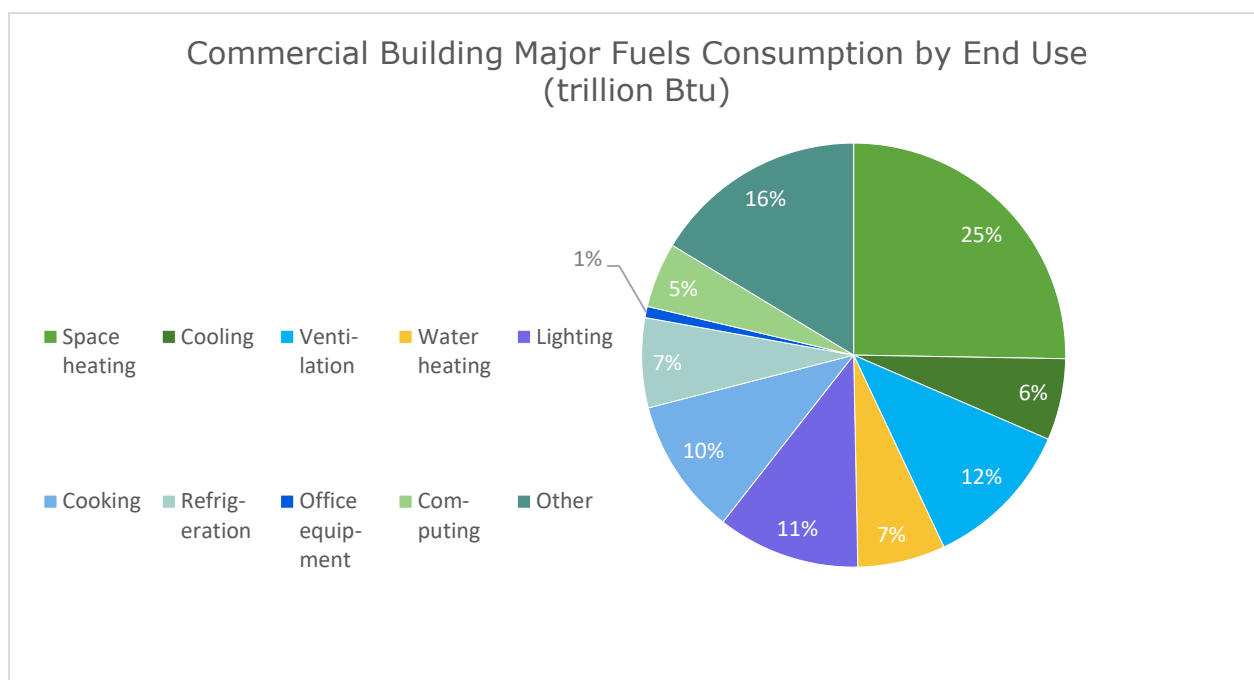


Figure 5. Commercial building major fuels consumption, West (trillion Btus, 2018 Commercial Buildings Energy Consumption Survey Data, EIA)⁴

³ <https://www.eia.gov/consumption/residential/data/2020/c&e/pdf/ce3.5.pdf>

⁴ <https://www.eia.gov/consumption/commercial/data/2018/index.php?view=consumption#e1-e11>

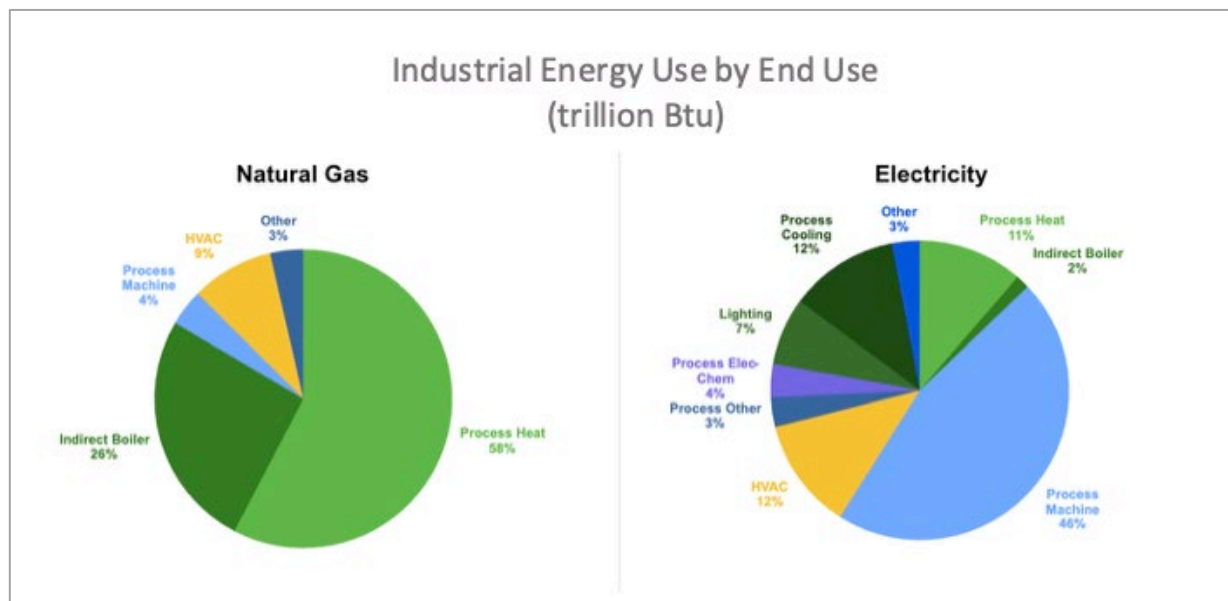


Figure 6. CA Industrial Energy Use by End Use (trillion Btus, CA IOU CASE Team Analysis)⁵

The Code Readiness team scored the building codes ROs on the above criteria using SME and stakeholder calls and survey data. In February 2025, the Code Readiness team presented the ROs to the CEC to gauge interest and regulatory priority across high-level policy drivers and goals in addition to individual ROs. The team invited SMEs to complete online surveys and identify top ROs based on the criteria of savings potential, cost-effectiveness, and market and regulatory feasibility. The survey results helped prepare for the upcoming workshop by generating an initial priority structure and ensuring a broad range of SMEs and stakeholders had the opportunity to provide feedback and influence research prioritization. In April 2025, the team held an all-day in-person workshop in Oakland with core crosscutting SMEs to prioritize the regulatory objectives and determine which ROs Code Readiness research should support first. SMEs identified research projects and key details for the highest-priority ROs.

The priority levels determined the target code cycle for the adoption of each RO. Finally, the team added additional references to known related research that would supplement Code Readiness research for each RO, including ongoing Code Readiness projects.

ROs and projects are tracked in the Master Measure/Project List. The Code Readiness team plans to review the Master Measure/Project List annually for priority updates and integration opportunities across initiatives.

⁵ Source: CA IOU CASE Team Analysis of NREL Industrial Energy Databook 2018 and 2021 DOE AMO/Energetics Manufacturing Energy and Carbon Footprints (developed using 2018 EIA Manufacturing Energy Consumption Survey data), <https://data.nrel.gov/submissions/122> and <https://www.energy.gov/eere/iedo/manufacturing-energy-and-carbon-footprints-2018-mecs>. Note: SIC 13 (Oil and Gas Extraction) not in charts since exempt from T24 coverage.

BUILDING CODES: POLICY DRIVERS AND REGULATORY OBJECTIVES

This section outlines the building code regulatory objectives the Code Readiness Subprogram will support through research over the next five to ten years. Each regulatory objective is accompanied by the target code cycle of Title 24 for achieving the objective and the anticipated Code Readiness research activities that will support the objective.

POLICY DRIVER 1: DECARBONIZATION

Code Readiness decarbonization research focuses on reducing operational carbon by electrifying residential and nonresidential buildings, industrial processes, and vehicles along with their associated infrastructure. These research goals align with the climate objectives outlined by key California policies, including:

- **SB 32:** Mandates a reduction of greenhouse gas emissions to 40% below 1990 levels by 2030.
- **SB 100 and SB 350:** Requires doubling the energy efficiency of existing buildings and accelerate the transition to renewable energy sources.
- **2022 Climate Change Scoping Plan:** Targets the installation of 6 million heat pumps in buildings by 2030 and the creation of 7 million climate-friendly homes by 2035.
- **SB 48:** Requires the development of a comprehensive strategy for managing greenhouse gas emissions from covered buildings.
- **Executive Order N-79-20:** Sets targets for 100% Zero Emission Vehicles (ZEVs), influencing building codes related to EV charging infrastructure and integrated energy management.
- **AB 1236:** Mandates streamlined ordinances for EV charging infrastructure.

Goal 1: Electrify Residential Buildings

Tech. Area	Objective	Target code cycle	CR Research Activities
HVAC	Require all-electric HVAC systems in all existing residential building alterations	2034	Conduct market research and interviews to define an alteration or renovation threshold for this requirement to be triggered, gather and analyze field data on electric HVAC installations in existing residential buildings, support building performance standards.
Water heating	Require all-electric water heating for all multifamily buildings	2034	Leverage existing research and conduct field case studies to collect statewide data on the performance, energy efficiency, and costs of HPWH systems in multifamily buildings, analyze data and model cost-effectiveness across climate zones.
Misc.	Require electric cooking equipment in residential new construction	2037+	Conduct market research on available products, complete a lit review and SME interviews to understand technical feasibility and the need for ventilation requirements for induction/electric cooktops, analyze existing data on product costs and electricity use to determine cost-effectiveness.

