Single Family Grid Integration

2022-SF-GRID-INT-F | Grid Integration | October 2020 FINAL CASE REPORT

Prepared by Frontier Energy, Energy Solutions, and Larson Energy Research

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Executive Summary

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Introduction

The Codes and Standards Enhancement (CASE) Initiative presents recommendations to support the California Energy Commission's (Energy Commission) efforts to update the California Energy Code (Title 24, Part 6) to include new requirements or to upgrade existing requirements for various technologies. Three California Investor Owned Utilities (IOUs) – Pacific Gas and Electric Company, San Diego Gas and Electric, and Southern California Edison– and two Publicly Owned Utilities – Los Angeles Department of Water and Power and Sacramento Municipal Utility District (herein referred to as the Statewide CASE Team when including the CASE Author) – sponsored this effort. The program goal is to prepare and submit proposals that will result in cost-effective enhancements to improve energy efficiency and energy performance in California buildings. This report and the code change proposals presented herein are a part of the effort to develop technical and cost-effectiveness information for proposed requirements on building energy-efficient design practices and technologies.

The Statewide CASE Team submits code change proposals to the Energy Commission, the state agency that has authority to adopt revisions to Title 24, Part 6. The Energy Commission will evaluate proposals submitted by the Statewide CASE Team and other stakeholders. The Energy Commission may revise or reject proposals. See the Energy Commission's 2022 Title 24 website for information about the rulemaking schedule and how to participate in the process: https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2022-building-energy-efficiency.

The overall goal of this CASE Report is to present a code change proposal for single family residential grid integration measures. The report contains pertinent information supporting the code change.

Measure Description

Background Information

Demand flexibility measures are increasingly important for California as a means to integrate buildings with a changing electrical grid. Increasing photovoltaic (PV) supply, both distributed and utility-scale, and wind generation coupled with building demand patterns on the grid has created challenges during late afternoon and early evening hours during certain times of the year. Additionally, the ever-growing penetration of renewable generation has contributed to increasing curtailment of renewables during the middle of the day, when photovoltaic output is highest. Consequently, technologies that effectively shift load to periods when renewable output is available tend to contribute to increased grid resilience and reduce the amount of renewables that need to be curtailed, which is an increasingly growing issue in California.

The grid integration measure is a cross-cutting measure with relevance for single family, multifamily, and nonresidential market sectors. This report focuses on single family applications but includes some discussion of how the measures might be affected when applied to other market sectors. Single family targeted applications include batteries, heat pump water heater (HPWH) load shifting, heating, ventilation, and air conditioning (HVAC) load shifting, and home energy management systems (HEMS). These proposed submeasures were all developed as compliance options for the residential sector. Compliance options differ from mandatory or prescriptive requirements in that they represent an alternative approach for achieving compliance with the Title 24, Part 6 energy standards as a means to increase compliance flexibility. These submeasures would impact the Total Energy Design Rating (EDR) which would provide credits for reducing photovoltaic system sizing but would not be available for tradeoff against building energy efficiency measures.

For clarity, changes to code language for each submeasure are presented in isolation, not in combination with other submeasures.

Battery Storage Systems

Battery storage systems provide benefit to the utility grid by serving the primary functions of daily charge and discharge cycling for the purpose of load shifting, maximizing solar self-utilization, and grid harmonization. The ability of a battery storage system to provide backup power for grid or weather-related emergencies has become an increasingly important driver for market growth. This proposed submeasure would modify the battery storage system compliance option that exists under 2019 Title 24, Part 6 to allow for a standalone storage compliance option, to ensure that battery control systems contribute value to owners and the utility grid, and to improve the enforcement and verification of battery storage system requirements.

HPWH Load Shifting

Load shifting HPWHs (LSHPWHs) are designed to operate in response to signals from utilities or third-party aggregators to control operation of the HPWH while still providing consistent and reliable hot water to the occupants. The water heater may “load up” – use electricity at a time advantageous to the grid (such as during a midday solar peak) – to store extra energy in the water tank prior to the start of utility peak periods to allow the tank to satisfy subsequent peak period hot water loads without requiring any additional operation. This ability to “load up” around solar noon becomes increasingly useful as California PV resources continue to grow.

The 2022 LSHPWH proposal provides compliance credit opportunities for the following strategies: mid-day biased operation in response to a programmed time of use (TOU) utility schedule loaded on the HPWH, oversized tank storage volumes, and higher tank setpoints. All these load shifting strategies have value in minimizing the curtailment of excess renewables on the electric grid year-round, which is becoming an increasing issue as more renewables enter the California grid.

The Statewide CASE Team has been involved in activities supporting the LSHPWH concept including modeling studies (Delforge and Larson 2018) and laboratory testing (Grant and Huestis 2018).

HVAC Load Shifting

Pre-cooling is an HVAC load shifting strategy in which the building is intentionally over-cooled early in the day when electricity rates are low. The thermal mass of the building is cooled down during these off-peak periods, and serves to gradually slow down warming of the space later during the on-peak period, minimizing or avoiding the need for cooling during the higher-cost peak periods. Since air-conditioning is the biggest contributor to peak energy use in most homes, moving it away from the peak period dramatically reduces peak kW, energy used during the peak period, and Time Dependent Valuation (TDV), which is the cost metric used by the state of California to evaluate the cost effectiveness of Title 24, Part 6 code change proposals. However, pre-cooling would almost always involve an increase in site energy consumption. Optimization of pre-cooling, then, would require finding an acceptable balance between reduction of TDV, kWh penalties, and the overall impact on utility bills. During the 2019 code change cycle, pre-cooling was introduced as a compliance option eligible for a Demand Flexibility credit. It requires the installation of an Occupant Controlled Smart Thermostat (OCST, as described in Joint Appendix 5 (JA5)). The modeled impact credit is de-rated by 70 percent, because its reliability is so heavily determined by occupant behavior.

Home Energy Management

Home Energy Management Systems (HEMS) are a subcategory of home automation that provides homeowners with the ability to control energy consuming devices through programmed schedules, control logic based on occupancy sensors or other measurements, machine learning, utility signals, and/or remote access through smartphones. Home automation technologies, including those with HEMS capabilities, have become much more commonplace in recent years, providing services ranging from energy management to home security, entertainment, and convenience. Voice recognition technology has made interacting with such systems accessible and fun for homeowners at all levels of technical sophistication. A HEMS may either be a master system that controls and monitors all end uses, or a system that controls appliances, lighting, and/or plug loads. HEMS can reduce TDV through either direct energy use reduction (e.g. turning off lights and TVs in unoccupied rooms), or through load shifting (e.g. suspending operation of clothes dryers during high demand periods). Energy and peak demand savings can also be achieved by providing information and recommendations to occupants, allowing them to modify their behavior in an informed manner. Home energy management is a quickly expanding market that is likely to have a large impact on energy use in homes, particularly in end-uses such as plug loads and lighting, where there are few if any opportunities to receive credit for energy savings in Title 24, Part 6.

Proposed Code Change

Battery Storage Systems

The main code change proposals include the inclusion of standalone storage, battery control strategy updates and software enhancements. Adding a standalone storage compliance option would expand the compliance credit to non-solar PV paired battery systems and would adapt battery control strategies for standalone storage operation. The "Time of Use" (TOU) operational control strategy would be updated to more closely align with utility TOU periods and to minimize TDV costs (Pacific Gas and Electric 2020, San Diego Gas and Electric 2020, Southern California Edison 2020). To improve the battery control strategy compliance verification process, thorough definitions of each control strategy would be added to the battery compliance form. A Round Trip Efficiency (RTE) user input option would be added in the CBECC-Res compliance software to more easily define performance. CBECC-Res would enforce the JA12 minimum RTE requirement by not providing a compliance credit for non-JA12 compliant battery storage systems. A new safety standard would be referenced to align with updated industry safety standards, and interconnection and enforcement sections in JA12 would be updated with clarifying language. Battery ready buildings would be added as an alternative compliance pathway to minimum solar zone area requirements. These proposed changes would apply to the battery storage system compliance option, and affect new construction, additions, and alterations in the single family residential sector.

HPWH Load Shifting

In July of 2020, the Energy Commission approved a compliance credit for LSHPWHs by adopting Joint Appendix JA13 (Qualification Requirements for Heat Pump Water Heater Demand Management Systems). The Energy Commission had previously opened a docket for JA13 in October 2019 and in June 2020 uploaded a final draft version of JA13 (California Energy Commission 2020b) for approval. The proposed 2022 LSHPWH submeasure is planning to expand the magnitude of the recently adopted compliance credit by recognizing increased benefits associated with a Load Up strategy whereby additional energy is stored in the HPWH tank in advance of the utility peak period. This new approach is being called the Basic Plus Load Up strategy. To maximize compliance flexibility, three configurations of the Basic Plus measure are proposed: Basic Plus-1 would involve onboard control logic to control tank overheating during favorable time of use operating periods, Basic Plus-2 would credit larger volume HPWHs due to increased thermal storage capacity, and Basic Plus-3 would recognize the benefit of HPWHs with storage tank temperatures maintained at least 10°F above the default water heater set point temperature.

This submeasure would remain a compliance option and would apply to residential scale HPWHs installed in single and multifamily buildings, with applicability in new buildings, additions and alterations.

HVAC Load Shifting

The pre-cooling measure would modify the compliance option that gives Demand Flexibility credit for installation and proper programming of a Pre-Cooling Thermostat (PCT). It would be offered for newly constructed single family residential buildings only in Climate Zones 9-15. No updates to software are proposed, other than changing the setpoint assumptions for calculating the credit. The proposed measure is simpler and can be implemented with a non-communicating thermostat, programmed to optimize operation to minimize costs under a TOU rate schedule, by defining a pre-cooling schedule and a “no-cooling” schedule.

Home Energy Management

This submeasure clarifies the current exception to the solar zone credit when a HEMS is installed in combination with a smart thermostat, by defining specific qualifying criteria that must be met. This change revises an alternative to the mandatory requirement for minimum solar zone area defined in Section 110.10(b)1A. Exception 6 currently allows home automation systems to qualify if they include demand response capabilities and the ability to control lighting and appliances. However, the specific functions that constitute these capabilities are not defined with enough specificity to estimate energy and peak load savings, or to verify that the desired capabilities are present in specific applications. In addition, the term “home automation systems” is a general term that can apply to systems that primarily provide convenience or home security functions. The proposed change would replace “home automation” with “home energy management”, which is the more common term of art used in the industry for systems that provide energy savings capabilities, and would require compliance with ENERGY STAR® SHEMS eligibility criteria and compatibility with other demand response technologies qualified under Title 24, Part 6. This submeasure would apply only to new construction, and to both single family and multifamily residential buildings.

Scope of Code Change Proposal

Table 1 summarizes the scope of the proposed changes and which sections of standards, Reference Appendices, Alternative Calculation Method (ACM) Reference Manual, and compliance documents that would be modified as a result of the proposed change(s).

Table 1: Scope of Code Change Proposal

Measure Name	Type of Requirement	Modified Section(s) of Title 24, Part 6	Modified Title 24, Part 6 Appendices	Would Compliance Software Be Modified	Modified Compliance Document(s)
Battery Storage Systems	Compliance Option	Section 100.1(b), 110.10 Residential Compliance Manual Chapter 7.5	Joint Appendix 12	Yes Residential ACM Reference Manual Section 2.1.5 Appendix D	CEC-CF2R-PVB-02-E CEC-CF2R-SRA-01-E
HPWH Load Shifting	Compliance Option	No	Joint Appendix 1 and 13. New Reference Appendix RA3.6.11	None, outside of current Energy Commission plan for 2020 LSHPWH software development)	CF1R-PRF-01E, CF2R-PLB-22a-HERS, CF3R-PLB-22a-HERS, CF1R-NCB-01-E
HVAC Load Shifting	Compliance Option	Section 150.1	Joint Appendix 5 Residential Appendix 3.4	Yes Residential ACM Reference Manual	Modified CF1R, New CF2R and CF3R
Home Energy Management	Compliance Option	Section 110.10,110.12, 100.1(b). Residential Compliance Manual -Sections 4.5.1, 4.8.1, 7.6, 7.8, and Appendix H; Non-Res Compliance Manual Section 9.4 and Appendix D.	Joint Appendix JA5 – Technical Specification s for Occupant Controlled Smart Thermostat	No	CF2R-SRA-01-E CF2R-SRA-02-E

Market Analysis and Regulatory Assessment

Battery Storage Systems

Residential battery storage remains an emerging market but has shown continual rise in the latter half of the decade. A combination of declining battery costs, increased electric-vehicle (EV) penetration, the need for grid resiliency, and the emergence of TOU rate structures have accelerated the adoption of battery technologies in residential homes (Utility Dive 2018). In general, the proposed code changes in Title 24, Part 6 are meant to align with predicted technical performance in terms of round-trip efficiency and safety developments for the residential battery storage market and to facilitate the growth of new storage installations. Outside of Title 24, Part 6, battery storage system requirements are also listed in Title 24, Part 3, Title 24, Part 9, and industry codes and standards (National Electric Code (NEC), Underwriters Laboratories (UL)). However, these standards pertain to the electrical safety standards of battery storage systems and there is minimal overlap with Title 24, Part 6.

HPWH Load Shifting

The current U.S. HPWH market is dominated by A.O. Smith, Bradford White, and Rheem. These manufacturers have been actively participating in the development of the JA13 specification as well as participating in laboratory and field pilot projects. Each manufacturer has taken their own proprietary approach in developing control logic to determine how their units would respond to various control signals. Much of this will continue to evolve in the coming years as JA13 is adopted and other activities related to grid connected water heaters move forward. In terms of technical feasibility, there should not be any significant barriers for the industry to sell JA13 compliant HPWHs at a small incremental cost over standard HPWH products. Since the LSHPWH market sector is just now beginning to grow, it is challenging to predict how product availability and control capabilities will develop as the market matures. It is the expectation of the Statewide CASE Team that all the major manufacturers would participate in this technology area as it offers significant market share growth potential.

HVAC Load Shifting

As of 2015, California households had about 4.4 million programmable (or smart) thermostats in the residential building stock. From 2016-2019, smart thermostat adoption rate in the U.S. tripled from 4 to 12 percent (ACHR News 2019), and as of 2015, smart thermostats accounted for over 40 percent of the nearly 10 million thermostats sold in the U.S. (Park Associates 2015). Starting in 1995, ENERGY STAR began promoting programmable thermostats as a means of reducing space conditioning energy use. The analysis typically assumed that without programmable thermostats, users maintained a constant setpoint, and that with programmable thermostats, a regular setback program would be used. It has been found that neither of these assumptions is necessarily accurate (Meier 2011) (Meier, Aragon, et al. 2000). The projected savings were not materializing, and the ENERGY STAR programmable thermostat program was suspended in 2009. Smart thermostats are not without their troubles either, however. Outcault et al (2014) found that user experience with a smart thermostat was generally not favorable. Six out of the ten users surveyed were "mostly unsure" that the smart thermostat did what they wanted it to do, and four reported being "completely unsure."

With most California residential customers being moved to TOU rates in the coming year (many not voluntarily), and the sensitivity and anxiety that that can cause, customers may be eagerly looking for a solution to control costs with the new TOU rates under which they would be operating their dwellings. They may also be looking for a simple and transparent solution that would not either overwhelm them with complexity or take their control away. This is why the Statewide CASE Team is recommending providing credit for installation of PCTs (based on programmable thermostats) in addition to DMTs.

Home Energy Management

There are currently hundreds of home energy management products on the market with varying levels of capability and compatibility (Ford, et al. 2017). Many are information-based products that rely on occupant behavior to achieve savings in response to knowledge about their energy use, while others are controls-based and tend to save energy more predictably because occupants do not have to intervene. There is no reason to expect the trend toward smarter homes with increasing levels of energy management services to abate in the coming years, and it is therefore important for energy codes to begin grappling with the impacts of HEMS products on energy use. A successful approach would lead to greater deployment of HEMS services and devices that provide positive impacts on grid resilience through effective energy management.

Cost Effectiveness

All four submeasures presented here are compliance options. As compliance options, cost effectiveness is not required. The Statewide CASE Team provided limited information on measure costs where available but did not complete detailed cost studies. See Section 5 for the methodology, assumptions, and results of the cost-effectiveness analysis.

Statewide Energy Impacts: Energy, Water, and Greenhouse Gas (GHG) Emissions Impacts

As compliance options, the four submeasures would not increase the stringency of the standards. As such, any savings attributed to the measures would likely be traded off by relaxing other measures resulting in no statewide energy impacts. These submeasures all serve to enhance grid harmonization by increasing demands from the electric grid during periods when renewable generation resources are most available and reducing demand during peak utility demand periods. Grid harmonization is an increasingly important concept as California's electric grid becomes more and more dependent on renewable generation sources.

Water and Water Quality Impacts

The proposed measure is not expected to have any impacts on water use or water quality, excluding impacts that occur at power plants.

Compliance and Enforcement

Overview of Compliance Process

The Statewide CASE Team worked with stakeholders to develop a recommended compliance and enforcement process and to identify the impacts this process would have on various market actors. The compliance process is described in Sections 2.1.5, 2.2.5, 2.3.5, and 2.4.5. Impacts that the proposed submeasure would have on market actors is described in Sections 3.1.3, 3.2.3, 3.3.3, 3.4.3 and Appendix E. The key issues related to compliance and enforcement are summarized below:

- Initial and ongoing verification of an eligible battery storage control system as specified in JA12, that delivers grid harmonization benefits.
- Verification that the specified HPWH is on the Energy Commission's list of JA13 certified products and, when relevant, meets a minimum first hour rating criteria for tank sizing.
- The installed HPWH must either be field configured with applicable TOU electric rates or field verified that pre-installed TOU rates are correct.
- The designer would have to investigate available PCTs and ensure that they are qualified.
- The allowed values of the Critical Field-Adjusted Parameters (CFAPs) for PCTs must be verified by the HERS Rater.
- Coordination would be needed between the mechanical system designer or installer and HEMS designer to make sure the HEMS can communicate with

the smart thermostat, two light fixtures, and other demand-responsive devices that may be present.

- The designer must specify a HEMS product that has been certified by the Energy Commission and ensure that connected devices are compatible with the HEMS.

Field Verification and Diagnostic Testing

The battery storage system submeasure does not require HERS field verification and diagnostic testing. Verification is completed during the inspection phase, in which a building inspector would verify that the information in the Certificate of Installation (CF2R) matches the battery storage system specifications found in the Certificate of Compliance (CF1R).

Load shifting HPWHs, smart thermostats, and HEMS components must be properly commissioned to ensure that the systems are operating consistent with the design specifications. No additional field tests are required.

1. Introduction

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The Codes and Standards Enhancement (CASE) initiative presents recommendations to support the California Energy Commission's (Energy Commission) efforts to update the California Energy Code (Title 24, Part 6) to include new requirements or to upgrade existing requirements for various technologies. Three California Investor Owned Utilities (IOUs) – Pacific Gas and Electric Company, San Diego Gas and Electric, and Southern California Edison– and two Publicly Owned Utilities – Los Angeles Department of Water and Power and Sacramento Municipal Utility District (herein referred to as the Statewide CASE Team when including the CASE Author) – sponsored this effort. The program goal is to prepare and submit proposals that will result in cost-effective enhancements to improve energy efficiency and energy performance in California buildings. This report and the code change proposal presented herein are a part of the effort to develop technical and cost-effectiveness information for proposed requirements on building energy-efficient design practices and technologies.

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The overall goal of this CASE Report is to present a code change proposal for single family residential grid integration measures. The report contains pertinent information supporting the code change.

When developing the code change proposal and associated technical information presented in this report, the Statewide CASE Team worked with a number of industry stakeholders including building officials, manufacturers, builders, utility incentive program managers, Title 24, Part 6 energy analysts, researchers, industry associations and others involved in the code compliance process. The proposal incorporates feedback received during public stakeholder workshops that the Statewide CASE Team held on September 10, 2019, and March 12, 2020. Meeting notes from those workshops are available online (California Statewide Utility Codes and Standards Team 2019a).

The following is a brief summary of the contents of this report:

- Section 2 – Measure Description provides a description of the measure and its background. This section also presents a detailed description of how this code change is accomplished in the various sections and documents that make up the Title 24, Part 6 Standards.

- Section 3 – In addition to the Market Analysis, this section includes a review of the current market structure. This section also describes the feasibility issues associated with the code change, including whether the proposed measure overlaps or conflicts with other portions of the building standards, such as fire, seismic, and other safety standards, and whether technical, compliance, or enforceability challenges exist.
- Section 4 – Energy Savings presents the per-unit energy, demand reduction, and energy cost savings associated with the proposed code change. This section also describes the methodology that the Statewide CASE Team used to estimate per-unit energy, demand reduction, and energy cost savings.
- Section 5 – This section includes a discussion and presents analysis of the materials and labor required to implement the measure and a quantification of the incremental cost. It also includes estimates of incremental maintenance costs, i.e., equipment lifetime and various periodic costs associated with replacement and maintenance during the period of analysis.
- Section 6 – First-Year Statewide Impacts presents the statewide energy savings and environmental impacts of the proposed code change for the first year after the 2022 code takes effect. This includes the amount of energy that would be saved by California building owners and tenants and impacts (increases or reductions) on material with emphasis placed on any materials that are considered toxic by the state of California. Statewide water consumption impacts are also reported in this section.
- Section 7 – Proposed Revisions to Code Language concludes the report with specific recommendations with ~~strikeout~~ (deletions) and <u>underlined</u> (additions) language for the Standards, Reference Appendices, Alternative Calculation Manual (ACM) Reference Manual, Compliance Manual, and compliance documents.
- Section 8 – Bibliography presents the resources that the Statewide CASE Team used when developing this report.
- Appendix A: Statewide Savings Methodology presents the methodology and assumptions used to calculate statewide energy impacts.
- Appendix B: Embedded Electricity in Water Methodology presents the methodology and assumptions used to calculate the electricity embedded in water use (e.g., electricity used to draw, move, or treat water) and the energy savings resulting from reduced water use.

- Appendix C: Environmental Impacts Methodology presents the methodologies and assumptions used to calculate impacts on GHG emissions and water use and quality.
- Appendix D: California Building Energy Code Compliance (CBECC) Software Specification presents relevant proposed changes to the compliance software (if any).
- Appendix E: Impacts of Compliance Process on Market Actors presents how the recommended compliance process could impact identified market actors.
- Appendix F: Summary of Stakeholder Engagement documents the efforts made to engage and collaborate with market actors and experts.
- Appendix G: Parametric Analysis of Pre-Cooling presents CBECC-Res simulation results for the pre-cooling strategy.
- Appendix H: Nominal Savings Tables presents the energy cost savings in nominal dollars by building type and climate zone.

2. Measure Description

The focus for the 2022 Title 24, Part 6 residential grid integration compliance option measure was to evaluate assumptions and performance of residential load shifting technologies to reduce grid impacts during peak demand periods. Demand flexibility measures are increasingly important for California as a means to integrate buildings with a changing electrical grid where increasing photovoltaic (PV) (both distributed and utility-scale) and wind generation coupled with building demand on the grid creates challenges during late afternoon and early evening, as shown in Figure 1. Technologies that effectively shift load to periods where renewable output is available tend to contribute to increased grid resilience.

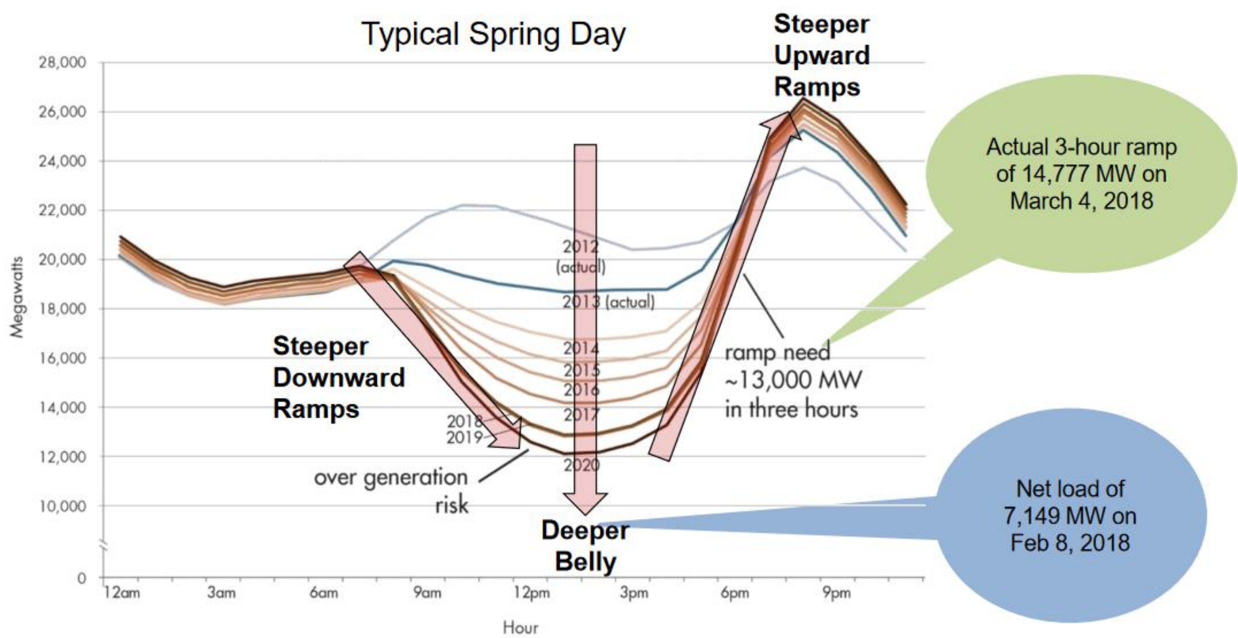

Figure 1: Statewide electricity demand on a typical spring day.

Source: (CAISO 2019)

The grid integration measure is a cross-cutting measure with relevance for single family, multifamily, and nonresidential market sectors. This report focuses on single family applications, but includes some discussion of how the submeasures might be affected when applied to other market sectors. The four submeasures are:

- Battery storage systems
- Load shifting heat pump water heaters (LSHPWHs)
- HVAC load shifting
- Home energy management systems (HEMS)

The proposed submeasures were all developed as compliance options for the residential sector. For clarity, changes to code language for each submeasure are presented in isolation, not in combination with other submeasures.

For the battery storage system and HVAC load shifting submeasures, the Statewide CASE Team evaluated the 2019 implementations to determine if the existing implementation is adequate and if the eligibility criteria or modeling should be modified. These are new technology areas for the Title 24, Part 6 Standards to recognize, and changes in the marketplace and new research information contributed to the proposed changes for 2022. Since HPWH load shifting and HEMS have not yet been formally implemented in Title 24, Part 6, the Statewide CASE Team evaluated past and ongoing research activities to determine if these submeasures are viable for 2022 implementation. These activities included review of prior load shifting HPWH modeling work to inform the 2022 effort and review of the JA13 document, along with a literature review of HEMS studies describing market barriers, technology developments, and field test results. Further details about the research performed for each submeasure are provided in upcoming sections of this report.

2.1 Battery Storage Systems

2.1.1 Measure Overview

This proposed measure would modify the battery storage system compliance option that exists under 2019 Title 24 Part 6 to allow for a standalone storage compliance option, to ensure that battery control systems contribute value to owners and the utility grid, to streamline the enforcement and verification of battery storage system requirements, and to align software modeling with efficiency requirements. In addition, a new exception to the solar zone area requirement would be added for when battery ready building criteria are met. The measure is intended to apply to new single-family residential buildings with battery storage systems. Current code requirements for battery storage systems are listed in the Reference Appendices, Joint Appendix 12 (JA12). Compliance qualifications include safety, performance, battery controls, interconnection, and enforcement requirements. The battery storage system measure is modeled in the CBECC-Res compliance software, with the modeling methodology defined in the Residential ACM Reference Manual. Battery storage systems are eligible for a Demand Flexibility credit (only credited towards the Total Energy Design Rating (EDR) and not the Energy Efficiency EDR), unless the self-utilization option is selected within CBECC-Res, in which case a portion of the Demand Flexibility credit would be applied to the Energy Efficiency EDR. The Energy Design Rating is an alternate way to express the energy performance of a home using a scoring system where 100 represents the performance of a building meeting the envelope requirements of the 2006 International Energy Conservation Code (IECC). A score of zero or less represents the energy performance of a building that combines high levels of energy efficiency and/or renewable generation to "zero out" its TDV energy use.

Battery storage systems provide benefit to the utility grid by serving the primary functions of daily cycling for the purpose of load shifting, maximizing solar self-utilization, and grid harmonization. This is achieved in the 2019 version of the CBECC-Res compliance software through three battery control strategy options – "Basic Control", "Time of Use (TOU) Control", and "Advanced Demand Response (DR) Control". Under "Basic Control", the battery storage system implements these functions by charging the battery from the PV system when there is limited electrical load demand at the building and discharging when building load exceeds generation. Under "Time of Use" control, the battery storage system is controlled to discharge during specified time windows to better respond to peak demand periods when the cost of electricity is high. Under "Advanced DR Control", the battery storage system is controlled to hold charge until a predicted DR event enacted by the utility takes place. This is modeled through a fixed TDV price trigger, whereby the battery will hold charge if the maximum TDV for that day if forecasted to exceed a certain amount.

Although these three battery control strategy options are recommended to remain within the proposed 2022 version of CBECC-Res, updates are proposed to the "Time of Use" operational control to more closely align with utility TOU rate plans (Pacific Gas and Electric 2020, San Diego Gas and Electric 2020, Southern California Edison 2020). Updated methodologies for these controls strategies are documented in Appendix D and would be configured in the 2022 version of CBECC-Res. Additional guidance has also been added to the Battery Storage System Certificate of Installation, which would help facilitate the inspection and verification process of battery control strategies.

Performance requirements in JA12 would be updated with greater clarity around the round trip efficiency requirements by specifying that the round trip efficiency requirement is based on beginning of life battery. Any CBECC-Res models with battery storage systems having less than the minimum RTE as specified in JA12 would mimic a model designed without battery storage. An option would be added in CBECC-Res to allow users to enter in a single battery round trip efficiency in CBECC-Res, as an alternative to entering in both a charging and discharging efficiency.

Code language has also been updated to provide greater clarity on safety, interconnection and certification requirements in JA12.

A new exception to the solar zone area requirement would be added for when battery ready building criteria are met. Criteria would including battery ready zone and battery interconnection design requirements to facilitate the ease of battery storage system installations.

The standalone battery storage system compliance option would extend the battery storage system compliance credit to standalone storage systems. This would be a change from the 2019 Title 24, Part 6 code, which requires battery storage systems to be coupled with a PV system. To accommodate a standalone storage system, both the "Time of Use" and "Advanced DR Control" control strategies would be adapted for standalone storage operation to allow for grid charging versus solar PV charging.

2.1.2 Measure History

Single family battery storage systems describe the battery storage system installed within single family residential homes. Primary functions of the battery storage system include:

1. Daily cycling for the purpose of load shifting
2. Maximized solar self-utilization
3. Grid integration

The battery storage system implements these functions by charging the battery from a solar photovoltaic (PV) system when there is limited electrical load at the building and discharging when building load exceeds generation. Additional controls strategies allow the battery system to adjust discharge time windows to better respond to peak demand periods when the cost of electricity is high. Figure 2 below shows a battery storage system, consisting of a battery and battery inverter, integrated into a home's energy system.

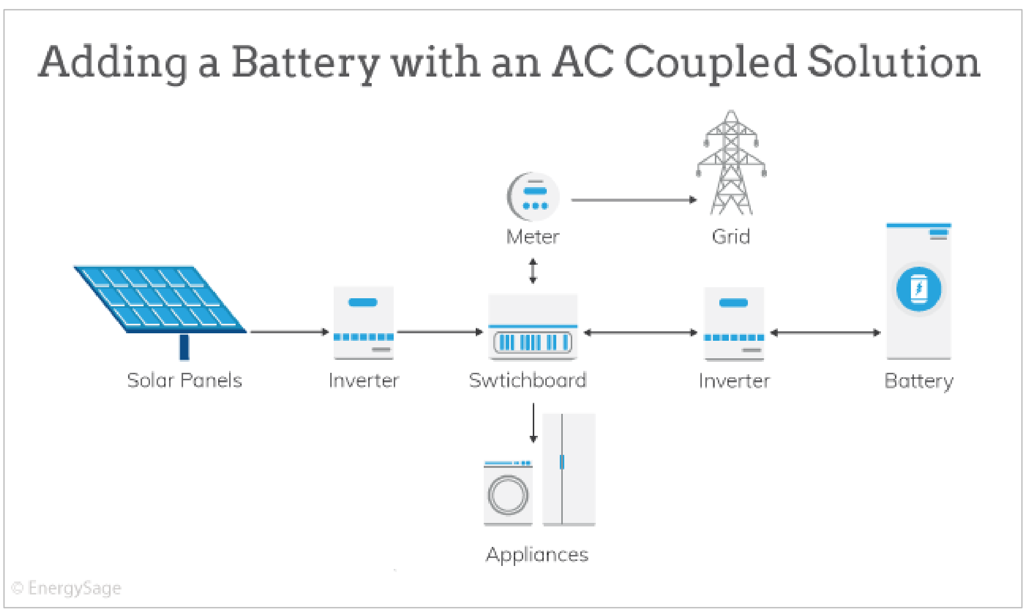

Figure 2: Battery storage system paired with solar PV.

Source: (Energy Sage 2019)

Title 24, Part 6 first included battery storage systems in the 2016 standards. Battery storage systems were offered as a compliance option in CBECC-Res and the modeling rules were documented in Section 3.5 of the 2016 Residential ACM Reference Manual. CBECC-Res provided an Energy Design Rating (EDR) credit for battery storage systems sized at 6 kWh or larger coupled with a PV array, allowing a project to downsize the PV system to reach a specific EDR target. Battery storage systems had two different control strategy options – a "Default Control" and an "Advanced/Utility or Aggregator-Controlled" strategy.

The 2019 standards added compliance requirements for battery storage systems through the creation of JA12 – Qualification Requirements for Battery Storage System. Safety requirements in JA12 referenced applicable Underwriters Laboratories (UL) standards for both battery storage systems and inverters used with battery storage systems. Minimum performance requirements were updated from 2016, with the minimum usable capacity decreasing from 6 kWh to 5 kWh. A minimum charge-discharge cycle AC to AC round trip efficiency of at least 80 percent was required and an energy capacity retention requirement was added.

The 2019 standards increased the number of control strategy options from two to three modes. The "Default Control" option was renamed as "Basic Control" and the "Advanced/Utility or Aggregator-Controlled" strategy was updated as the "Advanced DR" control strategy. A new "Time of Use" control strategy was added in anticipation of the TOU rates that California customers would be enrolled in. In alignment with utility requirements, new interconnection requirements were added with reference to Rule 21 and Net Energy Metering (NEM) rules as adopted by the California Public Utilities Commission (CPUC). A Certificate of Installation was also developed to enable a documented verification process for installed battery storage systems. The requirements in JA12 were also documented in the 2019 Residential Compliance Manual, Chapter 7.5.

With the updated and new battery storage system control strategies, the 2019 Residential ACM Reference Manual's section on battery storage systems, Appendix D – Status of Modeling Batteries for California Residential Code Compliance, was expanded to explain the modeling methodologies for the new control strategies. Battery modeling parameters that could be adjusted through the CBECC-Res user interface were listed, along with assumptions for hard coded battery storage system parameters.

New to 2019, a self-utilization credit was added to allow for tradeoff between the efficiency EDR and the effect of PV on the total EDR when the PV system is coupled with at least a 5 kWh battery storage system. The self-utilization credit could be used against building envelope and efficiencies of the equipment installed in the building and was provided as a checkbox option in CBECC-Res. The magnitude of the credit was equal to 90 percent of the difference between the 2019 and 2016 Standards prescriptive envelope improvements,[1] and climate zone specific credit percentages were listed in the 2019 Residential ACM Reference Manual, Sec. 2.1.5.

2.1.3 Summary of Proposed Changes to Code Documents

The sections below summarize how the standards, Reference Appendices, ACM Reference Manual, and compliance documents would be modified by the proposed change. See Section 7 of this report for detailed proposed revisions to code language.

2.1.3.1 Summary of Changes to the Standards

This proposal would modify the following sections of Title 24, Part 6 as shown below. See Section 7.1.2 of this report for marked-up code language.

SECTION 100.1 – DEFINITIONS AND RULES OF CONSTRUCTION

— **Section 100.1(b) – Definitions: Recommends new or revised definitions for the following terms:**

Revised definitions:

- BATTERY STORAGE SYSTEM is a rechargeable energy storage system consisting of a storage device and associated electrical equipment, including controls and inverters, designed to store and supply electrical power at a future time.

New definitions:

- BATTERY STORAGE SYSTEM READY INTERCONNECTION EQUIPMENT is equipment, e.g. a Battery Storage System ready panelboard, that can accommodate the connection of a distributed energy resource or an energy storage system and that includes provisions for either automatic or manual isolation from the utility power source.
- BATTERY STORAGE SYSTEM READY PANELBOARD is a panelboard that can accommodate either automatic or manual switching between a utility power source to a distributed energy resource or an energy storage system, such as a split bus panelboard.
- BATTERY STORAGE SYSTEM ZONE is an area on an interior or exterior wall designated and reserved for the installation of an energy storage system.

SECTION 110.10 MANDATORY REQUIREMENTS FOR SOLAR READY BUILDINGS

— **Section 110.10(b) Solar Zone:** A new exception to the solar zone area requirement would be added for when battery ready building criteria are met. Battery ready

[1] For High Performance Attics, High Performance Walls, Quality Insulation Installation, and High Performance Windows and Doors.

building criteria would include battery storage system zone and battery storage system interconnection design requirements.

2.1.3.2 Summary of Changes to the Reference Appendices

This proposal would modify the sections of the Reference Appendices identified below. See Section 7.1.3 of this report for the detailed proposed revisions to the text of the reference appendices.

— **JA12 – Qualification Requirements for Battery Storage System:** Clarity would be added to the certification and verification process by highlighting Certificate of Installation verification requirements and by updating the relevant section title to "Certificates and Enforcement Agency". The description of the "Time of Use" battery control strategy would be updated to more closely align with utility TOU rate plans, through year-round TOU operation. Standalone storage would be added as an allowable configuration use case and the "Time of Use" and "Advanced DR Response" control strategies would accommodate standalone storage.

2.1.3.3 Summary of Changes to the Residential ACM Reference Manual

This proposal would modify the following sections of the Residential ACM Reference Manual as shown below. See Section 7.1.4 of this report for the detailed proposed revisions to the text of the ACM Reference Manual.

— **2.1.5.4 - Battery Controls:** The proposed code change would update the description of "Time of Use Strategy" to more closely align with utility TOU rate design, which features year-round TOU peak periods. The "Time of Use" and "Advanced DR Response" control strategies would accommodate standalone storage.

— **Appendix D:** The proposed code change would update the description of "Time of Use Strategy" to more closely align with utility TOU design and the discharge hour for a few climate zones would be adjusted to optimize for TOU design and TDV savings. The battery simulation code would be updated accordingly to reflect the changes in battery storage utilization and operation. A new input, "Round Trip Efficiency", would be added as an alternative option to inputting both a "Charging Efficiency" and "Discharging Efficiency". For battery storage systems with round trip efficiencies less than what is specified in JA12, the model would mimic a system design that does not include battery storage. Advanced Control (old) would be removed as a battery control strategy option from CBECC-Res. The "Time of Use" and "Advanced DR Response" control strategies would be updated to accommodate standalone storage by charging during the four lowest TDV hours of the day. The self-utilization credit option would not apply to standalone battery storage systems.

The “Advanced DR Response” control strategy would be updated to allow for discharge for up to four hours of the day instead of for three hours.

2.1.3.4 Summary of Changes to the Residential Compliance Manual

The proposed code change would modify the following section of the Residential Compliance Manual: See Section 7.1.5 of this report for the detailed proposed revisions to the text of the Compliance Manuals.

— **7.5 – Battery Storage System:** The proposed code changes mirror the proposed changes for JA12 in Section 2.1.3.2, as this section refers directly to the requirements that are listed in JA12.

2.1.3.5 Summary of Changes to Compliance Documents

The proposed code change would modify the compliance documents listed below. Examples of the revised documents are presented in Section 7.1.6.

— **Battery Storage Systems Certificate of Installation, CEC-CF2R-PVB-02-E:** The proposed updates would provide additional guidance on the allowable battery control strategy options in the user instructions section to facilitate the control strategy verification process. The battery input field “Control” would be renamed to “Battery Control Strategy” for clarity. Three additional fields, “Charge Rate (kW)”, “Discharge Rate (kW)”, and “Round Trip Efficiency (%)” would be added to reflect new inputs in the 2022 CBECC-Res compliance software.

— **Solar Ready Buildings – New Construction, CEC-CF2R-SRA-01-E:** A new exception to the solar zone area requirement would be added for when battery ready building criteria are met.

2.1.4 Regulatory Context

2.1.4.1 Existing Requirements in Title 24, Part 6

The current code requirements for single family battery storage systems is captured in the 2019 Reference Appendices, JA12 and includes requirements on safety, performance, interconnection, and enforcement. Section 2.1.2 describes the existing requirements in further detail. Other areas of the code that reference battery storage system requirements include the 2019 Residential ACM Reference Manual, which documents the CBECC-Res modeling methodology, and the 2019 Residential Compliance Manual, which mirrors the requirements listed in JA12. There is a separate 2022 CASE Report addressing nonresidential grid integration measures, but there is no direct interaction between the proposed measures because this CASE Report is focused exclusively on single family battery storage and does not modify any of the requirements for Energy Management Control Systems (EMCS), which are computerized control systems designed to regulate the energy consumption of a building

2.1.4.2 Relationship to Requirements in Other Parts of the California Building Code

The California Electric Code, Title 24 Part 3, includes a section on energy storage systems in Article 706. The section contains energy storage standards, definitions, disconnects, and limitations. The section also outlines safety considerations when selecting locations for energy storage system installations and required power safety infrastructure. There is minimal overlap between the California Electric Code and the Title 24, Part 6.

The California Fire Code (CFC), Title 24 Part 9, Section 608 lists regulations based on battery storage system size (kWh) and type of batteries. CFC Section 608 also lists requirements for hazard mitigation analysis, installation location and construction, and suppression and detection systems. Both the CFC and Title 24, Part 6 reference UL standards UL9540 and UL1973. Aside from UL standards, there is minimal overlap between the CFC and Title 24, Part 6.

2.1.4.3 Relationship to Local, State, or Federal Laws

There are no existing local, state, or federal laws, mandates, or requirements identified for battery storage systems.

2.1.4.4 Relationship to Industry Standards

- The National Electric Code (NEC), Article 706 applies to all permanently installed energy storage systems and has been expanded to encompass other forms of energy storage including flow batteries, capacitors, flywheels, and compressed air systems. NEC 706 is adopted by the California Electric Code, Title 24 Part 3, for energy storage system electrical requirements and is not expected to overlap with the Title 24, Part 6.
- UL1973, Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power, and Light Electrical Rail (LER) Applications, evaluates the battery system's ability to safely withstand simulated abuse conditions and does not evaluate battery performance. UL 1973 is referenced in Title 24, Part 6, JA12.
- UL9540, Standard for Energy Storage Systems and Equipment, covers energy storage systems and contains requirements that address safety and installation. UL9540 is referenced in Title 24, Part 6, JA12.
- UL9540A, Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems, addresses battery energy storage system installation instructions, ventilation requirements, effectiveness of fire protection,

and fire service strategy and tactics. UL9540A allows for battery energy storage systems that exceed 250kWh, along with unit separation distances of less than three feet. UL9540A is referenced as a conditional requirement in UL9540.

- NFPA 855, Standard for Installation of Stationary Energy Storage Systems, provides the minimum requirements for mitigating the hazards associated with energy storage systems through comprehensive fire protection requirements. There is no expected overlap between NFPA 855 and Title 24, Part 6.