Goal 2: Electrify Nonresidential Buildings

Tech. Area	Objective	Target code cycle	CR Research Activities
HVAC	Require electric space heating and cooling in NR buildings	2031, 2034	Conduct a feasibility study of technology readiness in new construction vs gut rehab vs retrofit, research costs to convert existing buildings from gas to electric based on "baseline technology", conduct field and/or lab studies to validate selected design solutions and collect cost and performance data to support simulation model development and system performance validation.
Covered processes, etc.	Electrify SHW in commercial kitchens	2031, 2034	Investigate needs for health guideline (CCDEH) revisions to enable SHW electrification that is not 100% electric resistance heating. Conduct lab testing on HPWH equipment and related heating system configurations that replicate hot water systems commonly used in foodservice facilities.
Water heating	Enhance controls requirements for commercial HPWHs	2034, 2037	Perform modeling and data analysis to understand the impact of design and control options on system efficiency, interview installers/stakeholders to find the optimal control signals for maximizing benefits.
Water heating	Require electric water heating in NR buildings under a certain size	2037	Conduct market research to determine which light commercial applications are best suited to require HPWH, conduct a field study to determine energy savings from systems with recirculation versus systems without recirculation, identify the proper requirements for circulation system and controls that reduce the use of electric resistance heating.

Goal 3: Electrify Industrial and Covered Processes

Tech. Area	Objective	Target code cycle	CR Research Activities
Industrial, mechanical	Require electric boiler and chiller systems for industrial processes	2037+	Conduct an ASHP/AWHP technical feasibility for decarbonizing boiler/chiller systems, complete case studies on field installations to obtain cost, energy usage, and performance data, model cost-effectiveness across applications.

Covered processes, etc.	Require all-electric heating systems for agricultural applications associated with a building load	2037+	Conduct desk research on which applications would be most feasible and cost effective and the heating demands (max temp) and available equipment that can meet that temp, use interviews to confirm costs and performance and energy efficiency of the electric systems.
Industrial, mechanical	Require industrial heat pumps in all cost-effective applications	2040+	Characterize the largest statewide heating end uses and their HW temperature requirements and HW/steam load profiles, determine which end-uses could use heat pumps or hybrid heat pump systems, gather market data on real world design configurations and costs, collect field data on existing applications.

Goal 4: Electrify Vehicles

Tech. Area	Objective	Target code cycle	CR Research Activities
Transportation	Require EV-ready infrastructure for forklifts and yard vehicles	2037+	Conduct a market assessment to identify where and how this strategy has been implemented, evaluate the cost-effectiveness of incentives, quantify emissions reductions and operational savings, and assess infrastructure needs and barriers to fleet electrification adoption.

POLICY DRIVER 2: ENERGY EFFICIENCY

Code Readiness energy efficiency research focuses on reducing energy use in residential and nonresidential buildings; enhancing residential, commercial, and industrial appliances; using efficient technology in industrial processes; promoting the use of efficient industrial equipment controls and monitoring; and updating covered process requirements. These research goals align with the climate objectives outlined by key California policies, including:

- **SB 32:** Mandates reducing GHG emissions to 40% below 1990 levels by 2030, necessitating aggressive emission reduction measures across all sectors, including buildings where addressing energy efficiency opportunities first is best practice to achieve this goal.
- **SB 100 and SB 350:** Requires doubling the energy efficiency of existing buildings and accelerate the transition to renewable energy sources.
- **2022 Climate Change Scoping Plan:** Sets targets such as installing 6 million heat pumps in buildings by 2030 and achieving 7 million climate-friendly homes by 2035, emphasizing large-scale retrofits and new construction designs that integrate advanced energy performance measures.

Goal 1: Reduce Energy Use of Residential Building Systems

Tech. Area	Objective	Target code cycle	CR Research Activities
Water Heating	Tighten water heating loss requirements in multifamily buildings	2031	Collect field data on water heating losses and pipe sizing methodology practices. Utilize field data and modeling to evaluate energy savings and cost-effectiveness of regulating pipe sizing methodology, setting a heat loss budget/sq. ft., requiring heat traps at branch piping, and establishing pipe mounting requirements.
HVAC	Add design and installation requirements for residential AWHPs	2031, 2034	Conduct a field study to understand residential AWHP performance and efficiency climate zone and installation best practices.
Water heating	Add design, sizing, and enhance installation requirements for residential HPWHs and update compliance modeling DHW draw profiles	2031, 2034	Conduct a field study to understand residential HPWH performance and efficiency climate zone and installation best practices, analyze costs of compliance with NEEA list, determine appropriate HPWH storage sizing practices for residential, multifamily, and commercial applications.
Water heating	Require proper sizing of master mixing valves (MMV) and circulation pumps in multifamily new construction, additions, and alterations	2031, 2034	Research what spaces/zones within a building can use different MMV configurations (natural, mechanical) and what controls are needed for MMV systems, identify the most promising occupancy types and heating system characteristics for a new requirement, collect and analyze field data to develop savings and cost estimates for retrofit and new construction.
HVAC, Water Heating	Add definitions and modeling compliance credits for residential multi-function heat pumps	2034	Review existing cost data and conduct desk research to determine multifunction HP purchase and installation costs. Collect field data on field installations of non-Harvest Thermal systems to determine unit energy use, efficiency, and performance. Model cost-effectiveness across climate zones.
Water heating	Enhance controls requirements for residential HPWHs	2037	Research common controls through interviews and their efficiency through energy modeling to determine most efficient control methods.
HVAC	Add a compliance credit for completing the Manual Ts	2037	Interview HVAC designers and operators and compliance officials to evaluate the efficiency, behavioral, and comfort impacts of Manual T completion.

Water heating	Establish a prescriptive baseline and requirements to improve efficiency of res. water heating additions and alterations	2037	Collect data on the draw patterns and energy usage of HPWHs in residential alterations to inform baseline though field data collection, research available products and their efficiency to inform requirements.
HVAC	Require pool evaporative cooling	2037+	Conduct interviews with pool owners in CA to collect anecdotal data and field measurements at existing pool sites to understand pool cooling needs and strategies (vapor compression vs. evaporative spray cooling) in CA. Conduct field testing and model the impact of evaporative cooling and of pool cooling on evaporation rates.

Goal 2: Reduce Energy Use of Nonresidential Building Systems

Tech. Area	Objective	Target code cycle	CR Research Activities
HVAC, Water Heating, Demand Flex.	Require nonresidential air-to-water heat pump installations to include thermal energy storage systems	2034	Conduct a market and cost assessment of TES systems and characterize available TES solutions, research costs and case studies of TES installations in existing nonres buildings, model cost-effectiveness, conduct manufacturer interviews to collect information on TES products, HP/TES connectivity, and barriers to commercialization, conduct interviews to define criteria for minimum functionalities, investigate building or system types that may need exceptions due to cost-effectiveness limits, collect data on TES designs, TES charging timing/controls, and HP performance to determine best practices to minimize peak heating / electricity demand.
Water heating	Define system types for multifamily and commercial CHPWHs to evaluate and regulate design and installation as a system, including reducing heat losses at the system level	2031, 2034	Collect and analyze statewide data on CHPWH system configurations to understand most common systems and investigate design, installation and operational challenges. Measure losses in a set of sample buildings, monitor DHW system sites for data to inform models. Conduct interviews and desk research to assess added costs for materials and design costs for modeling WH distribution systems (selected measures to combat heat loss).

HVAC	Require efficient make up air units for buildings with large ventilation needs (such as commercial kitchens and gyms)	2031, 2034	Conduct a market assessment to understand the performance, efficiency, and availability of efficient make-up air units, conduct lab testing or collect field data to measure savings, conduct desk research to size market in California.
Water heating	Add design and installation requirements for commercial HPWHs	2034	Determine whether CHPWHs need additional regulatory requirements to ensure reliable and persistent savings, collect and analyze data from a field sample of CHPWH systems in CA, interview designers and installers on their typical configuration and installation practices and considerations.
HVAC	Improve commercial heat pump acceptance testing, looking to streamline and expand coverage	2034	Interview contractors to understand current barriers to and feedback on current acceptance testing, complete a market assessment to what new training/skills are needed to complete the tests, investigate product databases and opportunities to connect product databases to acceptance testing processes.
Covered processes, etc.	Incentivize or require heat recovery in commercial kitchens	2034	Investigate the status, barriers, and potential savings of heat recovery systems in commercial restaurants, interview commercial kitchen designers, installers, and owners to assess market barriers, sizing challenges, and cost-effectiveness of HPWH versus hybrid or heat recovery systems, collect and analyze field data on real-world installations.
HVAC	Set a maximum heat loss for PTAC sleeves (and a test procedure if needed)	2034	Conduct a literature review of PTAC manufacturers to determine average U-value for sleeves and lab testing to understand heat loss from various configurations of PTAC sleeves, conduct thermal loss testing on PTAC sleeves with and without insulation.
HVAC	Set a max ER heating capacity in commercial space heating systems to limit resistance reheat at terminal units	2037	Conduct a literature review to understand current sizing requirements for terminal unit resistance reheat and a field study to test configurations of sizing / limits for resistance reheat.

HVAC, Water Heating	Add definitions modeling compliance credits for commercial multi-function heat pumps	2037	Conduct product lit reviews and manufacturer/designer interviews once or twice a year to track trends and collect/vet product performance in more real-time rather than through field data, evaluate various design options through preliminary lab tests to identify high-performance options, then conduct field studies to validate selected design solutions and collect cost data.
Envelope, lighting, embodied carbon	Establish an alternative compliance pathway allowing the use of integrated lighting and daylighting controls to achieve a specified operational energy efficiency instead of fixed lighting power densities	2037	Research the capabilities of post Certificate of Occupancy compliance pathways and decide metrics to include for comparison in design and operational efficiency, conduct a field study on the operational efficiency of using integrated lighting and daylighting controls and compare the field energy data with Title 24 compliant design.
HVAC	Require mixed-mode ventilation in certain commercial end uses	2040+	Interview SMEs to evaluate building types and commercial end uses for measure qualification, collect field or case study data on real-world costs and energy savings of mixed-mode ventilation in new buildings and retrofits.

Goal 3: Use Efficient Technology in Industrial Processes

Tech. Area	Objective	Target code cycle	CR Research Activities
C&I refrigeration, industrial cold side, demand flex.	Require thermal mass load management in select cold storage applications	2031	Identify cold storage loads and characterize load management technologies, including costs and market readiness. Collect field data on cold storage thermal mass load management. Model energy usage and savings among different control schemes and electricity pricing schemes to determine control efficiency.

Industrial, mechanical	Require steam systems to use thermal vapor recompression (TVR) or mechanical vapor recompression (MVR)	2034	Conduct desk research on available technologies (types of TVR, MVR) and interviews to identify the largest energy savings opportunities for TVR and MVR. Collect field data on real-world TVR and MVR use to determine actual costs and energy savings. Define requirement criteria by analyzing the relative industrial segments, building types, and conditions where TVR and MVR are cost effective.
Industrial, Mechanical	Require heat recovery for industrial waste heat	2034	Complete an end-use characterization of industrial waste heat streams and facility types, identify available technologies and costs for heat recovery. Collect field data on load profiles for sink/source streams. 2028 measure not moving forward would have required design review of industrial facilities and include pinch analysis to identify heat recovery opportunities in the review - identify weaknesses as a measure and support as a first step.
C&I refrigeration, industrial cold side	Expand heat recovery requirements for commercial and industrial cold side applications (for space heating, DHW)	2034	Conduct a lit review of studies and manufacturer data on commercial cold side heat recovery, collect field data from comm sites with refrigeration heat recovery to understand real-world performance, energy savings, and costs, interview designers and compliance officials on equipment performance and costs.
C&I refrigeration, industrial cold side	Create a baseline and measure case model for various industrial central plant refrigeration and packaged refrigeration designs	2034, 2037	Conduct desk research and designer interviews to characterize common industrial central plant refrigeration and packaged refrigeration designs (cold storage warehouse, grocery), model designs to analyze applicability.
Industrial, mechanical	Introduce FEI minimum requirements for select fan system applications	2037	Conduct desk research and SME interviews to determine fan system applications with highest savings potentials, lab test or monitor field fan systems to determine FEI values for common systems and applications, model expected FEI values and energy savings for most common applications and efficient system replacements.

C&I refrigeration, industrial cold side	Add a design review requirement and condenser sizing tool for industrial and supermarket refrigeration	2037	Interview designers to understand existing sizing tools and design sizing needs, complete desk research to create specific sizing recommendations, draft sizing tool.
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Goal 4: Promote Efficient Industrial Equipment Controls and Monitoring

Tech. Area	Objective	Target code cycle	CR Research Activities
C&I refrigeration, industrial cold side	Require VFD controls for evaporator fans in process freezers and coolers and require design review to include a commissioning plan with recipe development	2031, 2034	Evaluate speed controls input requirements and consider an exemption for low operating hours/low load factors. Develop a Joint Appendix and engage stakeholders. Test blast chillers and freezer processes with VFDs. Interview code stakeholders to define control requirements within code scope.
C&I refrigeration, industrial cold side	Require advanced control algorithms in ambient driven cold storage loads, process driven loads, and combined cooling & dehumidification	2031, 2034	Conduct a baselining study to characterize how facilities are currently controlled. Research and define advanced control algorithm options for the relevant use cases, conduct lab testing or field data collection to determine the efficiency and cost effectiveness of advanced control algorithms.
Industrial, mechanical	Require or incentivize setpoint resets for load reshaping at cold storage facilities	2037	Complete desk research to identify case studies on load reshaping at cold storage facilities, interview operators to determine costs, conduct field testing to demonstrate savings potential, model cost-effectiveness.
Industrial, mechanical	Encourage preventative maintenance measures for industrial hot side equipment in addition to boilers	2037	Investigate the highest ROI equipment and monitoring points through interviews with industrial hot side equipment operators and manufacturers, identify potential issues with requiring acceptance testing, identifying heat exchanger fouling, condensate return issues, install monitoring at field sites and collect pre/post data to prove savings.

Industrial, mechanical	Require combustion furnaces to monitor air-to-fuel ratios and enact O2 trim control	2037	Interview furnace manufacturers and owners/operators to determine furnace efficiency across O2 levels.
Industrial, mechanical	Require differential pressure-based cleaning controls for dust collection systems in new or replacement bag houses with dust collection blower / fan hp > 20 hp	2037	Collect additional data on real-world dust collection system operation, energy usage, and efficiency through interviews with industrial representatives.
C&I refrigeration, industrial cold side	Ban low efficiency capacity control strategies used in chemical cold side industrial processes	2040+	Conduct interviews to determine range of control strategies used in industry and barriers and costs of higher efficiency strategies, model energy impacts of common control strategies,

Goal 5: Update Covered Process Requirements

Tech. Area	Objective	Target code cycle	CR Research Activities
Covered processes, etc.	Eliminate the practice of dilution ventilation in wineries and require CO ₂ to be vented directly outside.	2031	Find a site where this concept is implemented or work with a winery and a fabricating partner to understand feasibility, conduct a site assessment or rapid field metering with one-time measurements for fan air flow and exhaust ventilation air temperature to estimate savings.
Covered processes, etc.	Establish minimum efficiency requirements for laboratory equipment and supporting infrastructure	2031, 2034	Characterize market share and energy use of lab equipment, identify regulatory opportunities for energy savings, collect cost and energy savings data on recommended measures. Conduct interviews to close data gaps and ensure recommended measures are practical and collect field data to measure real-world costs and energy savings of potential measures.
Covered processes, etc.	Require a variable frequency drive so that elevator hydraulic pumps can modulate pump speed.	2031, 2034	Collect field data in California on hydraulic elevator energy use and real-world efficiencies of variable voltage variable frequency (VVVF) drives with electronic control valves.
Covered processes, etc.	Develop performance compliance energy modeling software capabilities for greenhouses and CEH across a range of crop types	2037	Conduct desk research to segment additional crop types, gather field data on thermal load profiles for the most common crop types to determine key drivers needed to characterize energy use and model energy usage. Collect grow room environmental data, grow cycle timeline data, and HVAC/D operational data to refine evapotranspiration latent load model.
Covered processes, etc.	Require or incentivize fluidized bed reactors in wineries	2037	Conduct desk research and interviews to estimate market size and assess the cost and performance of alternatives to the traditional method.

Covered processes, etc.	Require or incentivize the reuse of collected condensate from dehumidification equipment for irrigation in CEH facilities above certain size of HVAC/D system	2034, 2037	Conduct a market study on CEH facilities using reverse osmosis (RO) and its energy use, collect data from field sites on first cost, user acceptance, water and energy savings, ongoing system maintenance, confirm technology maturity, research the water quality of condensate and associated impact on yields and product quality to address potential opposition and the availability of space to install collection tanks and treatment system in existing buildings.
Covered processes, etc.	Add to existing escalator and moving walkway requirements to have VFD start and stop operation. Add a regenerative drive option for downward travelling escalators.	2034, 2037	CalOSHA Title 8 Regulations contain the safety orders for escalators. Verify if escalators are prevented from stopping and starting during occupied times. ASME 17.1-2010 was first edition that allowed stopping and starting. Title 8 references older versions.
Covered processes, etc.	Expand covered processes to include commercial clothes drying and require CCDs up to 65 cu ft to include insulation and air sealing.	2034, 2037	Review product specifications to verify insulation and air sealing requirements, conduct testing to determine insulation R values that will be required, interview stakeholders to determine alternate pathways to Title 24.
Covered processes, etc.	Require pulse cooling for select winery and other tank cooling applications	2040	Conduct lab testing or field demonstration to prove feasibility and energy savings, interview winery operators to determine barriers and costs of pulse cooling controls.
Covered processes, etc.	Add requirements for wastewater treatment	2040	Conduct desk research and interviews with SMEs and municipalities to determine regulatory opportunities and technical feasibility, interview stakeholders and SMEs to define measures, conduct field research to determine costs and savings of potential measures.

POLICY DRIVER 3: LOAD FLEXIBILITY

Code Readiness load flexibility research focuses on expanding the scope of the Flexible Demand Appliance Standards, advancing demand-flexible electric vehicle (EV) charging, and advancing load shifting capabilities in buildings. These research goals align with the climate objectives outlined by key California policies, including:

- **SB 32:** Mandates reducing GHG emissions to 40% below 1990 levels by 2030, necessitating aggressive emission reduction measures across all sectors, including buildings where addressing load flexibility opportunities is best practice to achieve this goal.