2.1.5 Compliance and Enforcement

When developing this proposal, the Statewide CASE Team considered methods to streamline the compliance and enforcement process and how negative impacts on market actors who are involved in the process could be mitigated or reduced. This section describes how to comply with the proposed code change. It also describes the compliance verification process. Appendix E presents how the proposed changes could impact various market actors.

The activities that would need to occur during each phase of the project are described below:

- **Design Phase:** During the design phase, an energy consultant would need to evaluate whether the addition of a battery storage system brings enough benefit to an end-user (or to the builder in terms of compliance credit) to warrant the cost of the system. For customers with PV-systems, the size and forecasted output of the PV system will be taken into consideration to determine how large the battery storage system should be sized. There is an array of battery models and sizes that consultants can recommend to the customer based on their sizing needs and price point. A list of Title 24, Part 6 certified battery and energy storage systems can be accessed through the California Energy Commission’s Solar Equipment Lists, although it is not required to select a device from the list (California Energy Commission 2020). Once the battery size has been selected, an energy modeling consultant would run a CBECC-Res model with the chosen battery design and performance parameters, and the chosen battery parameters (efficiency, size, control system, etc.) would be documented in the Battery Storage Systems Certificate of Compliance (CF1R-PVB).
- **Permit Application Phase:** To facilitate the permitting process for new battery storage systems, contractors or developers should prepare equipment specification sheets, a single line diagram, site/floor plan showing the location of the system, as well as any additional permit forms required by the local jurisdiction. Battery storage systems should follow current California Buildings

Codes and Standards and the design parameters that were specified in the Certificate of Compliance.

- **Construction Phase:** The battery storage system eligible contractor would install the system in-line with the site/floor plan that was developed during the permit application phase. Installation could take place either indoors or outdoors, typically located near to the main service panel. The contractor would need to verify that the installation location meets all relevant sections of the California Code and Standards, including Title 24, Part 6, the California Fire Code, and the California Electrical Code. The contractor would also need to set the battery storage system control strategy to the strategy listed on the CF1R . Once the installation has been completed the installer would need to verify performance data and the control system and fill out the Certificate of Installation (CF2R). The Certificate of Installation should be placed it in a visible area for the building inspector to review.
- **Inspection Phase:** Once the battery storage system has been installed, the local enforcement agency building inspector would verify that all applicable codes and standards have been met. With respect to Title 24, Part 6, the building inspector would verify that the information on the Certificate of Installation (CF2R), including the battery control system, efficiency, and size match what is on the Certificate of Compliance (CF1R).

The proposed code change would result in minor updates to the compliance process. For the Design Phase, energy consultants would need to ensure that the battery storage system meets the updated performance and safety requirements listed in JA12. For the Permit Application phase, no changes are expected to take place to the permit application process.

For the Construction Phase, battery storage system contractors would need to ensure that all updated safety standards in JA12 are being met. Contractors would also need to review the updated definitions for the battery storage system control strategies and document the strategy that most closely matches the installed system on the Certificate of Installation.

For the Inspection Phase, the building inspector would need to verify that the battery storage system meets the updated performance requirements in JA12. Additional guidance would be provided on the Certificate of Installation to support building inspectors with the verification process of the battery control strategy and performance requirements.

2.2 HPWH Load Shifting

2.2.1 Measure Overview

The July 2020 approved Appendix JA13 (entitled Qualification Requirements for Heat Pump Water Heater Demand Management Systems) provides a framework of the minimum capabilities of a load shifting HPWH. The Energy Commission recently posted a final JA13 to the HPWH Demand Management, in advance of the July 8, 2020 Business Meeting approval (California Energy Commission 2020b). The 2022 Residential LSHPWH proposal is intended to build on that work and offer both an additional path for more load shifting and increased reliability of HPWHs as a grid resource. Additionally, the Nonresidential Grid Integration team is proposing changes to JA13 as part of the Statewide CASE Team's work in that area (Jagger, et al. 2020).

LSHPWHs as defined in the adopted JA13 are designed to respond to a demand management price or dispatch signal to control operation of the HPWH system while still providing hot water to the occupants. The water heater may "load up" – use electricity at a time advantageous to the grid (such as during midday peak solar generation) – to store extra energy in the water tank prior to the start of the utility defined peak period.

The July 2020 adopted JA13 defines two strategies: Basic Load Up and Advanced Load Up. Basic Load Up would store extra thermal energy without exceeding the user's set point temperature (in other words, making sure the tank is fully charged). Advanced Load Up, which can only be enabled after agreement by the user and the utility (or aggregator), would raise the temperature above set point to overcharge the storage tank. In either case, this extra stored energy would allow the tank to satisfy subsequent on-peak period hot water loads without requiring any additional on-peak operation, except under unusual hot water events.

The 2022 compliance option proposal is focused on extended LSHPWH capability to increase value to the grid by defining a new Basic Plus Load Up strategy (or Basic Plus here foreword, for short). The Basic Plus strategy is a middle option sharing features of both the Basic and Advanced Load Up strategies. Retaining the installed TOU rate schedule from Basic Load Up and, likely, similar control logic the stored water temperature is allowed to rise above the user set point. By allowing the tank to rise above user set point, the water heater can shift more load than in the Basic Load Up. Further, the option can do so without the water heater being grid-connected, however recognizing that a fully connected water heater is a greater resource to the grid. The beneficial operating times can be set, according to the local TOU schedule, to strongly bias operation to align with maximum renewable generation on the California grid such as operation during the mid-day solar peak.

Alternative Basic Plus approaches which demonstrate equivalent benefits to the TOU rate based overheating strategy include an oversized JA13 certified HPWH, or a JA13-certified HPWH with mixing valve where the tank setpoint is set at least 10°F above the mixing valve setpoint (tank setpoint would need to be at least 130°F). Both of these “added storage” strategies are intended to provide equivalent TDV impacts as the TOU controlled overheating approach.

The proposed 2022 submeasure would be a compliance option applicable to single family residences and multifamily apartments where each apartment unit is served by a dedicated HPWH. As a compliance option, it is not a required measure, but does provide for a compliance credit under the performance compliance pathway. The submeasure would also be available for additions and alterations where LSHPWHs are installed.

This proposal would require residential LSHPWHs utilizing the compliance credit to have Consumer Technology Association (CTA) 2045 (Techstreet 2018) communications interface hardware to facilitate demand response and load-shifting capabilities. The open standard CTA-2045 interface provides for a standardized physical port but allows for communication to occur in a wide range of DR application languages including OpenADR2.0 and BACnet. This requirement builds on prior research activities in the Pacific Northwest leading to Washington state legislation requiring all electric water heaters manufactured after January 1, 2021 have a CTA-2045 compliant communications port (Washington State Legislature 2019). Similar legislation is being considered in Oregon and by adopting a California CTA-2045 HPWH requirement additional momentum would be created in moving towards a national consensus for a standardized communications interface. More details on CTA-2045 can be found in the Measure History section of the CASE Report.

As of August 2020, the Energy Commission’s software team is planning to start work on implementing algorithms to include HPWH load shifting in the 2019 CBECC-Res compliance software. The Statewide CASE Team’s understanding is that the currently planned software changes will include all the capabilities and input modifications to accommodate the 2022 LSHPWH proposal[2]. Under that assumption, there are no

[2] Planned work includes: Adding user inputs to model both Basic Load Up (no tank setpoint increase) and Basic Plus (setpoint increase), and Advanced Load Up control capabilities; Implementing algorithms to examine 24-hour ahead TDV and make plan for water heater operation; Add algorithms to be flexible enough to control based on TDV or Time-of-Use schedules; Add HPWH algorithms so the equipment is not just reactive to tank conditions but proactive in response to load shifting commands sent to water heater. This includes override possibilities to force operation in heat pump only mode, resistance only mode, or both, independent of current tank set point; Basic Load Up and Basic Plus; and a range of Shed commands.

software changes anticipated for this measure other than some compliance documentation updates.

2.2.2 Measure History

Residential HPWHs have been a niche residential water heating technology for thirty years or more, but recently have gained traction as the most recent Department of Energy standards require consumer electric storage tanks greater than 55 gallons to be heat pumps and mainstream water heater manufacturers have started to more aggressively promote the HPWH technology in both the standard 50 gallon and larger sizes. Nationally roughly half of the 8.7 million residential water heaters sold in the United States (AHRI 2018) each year are natural gas with the remainder electric (primarily electric storage). An estimated 72,000 HPWHs were sold in the United States in 2017 (Granda 2019), indicating that the HPWH market is still in its infancy. In California, widespread natural gas availability, a historical Title 24, Part 6 institutionalized bias toward gas water heating, and favorable natural gas rates (relative to electric) have contributed to a statewide residential gas water heater saturation rate of about 87 percent (KEMA, Inc. 2010).

Under the 2016 Title 24, Part 6 Standards development process, a detailed HPWH modeling methodology developed by Ecotope was added to the CBECC-Res compliance software (Kvaltine, N; Logsdon, M; Larson, B 2016). This significantly enhanced the modeling capabilities of the compliance software as it was derived from detailed model-specific lab testing sponsored by the Northwest Energy Efficiency Alliance to support utility program efforts in the Pacific Northwest. The new model modestly improved the Title 24, Part 6 compliance performance of HPWHs relative to gas water heating, but the use of a gas tankless water heater as the prescriptive standard combined with the gas and electric TDV levels still contributed to compliance challenges for HPWHs.

Under 2019 Title 24, Part 6 Standards activities, the Energy Commission developed an electric baseline, which allowed electric water heating to be compared to a minimum efficiency HPWH rather than a gas tankless water heater. This, in conjunction with increasing interests among many California municipalities to adopt policies supporting electrification (Building Decarbonization Coalition 2019) has spurred attention towards the HPWH technology heading into 2020.

Since HPWHs generally feature small compressors (~½ ton or less), operating cycles are considerably longer than conventional water heating technologies. Both gas water heaters and electric resistance storage water heaters have greater heating capacities. If the HPWH is unable to maintain tank temperature by using solely the compressor during high hot water draw events, supplemental electric resistance heating is energized. The 50 gallons of storage (or more) integrated with most HPWHs offers demand flexibility capabilities by allowing compressor operation to be shifted away from peak load events. A load-shifting operating mode could bias operation to the middle of the day (around solar noon) to maximize the use of available renewable generation resources and reduce the later use of non-renewable generation resources. When operated in this manner, storage can be charged beyond the normal setpoint with the HPWH compressor to provide extra stored energy. (A tempering valve is necessary in this case to ensure that the delivered hot water temperature is maintained in a safe range. Tempering valves are a required element under JA13.)

Significant work has been completed in recent years on the impacts and benefits of load-shifting with HPWHs. The Electric Power Research Institute (EPRI) has been actively involved in testing and evaluating the technology as well as developing the standardized CTA-2045 communications protocols to facilitate grid interconnectivity (Electric Power Research Institute 2015). A 2017 Pacific Gas and Electric (PG&E) funded laboratory test evaluated four HPWHs in a variety of modes to assess performance impacts of overheating storage, response of HPWH controls to different test conditions, and impact of load-shifting utilizing 2016 TDV values (Grant and Huestis 2018). A 2018 American Council for an Energy Efficient Economy Hot Water Forum presentation by the National Resources Defense Council (NRDC) and Ecotope on HPWH demand flexibility (Delforge and Larson 2018) focused on the modeling of different load-shifting strategies utilizing the detailed Ecotope HPWH simulation model.[3] Findings indicated that when load-shifting is driven by utility marginal costs (rather than TDV), greater value can be realized since marginal costs are more volatile by time of day than TDV values. Finally, a large Bonneville Power Administration (BPA) field study in the Pacific Northwest tested 277 electric storage and HPWHs in a large demand response demonstration pilot to assess the capabilities and impacts of water heater demand response control utilizing CTA-2045 (Bonneville Power Administration 2018). The BPA study was significant in demonstrating the benefits in a larger pilot study including load-shifting impact, occupant satisfaction, and effectiveness of the CTA-2045 communications strategy.

California utilities are also initiating pilots and programs to move the LSHPWHP approach into the marketplace. The Sacramento Municipal Utility District (SMUD) currently has a pilot project underway (Sacramento Municipal Utility District 2019) with plans to start a full-fledged LSHPWH program in two to three years (Rasin 2019), and PG&E expects to begin a five-year program with a 5 MW load shift goal in 2020 (Brown 2019).

Around the time of the 2019 Title 24, Part 6 Standards adoption in 2018, NRDC began an effort to develop minimum eligibility requirements for LSHPWHs within the

[3] The model is currently integrated in CBECC-Res for modeling of standard HPWH operation.

standards. A final version of Joint Appendix 13 (JA13) has been approved by the Energy Commission in July 2020. Similarly, work on implementing the demand flexibility load-shifting algorithm in CBECC-Res has recently started with beta software delivery expected in the late fall of 2020.

The EPA ENERGY STAR Program is revising their Residential Water Heater specifications to include an optional, grid connected feature. Manufacturers may choose to meet these product requirements but are not required to do so. EPA is currently on their second draft revision for Connected Water Heating Products, released November 26, 2019 (EPA, ENERGYSTAR Program Requirements Product Specification for Residential Water Heaters (Eligibility Criteria Version 3.3 Draft 2) 2019). Notable features of the draft include:

- Alignment with JA-13 regarding Basic and Advanced Load-up strategies
- Requirement for communications protocols to meet “CTA-2045-A or OpenADR 2.0b (Virtual End Node), or both.” Other protocols as are allowed but, at minimum, the device needs to support one of the two above.
- Reference to a test procedure to assess grid connectivity currently in development by both the U.S. Department of Energy and EPA.

The ENERGY STAR Eligibility Criteria document fills a significant void in the grid connected water heater arena. It provides useful definitions, requirements, explanations, and a test method (although the test method is still under development). In its current draft form, it is also completely compatible with current California requirements, or proposed requirements, for grid connected water heaters. The Statewide CASE Team anticipates a final version of the ENERGY STAR test method could be useful in defining/verifying load shifting behavior, however, the release date of that final version is unknown. If it is available in time for the 2022 standards development process, the Energy Commission could consider utilizing content from the ENERGY STAR document.

2.2.2.1 CTA-2045 Background

CTA-2045 is an ANSI standard—an extensible design that allows for continuous improvements to enhance functionality that maintains backward compatibility with previous revisions (Consumer Technology Association 2018). The standard defines a communications protocol and mechanical/electrical connection (i.e. socket) to enable open information to be privately exchanged between two different technologies, one being a smart grid device (i.e. water heater or other energy consuming device) and the other, a universal communication module or UCM.

In addition to the protocol and socket, the standard also defines the physical dimensions of the universal communication module so that water heaters can accommodate modules and UCMs can include the communication technologies. It is these communication technologies that provide a pathway between the device and the user's utility, demand response aggregator, or other energy service application. Because the CTA-2045 standard does not include any telecommunication requirements, it allows for market flexibility. For example, the telecom pathway could be accessed through Wi-Fi, Bluetooth, Cellular, FM radio, Zigbee, HomePlug, or through other protocols not yet created. A distinct advantage of this modular design is to eliminate the need to embed telecom technologies into the water heater, thus greatly reducing manufacturing cost and decreasing the risk of a "stranded" asset if a new preferred telecom pathway emerges.

The CTA-2045 standard contains two distinct communication protocols. The first, lower level defines the physical port (connector and pin layout) and rules that govern the exchange of binary data. Standardizing this lower layer is the key to lowering cost and creating flexibility. With a standard port the customer experience is identical for all water heaters or appliances—the manufacturer, installer, or customer, simply "plugs-in" a UCM to enable remote communications. Besides providing for any type of telecom pathway, the UCM can translate a message in the language received to a standard language that the water heater can understand. Importantly, this translation ability in the UCM means that the water heater itself only needs to know that one language. In this way, messages can be conveyed via OpenADR, IEEE 2030.5, MultiSpeak, etc. but the water heater does not need to support all those languages – only the UCM does. This also reduces the appliance manufacturing complexity while increasing market flexibility. It also means cyber security is in the UCM and implemented by a manufacturer that specializes in communication methods.

The standard also includes an application layer (a higher-level layer), where messages, definitions and rules are assigned to the binary code exchanged through the lower levels. The set of messages included in the CTA-2045's application layer is designed to support a wide range of energy/demand management services. For example, some messages are used to send or receive instructions (like demand response), while other messages are used to send or receive operational status information. The information included in the CTA-2045's application layer messages is analogous to information included in OpenADR 2.0 and IEEE 2030.5.

In sum, the CTA-2045 standard provides a highly flexible method, complementary to other "application layer" standards, to communicate with the water heater. The physical layer provides a method to connect the water heater to a universal communications module, the UCM allows for any telecommunications pathway to connect the water heater to the grid, and can translate commands sent in via any application layer, including OpenADR 2.0, IEEE 2030.5, and CTA-2045, to a standardized language the water heater can understand. Thus, pairing any application layer together with the CTA-

2045 physical layer, provides a complete, standardized pathway to communicate with the water heater, or any appliance.

To enable innovation and provide maximum market flexibility, the 2022 LSHPWH code change proposal plans to adopt the CTA-2045 standard as a requirement to receive any water heater load shifting credit under Title 24, Part 6. Adding the CTA-2045 hardware requirement is designed to maximize choice for utilities, third party aggregators, customers, and manufacturers while simultaneously minimizing cost. ANSI/CTA-2045-A is an enabling standard, at a fundamental level in the technology stack, allowing for nearly limitless communication paths, information exchange models, and security schema. There is a precedent in Title 24, Part 6 for OpenADR2.0. It is critical to note that OpenADR and CTA-2045 are complementary not competing. These two standards work well together because they operate in the same environments and address complementary, specific needs.

- CTA-2045-A defines a standard hardware port, including the physical dimensions, which serves as the connection point between a UCM and the appliance. It also defines a communications layer which translates any set of incoming signals from the UCM to a standard set of commands transmitted to the appliance.
- CTA-2045 also defines an information exchange model that <u>can</u> be used to convey signals from a utility or aggregator to the device. <u>This is not required to be implemented as part of CTA-2045-A and will likewise be optional in the proposed 2022 JA-13 revisions</u>.
- OpenADR is an open information exchange model that specifically <u>does not</u> define the hardware connection. OpenADR can operate and, in fact, is enabled to operate more widely, on top of a CTA-2045 compatible device. The CTA-2045 scope encompasses a more fundamental level by defining a modular, open standard for a physical port on the device.

2.2.3 Summary of Proposed Changes to Code Documents

The sections below summarize how the standards, Reference Appendices, ACM Reference Manual, and compliance documents would be modified by the proposed change. See Section 7 of this report for detailed proposed revisions to code language.

2.2.3.1 Summary of Changes to the Standards

This proposal would modify the following sections of Title 24, Part 6 as shown below. See Section 7.2.2 of this report for marked-up code language.

2.2.3.2 Summary of Changes to the Reference Appendices

This proposal would modify the sections of the Reference Appendices identified below. See Section 7.2.3 of this report for the detailed proposed revisions to the text of the reference appendices.

JOINT APPENDICES

JA1 will need to be modified to add definitions related to LSHPWHs.

Appendix JA1 – DEFINITIONS

New definitions:
"ANSI/CTA-2045" - a modular communications interface to facilitate communications with residential devices for applications such as energy management.

— **HEAT PUMP WATER HEATER (ADVANCED LOAD UP)** is a residential heat pump water heater system controlled to store extra thermal energy in the storage tank by exceeding the user setpoint temperature. This mode of operation is only enabled after agreement by the user and utility. It will avoid use of electric resistance elements unless user needs cannot be met.

— **HEAT PUMP WATER HEATER (BASIC LOAD UP)** is a residential heat pump water heater system controlled to store extra thermal energy in the storage tank without exceeding the user setpoint temperature. It will avoid use of electric resistance elements unless user needs cannot be met.

— **HEAT PUMP WATER HEATER (BASIC PLUS LOAD UP)** is a residential heat pump water heater system that is either controlled to store extra thermal energy in the storage tank by exceeding the user set point temperature or is sized to provide enhanced storage capacity of thermal energy. It will avoid use of electric resistance elements unless user needs cannot be met.

— **JA13 – Qualification Requirements for Heat Pump Water Heater Demand Management Systems:** Changes are proposed to the June 22, 2020 approved version of JA13 to require CTA-2045 hardware capabilities for LSHPWHs that are eligible for the Basic Plus credit. This would be a requirement only for HPWHs that are pursuing a LSHPWH compliance credit.

— **Reference Appendix section RA3.6.11** is proposed to be added to document the verification steps that will be needed for LSHPHWs that raise the storage tank temperature above the normal user set point (i.e. Basic Plus-1 and Basic Plus-3). Basic Plus-2, which credits a larger volume HPWH would not require any HERS verification.

2.2.3.3 Summary of Changes to the Residential ACM Reference Manual

The proposed code change would not modify the ACM Reference Manual.

2.2.3.4 Summary of Changes to the Residential Compliance Manual

The proposed code change would modify the following section of the Residential Compliance Manual:

Section 5.2.2.2 would be updated to clarify LSHPWHs as a potential demand flexibility compliance option available to HPWHs that are certified to be JA13 compliant and that units that raise the storage tank temperature above the normal set point be posted with a one page flyer describing to the homeowner how HPWH operation may vary based on time of day, but that installed mixing valve will provide safe and stable outlet water temperatures

2.2.3.5 Summary of Changes to Compliance Documents

The proposed code change would involve modifying compliance documents. CF1R-PRF-01E, CF2R-PLB-22a-HERS, CF3R-PLB-22a-HERS, and CF-1R-NCB-01-E would all change slightly to accommodate LSHPWHs.

2.2.4 Regulatory Context

2.2.4.1 Existing Requirements in Title 24, Part 6

There are currently no relevant existing requirements in Title 24, Part 6.

2.2.4.2 Relationship to Requirements in Other Parts of the California Building Code

There are no relevant requirements in other parts of the California Building Code.

2.2.4.3 Relationship to Local, State, or Federal Laws

California Assembly Bill 2868 (passed in 2016) was created to provide incentives to customers who purchase energy storage for permanent load shifting. Several California utilities are developing or rolling out load shifting programs specific to HPWHs. PG&E is pursuing a program to deliver 5 MW of load shifting by incenting LSHPWHs. The program is expected to begin later in 2020 and continue through 2025. Southern California Edison is in the preliminary stages of developing a similar program. The Sacramento Municipal Utility District is currently running a pilot study and hopes to have approval for a program in two to three years.

Federal water heater efficiency standards adopted April 30, 2015 effectively mandated HPWHs for all consumer electric storage water heaters greater than 55 gallons in rated storage volume (U.S. Department of Energy 2015). The one exception is for grid-enabled electric storage water heaters with rated storage volume greater than 75 gallons.

2.2.4.4 Relationship to Industry Standards

The proposed code change would reference CTA-2045, an open standard which defines a modular communications interface to facilitate communications with residential devices for applications such as energy management.

2.2.5 Compliance and Enforcement

When developing this proposal, the Statewide CASE Team considered methods to streamline the compliance and enforcement process and how negative impacts on market actors who are involved in the process could be mitigated or reduced. This section describes how to comply with the proposed code change. It also describes the compliance verification process. Appendix E presents how the proposed changes could impact various market actors.

The activities that would need to occur during each phase of the project are described below:

- **Design Phase:** In the design phase, the energy consultant would work with the designer and builder/owner to determine if the LSHPWH credit would be pursued as part of the building design. The designer would select from available JA13 certified products of the appropriate size and specify the unit to be installed. The designer should clearly communicate with the builder and installing contractor that a LSHPWH will be installed and specify if HERS verifications will be required. The compliance documents would be generated listing the model and specification of the Basic Plus compliance credit.
- **Permit Application Phase:** The permit review process would include verification that the specified HPWH is on the Energy Commission's list of JA13 certified products, if LSHPWH credits are developed to be model-specific. If Basic Plus-2 approach (oversized storage) is being pursued, the energy consultant would need to confirm that the proposed water heater meets the First Hour Rating (FHR) level specified in the proposed Table JA13-6 (see Section 7.2.3).
- **Construction Phase:** The installing contractor is responsible for installing the qualified (JA13 certified) HPWH specified in the compliance documents and installing a tempering valve, as per JA13 requirements. For Basic Plus-1, the installed LSHPWH unit must be set up with applicable local TOU electric rates programmed (either field configured, pre-installed, or downloaded from the Cloud). For all LSHPWHs, the installing plumbing contractor shall verify that the installed mixing valve is set at a safe temperature (nominally 120°F). Plumbers are familiar with mixing valves and the safety function that they provide.

- **Inspection Phase:** Once the LSHPWH system has been installed, and documented on the Certificate of Installation, the local building inspector would verify that all applicable requirements have been met. In the case of Basic Plus-2 (oversized storage), the building official would verify that the HPWH listed in the CF1R is installed.

  In the case of Basic Plus-1 or Basic Plus-3, a HERS Rater would verify that the information on the Certificate of Installation matches what is on the Certificate of Compliance. Proper configuration of TOU rates would need to be verified for Basic Plus-1, as well as presence of a tempering valve (as required by JA13). Both -1 and -3 would also require verification that a one page flyer is physically attached to the water heater outlining for the homeowner how tank temperatures may fluctuate above normal set points at times, but the mixing valve ensures a constant and safe hot water delivery temperature.

2.3 HVAC Load Shifting

2.3.1 Measure Overview

The Pre-cooling measure proposes to modify the compliance option that gives Demand Flexibility credit for installation and proper programming of a Pre-Cooling Thermostat (PCT).

This submeasure would be offered for new single family buildings and new construction, and it would only be allowed in Climate Zones 9-15 (where it has been estimated to result in TDV energy savings without a significant energy penalty). No updates to the compliance software are required other than changing the cooling setpoint assumptions for calculating the credit. Credit is calculated by the CBECC-Res software using temperatures and time periods that were updated based on analysis.

Pre-cooling is an existing Demand Flexibility Credit, and several changes to this existing measure are proposed:

- Modify the allowed values for pre-cooling times and temperatures and provide default values
- Add an option to implement the measure using a PCT that meets the required characteristics that improve its usability and reliability
- Add a requirement for designers to specify optimal (or default) pre-cooling times and temperatures, installers to set their values, and HERS Raters to verify their values in the field

2.3.2 Measure History

Pre-cooling is a strategy in which the building is intentionally over-cooled early in the day when rates are low. The thermal mass of the building is cooled down below normal indoor temperatures during these off-peak periods, and serves to gradually slow down warming of the space later during the on-peak period, minimizing or avoiding the need for cooling during the higher-cost peak periods.

Pre-cooling is offered under 2019 Title 24, Part 6 as a compliance option eligible for a Demand Flexibility credit (only credited towards the Total EDR and not the Energy Efficiency EDR). In calculating the credit, the compliance software currently assumes a pre-cooling setpoint and cooling start time that are determined by the forecast average outdoor temperature for that day. It requires the installation of an Occupant Controlled Smart Thermostat (OCST, as described in Joint Appendix 5 (JA5)). This current requirement for forecast outdoor temperatures or demand response signals from utilities requires installation of an OCST, which adds unnecessarily to the cost and complexity of pre-cooling. The modeled pre-cooling impact is de-rated by 70 percent, because its reliability is so heavily determined by occupant behavior.

In this 2022 proposal, pre-cooling would still be offered as a compliance option eligible for Demand Flexibility credit. The proposed measure is simpler and can be implemented with a non-communicating thermostat, programmed to optimize operation to minimize costs under a TOU rate schedule, by defining both a pre-cooling schedule and a "no-cooling" schedule.

Since air-conditioning is the biggest contributor to peak energy use in most California homes, moving operation away from the peak period dramatically reduces peak kW, energy used during the peak period, and TDV. However, pre-cooling would almost always involve an increase in site energy consumption.[4] TOU rates are intended to allow users to reduce their energy bills by moving the use of appliances such as air-conditioners to off-peak periods. If pre-cooling increases the overall energy use, however, the difference between TOU on-peak and off-peak rates will determine whether the homeowner's bill goes up or down with pre-cooling. Optimization of pre-cooling, then, will require finding an acceptable balance between reduction of TDV, kWh penalties, and bills.

Pre-cooling can be thought of as analogous to a battery: the thermal-mass of the home can be "charged" by pre-cooling and then "discharged" by exposing the mass to the rising indoor temperatures during the peak period. The amount of thermal mass in the home is analogous to the size of a battery, and typical home construction will have a

[4] Unless the pre-cooling is accomplished at nighttime when outside air temperatures are much cooler and air conditioners operate more efficiently, which is not proposed in this measure since few homes have sufficient thermal mass to store the "coolth" until the evening peak period.

limited capacity for thermal storage. However, it has some very critical differences. While charging and discharging the home as a thermal battery is primarily a financial decision, changing the space temperature in the home has implications on occupant comfort and occupants cannot be expected to tolerate wide ranges of space temperatures. Occupants also have much more control over their space temperature, and can be expected to change settings and override the pre-cooling strategy if it does not meet their comfort objectives. All of these factors suggest that pre-cooling can be thought of as a relatively unreliable battery.

On the other hand, pre-cooling is a much lower cost option than installation of an electric battery, so it may be a benefit in many homes. To account for this, in both the current and the proposed pre-cooling measures, savings calculated by the compliance software are de-rated by an “Occupant Controllability” factor, to account for the probabilities of both short- and long-term overrides and erroneous programming. This measure has been designed, therefore, to keep it low cost, while taking efforts to improve the reliability and persistence of the measure, and justify a lower de-rating factor, by

- Choosing initial parameters that make it more likely that occupants will not be inconvenienced or made uncomfortable,
- Choosing initial parameters that also ensure bills are reduced or will not increase significantly—increasing the likelihood that occupants will choose to continue to use pre-cooling,
- Verifying that the thermostat is set correctly initially—acknowledging that it may be changed over time,
- Providing consumers with information required to keep it set correctly over time,
- Providing temporary override functionality that is as easy to implement as possible in order to avoid permanent overrides, and
- Ensuring that the PCT is as usable as possible, to avoid incorrect reprogramming.

Based on these objectives, only the values of the Critical Field-Adjusted Parameters (CFAPs) shown in the “Allowed Ranges” column in Table 2 are allowed when a thermostat is initially handed over to a homeowner.

Table 2: Default Values, Allowed Ranged, and Design Considerations for Initial Values of Critical Field-Adjusted Parameters for Pre-Cooling

Parameter	Parameter Name	Default	Allowed Ranges	Design Considerations
NC-START	No-Cooling Start Time	4:00 PM	Between 2:00 PM and 6:00 PM	Beginning of Utility's TOU Peak Period
NC-END	No-Cooling End Time	9:00 PM	No later than 11:00 PM	End of Utility's TOU Peak Period
PC-START	Pre-Cooling Start Time	12:00 PM	4 to 8 hours before NC-START	As late as possible while avoiding on-peak cooling
NC-TEMP	No-Cooling Temperature Setpoint	83°F	No less than 78°F and at least 8°F above PC-TEMP	As high as it takes to avoid on-peak cooling; subject to occupant comfort constraints
PC-TEMP	Pre-Cooling Temperature Setpoint	75°F	No less than 72°F and at least 8°F below NC-TEMP	As high as possible while avoiding on-peak cooling; subject to occupant comfort constraints

Default values for each of these parameters are provided to designers, although they are encouraged to optimize the strategy for each home (based on its thermal mass and climate zone). Installers would record their selected values of these CFAPs on the CF2R. The CF2R would be used by HERS Raters, who would confirm that these values are within the allowed ranges and record the verified values on the CF3Rs.

There would also be a requirement that manufacturers (or designers) provide educational material to be left behind by the installer, describing the benefits of the pre-cooling strategy, expected savings, how to implement a temporary override, how to alter the programming if needed, cautions to take when altering the programming to avoid defeating the measure, and how to change the TOU period if the utility rate structure is changed. The manufacturer would also need to provide easy to use instructions for installers and HERS verifiers describing how to configure and verify CFAP values.

The Statewide CASE Team has been involved in prior ventilation and HVAC pre-cooling evaluation studies, focused on the potential to avoid air conditioner or heat pump operation during summer peak demand periods (German and Hoeschele 2014, Springer 2007, Statewide CASE Team 2011). Results of prior ventilation cooling research led to the addition of ventilation cooling compliance credit in the residential ACM Reference Manual for both whole house fans and central integrated night ventilation cooling systems (whole house fans became a prescriptive requirement in warmer climates for single family construction in 2013).

2.3.3 Summary of Proposed Changes to Code Documents

The sections below summarize how the standards, Reference Appendices, ACM Reference Manual, and compliance documents would be modified by the proposed change. See Section 7 of this report for detailed proposed revisions to code language.

2.3.3.1 Summary of Changes to the Standards

This proposal would modify the following sections of Title 24, Part 6 as shown below. See Section 7.3.2 of this report for marked-up code language.

This code change proposal would list PCTs as one of the systems requiring field verification, in Section 150.1.(b)3B.

2.3.3.2 Summary of Changes to the Reference Appendices

This proposal would modify the sections of the Reference Appendices identified below. See Section 7.3.3 of this report for the detailed proposed revisions to the text of the reference appendices.

This code change proposal would result in changes to JA5 and RA3.4—changing the name of JA5 and adding a new section JA5.3 to provide functionality and manufacturers' certification submittal requirements for PCTs and adding a new section RA 3.4.5 with requirements for field verification of PCTs.

— **JOINT APPENDIX 5.3 – TECHNICAL SPECIFICATIONS FOR PRE-COOLING THERMOSTATS**

- The proposed code change would change the name of JA5 to be "TECHNICAL SPECIFICATIONS FOR THERMOSTATS," and add a new section that describes the requirements for PCT functionality.

— **RESIDENTIAL APPENDIX 3.4. FIELD VERIFICATION OF INSTALLED HVAC SYSTEM COMPONENTS AN DEVICES**

- **Section RA3.4.5: Pre-Cooling Thermostat Verification Procedures:** The proposed code change would add a new section that describes field verification methods to confirm that PCTs are programmed to optimize pre-cooling by default.

2.3.3.3 Summary of Changes to the Residential ACM Reference Manual

This proposal would modify the following sections of the Residential ACM Reference Manual as shown below. See Section 7.3.4 of this report for the detailed proposed revisions to the text of the ACM Reference Manual.

Adds a section TBD that describes the requirements for pre-cooling in the software.

2.3.3.4 Summary of Changes to the Residential Compliance Manual

The proposed code change would not modify the Compliance Manuals.

2.3.3.5 Summary of Changes to Compliance Documents

The proposed code change would modify the compliance documents listed below. Examples of the revised documents are presented in Section 7.3.6.

— **CF1R – PRF-01 CERTIFICATE OF COMPLIANCE FORM**

- An additional column would need to be added to the existing HVAC Cooling – HERS Verification table on the existing CF1R form.

— **CF2R-MCH-36-PRECOOL CERTIFICATE OF INSTALLATION FORM**

- A new form would need to be created, to record the PCT make and model installed and the name and actual configured value of each CFAP.

— **CF3R-MCH-36-PRECOOL CERTIFICATE OF VERIFICATION FORM**

- A new form would need to be created, to record the PCT make and model verified by the HERS rater, and the actual verified value of each CFAP.

2.3.4 Regulatory Context

2.3.4.1 Existing Requirements in Title 24, Part 6

There are no relevant existing requirements in Title 24, Part 6.

2.3.4.2 Relationship to Requirements in Other Parts of the California Building Code

There are no relevant requirements in other parts of the California Building Code.

2.3.4.3 Relationship to Local, State, or Federal Laws

There are no relevant local, state, or federal laws.

2.3.4.4 Relationship to Industry Standards

There are no relevant industry standards.

2.3.5 Compliance and Enforcement

When developing this proposal, the Statewide CASE Team considered methods to streamline the compliance and enforcement process and how negative impacts on market actors who are involved in the process could be mitigated or reduced. This section describes how to comply with the proposed code change. It also describes the compliance verification process. Appendix E presents how the proposed changes could impact various market actors.

The activities that would need to occur during each phase of the project are described below:

- **Design Phase:** During the design phase, the energy consultant would analyze pre-cooling benefits as a function of climate zone, thermal mass, and other building features; decide if the pre-cooling credit is recommended to make the project comply; and include pre-cooling in compliance.
- **Permit Application Phase:** During the permit application phase, the plans examiner would review the Certificate of Compliance and plans to ensure that they match..
- **Construction Phase:** During the construction phase, the HVAC installer would identify a suitable PCT, and determine the optimal values of the CFAPs. Default values for each of these parameters are provided to installers, although they are encouraged to optimize the strategy for each home (based on its thermal mass and climate zone). The default values of the CFAPs, the range of allowed values, and the considerations made by installers in setting them are described in Table 2. The installer would record the PCT make and model and the values of the CFAPs on the CF2R. The installer would then install the PCT according to manufacturer instructions and program it by setting the CFAPs. There would also be a requirement that manufacturers (or installers) develop educational material to be left behind by the installer, describing the benefits of the pre-cooling strategy, expected savings, how to implement a temporary override, how to alter the programming if needed, cautions to take when altering the programming to avoid defeating the measure, and how to change the TOU period if the utility rate structure changes.
- **Inspection Phase:** During the inspection phase, the HERS Rater would verify that the make and model of the PCT are correct (as per the CF2R), that the observed values of the CFAPs match the values on the CF2R and that they are within the allowable range, and that manufacturer's information has been left for the homeowner. The HERS Rater would complete the CF3R document and the building inspector would verify that the appropriate forms have been completed by the HERS Rater.

This process is only slightly more involved than the standard compliance process. The designer would have to investigate available PCTs and ensure that they are certified. The optimal (or default) values of the CFAPs must be determined by the installer; communicated between the installer and HERS Rater via the CF2R form; programmed by the installer; and verified by the HERS Rater. The installer must leave information for the homeowner. There are no new burdens added on building officials.

All compliance during the design stage would be accomplished by the mechanical system designer, so little or no coordination with other designers would be required. All field installation would be done by the mechanical subcontractor, so little or no coordination with other installers would be required. There would be new compliance documents required, but no changes would be made to existing forms. No new HERS verifications would need to occur during the construction phase, but additional factors would have to be verified.

The Statewide CASE Team has mitigated any potential compliance and enforcement challenges by providing recommended changes to compliance manuals and compliance documents. The Statewide CASE Team is committed to working with industry stakeholders to help them prepare for the code change before it takes effect. With suitable mechanisms to provide expected values of CFAPs on the forms, this compliance procedure should not be burdensome.

There are no known potential loopholes to compliance. However, the reliability of this measure depends to a great extent on taking steps to ensure that the strategy and its value are well understood by the occupant, and that programming and adjusting of the PCT is transparent and intuitive.

2.4 Home Energy Management

2.4.1 Measure Overview

This measure clarifies the current exception to the solar zone area requirement when a HEMS is installed in combination with a smart thermostat, by defining specific qualifying criteria that must be met. This change revises an alternative to the mandatory requirement for minimum solar zone area defined in Section 110.10(b)1A. Exception 6 currently allows home automation systems to qualify if they include demand response capabilities and the ability to control lighting and appliances. However, the specific functions that constitute these capabilities are not defined with enough specificity to estimate energy and peak load savings, or to verify that the desired capabilities are present in specific applications. In addition, the term “home automation systems” is a general term that can apply to systems that primarily provide convenience or home security functions. The proposed change replaces “home automation” with “home energy management”, which is the more common terminology used in the industry for systems that provide energy savings capabilities.

The Statewide CASE Team considered the possibility of a compliance credit for HEMS, given the potential for both energy savings and peak demand savings. However, the actual energy savings for HEMS products is largely unproven beyond smart thermostats and energy monitoring, and it is premature to provide specific credits to HEMS until energy and peak demand savings can be more accurately quantified across a range of system designs.

As part of this submeasure, Joint Appendix JA5—Technical Specifications for Occupant Controlled Smart Thermostats (OCSTs)—is proposed to be expanded to include separate sections that define the specifications for the following thermostat categories. It also extends the exception to the solar zone credit to homes where any of these thermostats are installed.

- **Demand Management Thermostats (DMTs)**—this includes without modification all the functionality originally assigned to OCSTs—the ability to respond to utility price and event signals—with a new name;
- **Pre-Cooling Thermostats (PCTs)**—these requirements are also described elsewhere in this CASE Report); and
- **Advanced Energy Efficiency Thermostats (AEETs)**—this includes the specifications for "smart" thermostats—those that save energy by using advanced algorithms such as occupancy sensing, vacancy prediction, and optimization. These specifications refer to the requirements for the ENERGY STAR Program for Connected Thermostat Products.
- **Basic Energy Efficiency Thermostats (BEETs)**—this includes without modification all the existing requirements for setback thermostats.

The solar zone exception then is proposed to be restated to apply in single family residences when all thermostats meet the DMT, PCT, or AEET requirements, and the home automation system option is modified to refer to installation of a Home Energy Management System that communicates with a DMT, PCT, AEET, battery storage system, or heat pump water heater load shifting system.

This measure applies to both single family and multifamily residential buildings, which use similar language when describing the solar zone exception. The measure does not apply to additions and alterations, because these applications require additional study. No change to compliance software is proposed, but field verification is required to ensure minimum performance capabilities are present.

2.4.2 Measure History

HEMS is a subcategory of home automation that provides homeowners with the ability to control energy consuming devices through programmed schedules, control logic based on occupancy sensors or other measurements, machine learning, utility signals, and/or remote access through smartphones. A HEMS may either be a master system that controls and monitors all end uses (including smart thermostats, heat pump water heaters (HPWHs), and batteries), or a system that controls appliances, lighting, and/or plug loads. This section is primarily focused on the latter functionality, along with smart thermostats, because HPWHs and batteries have their own proposed minimum performance requirements that are addressed separately in this CASE Report.

HEMS can reduce TDV through either direct energy use reduction (e.g. turning off lights and TVs in unoccupied rooms), or through load shifting (e.g. suspending operation of clothes dryers upon receiving a demand response signal from the utility). Energy and peak demand savings can also be achieved by providing information and recommendations to occupants, allowing them to modify their behavior in an informed manner.

Home automation is a quickly expanding market that is likely to have a large impact on energy use in homes, particularly in end-uses such as plug loads and lighting, where there are few if any opportunities to receive credit for energy savings. The Statewide CASE Team believes it is important to recognize this reality by starting to include minimum requirements for HEMS in Title 24, Part 6, even if there are many questions that still need to be addressed. Ensuring that new homes are at least compatible with HEMS technologies would be another important step.

Two previous CASE Reports investigated energy savings potential for appliances, lighting, and plug loads. The 2016 CASE Report "Plug Loads and Lighting Modeling" developed by Energy Solutions studied representative energy use profiles and recommended default values for these end uses as a function of time of day, month of year, and house characteristics such as number of bedrooms (Rubin, et al. 2016). The report also provided recommendations for crediting certain energy efficient appliances. However, the report did not address potential credit for controls that reduce energy use relative to the default values. The 2019 CASE Report "Demand Response Cleanup" examined a number of code changes that would improve the consistency and clarity of code requirements related to demand responsiveness, and lead to greater compliance (Hauenstein and Kundu 2017). That report covers a variety of demand response technologies for both residential and nonresidential buildings. On the topic of home energy management, the report recommended removing the reference to "home automation" in Section 110.10 and replacing it with "energy management control system (EMCS)", but that change was not approved by the Energy Commission in the 2019 cycle. In any event, the requirements for EMCS in Title 24, Part 6 are perhaps more appropriate for nonresidential buildings, and the Statewide CASE Team has since decided that the term "home energy management system" should be used in Title 24, Part 6 for both single family and multifamily residential applications, along with a clear definition and corresponding minimum requirements.

The current exception to the solar zone requirement applies in single family residences whenever all thermostats are demand-responsive, in addition to implementing one of several optional measures. The list of optional measures includes installation of a dishwasher that meets ENERGY STAR requirements, a gray-water collection system, or a home automation system. Therefore, the current exception requires a smart thermostat, but not necessarily any other smart devices. This submeasure attempts to clarify the distinctions between various elements of a smart home, encourage their use, and ensure interoperability among them.

It should be noted that solar zone area requirements may have limited relevance because PV is now required by the 2019 update to Title 24, Part 6. However, there are situations where a home may be exempt from PV capacity requirements, but not solar readiness. Despite the limited practical impact of this measure, the CASE Authors believe it is important to clarify the terminology for smart home technology, which is likely to have a larger role in future code cycles.