- **SB 48:** Requires developing a comprehensive strategy for managing GHG emissions from covered buildings, prompting a re-evaluation of code requirements to ensure long-term emission reductions.
- **2022 Climate Change Scoping Plan:** Sets targets such as installing 6 million heat pumps in buildings by 2030 and achieving 7 million climate-friendly homes by 2035, emphasizing large-scale retrofits and new construction designs that integrate advanced energy performance measures.
- **Long-Term Energy Storage Projections:** The anticipated need for 52,000 MW of energy storage by 2045 highlights the intersection between decarbonization and grid reliability, with building codes playing a role in integrating these storage solutions.

Goal 1: Advance Demand-Flexible EV Charging

Tech. Area	Objective	Target code cycle	CR Research Activities
Transportation	Add EV and building requirements to facilitate EV2X readiness	2034, 2037	Conduct market research and an impact assessment to identify the availability and market size of existing V2X charging infrastructure, understand the demand for bidirectional EV chargers, evaluate costs and impacts, and assess the authority having jurisdiction (AHJ). Analyze data gaps in charging patterns, usage rates, and interconnection (Rule 21). Model impacts from V2X.

Goal 2: Advance Load Shifting Capabilities in Buildings

Tech. Area	Objective	Target code cycle	CR Research Activities
Demand flexibility	Require energy storage in residential and nonresidential new construction to supply a defined percentage of the building's peak load	2031	Research potential cost and carbon reduction of energy storage relative to LSC, whole building vs. individual building system implications (water heating), building types that may need exceptions or custom percentages of peak load, estimated energy savings, sizing constraints, and cost effectiveness. Investigate and characterize energy storage options, model cost-effectiveness and load shifting and grid impacts, conduct interviews to determine aggregate grid impacts to determine highest impact/most cost-effective sizing strategy.

Demand flexibility	Standardize building automation system (BAS) interoperability requirements, establish minimum performance criteria for integrated control systems, develop modeling methods, ACM rules, and adjustment factors for load flexibility in res. and nonres. buildings that specify control strategies and timing for load shifting, and establish a compliance pathway for grid-interactive buildings	2031, 2034	Survey BAS vendors, architects, energy consultants, and facility managers to assess market penetration and perceptions of integrated systems. Interview system integrators, controls engineers, architects, and permitting officials to evaluate implementation experience and Interview or survey vendors and installers to collect data on hardware, software, commissioning, and integration labor costs. Conduct pilot studies at three sites with existing BAS over one full year of operation, model savings potential across building types and use profiles.
Demand flexibility	Add requirements to optimize load shifting in nonresidential buildings	2037, 2040	Categorize load shifting options, identify energy-using equipment usage profiles under different controls schemes to understand when and how much energy can be reduced/increased through modeling. Conduct a market assessment to identify applicable appliance types, standard use profiles, and effective control strategies for load shifting. Evaluate the energy and cost savings potential, ensure compatibility of existing modeling methods with grid-interactive appliances, and address gaps in technology standardization and data availability.

Goal 3: Encourage Microgrids

Tech. Area	Objective	Target code cycle	CR Research Activities
Demand flexibility, transportation	Require DC microgrids in charging depots	2037	Conduct a market assessment to quantify potential energy savings statewide with recommended incentive structure via code mechanisms.
Demand flexibility, transportation	Require microgrids in multifamily buildings	2040+	Conduct a market assessment to evaluate the technical and economic feasibility of microgrid adoption in multifamily buildings, including metering strategies, technology availability, and implementation

			approaches. Identify barriers to adoption, quantify energy savings and emissions reductions, and assess the compatibility of microgrids with existing building energy systems and regulatory frameworks.
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POLICY DRIVER 4: EMISSIONS REDUCTION

Code Readiness emissions reduction research focuses on reducing refrigerant emissions for residential and commercial applications, lowering carbon emissions from building materials and construction, and reducing emissions from non-passenger vehicles. These research goals align with the climate objectives outlined by key California policies, including:

- **SB 32:** Mandates reducing GHG emissions to 40% below 1990 levels by 2030, necessitating aggressive emission reduction measures across all sectors, including buildings where addressing load flexibility opportunities is best practice to achieve this goal.
- **SB 48:** Requires developing a comprehensive strategy for managing GHG emissions from covered buildings, prompting a re-evaluation of code requirements to ensure long-term emission reductions.
- **Executive Order N-79-20:** Sets targets for 100% Zero Emission Vehicles (ZEVs), influencing building codes related to EV charging infrastructure and integrated energy management.
- **AB 1236:** Mandates streamlined ordinances for EV charging infrastructure, emphasizing the need for supportive building codes that allow for these system upgrades.

Goal 1: Reduce Emissions from Building Construction

Tech. Area	Objective	Target code cycle	CR Research Activities
Envelope, lighting, embodied carbon	Require low-carbon envelope design for all residential and NR new construction	2034	Conduct comprehensive life-cycle cost analyses (LCCA) comparing sustainable materials with traditional alternatives, including data on energy efficiency, maintenance costs, overall life-cycle costs, and LEED building design parameters, interview manufacturers of building envelope measures and installers.

Goal 2: Reduce Residential Refrigerant Emissions

Tech. Area	Objective	Target code cycle	CR Research Activities
Refrigerants	Expand allowed natural refrigerants for commercial and residential HPs and create a pathway for small AWHPs that use propane in residential buildings	N/A	Conduct desk research on the performance, efficiency, and risks of HPs with natural refrigerants, including propane, conduct seasonal performance testing and pilot installations at lab houses to further research safety considerations and the performance of ventilation systems and sensors at refrigerant deployments. Analyze the EU market of HPs with propane as a refrigerant, review any available data on the performance, safety, and current certification process for propane HPs in the US.
Refrigerants	Set a whole-building maximum level of refrigerant impact (as a function of modeled load) that takes both refrigerant volume and GWP into account	2034, 2037	Review manufacturer literature to understand low-GWP refrigerant volumes as a function of modeled load and building type, leverage research on equipment performance and efficiency with different low-GWP refrigerant types, model refrigerant volumes according to building types.
Refrigerants	Require refrigerant leakage detection and prevention in/at residential buildings	2040	Conduct market research on refrigerant leakage and recharge rates, interview SMEs and key industry players to discuss refrigerant leakage detection and prevention best practices and impact.

Goal 3: Reduce Commercial Refrigerant Emissions

Tech. Area	Objective	Target code cycle	CR Research Activities
Refrigerants	Require ultra-low-global warming potential (GWP) refrigerants in all residential and commercial heat pumps	N/A	Research product costs and risks of ultra-low GWP refrigerants via desk research, conduct a field study to evaluate the performance and efficiency of HPs with ultra-low-GWP refrigerants, develop design solutions and guidelines for low-GWP refrigerant systems in various commercial applications.

Refrigerants	Require advanced refrigerant leakage detection and prevention in/at nonresidential buildings with new refrigerant systems	2037+	Conduct market research on refrigerant leakage and recharge rates, interview SMEs and key industry players to discuss refrigerant leakage detection and prevention best practices and impact.
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Goal 4: Reduce Emissions from Non-Passenger Vehicles

Tech. Area	Objective	Target code cycle	CR Research Activities
Transportation	Require medium-duty and heavy-duty vehicles to use shore power instead of diesel idling	2034	Conduct a market assessment to evaluate the availability and cost of shore power infrastructure, identify applicable vehicle types and applications, assess the feasibility of retrofits, and quantify operational savings and emissions reductions. Include an analysis of driver behavior modifications, strategies for successful implementation, and the role of incentives or penalties in promoting adoption.

POLICY DRIVER 5: RESILIENCY, EQUITY, AND COMMUNITY WELLBEING

Code Readiness resiliency, equity, and community wellbeing research focuses on increasing building resiliency for residential and nonresidential buildings, as well as reducing building water use. These research goals align with the climate objectives outlined by key California policies, including:

- **SB 100 and SB 350:** Aims to double the energy efficiency of existing buildings and accelerate the transition to renewable energy, directly linking to updating building codes for more efficient systems.
- **SB 49:** Calls for new appliance standards to enable flexible demand technologies, directly linked with modernizing building codes for energy storage and load shifting.
- **2022 Climate Change Scoping Plan:** Sets targets such as installing 6 million heat pumps in buildings by 2030 and achieving 7 million climate-friendly homes by 2035, emphasizing large-scale retrofits and new construction designs that integrate advanced energy performance measures.
- **Long-Term Energy Storage Projections:** The anticipated need for 52,000 MW of energy storage by 2045 highlights the intersection between decarbonization and grid reliability, with building codes playing a role in integrating these storage solutions.

The full list of ongoing Code Readiness projects can be reviewed in Appendix E.

Goal 1: Increase Residential Building Resiliency

Tech. Area	Objective	Target code cycle	CR Research Activities
Envelope, lighting, embodied carbon	Update envelope alterations requirements for multifamily buildings	2034	Evaluate current multifamily envelope alterations, including conducting blower testing, to determine effectiveness of current requirements, interview SMEs and stakeholders to determine opportunities for code updates and collect cost data, conduct modeling to determine savings of updated requirements.
Envelope, lighting, embodied carbon	Tighten envelope requirements for single-family residential new construction, including limiting thermal bypasses and requiring high-performance windows and fenestration products	2037	Evaluate thermal bypasses and high-performance fenestration and their overall impact on the envelope, conduct pilot studies to gather real-world data on the performance and costs of advanced fenestration products in both new and retrofit applications.
Envelope, lighting, embodied carbon	Require cool roofing and cool walls in residential new construction and significant renovations	2040	Conduct desk research on manufacturers and costs, find field examples and conduct interviews or case studies to estimate savings, collect cost data from installers and manufacturers, model savings across building sizes and climate zones.