2.4.3 Summary of Proposed Changes to Code Documents

The sections below summarize how the standards, Reference Appendices, ACM Reference Manual, and compliance documents would be modified by the proposed change. See Section 7 of this report for detailed proposed revisions to code language.

2.4.3.1 Summary of Changes to the Standards

This proposal would modify the following sections of Title 24, Part 6 as shown below. See Section 7 of this report for marked-up code language.

SECTION 110.10 MANDATORY REQUIREMENTS FOR SOLAR READY BUILDINGS

— **Section 110.10(b) Solar Zone:** Replaces reference to “home automation system” with “home energy management system” and clarifies minimum requirements for HEMS combined with an AEET to qualify for an exception to the minimum solar zone area of 250 ft^2.

— **SECTION 110.12 MANDATORY REQUIREMENTS FOR DEMAND MANAGEMENT:** Clarifies that if a thermostat is used as a demand responsive control, it must meet the requirements in JA5.1 as well as the other requirements in this section.

— **SECTION 100.1 – DEFINITIONS AND RULES OF CONSTRUCTION**

- **Section 100.1(b)** – Definitions: Recommends new or revised definitions for the following term:

  New definitions:

  “home energy management system” – differentiates residential home energy management from “energy management control systems” that are more aligned with nonresidential requirements

2.4.3.2 Summary of Changes to the Reference Appendices

The proposed code change would modify Joint Appendix JA5 – Technical Specifications for Occupant Controlled Smart Thermostat, to include separate sections for DMTs (5.1), PCTs (5.2), AEETs (5.3)), and BEETs (5.4).

2.4.3.3 Summary of Changes to the Residential ACM Reference Manual

The proposed code change would not modify the Residential ACM Reference Manual.

2.4.3.4 Summary of Changes to the Residential Compliance Manual

The Residential Compliance Manual would need to be revised to change all references to Occupant Controlled Smart Thermostat (OCST) to Demand Management Thermostat (DMT), and to change all references to Home Automation Systems to Home Energy Management Systems that meet or exceed most of the ENERGY STAR SHEMS eligibility criteria and are compatible with other demand response technologies certified under Title 24, Part 6. These changes are generally straightforward and align with changes to the standards. See Section 7.4.5 of this report for the detailed proposed revisions to the text of the Compliance Manuals.

2.4.3.5 Summary of Changes to Compliance Documents

Compliance documents CF2R-SRA-01-E and CF2R-SRA-02-E must be revised to correct the terminology and clarify requirements that must be verified and documented by the DMT and HEMS installer. The specific revisions to the compliance documents are provided in Section 7.4.6.

2.4.4 Regulatory Context

2.4.4.1 Existing Requirements in Title 24, Part 6

Title 24, Part 6 currently has an explanation of Home Automation as a type of EMCS in Appendix H of the Residential Compliance Manual, but does not lay out specific requirements. The code includes a clear and concise definition of EMCS (a term more commonly used in the nonresidential sector) that allows stakeholders to understand the intent of EMCS requirements in various sections of the code. Because energy management systems in residential buildings must be more user friendly and must offer greater occupant control capabilities than similar systems in nonresidential buildings, the Statewide CASE Team recommends different requirements and different terminology for HEMS and EMCS. In addition, Title 24, Part 6 currently uses the term “home automation” in Section 110.10, which implies a difference in expected capabilities for residential and nonresidential energy management systems.

There is a separate 2022 CASE Report addressing nonresidential grid integration measures, but there is no direct interaction between the proposed measures because the residential Final CASE Report is focused exclusively on home automation and does not modify any of the requirements for EMCS.

2.4.4.2 Relationship to Requirements in Other Parts of the California Building Code

There are no relevant requirements in other parts of the California Building Code.

2.4.4.3 Relationship to Local, State, or Federal Laws

California Assembly Bill 793 was passed in 2015 and requires utility programs to begin including HEMS in their energy efficiency programs.

2.4.4.4 Relationship to Industry Standards

There are no relevant industry standards for HEMS. However, the proposed code change requires meeting most of the eligibility criteria for the ENERGY STAR SHEMS Program, which in turn references two industry standards:

- IEC 62301, E. 2.0, 2011-01: Household electrical appliances - Measurement of standby power
- CTA-2047: CE Energy Usage Information

The proposed code change also requires that AEETs meet the requirements of the ENERGY STAR Program for Connected Thermostat Products.

2.4.5 Compliance and Enforcement

When developing this proposal, the Statewide CASE Team considered methods to streamline the compliance and enforcement process and how negative impacts on market actors who are involved in the process could be mitigated or reduced. This section describes how to comply with the proposed code change. It also describes the compliance verification process. Appendix E explains how the proposed changes could impact various market actors.

The activities that would need to occur during each phase of the project are described below:

- **Design Phase:** The designer is responsible for specifying a HEMS package that meets Title 24, Part 6 requirements, and ensuring that the required minimum connected devices are present and communicate properly with the HEMS. However, HEMS performance evaluation through the compliance software is not required as part of the CF1R documentation. Similarly, the designer is responsible for specifying a qualified thermostat, whether it be a DMT, PCT, or AEET. The energy consultant must coordinate with the designer to ensure that a compliant HEMS and/or thermostat product is recorded on the compliance documents, plans, and specifications.

- **Permit Application Phase:** The plans examiner is responsible for verifying that the products specified in the plan match those listed in the CF1R.
- **Construction Phase:** The installer is responsible for ensuring that the specified products are installed according to manufacturer's instructions, and completing the applicable Certificate of Installation. If the installer completes their work before a homeowner moves in, the installer shall leave behind all necessary materials so that the homeowner can successfully set up the HEMS on their own.
- **Inspection Phase:** The building inspector is responsible for verifying that all compliance documents have been completed. No additional HERS requirements are envisioned for this submeasure.

This compliance process is quite simple compared to that for other submeasures. The designer would be responsible for identifying certified products. This would be facilitated if the Energy Commission maintains a website that lists certified products.

All compliance during the design stage would be accomplished by the mechanical system designer for thermostats, and the audio visual equipment (AVE) installer for HEMS. Little or no coordination with other designers would be required, but some coordination would be needed between the mechanical system designer and HEMS designer to make sure the HEMS can communicate with the thermostat. All field installation would be done by the mechanical subcontractor for the thermostat, and the electrician or AVE installer for HEMS, and the installations are likely to be relatively independent. Little or no coordination with other installers would be required. There would be several changes to existing forms, but no new compliance documents would be required. No new HERS verifications would need to occur during the construction phase, but additional factors would have to be verified.

The Statewide CASE Team has mitigated any potential compliance and enforcement challenges by providing recommended changes to compliance manuals and compliance documents. The Statewide CASE Team and Compliance Improvement Team are committed to work with industry stakeholders to help them prepare for the code change before it takes effect.

There are no known potential loopholes to compliance. However, the reliability of this measure depends to a great extent on taking steps to ensure that systems are installed and configured correctly by the installer, and that sufficient instructions are left behind to allow the homeowner to operate the product reliably.

3. Market Analysis

This section addresses the current state of the market for the technologies related to the proposed measure, including market structure, target applications, market barriers, characteristics of early adopters, technical challenges, and ongoing research. It also discusses how the proposed measure could positively or negatively affect the market for these technologies.

The Statewide CASE Team performed a market structure analysis with the goals of identifying current technology availability, current product availability, and market trends. It then considered how the proposed standard may impact the market in general as well as individual market actors. Information was gathered about the incremental cost of complying with the proposed measure. Estimates of market size and measure applicability were identified through research and outreach with stakeholders including utility program staff, Energy Commission staff, and a wide range of industry actors. In addition to conducting personalized outreach, the Statewide CASE Team discussed the current market structure and potential market barriers during a public stakeholder meeting that the Statewide CASE Team held on September 10th, 2019, and March 12th, 2019. Meeting notes from those workshops are available online (California Statewide Utility Codes and Standards Team 2019a).

3.1 Battery Storage Systems

3.1.1 Market Structure

The Statewide CASE Team developed an overview of the battery storage system market through stakeholder outreach to battery storage manufacturers, industry alliances, and energy consultants, as well as through an in-depth literature review of published market analysis, conference presentations, and battery storage system data sheets. The residential battery storage system market in California has been dominated by two main manufacturers, Tesla, Inc. and LG Chem, but has seen increased growth with manufacturers such as Sonnen and Enphase. In terms of the distribution channel, manufacturers have sold through both wholesale channels (i.e. third-party storage installer) and retail channels (i.e. directly to the homeowner). Residential battery storage remains an emerging market but has shown continual rise in the latter half of the decade. In the 2018 U.S Battery Storage Market Trends report published by the Energy Information Administration (EIA), it was estimated that 66 MW of small-scale storage capacity was deployed in the United States, with 90 percent of the capacity in California alone (U.S. Energy Information Administration 2018). Although California retains the largest market share of small-scale storage, EIA estimates that only 5 percent is dedicated to residential applications. Greentech Media's (GTM) U.S Annual Energy Storage Deployment Forecast projects the residential storage market to exceed 1 GW by 2023, with most of the capacity market share remaining in California (Greentech Media Research 2018).

California's Self-Generation Incentive Program (SGIP) has been a major driver for battery storage installations in California program and incentivizes up to $250 per kilowatt-hour for residential customers (Self-Generation Incentive Program 2020). The SGIP 2017 Annual Evaluation showed that 49 percent of rebates were awarded to residential customers, amounting to approximately 2 MW of installed capacity (California Public Utilities Commission 2018).

A combination of declining battery costs, increased electric-vehicle (EV) penetration, the need for grid resiliency, and the emergence of TOU rate structures have accelerated the adoption of battery technologies in residential homes (Utility Dive 2018). As batteries continue to become more prevalent in the residential market, it is important that developers, contractors, and homeowners understand how a battery energy system can not only benefit them, but the larger electric grid as well.

A small number of manufacturers currently own much of the market share in residential battery storage systems. These manufacturers include Tesla, LG Chem, and Sonnen. Because batteries are not required in residential homes, it is often up to the customer to identify a manufacturer and certified contractor to install the battery, often pairing with a solar system. Manufacturers can also suggest certified contractors and help customers identify how and where to install the battery systems in the homes. Electrical contractors for battery storage system installations can sometimes be different than the contractors for the PV installation, leading to increased cost for consumers.

New construction homes can claim compliance by following the requirements set forth in Title 24, Part 6, JA12. Installation of a battery requires identification of critical loads and rewiring of the main circuit panel. The battery is installed to service the local load of the home, giving precedence to the critical loads. Interconnection to the main electrical grid differs depending on the solar and storage system sizes. Compliance can be claimed if the battery control strategy meets one of three designated control strategies outlined in JA12. The CASE Team prioritized identifying if the JA12 requirements aligned with current market practices while developing proposed code changes. Since JA12 currently outlines performance, control, and safety requirements, all stakeholders may be affected by proposed changes.

3.1.2 Technical Feasibility, Market Availability, and Current Practices

Battery energy storage system installations for residential homes continue to rise. Although the market has traditionally been dominated by a small number of installers, more companies appear in the marketplace as the potential for the technology increases. From 2017 to 2018, the number of unique battery storage installers in PG&E territory increased by almost 200 percent (California Distributed Generation Statistics

2019). Residential battery systems inclusion in the reference appendices of the 2019 Title 24, Part 6 code demonstrate the feasibility of the technology. JA12 of the 2019 Title 24, Part 6 energy code details the safety, performance, and control requirements of residential systems for a battery system to claim compliance credit. Currently, systems must:

1) Comply with the test standards set forth in UL1973 and UL9540
2) Have a usable energy capacity of at least 5 kWh
3) Meet a round-trip efficiency (AC-to-AC) of at least 80 percent
4) Retain 70 percent of their nameplate capacity after 4,000 cycles or 10 years, covered by a manufacturer warranty
5) Abide by all control requirements set forth in JA12.2.3

The energy code does not require a battery installation in new construction homes, but instead allows for a Demand Flexibility credit (only credited towards the Total EDR and not the Energy Efficiency EDR). A self-utilization credit option can be applied to designs with solar and battery storage. This credit allows for subtraction from the Energy Efficiency EDR of the proposed design.

The Statewide CASE Team reached out to a variety of battery storage system stakeholders to gather input on code change requirements, including battery and inverter technology manufacturers (Tesla, Sunpower, Solar Edge), engineering consultants and researchers with experience in storage modeling (E3, Lawrence Berkeley National Labs, VCA Green), and storage alliances (California Solar and Storage Alliance). Stakeholders were contacted between September 2019 – December 2019 through email correspondence, followed by a meeting lasting one to two hours. The Statewide CASE Team used these meetings to gather input from stakeholders on the proposed code changes and additional code change proposals worth pursuing. Meeting minutes were sent following each meeting and the Statewide CASE Team continued discussions with specific stakeholders through follow-up Q&A emails.

The Statewide CASE Team interviewed battery manufacturers on their ability to meet an increase in the round-trip efficiency (RTE) requirements and learned that many lithium-ion batteries sold today are already meeting the JA12 requirements, if not exceeding them. Although additional types of energy storage technologies exist in the market, lithium-ion batteries are the dominant storage medium in the residential market based on a 2019 market assessment from the Self Generation Incentive Program (SGIP) program (Itron 2019). Interviews and literature review of lithium ion battery storage systems showed that these technologies had a round trip efficiency in the 85 percent – 90 percent range (Hydrowires, PNNL 2019). Therefore, the Statewide CASE Team feels confident that existing residential battery storage manufacturers would be able to meet an updated minimum round trip efficiency of 85 percent. However, the team is cognizant that new energy storage technologies may penetrate the residential market when the 2022 Title 24, Part 6 code goes into effect and is actively monitoring the progress of these technologies. Although these energy storage technologies may have lower round trip efficiencies than conventional lithium-ion batteries, they may offer other benefits including better safety, lower lifecycle costs, greater recyclability, and increased lifetime.

Battery manufacturers currently have the capability to meet the control requirements outlined in JA12, yet the Statewide CASE Team learned through stakeholder outreach that customers purchasing battery systems today may change their strategy and often opt for a backup system rather than more complex controls. The SGIP program evaluation noted similar findings, stating all the batteries in the evaluation sample were found to be idle and only serving as backup power throughout the year (Itron 2018). Qualifying for compliance with a battery system requires verification of the control strategy by inspection, and battery manufacturers have stated that their technologies meet the JA12 requirements, but there is no mechanism in place to ensure battery control is maintained. With an increase of customers moving to TOU rates, both the customer and the grid can benefit from more proactive control of the battery system. Also, with the advent of TOU rates becoming commonplace in California, the Statewide CASE Team recommends updates to the CBECC-Res software to more closely align with utility TOU rate periods. Some battery manufacturers allow customers this control already, but the most current schedules should be reflected in the compliance software to ensure accurate modeling for homeowners.

Residential customers purchase battery storage systems for a variety of use cases, including but not limited to solar PV self-consumption, backup power for grid emergencies, and shifting load away from TOU peaks. Batteries installed for the sake of backup power give customers confidence if the grid-at-large were to go down, but backup systems do not necessarily provide cost savings for customers, and do not benefit the grid to which they are interconnected. Reserving all or a portion of the battery capacity for backup storage limits the cycling capabilities of the battery to charge from a connected solar PV system, to discharge during peak TOU periods, and to participate in demand response events (charge or discharge form the grid). The 2017 SGIP evaluation noted that participation in programs such as the Capacity-Bidding-Program (CBP) can provide financial benefits to customers and system-level benefits to the grid (Itron 2018). The current version of JA12 was written before TOU rates were widely used in California. Reinforcing JA12 and educating consumers on the benefits of grid-connected systems can help customers shave peak load costs within their TOU rate structure and benefit the larger grid.

One stakeholder from a green building consultancy recommended that it should be against the code for battery storage systems to charge from the grid. The SGIP 2017 evaluation found that customers participating in the program saw a net increase in greenhouse gas (GHG) emissions relative to not installing a battery storage system. Minimizing battery charging from the grid would help reduce grid-GHG emissions and encourage customer self-consumption of solar. Grid-charging the battery during off-peak hours may be financially appealing to customers charging the battery but keeps the load – and grid emissions – higher during these hours. However, the effect of GHG emissions from grid charging is expected to minimize over time as more renewables are added to the utility grid.

There is financial incentive for batteries to solely charge from on-site renewables via the ITC tax credit and SGIP incentive credit, but verification of charging requires additional rewiring of AC systems (National Renewable Energy Laboratory 2018 , California Public Utilities Commission 2019). JA12 refers to Rule 21 for interconnection processes when installing a battery energy storage system. Updated language to Rule 21 disallowing grid-charged batteries may increase solar self-consumption and reduce grid-emissions in non-peak hours but would prevent standalone storage from receiving compliance credit. When asked about expanding the compliance option to standalone battery storage systems, utility stakeholders were in support of this change, as long as these systems aligned with grid harmonization efforts and TOU design.

The Statewide CASE Team questioned stakeholders on their thoughts regarding battery ready building requirements. Because the current code only applies to compliance there is no language on building homes that are battery storage ready. Stakeholders agreed that battery ready building requirements would help facilitate the installation of battery storage systems. However, stakeholders cautioned that storage ready requirements should not restrict the installation design process for storage contractors and expressed concern that requirements would result in unnecessary cost adders for new homes.

Based on stakeholder feedback, the CASE team has not proposed battery ready building requirements as a mandatory measure, but instead as an exception to the solar zone area requirement. Battery ready building design would streamline the installation of battery storage systems through battery ready zones, resulting in reduced installation costs. It would also simplify the process of wiring the battery storage system to the electrical circuit panel and designating critical loads to be supplied by the battery system during grid outages. For these reasons, the CASE Team would be in strong support of adding battery ready building requirements as a voluntary measure in CALGreen, Title 24, Part 11.

Stakeholder outreach on battery ready building requirements was led by the California Solar and Storage Association (CalSSA). Stakeholders contacted included the Solar Energy Industry Association (SEIA), the California Building Industry Association (CBIA), the California Department of Housing and Community Development (HCD), Underwriters Laboratory (UL), the Association of Electrical Equipment and Medical Imaging Manufacturers (NEMA), Sunrun, Planet Plan Sets, Enphase, Solaredge, Sunpower, Tesla, New Day Solar, Outback, MK Battery, Span, Siemens, and Square-D.

Through research and stakeholder input, the Statewide CASE Team identified the following potential challenges in the battery energy storage market with the current JA12 requirements:

1) Battery control strategies claimed for compliance have little to no verification that the control strategy is active throughout the year.
2) Round-trip efficiency tests are subjective to manufacturers.
3) TOU rates are not currently controllable in the compliance software.
4) Customers, through lack of incentive or education, use their systems for backup power over active grid harmonization.

The code change proposals introduced in this CASE report serve to address these challenges. To improve battery storage control strategy verification, additional guidance for building inspectors to verify battery control strategies at installation would be added to the Certificate of Installation. The Statewide CASE team also confirmed that battery control strategies offered in the market are JA12 compliant, which minimizes the potential that a JA12 approved control strategy is not active.

The Statewide CASE Team also updated the 2022 TDV figures, which forecast hourly electricity, natural gas, and propane costs, to align with retail rates (including TOU) in California. This minimizes the possibility that the "Time Of Use" control strategy is not accurately capturing the benefits of discharging during TOU peak periods.

Increasing grid harmonization use cases for battery storage systems is being addressed by battery storage manufacturers and installers who are educating customers on the cycling benefits provided by battery storage, as well as the cycling requirements for the SGIP program, if applicable.

3.1.3 Market Impacts and Economic Assessments

3.1.3.1 Impact on Builders

Builders of residential and commercial structures are directly impacted by many of proposed measures for the 2022 code cycle. It is within the normal practices of these businesses to adjust their building practices to changes in building codes. When necessary, builders engage in continuing education and training in order to remain compliant with changes to design practices and building codes.

California’s construction industry is comprised of about 80,000 business establishments and 860,000 employees (see Table 3).[5] In 2018, total payroll was $80 billion. Nearly 60,000 of these business establishments and 420,000 employees are engaged in the residential building sector. The remainder of establishments and employees work in commercial, industrial, utilities, infrastructure, and other heavy construction (industrial sector).

Table 3: California Construction Industry, Establishments, Employment, and Payroll

Construction Sectors	Establishments	Employment	Annual Payroll (billions $)
Residential	**59,287**	**420,216**	**$23.3**
Residential Building Construction Contractors	22,676	115,777	$7.4
Foundation, Structure, & Building Exterior	6,623	75,220	$3.6
Building Equipment Contractors	14,444	105,441	$6.0
Building Finishing Contractors	15,544	123,778	$6.2
Commercial	**17,273**	**343,513**	**$27.8**
Commercial Building Construction	4,508	75,558	$6.9
Foundation, Structure, & Building Exterior	2,153	53,531	$3.7
Building Equipment Contractors	6,015	128,812	$10.9
Building Finishing Contractors	4,597	85,612	$6.2
Industrial, Utilities, Infrastructure, & Other	**4,103**	**96,550**	**$9.2**
Industrial Building Construction	299	5,864	$0.5
Utility System Construction	1,643	47,619	$4.3
Land Subdivision	952	7,584	$0.9
Highway, Street, and Bridge Construction	770	25,477	$2.4
Other Heavy Construction	439	10,006	$1.0

Source: (State of California, Employment Development Department n.d.)

The proposed change to battery storage systems would likely affect residential builders but would not impact firms that focus on construction and retrofit of industrial buildings, utility systems, public infrastructure, or other heavy construction. The effects on the residential and commercial building industry would not be felt by all firms and workers, but rather would be concentrated in specific industry subsectors. Table 4 shows the residential building subsectors. Sectors that are involved with the installation of battery storage systems would need to account for updated battery storage code requirements.

[5] Average total monthly employment in California in 2018 was 18.6 million; the construction industry represented 4.5 percent of 2018 employment.

The Statewide CASE Team's estimates of the magnitude of these impacts are shown in Section 3.1.4 Economic Impacts.

Table 4: Size of the California Residential Building Industry by Subsector

Residential Building Subsector	Establishments	Employment	Annual Payroll (billions $)
New single family general contractors	10,968	55,592	$3.7
Residential Remodelers	11,122	52,133	$3.0
Residential Electrical Contractors	6,095	37,933	$2.2
Other Residential Equipment Contractors	263	1,331	$0.1
Residential Site Preparation Contractors	1,265	11,130	$0.7
All other residential trade contractors	2,356	21,280	$1.2

Source: (State of California, Employment Development Department n.d.)

3.1.3.2 Impact on Building Designers and Energy Consultants

Adjusting design practices to comply with changing building codes practices is within the normal practices of building designers. Building codes (including Title 24, Part 6) are typically updated on a three-year revision cycle and building designers and energy consultants engage in continuing education and training in order to remain compliant with changes to design practices and building codes.

Businesses that focus on residential, commercial, institutional, and industrial building design are contained within the Architectural Services sector (North American Industry Classification System 541310). Table 5 shows the number of establishments, employment, and total annual payroll for Building Architectural Services. The proposed code changes for the 2022 code cycle would potentially impact all firms within the Architectural Services sector. The Statewide CASE Team anticipates the impacts for the battery storage system submeasure to affect firms that focus on single family construction.

There is not a North American Industry Classification System (NAICS)[6] code specific for energy consultants. Instead, businesses that focus on consulting related to building energy efficiency are contained in the Building Inspection Services sector (NAICS 541350), which is comprised of firms primarily engaged in the physical inspection of

[6] NAICS is the standard used by federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy. NAICS was development jointly by the U.S. Economic Classification Policy Committee (ECPC), Statistics Canada, and Mexico's Instituto Nacional de Estadistica y Geografia, to allow for a high level of comparability in business statistics among the North American countries. NAICS replaced the Standard Industrial Classification (SIC) system in 1997.

residential and nonresidential buildings.[7] It is not possible to determine which business establishments within the Building Inspection Services sector are focused on energy efficiency consulting. The information shown in Table 5 provides an upper bound indication of the size of this sector in California.

Table 5: California Building Designer and Energy Consultant Sectors

Sector	Establishments	Employment	Annual Payroll (billions $)
Architectural Services [a]	3,704	29,611	$2.91
Building Inspection Services [b]	824	3,145	$0.22

Source: (State of California, Employment Development Department n.d.)

a. Architectural Services (NAICS 541310) comprises private-sector establishments primarily engaged in planning and designing residential, institutional, leisure, commercial, and industrial buildings and structures;
b. Building Inspection Services (NAICS 541350) comprises private-sector establishments primarily engaged in providing building (residential & nonresidential) inspection services encompassing all aspects of the building structure and component systems, including energy efficiency inspection services.

3.1.3.3 Impact on Occupational Safety and Health

The proposed code change does not alter any existing federal, state, or local regulations pertaining to safety and health, including rules enforced by the California Division of Occupational Safety and Health (Cal/OSHA). All existing health and safety rules would remain in place. Complying with the proposed code change is not anticipated to have adverse impacts on the safety or health of occupants or those involved with the construction, commissioning, and maintenance of the building.

3.1.3.4 Impact on Building Owners and Occupants

Residential Buildings

According to data from the U.S. Census, American Community Survey (ACS), there were nearly 14.3 million housing units in California in 2018 and nearly 13.1 million were occupied (see Table 6). Most housing units (nearly 9.2 million were single-family homes (either detached or attached), while about 2 million homes were in building containing

[7] Establishments in this sector include businesses primarily engaged in evaluating a building's structure and component systems and includes energy efficiency inspection services and home inspection services. This sector does not include establishments primarily engaged in providing inspections for pests, hazardous wastes or other environmental contaminates, nor does it include state and local government entities that focus on building or energy code compliance/enforcement of building codes and regulations.

two to nine units and 2.5 million were in multi-family building containing 10 or more units. The U.S. Census reported that 59,200 single-family and 50,700 multi-family homes were constructed in 2019.

Table 6: California Housing Characteristics

Housing Measure	**Estimate**
Total housing units	14,277,867
Occupied housing units	13,072,122
Vacant housing units	1,205,745
Homeowner vacancy rate	1.2%
Rental vacancy rate	4.0%
Units in Structure	**Estimate**
1-unit, detached	8,177,141
1-unit, attached	1,014,941
2 units	358,619
3 or 4 units	783,963
5 to 9 units	874,649
10 to 19 units	742,139
20 or more units	1,787,812
Mobile home, RV, etc.	538,603

Source: (2018 American Community Survey n.d.)

Table 7 shows the distribution of California homes by vintage. About 15 percent of California homes were built in 2000 or later and another 11 percent built between 1990 and 1999. The majority of California's existing housing stock (8.5 million homes – 59 percent of the total) were built between 1950 and 1989, a period of rapid population and economic growth in California. Finally, about 2.1 million homes in California were built before 1950. According to Kenney et al, 2019, more than half of California's existing multifamily buildings (those with five or more units) were constructed before 1978 when there no building energy efficiency standards (Kenney, 2019 California Energy Efficiency Action Plan 2019).

Table 7: Distribution of California Housing by Vintage

Home Vintage	Units	Percent	Cumulative Percent
Built 2014 or later	343,448	2.4%	2.4%
Built 2010 to 2013	248,659	1.7%	4.1%
Built 2000 to 2009	1,553,769	10.9%	15.0%
Built 1990 to 1999	1,561,579	10.9%	26.0%
Built 1980 to 1989	2,118,545	14.8%	40.8%
Built 1970 to 1979	2,512,178	17.6%	58.4%
Built 1960 to 1969	1,925,945	13.5%	71.9%
Built 1950 to 1959	1,896,629	13.3%	85.2%
Built 1940 to 1949	817,270	5.7%	90.9%
Built 1939 or earlier	1,299,845	9.1%	100.0%
Total housing units	**14,277,867**	**100%**	

Source: (2018 American Community Survey n.d.)

Table 8 shows the distribution of owner- and renter-occupied housing by household income. Overall, about 55 percent of California housing is owner-occupied and the rate of owner-occupancy generally increases with household income. The owner-occupancy rate for households with income below $50,000 is only 37 percent, whereas the owner occupancy rate is 72 percent for households earning $100,000 or more.

Table 8: Owner- and Renter-Occupied Housing Units in California by Income

Household Income	Total	Owner Occupied	Renter Occupied
Less than $5,000	391,235	129,078	262,157
$5,000 to $9,999	279,442	86,334	193,108
$10,000 to $14,999	515,804	143,001	372,803
$15,000 to $19,999	456,076	156,790	299,286
$20,000 to $24,999	520,133	187,578	332,555
$25,000 to $34,999	943,783	370,939	572,844
$35,000 to $49,999	1,362,459	590,325	772,134
$50,000 to $74,999	2,044,663	1,018,107	1,026,556
$75,000 to $99,999	1,601,641	922,609	679,032
$100,000 to $149,999	2,176,125	1,429,227	746,898
$150,000 or more	2,780,761	2,131,676	649,085
Total Housing Units	**13,072,122**	**7,165,664**	**5,906,458**
Median household income	**$75,277**	**$99,245**	**$52,348**

Source: (2018 American Community Survey n.d.)

Understanding the distribution of California residents by home type, home vintage, and household income is critical for developing meaningful estimates of the economic impacts associated with proposed code changes affecting residents. Many proposed code changes specifically target single-family or multi-family residences and so the counts of housing units by building type shown in Table 6 provides the information necessary to quantify the magnitude of potential impacts. Likewise, impacts may differ for owners and renters, by home vintage, and by household income, information provided in Table 7 and Table 8.

3.1.3.5 Impact on Building Component Retailers (Including Manufacturers and Distributors)

The Statewide CASE Team anticipates the proposed change would have no material impact on California component retailers.

3.1.3.6 Impact on Building Inspectors

Table 9 shows employment and payroll information for state and local government agencies in which many inspectors of residential and commercial buildings are employed. Building inspectors participate in continuing training to stay current on all aspects of building regulations, including energy efficiency. The Statewide CASE Team, therefore, anticipates the proposed change would have no impact on employment of building inspectors or the scope of their role conducting energy efficiency inspections.

Table 9: Employment in California State and Government Agencies with Building Inspectors

Sector	Govt.	Establishments	Employment	Annual Payroll (millions $)
Administration of Housing Programs[a]	State	17	283	$29.0
	Local	36	2,882	$205.7
Urban and Rural Development Admin[b]	State	35	552	$48.2
	Local	52	2,446	$186.6

Source: (State of California, Employment Development Department n.d.)

a. Administration of Housing Programs (NAICS 925110) comprises government establishments primarily engaged in the administration and planning of housing programs, including building codes and standards, housing authorities, and housing programs, planning, and development.

b. Urban and Rural Development Administration (NAICS 925120) comprises government establishments primarily engaged in the administration and planning of the development of urban and rural areas. Included in this industry are government zoning boards and commissions.

3.1.3.7 Impact on Statewide Employment

As described in Sections 3.1.3.1 through 3.1.3.6, the Statewide CASE Team does not anticipate significant employment or financial impacts to any particular sector of the California economy. This is not to say that the proposed change would not have modest impacts on employment in California. In Section 3.1.4, the Statewide CASE Team estimated the proposed change in battery storage system submeasure would affect statewide employment and economic output directly and indirectly through its impact on builders, designers and energy consultants, and building inspectors. In addition, the Statewide CASE Team estimated how energy savings associated with the proposed change in battery storage system submeasure would lead to modest ongoing financial savings for California residents, which would then be available for other economic activities.

3.1.4 Economic Impacts

The code change proposal is for a compliance option and as a result Market Analysis Economic Impacts are not presented.

3.2 HPWH Load Shifting

3.2.1 Market Structure

The national residential water heater market is dominated by three main manufacturers who market products under various brand names: A.O. Smith, Rheem, and Bradford White. In terms of the distribution channel, some manufacturers sell only through wholesale channels, while some sell through both wholesale and retail channels. The estimated 72,000 HPWHs sold nationally in 2018 represent a small fraction of the 8.75 million residential water heaters sold in that year (0.8 percent). However, sales are increasing and changes in California will impact the market in the years ahead. The 2019 Title 24, Part 6 code, which took effect January 2020, and the introduction of the all-electric baseline in the 2019 code cycle removes a key compliance barrier to wider spread adoption of HPWHs. In addition, reach code activities (whereby California jurisdictions adopt building codes surpassing Title 24, Part 6 requirements) have resulted in over 30 jurisdictions (Building Decarbonization Coalition 2019) adopting building energy requirements based on all-electric only codes (as of September 2020). Utility programs are also becoming more active in promoting residential HPWHs with rebates ranging from $300 to up to $3,000 from various California electric utility agencies (SMUD 2019) (Pacific Gas and Electric 2019) (San Diego Gas and Electric 2019).

3.2.2 Technical Feasibility, Market Availability, and Current Practices

HPWH manufacturers have been actively participating in various LSHPWH laboratory and field pilot projects over the past five years, such as the 2018 BPA study. Rheem is currently participating in a load shifting pilot project with PG&E in which the HPWH storage tank setpoint is raised to 140°F in the afternoon. This pilot effort is in anticipation for PG&E’s WattSaver LSHPWH program that is planned for mid-to-late

2020 rollout[8]. In strategically overheating the storage tank, the HPWHs will shape their electrical load profile to better align with the renewable generation characteristics of California's electrical grid. Heating above normal setpoints, up to ~140°F, will have implications on HPWH operating efficiency but does not place any undue demands on the equipment itself which already has capabilities to operate to those tank temperatures or higher (in fact users may adjust the set point up to 140°F on all currently available products).

Each manufacturer has taken their own proprietary approach in developing control logic to determine how their units will respond to various control signals. Much of this will continue to evolve in the coming months and years as various activities currently underway move towards completion. The recent adoption of JA13, the impact of the Washington state legislation, and the finalization of ENERGY STAR's grid connected water heater specification will also inform manufacturer's LSHPWH control strategies. Based on product offerings and capabilities of new and emerging HPWHs (as observed at the SMUD Statewide Advanced Water Heating Initiative Meeting and Heat Pump Water Heater Exposition held January 23rd and 24th, 2020), all the major manufacturers (including AO Smith, Bradford White, General Electric, and Rheem, among others) are working towards implementing grid connected LSHPWH capabilities, including implementing CTA-2045, in the near term. From a technical feasibility perspective, there should not be any significant barriers for the industry to develop these water heaters and control capabilities at a low incremental cost over standard HPWH products (see cost discussion in Section 5.2). The Statewide CASE Team feels that all the major manufacturers are supportive of this technology area as it offers significant market share growth potential.

The Statewide CASE Team reached out to key stakeholders and manufacturers to discuss the proposed LSHPWH submeasure. Communications with BPA, NEEA, and EPRI helped inform the Statewide CASE Team on activities and lessons learned from recent projects. Manufacturer communications and participation in venues such as the SMUD HPWH Expo provided additional indications of where the industry is heading. Finally, outreach to utility program managers informed on the status of upcoming LSHPWH incentive programs that should be available in the 2020 to 2025 timeframe.

The estimated impacts of the LSHPWH Basic Plus measure are expected to show persistence over time. Although there is commonly variability in hot water load magnitude and timing of draw events from day to day in typical households, the savings generated through the CBECC-Res software also reflects a wide range of daily load diversity. This representation of load diversity coupled with known performance of HPWHs under varying average tank temperatures should result in stable performance

[8] Personal communication with Ben Brown, PG&E (December 20, 2019)

over many years. Changes in time of use schedules or other control inputs over the years may influence the impacts to some degree, presumably to better align with the market signals. If TOU rates are stored on the Cloud, any rate change updates can easily be communicated to dispersed HPWHs.

One potential risk to savings longevity is the specific communications pathway used to connect to the water heater. While time of use schedules will be imbedded in the water heater as per the requirements outlined in JA13, increased savings due to direct and active water heater control will require connectivity. Homeowner based WiFi communication pathways are known to have increased dropout rates over time as documented in the 2018 BPA pilot study (Bonneville Power Administration 2018). Consequently, the Statewide CASE Team is recommending that the 2022 LSHPWH submeasure require the CTA-2045 interface to establish a more robust and diverse set of communications possibilities with the water heater. This would increase the savings persistence over the life of the appliance and standardize the hardware solution resulting in lower costs.

One key element of the JA13 specification is the requirement to install a tempering valve. This represents a deviation from typical residential plumbing practice, but by no means is a process that is foreign to the mainstream plumbing industry. Tempering valves are flow control devices that blend incoming hot water from the water heater and cold potable water to provide a mixed water stream at a specified temperature. With LSHPWHs operating in Basic Plus or Advanced Load Up modes boosting tank temperatures above normal setpoint, the tempering valve will ensure that the supplied hot water temperature is delivered at a safe temperature to the end user. General Electric debuted a new HPWH with an integrated mixing valve at the SMUD HPWH Expo on January 23, 2020 and has plans to start selling the product within the year. For all other water heaters, tempering valves currently need to be installed separately at time of water heater installation[9]. In the future, more LSHPWH products may be built with integrated tempering valves which will decrease the system installed cost due to reduced field labor. From an occupant perspective, the tempering valve will result in hot water delivery at a fixed and safe supply water temperature, regardless if the tank is heated above normal set points.

HERS verification requirements would not require any diagnostic testing. It is anticipated that any HERS verifications would be limited to confirming HPWH make and model number, confirming that the installed unit is configured to operate in a Basic Plus control mode under a site appropriate TOU rate schedule, and the one page operational flyer is attached to the water heater.

[9] Sanden HPWHs includes a tempering valve with the installation kit for their water heater.

3.2.3 Market Impacts and Economic Assessments

3.2.3.1 Impact on Builders

Builders of residential and commercial structures are directly impacted by many of the proposed measures for the 2022 code cycle. It is within the normal practices of these businesses to adjust their building practices to changes in building codes. When necessary, builders engage in continuing education and training in order to remain compliant with changes to design practices and building codes.

California's construction industry is comprised of about 80,000 business establishments and 860,000 employees (see Table 10).[10] In 2018, total payroll was $80 billion. Nearly 60,000 of these business establishments and 420,000 employees are engaged in the residential building sector. The remainder of establishments and employees work in commercial, industrial, utilities, infrastructure, and other heavy construction (industrial sector).

Table 10: California Construction Industry, Establishments, Employment, and Payroll

Construction Sectors	Establishments	Employment	Annual Payroll (billions $)
Residential	**59,287**	**420,216**	**$23.3**
Residential Building Construction Contractors	22,676	115,777	$7.4
Foundation, Structure, & Building Exterior	6,623	75,220	$3.6
Building Equipment Contractors	14,444	105,441	$6.0
Building Finishing Contractors	15,544	123,778	$6.2
Commercial	**17,273**	**343,513**	**$27.8**
Commercial Building Construction	4,508	75,558	$6.9
Foundation, Structure, & Building Exterior	2,153	53,531	$3.7
Building Equipment Contractors	6,015	128,812	$10.9
Building Finishing Contractors	4,597	85,612	$6.2
Industrial, Utilities, Infrastructure, & Other	**4,103**	**96,550**	**$9.2**
Industrial Building Construction	299	5,864	$0.5
Utility System Construction	1,643	47,619	$4.3
Land Subdivision	952	7,584	$0.9
Highway, Street, and Bridge Construction	770	25,477	$2.4
Other Heavy Construction	439	10,006	$1.0

Source: (State of California, Employment Development Department n.d.)

[10] Average total monthly employment in California in 2018 was 18.6 million; the construction industry represented 4.5 percent of 2018 employment.

The proposed change to the LSHPWH submeasure would likely affect residential builders but would not impact firms that focus on construction and retrofit of industrial buildings, utility systems, public infrastructure, or other heavy construction. The effects on the residential and commercial building industry would not be felt by all firms and workers, but rather would be concentrated in specific industry subsectors. Table 11 shows the residential building subsectors. Sectors that are involved with the installation of LSHPWHs would need to account for updated code requirements.

Table 11: Size of the California Residential Building Industry by Subsector

Residential Building Subsector	Establishments	Employment	Annual Payroll (billions $)
New single family general contractors	10,968	55,592	$3.7
New multifamily general contractors	406	5,333	$0.5
New housing for-sale builders	180	2,719	$0.3
Residential Remodelers	11,122	52,133	$3.0
Residential Electrical Contractors	6,095	37,933	$2.2
Residential plumbing and HVAC contractors	8,086	66,177	$3.8

Source: (State of California, Employment Development Department n.d.)

3.2.3.2 Impact on Building Designers and Energy Consultants

Adjusting design practices to comply with changing building codes practices is within the normal practices of building designers. Building codes (including Title 24, Part 6) are typically updated on a three-year revision cycle and building designers and energy consultants engage in continuing education and training in order to remain compliant with changes to design practices and building codes.

Businesses that focus on residential, commercial, institutional, and industrial building design are contained within the Architectural Services sector (North American Industry Classification System 541310). Table 12 shows the number of establishments, employment, and total annual payroll for Building Architectural Services. The proposed code changes for the 2022 code cycle would potentially impact all firms within the Architectural Services sector. The Statewide CASE Team anticipates the impacts for the LSHPWH submeasure to affect firms that focus on single family construction.

There is not a North American Industry Classification System (NAICS)[11] code specific

[11] NAICS is the standard used by federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy. NAICS was development jointly by the U.S. Economic Classification Policy Committee (ECPC), Statistics

for energy consultants. Instead, businesses that focus on consulting related to building energy efficiency are contained in the Building Inspection Services sector (NAICS 541350), which is comprised of firms primarily engaged in the physical inspection of residential and nonresidential buildings.[12] It is not possible to determine which business establishments within the Building Inspection Services sector are focused on energy efficiency consulting. The information shown in Table 12 provides an upper bound indication of the size of this sector in California.

Table 12: California Building Designer and Energy Consultant Sectors

Sector	Establishments	Employment	Annual Payroll (billions $)
Architectural Services [a]	3,704	29,611	$2.91
Building Inspection Services [b]	824	3,145	$0.22

Source: (State of California, Employment Development Department n.d.)

a. Architectural Services (NAICS 541310) comprises private-sector establishments primarily engaged in planning and designing residential, institutional, leisure, commercial, and industrial buildings and structures;
b. Building Inspection Services (NAICS 541350) comprises private-sector establishments primarily engaged in providing building (residential & nonresidential) inspection services encompassing all aspects of the building structure and component systems, including energy efficiency inspection services.

3.2.3.3 Impact on Occupational Safety and Health

The proposed code change does not alter any existing federal, state, or local regulations pertaining to safety and health, including rules enforced by the California Division of Occupational Safety and Health (Cal/OSHA). All existing health and safety rules would remain in place. Complying with the proposed code change is not anticipated to have adverse impacts on the safety or health of occupants or those involved with the construction, commissioning, and maintenance of the building.

Canada, and Mexico's Instituto Nacional de Estadistica y Geografia, to allow for a high level of comparability in business statistics among the North American countries. NAICS replaced the Standard Industrial Classification (SIC) system in 1997.

[12] Establishments in this sector include businesses primarily engaged in evaluating a building's structure and component systems and includes energy efficiency inspection services and home inspection services. This sector does not include establishments primarily engaged in providing inspections for pests, hazardous wastes or other environmental contaminates, nor does it include state and local government entities that focus on building or energy code compliance/enforcement of building codes and regulations.

3.2.3.4 Impact on Building Owners and Occupants

According to data from the U.S. Census, American Community Survey (ACS), there were nearly 14.3 million housing units in California in 2018 and nearly 13.1 million were occupied (see Table 13). Most housing units (nearly 9.2 million were single-family homes (either detached or attached), while about 2 million homes were in building containing two to nine units and 2.5 million were in multi-family building containing 10 or more units. The U.S. Census reported that 59,200 single-family and 50,700 multi-family homes were constructed in 2019.

Table 13: California Housing Characteristics

Housing Measure	**Estimate**
Total housing units	14,277,867
Occupied housing units	13,072,122
Vacant housing units	1,205,745
Homeowner vacancy rate	1.2%
Rental vacancy rate	4.0%
Units in Structure	**Estimate**
1-unit, detached	8,177,141
1-unit, attached	1,014,941
2 units	358,619
3 or 4 units	783,963
5 to 9 units	874,649
10 to 19 units	742,139
20 or more units	1,787,812
Mobile home, RV, etc.	538,603

Source: (2018 American Community Survey n.d.)