Goal 2: Increase Nonresidential Building Resiliency

Tech. Area	Objective	Target code cycle	CR Research Activities
Envelope, lighting, embodied carbon	Tighten NR and multifamily envelope requirements, including limiting thermal bypasses, supporting thermal bridging limits and/or envelope trade-off limits, and updating thermal bridging assumptions.	2031, 2034	Evaluate the consistency and levels of current air tightness and QII inspections, test current envelopes in MF buildings that have met the compartmentalization requirement, conduct a cost impact assessment, lit review, and interviews to assess causes, energy loss, and magnitude of thermal bridging in real world environments.

Envelope, lighting, embodied carbon	Require NR building envelope air tightness testing	2034	Research the effectiveness of air barrier testing by testing existing buildings against the required leakage rate, collect cost data on testing.
Envelope, lighting, embodied carbon	Require cool roofing and cool walls in non-residential new construction and significant renovations	2040	Research the energy and cost-saving potential of cool roofs in various climate zones, characterize different cool roofing material performance and durability, conduct desk research on manufacturers and costs, find field examples and conduct interviews or case studies to estimate savings, collect cost data from installers and manufacturers, model savings across building sizes and climate zones.

Goal 3: Reduce Building Water Use

Tech. Area	Objective	Target code cycle	CR Research Activities
Misc.	Require greywater reuse for large commercial buildings	2037+	Interview stakeholders in San Francisco to discuss greywater mandate impact, success, and best practices and interview building owners and designers to discuss costs and impacts. Model greywater reuse savings for different building types in CA.

APPLIANCE STANDARDS: REGULATORY OBJECTIVES

This section outlines the appliance standard regulatory objectives the Code Readiness Subprogram will support through research over the next five to ten years. Each regulatory objective is accompanied by the Code Readiness research that will support the objective, and the target research dates, subject to change with evolving regulatory priorities, industry and stakeholder needs, and technological progress.

DOE's proposals in early 2025 to repeal coverage determinations for various products pose large uncertainty for the near future of appliance standards at the federal level. These activities will almost certainly delay DOE's adoption of new standards in the future, which could prompt the Code Readiness team to adjust timelines and prioritize state measures over federal ones in the near term where federal preemption is not a barrier.

Technology Area 1: Industrial and Covered Processes

Regulatory Body	Regulatory Objective	Proposed Research Timing	Code Readiness Project Activities
CEC (Title 20)	Establish standards for air dryer efficiency	2025-2026	Conduct market assessment of air dryers, lab test air dryers to determine energy usage across products and analyze data to develop proposed standards, engage key stakeholders to align on standards.
CEC (Title 20)	Adopt test procedures for industrial heat pumps	2025-2029	Test IHPs in labs or controlled field environments, evaluate testing methods and equipment performance, engage with key industry stakeholders to align on test methods.
CEC (Title 20)	Add standards for computer room / data center servers, storage, and LNE (PSUs, routers, switches, etc.)	2028-2029	Complete market research and literature review to characterize available products, collect cost data from manufacturers, lab test products to confirm energy use and efficiency across load profiles, engage stakeholders to develop test procedure and standards.
CEC (Title 20)	Introduce Title 20 wet well submersible product standards (for water treatment)	2030-2031	Lab test wet well submersible products, evaluate testing methods and equipment performance, engage with key industry stakeholders to align on test methods.

DOE	Update DOE motor TP and standards to require VFD+ motors in all applications where cost effective	2032	Conduct market research and end use segmentation, collect data on product performance, energy efficiency, and costs through SME interviews and lab testing, engage stakeholders to align on test method updates and requirements.
CEC (Title 20)	Add a test and list for specific air equipment (compressed air blower nozzles, valves, actuators, air knives, air-driven packaging equipment)	2033	Conduct market research on air equipment products, availability, performance, energy efficiency, and cost. Lab test specific air equipment to evaluate test methods.

Technology Area 2: Commercial and Industrial Refrigeration

Regulatory Body	Regulatory Objective	Proposed Research Timing	Code Readiness Project Activities
DOE	Update additional CRE equipment test procedures, standards, and equipment efficiency options	2025-2029	Investigate opportunities and next steps based on CRA disapproval, conduct surveys or a field study of door opening frequency for various CRE equipment classes, research the prevalence of evaporator fan controls through spec sheets and manufacturer discussions and test units with evaporator fan control, conduct additional testing as needed.
DOE	Require or incentivize load flexibility and thermal storage in self-contained CRE	2027-2028	Evaluate potential for load flexibility and thermal storage in self-contained CRE.
EPA, CARB RMP	Inform specifications for CRE to service over counter equipment and ice cream freezers	2027-2028	Research typical design options associated with Service Over Counter equipment through manufacturers or trade groups, characterize the energy consumption of 5-10 Service Over Counter units from various manufacturers, investigate market size and potential energy savings for ice cream freezers.
ENERGY STAR	Enhance walk-in cooler and freezer test procedures and standards	2029-2030	Conduct research and testing as needed to support walk-in cooler and freezer test procedure development and standards enhancements, including lab testing walk-in coolers and freezers.

DOE	Enhance automatic commercial ice maker test procedures and standards	2029-2030	Characterize design options and energy consumption of popular ice makers, conduct field interviews or case studies on ice maker use, test commercial ice makers to validate test procedure and determine impacts of enhancements based on field and interview data.
DOE	Enhance beverage vending machine test procedures and standards	2029-2030	Characterize design options and energy consumption of popular vending machines, conduct field interviews or case studies on beverage vending machine use, test beverage vending machines to validate test procedure and determine impacts of enhancements based on field and interview data.

Technology Area 3: HVAC (including Pool/Spa Heating)

Regulatory Body	Regulatory Objective	Proposed Research Timing	Code Readiness Project Activities
AHRI, CEC (Title 20)	Update AHRI TP commercial AWHP (HVAC) and standards to improve off-mode standby power, crankcase heating, and defrost	2026-2027	Conduct a literature review and interviews to determine the spread of product off-mode standby power, crankcase heating, and defrost methods and associated energy use in available commercial products. Leverage results of interviews and R. Tharp's testing to recommend updates to TP and standards.
DOE or CEC (Title 20)	Update test procedures for residential air purifiers, including adding testing that accounts for sensor driven mode	2027-2028	Conduct a lit review of Dyson's published alternative test procedure. Conduct product lab testing to analyze and validate current test procedure, test impacts of lower speeds on efficiency, energy use, and consumer usage, conduct surveys or collect field data on consumer operation and usage of air purifiers, both single and flexible speed.
DOE, AHRI	Update the VRF test procedure to reflect real-world deviations in indoor unit size	2029-2030	Conduct testing of VRF indoor/outdoor unit combinations to analyze system efficiency with larger/high-capacity indoor units and recommend updates to TP.

DOE, CEC (Title 20, Title 24)	Standardize an industry-supported test procedure and standards for residential multi-function HPs	2031-2032	Conduct market research and a literature review on available products, collect product cost and real-world performance data from interviews. Analyze data from the Energy-Smart Homes project and conduct product testing to determine how well DOE AAHP and WH test procedures and requirements apply to multi-function HP testing, engage stakeholders to determine test procedure and standards.
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Technology Area 4: Demand Flexibility

Regulatory Body	Regulatory Objective	Proposed Research Timing	Code Readiness Project Activities
CEC (Title 20 or Title 24)	Establish FDAS for DHW water heaters and specify control strategies and timing for load shifting to optimize energy use and reduce peak demand	2026-2027	Conduct lab testing or collect field data through monitoring or case studies on the ability of DHW water heaters to successfully shift peak loads, interview manufacturers on controls design and optimization, interview utility representatives and energy modelers on the appropriate way to estimate savings.
CEC (Title 20)	Implement FDAS for additional residential appliance types, such as electric clothes dryers and dishwashers	2027-2028	Conduct market research to characterize available products, collect cost data, test product ability to successfully load shift, collect field data on product performance
CEC (Title 20)	Implement FDAS for non-residential HVAC systems	2028-2029	Interview manufacturers on nonres HVAC flexible demand capabilities, interview utility representatives to determine technical and market needs, conduct lab testing or collect field data through monitoring or case studies to evaluate the nonres HVAC load shifting performance.
CEC Title 20, AHRI	Implement FDAS for residential BTM battery systems and introduce configuration standards for them	2029-2030	Research configurations and develop commissioning guidelines for BES, conduct market research on residential battery systems and lab testing or collect field data through monitoring or case studies on their ability to successfully shift peak loads with real-world signals.