Table 14 shows the distribution of California homes by vintage. About 15 percent of California homes were built in 2000 or later and another 11 percent built between 1990 and 1999. The majority of California's existing housing stock (8.5 million homes – 59% of the total) were built between 1950 and 1989, a period of rapid population and economic growth in California. Finally, about 2.1 million homes in California were built before 1950. According to Kenney et al, 2019, more than half of California's existing multifamily buildings (those with five or more units) were constructed before 1978 when there no building energy efficiency standards (Kenney, 2019 California Energy Efficiency Action Plan 2019).

Table 14: Distribution of California Housing by Vintage

Home Vintage	Units	Percent	Cumulative Percent
Built 2014 or later	343,448	2.4%	2.4%
Built 2010 to 2013	248,659	1.7%	4.1%
Built 2000 to 2009	1,553,769	10.9%	15.0%
Built 1990 to 1999	1,561,579	10.9%	26.0%
Built 1980 to 1989	2,118,545	14.8%	40.8%
Built 1970 to 1979	2,512,178	17.6%	58.4%
Built 1960 to 1969	1,925,945	13.5%	71.9%
Built 1950 to 1959	1,896,629	13.3%	85.2%
Built 1940 to 1949	817,270	5.7%	90.9%
Built 1939 or earlier	1,299,845	9.1%	100.0%
Total housing units	**14,277,867**	**100%**	

Source: (2018 American Community Survey n.d.)

Table 15 shows the distribution of owner- and renter-occupied housing by household income. Overall, about 55 percent of California housing is owner-occupied and the rate of owner-occupancy generally increases with household income. The owner-occupancy rate for households with income below $50,000 is only 37 percent, whereas the owner occupancy rate is 72 percent for households earning $100,000 or more.

Table 15: Owner- and Renter-Occupied Housing Units in California by Income

Household Income	Total	Owner Occupied	Renter Occupied
Less than $5,000	391,235	129,078	262,157
$5,000 to $9,999	279,442	86,334	193,108
$10,000 to $14,999	515,804	143,001	372,803
$15,000 to $19,999	456,076	156,790	299,286
$20,000 to $24,999	520,133	187,578	332,555
$25,000 to $34,999	943,783	370,939	572,844
$35,000 to $49,999	1,362,459	590,325	772,134
$50,000 to $74,999	2,044,663	1,018,107	1,026,556
$75,000 to $99,999	1,601,641	922,609	679,032
$100,000 to $149,999	2,176,125	1,429,227	746,898
$150,000 or more	2,780,761	2,131,676	649,085
Total Housing Units	**13,072,122**	**7,165,664**	**5,906,458**
Median household income	**$75,277**	**$99,245**	**$52,348**

Source: (2018 American Community Survey n.d.)

Understanding the distribution of California residents by home type, home vintage, and household income is critical for developing meaningful estimates of the economic impacts associated with proposed code changes affecting residents. Many proposed code changes specifically target single-family or multi-family residences and so the counts of housing units by building type shown in Table 13 provides the information necessary to quantify the magnitude of potential impacts. Likewise, impacts may differ for owners and renters, by home vintage, and by household income, information provided in Table 14 and Table 15.

3.2.3.5 Impact on Building Component Retailers (Including Manufacturers and Distributors)

The Statewide CASE Team anticipates the proposed change would have no material impact on California component retailers.

3.2.3.6 Impact on Building Inspectors

Table 16 shows employment and payroll information for state and local government agencies in which many inspectors of residential and commercial buildings are employed. Building inspectors participate in continuing training to stay current on all aspects of building regulations, including energy efficiency. The Statewide CASE Team, therefore, anticipates the proposed change would have no impact on employment of building inspectors or the scope of their role conducting energy efficiency inspections.

Table 16: Employment in California State and Government Agencies with Building Inspectors

Sector	Govt.	Establishments	Employment	Annual Payroll (millions $)
Administration of Housing Programs[a]	State	17	283	$29.0
	Local	36	2,882	$205.7
Urban and Rural Development Admin[b]	State	35	552	$48.2
	Local	52	2,446	$186.6

Source: (State of California, Employment Development Department n.d.)

a. Administration of Housing Programs (NAICS 925110) comprises government establishments primarily engaged in the administration and planning of housing programs, including building codes and standards, housing authorities, and housing programs, planning, and development.
b. Urban and Rural Development Administration (NAICS 925120) comprises government establishments primarily engaged in the administration and planning of the development of urban and rural areas. Included in this industry are government zoning boards and commissions.

3.2.3.7 Impact on Statewide Employment

As described in Sections 3.2.3.1 through 3.2.3.6, the Statewide CASE Team does not anticipate significant employment or financial impacts to any particular sector of the California economy. This is not to say that the proposed change would not have modest impacts on employment in California. In Section 3.2.4, the Statewide CASE Team estimated the proposed change in LSHWPH submeasure would affect statewide employment and economic output directly and indirectly through its impact on builders, designers and energy consultants, and building inspectors. In addition, the Statewide CASE Team estimated how energy savings associated with the proposed change in the LSHPWH submeasure would lead to modest ongoing financial savings for California residents, which would then be available for other economic activities.

3.2.4 Economic Impacts

The code change proposal is for a compliance option and as a result Market Analysis Economic Impacts are not presented.

3.3 HVAC Load Shifting

3.3.1 Market Structure

According to the DOE Energy Information Administration's Residential Energy Consumption Survey, in 2015 only about 12 percent of the nation's 118 million households had a central air-conditioning unit that is actually controlled using a programmed thermostat. About one in three households using central air conditioning do not have a programmable thermostat. But even for those households that use central air conditioning and have a programmable thermostat, more than two-thirds of those households control temperatures without actually programming the thermostat (DOE EIA 2017).

In the Pacific Region of the US in 2015, about half of homes used central air conditioning, and of those almost all used a thermostat (DOE EIA 2015). About 83 percent of thermostats were programmable (or smart). California had about 11.3 million households in 2015 (California Energy Commission Demand Analysis Office 2015-2024 Forecast), corresponding to about 4.4 million programmable (or smart) thermostats in the residential building stock.

And it is estimated that about 5-6 percent of US homes currently use a smart thermostat. From 2016-2019, smart thermostat adoption rate in the U.S. tripled from 4 to 12 percent (ACHR News 2019). Smart thermostats represented over a billion dollars in sales in the U.S. in 2016. (NEEP 2016), and the primary manufacturers include Nest, Honeywell, and Ecobee. Existing HVAC competitors include Trane, Carrier, Lennox and Emerson.

Despite their low saturation, as of 2015, smart thermostats accounted for over 40 percent of the nearly 10 million thermostats sold in the U.S. (Park Associates 2015), so they are a growing market. The distribution channels of smart thermostats are different than programmable thermostats (and most other energy efficient products). According to Parks & Associates (cited in NEEP, 2016), the identified distribution channels in 2015 are shown in Table 17.

Table 17: Distribution Channels for Smart Thermostats

Distribution Channel	Percent of Smart Thermostat Market	Programmable Thermostats using this Channel?
National or local retailer	28	Yes
Online-only retailer	18	Yes
Broadband service provider	15	No
Custom installer	10	No
HVAC Contractor	10	Yes
Security dealer	10	No
Electricity provider	5	No
Other service contractor	4	No

Source: Parks Associates 2015, cited in NEEP 2016

3.3.2 Technical Feasibility, Market Availability, and Current Practices

Starting in 1995, ENERGY STAR began promoting programmable thermostats as a means of reducing space conditioning energy use. Estimates of savings impact suggested programmable thermostats could reduce heating and cooling bills by 10-30 percent, based on simple simulations (Malinick, Wilairat, et al. 2012). The analysis typically assumed that without programmable thermostats, users maintained a constant setpoint, and that with programmable thermostats, a regular setback program would be used.

It has been found that neither of these assumptions is necessarily accurate (Meier 2011) (Meier, Aragon, et al. 2000). The projected savings were not materializing, and the ENERGY STAR programmable thermostat program was suspended in 2009. A new program was established in 2016, to certify Connected Thermostat products.

Smart thermostats are not without their troubles either, however. Outcault et al (2014) found that user experience with a smart thermostat was generally not favorable. Six out of the ten users surveyed were “mostly unsure” that the smart thermostat did what they wanted it to do (only one reported the same concerns about their prior programmable thermostat), and four reported being “completely unsure.” In open-ended comments, at least half mentioned things like “the thermostat seems to have a mind of its own”; “it does not do what I want it to do” or “it turns on and off at will.” One asked “how can the thermostat be put back into mode where it operates like a normal thermostat?”

Smart thermostats are also much more expensive than standard thermostats. Costs for smart thermostats range from $145 to $249 (NEEP 2016), while simple programmable thermostats can be found for as low as about $20 (and nonprogrammable thermostats as low as $15). To the extent that smart thermostats rely on connectivity in order to implement control optimization or demand response strategies, then, their implementation cost might need to include the cost of bringing internet into the home and monthly service fees. Keeping the internet up and running, as well as establishing and maintaining connectivity of the thermostat can also be problematic in households that are not "tech savvy."

Given the concerns that programmable thermostats do not provide reliable savings, and usability issues with smart thermostats, what is the most reliable way to control HVAC systems in single family homes? Until the Energy Commission can be confident that smart thermostats can be delivered and operated without usability issues, some form of programmable or setback thermostat with pre-cooling features will have to be considered to reach the broadest cross-section of the households throughout the state. This is why the Statewide CASE Team is recommending providing credit for installation of PCTs (based on programmable thermostats) in addition to DMTs.

With most California residential customers being moved to TOU rates in the coming year (many not voluntarily), and the sensitivity and anxiety that that can cause, customers may be eagerly looking for a solution to control costs with the new TOU rates under which they will be operating their dwellings. They may also be looking for a simple and transparent solution that will not either overwhelm them with complexity or take their control away (either in reality or in perception).

3.3.3 Market Impacts and Economic Assessments

3.3.3.1 Impact on Builders

Builders of residential and commercial structures are directly impacted by many of the proposed measures for the 2022 code cycle. It is within the normal practices of these businesses to adjust their building practices to changes in building codes. When necessary, builders engage in continuing education and training in order to remain compliant with changes to design practices and building codes.

California's construction industry is comprised of about 80,000 business establishments and 860,000 employees (see Table 18).[13] In 2018, total payroll was $80 billion. Nearly 60,000 of these business establishments and 420,000 employees are engaged in the residential building sector. The remainder of establishments and employees work in commercial, industrial, utilities, infrastructure, and other heavy construction (industrial sector).

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[13] Average total monthly employment in California in 2018 was 18.6 million; the construction industry represented 4.5 percent of 2018 employment.

Table 18: California Construction Industry, Establishments, Employment, and Payroll

Construction Sectors	Establishments	Employment	Annual Payroll (billions $)
Residential	**59,287**	**420,216**	**$23.3**
Residential Building Construction Contractors	22,676	115,777	$7.4
Foundation, Structure, & Building Exterior	6,623	75,220	$3.6
Building Equipment Contractors	14,444	105,441	$6.0
Building Finishing Contractors	15,544	123,778	$6.2
Commercial	**17,273**	**343,513**	**$27.8**
Commercial Building Construction	4,508	75,558	$6.9
Foundation, Structure, & Building Exterior	2,153	53,531	$3.7
Building Equipment Contractors	6,015	128,812	$10.9
Building Finishing Contractors	4,597	85,612	$6.2
Industrial, Utilities, Infrastructure, & Other	**4,103**	**96,550**	**$9.2**
Industrial Building Construction	299	5,864	$0.5
Utility System Construction	1,643	47,619	$4.3
Land Subdivision	952	7,584	$0.9
Highway, Street, and Bridge Construction	770	25,477	$2.4
Other Heavy Construction	439	10,006	$1.0

Source: (State of California, Employment Development Department n.d.)

The proposed change to HVAC control would likely affect residential builders but would not impact firms that focus on construction and retrofit of industrial buildings, utility systems, public infrastructure, or other heavy construction. The effects on the residential and commercial building industry would not be felt by all firms and workers, but rather would be concentrated in specific industry subsectors. Table 19 shows the residential building subsectors. Sectors that are involved with the installation of pre-cooling thermostats would need to account for updated code requirements. The Statewide CASE Team's estimates of the magnitude of these impacts are shown in Section 3.3.4 Economic Impacts.

Table 19: Size of the California Residential Building Industry by Subsector

Residential Building Subsector	Establishments	Employment	Annual Payroll (billions $)
New single family general contractors	10,968	55,592	$3.7
Residential Remodelers	11,122	52,133	$3.0
Other Residential Equipment Contractors	263	1,331	$0.1
All other residential trade contractors	2,356	21,280	$1.2

Source: (State of California, Employment Development Department n.d.)

3.3.3.2 Impact on Building Designers and Energy Consultants

Adjusting design practices to comply with changing building codes practices is within the normal practices of building designers. Building codes (including Title 24, Part 6) are typically updated on a three-year revision cycle and building designers and energy consultants engage in continuing education and training in order to remain compliant with changes to design practices and building codes.

Businesses that focus on residential, commercial, institutional, and industrial building design are contained within the Architectural Services sector (North American Industry Classification System 541310). Table 20 shows the number of establishments, employment, and total annual payroll for Building Architectural Services. The proposed code changes for the 2022 code cycle would potentially impact all firms within the Architectural Services sector. The Statewide CASE Team anticipates the impacts for the battery storage system submeasure to affect firms that focus on single family construction.

There is not a North American Industry Classification System (NAICS)[14] code specific for energy consultants. Instead, businesses that focus on consulting related to building energy efficiency are contained in the Building Inspection Services sector (NAICS 541350), which is comprised of firms primarily engaged in the physical inspection of residential and nonresidential buildings.[15] It is not possible to determine which business establishments within the Building Inspection Services sector are focused on energy efficiency consulting. The information shown in Table 20 provides an upper bound indication of the size of this sector in California.

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[14] NAICS is the standard used by Federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy. NAICS was development jointly by the U.S. Economic Classification Policy Committee (ECPC), Statistics Canada, and Mexico's Instituto Nacional de Estadistica y Geografia, to allow for a high level of comparability in business statistics among the North American countries. NAICS replaced the Standard Industrial Classification (SIC) system in 1997.

[15] Establishments in this sector include businesses primarily engaged in evaluating a building's structure and component systems and includes energy efficiency inspection services and home inspection services. This sector does not include establishments primarily engaged in providing inspections for pests, hazardous wastes or other environmental contaminates, nor does it include state and local government entities that focus on building or energy code compliance/enforcement of building codes and regulations.

Table 20: California Building Designer and Energy Consultant Sectors

Sector	Establishments	Employment	Annual Payroll (billions $)
Architectural Services [a]	3,704	29,611	$2.91
Building Inspection Services [b]	824	3,145	$0.22

Source: (State of California, Employment Development Department n.d.)

a. Architectural Services (NAICS 541310) comprises private-sector establishments primarily engaged in planning and designing residential, institutional, leisure, commercial, and industrial buildings and structures;

b. Building Inspection Services (NAICS 541350) comprises private-sector establishments primarily engaged in providing building (residential & nonresidential) inspection services encompassing all aspects of the building structure and component systems, including energy efficiency inspection services.

3.3.3.3 Impact on Occupational Safety and Health

The proposed code change does not alter any existing federal, state, or local regulations pertaining to safety and health, including rules enforced by the California Division of Occupational Safety and Health (Cal/OSHA). All existing health and safety rules would remain in place. Complying with the proposed code change is not anticipated to have adverse impacts on the safety or health of occupants or those involved with the construction, commissioning, and maintenance of the building.

3.3.3.4 Impact on Building Owners and Occupants

Residential Buildings

According to data from the U.S. Census, American Community Survey (ACS), there were nearly 14.3 million housing units in California in 2018 and nearly 13.1 million were occupied (see Table 21). Most housing units (nearly 9.2 million were single-family homes (either detached or attached), while about 2 million homes were in building containing two to nine units and 2.5 million were in multi-family building containing 10 or more units. The U.S. Census reported that 59,200 single-family and 50,700 multi-family homes were constructed in 2019.

Table 21: California Housing Characteristics

Housing Measure	Estimate
Total housing units	14,277,867
Occupied housing units	13,072,122
Vacant housing units	1,205,745
Homeowner vacancy rate	1.2%
Rental vacancy rate	4.0%
Units in Structure	**Estimate**
1-unit, detached	8,177,141
1-unit, attached	1,014,941
2 units	358,619
3 or 4 units	783,963
5 to 9 units	874,649
10 to 19 units	742,139
20 or more units	1,787,812
Mobile home, RV, etc.	538,603

Source: (2018 American Community Survey n.d.)

Table 22 shows the distribution of California homes by vintage. About 15 percent of California homes were built in 2000 or later and another 11 percent built between 1990 and 1999. The majority of California's existing housing stock (8.5 million homes – 59 percent of the total) were built between 1950 and 1989, a period of rapid population and economic growth in California. Finally, about 2.1 million homes in California were built before 1950. According to Kenney et al, 2019, more than half of California's existing multifamily buildings (those with five or more units) were constructed before 1978 when there no building energy efficiency standards (Kenney, 2019 California Energy Efficiency Action Plan 2019).

Table 22: Distribution of California Housing by Vintage

Home Vintage	Units	Percent	Cumulative Percent
Built 2014 or later	343,448	2.4%	2.4%
Built 2010 to 2013	248,659	1.7%	4.1%
Built 2000 to 2009	1,553,769	10.9%	15.0%
Built 1990 to 1999	1,561,579	10.9%	26.0%
Built 1980 to 1989	2,118,545	14.8%	40.8%
Built 1970 to 1979	2,512,178	17.6%	58.4%
Built 1960 to 1969	1,925,945	13.5%	71.9%
Built 1950 to 1959	1,896,629	13.3%	85.2%
Built 1940 to 1949	817,270	5.7%	90.9%
Built 1939 or earlier	1,299,845	9.1%	100.0%
Total housing units	**14,277,867**	**100%**	

Source: (2018 American Community Survey n.d.)

Table 23 shows the distribution of owner- and renter-occupied housing by household income. Overall, about 55 percent of California housing is owner-occupied and the rate of owner-occupancy generally increases with household income. The owner-occupancy rate for households with income below $50,000 is only 37 percent, whereas the owner occupancy rate is 72 percent for households earning $100,000 or more.

Table 23: Owner- and Renter-Occupied Housing Units in California by Income

Household Income	Total	Owner Occupied	Renter Occupied
Less than $5,000	391,235	129,078	262,157
$5,000 to $9,999	279,442	86,334	193,108
$10,000 to $14,999	515,804	143,001	372,803
$15,000 to $19,999	456,076	156,790	299,286
$20,000 to $24,999	520,133	187,578	332,555
$25,000 to $34,999	943,783	370,939	572,844
$35,000 to $49,999	1,362,459	590,325	772,134
$50,000 to $74,999	2,044,663	1,018,107	1,026,556
$75,000 to $99,999	1,601,641	922,609	679,032
$100,000 to $149,999	2,176,125	1,429,227	746,898
$150,000 or more	2,780,761	2,131,676	649,085
Total Housing Units	**13,072,122**	**7,165,664**	**5,906,458**
Median household income	**$75,277**	**$99,245**	**$52,348**

Source: (2018 American Community Survey n.d.)

Understanding the distribution of California residents by home type, home vintage, and household income is critical for developing meaningful estimates of the economic impacts associated with proposed code changes affecting residents. Many proposed code changes specifically target single-family or multi-family residences and so the counts of housing units by building type shown in Table 21 provides the information necessary to quantify the magnitude of potential impacts. Likewise, impacts may differ for owners and renters, by home vintage, and by household income, information provided in Table 22 and Table 23.

3.3.3.5 Impact on Building Component Retailers (Including Manufacturers and Distributors)

The Statewide CASE Team anticipates the proposed change would have no material impact on California component retailers.

3.3.3.6 Impact on Building Inspectors

Table 24 shows employment and payroll information for state and local government agencies in which many inspectors of residential and commercial buildings are employed. Building inspectors participate in continuing training to stay current on all aspects of building regulations, including energy efficiency. The Statewide CASE Team, therefore, anticipates the proposed change would have no impact on employment of building inspectors or the scope of their role conducting energy efficiency inspections.

Table 24: Employment in California State and Government Agencies with Building Inspectors

Sector	Govt.	Establishments	Employment	Annual Payroll (millions $)
Administration of Housing Programs[a]	State	17	283	$29.0
	Local	36	2,882	$205.7
Urban and Rural Development Admin[b]	State	35	552	$48.2
	Local	52	2,446	$186.6

Source: (State of California, Employment Development Department n.d.)

a. Administration of Housing Programs (NAICS 925110) comprises government establishments primarily engaged in the administration and planning of housing programs, including building codes and standards, housing authorities, and housing programs, planning, and development.
b. Urban and Rural Development Administration (NAICS 925120) comprises government establishments primarily engaged in the administration and planning of the development of urban and rural areas. Included in this industry are government zoning boards and commissions.

3.3.3.7 Impact on Statewide Employment

As described in Sections 3.3.3.1 through 3.3.3.6, the Statewide CASE Team does not anticipate significant employment or financial impacts to any particular sector of the California economy. This is not to say that the proposed change would not have modest impacts on employment in California. In Section 3.3.4, the Statewide CASE Team estimated the proposed change in battery storage system submeasure would affect statewide employment and economic output directly and indirectly through its impact on builders, designers and energy consultants, and building inspectors. In addition, the Statewide CASE Team estimated how energy savings associated with the proposed change in battery storage system submeasure would lead to modest ongoing financial savings for California residents, which would then be available for other economic activities.

3.3.4 Economic Impacts

The code change proposal is for a compliance option and as a result Market Analysis Economic Impacts are not presented.

3.4 Home Energy Management

3.4.1 Market Structure

There are currently hundreds of HEMS products on the market with varying levels of capability and compatibility (Ford, et al. 2017). Many are information-based products that rely on occupant behavior to achieve savings in response to knowledge about their energy use, while others are controls-based and tend to save energy more predictably because occupants do not have to intervene. The most common categories of HEMS products include:

- Smart thermostats (generally included in new homes; may operate independently, accept grid signals, or be part of a HEMS)
- Smart appliances (often included in new homes, may accept grid signals or be part of a HEMS)
- Smart lighting (sometimes included in new homes, usually part of a HEMS)
- Smart plugs/outlets (smart outlets may be included by builder, smart power strips more likely to be purchased separately by homeowner)
- Smart hubs (centralized communications and control for devices from different manufacturers)
- Software platforms (data analytics, web interface, smart phone apps)

Although Amazon Echo and Google Home are dominant user interfaces for home energy management, these applications must generally be combined with a hub such as Samsung SmartThings and any number of individual devices (Saul-Rinaldi and Bunnen 2018). A recent study by PG&E (Ford, et al. 2017) discovered that over 40 percent of HEMS technologies disappeared from the market during the three years since the previous version of the study, highlighting the rapid change in the industry. In addition, manufacturer stakeholders interviewed by the Statewide CASE Team have expressed plans to provide both complete systems and components of systems that will be marketed by other companies. This diversity of products and the emerging nature of the HEMS market make it challenging to define and characterize HEMS attributes, costs, and energy savings potential.

A recent study of 1414 consumers by See Change Institute indicated that 21 percent owned at least one HEMS product. Market penetration for specific categories included 14 percent smart thermostats, 12 percent smart appliances, 7 percent plug load controls, and 5 percent lighting controls (Karlin 2019). A similar study by CLEAResult determined that approximately 32 percent of households had products that could be controlled by a smartphone, and 18 percent had a home automation device (most commonly smart thermostats, cameras/video doorbells, and smart lighting) (Kemper

2019). Other types of metering devices provide circuit level readings and can even use Non-Intrusive Load Monitoring (NILM) algorithms to disaggregate end-uses based on their transient electricity draws.

These studies predate the creation of the ENERGY STAR SHEMS certification process, and it is unlikely that many existing systems would fully comply with the SHEMS criteria. However, several manufacturers have confirmed to the Statewide team that they are working to develop ENERGY STAR certified systems, or components that will be included in systems certified by other manufacturers. For this reason, the Statewide CASE Team developed proposed code language that leverages ENERGY STAR SHEMS eligibility criteria to the extent possible, while avoiding a requirement for ENERGY STAR certification, which would be inappropriate in Title 24.

Most of the early adopters of HEMS are technologically savvy and have middle class incomes (Saul-Rinaldi and Bunnen 2018). One of the most significant barriers to deployment of HEMS is the level of technical sophistication required to select, install, and program compatible devices into a single integrated system. While strides are being made in user-friendliness, technical capabilities continue to grow, resulting in greater complexity. Several additional market barriers are summarized below (NEEP 2019):

- High product costs
- Unproven and unpredictable savings
- Data security/privacy
- Flat utility rates
- Proliferation of HEMS products with unknown and unregulated performance
- Unclear value proposition for all stakeholders (homeowners, builders, installers)
- Lack of interoperability among control systems and devices

Industry initiatives such as Project Connected Home over IP are bringing together leaders in smart home technology to enhance communication among smart technologies used in the home, and to strengthen the security of information shared on the internet. Project Connected Home over IP includes Google, Amazon, Apple, and other key players in the HEMS market, and offers the potential for greater standardization, increased homeowner confidence, and more predictable and reliable energy savings potential.

Audio visual equipment (AVE) installers would be responsible for documenting that the HEMS is listed as an approved product on the Energy Commission website, completing the CF2R compliance document, verifying that the HEMS communicates with connected devices and the utility, and submitting this information to the HERS rater. AVE installers also have an essential role in commissioning the HEMS to make sure it functions correctly, so homeowners receive the expected benefits of the system. Several contractors, including the AVE installer, HVAC installer, and electrician may need to coordinate the initial setup of HEMS components that include smart thermostats, occupancy sensors, lighting, appliances, and other devices. The AVE installer may also be responsible for explaining to homebuyers how to operate the HEMS functions in their new home, which is a key to achieving consistent energy savings. Approaches such as pay-for-performance may be another way for AVE installers to offer services to homebuyers skeptical about savings, for example using M&V 2.0 (Saul-Rinaldi and Bunnen 2018). Further information about market actors can be found in Appendix E.

3.4.2 Technical Feasibility, Market Availability, and Current Practices

3.4.2.1 Technical Feasibility

Home energy management has proven to be technically feasible given the large number of products on the market with an ever-growing range of capabilities. However, one factor limiting the recognition of HEMS as an energy efficiency measure in codes and incentive programs is how difficult it is to quantify energy and peak demand benefits based on the current state of scientific knowledge and on the wide diversity of functions and capabilities available. The following practical challenges must be addressed before specific energy efficiency and/or demand flexibility credits can be justified in Title 24, Part 6:

1. There are literally hundreds of HEMS devices available on the market, with various types of control logic, and they can be packaged in thousands of combinations. Many of these devices will be purchased and installed by homeowners after they move in, affecting energy savings for the HEMS in potentially unexpected ways.
2. A HEMS will generally consume standby energy as it tracks and reports on energy use and may include security or convenience features that increase energy use for some devices and could nullify overall HEMS savings. These negative effects must be factored into any net savings calculations, but there is very little reliable data currently available.
3. Homeowner acceptance of HEMS as part of a demand response program appears to be a significant challenge. A survey conducted by Evergreen Economics on behalf of the Statewide CASE Team indicated that only 32 percent of households would be likely to allow utility control of certain home appliances and electronics during peak demand hours, even with an incentive of $20/month (Evergreen Economics 2020). Lower income homeowners were more likely (39%) to accept the incentive and give up some control over their home electronics than higher income homeowners (26%). This suggests that wealthier

homeowners, who are likely to have a greater number of energy consuming devices in their homes, may be an especially challenging market for HEMS. Among the homeowners expressing reluctance, 69 percent identified loss of control of their living environment as a major concern. Other important concerns were inconvenience and potential intrusion on privacy. These results suggest that many homeowners would either decline to enroll in demand response programs that include utility control of their HEMS, or would override the utility signal frequently.

4. Occupant behavior has a very large effect on TDV savings, not simply based on how occupants interact with the HEMS (programming, disabling), but how often they would have left devices on when they weren't being used and how often they would have used devices during peak demand periods without using a HEMS. This behavior is not only impossible to predict for a specific set of occupants, it is extremely difficult to determine for average or representative occupants without large-scale studies of behavioral patterns that may cross the line on privacy. It may also change over time, as new energy-consuming devices become available and occupant behaviors change.
5. Reliable and secure communications and messaging protocols between smart homes hubs/central controllers, smart devices, and the grid must be established to ensure that the potential energy savings and demand reduction are realized in practice, On-site electricity generation and usage patterns should be factored into the control logic for the HEMS to enhance grid resilience. ZigBee SEP 1.x exists in most AMI meters in California, but there are limitations to its effectiveness as smart technologies continue to advance in their capabilities, and improved protocols will be needed.
6. Field studies of energy savings must include a very large number of houses to provide enough data for statistically significant conclusions, because of the wide range of HEMS products, connected devices, and occupant behavior. This would be extremely expensive, and the results would likely be meaningless when the next generation of HEMS technology arrives on the market. As a result, there are only a few reliable field studies, and they tend to be highly focused on a particular HEMS component or capability.
7. Building simulation tools do not include algorithms that can accurately estimate realistic time-dependent impacts of HEMS, primarily because of the unknown inputs described above.

Through discussions with stakeholders, four long term strategies seem viable for estimating energy savings for HEMS with some degree of accuracy, but further study may be needed to determine which approach will provide the best results:

1. Field Studies: The most convincing evidence of energy savings would be objective third-party testing of a large number of HEMS in a random sample of homes with different baseline use profiles of energy-consuming devices. The range of HEMS capabilities, control logic, and product combinations should be limited to just a few in order to keep sample sizes manageable. This would likely require the entity funding the field study to pay for the systems. An effort should be made to focus on the most impactful capabilities of HEMS (load disaggregation, smart outlets, smart appliances) and to use products that are proven in the market, which will limit the risk of test results becoming obsolete before they are published. The negatives of this approach include very high cost for the field study, and the limited range of features that can be evaluated.
2. Lab Studies: A more controlled and lower cost approach would be to test a variety of HEMS systems in combination with a representative set of actual or simulated plug loads, appliances, and lights in a laboratory environment. This approach allows greater flexibility, including the ability to test new HEMS designs in the future. It also allows straightforward comparisons across systems, and the ability to try what-if scenarios without the need to address human subjects issues. The largest negative of this approach is the reliance on simulated human behavior and decision-making processes that are largely unknown in reality.
3. Analytical Modeling: This approach would focus on simulating the functionality and control logic of various HEMS designs through modeling, instead of using actual systems and connected devices. In theory, this would provide a completely flexible and low cost method for predicting the energy savings of any theoretical combination of HEMS capabilities and connected devices, combined with any number of behavioral patterns. The negatives for this approach are the largely speculative inputs for occupant behavior (similar to Approach #2), and the likely challenge of obtaining proprietary control logic for many HEMS products.
4. Statistical Modeling: An alternative modeling approach would use statistical analysis to disaggregate the impacts of HEMS characteristics that could potentially be collected through incentive programs such as the California Advanced Homes Program (CAHP) Master Builder or labeling programs like ENERGY STAR. This approach avoids making assumptions about the decision-making processes of occupants and focuses on the end-results in real homes. The negatives include the potentially very high uncertainty when analyzing data with numerous uncontrolled variables, as well as the need to establish an incentive program that tracks enough information about the installed HEMS to allow accurate regression analysis of energy savings without a “baseline” case for comparison.

Persistence of energy savings is an additional uncertainty when considering the impact of HEMS on grid integration. There is clear potential for homeowners to begin disabling or overriding the energy management functions if they result in inconvenience or discomfort, as indicated by the Evergreen Economics survey (Evergreen Economics 2020). They may also replace components or the whole system as new technologies appear on the market. Even if homeowners are happy with the performance of a system, its useful life is unlikely to exceed five to ten years due to technology obsolescence.

3.4.2.2 Market Availability

Home automation technologies have become much more commonplace in recent years, providing services ranging from energy management (i.e. HEMS) to home security, entertainment, and convenience. Voice recognition technology has made interacting with such systems accessible and fun for homeowners at all levels of technical sophistication. ENERGY STAR has established certification criteria for SHEMS, which will likely lead to new fully packaged systems that increase homeowner confidence in performance, leading to greater demand for HEMS in the marketplace. There is no reason to expect the trend toward smarter homes with increasing levels of service to abate in the coming years, and it is therefore important for energy codes to begin grappling with the impacts of home automation on energy use. A successful approach will lead to greater deployment of home automation systems with HEMS capabilities that provide positive impacts on grid resilience through effective energy management.

Northeast Energy Efficiency Partnerships (NEEP) emphasizes the importance of certain essential attributes for an ideal Smart Home application (NEEP 2019):

- Highly efficient building envelope and mechanical equipment
- Presence of distributed energy resources (DERs), including PV, batteries, and EVs
- Electric space heating and water heating
- Integrated non-energy home automation components, such as home security and indoor air quality monitoring
- Two-way communication between the home and the utility or HEMS provider

There are several additional opportunities that could lead to HEMS with greater energy savings potential being deployed more effectively in the marketplace:

- Inherent data monitoring capabilities could assist with documenting energy savings for HEMS across a broad range of occupants and connected device combinations, although the data streams can be very large and cumbersome to process

- Expanded rebate programs for HEMS
- Greater use of TOU rates
- More advanced machine learning algorithms that can customize control logic to maximize savings based on the specific occupants and connected devices
- Bundling of compatible components
- Automatic detection, identification, and setup of devices when they are first connected
- Integration with fault detection capability, such as detecting an inefficient air conditioner or refrigerator
- Protection of data privacy. Many people believe their activities are being tracked and reported by home automation systems, and possibly sold to marketing firms.

3.4.2.3 Current Practices

Most HEMS products are currently purchased by homeowners and installed as retrofits. The new construction market offers opportunities for less expensive integrated systems that are fully compatible and hard-wired. However, the risk of technology obsolescence may discourage builders from installing a complete HEMS in new homes, unless the system is designed in a manner that can be readily upgraded as smart home technologies evolve. Certain HEMS components such as smart thermostats, smart outlets, and smart appliances are more likely to be provided in a new home than other devices, such as advanced power strips and smart TVs.

The requirements for AEETs rely to a great extent on those of the ENERGY STAR Program for Connected Thermostat Products. These requirements resulted from EPA’s extensive negotiations with industry and other stakeholders. The California investor owned utilities (IOUs) participated in ENERGY STAR negotiations for these products and provided extensive comments on draft requirements for the program, many of which were addressed in the final specifications. Some of their outstanding issues are addressed in the proposed measure.

The eligibility criteria for the proposed thermostat measure recognize EPA’s approach to verify savings embodied in the document “Method to Demonstrate Field Savings, Version 1.0 (rev. Dec-2016)” (EPA 2016) and relevant sections of “ENERGY STAR Program Requirements for Connected Thermostat Products.” (EPA 2017). ENERGY STAR metrics compare Smart Thermostat performance to a baseline of a constant-setpoint operation, while Title 24, Part 6 already requires setback thermostats and assumes a setback schedule. If Title 24, Part 6 gave full ENERGY STAR credit above and beyond CBECC-RES modeled performance, it would be double counting savings. It is not recommended, therefore, that ENERGY STAR savings be adopted by Title 24, Part 6. However, it is proposed that AEETs that meet the requirements of ENERGY STAR certification earn some credit under 2022 Title 24, Part 6: it is proposed that they be treated on an equal footing with DMTs (formerly known as OCSTs) as an exception to the solar zone area requirements, and as an option when performing winter HVAC refrigerant charge verification.

3.4.3 Market Impacts and Economic Assessments

3.4.3.1 Impact on Builders

Builders of residential and commercial structures are directly impacted by many of the proposed measures for the 2022 code cycle. It is within the normal practices of these businesses to adjust their building practices to changes in building codes. When necessary, builders engage in continuing education and training in order to remain compliant with changes to design practices and building codes.

California's construction industry is comprised of about 80,000 business establishments and 860,000 employees (see Table 25).[16] In 2018, total payroll was $80 billion. Nearly 60,000 of these business establishments and 420,000 employees are engaged in the residential building sector. The remainder of establishments and employees work in commercial, industrial, utilities, infrastructure, and other heavy construction (industrial sector).

Table 25: California Construction Industry, Establishments, Employment, and Payroll

Construction Sectors	Establishments	Employment	Annual Payroll (billions $)
Residential	**59,287**	**420,216**	**$23.3**
Residential Building Construction Contractors	22,676	115,777	$7.4
Foundation, Structure, & Building Exterior	6,623	75,220	$3.6
Building Equipment Contractors	14,444	105,441	$6.0
Building Finishing Contractors	15,544	123,778	$6.2
Commercial	**17,273**	**343,513**	**$27.8**
Commercial Building Construction	4,508	75,558	$6.9
Foundation, Structure, & Building Exterior	2,153	53,531	$3.7
Building Equipment Contractors	6,015	128,812	$10.9
Building Finishing Contractors	4,597	85,612	$6.2

[16] Average total monthly employment in California in 2018 was 18.6 million; the construction industry represented 4.5 percent of 2018 employment.

Construction Sectors	Establishments	Employment	Annual Payroll (billions $)
Industrial, Utilities, Infrastructure, & Other	**4,103**	**96,550**	**$9.2**
Industrial Building Construction	299	5,864	$0.5
Utility System Construction	1,643	47,619	$4.3
Land Subdivision	952	7,584	$0.9
Highway, Street, and Bridge Construction	770	25,477	$2.4
Other Heavy Construction	439	10,006	$1.0

Source: (State of California, Employment Development Department n.d.)

The proposed change to the HEMS submeasure would likely affect residential builders but would not impact firms that focus on construction and retrofit of industrial buildings, utility systems, public infrastructure, or other heavy construction. The effects on the residential and commercial building industry would not be felt by all firms and workers, but rather would be concentrated in specific industry subsectors. Table 26 shows the residential building subsectors the Statewide CASE Team expects to be impacted by the changes proposed in this report. Sectors that are involved with the installation of HEMS, smart thermostats, and other smart devices would need to account for updated code requirements. These sectors include electrical contractors and HVAC installers, in addition to builders and general contractors.

Table 26: Size of the California Residential Building Industry by Subsector

Residential Building Subsector	Establishments	Employment	Annual Payroll (billions $)
New single family general contractors	10,968	55,592	$3.7
New multifamily general contractors	406	5,333	$0.5
New housing for-sale builders	180	2,719	$0.3
Residential Electrical Contractors	6,095	37,933	$2.2
Residential plumbing and HVAC contractors	8,086	66,177	$3.8
Other Residential Equipment Contractors	263	1,331	$0.1

Source: (State of California, Employment Development Department n.d.)

3.4.3.2 Impact on Building Designers and Energy Consultants

Adjusting design practices to comply with changing building codes practices is within the normal practices of building designers. Building codes (including Title 24, Part 6) are typically updated on a three-year revision cycle and building designers and energy consultants engage in continuing education and training in order to remain compliant with changes to design practices and building codes.

Businesses that focus on residential, commercial, institutional, and industrial building design are contained within the Architectural Services sector (North American Industry Classification System 541310). Table 27 shows the number of establishments, employment, and total annual payroll for Building Architectural Services. The proposed code changes for the 2022 code cycle would potentially impact all firms within the Architectural Services sector. The Statewide CASE Team anticipates the impacts for the HEMS submeasure to affect firms that focus on single family construction.

There is not a North American Industry Classification System (NAICS)[17] code specific for energy consultants. Instead, businesses that focus on consulting related to building energy efficiency are contained in the Building Inspection Services sector (NAICS 541350), which is comprised of firms primarily engaged in the physical inspection of residential and nonresidential buildings.[18] It is not possible to determine which business establishments within the Building Inspection Services sector are focused on energy efficiency consulting. The information shown in Table 27 provides an upper bound indication of the size of this sector in California.

Table 27: California Building Designer and Energy Consultant Sectors

Sector	Establishments	Employment	Annual Payroll (billions $)
Architectural Services [a]	3,704	29,611	$2.91
Building Inspection Services [b]	824	3,145	$0.22

Source: (State of California, Employment Development Department n.d.)

a. Architectural Services (NAICS 541310) comprises private-sector establishments primarily engaged in planning and designing residential, institutional, leisure, commercial, and industrial buildings and structures;
b. Building Inspection Services (NAICS 541350) comprises private-sector establishments primarily engaged in providing building (residential & nonresidential) inspection services encompassing all aspects of the building structure and component systems, including energy efficiency inspection services.

[17] NAICS is the standard used by federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy. NAICS was development jointly by the U.S. Economic Classification Policy Committee (ECPC), Statistics Canada, and Mexico's Instituto Nacional de Estadistica y Geografia, to allow for a high level of comparability in business statistics among the North American countries. NAICS replaced the Standard Industrial Classification (SIC) system in 1997.

[18] Establishments in this sector include businesses primarily engaged in evaluating a building's structure and component systems and includes energy efficiency inspection services and home inspection services. This sector does not include establishments primarily engaged in providing inspections for pests, hazardous wastes or other environmental contaminates, nor does it include state and local government entities that focus on building or energy code compliance/enforcement of building codes and regulations.

3.4.3.3 Impact on Occupational Safety and Health

The proposed code change does not alter any existing federal, state, or local regulations pertaining to safety and health, including rules enforced by the California Division of Occupational Safety and Health (Cal/OSHA). All existing health and safety rules would remain in place. Complying with the proposed code change is not anticipated to have adverse impacts on the safety or health of occupants or those involved with the construction, commissioning, and maintenance of the building.

3.4.3.4 Impact on Building Owners and Occupants

According to data from the U.S. Census, American Community Survey (ACS), there were nearly 14.3 million housing units in California in 2018 and nearly 13.1 million were occupied (see Table 28). Most housing units (nearly 9.2 million were single-family homes (either detached or attached), while about 2 million homes were in building containing two to nine units and 2.5 million were in multi-family building containing 10 or more units. The U.S. Census reported that 59,200 single-family and 50,700 multi-family homes were constructed in 2019.

Table 28: California Housing Characteristics

Housing Measure	**Estimate**
Total housing units	14,277,867
Occupied housing units	13,072,122
Vacant housing units	1,205,745
Homeowner vacancy rate	1.2%
Rental vacancy rate	4.0%
Units in Structure	**Estimate**
1-unit, detached	8,177,141
1-unit, attached	1,014,941
2 units	358,619
3 or 4 units	783,963
5 to 9 units	874,649
10 to 19 units	742,139
20 or more units	1,787,812
Mobile home, RV, etc.	538,603

Source: (2018 American Community Survey n.d.)

Table 29 shows the distribution of California homes by vintage. About 15 percent of California homes were built in 2000 or later and another 11 percent built between 1990 and 1999. The majority of California's existing housing stock (8.5 million homes – 59 percent of the total) were built between 1950 and 1989, a period of rapid population and economic growth in California. Finally, about 2.1 million homes in California were built before 1950. According to Kenney et al, 2019, more than half of California's existing multifamily buildings (those with five or more units) were constructed before 1978 when there no building energy efficiency standards (Kenney, 2019 California Energy Efficiency Action Plan 2019).

Table 29: Distribution of California Housing by Vintage

Home Vintage	Units	Percent	Cumulative Percent
Built 2014 or later	343,448	2.4%	2.4%
Built 2010 to 2013	248,659	1.7%	4.1%
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Built 1980 to 1989	2,118,545	14.8%	40.8%
Built 1970 to 1979	2,512,178	17.6%	58.4%
Built 1960 to 1969	1,925,945	13.5%	71.9%
Built 1950 to 1959	1,896,629	13.3%	85.2%
Built 1940 to 1949	817,270	5.7%	90.9%
Built 1939 or earlier	1,299,845	9.1%	100.0%
Total housing units	**14,277,867**	**100%**	

Source: (2018 American Community Survey n.d.)

Table 30 shows the distribution of owner- and renter-occupied housing by household income. Overall, about 55 percent of California housing is owner-occupied and the rate of owner-occupancy generally increases with household income. The owner-occupancy rate for households with income below $50,000 is only 37 percent, whereas the owner occupancy rate is 72 percent for households earning $100,000 or more.