CEC (Title 20)	Incentivize and create standards for residential intelligent power management technologies (IPMTs), including smart panels and home energy management systems (HEMS)	2030-2031	Complete market research and literature review to characterize available products, collect cost data from manufacturers, lab test products to confirm energy use and efficiency across load profiles, engage stakeholders to develop test procedure and standards.
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Technology Area 5: Water Heating

Regulatory Body	Regulatory Objective	Proposed Research Timing	Code Readiness Project Activities
DOE	Establish standards for condensing-level gas storage water heaters	2024-2025	Conduct data analysis to develop proposed standards and engage key stakeholders to align on standards.
AHRI, DOE, ENERGY STAR, CEC (Title 24)	Update (DOE TP and) standard for commercial HPWHs, including defrost best practices and simulation tools	2024-2026	Conduct lab testing on commercial HPWHs to evaluate defrost performance and efficiency, interview manufacturers on defrost practices and controls, conduct interviews to evaluate commercial HPWH TP usage and assumptions, evaluate the existing test procedure TP repeatability and test burden, and build consensus with stakeholders for updates.
DOE	Support a new class of split system WHs	2028-2029	Test split system water heaters using electric storage water heater TP, but research TBD depending on market development in the next ~5 years.
DOE	Update (DOE TP and) standards for residential HPWH	2029-2030	Conduct res. HPWH simulations and testing: Run simulations to pinpoint testing and run testing to determine opportunities for improvement, evaluate TP repeatability and test burden. Conduct field research on HW use patterns today to evaluate first hour rating metric.

Technology Area 6: Water Products

Regulatory Body	Regulatory Objective	Proposed Research Timing	Code Readiness Project Activities
CEC (Title 20)	Develop a TP and standards for sprinkler spray nozzles	2027-2028	Conduct case studies or interviews to analyze the relationship between improved irrigation management and carbon and energy savings, conduct product market research, collect field data on real-world costs, water usage, and energy efficiency and leverage Water Sense specs and engage stakeholders to develop a test procedure.
CEC (Title 20)	Develop a TP and standards for pressure regulating irrigation products (stand-alone pressure regulators and/or pressure regulating sprinkler valves)	2029-2030	Collect data on the relationship between improved irrigation management and carbon and energy savings through case studies or interviews, conduct product market research, lab test products, collect real-world costs and water and energy savings data through field studies, and engage stakeholders to develop a test procedure.
CEC (Title 20)	Develop a TP and standards for ozone laundries	2030-2031	Collect market and manufacturer data on product availability, costs, and energy use, test product water and energy use, collect field data on real-world performance and water and energy use.
CEC (Title 20)	Update standards for evaporative air conditioners (not swamp coolers)	2031	Identify market landscape and collect market characterization data, conduct field research on actual water use across use cases and equipment sizes.

Technology Area 7: Consumer Electronics

Regulatory Body	Regulatory Objective	Proposed Research Timing	Code Readiness Project Activities
CEC (Title 20)	Establish standards for computer active mode	2025-2027	Administer consumer surveys to understand computer usage and to determine customer acceptance and satisfaction of performance criteria. Conduct online market research and manufacturer interviews to collect market and manufacturer data on computer availability, costs, and energy use. Lab test computer energy use and performance in active mode and non-active mode and compare to existing benchmarks. Engage stakeholders to develop a test procedure.
CEC (Title 20)	Establish standards for electronic displays, including computer monitors	2028	Conduct online market research and manufacturer interviews to collect market and manufacturer data on computer availability, costs, and energy use. Lab test product energy use and performance using ENERGY STAR test procedure. Evaluate the test procedure and engage stakeholders to refine for Title 20 adoption.

Technology Area 8: White Goods

Regulatory Body	Regulatory Objective	Proposed Research Timing	Code Readiness Project Activities
DOE	Update the test procedures for residential washers and dryers to better reflect real-world conditions	2026	Conduct a field study to evaluate the use of load sizes, program settings and cycle modifiers in clothes washers and dryers, investigate the need for adding small loads to the dryer test procedure and the impact of cloth type on test procedure representativeness.
DOE	Raise gas oven standards and create product listings, including creating a performance	2029	Conduct market research to characterize available products in the market, collect cost data, test the energy use of ovens of various sizes.

	test for ovens that takes cavity size into account		
CEC (Title 20)	Require automated range hoods in residential new construction and major alterations to improve IAQ	2031	Collect market data on automated range hoods via online research and manufacturer interviews, test product effectiveness at improving IAQ in residential or laboratory settings.
DOE	Update residential dishwasher and clothes washer test procedures to account for variation in water heating recovery	2030-2031	Conduct product testing and validate test procedure, collect real-world usage and performance data to inform updates, collect market characterization data.

NEXT STEPS

CODE READINESS PROJECT APPROVAL AND INITIATION

The Code Readiness project development process begins with early ideation. In addition to the research activities described in the Master Measure/Project List, Code Readiness team members and collaborators are encouraged to brainstorm innovative ideas that support the advancement of California's energy codes or appliance standards. These ideas may be entirely new to Code Readiness, may build upon emerging technology research from external initiatives, or may be derived from earlier phases of Code Readiness projects. Concepts that clearly align with the Code Readiness Strategic Roadmap contained in this document will be prioritized for further development.

Once an idea is identified, the next step involves conducting preliminary market research. The proposer will review industry trends and relevant available data to understand the potential value and feasibility of the concept within the regulatory and market landscape. The proposer may consult stakeholders or subject matter experts to validate the idea.

Following this preliminary validation, the proposer completes the Code Readiness [New Project Template](#) and submits it to the Code Readiness Program Manager at 2050 Partners for review. This step initiates an internal discussion to refine the concept based on the outcomes of the market research. Constructive feedback from this review helps ensure the idea is well-scoped and ready for advancement.

If the idea receives internal approval, it is presented to PG&E. The presentation serves as an opportunity to pitch the refined concept, gather additional feedback, and receive a go/no-go decision on whether to proceed with full proposal development. PG&E's input at this stage is critical for determining whether the concept merits investment and further exploration.

Upon receiving PG&E's approval, the proposer develops a full research proposal. This includes articulating the project's goals, research approach, anticipated outcomes, and alignment with regulatory priorities. A detailed schedule and budget will be developed using the Code Readiness Research Proposal Budget Template. These documents form the basis for PG&E's final review and approval.

Once approved, the project is formally transitioned from the ideation stage to the active project list. At this point, the project becomes part of the broader Code Readiness portfolio and will be tracked accordingly. This process ensures that new project ideas are vetted thoroughly, strategically aligned, and developed in close coordination with both internal and external stakeholders.

AD HOC RESEARCH NEEDS

Immediate Code Readiness Needs

The Code Readiness team evaluates and addresses immediate research and technical support needs through weekly check-ins with the PG&E Program Manager. These needs may include targeted research, ad hoc analysis, data requests, technical reviews, or preparation of presentation materials to support ongoing program goals.

Codes and Standards Advocacy Team Needs

During active code development cycles, a Code Readiness representative participates in measure selection meetings to identify and track emerging data gaps for Code Readiness to address, either in support of upcoming CASE reports or looking ahead towards future cycles.

CPUC Reporting and Data Requests

The Code Readiness team maintains readiness to respond to California Public Utilities Commission (CPUC) reporting requirements and data requests, and provide timely support and documentation as needed.

PROJECT TRACKING, COMPLETION, AND KNOWLEDGE TRANSFER

All Code Readiness projects are actively tracked throughout their lifecycle using the Code Readiness Project Tracker. This tool provides a central location for maintaining project statuses, milestones, and key documentation. In addition to tracker updates, the Code Readiness team holds regular project details meetings with the PG&E Program Manager to communicate project activities, address emerging issues, and keep projects on track.

Once a project is complete, the Code Readiness project team holds a formal close-out meeting to review final outcomes, ensure deliverables are completed and stored, and identify any lessons learned. Final reports are published on the Energy Transition Coordinating Council (ETCC) website to ensure public accessibility. Project leads are encouraged to share the report link on their individual LinkedIn pages to further extend the research's reach. Key findings are also shared at conferences, industry events, and other relevant forums as appropriate to increase visibility and drive impact.

The Code Readiness team is exploring additional strategies to enhance research dissemination and reach beyond the current process. A dedicated Code Readiness webpage or Code Readiness LinkedIn profile could describe completed projects, highlight major findings, and share project outcomes, updates, and announcements. Blog posts or webinars could provide deeper insight into research findings and encourage engagement from a broader audience. Key stakeholders including regulators, industry representatives, and advocacy groups should be proactively notified of research outputs that may support their work. A digital Code Readiness newsletter could further support consistent communication, offering periodic updates on active projects, recent publications, and upcoming events. Finally, a formal handoff process to the Advocacy team could ensure continuity in stakeholder engagement and support the application of research findings in regulatory proceedings.

UPDATES TO THE STRATEGIC ROADMAP AND MASTER MEASURE/PROJECT LIST

The Code Readiness team will update the Master Measure/Project List as part of the program's annual reporting process to ensure it remains current and strategically relevant. The update will primarily include a review and adjustment of RO priority levels based on evolving policy needs, stakeholder input, and market developments. The team will also refresh the Code Readiness research activities and related ongoing research associated with high-priority ROs to reflect progress, shifting timelines, and emerging opportunities.

In addition to updating existing entries, the team will assess new project ideas against the master list to identify gaps or overlaps. Where appropriate, new projects and corresponding ROs will be added to the list to ensure that promising research concepts are captured and advanced in a timely manner. This structured, recurring update process will maintain alignment between Code Readiness efforts and California's energy and climate goals.

APPENDIX A: MASTER CODE READINESS MEASURE/PROJECT LIST

[This Excel document](#) contains additional details on the Regulatory Objectives and the Code Readiness research activities to support them. The included Regulatory Objectives and research activities were written at the time of publication and are subject to refinement based on evolving regulatory and PG&E priorities, budget constraints, lab availability, or other related factors.