Table 30: Owner- and Renter-Occupied Housing Units in California by Income

Household Income	Total	Owner Occupied	Renter Occupied
Less than $5,000	391,235	129,078	262,157
$5,000 to $9,999	279,442	86,334	193,108
$10,000 to $14,999	515,804	143,001	372,803
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$20,000 to $24,999	520,133	187,578	332,555
$25,000 to $34,999	943,783	370,939	572,844
$35,000 to $49,999	1,362,459	590,325	772,134
$50,000 to $74,999	2,044,663	1,018,107	1,026,556
$75,000 to $99,999	1,601,641	922,609	679,032
$100,000 to $149,999	2,176,125	1,429,227	746,898
$150,000 or more	2,780,761	2,131,676	649,085
Total Housing Units	**13,072,122**	**7,165,664**	**5,906,458**
Median household income	**$75,277**	**$99,245**	**$52,348**

Source: (2018 American Community Survey n.d.)

Understanding the distribution of California residents by home type, home vintage, and household income is critical for developing meaningful estimates of the economic impacts associated with proposed code changes affecting residents. Many proposed code changes specifically target single-family or multi-family residences and so the counts of housing units by building type shown in Table 28 provides the information necessary to quantify the magnitude of potential impacts. Likewise, impacts may differ for owners and renters, by home vintage, and by household income, information provided in Table 29 and Table 30.

3.4.3.5 Impact on Building Component Retailers (Including Manufacturers and Distributors)

The Statewide CASE Team anticipates the proposed change would have no material impact on California component retailers other than a small increase in the demand for smart home technologies.

3.4.3.6 Impact on Building Inspectors

Table 31 shows employment and payroll information for state and local government agencies in which many inspectors of residential and commercial buildings are employed. Building inspectors participate in continuing training to stay current on all aspects of building regulations, including energy efficiency. The Statewide CASE Team, therefore, anticipates the proposed change would have no impact on employment of building inspectors or the scope of their role conducting energy efficiency inspections.

Table 31: Employment in California State and Government Agencies with Building Inspectors

Sector	Govt.	Establishments	Employment	Annual Payroll (millions $)
Administration of Housing Programs[a]	State	17	283	$29.0
	Local	36	2,882	$205.7
Urban and Rural Development Admin[b]	State	35	552	$48.2
	Local	52	2,446	$186.6

Source: (State of California, Employment Development Department n.d.)

a. Administration of Housing Programs (NAICS 925110) comprises government establishments primarily engaged in the administration and planning of housing programs, including building codes and standards, housing authorities, and housing programs, planning, and development.

b. Urban and Rural Development Administration (NAICS 925120) comprises government establishments primarily engaged in the administration and planning of the development of urban and rural areas. Included in this industry are government zoning boards and commissions.

3.4.3.7 Impact on Statewide Employment

As described in Sections 3.4.3.1 through 3.4.3.6, the Statewide CASE Team does not anticipate significant employment or financial impacts to any particular sector of the California economy. This is not to say that the proposed change would not have modest impacts on employment in California. In Section 3.4.4, the Statewide CASE Team estimated how the proposed change in HEMS requirements would affect statewide employment and economic output directly and indirectly through its impact on builders, designers and energy consultants, and building inspectors. In addition, the Statewide CASE Team estimated how energy savings associated with the proposed change in the HEMS submeasure would lead to modest ongoing financial savings for California residents, which would then be available for other economic activities.

3.4.4 Economic Impacts

This code change proposal is for a compliance option and as a result Economic Impacts are not presented.

4. Energy Savings

As a compliance option, these code change proposal submeasures would not modify the stringency of the existing Title 24, Part 6 Standards, so there would be no savings realized on a per-unit basis. Section 4 of the Final CASE Reports, which typically presents the methodology, assumptions, and results of the per-unit energy impacts, has been truncated for this measure. Although this measure does not result in electricity or gas savings, the measure would promote technologies that can lead to cost-effective code improvements in the future, and can have a very large statewide impact on grid resilience and greenhouse gas emissions.

The following sections provide limited analysis of energy savings potential for the four technology areas addressed in this Final CASE Report. The primary purpose of the analysis was to demonstrate that the potential impact of the technology justifies consideration as a compliance option, establish minimum levels of system capabilities commensurate with the credit being provided, and evaluate control strategies that should be included in modeling software or as programming defaults.

The energy and cost analysis presented in this report used the TDV factors that were released in the 2022 CBECC-Res research version that was released in December 2019. These TDV factors were consistent with the TDV factors that the Energy Commission presented during their public workshop on compliance metrics held October 17, 2019 (California Energy Commission 2019). The electricity TDV factors did not include the 15 percent retail adder and the natural gas TDV factors did not include the impact of methane leakage on the building site, updates that the Energy Commission presented during their workshop on March 27, 2020 (California Energy Commission 2020a). Presentations from Bruce Wilcox and NORESCO during the March 27, 2020 workshop indicated that the 15 percent retail adder and methane leakage would result in most energy efficiency measures having slightly higher TDV energy and energy cost savings than using the TDV factors without these refinements. As a result, the TDV energy savings presented in this report are lower than the values that would have been obtained using TDV with the 15 percent retail adder and methane leakage, and the proposed code changes will be more cost effective using the revised TDV. The Energy Commission notified the Statewide CASE Team on April 21, 2020 that they were investigating further refinements to TDV factors using 20-year global warming potential (GWP) values instead of the 100-year GWP values that were used to derive the current TDV factors. It is anticipated that the 20-year GWP values may increase the TDV factors slightly making proposed changes that improve energy efficiency more cost effective. Energy savings presented in kWh and therms are not affected by TDV or demand factors.

4.1 Battery Storage Systems

4.1.1 Key Assumptions for Energy Savings Analysis

To assess the energy, demand and energy cost impacts, the Statewide CASE Team compared current design practices to design practices that would comply with the proposed requirements. There are existing Title 24, Part 6 standards that cover battery storage systems, so the existing conditions assume a building minimally complies with the 2019 Title 24, Part 6 Standards. The baseline battery parameters are assumed to match the minimum performance requirements in the 2019 version of JA12. This includes an AC-AC RTE of 80 percent, 5 kWh of storage capacity, and 70 percent cycle retention over 10 years. The 5 kWh of storage capacity is assumed to be the usable capacity of the battery, and a 15 percent de-rate factor is applied to account for battery degradation across 10 years. The model includes a solar PV system, which was sized to meet the minimum Title 24, Part 6 prescriptive requirements for PV sizing (i.e. Standard Design PV).

The Energy Commission provided guidance on the type of prototype buildings that must be modeled. The savings analysis was based on the two all-electric single family residential building prototypes available in CBECC-Res. The 2,100ft^2 and 2,700 ft^2 prototype models were each weighted at 50 percent. These weightings for the prototype models are aligned with the values set for all Title 24, Part 6 single family measures.

However, none of the proposed code changes to the battery storage system submeasure are expected to impact energy savings. As a result, energy savings are not presented. If future proposals impact energy savings or usage, these impacts will be listed in this section of the CASE Report.

4.1.2 Energy Savings Methodology

4.1.2.1 Energy Savings Methodology per Prototypical Building

The Energy Commission directed the Statewide CASE Team to model the energy impacts using specific prototypical building models that represent typical building geometries and performance for different types of buildings. The prototype buildings that the Statewide CASE Team used in the analysis are presented in Table 32.

Table 32: Prototype Buildings Used for Energy, Demand, Cost, and Environmental Impacts Analysis

Prototype Name	Number of Stories	Floor Area (square feet)	Description
Prototype 2,100	1	2,100	single story house with attached garage, pitched roof, attic. 9-ft ceilings, 1 ft overhang, front door, garage door.
Prototype 2,700	2	2,700	2-story home with attached 2-car garage. 9-ft ceilings, 1-ft between floors, 1-ft overhang.

If code change proposals were expected to result in energy savings, the Statewide CASE Team would estimate energy and demand impacts by simulating the proposed code change using the 2022 Research Version of the California Building Energy Code Compliance (CBECC) software for residential buildings (CBECC-Res) (CalCERTS, Inc. 2019).

However, none of the proposed code changes to the battery storage system submeasure are expected to impact energy savings. As a result, energy savings are not presented. If future proposals impact energy savings or usage, these impacts will be listed in this section of the CASE Report.

4.1.3 Per-Unit Energy Impacts Results

None of the proposed code changes to the battery storage system submeasure are expected to impact energy savings. As a result, per-unit energy impacts results are not presented. If future proposals impact energy savings or usage, these impacts will be listed in the CASE report.

4.2 HPWH Load Shifting

4.2.1 Key Assumptions for Energy Savings Analysis

As a compliance option, energy savings and demonstrated cost effectiveness are not required elements of this CASE Report. The Statewide CASE Team is presenting some preliminary results in this section to help inform stakeholders on potential impacts of a Basic Plus load shifting measure. The presented results are approximate at this time pending the Energy Commission's final implementation of LSHPWHs algorithms into CBECC-Res in 2020. However, the analysis presented here is based on the same HPWHsim load shifting algorithm that will be implemented in CBECC-Res in 2020. For this Final CASE Report, preliminary LSHPWH results are based on evaluations completed using 2019 TDV. This was done for two reasons: 1) there is uncertainty in how the 2020 software implementation will unfold, diminishing any benefit of requiring the additional precision associated with using the 2022 TDV data, and 2) utilizing the current stand-alone Ecotope HPWHsim model would require a labor intensive process with little overall benefit to the overall report content.

4.2.2 Energy Savings Methodology

4.2.2.1 Energy Savings Methodology per Prototypical Building

The Energy Commission directed the Statewide CASE Team to model the energy impacts using specific prototypical building models that represent typical building geometries for different types of buildings. Residential water heating loads in CBECC-Res are not primarily impacted by the size and configuration of the building, but instead by the number of bedrooms, which serves as a proxy for both hot water load magnitude and hot water distribution losses as defined in (Kruis 2017).

Energy, TDV, and homeowner annual utility costs are presented in this section by climate zone for average impacts across all hot water load cases for standard HPWH operation, "estimated" Basic Load Up impacts, and Basic Plus impacts. For the Basic Load Up case, the water heater can be scheduled to store "extra" energy under two conditions. First, the temperature deadband in the tank allows the temperature to drift down over time. Second, small water uses result in pools of cooler water accumulating at the bottom of the tank that may not be heated during normal operation. Both of these conditions can occur during the mid-day time window or other off-peak periods. Consequently, there is "room" in the tank to heat it back to the user setpoint. In addition, tank recovery can often be delayed somewhat beyond normal operation. Combined, these effects constitute the amount of energy that can be shifted without imposing a set point adjustment on the tank. For comparison purposes, placed in terms of water temperature, prior analysis suggests that these two conditions roughly equate to an energy equivalent of 5°F average tank temperature change.

For the Basic Plus case, the water heater setpoint can be elevated above the user setpoint, allowing for additional increased stored energy. The same operational strategy, of when to turn on or off the HPWH, can be used as in the Basic Load Up case. Previous work suggests an optimum temperature increase is to ~135°F which allows for added energy storage but does not suffer from an undue loss in heat pump efficiency. Therefore, this analysis assumes a temperature increase of 10°F (to 135°F over the default model setpoint of 125°F), however, the exact amount is purposefully not specified in the proposal to allow manufacturers to design optimum controls as they see fit.

Alternative strategies to meet the Basic Plus load shifting impact include increasing the tank storage volume above the JA13 prescribed level (Basic Plus-2), or raising the tank set point temperature a minimum of 10°F above the mixing valve setpoint, resulting in a tank set point of 130°F or more (Basic Plus-3). Either of these approaches would provide comparable benefit to the Basic Plus-1 approach utilizing TOU schedules to define optimal mid-day periods for tank overheating.

For the load shifted cases, the control of the water heater is determined by a time of use rate selected to bias the water heater operation towards the mid-day solar PV peak and away from the late afternoon/evening operation. Individual implementations of the load shifting measure in different utility service territories are anticipated to have different TOU schedules. Nevertheless, exploratory analysis showed that the qualitative shape of the TOU schedule is a primary driver of load shifting. Consequently, the schedule used in this analysis is expected to produce reasonably representative results of future load shift implementations as long as the goal of those schedules is largely to mitigate negative impacts of the duck curve.

To simplify presentation of these initial results, California-specific data from the U.S. Census Bureau (U.S. Census Bureau 2020) were used to weight the various hot water load levels (based on number of bedrooms) to arrive at single average impacts for each climate zone. All runs are completed for a HPWH representative of efficiency levels for products currently available on the market. The HPWHs are modeled in garage locations to reflect the preferred installation location of most water heaters in California.

4.2.3 Per-Unit Energy Impacts Results

Figure 3 plots the bedroom and climate zone weighted annual average daily demand profile for the Base Case (non-LSHPWH) and the Basic Plus scenario. The plotted demand profile is superimposed on the assumed TOU rate (shown in yellow shading). Although averaged for all seasons and climate zones, the plot demonstrates the enhanced ability to build load mid-day and shed load during the peak period.

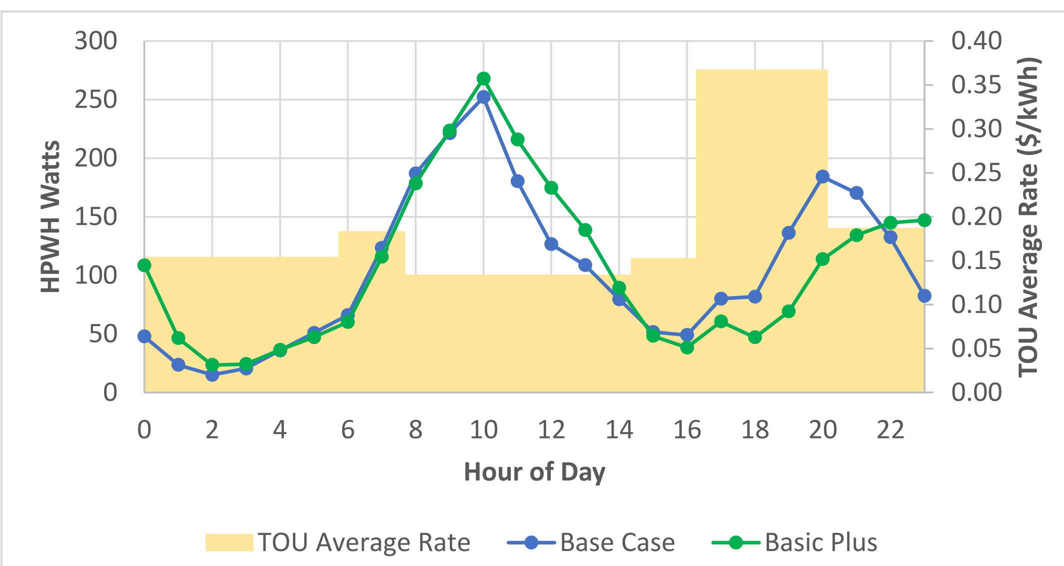

Figure 3: Statewide annual average LSHPWH load profile and assumed TOU rate.

Annual energy savings, annual TDV impacts (2019 TDV reported at this time), and estimate operating costs under the hypothetical TOU electric rate[19] are shown in Table 33, Table 34, and Table 35, respectively.

Averaged across all climate zones, Table 33 shows average Basic Load Up annual energy consumption is 1.3 percent higher than standard HPWH operation (range of 1.0-2.9 percent) and Basic Plus usage is 2.5 percent higher than standard (range of 1.9-5.5 percent).

Similarly for 2019 TDV, Table 34 shows average Basic Load Up TDV water heating is 2.6 percent lower than standard HPWH operation (range of 0.3-4,1 percent) and Basic Plus TDV is 5.6 percent lower (range of 0.7 percent-11.7 percent).

Finally, homeowner HPWH operating costs are shown in Table 35 under the hypothetical TOU rate (see Figure 3 for an annual average representation of the rate). Table 35 shows average Basic Load Up annual water heating costs are 8.0 percent lower than standard HPWH operation (range of 6.0-8.7 percent) and Basic Plus costs are 19.1 percent lower (range of 13.6 percent-21.0 percent).

Table 33: First-Year Energy Impacts Per LSHPWH

Climate Zone	Base HPWH Usage (kWh/yr)	Basic Load Up LSHPWH Usage (kWh/yr)	Basic Plus LSHPWH Usage (kWh/yr)
1	1,290	1,305	1,319
2	1,069	1,082	1,094
3	1,053	1,065	1,077
4	979	991	1,002
5	1,087	1,097	1,107
6	863	874	884
7	827	839	851
8	803	813	823
9	814	824	833
10	817	828	837
11	941	956	969
12	985	997	1,008
13	879	893	907
14	992	1,007	1,020
15	550	566	580
16	1,830	1,848	1,864

[19] The assumed TOU rate has weekend/weekday differentiation with an ~ 3 to 1 ratio of peak summer 5-9 PM rates relative to the minimum off-peak rates.

Table 34: Annual 2019 TDV Estimated Impacts Per LSHPWH

Climate Zone	Base HPWH TDV (TDV kBtu/yr)	Basic Load Up LSHPWH Usage (TDV kBtu/yr)	Basic Plus LSHPWH Usage (TDV kBtu/yr)
1	35,256	34,252	33,127
2	27,908	27,131	26,259
3	29,032	27,867	26,494
4	25,628	24,827	23,912
5	29,273	28,064	26,635
6	21,728	21,063	20,307
7	21,271	20,671	19,998
8	19,691	19,299	18,872
9	19,514	19,143	18,728
10	19,575	19,116	18,602
11	23,851	23,451	23,015
12	25,232	24,553	23,792
13	23,031	22,408	21,689
14	23,659	23,477	23,288
15	13,246	13,202	13,153
16	57,078	54,085	50,377

Table 35: Annual Estimated Operating Cost Impacts Per LSHPWH

Climate Zone	Base HPWH DHW Costs ($/yr)	Basic Load Up LSHPWH DHW Costs ($/yr)	Basic Plus LSHPWH DHW Costs ($/yr)
1	$238	$224	$206
2	$197	$183	$164
3	$197	$182	$161
4	$181	$167	$148
5	$203	$188	$166
6	$161	$148	$129
7	$156	$143	$124
8	$150	$137	$118
9	$151	$138	$119
10	$151	$138	$120
11	$171	$159	$143
12	$180	$167	$149
13	$160	$148	$133
14	$179	$167	$152
15	$100	$92	$81
16	$340	$319	$292

In summary, energy use is projected to be marginally higher with the load up strategies (as expected with elevated tank temperatures), but TDV savings and operating cost savings are realized due to the load-shifting operation. As future California residential TOU rates will likely better align with the continuing trends in California's generation mix with more mid-day renewable over-generation, TOU operating cost savings associated with LSHPWHs should be expected to increase over time.

4.3 HVAC Load Shifting

4.3.1 Key Assumptions for Energy Savings Analysis

A range of potential alternative scenarios were analyzed using CBECC-Res, including varying the pre-cooling schedule (10 AM - 4 PM and 12-4 PM), the pre-cooling temperature setpoint (72°F and 75°F), and the amount of thermal mass (changing the percent of exposed slab from 20 percent to 100 percent—this is the primary means of modifying thermal mass in CBECC-Res). Criteria were set for allowable values for TDV savings and energy penalties in order to be considered a viable measure: total TDV savings must be positive and total whole building energy consumption must increase by no more than 5 percent. The results of the parametric analysis are shown in Appendix G for different combinations of thermal mass, pre-cooling temperature, and pre-cooling schedule. The findings from this parametric analysis were used to identify the allowed parameters for the measure and the assumed values to use in the final CBECC-Res model, described in Section 4.3.2.

- It was found that only in Climate Zones 9-15 were the criteria—positive Total TDV savings and no more than 5 percent Total kWh penalty—met for all combinations of thermal mass, pre-cooling schedule, and pre-cooling temperature. These are the only climate zones in which the proposed credit would be allowed.
- The amounts of thermal mass in the modeled home did not appreciably affect the savings. The estimated savings shown in Section 4.3.3 assumed the default amount of 20 percent exposed slab.
- Longer pre-cooling hours generated slightly higher TDV savings in Climate Zones 9-15. The estimated savings shown in Section 4.3.3 assumed a shorter period of four hours of pre-cooling in order to be conservative.
- Lower pre-cooling temperatures generated slightly lower TDV savings, and slightly increased kWh (in some cases above the threshold of a 5 percent increase in Total kWh in Climate Zones 9-15). The estimated savings shown in Section 4.3.3 assumed a higher pre-cooling temperature setpoint of 75°F in order to be conservative.
- The Derating Factor of 70 percent is not proposed to be changed in this code

cycle, and this factor would be used to reduce the TDV credit. The estimated savings shown in Section 4.3.3 shows the credit as the total TDV savings reduced by 70 percent.
- With these assumptions, whole-building energy penalties ranged from 0 percent to 3 percent, but total TDV savings ranged from 2 percent to 20 percent.

Derating Factor Analysis:

The Statewide CASE Team conducted a survey to understand occupants' tolerance for discomfort or inconvenience of set point adjustments, to identify if there is value in developing voluntary system requirements that may allow for additional credits, to assess likelihood of disabling smart feature both permanently and temporarily, and to determine how to reduce the likelihood of both.

Before questioning acceptability of pre-cooling, it was defined as follows:

> "Pre-cooling your home means using a thermostat to automatically cool your house a little extra (say, below 72°F) from 2PM to 5PM, followed by having the AC off from 5PM to 9PM (which could result in the home being extra warm, say over 82°F)."

Survey respondents were asked how likely they would be to precool their home if they received a monthly incentive. 79 percent were somewhat, very, or extremely likely to utilize precooling if they received $30 per month, and 88 percent if they received $60 per month. When asked how likely they would be to override pre-cooling settings under various scenarios, 58 percent reported that they would be somewhat, very, or extremely likely to override the pre-cooling settings under normal circumstances. This is less than the 70 percent derating factor. They didn't expect that thermostat design features would impact that likelihood very much. 78 percent were likely to override the settings if they were having company, which is to be expected. The most concerning response was that 90 percent were likely to override the settings on a day when warmer temperatures made them uncomfortable. While the Statewide CASE Team did expect that this rate would be higher, it is quite high. Open-ended responses to questions about the HEMS measure suggested that respondents were somewhat hostile to the idea of being asked to conserve. This suggests that these respondents (selected at random) may not represent the population who would voluntarily opt-in to this measure for code compliance, whom the Statewide CASE Team would expect to be less likely to override. Altogether, the results of the survey did not provide any evidence that the de-rating factor should be changed.

In addition, the Statewide CASE Team analyzed the impact of the measure on utility bills, since homeowners cannot be expected to reliably utilize pre-cooling if it increases their bills significantly. The hourly results of the analysis described above were utilized to estimate utility bills using several different TOU rates, including current PG&E and SCE rates. The results of this analysis are shown in Table 36 for the 2,100 and 2,700 single family prototypes (SF 2100 and SF 2700, respectively). In all climate zones analyzed, the savings (noted as SAV in the Table) are either positive (reduced bills) or only slightly negative (slightly increased bills). (Although bills are slightly increased in Climate Zone 12, the TDV savings shown in Section 4.3.3 are still positive, so it is a valid measure.) In all climate zones except 15, the impact is probably minor, although in Climate Zone 15 the savings may be significant enough to strongly motivate pre-cooling behavior.

Table 36: Annual Energy Bill Impacts of Pre-Cooling Using Time-of-Use Rates

		SF 2100				SF 2700			
CZ	**RATE**	**BASE**	**PROP**	**SAV**	**SAV%**	**BASE**	**PROP**	**SAV**	**SAV%**
9	SCE – TOU-D1	$727	$709	$18	2%	$862	$829	$33	4%
10	SCE – TOU-D1	$780	$746	$34	4%	$921	$866	$55	6%
11	PG&E – TOU-B	$1,094	$1,045	$49	4%	$1,272	$1,200	$72	6%
12	PG&E – TOU-B	$997	$1,012	-$15	-1%	$1,139	$1,148	-$9	-1%
13	PG&E – TOU-B	$1,021	$963	$58	6%	$1,199	$1,117	$82	7%
14	SCE – TOU-D1	$1,187	$1,094	$93	8%	$1,414	$1,282	$132	9%
15	SCE – TOU-D1	$1,037	$755	$282	27%	$1,263	$915	$348	28%

4.3.2 Energy Savings Methodology

4.3.2.1 Energy Savings Methodology per Prototypical Building

The Energy Commission directed the Statewide CASE Team to model the energy impacts using specific prototypical building models that represent typical building geometries for different types of buildings. The prototype buildings that the Statewide CASE Team used in the analysis are presented in Table 37.

Table 37: Prototype Buildings Used for Energy, Demand, Cost, and Environmental Impacts Analysis

Prototype Name	Number of Stories	Floor Area (square feet)	Description
SF 2100	1	2,100	single story house with attached garage, pitched roof, attic. 9-ft ceilings, 1 ft overhang, front door, garage door.
SF 2700	2	2,700	2-story home with attached 2-car garage. 9-ft ceilings, 1-ft between floors, 1-ft overhang.

The Statewide CASE Team estimated energy and demand impacts by simulating the proposed code change using the 2022 Research Version of the California Building Energy Code Compliance (CBECC) software for residential buildings (CBECC-Res) (CalCERTS, Inc. 2019).

CBECC-Res generates two models based on user inputs: the Standard Design and the Proposed Design.[20] The Standard Design represents the floor area and number of stories as the proposed design, but with the prescriptive energy features that result in an energy budget that is compliant with 2019 Title 24, Part 6 code requirements. Features used in the Standard Design are described in the 2019 Residential ACM Reference Manual. To develop savings estimates for the proposed code changes, the Statewide CASE Team created a Standard Design compliant file for each prototype building. The Proposed Design was identical to the Standard Design in all ways except for the revisions that represent the proposed changes to the code. Table 38 presents precisely which parameters were modified and what values were used in the Standard Design and Proposed Design.

Specifically, the proposed conditions assume different values for the Cooling Space Temperature Setpoint. The Cooling space temperature setpoints used for the standard construction, and for all hours that are not considered pre-cooling or non-cooling hours were taken from Table 22 of the ACM Reference Manual Section 2.5.3.7.

[20] CBECC-Res creates a third model, the Reference Design, that represents a building similar to the Proposed Design, but with construction and equipment parameters that are minimally compliant with the 2006 International Energy Conservation Code (IECC). The Statewide CASE Team did not use the Reference Design for energy impacts evaluations.

Table 38: Modifications Made to Standard Design to Simulate Proposed Code Change, for SF 2100 and SF 2700 Prototypes and all Climate Zones (hours with blue shading are using Pre-Cooling, and hours with pink shading are using No-Cooling).

Parameter Name: Cooling Setpoint Temperature	Standard Design Parameter Value (°F)	Proposed Design Parameter Value (°F)
12pm-1am	78	78
1am-2am	78	78
2am-3am	78	78
3am-4am	78	78
4am-5am	78	78
5am-6am	78	78
6am-7am	78	78
7am-8am	83	83
8am-9am	83	83
9am-10am	83	83
10am-11am	83	83
11am-12pm	83	83
12pm-1pm	83	75
1pm-2pm	82	75
2pm-3pm	81	75
3pm-4pm	80	75
4pm-5pm	79	83
5pm-6pm	78	83
6pm-7pm	78	83
7pm-8pm	78	83
8pm-9pm	78	83
9pm-10pm	78	78
10pm-11pm	78	78
11pm-12pm	78	78

Comparing the energy impacts of the Standard Design to the Proposed Design reveals the impacts of the proposed code change relative to a building that is minimally compliant with the 2019 Title 24, Part 6 requirements.

CBECC-Res calculates whole-building energy consumption for every hour of the year measured in kWh/yr and therms/yr. It then applies the 2022 TDV factors to calculate annual energy use in kBtu/yr and annual peak electricity demand reductions measured in kW. CBECC- Res also generates TDV energy cost savings values measured in 2023 present value dollars (2023 PV$) and nominal dollars.

The energy impacts of the proposed code change vary by climate zone. The Statewide CASE Team simulated the energy impacts in every climate zone and applied the climate-zone specific TDV factors when calculating energy and energy cost impacts.

Per unit energy impacts for single family buildings are presented in savings per prototype building. Savings are presented for both single family prototypes. As described in Section 6, the Statewide CASE Team developed a weighted average savings of the two prototypes to calculate statewide savings.

4.3.2.2 Statewide Energy Savings Methodology

The per-unit energy impacts were extrapolated to statewide impacts using the Statewide Construction Forecasts provided by the Energy Commission (California Energy Commission Building Standards Office n.d.). The Statewide Construction Forecasts estimate new construction that will occur in 2023, the first year that the 2022 Title 24, Part 6 requirements are in effect. It also estimates the size of the total existing building stock in 2023 that the Statewide CASE Team used to approximate savings from building alterations. The construction forecast provides construction (new construction and existing building stock) by building type and climate zone. The building types used in the construction forecast, Building Type ID, are not identical to the prototypical building types available in CBECC-Res, so the Energy Commission provided guidance on which prototypical buildings to use for each Building Type ID when calculating statewide energy impacts. Table 39 presents the prototypical buildings and weighting factors that the Energy Commission requested the Statewide CASE Team use for each Building Type ID in the Statewide Construction Forecast.

Table 39: Residential Building Types and Associated Prototype Weighting

Building Type ID from Statewide Construction Forecast	Building Prototype for Energy Modeling	Weighting Factors for Statewide Impacts Analysis
Single Family	SF2100	50%
	SF2700	50%

4.3.3 Per-Unit Energy Impacts Results

The final energy savings and peak demand reductions per unit are presented in Table 40 and Table 41, for new construction. The per-unit energy savings figures do not account for naturally occurring market adoption or compliance rates. The proposed design is projected to consume more energy than the standards design, as expected. Per-unit energy penalties for the first year are expected to range from 51 to 200 kWh/year, depending upon home size and climate zone. Per-unit demand reductions are expected to range between 224 to 747 W, depending on home size and climate zone. TDV savings range from 488 to 13,647 TDV kBtu/year, depending on home size and climate zone.

Table 40: First-Year Energy Impacts Per Home – SF2100 Prototype Building

Climate Zone	Electricity Savings (kWh/year)	Peak Electricity Demand Reductions* (kW)	Natural Gas Savings* (therms/year)	TDV Energy Savings* (TDV kBtu/year)
9	(154)	0.333	N/A	1,831
10	(153)	0.350	N/A	2,368
11	(70)	0.454	N/A	6,844
12	(104)	0.224	N/A	488
13	(70)	0.538	N/A	10,407
14	(114)	0.429	N/A	4,197
15	(95)	0.616	N/A	13,138

(Note: * indicates metrics that are de-rated by 70 percent)

Table 41: First-Year Energy Impacts Per Home – SF2700 Prototype Building

Climate Zone	Electricity Savings (kWh/year)	Peak Electricity Demand Reductions* (kW)	Natural Gas Savings* (therms/year)	TDV Energy Savings* (TDV kBtu/year)
9	(200)	0.479	N/A	2,790
10	(196)	0.489	N/A	3,339
11	(63)	0.575	N/A	8,923
12	(125)	0.379	N/A	2,525
13	(51)	0.625	N/A	13,647
14	(117)	0.550	N/A	6,607
15	(92)	0.747	N/A	16,274

(Note: * indicates metrics that are de-rated by 70 percent)

4.4 Home Energy Management

Energy savings for HEMS is highly dependent on factors such as occupant behavior, connected loads, and control technology. As a result, field test and modeling studies documented in the literature provide only a limited picture of energy savings for specific systems under specific conditions (see Table 42). Additionally, many field studies do not reflect “naturalistic adoption”, meaning there may be self-selection bias and additional homeowner support that could lead to overestimation of potential savings (Ford, et al. 2017). Another issue is that many studies do not fully document the methodologies used to select participants, gather data, and calculate savings, making it difficult to verify objectivity or repeat the study. However, these studies at least illustrate the rough magnitude of potential HEMS savings, which capabilities have the largest impacts, and where the greatest uncertainties lie.

In general, the greatest savings potential resides with HVAC controls through AEETs. However, several studies indicate that whole-house electricity savings in the range of 5-15 percent can be achieved through savings in the lighting, appliance, and end-use categories. Lighting is a particular challenge, because LED lighting has become so efficient and prevalent over the past few years that any savings tends to get lost in the noise of other electronic devices used in the home. Appliances and plug loads appear to offer greater opportunities for large-scale grid benefits.

Table 42: HEMS Energy and Peak Savings from Past Research and SME Interviews

Type of HEMS	Energy Savings	Peak Demand Savings	Persistence	Notes	Source
Complete system	1760-2150 kWh/yr (20-25%); 80 therms/yr (15-20%)	N/A	N/A	Smart thermostat, plug, lighting, power strip, water heater, and home energy monitor	(Kemper 2019)
Complete system	11% total energy use (15% may be possible with improved technology)	N/A	10% rebound effect	Need better communication protocols, savings documentation, homeowner education	(Nadel and Ungar 2019)
HVAC, lighting, plug loads	1241 kWh/yr (16% total electricity); 52 therms/yr. 553 kWh/yr without HVAC (~7% total electricity)	N/A	N/A	Theoretical savings based on monitored performance pre-retrofit	(Piper, et al. 2017)
HVAC, lighting	43% actual electricity savings, 25% modeled	N/A	N/A	Case study of actual versus theoretical savings in one house	(Oh 2017)
In-home display	0-18% total electricity	N/A	N/A	Based on multiple field studies	(Ford, et al. 2017)
Smart appliances and in-home display	12-20% total electricity	N/A	N/A	Primarily based on pilot technologies	(Ford, et al. 2017)
Smart appliances and in-home display	3-6% total electricity	N/A	N/A	Commercially available technologies	(Ford, et al. 2017)
Smart thermostat	-5% to +13% heating; 10 to 25% cooling	Up to 55%	N/A		(Ford, et al. 2017)
Programmable thermostat	3% total energy	N/A	N/A	Does not include remote control, machine learning, demand response	(Ford, et al. 2017)
Smart thermostat and appliances, HVAC zoning	26% total energy	N/A	N/A		(Ford, et al. 2017)
In-home display	4-7% total energy	N/A	Diminishes over time	Meta-analysis of 42 studies	(Karlin, Ford, et al. 2015)
Smart lighting	3-6% total electricity	N/A	N/A	Fraction LED may be much lower than in 2020; 1-2% additional electricity use for controls	(Urban, Roth and Harbor 2016)

Type of HEMS	Energy Savings	Peak Demand Savings	Persistence	Notes	Source
Circuit level controls	6.5% total electricity	N/A	N/A	Smart power strips, outlets	(Urban, Roth and Harbor 2016)
Advanced power strips	1% total electricity	10 W	84% after 6-8 weeks	Limited to home entertainment	(Valmiki and Corradini 2015)

It is important to note that under some circumstances home automation systems can increase energy use even when they include energy management capabilities. There are several possible contributors to higher energy use, or reduced energy savings, in certain applications:

- HEMS use some amount of electricity (typically a few watts) even in standby mode to track occupant movements, evaluate connected device operation, activate controllers, and report energy use on a display.
- Many homeowners will activate lights and other devices while they are away for security reasons, to deter intruders by making it appear that someone is home.
- Using scheduling or remote control with a smartphone, return from setback may be started earlier so the house is more comfortable when occupants wake up in the morning or return home from work or vacation.
- Occupants may use electronic devices more often because of the convenience, such as asking Alexa to play music while they are working around the house.

Several elements of the ENERGY STAR SHEMS specification would be implemented in the proposed code change to limit these potential barriers to achieving energy savings. However, not all ENERGY STAR SHEMS eligibility criteria are appropriate for Title 24 implementation, most notably the requirement for ENERGY STAR Smart Thermostats and Smart Lighting. Instead, the Title 24 requirements for AEETs and energy efficient lighting would apply. The following minimum performance capabilities would be required for a HEMS to qualify for the solar zone area exception under Title 24, Part 6:

- Occupancy sensors that result in direct savings for non-essential end uses when nobody is home
- User-established rules and schedules
- Pattern recognition that can lead to automatic actions or recommendations to occupants on how they may be able to save energy with no negative affect on comfort or convenience
- Energy monitoring and display in a user-friendly format
- Maximum allowable standby power
- Decision making based on TOU electricity pricing
- Automatic device recognition
- Alerts when sensors or other devices are not working correctly
- Energy efficient default settings that must be actively overridden by occupants
- Minimum number of connected devices
- Demand response capability with temporary manual override

Energy savings for DMTs and AEETs are also highly dependent on occupant behavior and control technology. There are many different algorithms and strategies implemented in AEETs. It would not be feasible or advisable to try to create requirements or credit for particular types of features or functionality, since this is such an innovative and rapidly changing technology. Also, the type of functionality provided by Smart Thermostats can only be assessed by measuring performance in the field, since they are so occupant-responsive. ENERGY STAR recognizes this and awards a rating only to thermostats that collect data from field installations and record a sufficient percentage reduction in HVAC runtime due to the operation of the thermostat. It would be inefficient to attempt to develop a California-specific set of requirements when a fairly sophisticated specification is already available. It would also be burdensome to ask manufacturers to do two similar—but different—data collection efforts. For these reasons, the ENERGY STAR program requirements will be leveraged. The savings must meet the savings criteria of the program requirements. However, these savings estimates cannot be used to estimate energy savings for several reasons.

- The baseline for the ENERGY STAR program savings estimates (a constant temperature setpoint at all times) is not the same as the baseline for Title 24, Part 6 (a temperature setback schedule).
- It is likely that savings estimated in a manufacturer's field study of non-California manufacturer-selected or self-selected may not match the adoption profiles for Title 24, Part 6, and may bias the savings estimates. This is particularly a concern since many homeowners would not have personally selected installation of this measure and may therefore not have bought into the strategies that are relied upon for savings.

Additional research over the next three years may provide the Energy Commission with greater confidence in the energy savings that will be realized.

5. Cost and Cost Effectiveness

The code change proposal would not modify the stringency of the existing Title 24, Part 6 Standards, so the Energy Commission does not need a complete cost-effectiveness analysis to approve the proposed change. Section 5 of the Final CASE Reports typically presents a detailed cost-effectiveness analysis. For this proposed change, the Statewide CASE Team is presenting information on the cost implications in lieu of a full cost-effectiveness analysis.

5.1 Battery Storage Systems

5.1.1 Energy Cost Savings Methodology

The code change proposal is for a compliance option and as a result a full-cost effectiveness analysis is not presented.

5.1.2 Energy Cost Savings Results

The code change proposal is for a compliance option and as a result a full-cost effectiveness analysis is not presented.

5.1.3 Incremental First Cost

Incremental first cost is the initial cost to adopt more efficient equipment or building practices when compared to the cost of an equivalent baseline project. Therefore, it was important that the Statewide CASE Team consider first costs in evaluating overall measure cost effectiveness. Incremental first costs are based on data available today and can change over time as markets evolve and professionals become familiar with new technology and building practices.

The proposed code change is meant to align with developments in battery storage technologies since the 2019 Title 24, Part 6 code was approved, along with expected improvements in performance until the 2022 Title 24, Part 6 code is adopted. Therefore, the proposed code change is not expected to impact the incremental first cost of battery storage systems.

5.1.4 Incremental Maintenance and Replacement Costs

The proposed code change is not expected to impact the incremental maintenance and replacement costs of battery storage systems.

5.1.5 Cost Effectiveness

The code change proposal is for a compliance option and as a result a full-cost effectiveness analysis is not presented.

5.2 HPWH Load Shifting

5.2.1 Energy Cost Savings Methodology

The code change proposal is for a compliance option and as a result a full-cost effectiveness analysis is not presented.

5.2.2 Energy Cost Savings Results

The code change proposal is for a compliance option and as a result a full-cost effectiveness analysis is not presented.

5.2.3 Incremental First Cost

Incremental first cost is the initial cost to adopt more efficient equipment or building practices when compared to the cost of an equivalent baseline project. Therefore, it was important that the Statewide CASE Team consider first costs in evaluating overall measure cost effectiveness. Incremental first costs are based on data available today and can change over time as markets evolve and professionals become familiar with new technology and building practices. For compliance options, cost effectiveness is not a required CASE report element. The discussion below presents high level information on measure costs related to LSHPWHs.

Communications with the key researchers leading the Pacific Northwest market transformation activities[21] help to provide some context to the potential cost implications associated with connected HPWHs. In the BPA CTA-2045 market transformation study, the transformation plan considered three phases. The first assumed communications would be possible through an add-on module that adapted the HPWH's proprietary communications interface to the CTA-2045 standard. This first phase, with the adaptor module was assumed to exist for a few years. After the adapter phase the transformation plan assuming funding for the original equipment manufacturers (OEMs) to change their proprietary socket to the CTA-2045 approved socket and move the CTA-2045 control logic on to the water heater internal control, eliminating the need for the adapter. After several years, the market transformation plan assumed state code would make the CTA-2045 changes a requirement. Subsequent to the completion of the BPA study, Washington state passed a law requiring OEMs to provide a CTA-2045 port on heat pump water heaters sold in the state as of January 2021, followed by all electric resistance water heaters as of January 2022 (Washington State Legislature 2019). Likewise, the State of Oregon is pursuing a rulemaking to require CTA-2045 on all electric water heaters beginning January 2022 (Energy 2020).

[21] Personal communication with Conrad Eustis and Tony Koch (December 2019)

The price of all these components is highly dependent on the volume of production. When an OEM buys 100,000 sockets their price should be below $2, however in low volumes it might be $5 or more. In addition to the short-term adapter costs, there are the engineering, development, and testing costs to enable commercial production. Rough estimates of this is on the order of half a million dollars for the industry as whole. This might amount to an incremental wholesale cost of $10-$30 per unit over the first 100,000 units manufactured. Given that the OEMs will be selling CTA-2045 heat pump water heaters in Washington state as of January 2021, and electric resistance tanks as of January 2022, most of the development costs should have been incurred by the large OEMs before the 2023 implementation date of the 2022 Title 24, Part 6 standards.

The UCM that is plugged into the appliance socket is a required element, but the costs for this should be borne by the utility or aggregator, not the HPWH manufacturer. While current costs of the UCM in low volume is around $200, Tony Koch of BPA estimates these costs at $100 per unit in volumes of a few thousand units. If the HPWH market expands as anticipated in the Pacific west coast states, volumes may well increase to several hundred thousand units per year and costs could reasonably fall to under $30 per unit.

In addition to these “direct” costs, adopting an open standard, such as CTA-2045, is likely to keep “indirect” costs down compared to other approaches. For instance, a CTA-2045 port guarantees a low-cost, universal method to access the water heater with new technologies throughout its lifetime. Changing out the UCM allows an inexpensive method of switching communications to the water heater, avoiding potentially expensive workarounds, or insurmountable costs associated with maintaining connection to a fixed, outdated communication method on the water heater. Next, the open standard, with the socket, relieves the manufacturer, if they so choose, of the need to implement all the demand response functionality on the water heater. Most of the that functionality can be moved to the UCM which eases the manufacturing burden and should effectively lower the barrier to market entry for demand response features.

5.2.4 Incremental Maintenance and Replacement Costs

The code change proposal is for a compliance option and is not expected to increase maintenance and replacement costs.

5.2.5 Cost Effectiveness

The code change proposal is for a compliance option and as a result a full-cost effectiveness analysis is not presented.

5.3 HVAC Load Shifting

5.3.1 Energy Cost Savings Methodology

The code change proposal is for a compliance option and as a result a full-cost effectiveness analysis is not presented.

5.3.2 Energy Cost Savings Results

The code change proposal is for a compliance option and as a result a full-cost effectiveness analysis is not presented.

5.3.3 Incremental First Cost

Incremental first cost is the initial cost to adopt more efficient equipment or building practices when compared to the cost of an equivalent baseline project. Therefore, it was important that the Statewide CASE Team consider first costs in evaluating overall measure cost effectiveness. Incremental first costs are based on data available today and can change over time as markets evolve and professionals become familiar with new technology and building practices.

The proposed code change is not expected to increase first costs. It is expected that the cost of a compliant PCT can be equivalent to the cost of a standard programmable thermostat.