APPENDIX B: DEFINITIONS AND ACRONYMS

Term	Definition
AAHP	Air-to-Air Heat Pump
AB	Assembly Bill
ACM	Alternative Calculation Method Reference Manual
AHJ	Authorities Having Jurisdiction
AHRI	Air Conditioning, Heating and Refrigeration Institute
ANSI	American National Standards Institute
ASHP	Air-Source Heat Pump
ASHRAE	The American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASHRAE 90.1	ASHRAE – Energy Standard for Sites and Buildings Except Low-Rise Residential Buildings
ASME	American Society of Mechanical Engineers
ATS	Acceptance Testing System
AWHP	Air-to-Water Heat Pump
BAS	Building Automation System
BES	Battery Energy Storage
BTM	Behind-The-Meter
CA	California
CARB	California Air Resources Board
CASE	Codes and Standards Enhancement
CBECC	California Building Energy Code Compliance, a software tool used to demonstrate compliance with energy codes
CEDA	California Energy Design Assistance
CCDEH	California Conference of Directors of Environmental Health
CEC	California Energy Commission
CEH	Controlled Environment Horticulture
CFM	Cubic Feet per Minute
CHPWH	Central Heat Pump Water Heater
CKHWS	Commercial Kitchen Hot Water Systems

CHW	Chilled Water
CPUC	California Public Utilities Commission
CR	Code Readiness
CRE	Commercial Refrigeration Equipment
CVRH	Central Valley Research Homes
DHW	Domestic Hot Water
DOE	Department of Energy
DX	Direct Expansion (cooling)
ECM	Electronically Commutated Motor
EE	Energy Efficiency
EO	Executive Order
EPA	Environmental Protection Agency
EER	Energy Efficiency Ratio
ER, ERV	Energy Recovery, Energy Recovery Ventilator
ESH	Energy-Smart Homes
ETCC	Energy Transition Coordinating Council
EV, EVCS	Electric Vehicle, Electric Vehicle Charging Stations
F	Degrees Fahrenheit
FDAS	Flexible Demand Appliance Standards
FEI	Fan Energy Index
GHG	Greenhouse Gas
GWP	Global Warming Potential
HEMS	Home Energy Management System
HI	Hydraulic Institute
HP, HPWH	Heat Pump, Heat Pump Water Heater
HR, HRV	Heat Recovery, Heat Recovery Ventilator
HVAC	Heating, Ventilation, Air Conditioning
HW	Hot Water
IAQ	Indoor Air Quality
IECC	International Energy Conservation Code
IOU	Investor-Owned Utility
ISO	International Organization for Standardization
LBL, LBNL	Lawrence Berkeley Laboratory, Lawrence Berkeley National Laboratory
LCCA	Life-Cycle Cost Analysis
LSC	Long-term System Cost
LTTP	Code Readiness' Long-Term Tactical Plan

MF	Multifamily
MMV	Master Mixing Valve
MVR	Mechanical Vapor Recompression
MW	Megawatt
NCSA	National Codes and Standards Advocacy
NEEA	Northwest Energy Efficiency Alliance
NFPA	National Fire Protection Association
NR, NRCC	Non-Residential, Non-Residential Code of Compliance
PRC	Processes (Covered Processes)
RO	Regulatory Objective
ROI	Return on Investment
SB	Senate Bill
SHW	Service Hot Water
SME	Subject Matter Expert
ST	Submersible Turbine
TES	Thermal Energy Storage
Title 24	Title 24, Part 6 Building Energy Efficiency Standards
TP	Test Procedure
TVR	Thermal Vapor Recompression
USGBC	United States Green Building Council
VAV	Variable Air Volume
VFD, VSD	Variable Frequency Drive, Variable Speed Drive
VRF	Variable Refrigerant Flow
WH	Water Heating
ZEV	Zero Emission Vehicle

APPENDIX C: CALIFORNIA CLIMATE AND ENERGY GOALS

- 2022 Climate Change Scoping Plan**

The 2022 Climate Change Scoping Plan, developed by the California Air Resources Board (CARB), outlines a comprehensive strategy for the state to achieve carbon neutrality by 2045. This plan includes sector-specific targets to guide California's climate action efforts. Notably, it sets goals for the installation of six million heat pumps in buildings by 2030 and the development of seven million climate-friendly homes by 2035. These targets aim to reduce emissions from the building sector, promote energy efficiency, and support the transition to clean energy sources. The plan also emphasizes the importance of equity, ensuring that climate policies benefit all Californians, particularly those in disadvantaged communities.

[2022 Scoping Plan – CARB](#)

- **AB 1236 – Electric Vehicle Charging Stations: Open Access Requirements**
 Assembly Bill 1236, enacted in 2015, requires all California cities and counties to develop an expedited, streamlined permitting process for electric vehicle charging stations (EVCS). The legislation aims to facilitate the rapid deployment of EVCS by removing administrative barriers, thereby supporting the state's goals for electric vehicle adoption and GHG emissions reduction. By standardizing and simplifying the permitting process, AB 1236 helps to ensure that the infrastructure needed for widespread EV adoption is in place, promoting cleaner transportation options for Californians.
[Cal. Gov. Code § 65850.7](#)
- **Executive Order N-79-20 – Zero-Emission Vehicle Mandate**
 Issued on September 23, 2020, by Governor Gavin Newsom, Executive Order N-79-20 sets ambitious targets to transition California's transportation sector to zero-emission vehicles (ZEVs). The order mandates that 100% of in-state sales of new passenger cars and trucks be zero-emission by 2035. Additionally, it sets goals for medium- and heavy-duty vehicles to be zero-emission by 2045 for all operations where feasible and by 2035 for drayage trucks. The executive order also aims for the transition to 100% zero-emission off-road vehicles and equipment by 2035 where feasible. This directive is part of California's broader strategy to reduce GHG emissions, improve air quality, and combat climate change.
[Executive Order N-79-20](#)
- **SB 100 – The 100 Percent Clean Energy Act of 2018**
 Senate Bill 100, enacted in 2018, accelerates and expands California's commitment to clean energy. The bill advances the state's Renewables Portfolio Standard, requiring that 50% of California's electricity come from renewable resources by 2025 and 60% by 2030. Furthermore, SB 100 sets a groundbreaking policy that mandates 100% of the state's electricity to be sourced from renewable or zero-carbon sources by 2045. This ambitious goal positions California at the forefront of the transition to clean energy, aiming to reduce reliance on fossil fuels, decrease GHG emissions, and promote technological innovation in the energy sector.
[Cal. Public Utilities Code § 399.11 et seq.](#)
- **Long-Term Energy Storage Projections**
 California's 2021 SB 100 Joint Agency Report outlines the state's strategy to achieve 100% clean electricity by 2045. The report emphasizes the necessity of substantial investments in energy storage to ensure grid reliability and effective integration of renewable energy sources. While specific megawatt targets for energy storage are not detailed in the report, it emphasizes the importance of developing and deploying a diverse portfolio of storage technologies. These technologies include battery storage, long-duration storage solutions, and other emerging storage methods. The report also highlights the need for sustained record-setting build rates of renewable resources and integration solutions, such as storage, to meet the 2045 clean electricity goals.
[California Energy Commission SB 100 Joint Agency Report \(CEC, CPUC, CARB, 2021\)](#)
- **SB 32 – California Global Warming Solutions Act of 2006: Emissions Limit**
 Enacted in 2016, Senate Bill 32 builds upon the original California Global Warming Solutions Act of 2006 (AB 32). While AB 32 required California to reduce its greenhouse gas (GHG) emissions to 1990 levels by 2020—a reduction of approximately 15% below emissions expected under a "business as usual" scenario—SB 32 sets a more ambitious target. It mandates a 40% reduction in GHG emissions below 1990 levels by 2030. This legislation provides a framework for statewide emission reductions across all sectors,

including transportation, industry, and buildings. The California Air Resources Board (CARB) is tasked with implementing measures to achieve these targets, ensuring that California continues its leadership in addressing climate change.

[Cal. Health & Safety Code § 38566](#)

- **SB 350 – Clean Energy and Pollution Reduction Act of 2015**

The Clean Energy and Pollution Reduction Act, known as Senate Bill 350, was enacted in 2015 to advance California's clean energy and climate goals. The legislation establishes targets to reduce GHG emissions to 40% below 1990 levels by 2030 and 80% below 1990 levels by 2050. It also aims to increase the state's renewable electricity procurement to 50% by 2030. Additionally, SB 350 emphasizes the importance of energy efficiency, requiring a doubling of energy efficiency savings in electricity and natural gas end uses by 2030. The bill also includes provisions to promote transportation electrification and improve air quality, particularly in disadvantaged communities.

[Cal. Public Utilities Code §§ 25310–25327](#)

- **SB 48 – Building Energy Savings Act of 2023**

Senate Bill 48, enacted in 2023, requires the California Energy Commission (CEC), in consultation with the State Air Resources Board, Public Utilities Commission, and the Department of Housing and Community Development, to develop a strategy for using benchmarking data to track and manage the energy usage and GHG emissions of covered buildings. The goal is to achieve the state's energy savings and emissions reduction targets. The strategy is to be submitted to the legislature by August 1, 2026. This initiative aims to enhance transparency and accountability in building energy performance, facilitating informed policy decisions and promoting energy efficiency improvements in the building sector.