5.3.4 Incremental Maintenance and Replacement Costs

The proposed code change is not expected to increase maintenance and replacement costs. It is expected that the cost of a compliant PCT can be equivalent to the cost of a standard programmable thermostat, and the thermostat will not require maintenance or replacement more frequently than a standard programmable thermostat.

5.3.5 Cost Effectiveness

The code change proposal is for a compliance option and as a result a full-cost effectiveness analysis is not presented.

5.4 Home Energy Management

5.4.1 Energy Cost Savings Methodology

The code change proposal is for a compliance option and as a result a full-cost effectiveness analysis is not presented.

5.4.2 Energy Cost Savings Results

The code change proposal is for a compliance option and as a result a full-cost effectiveness analysis is not presented.

5.4.3 Incremental First Cost

Incremental first cost is the initial cost to adopt more efficient equipment or building practices when compared to the cost of an equivalent baseline project. Therefore, it was important that the Statewide CASE Team consider first costs in evaluating overall measure cost effectiveness. Incremental first costs are based on data available today and can change over time as markets evolve and professionals become familiar with new technology and building practices.

The code change proposal is for a compliance option and is not expected to increase first costs.

5.4.4 Incremental Maintenance and Replacement Costs

The code change proposal is for a compliance option and is not expected to increase maintenance and replacement costs.

5.4.5 Cost Effectiveness

Costs are not required for a compliance option, but some informational data on cost-effectiveness is provided in this section based on information gleaned from stakeholder outreach and a literature search. Energy cost savings and first costs have not been analyzed in detail for HEMS due to the diversity of products available and the emerging nature of the market. Very little cost data is available from previous studies based on the literature review performed for this Final CASE Report, but what was found is summarized in Table 43.

Table 43: Cost Effectiveness Data for HEMS Based on Past Research

Type of HEMS	First Cost	Energy Cost Savings	Cost Effectiveness	Notes	Source
Complete system (HVAC, lighting, plug loads)	$1853	$268/yr	7 year payback	New York prices and utility rates. Estimated savings, real costs	(Piper, et al. 2017)
Smart thermostat	$200	$174/yr	1.1 year payback	New York prices and utility rates. Estimated savings, real costs	(Piper, et al. 2017)
Hub, monitors, sensors	$153	-	-	New York prices and utility rates. Real costs	(Piper, et al. 2017)
Occupancy/ geofencing sensors	$316	-	-	New York prices and utility rates. Real costs	(Piper, et al. 2017)
Smart lights/ switches	$315	$36/yr	8.8 year payback	New York prices and utility rates. Estimated savings, real costs	(Piper, et al. 2017)
Smart outlets	$268	$58/yr	4.6 year payback	New York prices and utility rates. Estimated savings, real costs	(Piper, et al. 2017)

6. First-Year Statewide Impacts

The code change proposal would not modify the stringency of the existing Title 24, Part 6 Standards, so the savings associated with this proposed change are minimal. Typically, the Statewide CASE Team presents a detailed analysis of statewide energy and cost savings associated with the proposed change in Section 6 of the Final CASE Report. As discussed in Section 4, although the energy savings are limited, the measure would promote greater use of grid integration technologies and strengthening of an emerging product market, leading to opportunities for cost-effective code stringency improvements in future Title 24, Part 6 code change cycles.

6.1 Statewide Energy and Energy Cost Savings

The code change proposal is for a compliance option and as a result the statewide energy and energy cost savings are not presented.

6.2 Statewide Greenhouse Gas (GHG) Emissions Reductions

The code change proposal is for a compliance option and as a result the statewide greenhouse gas (GHG) emissions reductions are not presented.

6.3 Statewide Water Use Impacts

The code change proposal is for a compliance option and as a result the statewide water use impacts are not presented.

6.4 Statewide Material Impacts

The code change proposal is for a compliance option and as a result the statewide material impacts are not presented.

6.5 Other Non-Energy Impacts

The code change proposal is for a compliance option and as a result the other non-energy impacts are not presented.

7. Proposed Revisions to Code Language

7.1 Battery Storage Systems

7.1.1 Guide to Markup Language

The proposed changes to the standards, Reference Appendices, and the ACM Reference Manual are provided below. Changes to the 2019 documents are marked with red underlining (new language) and ~~strikethroughs~~ (deletions).

7.1.2 Standards

SECTION 100.1 – DEFINITIONS AND RULES OF CONSTRUCTION

BATTERY ~~SYSTEM, STATIONARY~~ STORAGE SYSTEM. A rechargeable energy storage system consisting of ~~electrochemical~~ a storage device~~batteries, battery chargers, controls,~~ and associated electrical equipment, including controls and inverters, designed to store and supply electrical power at a future time~~provide electrical power to a building~~. ~~The system is typically used to provide standby or emergency power, and uninterruptable power supply, load shedding, load sharing or similar capabilities.~~

BATTERY STORAGE SYSTEM READY INTERCONNECTION EQUIPMENT is equipment, e.g. a battery storage system ready panelboard, that can accommodate the connection of a distributed energy resource or an energy storage system and that includes provisions for either automatic or manual isolation from the utility power source.

BATTERY STORAGE SYSTEM READY PANELBOARD is a panelboard that can accommodate either automatic or manual switching between a utility power source to a distributed energy resource or an energy storage system, such as a split bus panelboard.

BATTERY STORAGE SYSTEM ZONE is an area on an interior or exterior wall designated and reserved for the installation of an energy storage system.

SECTION 110.10 – MANDATORY REQUIREMENTS FOR SOLAR READY BUILDINGS

(b) Solar Zone.

1. **Minimum Solar Zone Area.** The solar zone shall have a minimum total area as described below. …

   A. **Single Family Residences.** The solar zone shall be located on the roof or overhang of the building and have a total area no less than 250 square feet.

      EXCEPTION 6 to Section 110.10(b)1A: Single family residences meeting the following conditions:

A. All thermostats are demand responsive controls that comply with Section 110.12(a), and are capable of receiving and responding to Demand Response Signals prior to granting of an occupancy permit by the enforcing agency.

B. Comply with one of the following measures:

…

iv. Install a rainwater catchment system designed to comply with the California Plumbing Code and any applicable local ordinances, and that uses rainwater flowing from at least 65 percent of the available roof area; or

v. Install battery storage system ready interconnection equipment with a minimum backed up capacity of 60 Amps and a minimum of four ESS supplied branch circuits with a dedicated raceway from this equipment to the ESS zone; or a dedicated raceway from the main panelboard to a panelboard that supplies a minimum of four branch circuits to be supplied by the battery storage system; with at least one circuit supplying the refrigerator, and at least one circuit supplying a sleeping room receptacle outlet; and the single family residence shall be provided with at least one battery storage system zone, indicated on the construction documents.

7.1.3 Reference Appendices

Appendix JA12 – Qualification Requirements for Battery Storage System

JA12.1 Purpose and Scope

Joint Appendix JA12 provides the qualification requirements for battery storage system to meet the requirements for battery storage compliance credit(s) available in the performance standards set forth in Title 24, Part 6, Sections 150.1(b) in combination with an on-site photovoltaic system. The primary function of the battery storage system is daily cycling for the purpose of load shifting, maximized solar self-utilization, and grid harmonization.

JA12.2.1 Safety Requirements

The battery storage system shall be tested in accordance with the applicable requirements given in UL1973 and UL9540. Inverters used with battery storage systems shall be tested in accordance with the applicable requirements in UL1741 and UL1741 Supplement A.

JA12.2.2 Minimum Performance Requirements

The installed battery storage system should meet or exceed the following performance specification:

(a) Usable capacity of at least 5 kWh.

(b) Single Charge-discharge cycle AC to AC (round-trip) efficiency of at least 80 percent, at beginning of life.

(c) Energy capacity retention of 70 percent of nameplate capacity after 4,000 cycles covered by a warranty, or 70 percent of nameplate capacity under a 10-year warranty.

…

JA12.2.3 Control Requirements

The requirements below are applicable to all control strategies.

(a) The battery storage system shall have the capability of being remotely programmed to change the charge and discharge periods.

(b) During discharge, the battery storage system shall be programmed to first meet the electrical load of the dwelling unit(s). If during the discharge period the electrical load of the dwelling unit(s) is less than the maximum discharge rate, the battery storage system shall have the capability to discharge electricity into the grid ~~upon receipt of a demand response signal from the local utility or a third-party aggregator~~.

…

JA12.2.3.2 Time-of-Use (TOU) Control

To qualify for the TOU Control, the battery storage system shall be installed in the default operation mode to allow charging from an on-site photovoltaic system or from the utility grid if a standalone battery storage system. The battery storage system shall begin discharging during the highest priced TOU hours of the day, for each season ~~which varies by time of the year~~ and ~~the~~ local utility. The operation schedule shall be preprogrammed from factory, updated remotely, or programmed during the installation/commissioning of the system. At a minimum, the system shall be capable of programming three separate seasonal TOU schedules, such as spring, summer, and winter.

…

JA12.3 Interconnection and Net Energy Metering Requirements

The battery storage system and the associated components, including inverters, shall comply with all applicable requirements specified in Rule 21 and Net Energy Metering (NEM) rules as adopted by the California Public Utilities Commission (CPUC), in addition to all applicable local utility requirements.

JA12.4 Certificates and Enforcement Agency

The local enforcement agency shall verify that all Certificate of Installations are valid. The battery storage systems shall be verified as a model certified to the Energy Commission as qualified for credit as a battery storage system. In addition, the enforcement agency shall verify that the battery storage system is programmed and operational with one of the control strategies listed in JA12.2.3.1, JA12.2.3.2, JA12.2.3.3, or JA12.2.3.4. The programmed control strategy at system final inspection and commissioning shall be the strategy that was used in the Certificate of Compliance.

7.1.4 ACM Reference Manual

2.1.5 Photovoltaics Requirements

…

2.1.5.4 Battery Controls

The three control options available are:

1. Basic (Default Control). A simple control strategy that provides a modest credit. The software assumes that the batteries are charged anytime PV generation (generation) is greater than the house load (load); conversely, the batteries are discharged when load exceeds generation. This control strategy does not allow the batteries to discharge into the grid.
2. Time of Use. To qualify for the TOU control, the battery storage system shall be installed in the default operation mode to allow charging from an on-site photovoltaic system or from the utility grid if a standalone battery storage system. The battery storage system shall begin discharging during the highest priced TOU hours of the day, for each season ~~which varies by time of the year~~ and ~~the~~ local utility. At a minimum, the system shall be capable of programming three seasonal TOU schedules, such as spring, summer, and winter.
3. Advanced DR Control. To qualify for the advanced demand response control, the battery storage system shall be programmed by default as basic control or TOU control, as described above. The battery storage control shall meet the demand responsive control requirements specified in Section 110.12(a). The battery storage system shall have the capability to change the charging and discharging periods in response to signals from the local utility or a third-party aggregator. Upon receiving a demand response signal from a grid operator, this option allows discharging directly into the grid.

APPENDIX D – STATUS OF MODELING BATTERIES FOR CALIFORNIA RESIDENTIAL CODE COMPLIANCE

…

Battery Representation in CSE

The battery has maximum charge and discharge rates (kW), which are user-defined: ~~set based on the battery's size. CBECC-Res defines both as the same fixed fraction (kW/kWh) of the battery's user-defined maximum capacity (kWh).~~

```
max_charge_power ~~= 0.42 * max_capacity~~
```

max_discharge_power~~ = 0.42 * max_capacity~~

And both a charge and discharge efficiency (fraction), which are user-defined:

η_charge

η_discharge

The user has the option to input a round-trip efficiency (fraction) as an alternative to inputting both the charge and discharge efficiencies. In this case, the charge and discharge efficiency would be equal to:

η_charge = sqrt(η_rte)

η_discharge = sqrt(η_rte)

…

At the conclusion of that timestep, the battery's charge level will have been updated:

```
if charge_power > 0: // charging
    charge_level = charge_level + charge_power*η_charge
else if charge_power < 0 // discharging
    charge_level = charge_level + charge_power/η_discharge
else:
    charge_level = charge_level
```

If the battery round trip efficiency does not meet the minimum round trip efficiency requirements as specified in JA12, the CSE model should be simulated to mimic a design without a battery storage system. Therefore, the inclusion of a non-JA12 compliant battery storage system would have no impact on the resulting compliance credit.

…

There are ~~four~~ three battery control strategies enabled in CBECC-Res~~ as of May 2018~~: "Basic", "Time of use" (TOU), and "Advanced DR Control"~~, and "Advanced Control (old)"~~. These strategies are responsible for the timestep-by-timestep charge requests that are sent to the CSE battery module.

…

Time of Use Strategy

The TOU strategy attempts to preferentially discharge during ~~high-value hours~~ the highest priced TOU hours of the day hours, for each season and local utility~~ during summer (June - September)~~. Charging rules are the same as the basic strategy for battery storage systems paired with a solar PV system.

For standalone battery storage systems, the charging strategy finds the lowest four hours by TDV. The algorithm asks for full charge during the lowest three hours and charges the remainder during the fourth-lowest hour, if applicable. The 'lowest four hours' is hardcoded: the strategy assumes the battery holds no more than four hours of charge. If simulations are to allow other battery storage ratios, the algorithm will have to be upgraded.

The discharge period is statically defined (per climate zone) by the first hour of the expected evening TDV TOU peak., which is a user-input within CBECC-Res called "First Hour of the Summer Peak". The default value for "First Hour of the Summer Peak" is 18:00 for Climate Zones 8-9, 19:00 for Climate Zones 2, 4, 6, 10-15, and 20:00 for Climate Zones 1, 3, 5, and 7. The user has the option to change this value within CBECC-Res if desired.

Consider a summer day in which the evening peak is defined to start at 20:00 but during which simulation load exceeds PV production during the 19:00 hour. While a simulation utilizing the Basic strategy would discharge to neutralize the net load during the 19:00 hour, a simulation on the TOU strategy would reserve the battery until 20:00 before commencing discharge. Because the TDV at 20:00 is likely to be higher than the TDV at 19:00, this strategy of reserving the battery for higher-value hours results in a lower (better) annual TDV.

A second difference: During the peak window, the battery is permitted to discharge at full power, even exceeding the site's net load. This is in contrast to the Basic strategy, which is limited to the net load.

```
if this_hour < first_peak_hr:
    charge_request = -min(load_seen, 0)  // only charge
else:
    charge_request = -1000  // maximum discharge
```

Outside of July-September the TOU strategy reverts to the Basic strategy.

…

Advanced DR Control

The Advanced DR (i.e., Demand Response) strategy uses the current day's TDV schedule to make dynamic time-of-use priorities. This strategy activates on days that have a peak TDV greater than 1034.13 TDV/kBTU. On all other days, the simulation reverts to the Basic strategy for battery storage systems paired with a solar PV system and to the Time of Use strategy for standalone storage systems.

On a peak day (as defined by a peak greater than 1034.13 TDV/kBTU), the strategy finds the top threefour hours by TDV. The algorithm asks for full discharge during the top twothree hours and uses the remainder during the thirdfourth-highest hour. The 'top threefour hours' is hardcoded: the strategy assumes the battery holds between two and threeno more than four hours of charge. If simulations are to allow other battery storage ratios, the algorithm will have to be upgraded. Charging rules are the same as the basic strategy for battery storage systems paired with a solar PV system. For standalone battery storage systems, the charging strategy should mimic the standalone battery charging strategy defined for Time of Use control.

As with the TOU strategy, the battery may discharge in excess of net load during peak hours. The Advanced DR strategy is also allowed to charge from the PV system before production overtakes load. Whereas the Basic and TOU strategies only charge with surplus production, this strategy will—on a peak day—charge from the first PV production available.

```
if day_tdv_peak > 1034.13:
     if tdv_rank(this_hour) in [1, 2]:
        // maximum discharge top two TDV hours
        charge_request = -1000
     else if tdv_rank(this_hour) == 3:
        // in third TDV hour, use remaining charge
        charge_request = max_capacity -
                2*(max_discharge_rate/η_discharge)
     else:
        // charge from PV, without subtracting load
        charge_request = pv_production
else:
     // on non-peak days, revert to basic strategy
     charge_request = -load_seen
```

~~**Advanced Control (old)**~~

~~The "Advanced Control (old)" strategy is an omniscient system that runs two simulations to fine-tune the battery operation to minimize overall TDV. The first simulation--run without a battery--produces timeseries for load and PV production. An intermediate Python script compares the resulting net-load to a TDV timeseries and produces an optimal battery strategy for each day given that building-battery-array-weather-TDV combination. Unlike the other three strategies, which make charge/discharge decisions within the simulation, this strategy allows perfect foresight. The algorithmic details are described in a methodology report from Energy and Environmental Economics, Inc., the firm that wrote the Advanced Control (old) algorithm (E3, undated). This strategy is not available for compliance and is included in the program for research purposes only~~

7.1.5 Compliance Manuals

Chapter 7.5 of the Residential Compliance Manual would need to be revised.

7.5 Battery Storage System

…

The list of qualified JA12 products ~~list~~ can be found here:

~~http://www.energy.ca.gov/title24/equipment_cert/~~ https://www.energy.ca.gov/programs-and-topics/topics/renewable-energy/solar-equipment-lists

7.5.1 Minimum Performance Requirements

JA12 specifies that the battery storage system must meet or exceed the following performance specifications:

a. Usable capacity of at least 5 kWh.

b. Single Charge-discharge cycle AC to AC (round-trip) efficiency of at least 80 percent, at beginning of life.

c. Energy capacity retention of 70 percent of nameplate capacity after 4,000 cycles covered by a warranty, or 70 percent of nameplate capacity under a 10-year warranty.

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7.5.2 Controls Requirements

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The following JA12 requirements apply to all control strategies, including Basic Control, Time-of-Use (TOU) Control, and Advanced Demand Response Control, described in Section 7.5.3 below:

1. The battery storage system shall have the capability of being remotely programmed to change the charge and discharge periods.

2. During discharge, the battery storage system shall be programmed to first meet the electrical load of the dwelling unit(s). If during the discharge period the electrical load of the dwelling unit(s) is less than the maximum discharge rate, the battery storage system shall have the capability to discharge electricity into the grid ~~upon receipt of a demand response signal from the local utility or a third-party aggregator~~.

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7.5.3 Control Strategies

JA12 includes three control strategies that are designed to encourage charging the batteries when electricity prices are low, generally in the middle of the day when solar resources are plentiful and demand is low, and discharge the batteries later in the day when demand is high and solar resources are diminished:

Basic Control: Designed as a simple control that can be employed as the default control in the absence of TOU or Advanced Demand Response Controls, or where communication between batteries and outside parties are not possible. ~~This control strategy does not allow discharging into the grid.~~ To qualify for the Basic Control, the battery storage system shall be installed in the default operation mode to allow charging only from an on-site photovoltaic system when the photovoltaic system production is greater than the on-site electrical load. The battery storage system shall discharge only when the photovoltaic system production is less than the on-site electrical load.

Time-of-Use (TOU) Control: Designed to take advantage of TOU rates where they are available. This control strategy generally results in a greater Energy Design Rating (EDR) impact than the Basic Control. ~~This control strategy does not allow discharging into the grid.~~ To qualify for the TOU Control, the battery storage system shall be installed in the default operation mode to allow charging from an on-site photovoltaic system or from the utility grid if a standalone battery storage system . The battery storage system shall begin discharging during the highest priced TOU hours of the day hours, for each season-and local utility. The operation schedule shall be preprogrammed from factory, updated remotely, or programmed during the installation/commissioning of the system. At a minimum, the system shall be capable of programming three separate seasonal TOU schedules, such as spring, summer, and winter.

Advanced Demand Response Control: Designed to bring the maximum value to the PV system generations by placing the charge/discharge functions of the battery storage system under the control of a utility or a third party aggregator. This ~~is the only~~ control strategy ~~that~~ allows discharging into the gird upon receiving a demand response signal from a grid operator. This option requires robust communication capabilities between the battery storage system and the local utility or the third party aggregator. To qualify for the Advanced Demand Response Control, the battery storage system shall be programmed by default as Basic Control or TOU control as described above. The battery storage control shall meet the demand responsive control requirements specified in Section 110.12(a). Additionally, the battery storage system shall have the capability to change the charging and discharging periods in response to signals from the local utility or a third-party aggregator

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7.5.4 Other Requirements

In addition to the requirements above, the battery storage system must also meet the following requirements in JA12:

Safety Requirements: The battery storage system shall be tested in accordance with the applicable requirements given in UL1973 and UL9540. Inverters used with battery storage systems shall be tested in accordance with the applicable requirements in UL1741 and UL1741 Supplement A.

Interconnection and Net Energy Metering Requirements: The battery storage system and the associated components, including inverters, shall comply with all applicable requirements specified in Rule 21 and Net Energy Metering (NEM) rules as adopted by the California Public Utilities Commission (CPUC), in addition to all applicable local utility requirements.

Enforcement Agency: The local enforcement agency shall verify that all Certificate of Installations are valid. The battery storage systems shall be verified as a model certified to the Energy Commission as qualified for credit as a battery storage system. In addition, the enforcement agency shall verify that the battery storage system is programmed and operational with one of the control strategies listed in Section 7.5.2 above. The programmed control strategy at system final inspection and commissioning shall be the strategy that was used in the Certificate of Compliance.

7.1.6 Compliance Documents

Compliance document CEC-CF2R-PVB-02-E Battery Storage Systems Certificate of Installation would need to be revised. The revision is intended to facilitate the verification of battery control strategies by listing the allowable battery control strategies as specified in JA12. Charge rate, discharge rate, and round trip efficiency, which would be new user inputs in CBECC-Res, have also been added to the battery storage systems information tables.

…

B. Design Battery Storage Systems Information						
01	02	03	04	~~04~~05	06	07
Battery Capacity (kWh)	Battery Control Strategy	Charging Efficiency (%)	Charge Rate (kW)	Discharging Efficiency (%)	Discharge Rate (kW)	Round Trip Efficiency (%)

C. Installed Battery Storage Systems Information								
01	02	03	04	05	06	~~06~~07	08	09
Manufacturer	Model ~~#~~	Battery Capacity (kWh)	Battery Control Strategy	Charging Efficiency (%)	Charge Rate (kW)	Discharging Efficiency (%)	Discharge Rate (kW)	Round Trip Efficiency (%)
~~07~~10	Battery Storage System ~~C~~certified by CEC	☐ **Yes** ☐ **No**						

…

CF2R-PVB-02-E User Instructions

A. General Information

This table reports the general information that were specified on the registered CF1R compliance document for this project. For information only and requires no user input.

B. Design Battery Storage Systems Information

This table reports the battery storage system features that were specified on the registered CF1R compliance document for this project. For information only and requires no user input.

C. Installed Battery Storage Systems Information

01 Manufacturer – Enter the name of the manufacturer
02 Model # - Enter the model name or number of the battery storage system
03 Battery Capacity – Enter the rated usable battery capacity in kWh
04 Battery Control Strategy – Enter the control strategy ~~of the~~from the options below that most closely resembles the control strategy of the installed battery storage system. ~~The options are basic, TOU, and Advanced DR.~~ The battery control strategy (or control mode) can be located in either the battery user manual or in the battery settings.

- Basic Control: Battery charges whenever there is excess PV. Battery discharges to meet house load when PV does not cover it.
- Time of Use Control: Battery charges whenever there is excess PV if paired with a PV system. Standalone systems should charge from the grid at the lowest priced TOU hours of the day. Battery discharges during the highest priced TOU hours of the day for each season and local utility. Battery will put power into grid after meeting house load if discharge rate allows it.
- Advanced DR Control: On a peak day, use all PV to charge the battery until it is full. Discharge at maximum rate during three highest TDV hours. Otherwise run with either Basic or Time of Use control. Battery will put power into grid after meeting house load if discharge rate allows it.

05 Charging Efficiency – Enter the rated AC charging efficiency in percent
06 Charge Rate – Enter the rate in kW at which the battery is charged
~~06~~07 Discharging Efficiency – Enter the rated AC discharging efficiency in percent
08 Discharge Rate – Enter the rate in kW at which the battery is discharged
09 Round Trip Efficiency – Enter the rated AC-AC round trip efficiency in percent as an alternative to entering both the charging efficiency and discharging efficiency
~~07~~10 Battery Storage System ~~C~~certified and listed be CEC – Check whether the battery storage system is certified and listed in the Energy Commission Website at https://www.energy.ca.gov/programs-and-topics/topics/renewable-energy/solar-equipment-lists. Note that this is not a comprehensive list. However, all battery storage systems listed on this website have been verified to meet JA12 requirements.

Compliance document CF2R-SRA-01-E would need to be updated with a new exception to the solar zone area requirement for when battery ready building criteria are met.

CF2R-SRA-01-E: Solar Ready Buildings– New Construction

E. Smart Thermostats and Alternative Efficiency Measure (Single Family)		
01	All thermostats comply with Reference Joint Appendix JA5 and are capable of receiving and responding to Demand Response Signals prior to granting of an occupancy permit by the enforcing agency.	
02	Alternative Efficiency Measure:	… *Install a rainwater catchment system designed to comply with the California Plumbing Code and any applicable local ordinances, and that uses rainwater flowing from at least 65% of the available roof area; or *Install battery storage system ready interconnection equipment with a minimum backed up capacity of 60 Amps and a minimum of four ESS supplied branch circuits with a dedicated raceway from this equipment to the ESS zone; or a dedicated raceway from the main panelboard to a panelboard that supplies a minimum of four branch circuits to be supplied by the battery storage system; with at least one circuit supplying the refrigerator, and at least one circuit supplying a sleeping room receptacle outlet; and the single family residence shall
The responsible person's signature on this compliance document affirms that all applicable requirements in this table have been met.		

7.2 HPWH Load Shifting

7.2.1 Guide to Markup Language

The proposed changes to the standards, Reference Appendices, and the ACM Reference Manual are provided below. Changes to the 2019 documents are marked with red underlining (new language) and ~~strikethroughs~~ (deletions).

7.2.2 Standards

No changes to the standards.

7.2.3 Reference Appendices

Appendix JA1 – Definitions

ANSI/CTA-2045 is a modular communications interface to facilitate communications with residential devices for applications such as energy management. ANSI/CTA–2045-A is the Consumer Technology Association document titled "Modular Communications Interface for Energy Management" 2018 (ANSI/CTA-2045-A-2018)

HEAT PUMP WATER HEATER (ADVANCED LOAD UP) is a residential heat pump water heater system controlled to store extra thermal energy in the storage tank by exceeding the user setpoint temperature. It will avoid use of electric resistance elements unless user needs cannot be met. This mode must only be enabled after agreement by the user and utility.

HEAT PUMP WATER HEATER (BASIC LOAD UP) is a residential heat pump water heater system controlled to store extra thermal energy in the storage tank without exceeding the user setpoint temperature. It will avoid use of electric resistance elements unless user needs cannot be met.

HEAT PUMP WATER HEATER (BASIC PLUS LOAD UP) is a residential heat pump water heater system that is either controlled to store extra thermal energy in the storage tank by exceeding the user setpoint temperature or is sized to provide enhanced storage capacity of thermal energy. It will avoid use of electric resistance elements unless user needs cannot be met.

The July 8th, 2020 adopted Joint Appendix 13 would require the following modifications:

Appendix JA13 – Qualification Requirements for Heat Pump Water Heater Demand Management Systems (June 22, 2020 final version)

The proposed edits to JA13 shown below include edits provided by the Nonresidential Statewide CASE Team as it relates to LSHPWHs.

JA13.1 Purpose and Scope

Joint Appendix JA13 provides the qualification requirements for a heat pump water heater (HPWH) demand management system ("System") to meet the requirements for HPWH demand flexibility compliance credit available in the performance standards specified in Title 24, Part 6, Sections 150.1(b) and 140.1. The primary function of the System is to serve the users' domestic hot water needs and provide daily load shifting, as applicable, for the purpose of user bill reductions, maximized solar self- utilization, and grid harmonization.

User interfaces referenced in these requirements shall be designed for use by a typical ~~residential~~ user.

JA13.2 Definitions

Heat Pump Water Heater Demand Management System

The HPWH Demand Management System is comprised of:

1. Any hardware or software contained inside the water heater;
2. Any hardware or software installed on premise (including a module); and
3. Any software contained in applications or in the cloud;

which are necessary to fulfil the primary function of the System.

Heat Pump Water Heater System Types

The minimum thermal storage and load shifting requirements are dependent on the type of HPWH installed. The below table defines each system as referenced throughout the appendix.

Table JA13- 1: Types of Heat Pump Water Heaters

HPWH Type	**Definition**
Unitary Residential	Heat pump water heater with a total nominal compressor output power of 6 kW or less, including integrated heat pumps with storage as shipped from the point of manufacture and split-system heat pumps that consist of a separate heat pump and storage tank that are designed and marketed to operate together.
Unitary Nonresidential	Heat pump water heater with a total nominal compressor output power greater than 6 kW with integrated storage as shipped from the point of manufacture, including skid systems that are pre-plumbed and wired.
Central Residential	Heat pump water heater(s) without integrated storage as shipped from the manufacturer, and designed for residential, single and multifamily applications.
Central Nonresidential	Heat pump water heater(s), without integrated storage as shipped from the manufacturer, and designed for nonresidential applications.

Local and Remote Methods

A Local Method means a method that can be performed from within the building that does not require the System to have a live connection to an off-premise source. A temporary connection to a live off- premise source such as via a smart phone, may be used for local setup and updates.

A Remote Method means a method that is performed via a live connection to an off-premise source, such as the internet, advanced metering infrastructure (AMI), or cellular communication.

JA13.3 Qualification Requirements

To qualify for the HPWH Demand Management System performance compliance credit, the System shall be certified to the Energy Commission to meet the following requirements:

JA13.3.1 Safety Requirements

The System shall comply with applicable installation standards in the California electrical, mechanical, building and plumbing codes.

A thermostatic mixing valve conforming to ASSE 1017 shall be installed on the hot water supply line following all manufacturer installation instructions or the water heater shall conform to UL 60730-1, ASSE 1082, or ASSE 1084.

JA13.3.2 Minimum Performance Requirements

The installed System shall meet or exceed the following performance specification:

Efficiency: meet all requirements specified in Table JA13- 2. ~~of the version 7.0 of the Northwest Energy Efficiency Alliance (NEEA) Advanced Water Heater Specification Tier 3 or higher, excluding Appendix A~~

Table JA13- 2: Minimum efficiency requirements for each type of HPWH

Type of HPWH	**Efficiency Requirements**
Unitary Residential	Compliant with version 6.0 or 7.0 of the Northwest Energy Efficiency Alliance (NEEA) Advanced Water Heater Specification Tier 3 or higher
Unitary Nonresidential	ENERGY STAR certified
Central Residential	N/A
Central Nonresidential	N/A

Thermal storage: comply with the first hour rating requirements in Table JA13- 3 ~~the following table~~ (consistent with requirements in Chapter 5, Table 501.1(2) of the ~~in~~ 2019 California Plumbing Code):

Table JA13- 3: Thermal storage requirements for each type of HPWH

Type of HPWH	Storage or Delivery Capacity Requirements
Unitary Residential	Comply with the first hour rating requirements in Table JA13- 3 (consistent with requirements in Chapter 5, Table 501.1(2) of the 2019 California Plumbing Code)
Unitary Nonresidential	Shall have a minimum hot water delivery of 300 gallons per day
Central Residential	Shall have a minimum 0.84 kWh thermal storage per person based on design occupancy of the project described in the NRCC-PRF-01-E. The sizing calculation is based on an ambient air temperature of 67.5 F and an inlet water temperature of 58 F
Central Nonresidential	Shall have sufficient thermal storage to support a minimum 4 hours of compressor operation. The sizing calculation is based on an ambient air temperature of 67.5 F and an inlet water temperature of 58 F

Table JA13- 4: First Hour Rating Requirements for Unitary Residential HPWHs (Replication of Table 501.1(2) in Chapter 5 of the 2019 California Plumbing Code

Number of bathrooms	1 to 1.5			2 to 2.5				3 to 3.5			
Number of bedrooms	1	2	3	2	3	4	5	3	4	5	6
First Hour Rating (gallons)	38	49	49	49	62	62	74	62	74	74	74

Grid Connectivity: the installed system shall have a modular demand response communications port compliant with the March 2018 version of the ANSI/CTA–2045-A communication interface standard.

JA13.3 Control Requirements

The requirements below are applicable to all control strategies:

a) **Time-of-use schedules:** The System shall have the capability of storing at a minimum five time-of-use schedule(s) locally, each supporting at a minimum five distinct time periods for both weekdays and weekends, at least three separate seasonal schedules, and daylight savings time changes. The System shall support both local and remote setup, selection, and update of time-of-use schedules.

Local and remote setup, selection, and update shall be possible through a user interface (such as an app).

b) **Demand management functionality**

Upon receiving a demand management price or dispatch signal, the System shall be capable of all the following automatic event responses:

1. **Basic Load Up:** The System will store extra thermal energy without exceeding the user set point temperature. It will avoid use of electric resistance elements unless user needs cannot be met;

2. **Basic Plus Load Up:** The System stores extra thermal energy, where some or all of the tank may exceed the set point temperature chosen by the user, within safe operating conditions. It will avoid use of electric resistance elements unless user needs cannot be met.

3. **Advanced Load Up:** The System stores extra thermal energy, where some or all of the tank may exceed the set point temperature chosen by the user, within safe operating conditions. Advanced Load Up must only be enabled after agreement by the user and utility as defined below. It will avoid use of electric resistance elements unless user needs cannot be met. Advanced Load Up will only be available in Advanced Demand Response Control mode as defined in JA13.3.3.2;

4. **Return to Standard Operation:** The System terminates any demand management function and returns to user-selected standard operation mode until the next demand management function is activated;

5. **Light Shed:** The System will defer complete recovery for the duration of the shed event unless user needs cannot be met; The water heater shall avoid use of electric resistance elements during and immediately after the event unless user needs cannot be met;

6. **Deep Shed:** same as Light Shed, but the System will completely avoid use of electric resistance elements during the event;

7. **Full Shed:** same as Light Shed, but the System will completely avoid use of both compressor and electric resistance element during the event.

The demand management signals may be sent from a local utility, a remote aggregator, a local demand manager (e.g. local time-of-use demand manager), or be internal to the System (e.g. internal schedule- or price-based demand management).

The “Advanced Load Up” function shall only be enabled by a deliberate action of the user through the system’s physical or remote interface upon enrolling in a utility’s demand response program. The “Advanced Load Up” function shall be capable of being disabled deliberately by the user, or remotely by the utility or third-party service provider without deliberate action by the user.

For a water heater sized in accordance with JA13.3.2(b) and with the default set point as shipped from the manufacturer, the System shall be able to shift in accordance with requirements in Table JA13- 5.:

- A minimum of 0.5 kWh of user electrical energy per (Basic Load Up + Light Shed) event; and
- A minimum of 1 kWh of user electrical energy per (Advanced Load Up + Light Shed) event, including at least 0.5 kWh on Advanced Load Up.

Table JA13- 5: Demand management functionality for each type of HPWH

Type of HPWH	**Basic Load Up + Light Shed**	**Basic Plus Load Up + Light Shed**	**Advanced Load Up + Light Shed**
Unitary Residential	A minimum of **0.5 kWh** of electrical energy per event	A minimum of **0.75 kWh** of electrical energy per event	A minimum of **1 kWh** of electrical energy per event, including at least **0.5 kWh** on Advanced Load Up
Unitary Nonresidential	A minimum of **1 kWh** of electrical energy **per 100 gallon** storage per event	N/A	A minimum of **2 kWh** of electrical energy **per 100 gallon** storage per event.
Central Residential	A minimum of **0.2 kWh** of electrical energy per person per event (design occupancy)	N/A	A minimum of **0.4 kWh** of electrical energy per person per event, including at least **0.2 kWh** on Advanced Load Up (design occupancy)
Central Nonresidential	**4 hours** minimum of compressor run time at nominal rated power (same 4 hours as thermal storage requirement, not additive)		

c) **Non-standard mode exception:** The demand management functionality shall be achieved in all user-selected modes except for vacation and off modes, which are deemed non- standard modes. The System shall return to the previous standard operation mode once the water heater exits from a non-standard mode.

d) **Local time management:** In the event of a loss of power, the System settings, including operating mode, time-of-use schedules, and local clock, shall be retained, or reacquired, for at least three months. The local clock shall have a maximum drift of less than 5 minutes per year under standard operating conditions and without requiring remote connectivity.
e) **Override and permanent disabling:** The System shall provide local and remote means for the user to override or permanently disable the demand management functions. The override shall be temporary and have a maximum duration of 72 hours. Permanent disabling shall not be available as an operating mode or as an option in the primary menu.
f) **User interface:** The System shall provide both a remote and local user interface, such as a web-based portal or a mobile device application, that at a minimum provides the dwelling occupants access to the following information: control strategy that is currently active, remote or local demand management mode, selected time-of-use schedule if applicable, and confirmation of any settings change.
g) **Measurement and validation:** When connected remotely, the System shall make the following data available to the local utility, remote aggregator, or local demand manager: Demand Management Override Status, Demand Management Disabled Status; power demand (watts); cumulative energy consumption (watt-hours); total energy storage capacity (watt-hours), available energy storage capacity (watt-hours).

The System shall be capable to use one of the following control strategies at the time of installation. The System also shall have the capability to switch to other control strategies if available. The “Advanced Load Up” function shall not be enabled at time of installation.

JA13.3.3.1 Time-of-Use (TOU) Control

To qualify for the TOU Control, the System shall be installed in the default operation mode to serve domestic hot water user needs while optimizing System operation to reduce user bills under the selected time-of-use schedule. The System shall load up (charge) during the lowest priced TOU hours of the day and shed (minimize charging while serving user needs) during the highest priced TOU hours.

JA 13.3.3.2 Basic Plus Option

To qualify for the Basic Plus Option, the System shall meet the requirements of section JA13.3.1 and be installed with the capability of achieving the energy shift listed in Table JA13-5 under “Basic Plus Load Up + Light Shed.” The System shall be capable of shifting more electrical energy than under the Basic case by making more energy storage in the tank available through any of the following means:

(a) Increased tank volume: The System shall be sized to meet the first hour rating requirements in Table JA13-6:

Table JA13- 6: First Hour Rating Requirements for Basic Plus Option

Number of bathrooms	1 to 1.5			2 to 2.5				3 to 3.5			
Number of bedrooms	1	2	3	2	3	4	5	3	4	5	6
First Hour Rating (gallons)	49	62	62	62	74	74	85	74	85	85	85

(b) Increased storage temperature with integrated thermostatic mixing valve: The System shall have the capability of increasing the tank set point temperature higher to achieve the "Basic Plus Load Up + Light Shed" shift amount listed in Table JA13- 5. The installed water heater shall conform to UL 60730-1, ASSE 1082, or ASSE 1084.

(c) Increased storage temperature with external thermostatic mixing valve: The System shall be installed with a thermostatic mixing valve conforming to ASSE 1017 external to the water heater. At time of installation, the mixing valve and water heater shall be configured such that the water heater set point temperature is at minimum 10 F above the mixing valve outlet temperature. A notice, informing the occupants that the water heater is configured to shift its operation to grid beneficial time periods and that the water heater temperature is set above the mixing valve outlet temperature shall be posted on the water heater.

JA13.3.3.3 Advanced Demand Response Control

To qualify for the Advanced Demand Response Control, the System shall meet the demand responsive control requirements specified in Section 110.12(a) of the 2019 Building Energy Efficiency Standards. Additionally, the System shall be capable of changing the load-up and shed periods in response to real-time or day-ahead dispatch or price signals from the local utility, a remote aggregator, or a local demand manager. If remote communication is lost for more than 12 hours while the water heater is under Advanced Demand Response Control, the water heater shall revert to TOU Control until remote communication is reestablished, and then revert back to Advanced Demand Response Control.

JA13.3.3.4 Alternative Control Approved by the Executive Director

The Executive Director may, after stakeholder comments, approve alternative control strategies that demonstrate equal or greater benefits to one of the JA13 control strategies. To qualify for Alternative Control, the System shall be operated in a manner that increases self-utilization of the PV array output, responds to utility rates, responds to demand response signals, and/or other strategies that achieve equal or greater benefits. This alternative control option shall be accompanied with well-documented algorithms for incorporation into the compliance software for compliance credit calculations.

JA13..5 Enforcement Agency

To receive the HPWH Demand Management System compliance credit, the completed Certificate of Installation shall be a model that has been certified to the Energy Commission as qualified for the credit. As part of their normal enforcement activities, this certification shall be subject to local building department checking.

New Reference Appendix Section 3.6.11 would need to be added:

RA3.6.11 Verified Load-Shifting HPWH with Raised Set Point (Basic Plus Load Up)

A HERS inspection is required to obtain a compliance credit for any load shifting HPWH that raises the tank set point above the default setting. All eligible HPWH unit(s) shall be certified to the Energy Commission to be compliant with Joint Appendix 13 (Qualification Requirements for Heat Pump Water Heater Demand Management Systems).

The HERS inspector shall verify that the installed HPWH unit(s):

(a) Have a tempering or thermostatic mixing valve installed.
(b) Have a current time of use electric rate properly programmed and appropriate for the HPWHs local electric utility provider (Basic Plus-1 only).
(c) Provide an indication that the unit is configured to operate in the Basic Plus mode whereby the System shall provide a minimum of 0.75 kWh of shifted electrical energy as per JA13.3.3(b). Specification of setting and confirming the Basic Plus Load Up mode must be clearly defined in the System's User Manual and can be displayed with an indicator light, equipment display screen, or other means identified by the manufacturer (Basic Plus-1 only).
(d) Verify that one page flyer is physically attached and visible on the water heater. Flyer will outline how a LSHPWH operates with fluctuating tank temperatures but maintains a safe hot water delivery temperature at all times due to mixing valve.

7.2.4 ACM Reference Manual

There are no proposed changes to the ACM Reference Manual at this time, pending implementation of the load shifting algorithms into CBECC-Res (expected late Fall 2020), which is expected to inform any ACM Reference Manual additions.

7.2.5 Compliance Manuals

There are no proposed changes to the Residential Compliance Manual at this time, pending any content supplied by the Energy Commission as part of the JA13 approval process.

7.2.6 Compliance Documents

The CF1R-PRF-01E will need to be updated to reflect the option of the Basic Plus LSHPWH compliance option as shown below. Basic Plus-"X" would denote which mode is being implemented (where "X" is either 1, 2, or 3) based on the information entered in the CBECC-Res input editor. If mode 2, the software would internally compute that the proposed water heater meets the FHR requirement based on the number of bedrooms and bathrooms in the house or apartment. For modes 1 or 3, HERS verifications would be required.

WATER HEATING - HERS VERIFICATION				
01	02	03	04	05
Name	**Pipe Insulation**	**Parallel Piping**	**Compact Distribution**	**Load Shifting HPWH**
DHWHeatpump - 1/1	Not Required	Not Required	Not Required	Basic Plus-"X"

The CF-1R-NCB-01-E document will need to be modified as shown below.

…

P. HERS Verification Summary The enforcement agency shall pay special attention to the HERS Measures specified in this checklist below. A registered Certificate of Verification for all the measures specified shall be submitted to the building inspector before final inspection.
Quality Insulation Installation – Section 150.1(c)1E The dwelling unit shall meet all requirements of Quality Insulation Installation (QII) as specified in Reference Appendix RA3.5 as verified by a HERS rater. EXCEPTION: Multifamily dwelling units in Climate Zone 7.
Duct Leakage Verification- Section 150.0(m)11 • Duct leakage testing is required (Residential Appendix RA3.1) in all climate zones for ducted heating and cooling systems.
Zonally Controlled Systems – Bypass Dampers - Section 150.1(c)13 • If system is zonally controlled, no bypass ducts are allowed, as confirmed by HERS verification (Reference Appendix RA 3.4.1.6).
Refrigerant Charge Verification – Section 150.1(c)7a • Refrigerant charge testing is required (Residential Appendix RA3.2) in climate zones 2 and 8-15 for all air-cooled air conditioners and air source heat pumps, including ducted split systems, ducted package systems, small duct high velocity systems, and mini-split systems. • Some exceptions apply to factory charged package systems.

Central System Air Handlers – Air Flow and Fan Efficacy Verification - Section 150.0(m)13 • Airflow (minimum 350 cfm/ton) and Fan Efficacy (max 0.45 Watts/cfm for gas furnace air handlers / 0.58 Watts/cfm for air handlers that are not gas furnaces) on systems with ducted air conditioning as field verified by a HERS rater or Return Duct and Filter System Design according to tables 150.0-B/C will be HERS verified • Heat-only systems with Central Fan Integrated (CFI) ventilation are required to have less than 0.45 Watts/cfm as verified by a HERS rater. • Small duct high velocity systems: airflow (minimum 250 cfm/ton) and fan efficacy (max 0.62 W/cfm) as verified by a HERS rater..
Indoor Air Quality Mechanical Ventilation – Section 150.0(o) • Mechanical ventilation airflow rate according to ASHRAE 62.2 is required to be verified by a HERS rater (RA3.7).
Load Shifting HPWH - Basic Plus • If compliance credit is taken for Basic Plus-1 or Basic Plus-3, installation is to be verified by a HERS rater (RA3.6.11).

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CF1R-NCB-01-E User Instructions

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M. Water Heating Systems for Individual Dwelling Units

1. Water Heating System Identification or Name: Provide a unique name for each unique water heating system type in the building. If the same water heating system type is used in more

than one location in the building, it is sufficient to list the unique water heating system type only once.

2. Water Heater System Type: Domestic Hot Water (DHW), Hydronic, Combined Hydronic, or Central. DHW is for domestic hot water, hydronic is a water heating system used for space heating only; combined hydronic are when the water heater will provide both space conditioning and domestic hot water. A central water heater serves multiple dwelling units in a multi- family building.
3. System option:
   (1) A single gas or propane instantaneous water heater with an input of 200,000 Btu per hour or less and no storage tank.

   (2) A single gas or propane storage type water heater with an input of 75,000 Btu per hour or less, rated volume less than or equal to 55 gallons and that meets the requirements of
   Sections 110.1 and 110.3. The dwelling unit shall have installed fenestration products with a weighted aver U-factor of 0.24 or less and either:

      A. A compact hot water distribution system that is field verified as specified in the Reference Appendix RA4.4.16; or

B. A drain water heat recovery system that is field verified as specified in the Reference Appendix RA3.6.9.

(3) A single gas or propane storage type water heater (small storage or consumer storage) with an input of 75,000 Btu per hour or less, rated volume greater than 55 gallons.

(4) A heat pump water heater located in the garage or conditioned space, and either:

C. A compact hot water distribution system as specified in the Reference Appendix RA4.4.6, and a drain water heat recovery system that is field verified as specified in the Reference Appendix RA3.6.9; or

D. In climate zones 2-15, a PV system with 0.3 kWdc capacity larger than the PV requirements in Table O; or

E. In climate zones 1 or 16, a PV system with 1.1 kWdc capacity larger than the PV requirements in Table O.

(5) A single NEEA Tier 3 heat pump water heater located in the garage or conditioned space, and:

A. In climate zones 1 or 16, a PV system with 0.3 kWdc capacity larger than the PV requirements in Table O, and

B. In climate zones 1 or 16, a compact hot water distribution system as specified in the Reference Appendix RA4.4.6.

4. # of Dwelling Units: Enter a whole number for how many dwelling units are in the building.
5. # of Recirculation loops: User entry based on number of dwelling units
6. Water heater Type: Tankless, storage, heat pump, load shifting Basic Plus heat pump water heater (HPWH-LS-BP).

...

The CF2R-PLB-22a-HERS will need to be updated to reflect the Basic Plus LSHPWH compliance option as shown below.

…

E. Installed Water Heater Manufacturer Information			
01	02	03	04
Water Heating System ID or Name	Manufacturer	Model Number	JA13 Listed Load Shifting Heat Pump Water Heater

…

R. HERS-Verified Load Shifting Heat Pump Water Heater (RA3.6.11) Requirements

Basic Plus-1 or Basic Plus-3 HPWHs utilizing this compliance option credit shall comply with these requirements	
01	Have a tempering or thermostatic mixing valve installed.
02	Have a current time of use electric rate properly programmed and appropriate for the HPWHs local electric utility provider.
03	Heat pump water heater is configured to operate in the Basic Plus Load Up mode of operation (confirmation of operating mode as identified in the water heater's installation manual).
04	Verify that one page flyer is physically attached and visible on the water heater. Flyer will outline how a LSHPWH operates in response to TOU price signals and maintains a safe hot water delivery temperature at all times due to mixing valve.
The responsible person's signature on this compliance document affirms that all applicable requirements in this table have been met.	

The CF3R-PLB-22a-HERS will need to be updated to reflect the Basic Plus LSHPWH HERS verification as shown below.

,,,

R. HERS-Verified Load Verified Load Shifting Heat Pump Water Heater (RA3.6.11) Requirements Basic Plus-1 or Basic Plus-3 systems that utilize this compliance credit shall comply with these requirements		
01	Recognized by the Energy Commission as Joint Appendix 13 compliant heat pump water heater (mixing valve installed) and capable of Basic Plus Load Up operation.	
02	Heat pump water heater properly programmed with local utility time-of-use electric rate (Basic Plus-1 only).	
03	Heat pump water heater is configured to operate in the Basic Plus Load Up mode of operation (confirmation of operating mode as identified in the water heater's installation manual). (Basic Plus-1 only).	
04	One page flyer outlining how a LSHPWH operates in response to TOU price signals and maintains a safe hot water delivery temperature at all times due to mixing valve is visible and physically attached to HPWH.	
05	Verification Status:	D Pass - all applicable requirements are met; or D Fail - one or more applicable requirements are not met. Enter reason for failure in corrections notes field below; or D All N/A - This entire table is not applicable

06	Correction Notes:
The responsible person's signature on this compliance document affirms that all applicable requirements in this table have been met unless otherwise noted in the Verification Status and the Corrections Notes in this table.	

7.3 HVAC Load Shifting

7.3.1 Guide to Markup Language

The proposed changes to the standards, Reference Appendices, and the ACM Reference Manual are provided below. Changes to the 2019 documents are marked with red underlining (new language) and ~~strikethroughs~~ (deletions).

7.3.2 Standards

Section 150.1(b)3.B: Field Verification.

xi. Pre-Cooling. When performance compliance requires field verification of the installation and programming of a Pre-Cooling Thermostat, it shall be field verified in accordance with the procedures in Reference Residential Appendix RA3.4.5.

7.3.3 Reference Appendices

RESIDENTIAL APPENDIX 2.2 MEASURES THAT REQUIRE FIELD VERIFICATION AND DIAGNOSTIC TESTING

Table RA2-1 – Summary of Measures Requiring Field Verification and Diagnostic Testing

Measure Title	Description	Procedure(s)
	Air Conditioning Measures	
Residential Pre-Cooling	When a Pre-Cooling Thermostat is installed and verification of its installation and configuration is required by Section 150.1(b)3B, the installed system equipment shall be verified according to the procedure specified in this section.	RA 3.4.6

RESIDENTIAL APPENDIX 3.4. FIELD VERIFICATION OF INSTALLED HVAC SYSTEM COMPONENTS AN DEVICES

Residential Appendix 3.4.6: Pre-Cooling Thermostat Verification Procedures

When a Pre-Cooling Thermostat (PCT) is installed and verification of the PCT's programming is required by Section 150.1(b)3.B.x, the installed system equipment shall be verified according to the procedure specified in this section.

The procedure shall consist of visual verification of installation of the following system equipment components and confirmation that the installed equipment is certified to conform with the requirements of JA5.2:

(a) Verify the PCT matches the make and model reported on the design drawings and CF2R

(b) Verify that any components required for PCT operation are permanently installed

(c) Verify that the observed values of the Critical Field-Adjusted Parameters match the values indicated on the CF2R, and that they are within the range allowed.

(d) Verify that educational material has be left behind by the installer and made available to the occupants.

JOINT APPENDIX 5 – TECHNICAL SPECIFICATIONS FOR THERMOSTATS

JA5.2 Technical Specifications for Thermostats for Pre-Cooling

JA5.2.1 Introduction

Joint Appendix 5.2 (JA5.2) provides the technical specifications for a Pre-Cooling Thermostat (PCT). A PCT can be an independent device or part of a control system comprised of multiple devices.

The requirements in this appendix are intended to be compatible with National Electrical Manufacturers Association (NEMA) Standard DC 3-2013 Residential Controls – Electrical Wall Mounted Thermostats and NEMA DC 3 Annex A-2013 Energy-Efficiency Requirements for Programmable Thermostats.

JA5.2.2 Required Functional Specifications

(1) PCT can be programmed either using a dedicated "Pre-Cooling" mode or using pre-existing schedule programming functionality:

   (a) Pre-Cooling mode: With a simple gesture, initiate a pre-cooling schedule using the selected Pre-Cooling and No-Cooling times and setpoints.

   (b) Programmed schedule: For example, provide named schedules (similar to WAKE, LEAVE, RETURN, SLEEP) for PRE-COOL and NO-COOL, using the selected Pre-Cooling and No-Cooling times and setpoints.

(2) Temporary Override:

   (a) A temporary override shall be provided.

   (b) Temporary override shall be simple to initiate, and it shall not be confused with a permanent override.

(c) Temporary override shall be limited to no more than 72 hours at a time.

(3) Critical Field-Adjusted Parameters:

(a) Provides the ability to set the following parameters easily, in such a way that they can be readily confirmed by a HERS Rater:

- Pre-Cooling Start Time
- No-Cooling Start Time
- No-Cooling End Time
- Pre-Cooling Temperature Setpoint
- No-Cooling Temperature Setpoint

(4) Usability Considerations.

(a) It shall be easy to program the pre-cooling schedule correctly.

(b) It shall be difficult to inadvertently change the pre-cooling schedule or permanently override the pre-cooling strategy.

(c) It shall be easy to temporarily override the Pre-Cooling and No-Cooling Mode, for a limited amount of time.

(d) There shall be a clear indication to the user that the Pre-Cooling or No-Cooling Mode is in effect.

(5) Educational Materials:

(a) The manufacturer shall produce and supply educational material to be left behind by the installer, describing the benefits of the pre-cooling strategy, expected savings, how to implement a temporary override, how to alter the programming if needed, cautions to take when altering the programming to avoid defeating the measure, and explaining how to change the TOU period if utility rate structure changes. The manufacturer must also provide easy to use instructions for installers and HERS verifiers describing how to configure and verify CFAP values.

7.3.4 ACM Reference Manual

ACM Reference Manual Section 2.4.11: Pre-Cooling

When pre-cooling is selected, the schedule of space temperature setpoints is modified as described below. The savings derived from this change in setpoint schedule shall be de-rated by 70 percent in calculating the final credit, due to the occupancy controllability characteristic of this measure. The credit shall be applied to the Demand Flexibility credit that is a part of the Total EDR and not the Energy Efficiency EDR. When this credit is used, proper programming must be verified according to the procedures found in RA 3.4.5. Pre-cooling shall be accomplished using a Pre-Cooling Thermostat with features certified to the California Energy Commission to comply with the requirements laid out in JA5.2.

Proposed Design

The software assumes the setpoint schedule shown in Table 22 for space cooling for the following hours. For hours other than those listed, the space temperature setpoints shall be as specified in Table 22 of the ACM Reference Manual Section2.5.3.7.

Table 22. Cooling Setpoint Schedule

Time Period	Cooling Setpoint Temperature (°F)
12pm-1pm	75
1pm-2pm	75
2pm-3pm	75
3pm-4pm	75
4pm-5pm	83
5pm-6pm	83
6pm-7pm	83
7pm-8pm	83
8pm-9pm	83

Standard Design

The software assumes the space cooling setpoint schedule specified in Table 22 of the ACM Reference Manual Section 2.5.3.7.

7.3.5 Compliance Manuals

Changes to be made to the Compliance Manuals are described in section 7.4.5.

7.3.6 Compliance Documents

CF2R-MCH-36-PRECOOL CERTIFICATE OF INSTALLATION

A. Pre-Cooling Thermostat Installation and Configuration Procedures for the Pre-Cooling Thermostat (PCT) verification are detailed in RA3.4.5. "CFAPs" are Critical Field Adjusted Parameters		
01	PCT Manufacturer Name	
02	PCT Model Number	

03	PCT Unique CEC ID	
04	NC-START Configured Value	
05	NC-END Configured Value	
06	PC-START Configured Value	
07	NC-TEMP Configured Value	
08	PC-TEMP Configured Value	

CF3R-MCH-36-PRECOOL CERTIFICATE OF VERIFICATION

A. Pre-Cooling Thermostat Instllation and Configuration Procedures for the Pre-Cooling Thermostat (PCT) verification are detailed in RA3.4.5. "CFAPs" are Critical Field Adjusted Parameters		
01	PCT Manufacturer Name	
02	PCT Model Number	
03	PCT Unique CEC ID	
04	NC-START Verified Value	
05	NC-END Verified Value	
06	PC-START Verified Value	
07	NC-TEMP Verified Value	
08	PC-TEMP Verified Value	

7.4 Home Energy Management

7.4.1 Guide to Markup Language

The proposed changes to the standards, Reference Appendices, and the ACM Reference Manual are provided below. Changes to the 2019 documents are marked with red underlining (new language) and ~~strikethroughs~~ (deletions).

7.4.2 Standards

The following changes are proposed for the Title 24, Part 6 standards.

SECTION 100.1 – DEFINITIONS AND RULES OF CONSTRUCTION

HOME ENERGY MANAGEMENT SYSTEM (HEMS) is a control system that monitors and controls energy consuming devices through programmed schedules, control logic based on occupancy sensors or other measurements, machine learning, demand response signals, and/or remote access through smartphones.

SECTION 110.10 – MANDATORY REQUIREMENTS FOR SOLAR READY BUILDINGS

(b) Solar Zone.

1. **Minimum Solar Zone Area.** The solar zone shall have a minimum total area as described below. …

A. **Single Family Residences.** The solar zone shall be located on the roof or overhang of the building and have a total area no less than 250 square feet.

EXCEPTION 6 to Section 110.10(b)1A: Single family residences meeting the following conditions in both A and B below:

A. Comply with one of the following measures:

i. All thermostats are demand responsive controls that comply with Section 110.12(a), and are capable of receiving and responding to Demand Response Signals prior to granting of an occupancy permit by the enforcing agency; or

ii. All thermostats are Advanced Energy Efficiency Thermostats, as defined in JA5.3.

B. Comply with one of the following measures:

…

ii. Install a home ~~automation~~ energy management system ~~capable of, at a minimum, controlling the appliances and lighting of the dwelling and responding to demand response signals~~ that complies with Section 110.12(a); meets or exceeds the Eligibility Criteria of Version 1.0 of the ENERGY STAR "Program Requirements for Smart home Energy Management Systems" (published September 3, 2019) except Sections 4.3A(a-b); includes an Advanced Energy Efficiency Thermostat, as defined in JA5.3; controls at least two light fixtures; and communicates with any qualified Battery Storage System as defined in Joint Appendix JA12, or Heat Pump Water Heater Load Shifting System as defined in Joint Appendix JA13; or

…

EXCEPTION 4 to Section 110.10(b)1B: Low-rise and high-rise multifamily buildings meeting conditions in A and in either B or C below:

A. In each dwelling unit, comply with one of the following measures:

i. ~~with a~~All thermostats ~~in each dwelling unit~~ are demand response controls that comply with Section 110.12(a), and are capable of receiving and responding to Demand Response Signals prior to granting of an occupancy permit by the enforcing agency. ~~In addition, either A or B below:~~; or

ii. All thermostats are Advanced Energy Efficiency Thermostats, as defined in JA5.3.

B. ~~A.~~ In each dwelling unit, comply with one of the following measures:

…

ii. Install a home ~~automation~~ energy management system ~~capable of, at a minimum, controlling the appliances and lighting of the dwelling and responding to demand response signals~~ that complies with Section 110.12(a); meets or exceeds the Eligibility Criteria of Version 1.0 of the ENERGY STAR "Program Requirements for Smart home Energy Management Systems" (published September 3, 2019) except Sections 4.3A(a-b); includes an Advanced Energy Efficiency Thermostat, as defined in JA5.3; controls at least two light fixtures; and communicates with any qualified Battery Storage System as defined in Joint Appendix JA12, or Heat Pump Water Heater Load Shifting System as defined in Joint Appendix JA13; or

…

C. ~~B.~~ Meet the Title 24, Part 11, Section A4.106.8.2 requirements for electric vehicle charging spaces.

SECTION 110.12 – MANDATORY REQUIREMENTS FOR DEMAND MANAGEMENT

5. Demand responsive control thermostats shall meet the above requirements, and in addition shall also comply with Demand Management Thermostat (DMT) requirement in Reference Joint Appendix 5.1 (JA5.1), Technical Specifications For Thermostat Functionality for Demand Management ~~**Occupant Controlled Smart Thermostats**~~.

7.4.3 Reference Appendices

JOINT APPENDIX JA5 – TECHNICAL SPECIFICATIONS FOR ~~OCCUPANT CONTROLLED SMART~~ THERMOSTATS

JA5.1 Technical Specifications For ~~Occupant Controlled Smart~~ Thermostat Functionality for Demand Response

JA5.1.1 Introduction

Joint Appendix 5.1 (JA5.1) provides the technical specifications for a~~n Occupant Controlled Smart~~Demand Management Thermostat (~~OCST~~DMT). ~~An OCST~~A DMT can be an independent device or part of a control system comprised of multiple devices.

The requirements in this appendix are intended to be compatible with National Electrical Manufacturers Association (NEMA) Standard DC 3-2013 Residential Controls – Electrical Wall

Mounted Thermostats and NEMA DC 3 Annex A-2013 Energy-Efficiency Requirements for Programmable Thermostats.

JA5.1.1.1 Manufacturer Self-Certification

~~An OCST~~A DMT is compliant with Title 24, Part 6, only if it has been certified to the Energy Commission as meeting all of the requirements in this Appendix. Certification to the Energy Commission shall be as specified in Section 110.0.

JA5.1.2 Required Functional Specifications

JA5.1.2.1 Setback Capabilities

~~An OCST~~A DMT shall meet the requirements of Section 110.2(c). Thermostats for heat pumps shall also meet the requirements of Section 110.2(b).

JA5.1.2.2 Restart Settings

In the event of a disruption of power to the device that results in power off or restart, upon device restart, the device shall automatically restore the most recently programmed settings, including reconnection to a network, if the device was previously enabled and network connectivity is available.

JA5.1.2.3 Automatic Rejoin

~~An OCST~~A DMT shall connect, and remain connected in its communication path and control end point. The ~~OCST~~DMT shall incorporate an automatic rejoin function. When physical and/or logical communication is lost, the ~~OCST~~DMT shall trigger its automatic rejoin function to restore the physical and/or logical communication.

JA5.1.2.4 Event Responses

Event response, unless overridden by the occupant or modified by an energy management control system or service, may be triggered by price signals or Demand Response Signals. The ~~OCST~~DMT shall provide one set of event responses for price signals and one set of event responses for Demand Response Signals. The responses may be common for both types of events. The ~~OCST~~DMT's default responses shall comply with the following:

(a) A Demand Response Signal shall trigger the ~~OCST~~DMT to adjust the thermostat setpoint by either the default number of degrees or the number of degrees established by the occupant.

(b) When a price signal indicates a price in excess of a price threshold established by the occupant, the ~~OCST~~DMT shall adjust the thermostat setpoint by either the default number of degrees or the number of degrees established by the occupant.

(c) In response to price signals or Demand Response signals, the ~~OCST~~DMT shall default to an event response that initiates setpoint offsets of +4°F for cooling and -4°F for heating relative to the current setpoint.

(d) The ~~OCST~~DMT shall have the capability to allow occupants or their representative to modify the default event response with occupant defined event responses for cooling and heating relative to the current setpoint in response to price signals or Demand Response Signals.

(e) Override Function: Occupants shall be able to change the event responses and thermostat settings or setpoints at any time, including during price events or Demand Response Periods.

(f) The Demand Response Signal shall start the Demand Response Period either immediately or at a specific start time as specified in the event signal and continue for the Demand Response Period specified in the Demand Response Signal or until the occupant overrides the event setpoint.

(g) The thermostat's price response shall start either immediately or at a specific start time as specified in the pricing signal and continue for the duration specified in the pricing signal or until the occupant overrides the event setpoint.

(h) The ~~OCST~~DMT shall have the capability to allow occupants to define setpoints for cooling and heating in response to price signals or Demand Response signals as an alternative to the default event response.

(i) At the end of a price event or Demand Response Period, the thermostat setpoint shall be set to the

(j) setpoint that is programmed for the point in time that the event ends or to the manually established setpoint that existed just prior to the Demand Response Period.

The ~~OCST~~DMT shall include the capability to allow the occupant to restore the factory installed default settings.

JA5.1.2.5 User Display and Interface

The ~~OCST~~DMT shall have the capability to display information to the user. The following information shall be readily available whenever the ~~OCST~~DMT display is active:

(a) communications system connection status,

(b) an indication that a Demand Response Period or pricing event is in progress,

(c) the currently sensed temperature,

(d) the current setpoint.

JA5.1.2.6 Required Functional Behavior

(a) Normal Operation. Normal operation of ~~an OCST~~A DMT is defined to be the ~~OCST~~DMT's prevailing mode of operation as determined by the occupant's prior settings and use of features provided by the ~~OCST~~DMT manufacturer's design. Aspects of normal operation of ~~an OCST~~A DMT may be modified or interrupted in response to occupant subscribed price signals or when Demand Response Periods are in progress, but only to the extent specified by occupants or their representatives.

Unless an occupant has elected to connect the ~~OCST~~DMT to an energy management control system or service that provides for alternate strategies, the ~~OCST~~DMT shall provide a mode of operation whereby it controls temperature by following the scheduled temperature setpoints.

Occupants shall always have the ability to change ~~OCST~~DMT settings or use other features of ~~an OCST~~A DMT during an event. Those changes may alter what is considered to be the prevailing mode of operation when a Demand Response Period is terminated and the ~~OCST~~DMT returns to normal operation.

(b) Demand Responsive Control. Upon receiving a price signal or a Demand Response Signal, ~~OCST~~DMTs shall be capable of automatic event response by adjusting the currently applicable temperature setpoint by the number of degrees indicated in the temperature offset (heating or cooling, as appropriate).

Override: ~~OCST~~DMTs shall allow an occupant or their representative to alter or eliminate the default response to price signals or Demand Response Signals, and to override any individual price response or Demand Responsive Control and allow the occupant to choose any temperature setpoint at any time including during a price event or a Demand Response Period.

When the price signal changes to a non-response level or the Demand Response Period is concluded, ~~OCST~~DMTs shall return to normal operation. The thermostat setpoint shall be set to the setpoint that is programmed for the point in time that the event ends or to the manually established setpoint that existed just prior to the Demand Response Period.

The ~~OCST~~DMT shall also be equipped with the capability to allow occupants to define setpoints for cooling and heating in response to price signals or Demand Response Signals as an alternative to the default event response. The default setpoint definitions unless redefined by the occupant shall be as follows:

1. The default price response or Demand Response Period setpoint in the cooling mode for ~~OCST~~DMTs shall be 82°F. The ~~OCST~~DMT shall allow the occupant to change the default event setpoint to any other value.

2. The default price response or Demand Response Period setpoint in the heating mode for ~~OCST~~DMTs shall be 60°F. The ~~OCST~~DMT shall allow the occupant to change the default event setpoint to any other value.
3. The ~~OCST~~DMT shall ignore price response or Demand Response Period setpoints that are lower (in cooling mode) or higher (in heating mode) than the programmed or occupant selected prevailing setpoint temperature upon initiation of the price event or Demand Response Period.
4. By default, thermostats shall not be remotely set above 90°F or below 50°F. Occupants shall have the ability to redefine these limits. This measure protects occupant premises from extreme temperatures that might otherwise be imposed by event responses, should the occupant already have a very high or low temperature setpoint in effect.

The occupant may still override or change the setpoint during all price events and Demand Response Periods. Price signal response and Demand Responsive Control only modify the operating range of the thermostat. They do not otherwise affect the operation and use of features provided by the manufacturer's design.

JA5.1.3 HVAC System Interface

HVAC wiring terminal designations shall be clearly labeled. ~~OCST~~DMTs shall use labels that comply with Table 5-1 in NEMA DC 3-2013.

JA5.2 Technical Specifications for Thermostat Functionality for Pre-Cooling

(see specifications in Section 7.3.3, for HVAC Load Shifting).

JA5.3 Technical Specifications for Thermostat Functionality for Advanced Energy Efficiency

JA5.3.1 Introduction

Joint Appendix 5.3 (JA5.3) provides the technical specifications for an Advanced Energy-Efficiency Thermostat (AEET). An AEET can be an independent device or part of a control system comprised of multiple devices.

JA5.3.2 Required Functional Specifications

For systems that qualify for a credit for installing an Advanced Energy Efficiency Thermostat (AEET), the AEET shall meet the following requirements:

(1) The AEET shall meet or exceed the requirements of Version 1 of the ENERGY STAR "Program Requirements for Connected Thermostat Products," revised January 2017.

JA5.4 Technical Specifications for Thermostat Functionality for Basic Energy Efficiency

JA5.4.1 Introduction

Joint Appendix 5.4 (JA5.4) provides the technical specifications for a Basic Energy-Efficiency Thermostat (B). A BEET can be an independent device or part of a control system comprised of multiple devices.

The requirements in this appendix are intended to be compatible with National Electrical Manufacturers Association (NEMA) Standard DC 3-2013 Residential Controls – Electrical Wall Mounted Thermostats and NEMA DC 3 Annex A-2013 Energy-Efficiency Requirements for Programmable Thermostats.

JA5.4.2 Required Functional Specifications

For all systems that are required to have a thermostat per Section 110.2(c), the BEET thermostat shall

(1) allow the building occupant to program the temperature setpoints for at least four periods within 24 hours. Thermostats for heat pumps shall meet the requirements of Section 110.2(b).

(2) have a clock mechanism that allows the building occupant to program the temperature setpoints for at least four periods within 24 hours. Thermostats for heat pumps shall meet the requirements of Section 110.2(b).

7.4.4 ACM Reference Manual

There are no proposed changes to the ACM Reference Manual.

7.4.5 Compliance Manuals

The Residential and Nonresidential Compliance Manuals would need to be revised to change all references to Occupant Controlled Smart Thermostat (OCST) to Demand Management Thermostat (DMT), and to change all references to Home Automation Systems to Home Energy Management Systems meeting or exceeding the ENERGY STAR SHEMS eligibility requirements and compatible with other demand response technologies approved under Title 24, Part 6.

The following specific revisions need to be made to the Residential Compliance Manual:

4.5.1 Thermostats

Thermostats can function in several different ways to ~~Automatic setback thermostats can~~ add comfort and convenience to a home. Occupants can wake up to a warm house in the winter and come home to a cool house in the summer without using unnecessary energy, and can control when energy is used in order to minimize their bills.

§110.2 (b) & (c), §150.0(i)

A thermostat is always required for central systems whether the prescriptive or performance compliance method is used. An exception is allowed only if the system is one of the following non-central types:

1. Non-central electric heaters.
2. Room air conditioners.
3. Room air conditioner heat pumps.
4. Gravity gas wall heaters.
5. Gravity floor heaters.
7. Wood stoves.
8. Fireplace or decorative gas appliances.

When it is required, a ~~the~~ setback thermostat or Basic Energy Efficiency Thermostat (BEET) must meet the requirements of Joint Appendix 5.4: Technical Specifications for Thermostat Functionality Basic Energy Efficiency. It must have a clock or other mechanism that allows the building occupant to schedule the heating and/or cooling set points for at least four periods over 24 hours.

If more than one piece of heating equipment is installed in a residence or dwelling unit of a multifamily building, the setback requirement may be met by controlling all heating units by one thermostat or by controlling each unit with a separate thermostat. Separate heating units may be provided with a separate on/off control capable of overriding the thermostat.

Thermostats for heat pumps must be "smart thermostats" that minimize the use of supplementary electric resistance heating during startup and recovery from setback, as discussed earlier in the heating equipment section.

A Demand Flexibility credit is provided for installation of a Pre-Cooling Thermostat (PCT), complying with the requirements of Joint Appendix 5.2: Technical Specifications for Thermostat Functionality for Pre-Cooling. To obtain credit, a thermostat must meet the following performance specifications:

- It can be programmed either using a dedicated "Pre-Cooling" mode or using pre-existing schedule programming functionality.
- A temporary override shall be provided that is simple to initiate and shall be limited to no more than 72 hours at a time.
- It provides the ability to set the following parameters easily, in such a way that they can be readily confirmed by a HERS Rater:

- Pre-Cooling Start Time (required to be
- No-Cooling Start Time
- No-Cooling End Time
- Pre-Cooling Temperature Setpoint
- No-Cooling Temperature Setpoint

(6) It is easy to program correctly, it is difficult to inadvertently change the schedule or permanently override, and it has a clear indication.

(7) The manufacturer has supplied educational material to be left behind by the installer

The presence and appropriate programming of the PCT is required to be verified by a HERS Rater.

When installation of an Advanced Energy Efficiency Thermostat (AEET) is specified, it must meet the requirements of Joint Appendix 5.3: Technical Specifications for Thermostat Functionality Advanced Energy Efficiency. To obtain credit, a thermostat must meet the eligibility criteria of the ENERGY STAR program for Communicating Thermostats, V1.0., revised January 2017.

4.8.1.10 Using Weigh-In Charging Procedure at Low Outdoor Temperatures

When a new HVAC system is installed, the HVAC installer must check the refrigerant charge, and a HERS Rater must verify the correct charge; however, an exception to §150.1(c)7A provides for an alternative third-party HERS verification if the weigh-in method is used when the outdoor temperature is less than 55° F.

Typically, when the weigh-in method is used by the installing contractor, a HERS Rater must perform a charge verification in accordance with the RA3.2. standard charge procedure. However, because the RA3.2.2 procedures cannot be used when the outdoor temperatures are less than 55°F, the Energy Standards provide the installer with two choices:

1. Use the RA3.2.3.2 HERS Rater Observation of Weigh-In Charging Procedure to demonstrate compliance, and install ~~an occupant-controlled smart thermostat (OCST).~~ a demand management thermostat (DMT) or Advanced Energy Efficiency Thermostat (AEET).

7.3.3 Performance Approach Compliance for Photovoltaic System – Additional Requirements

~~Example 7-7 – Precooling~~

~~Question:~~

~~Can you explain precooling strategy requirements and how to comply with them?~~

~~Answer:~~

~~Precooling is a strategy that allows cooling the house by two or three degrees below the setpoint in the hours preceding the onset of peak time-of-use (TOU) hours, when the electricity rates are relatively low, and then turning off the air conditioning during the TOU peak hours, resulting in significant cost savings for the building occupants.~~

~~To obtain this credit, a JA5 compliant communicating thermostat must be installed in the dwelling unit, and indicated on both CF1R and CF2R forms.~~

~~The precooling credit may only be used to lower the EDR score towards a more stringent EDR goal set by a reach code such as a local ordinance; this credit cannot be used to tradeoff the energy efficiency features of the building.~~

~~Finally, if the dwelling unit is already equipped with a battery storage system coupled with a PV system, the precooling strategy may have negligible impact on further lowering the EDR score.~~

7.6.2.2 Solar Zone Area for Single Family Residential Buildings

The solar zone must be located on the roof or overhang of the building. The "designated" solar zone's total area must be no less than 250 square feet (§110.10(b)1A).

There are six allowable exceptions to the required solar zone area. Exceptions 1 and 6 allow alternate efficiency measures instead of an actual solar zone, so the requirements for zone shading, azimuth and design load; interconnection pathway, owner documentation, and electric service panel do not apply either.

Submit a CF1R-SRA-01-E to the building department with the building permit application for all projects covered by solar ready, even when using a Solar Zone Exception. In addition, submit a CF1R-SRA-02-E solar zone worksheet for all projects with a solar zone, including Exceptions that allow a reduced solar zone area.

Solar Zone Exceptions for Single Family Buildings:

…

Exception 6 allows no solar zone when the following energy efficiency features are installed:

All thermostats have demand responsive controls that comply with Section 110.12(a) ~~and Joint Appendix JA5.1.~~ and are capable of receiving and responding to Demand Response Signals prior to granting of an occupancy permit by the enforcing agency, or are Advanced Energy Efficiency Thermostats (AEETs) (please see Exception 5, above, for more details). AND one of the following four measures (i – iv):

i. Install a dishwasher that meets or exceeds the ENERGY STAR® program requirements with a refrigerator that meets or exceeds the ENERGY STAR program requirements, OR one of the following:

- a whole-house fan driven by an electronically commutated motor, OR
- an SAE J1772 Level 2 Electric Vehicle Supply Equipment (EVSE or EV Charger) with a minimum of 40 amperes. SAE J1772 is the SAE International document titled "SAE Electric Vehicle and Plug in Hybrid Electric Vehicle Conductive Charge Coupler" (SAE J1772_201710).

ii. Install a home ~~automation~~ energy management system ~~capable of, at a minimum, controlling the appliances and lighting of the dwelling and responding to demand response signals~~ that complies with Section 110.12(a); meets or exceeds the Eligibility Criteria of Version 1.0 of the ENERGY STAR "Program Requirements for Smart home Energy Management Systems" (published September 3, 2019) except Sections 4.3A(a-b); includes an Advanced Energy Efficiency Thermostat, as defined in JA5.3; controls at least two light fixtures; and communicates with any qualified Battery Storage System as defined in Joint Appendix JA12, or Heat Pump Water Heater Load Shifting System as defined in Joint Appendix JA13; or

iii. Install alternative plumbing piping to permit the discharge from the clothes washer and all showers and bathtubs to be used for an irrigation system in compliance with the California Plumbing Code; OR

iv. Install a rainwater catchment system designed to comply with the California Plumbing Code and uses rainwater flowing from at least 65 percent of the available roof area.

…

Solar Zone Area for Low-Rise Multifamily Residential Buildings

The solar zone requirement for low-rise multifamily buildings is located in the 2019 Energy Standards with the requirements for high-rise multifamily, hotel/motel and nonresidential buildings in §110.10(b)1B. The solar zone requirement for low-rise multifamily buildings applies to mixed occupancy buildings as well.

…

Exception 4 says multifamily residential buildings do not need a solar zone if all thermostats have demand responsive controls that comply with Section 110.12(a), or all thermostats are Advanced Energy Efficiency Thermostats (AEETs) ~~and Joint Appendix JA5~~. See Exception 5 for single family homes (above) for more thermostat details. In addition to the compliant thermostats, choose A or B below:

A. One of the following four measures installed in each dwelling unit (i. – iv.):

i. Install a dishwasher that meets or exceeds the ENERGY STAR® program requirements with a refrigerator that meets or exceeds the ENERGY STAR program requirements, or a whole-house fan driven by an electronically commutated motor.

ii. Install a home ~~automation~~ energy management system ~~capable of, at a minimum, controlling the appliances and lighting of the dwelling and responding to demand response signals~~ that complies with Section 110.12(a); meets or exceeds the Eligibility Criteria of Version 1.0 of the ENERGY STAR "Program Requirements for Smart home Energy Management Systems" (published September 3, 2019) except Sections 4.3A(a-b); includes an Advanced Energy Efficiency Thermostat, as defined in JA5.3; controls at least two light fixtures; and communicates with any qualified Battery Storage System as defined in Joint Appendix JA12, or Heat Pump Water Heater Load Shifting System as defined in Joint Appendix JA13; or

iii. Install alternative plumbing piping to permit the discharge from the clothes washer and all showers and bathtubs to be used for an irrigation system in compliance with the California Plumbing Code; or

iv. Install a rainwater catchment system designed to comply with the California Plumbing Code and that uses rainwater flowing from at least 65 percent of the available roof area.

7.8 Compliance and Enforcement

There are ~~four~~five forms associated with the low-rise residential solar-ready requirements. Each form is briefly described below.

…

2. CF2R-SRA-02-E: Certificate of Compliance: Minimum Solar Zone Area Worksheet

This form is required when buildings comply with the solar-ready requirement by including a solar zone. That is, an appropriately sized solar PV system is not installed, an appropriately sized solar water heating system is not installed, the building does not comply with all the ~~OCST~~ DMT/AEET and high-efficacy lighting requirements or the roof is not designed for vehicle traffic or a heliport.

…

4. CF2R-MCH-36-Precool Certificate of Installation

This form describes the procedures for verification of the Pre-Cooling Thermostat (PCT), and lists the installed values of the Critical Field Adjusted Parameters (No-Cooling start and end time and temperature, and Pre-Cooling start time and temperature).

5. CF3R-MCH-36-Precool Certificate of Verification

This form describes the procedures for verification of the Pre-Cooling Thermostat (PCT), and lists the verified values of the Critical Field Adjusted Parameters (No-Cooling start and end time and temperature, and Pre-Cooling start time and temperature).

Appendix H – Demand Responsive Controls—2. Other Requirements for DR Controls

2.2 Certification requirements for ~~DR~~Demand Management Thermostats

Residential Demand ~~R~~Management thermostats, ~~also called Occupant Controlled Smart Thermostats~~ (~~OCSTs~~DMTs), must comply with the technical specifications described in Joint Appendix 5.1 (JA5.1). According the requirement in JA5.1, manufacturers of ~~DR thermostats~~ DMTs must submit documentation to the Energy Commission to certify that the thermostat meets the code requirements. See the Energy Commission's website for a list of certified products and for instructions to manufacturers that wish to certify products: http://www.energy.ca.gov/title24/equipment_cert/.

…

4. Energy Management Control Systems / Home ~~Automation~~ Energy Management Systems

Required thermostatic and lighting control functions (including DR control functions) can be incorporated into and performed by an energy management control system (EMCS). Using an EMCS to perform these control functions complies with Title 24, Part 6 provided that all of the criteria that would apply to the control are met by the EMCS.

A Home ~~Automation~~ Energy Management System~~s~~ that manages energy loads (such as HVAC and lighting systems) is considered a type of energy management control system more suitable for residential applications and, as such, can similarly incorporate the ability to provide required control functions.

The following specific revisions need to be made to the Non-Residential Compliance Manual:

NCM 9.4 Solar Zone Exceptions

§110.12 is a new section in the 2019 Energy Standards that specifies capabilities for demand responsive controls. A "demand responsive control" is defined in §100.1 as an "automatic control capable of receiving and automatically responding to a demand response signal."~~The~~ Additional technical specifications for compliant demand responsive control thermostats are detailed in JA5.1.

In addition to the demand responsive thermostats, choose option A or option B (below).

A. Each dwelling unit must have one of the following four measures (1 – 4):

1. Install a dishwasher that meets or exceeds the ENERGY STAR® program requirements with either a refrigerator that meets or exceeds the ENERGY STAR program requirements or a whole-house fan driven by an electronically commutated motor.

2. Install a home ~~automation~~ energy management system ~~capable of, at a minimum, controlling the appliances and lighting of the dwelling and responding to demand response signals~~ that complies with Section 110.12(a); meets or exceeds the Eligibility Criteria of Version 1.0 of the ENERGY STAR “Program Requirements for Smart home Energy Management Systems” (published September 3, 2019) except Sections 4.3A(a-b); includes an Advanced Energy Efficiency Thermostat, as defined in JA5.3; controls at least two light fixtures; and communicates with any qualified Battery Storage System as defined in Joint Appendix JA12, or Heat Pump Water Heater Load Shifting System as defined in Joint Appendix JA13;

…

Appendix D – Demand Responsive Controls—2. Other Requirements for DR Controls

2.2 Certification requirements for ~~DR~~Demand Management Thermostats

Demand ~~R~~Management thermostats, ~~also called Occupant Controlled Smart Thermostats~~ (~~OCSTs~~DMTs), must comply with the technical specifications described in Joint Appendix 5.1 (JA5.1). According the requirement in JA5.1, manufacturers of ~~DR thermostats~~ DMTs must submit documentation to the Energy Commission to certify that the thermostat meets the code requirements. See the Energy Commission’s website for a list of certified products and for instructions to manufacturers that wish to certify products: http://www.energy.ca.gov/title24/equipment_cert/.

7.4.6 Compliance Documents

Compliance documents CF2R-SRA-01-E and CF2R-SRA-02-E must be revised to correct the terminology and clarify certification requirements that must be verified and documented by the DMT and HEMS installer.

CF2R-SRA-01-E: Solar Ready Buildings– New Construction

E. Smart Thermostats and Alternative Efficiency Measure (Single Family)

01	All thermostats are demand responsive controls that comply with Section 110.12(a), and are capable of receiving and responding to Demand Response Signals prior to granting of an occupancy permit by the enforcing agency; or are Advanced Energy Efficiency Thermostats, as defined in JA5.3. ~~All thermostats comply with Reference Joint Appendix JA5 and are capable of receiving and responding to Demand Response Signals prior to granting of an occupancy permit by the enforcing agency.~~	
02	Alternative Efficiency Measure:	*Install a dishwasher that meets or exceeds ENERGY STAR Program requirements with either a refrigerator that meets or exceeds the ENERGY STAR Program requirements or a whole house fan driven by an electronically commutated motor or a Level 2 EVSE/EV Charger; or * Install a home ~~automation~~ energy management system ~~capable of, at a minimum, controlling the appliances and lighting of the dwelling and responding to demand response signals~~ that complies with Section 110.12(a); meets or exceeds the Eligibility Criteria of Version 1.0 of the ENERGY STAR "Program Requirements for Smart home Energy Management Systems" (published September 3, 2019) except Sections 4.3A(a-b); includes an Advanced Energy Efficiency Thermostat, as defined in JA5.3; controls at least two light fixtures; and communicates with any qualified Battery Storage System as defined in Joint Appendix JA12, or Heat Pump Water Heater Load Shifting System as defined in Joint Appendix JA13; or *Install alternative plumbing piping to permit the discharge from the clothes washer and all showers and bathtubs to be used for an irrigation system in compliance with the California Plumbing Code and any applicable local ordinances; or *Install a rainwater catchment system designed to comply with the California Plumbing Code and any applicable local ordinances, and that uses rainwater flowing from at least 65% of the available roof area
The responsible person's signature on this compliance document affirms that all applicable requirements in this table have been met.		

F. Smart Thermostats and Alternative Efficiency Measure (Multifamily)

01	All thermostats are demand responsive controls that comply with Section 110.12(a), and are capable of receiving and responding to Demand Response Signals prior to granting of an occupancy permit by the enforcing agency; or are Advanced Energy Efficiency Thermostats, as defined in JA5.3. ~~All thermostats comply with Reference Joint Appendix JA5 and are capable of receiving and responding to Demand Response Signals prior to granting of an~~	
02	Alternative Efficiency Measure:	*Install a dishwasher that meets or exceeds ENERGY STAR Program requirements with either a refrigerator that meets or exceeds the ENERGY STAR Program requirements or a whole house fan driven by an electronically commutated motor; or * Install a home ~~automation~~ energy management system ~~capable of, at a minimum, controlling the appliances and lighting of the dwelling and responding to demand response signals~~ that complies with Section 110.12(a); meets or exceeds the Eligibility Criteria of Version 1.0 of the ENERGY STAR "Program Requirements for Smart home Energy Management Systems" (published September 3, 2019) except Sections 4.3A(a-b); includes an Advanced Energy Efficiency Thermostat, as defined in JA5.3; controls at least two light fixtures; and communicates with any qualified Battery Storage System as defined in Joint Appendix JA12, or Heat Pump Water Heater Load Shifting System as defined in Joint Appendix JA13; or *Install alternative plumbing piping to permit the discharge from the clothes washer and all showers and bathtubs to be used for an irrigation system in compliance with the California Plumbing Code and any applicable local ordinances; or *Install a rainwater catchment system designed to comply with the California Plumbing Code and any applicable local ordinances, and that uses rainwater flowing from at least 65% of the available roof area *The building meets the T24, Part 11, Section A4.106.8.2 requirement of 15% of total parking as EV charging spaces
The responsible person's signature on this compliance document affirms that all applicable requirements in this table have been met.		