[SB 48 Bill Text](#)

- **SB 49 – Appliance Standards for Flexible Demand Technologies**

Senate Bill 49, enacted in 2019, authorizes the California Energy Commission (CEC) to adopt standards for appliances to facilitate the deployment of flexible demand technologies. These standards aim to reduce GHG emissions by enabling appliances to schedule, shift, or curtail operations with consumer consent, thereby enhancing load flexibility and supporting grid reliability. The legislation requires that these standards be both feasible and cost-effective, ensuring that they provide tangible benefits to consumers and the energy system.

[SB 49 Bill Text](#)

APPENDIX D: KEY RULEMAKING SCHEDULES

Category	Proceeding	Key Influence Period
California Energy Code (Title 24, Part 6)	2028 Code Cycle	~Jan 2024 to early 2026
	2031 Code Cycle	~Jan 2027 to early 2029
	2034 Code Cycle	~Jan 2030 to early 2032
CALGreen	2028 CALGreen	~Sep 2026 to Mar 2027

(Title 24, Part 11)	2031 CALGreen	~Sep 2029 to Mar 2030
	2034 CalGreen	~Sep 2032 to Mar 2033
California Appliance Standards (Title 20)	Variable - No regular update schedule or mandate	Pre-OIR (determined through frequent contact with CEC staff) to inform appliance selection, in response to the RFI, and in submitting the CASE Report in response to the RFP
DOE Test Procedures	Variable - DOE must review and update each test procedure every 7 years	During industry standard updates (timing variable) to inform negotiation. If unable to change the industry standard, then as early as possible to DOE, targeting ~1 year before DOE issues a NOPR (which takes place ~1 or 1.5 years before the final rule is due)
DOE Appliance Standards	Variable - DOE must review each standard and publish a NOPR or determination every six years, with a final rule two years later	~1-2 years before a NOPR is due, or in response to an RFI or the preliminary Technical Support Document (if published)
National Model Codes	ASHRAE 90.1 - 2028	~Early 2024 to Late 2025
	ASHRAE 90.1 - 2031	~Early 2027 to Late 2028
	2027 IECC	~Early 2024 to early 2025 for negotiations that result in code change proposals
	2030 IECC	~Early 2027 to early 2028

APPENDIX E: EXISTING CODE READINESS PROJECT STATUS

This section provides an overview of the Code Readiness Subprogram's projects across key sectors. Table 3 and Table 4 outline the regulatory objectives that should be fully addressed by the research activities in ongoing Code Readiness research projects for building codes and appliance standards. Table 5 outlines all current Code Readiness projects within each sector, detailing their current development stage, categorizing projects as either long-term (noted by an L) or short-term (noted by an S), and indicating their status at the time of this Roadmap including the planned finish date for the entire project. 2050 Partners maintains an online tracker of Code Readiness projects that is routinely updated and available to view [at this link](#). Detailed project summaries can be found in the [2024 Code Readiness Annual Report](#). Projects in the pre-scoping phase are listed as informational only and are provided in Table 6.

Table 3. Regulatory Objectives Fully Addressed by Ongoing Code Readiness Research: Building Codes

Project Sector	RO	Regulatory Vehicle	Ongoing CR Project
Residential	Implement prescriptive and mandatory requirements, acceptance testing, and installation requirements for residential universal heat pumps	CEC (Title 24)	CVRH: Universal VCHP Outdoor Unit Heat Pump Retrofit Equipment Option
Non-Residential	Require multifamily and nonresidential circulator pumps to utilize internal or external controls to reduce energy use at the pump and/or water heater.	CEC (Title 24)	Circulator Pumps
	Enhance efficiency requirements for computer rooms / data centers	CEC (Title 24)	Data Center Energy Efficiency
	Require thermal energy storage for commercial chilled water (CHW) installations.	CEC (Title 24)	Thermal Energy Storage
Industrial, Agricultural, and Covered Processes	Develop HPWH sizing guidelines for commercial kitchens for use by CA health departments and CCDEH	CA Health Depts, CCDEH, CEC (Title 24)	CKHWS Performance Testing
	Establish a definition of industrial heat pump in Title 24, Part 6 code.	CEC (Title 24)	Industrial Heat Pumps
Crosscutting & Other	Enhance ACM and CBECC capabilities to support 2025 and 2028 code requirements, including updating heat recovery curves, improving HVAC modeling, simulating variable speed fans for VRF systems, and adding HRV/ERV bypass simulation capabilities.	CEC (CBECC)	Compliance Software Enhancement, Multifamily DHW Draw Study

Table 4. Regulatory Objectives Fully Addressed by Ongoing Code Readiness Research: Appliance Standards

Project Sector	RO	Regulatory Vehicle	Ongoing CR Project
Residential	Update energy efficiency rating metrics for VCHPs	ASHRAE	CVRH: VCHP EER2 Ratings and Heat Pump Retrofit Equipment Options

Project Sector	RO	Regulatory Vehicle	Ongoing CR Project
Non-Residential	Update blast chiller and blast freezer test procedure and establish a standard	DOE	Blast Chillers and Freezer Testing
Industrial, Agricultural, and Covered Processes	Expand DOE or Title 20 standards coverage to include oil-free air compressors and air compressors over 1250 CFM, update air compressor ISO TP to account for cycle efficiency	ISO, DOE (maybe CEC: Title 20)	Air Compressor and Air Dryer Testing
	Update draft IEC test procedure, enhance DOE stringency and coverage of ST products, including motor submersible pumps, and establish coverage of larger ST products (>459 ft of head)	IEC, DOE	Submersible Turbine (ST) Pump Testing
	Draft a new smart pump test procedure that takes variable frequency drive (VFD) pumps, controls, and dynamic operation modes into account and expand DOE coverage of smart pumps as feasible	ANSI, HI, DOE	Smart Pumps Testing
	Update AHRI industrial heat pump test procedures with test conditions that are representative of typical industrial process loads	AHRI	Industrial Heat Pumps

Table 5. Status of Ongoing Code Readiness Subprogram Projects

Project Sector	Project (L)ong-term, (S)hort-term, *=new 2024	Status/Notes
Crosscutting	<i>California Energy Design Assistance (CEDA) Program</i> (L)	Site selection and recruitment. Part of Task 6 (New Construction) work.
	<i>Circulator Pumps with Controls</i> (S)*	Supports a 2028 Title 24 proposal. Data collection is in progress.
	<i>Central Heat Pump Water Heater (CHPWH) with minimal Energy Resistance</i> (S)*	Supports a 2028 Title 24 proposal. Field demonstrations are in progress.
	<i>Compliance Software Enhancement</i> (L)*	Scoping in progress.
	<i>Industry Standards</i> (Multiple Efforts, S)	Testing VAV boxes and controllers based on ASHRAE Standard 195. Led by Taylor Engineering.
		Conducting stakeholder engagement on ventilation and indoor air quality with the ASHRAE

Project Sector	Project (L)ong-term, (S)hort-term, *=new 2024	Status/Notes
		62.2 committee. Led by TRC Engineers.
		Participating in committees to update the National Model Energy Code. Hosted by Energy Solutions. Supporting a 2028 Title 24 proposal. Final reporting in progress.
	<i>Smart Pumps (L)</i>	Testing of smart pumps and baseline is underway.
Industrial, Agricultural, and Covered Processes	<i>Air Compressor Testing (L)*</i>	Market assessment in progress.
	<i>Industrial Heat Pumps Case Studies (L)</i>	Case studies, economic analysis, and test procedure development
	<i>Steam Traps (L)</i>	Final reporting in progress.
	<i>Submersible Turbine Pump Testing (L)*</i>	Market assessment in progress.
Nonresidential	<i>Blast Chillers and Freezers (L)*</i>	Test plan development, equipment selection, and purchase in progress.
	<i>Commercial Space Heating Electrification: Product Capabilities (L)</i>	Field site outreach and recruitment.
	<i>Existing Buildings Electrification Baseline (S)*</i>	Coordination and gathering of ESH data.
	<i>Heat Pump Water Heater (HPWH) Defrost (L)*</i>	Preliminary test plans are under revision.
	<i>Thermal Energy Storage (L)*</i>	Identifying, recruiting, and collecting data from commercial buildings.
	<i>Thermal Load Management (L)</i>	Project reporting.
Non-Residential Covered Process	<i>Commercial Kitchen Hot Water Systems (CKHWS) Lab Testing at ATS (L)*</i>	Lab setup complete; testing underway.
	<i>Data Center Energy Efficiency (L)*</i>	SME interview preparation and memo development.
Residential	<i>Central Valley Research Homes (L)</i>	Research projects in progress.
	<i>Energy Smart Homes Data Mining (L)</i>	Data collection is in progress. Part of Task 6 (New Construction) work.
	<i>Multifamily Domestic Hot Water (DHW) Draw Study (L)</i>	Field data collection is in progress.

Table 6. Summary of Code Readiness Subprogram Projects in Pre-Scoping Phase⁶ During 2025

Project Sector	Project
Non-Residential	<i>Whole Building Integrated Control Systems (L)</i>
Industrial, Agricultural, and Covered Processes	<i>Industrial Refrigeration (L)</i>
	<i>Winery Building Codes (L)</i>
Transportation & Demand Flexibility	<i>EV-to-Grid (EV2G) (L)</i>
	<i>Idling Reduction (L)</i>

⁶ Topics in the pre-scoping phase are subject to review and are not guaranteed for Code Readiness project development.