CF2R-SRA-02-E: Minimum Solar Zone Area Worksheet – New Construction

B. Minimum Required Solar Zone Area for Single Family Residence

06	~~Are all the thermostats Occupant Controlled Smart Thermostats (OCSTs), certified to the Energy Commission and listed on the Commission's appliances database?~~ ~~Alternatively, a networked system of devices may be installed that provides functionality equivalent to an OCST.~~ Are all thermostats demand responsive controls that comply with Section 110.12(a), and capable of receiving and responding to Demand Response Signals?

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Appendix A: Statewide Savings Methodology

The Statewide CASE Team has not estimated statewide impacts because the submeasures addressed in this Final CASE Report are compliance options.

Appendix B: Embedded Electricity in Water Methodology

The Statewide CASE Team has determined that there are no on-site water savings associated with the proposed code change.

Appendix C: Environmental Impacts Methodology

Greenhouse Gas (GHG) Emissions Factors

As directed by Energy Commission staff, GHG emissions were calculated making use of the average emissions factors specified in the United States Environmental Protection Agency (U.S. EPA) Emissions & Generation Resource Integrated Database (eGRID) for the Western Electricity Coordination Council California (WECC CAMX) subregion (United States Environmental Protection Agency 2018). This ensures consistency between state and federal estimations of potential environmental impacts. The electricity emissions factor calculated from the eGRID data is 240.4 metric tons CO2e per GWh. The Summary Table from eGrid 2016 reports an average emission rate of 529.9 pounds CO2e/MWh for the WECC CAMX subregion. This value was converted to metric tons/GWh.

Avoided GHG emissions from natural gas savings attributable to sources other than utility-scale electrical power generation are calculated using emissions factors specified in Chapter 1.4 of the U.S. EPA's Compilation of Air Pollutant Emissions Factors (AP-42) (United States Environmental Protection Agency 1995). The U.S. EPA's estimates of GHG pollutants that are emitted during combustion of one million standard cubic feet of natural gas are: 120,000 pounds of CO_2 (Carbon Dioxide), 0.64 pounds of N_2O (Nitrous Oxide) and 2.3 pounds of CH_4 (Methane). The emission value for N_2O assumed that low NOx burners are used in accordance with California air pollution control requirements. The carbon equivalent values of N_2O and CH_4 were calculated by multiplying by the global warming potentials (GWP) that the California Air Resources Board used for the 2000-2016 GHG emission inventory, which are consistent with the 100-year GWPs that the Intergovernmental Panel on Climate Change used in the fourth assessment report (AR4). The GWP for N_2O and CH_4 are 298 and 25, respectively. Using a nominal value of 1,000 Btu per standard cubic foot of natural gas, the carbon equivalent emission factor for natural gas consumption is 5,454.4 metric tons per million therms.

GHG Emissions Monetization Methodology

The 2022 TDV energy cost factors used in the lifecycle cost-effectiveness analysis include the monetary value of avoided GHG emissions based on a proxy for permit costs (not social costs). To demonstrate the cost savings of avoided GHG emissions, the Statewide CASE Team disaggregated the value of avoided GHG emissions from the other economic impacts. The authors used the same monetary values that are used in the TDV factors – \$106/MTCO$_2$e.

Water Use and Water Quality Impacts Methodology

There are no impacts to water quality or water use associated with the proposed code changes.

Appendix D: California Building Energy Code Compliance (CBECC) Software Specification

Introduction

The purpose of this appendix is to present proposed revisions to CBECC for residential buildings (CBECC-Res) along with the supporting documentation that the Energy Commission staff and the technical support contractors would need to approve and implement the software revisions.

Battery Storage Systems

Technical Basis for Software Change

Residential battery systems have seen a large increase in growth and are expected to see a continuous trend in growth as outlined in Section 3. The impact that these storage systems have on both the utility grid and on home loads needs to be properly accounted for in CBECC-Res. These impacts are captured by the allowable battery control strategies, which determine when and from what source / sink the battery storage system charges and discharges. These control strategies should be updated to adjust for new 2022 TDV figures, new utility TOU rates, and predicted demand response grid participation activities. The Advanced Control (Old) control strategy should be removed as it was not intended to be used for real-world models. Standalone storage should be added as an allowable design configuration, and control strategies should be updated to allow for standalone storage operation.

The way that battery efficiency is specified by manufacturers, typically as a single round-trip efficiency, also needs to be accounted for as a modeling input option. In addition, the minimum round trip efficiency specified in JA12 needs integrated into the CBECC-Res modeling software.

Description of Software Change

Background Information for Software Change

Battery control strategies determine when a battery is being charged and discharged based on the battery's charge state, time of year/day, and/or the hourly TDV factors. CBECC-Res currently has four types of control strategies available for battery storage systems: "Basic", "Time of Use", "Advanced DR Control", and "Advanced Control (old)". Although the first three options are expected to stay in name, the underlying algorithms for these control strategies were re-evaluated for the 2022 code cycle. Alignment between battery control strategies with 2022 TDV factors, which serve as proxies for utility TOU rate schedules and demand response event triggers, were analyzed in support of this measure. This includes evaluating the TDV energy impacts associated with changing the Time of Use control to be enabled during different periods throughout the day, as well as extending the Time of Use control to be active year-round. The Statewide CASE Team also simulated demand response operation ("Advanced DR Control") during only the demand response season of June through September, with the control mode reverting to TOU and Basic outside of this window. The fourth control option, "Advanced Control (old)", is intended to be a research-only control strategy not for Title 24, Part 6 compliance and should be removed from the list of control strategies.

The addition of a round-trip efficiency input provides greater flexibility in the process of entering battery performance efficiency. Commonly, battery storage datasheets list a single round trip efficiency for the battery storage system. With the existing CBECC-Res efficiency input method, an energy consultant would be required to separate the round-trip efficiency into a charging efficiency and discharging efficiency, which is not a straightforward process. However, it is still recommended that the charging efficiency and discharging efficiencies are left as user inputs, as two efficiencies may be useful for a DC-coupled system where the charging efficiency could potentially be higher than a discharging efficiency. The software should be configured so that if a charging or discharging efficiency is entered, the round-trip efficiency is greyed out, and vice versa.

The 2019 code cycle specifies a battery minimum round trip efficiency of 80 percent. However, this minimum round trip efficiency is not programmed into the California Simulation Engine and therefore is not currently accounted for in CBECC-Res modeling. 2022 CBECC-Res should be updated to account for the minimum round trip efficiency when running simulation models.

Currently CBECC-Res only allows for the addition of a battery storage system if a solar PV systems is part of the modeled design. This proposal would allow for standalone storage systems, not paired with solar PV systems, to be added as an option in CBECC-Res. This addition would provide a compliance credit to homeowners that meet an exception to solar PV requirements but still desire to install a battery storage system. Existing control strategies would need to be adapted for a standalone storage use case.

Existing CBECC- Res Modeling Capabilities

CBECC-Res allows a user to choose one of four control options, "Basic", "Time of Use", "Advanced DR Control", and "Advanced Control (old)". Under "Time of Use" control, the battery will hold charge until the specified discharge time, labeled as "First Hour of Summer Peak" in CBECC-Res. The default TOU discharge time is currently set to 7pm for Climate Zones 2, 4, 8 -15 and 8pm for all other climate zones. These default discharge times have been reevaluated for alignment with 2022 TDV peaks and utility TOU peak periods.

CBECC-Res includes two inputs for efficiency, charging efficiency and discharging efficiency. Efficiency is represented as a number between 0 and 1 and the default efficiency is set to 0.95 for both charging efficiency and discharging efficiency. A single round trip efficiency is more commonly found on battery datasheets and should be included as a user input option.

Summary of Proposed Revisions to CBECC Res

The CASE team proposes four modifications to the existing “Time of Use” and “Advanced DR battery control strategies offered by CBECC-Res.

The first modification is to shift the “Time of Use” control strategy’s “Default First Hour of the Summer Peak” for Climate Zones 8 and 9 by one hour from 7pm to 6pm and for Climate Zone 6 by one hour from 8pm to 7pm. This shift results in a more optimal TDV result, while still keeping battery discharge within the TOU peak period. It also optimizes for full discharge of the battery throughout the evening hours.

The second modification is to extend the “Time of Use” strategy to operate year-round. Currently, the “Time of Use” control strategy selectively discharges only during the summer months of June – September and reverts back to the “Basic” control strategy from October – May. Extending the “Time of Use” control strategy year-round aligns with utility TOU rate designs, which operate year-round, and results in increased TDV benefit.

The third modification is to allow for charging from the utility grid for standalone storage systems. The charging strategy should find the lowest four hours by TDV. The algorithm asks for full charge during the lowest three hours and charges the remainder during the fourth-lowest hour. The ‘lowest four hours’ is hardcoded: the strategy assumes the battery holds no more than four hours of charge. If simulations are to allow other battery storage ratios, the algorithm will have to be upgraded.

CBECC-Res should be updated to allow for standalone storage only if a solar PV requirement exception is met. Only the “Time of Use” and “Advanced DR” control strategies should be allowable control strategies for standalone storage. If the “Advanced DR” control strategy is selected, the default control strategy must be “Time of Use” for days when the Advanced DR TDV trigger is not met. The self-utilization credit should not be an allowable option for standalone storage systems.

The fourth modification is to increase the “Advanced DR” control strategy’s discharge hours from the top three TDV to the top four TDV hours. Battery manufacturers are designing more storage systems with longer duration discharge in order to meet homeowner resiliency needs. Some homeowners are also buying more than one battery for their homes, which if discharged in succession, would increase the battery storage system’s discharge duration.

The addition of a new Round-Trip Efficiency field should show up beside the Charging Efficiency and Discharging Efficiency fields. If a Round-Trip Efficiency is entered, the

Charging Efficiency and Discharging Efficiency fields should be greyed out and vice versa. If a user inputs a Round-Trip Efficiency, then the CSE file should use this single value to represent the battery efficiency instead of multiplying the charging and discharging efficiencies.

If the battery round trip efficiency does not meet the minimum round trip efficiency requirements as specified in JA12, the CSE model should be simulated to mimic a design without a battery storage system. Therefore, the inclusion of a non-JA12 compliant battery storage system would have no impact on the resulting compliance credit. A new fixed value, the minimum round trip efficiency, would need to be added to the California Simulation Engine to realize this functionality.

User Inputs to CBECC-Res

Table 44 lists the new CBECC-Res user inputs for battery storage systems.

Table 44: Additional User Inputs Relevant to Battery Storage Systems

Input Screen	Variable Name	Data Type	Units	User Editable	Recommended Label
Battery	Round-Trip Efficiency	Float	None	Yes	Round-Trip

Simulation Engine Inputs

California Simulation Engine Inputs

Table 45 provides recommended translation information for generating CSE inputs from CBECC-Res generated data.

Table 45: California Simulation Engine Input Variables Relevant to a Construction Assembly for Battery Storage Systems

CSE Recommended Variable Name	**CBECC - Res User** Input Variable Name
η_rte	Round-Trip Efficiency

Calculated Values, Fixed Values, and Limitations

A new fixed value, the minimum round trip efficiency (η_min), would need to be defined in CSE. This fixed value should be equal to the minimum round trip efficiency specified in JA12. If the user inputs a round-trip efficiency below this value, the CSE model should be simulated to mimic a design without a battery storage system.

Alternate Configurations

There are no alternate configurations or options for the battery storage system compliance option.

Simulation Engine Output Variables

CBECC-Res generates hourly CSE simulation results to CSV files during analysis. These hourly simulation results can be used by the analyst to determine if the battery control system has been updated. Variables of particular interest in this case would include:

- Battery [kBtu]
- Solar PV [kBtu]

Compliance Report

CBECC-Res generates a Title 24, Part 6 Compliance Report that presents the results of the building's compliance analysis. If a battery storage system is modeled, the compliance report would include a table titled "Energy Design Rating Battery Inputs". This table should be updated as shown below to match the Design Battery Storage System Information table found in the Certificate of Installation

Energy Design Rating Battery Inputs						
01	02	03	04	05	06	07
Battery Capacity (kWh)	Battery Control Strategy	Charging Efficiency (%)	Charge Rate (kW)	Discharging Efficiency (%)	Discharge Rate (kW)	Round Trip Efficiency (%)

Compliance Verification

After a battery storage system has been installed, the Certificate of Installation should be filled out by the installing contractor and placed in a visible location. A building inspector from the local jurisdiction would verify that the information on the Certificate of Installation is accurate. Although the programmed battery control strategy name from the manufacturer may not exactly match one of the control strategies in JA12, the building inspector should verify that the installed battery control strategy matches the operation of the chosen allowable battery control strategy in JA12. The building inspector can find information on the installed battery control strategy in the battery storage system user guide, data sheet, or battery settings (if available). The building inspector should also verify that the battery capacity and round trip efficiency listed on the Certificate of Installation matches the round-trip efficiency listed in the battery data sheet.

Testing and Confirming CBECC-Res Modeling

The Statewide CASE team performed a series of energy simulations to test the effectiveness (in terms of TDV energy savings potential) of existing and new battery control strategies, as stated in D.2.2.1. The 2100 ft^2 single family all-electric prototype models were simulated with Standard Design PV and a 5-kW battery system in each climate zone using CBECC-Res 2022.0.1 RV. The following existing battery control strategies were simulated:

1. Basic: Batteries charge whenever PV generation exceeds the building load. Batteries discharge when building load exceeds generation, until batteries are depleted. Abbreviated: basic
2. Time of Use: Batteries operate in Basic control mode except during peak months (June 1 through September 30). During peak months, batteries discharge at the maximum discharge rate starting at the First Hour of Summer Peak. First Hour of the Summer Peak defaults are summarized in Table 46, but can be overridden by the user. Abbreviated: tou

Table 46: Default First Hour of the Summer Peak by Climate Zone

Climate Zone	First Hour of Summer Peak (default)
1	20
2	19
3	20
4	19
5	20
6	20
7	20
8	19
9	19
10	19
11	19
12	19
13	19
14	19
15	19
16	20

3. Advanced DR: PV-generated electricity is used to charge batteries until they reach full charge. After the batteries are fully charged, excess PV-generated electricity is used for building loads. Batteries discharge only during the top three ranked TDV hours of each day. Abbreviated: adv

The following new battery control strategies were simulated:

4. Time of Use (+1 hour to default "First Hour of the Summer Peak"): TOU control with start hour one hour after the default. Abbreviated: tou_+1

5. Time of Use (-1 hour from default “First Hour of the Summer Peak”): TOU control with start hour one hour before the default. Abbreviated: tou_-1
6. Time of Use Year-Round: TOU control year-round (not limited to June through September). Abbreviated: tou_yr
7. Time of Use Year-Round (+1 hour to default “First Hour of the Summer Peak”): TOU control year-round with start hour one hour after the default. Abbreviated: tou_yr_+1
8. Time of Use Year-Round (-1 hour from default “First Hour of the Summer Peak”): TOU control year-round with start hour one hour before the default. Abbreviated: tou_yr_-1
9. Advanced DR – Peak months only: Advanced DR control June through September. Basic control all other months. Abbreviated: adv_basic
10. Advanced DR – Peak months only, TOU default: Advanced DR control June through September. TOU control all other months. Abbreviated: adv_tou

The new control strategies were simulated by adjusting the expressions of the btChgReq and btControlAlg variables within the CSE input files generated by CBECC-Res. The modified CSE input files were then simulated in CSE directly via command line using the CSE executable program installed as part of the CBECC-Res software package.

Results from the simulations indicate that the Advanced DR control strategy outperforms the other strategies in all climate zones except Climate Zone 15. The Climate Zone 15 prototype model performed best under the “Advanced DR – Peak Months only, TOU default” strategy, followed by “Time of Use Year-Round”. Several of the new battery control strategies outperformed the existing control strategies, particularly “Advanced DR – Peak months only, TOU default”, “Time of Use Year-Round”, “Time of Use Year-Round +1”, and “Time of Use Year-Round -1”. Results from the simulations were used to rank each of the control strategies for each climate zone, in order of lowest TDV energy consumption (Table 47).

Table 47: Control Strategy Ranking by Climate Zone

	Control Strategy Rank									
	1	2	3	4	5	6	7	8	9	10
ClimateZone1	adv	adv_tou	tou_yr	tou_yr_-1	tou_yr_+1	tou	adv_basic	tou_+1	tou_-1	basic
ClimateZone2	adv	adv_tou	tou_yr	adv_basic	tou	tou_+1	tou_yr_+1	basic	tou_yr_-1	tou_-1
ClimateZone3	adv	tou_yr_+1	tou_yr	adv_tou	tou_yr_-1	tou	adv_basic	tou_+1	tou_-1	basic
ClimateZone4	adv	adv_tou	adv_basic	tou_yr	tou	tou_+1	tou_-1	tou_yr_+1	tou_yr_-1	basic
ClimateZone5	adv	tou_yr_+1	adv_tou	tou_yr	tou_yr_-1	adv_basic	tou	tou_+1	basic	tou_-1
ClimateZone6	adv	tou_yr_-1	adv_tou	adv_basic	tou_yr_+1	tou_yr	tou	tou_+1	tou_-1	basic
ClimateZone7	adv	adv_tou	tou_yr_+1	adv_basic	tou_yr	tou	tou_yr_-1	tou_+1	tou_-1	basic
ClimateZone8	adv	adv_tou	adv_basic	basic	tou_yr_-1	tou_-1	tou_yr	tou	tou_+1	tou_yr_+1
ClimateZone9	adv	adv_tou	adv_basic	tou_yr_-1	tou_-1	tou	tou_yr	basic	tou_+1	tou_yr_+1
ClimateZone10	adv	adv_tou	adv_basic	tou_yr	tou_yr_-1	tou	tou_-1	tou_yr_+1	tou_+1	basic
ClimateZone11	adv	adv_tou	tou_yr	tou_yr_-1	tou_yr_+1	adv_basic	tou	tou_-1	tou_+1	basic
ClimateZone12	adv	adv_tou	tou_yr	adv_basic	tou_yr_+1	tou	tou_+1	tou_yr_-1	tou_-1	basic
ClimateZone13	adv	adv_tou	tou_yr	tou_yr_+1	tou_yr_-1	tou	adv_basic	tou_+1	tou_-1	basic
ClimateZone14	adv	adv_basic	adv_tou	tou	tou_yr	tou_-1	tou_yr_-1	tou_+1	basic	tou_yr_+1
ClimateZone15	adv_tou	tou_yr	adv	tou_yr_+1	tou_yr_-1	tou	tou_+1	adv_basic	tou_-1	basic
ClimateZone16	adv	tou_yr	adv_tou	tou_yr_-1	tou_yr_+1	tou	adv_basic	tou_+1	tou_-1	basic

The overall ranking of control strategies was calculated as the frequency of the strategy achieving a rank, multiplied by the rank value. For example, the Advanced DR control strategy achieved a rank of 1 in 15 climate zones and achieved a rank of 3 in one climate zone. Therefore, the overall ranking score for Advanced DR is $15 \times 1 + 1 \times 3 = 18$. The overall control strategy ranking is summarized in Table 48.

Table 48: Overall Ranking of Battery Control Strategies

Abbreviated Strategy Name	Overall Ranking Score	Overall Rank
adv	18	1
adv_tou	37	2
tou_yr	64	3
tou_yr_-1	88	5
tou_yr_+1	93	6
tou	97	7
adv_basic	78	4
tou_+1	126	8
tou_-1	131	9
basic	148	10

The discovery that the "tou_-1" control strategy outperformed the existing "Time of Use" control strategy for Climate Zones 6, 8 and 9 suggests that the default "First Hour of the Summer Peak" should be moved up one hour for these climate zones. Similarly, all the new variations of the "Time of Use Year-Round" control strategy (i.e. tou_yr, tou_yr_-1, and tou_yr_+1) outperformed the existing "Time of Use" strategy, which indicates that TOU battery control should be extended throughout the year to maximize TDV energy savings.

The "Time of Use" control strategy is intended to represent a strategy where the battery charges during off-peak hours (when electricity costs are low) and discharges during peak hours (when electricity costs are high). TOU electricity rates in California extend throughout the year, albeit with less dramatic differences between on- and off-peak rates outside of the peak season. Therefore, a more realistic "Time of Use" control strategy should also extend throughout the year.

Description of Changes to ACM Reference Manual

The code change proposal includes updating the description of "Time of Use" control strategy to reflect a year-round TOU control. A description on the default "First Hour of the Summer Peak" time for each climate zone under TOU control is proposed to be added, with the default start hour for Climate Zones 8 and 9 set at 18 (6pm) instead of 19 (7pm) and for Climate Zone 6 set at 19 (7pm) instead of 20 (8pm). The "Time of Use" and "Advanced DR" control strategies descriptions would also be updated to allow for standalone storage operation, and a standalone storage charging strategy would be added in which the battery charges during the lowest three TDV hours of the day.

In addition, a new user input, "Round Trip Efficiency", is proposed to be added as an alternative option to inputting both a "Charging Efficiency" and "Discharging Efficiency". For marked-up language in the ACM Reference Manual, please refer to Section 7.

If the battery round trip efficiency does not meet the minimum round trip efficiency requirements as specified in JA12, the CSE model should be simulated to mimic a design without a battery storage system. Therefore, the inclusion of a non-JA12 compliant battery storage system would have no impact on the resulting compliance credit.

HPWH Load Shifting

CASE measure collaborator, Ben Larson, also provides services to the Energy Commission's CBECC software development team, specifically for water heating measures. Mr. Larson will be working on the 2020 LSHPWH software implementation. Indications at this time suggest that there would not need to be any additional software modifications completed to accommodate the Basic Plus modeling capabilities, as all capabilities will be added (at least in a research version of the software) as part of the Energy Commission's 2020 software work. The latest information from the Energy Commission suggests that the beta version implementation of the LSHPWH algorithms will be completed in the late fall of 2020.

HVAC Load Shifting

The only compliance software changes required for HVAC Load Shifting in the 2020 code change cycle are to conform assumptions for pre-cooling times and temperatures with those specified for the proposed measure. The default values presented in Table 2 would be used in the calculation. The derating factor shall be kept at 70 percent, as in the previous version.

Home Energy Management

No compliance software changes are recommended for Home Energy Management Systems in the 2022 code change cycle.

Appendix E: Impacts of Compliance Process on Market Actors

This appendix discusses how the recommended compliance process, which is described in Section 2.1.5, could impact various market actors. Table 49 through Table 52 identify the market actors who would play a role in complying with the proposed changes, the tasks for which they will be responsible, their objectives in completing the tasks, how the proposed code changes could impact their existing work flow, and ways negative impacts could be mitigated. The information contained in those tables is a summary of key feedback the Statewide CASE Team received when speaking to market actors about the compliance implications of the proposed code changes. Appendix F summarizes the stakeholder engagement that the Statewide CASE Team conducted when developing and refining the code change proposal, including gathering information on the compliance process.

Battery Storage Systems

Table 49: Roles of Market Actors in the Proposed Compliance Process – Battery Storage Systems

Market Actor	Task(s) In Compliance Process	Objective(s) in Completing Compliance Tasks	How Proposed Code Change Could Impact Work Flow	Opportunities to Make this Measure Successful
Homeowner	• Place value on battery storage system as a cost savings or resiliency feature. • Ongoing maintenance of battery storage system once project is complete. • Chooses battery storage control system if offered as a customer-enabled control option.	• Create market demand. • Achieve expected energy savings, demand reduction, or resiliency benefit.	• Update battery control system settings if preferable to current market conditions. • Battery ready building design criteria, as an alternative compliance option to solar ready building requirements, would reduce the cost of storage installation and increase market demand.	• Ability to adjust battery control system through an UI. • Quality assurance from battery storage manufacturer on efficiency / performance. • Provide homeowner with the knowledge that their home is “battery ready”.
Battery Storage System Manufacturer	• Certify that their product complies with JA12 requirements. May involve lab testing, modeling. • Supply products that are certified.	• Deliver JA12 compliant battery storage system products that are eligible for a compliance credit. • Make the installation and commissioning process, incl. tie-in to the main service panel, as streamlined as possible.	• Would need to verify that battery storage systems meets updated JA12 requirements, including performance and safety requirements.	• Follow national and international battery storage standards to meet safety requirements. • Clearly label battery performance and control strategies / modes in data sheets, user guides, and additional documentation.
Energy Consultant	• Decide if the battery storage system credit is recommended to make project comply. • Decide if battery storage provides cost-benefit to the customer.	• Deliver energy savings to the homeowner.	• Account for updated performance and control requirements in JA12 when evaluating cost-benefit.	• Access to JA12 certified list of battery storage systems on the Energy Commission website.

Market Actor	Task(s) In Compliance Process	Objective(s) in Completing Compliance Tasks	How Proposed Code Change Could Impact Work Flow	Opportunities to Make this Measure Successful
Battery Storage System Designer	• Model system in CBECC-Res and generate Certificate of Compliance. • Indicate battery storage system on site plans.	• Attain Title 24, Part 6 compliance credits for battery storage systems.	• Account for new or updated storage modeling inputs in CBECC-Res. • Account for standalone storage as a new compliance option	• Datasheets or battery specifications provided from Energy Consultant / Modeler. • Update CBECC-Res to allow for a battery storage system to be modeled without having to specify a solar PV system
Plan Examiner	• Verify what's indicated on Certificate of Compliance is also documented on site plans. • Approve permit for battery storage installation.	• Quickly and easily determine if data in Certificate of Compliance matches site plans / specs.	• If battery ready building design criteria is selected as an alternative compliance pathway to solar ready building requirements, the examiner should verify that the design criteria are factored in the plans.	• Site plans should clearly indicate both storage zone area and storage interconnection equipment, if applicable.
Battery Storage System Contractor	• Install and commission equipment. • Educate the homeowner on how the battery storage system will operate and any customizable features for the battery. • Fill out the Certificate of Installation.	• Want equipment to work to reduce call backs. • Install system following all JA12 requirements.	• Account for updated battery requirements during install and completion of the Certificate of Installation.	• Additional guidance on Certificate of Installation under the User Instructions section.

Market Actor	Task(s) In Compliance Process	Objective(s) in Completing Compliance Tasks	How Proposed Code Change Could Impact Work Flow	Opportunities to Make this Measure Successful
Building Inspector	• Verify that the Certificate of Installation has been accurately filled out. • Send Certificate of Installation to local building department / local Authority Having Jurisdiction (AHJ). • Verify that the battery complies with the standards in JA12 not captured by the Certificate of Installation.	• Ensure battery storage system is installed in a safe location. • Ensure the battery is properly integrated with system interfaces (e.g. solar photovoltaics (PV), main panel).	• If the home is designed with battery ready building design criteria, verify the location of the storage zone area and storage interconnection equipmentAccount for updated JA12 requirements.	• Clear labeling of battery storage design features in the site plans (e.g. conduit runs, storage zone area, etc.)ns for round-trip efficiency (RTE) testing.
Builder	• Make decision to include battery ready building requirements as an optional design feature. • Educate homebuyers about benefits of battery ready building design	• Facilitate battery installation and reduce installation costs for homeowners	• Storage zone area and storage interconnection equipment must be designed to receive exemption from solar readiness requirements	• A battery ready building construction guide for builders with detailed design guidelines

HPWH Load Shifting

Table 50: Roles of Market Actors in the Proposed Compliance Process

Market Actor	Task(s) In Compliance Process	Objective(s) in Completing Compliance Tasks	How Proposed Code Change Could Impact Work Flow	Opportunities to Minimize Negative Impacts of Compliance Requirement
Builder/ Homeowner	• Coordinate with energy consultant and designer to clearly understand the elements and details needed to certify building. • Ensure construction managers/superintendents know all the requirements. • Coordinate with all subs to ensure everyone understands requirements and installation quality is met. • Coordinate with HERS Rater to schedule inspections, if needed.	• Meet project budgets and schedules. • Minimize/eliminate inspection failures and callbacks. • Ensure inspections do not cause schedule delays. • Minimize paperwork required. • Avoid warranty issues.	• Need to be aware of JA13 certified products.	• Clearly articulate goals and expectations to contractors. • Ensure job superintendent understands expectations and knows when a job is ready for HERS Rater. • Builder should communicate LSHPWH setup and expected operational patterns with homeowner.
HPWH Manufacturer	• Ensure that products meet federal efficiency requirements and have any necessary certifications (e.g UL).	• Deliver JA13 compliant products that are eligible for a compliance credit. • Build market share. • Make the installation and commissioning process as streamlined as possible.	• Certify that their product complies with JA13 requirements. May involve software development and testing; UL certification. • Certify products to Energy Commission. • May complicate inventory control unless all HPWHs meet the JA13 requirements.	• Update installation materials and training videos to clearly communicate steps to properly configure LSHPWH operation (TOU schedules, other settings), as needed.

Market Actor	Task(s) In Compliance Process	Objective(s) in Completing Compliance Tasks	How Proposed Code Change Could Impact Work Flow	Opportunities to Minimize Negative Impacts of Compliance Requirement
Title 24 Consultant	• Complete required calculations to confirm compliance; provide compliance documents for permit application. • Coordinate with design team to ensure that all required measures are included in the design documents.	• Clearly communicate requirements and ensure that builder/construction team are aware of requirements and there are no surprises. • Demonstrate compliance and energy performance goals are met.	• Be aware of JA13 certified products. • Needs to understand and convey timing of additional potential HERS inspections to builder/construction team, if needed. • Verify if LSHPWH measure is specified by builder/ owner and that they are aware that HPWH is on Energy Commission's certified list.	• Ensure that any requirements are clearly articulated in specifications and plans and that design team and builder are aware of any construction impacts .
Plans Examiner	• Verify what is indicated on Certificate of Compliance is also documented on site plans. • Approve permit.	• Minimize amount of paperwork needed to review.	• No significant impacts anticipated.	• Understand JA13 requirements.
Installation Contractor	• Install and commission equipment. • Fill out the Certificate of Installation.	• Want equipment to operate properly to reduce call backs. • Minimize/eliminate inspection failures and callbacks. • Minimize paperwork required. • Avoid warranty issues.	• Need to understand LSHPWH setup for models that they install. • May need to program TOU rates at system startup.	• Communicate LSHPWH setup and configuration options with builder and homeowner (e.g. one page flyer attached for HPWHs that raise tank temperature above normal set point).
Building Inspector	• Verify that all required HERS inspections listed on plans have been completed and signed by HERS Rater. • Sign off on permit.	• Minimize amount of time and paperwork needed to approve.	• Verify installed HPWH is on Energy Commission JA13 certified list.	• Gain familiarity with LSHPWH control strategy and available listed equipment at Energy Commission website.

Market Actor	Task(s) In Compliance Process	Objective(s) in Completing Compliance Tasks	How Proposed Code Change Could Impact Work Flow	Opportunities to Minimize Negative Impacts of Compliance Requirement
HERS Rater	• Review design documents to understand required verifications. • Makes sure all parties are aware of responsibilities, expectations, and schedule of inspections. • Complete verifications/ diagnostic testing and required CF3R forms.	• Coordinate w/ builder on scheduling necessary inspections. • Maintain positive working relationships with builder and construction team without impacting construction schedule.	• Verify installed HPWH is on Energy Commission JA13 certified list. • Timing of inspections needs to be accounted for. • If project does not pass, communicate issues with responsible parties and complete re-inspection. • Complete and submit required forms for permit.	• Work with builder to ensure that goals and expectations are set by team to achieve compliance. • Provide as-needed pre-installation training and coordination with construction team prior to installation inspections. • Gain familiarity with LSHPWH technology and available listed equipment at Energy Commission website.
Energy Commission	• Develop procedures and verification requirements. • Educate builders, installers, building officials, and HERS Raters.	• Ensure compliance is being achieved.	• Need to update forms (CF2R and CF3R), Reference Appendices, ACM Reference Manual, and RCM manuals. • Need to maintain JA13 certified products list.	• Maintain JA13 certified products list. • Provide educational and training information on LSHPWHs to HERS Raters, Title 24 consultants, architects, and building officials.

HVAC Load Shifting

Table 51: Roles of Market Actors in the Proposed Compliance Process – HVAC Load Shifting

Market Actor	Task(s) In Compliance Process	Objective(s) in Completing Compliance Tasks	How Proposed Code Change Could Impact Work Flow	Opportunities to Make this Measure Successful
PCT Manufacturer	• Review JA5 Requirements for programmability, overrides, CFAPs, and usability, and ensure and communicate to potential installers that PCT meets criteria. • Produce educational materials to be left behind by installer and make them available to dealers. •	• Expand market for their products. • Have successful products that lead to future sales and future code credits.	• Additional task to review designs. • May require new designs to take advantage of credit.	• Review design of thermostat for programmability, override functionality, and usability. • Produce informative and useful educational materials.
EC/Modeler	• Decide if the Pre-Cooling credit is recommended to make project comply • Include this in the model as a credit. • Include Pre-Cooling in the table of requirements on the CF1R-PRF-01, indicating that HERS verification is required..	Identify measures that can meet compliance targets.	Another tool in toolbox to make projects comply.	
Mechanical Designer	Same as Energy Consultant / Modeler.	Create a compliant design that ensures a happy customer and no complaints.		
Plans Examiner	Ensure that compliance documents match plans.	Spend as little time as possible to verify that compliance documents match plans.	Minimal additional review time.	

Market Actor	Task(s) In Compliance Process	Objective(s) in Completing Compliance Tasks	How Proposed Code Change Could Impact Work Flow	Opportunities to Make this Measure Successful
HVAC Contractor/ Technician	• Identify a suitable PCT. • Determine the expected values of the required CFAPs within the allowable ranges, either utilizing default values or conducting optimization. • Include PCT model and values of CFAPs on the plans and specifications, as well as on the CF2R • Install the PCT according to manufacturer instructions. • Configure the PCT by programming CFAPs. • Provide educational materials supplied by manufacturer to homeowner.	• Want equipment to work to reduce call backs • Clearly be able to see the requirement on the construction docs. • Have clear direction on how to install and configure PCTs. • Possibly expand service customer base.	• Spend more time in specifying thermostat. • Spend time to understand how Pre-cooling works, and determine optimal CFAPs. • If necessary, customize CFAPs for location (TOU rate periods). • Stay up to date on current TOU rates and time periods. • Spend time to learn how to program PCTs correctly.	• Do thoughtful analysis of benefits in individual buildings, and identify optimal values of CFAPs. • Stay up to date on current TOU rates and time periods. • Learn how to program PCTs correctly, including normal scheduling functionality. • Talk with customers about benefits of Pre-cooling.
HERS Rater	• Conduct a HERS verification, verifying that: • the PCT model matches the one on the CF2R, • CFAPs match the values on the CF2R, and • educational materials have been left for the homeowner. • Record these results on the CF3R.	Have clear direction on how to verify programming of PCTs.	Additional task to review programming and values of CFAPs.	Look at normal setback programming of PCT and inform owner of errors.
Building Inspector	Verify forms are completed by HERS Rater.	Have clear requirements for compliance forms.	No new tasks.	Consistently require forms for all required projects.
Homeowner	• Review educational materials upon occupancy. • Only use temporary overrides, when comfort considerations override cost savings. • Consider the benefits of the Pre-Cooling strategy when changing programming. • Update programming when TOU rates change.	Reduce energy costs while maintaining adequate comfort.	Would require some added awareness of thermostat settings.	Become more aware of thermostat programming.

Home Energy Management

The proposed compliance process would be more formalized but would also have more clarity because a qualifying HEMS would have well-defined minimum requirements. Audio visual equipment (AVE) contractors would be responsible for installing all the necessary components of a HEMS that meets the specified criteria and is compatible with other qualifying grid integration technologies such as batteries, load shifting HPWHs, and DMTs. CF2R-SRA-01-E: Solar Ready Buildings – New Construction must be completed and submitted to the HERS rater, indicating the presence of a qualifying HEMS in a modified drop-down menu. The CF2R certifies that the system has been installed in accordance with Title 24 requirements and that the make and model are included in the directory of approved HEMS on the Energy Commission website.

This submeasure may require additional training for installers. The HEMS requirements are fairly complicated, and many elements relate to how the systems is installed, how it is programmed, and what devices are connected. Documenting that the make and model are on the Energy Commission qualified list would not be sufficient to guarantee the installed system would be compliant with Title 24, Part 6. However, the requirements are clear, and the HEMS interface itself can provide most of the information needed to confirm that it is installed properly, communicating with the utility, receiving signals from all connected devices and sensors, and operating under a default schedule that would provide energy cost savings.

A summary of the HEMS compliance process is provided in Table 52. This table describes the major market actors, their roles and responsibilities, and how the proposed change would affect their work flow.

Table 52: Roles of Market Actors in the Proposed Compliance Process – Home Energy Management

Market Actor	Task(s) In Compliance Process	Objective(s) in Completing Compliance Tasks	How Proposed Code Change Could Impact Work Flow	Opportunities to Make this Measure Successful
Electrician/ AVE contractor	• Install HEMS. • Identify it on the CF2R for solar readiness & include in bid. • If AVE, would need to coordinate with electrician and other trades which would be connected so electrician doesn't bypass the functionality that requires rework.	Install a HEMS that meets minimum Title 24, Part 6 requirements to receive exemption to minimum solar zone area.	• There is almost never any AVE on the plans. So the only documentation would be on the CF2R. May make this difficult to enforce. • Would likely require more coordination between trades.	Development of clear minimum requirements that the installed HEMS must meet.
Homeowner	• Place value on HEMS as a new home feature. • Program system to save energy and reduce peak demand, or accept default settings. • Don't override programmed or utility signals to turn off devices • Purchase and connect compatible devices.	• Create market demand. • Achieve expected energy savings and demand reduction.	Installer may need to explain HEMS operation.	• Quality assurance for HEMS. • Option to override controls when necessary.
Builder	• Make decision to include HEMS as a standard or optional home feature in product line. • Educate homebuyers about benefits of HEMS.	Achieve market availability of HEMS in new homes.	Minimum number of smart appliances, lights, outlets must be included to receive exemption.	Flexibility in system design and minimum connected devices.
Inspector	Verify that the minimum requirements specified have been met	Ensure HEMS is capable of providing expected savings and grid benefits.	Additional verification steps.	Clear requirements for compliance.
HEMS Manufacturer	• Provide clear operating instructions. • Design user-friendly interface.	• Make it easy for homeowners to operate system effectively. • Allow straightforward integration of HEMS components.	Additional documentation may be required.	Align with ENERGY STAR SHEMS product requirements as closely as possible.

Market Actor	Task(s) In Compliance Process	Objective(s) in Completing Compliance Tasks	How Proposed Code Change Could Impact Work Flow	Opportunities to Make this Measure Successful
AEET Manufacturer	• Provide clear documentation to installers that they meet the relevant ENERGY STAR criteria.	• Expand market for their products. • Have successful products that lead to future sales and future code credits.	Additional work to communicate that they meet the relevant ENERGY STAR criteria.	

Appendix F: Summary of Stakeholder Engagement

Collaborating with stakeholders that might be impacted by proposed changes is a critical aspect of the Statewide CASE Team's efforts. The Statewide CASE Team aims to work with interested parties to identify and address issues associated with the proposed code changes so that the proposals presented to the Energy Commission in this Final CASE Report are generally supported. Public stakeholders provide valuable feedback on draft analyses and help identify and address challenges to adoption including: cost effectiveness; market barriers; technical barriers; compliance and enforcement challenges; or potential impacts on human health or the environment. Some stakeholders also provide data that the Statewide CASE Team uses to support analyses.

This appendix summarizes the stakeholder engagement that the Statewide CASE Team conducted when developing and refining the recommendations presented in this report.

Utility-Sponsored Stakeholder Meetings

Utility-sponsored stakeholder meetings provide an opportunity to learn about the Statewide CASE Team's role in the advocacy effort and to hear about specific code change proposals that the Statewide CASE Team is pursuing for the 2022 code cycle. The goal of stakeholder meetings is to solicit input on proposals from stakeholders early enough to ensure the proposals and the supporting analyses are vetted and have as few outstanding issues as possible. To provide transparency in what the Statewide CASE Team is considering for code change proposals, during these meetings the Statewide CASE Team asks for feedback on:

- Proposed code changes
- Draft code language
- Draft assumptions and results for analyses
- Data to support assumptions
- Compliance and enforcement, and
- Technical and market feasibility

The Statewide CASE Team hosted two stakeholder meetings for Single Family Residential grid integration via webinar. Please see below for dates and links to event pages on Title24Stakeholders.com. Materials from each meeting, such as slide presentations, proposal summaries with code language, and meeting notes, are included in the bibliography section of this report (California Statewide Utility Codes and

Standards Team 2019a, California Statewide Utility Codes and Standards Team 2019b, California Statewide Utility Codes and Standards Team 2019c).

Meeting Name	Meeting Date	Event Page from Title24stakeholders.com
First Single Family Residential Grid Integration Utility-Sponsored Stakeholder Meeting	Tuesday, September 10, 2019	https://title24stakeholders.com/event/grid-integration-utility-sponsored-stakeholder-meeting/
Second Single Family Residential Grid Integration Utility-Sponsored Stakeholder Meeting	Thursday, March 19, 2020	https://title24stakeholders.com/event/grid-integration-utility-sponsored-stakeholder-meeting-2/

The first round of utility-sponsored stakeholder meetings occurred from September to November 2019 and were important for providing transparency and an early forum for stakeholders to offer feedback on measures being pursued by the Statewide CASE Team. The objectives of the first round of stakeholder meetings were to solicit input on the scope of the 2022 code cycle proposals; request data and feedback on the specific approaches, assumptions, and methodologies for the energy impacts and cost-effectiveness analyses; and understand potential technical and market barriers. The Statewide CASE Team also presented initial draft code language for stakeholders to review.

The second round of utility-sponsored stakeholder meetings occurred from March to May 2020 and provided updated details on proposed code changes. The second round of meetings introduced early results of energy, cost-effectiveness, and incremental cost analyses, and solicited feedback on refined draft code language.

Utility-sponsored stakeholder meetings were open to the public. For each stakeholder meeting, two promotional emails were distributed from info@title24stakeholders.com One email was sent to the entire Title 24 Stakeholders listserv, totaling over 1,900 individuals, and a second email was sent to a targeted list of individuals on the listserv depending on their subscription preferences. The Title 24 Stakeholders' website listserv is an opt-in service and includes individuals from a wide variety of industries and trades, including manufacturers, advocacy groups, local government, and building and energy professionals. Each meeting was posted on the Title 24 Stakeholders' LinkedIn page[22] (and cross-promoted on the Energy Commission LinkedIn page) two weeks before each meeting to reach out to individuals and larger organizations and channels outside of the listserv. The Statewide CASE Team conducted extensive personal outreach to stakeholders identified in initial work plans who had not yet opted in to the listserv. Exported webinar meeting data captured attendance numbers and individual comments,

[22] Title 24 Stakeholders' LinkedIn page can be found here: https://www.linkedin.com/showcase/title-24-stakeholders/.

and recorded outcomes of live attendee polls to evaluate stakeholder participation and support.

Statewide CASE Team Communications

The Statewide CASE Team held personal communications over email and phone with numerous stakeholders when developing this report. A summary of key contacts is provided in Table 53, however the list is not exhaustive.

Table 53: Key Stakeholders Contributing to the Development of Proposed Code Change for Single Family Residential Grid Integration

Stakeholder Organization	Stakeholder Name	Date of Communication	Submeasure
CLEAResult	Emily Kemper	October 3, 2019	HEMS
AnnDyl Policy Group/ Building Performance Association	Kara Saul-Rinaldi	September 6, 2019	HEMS
Lawrence Berkeley National Laboratory	Marco Pritoni	August 6, 2019	HEMS
National Renewable Energy Laboratory	Lieko Earle	August 5, 2019	HEMS
Commonwealth of Massachusetts/NEEP	Claire Miziolek	August 2, 2019	HEMS
Google/NEST	Richard Counihan, Chase Maxwell	March 17, 2020; May 3, 2020	HEMS
U.S. Environmental Protection Agency	Abigail Daken, Taylor Jantz-Sell, Theo Keeley-LeClaire (ICF)	April 7, 2020	HEMS
Zen Ecosystems	Grant Hatamosa, James Muraca, Ana-Paula Issa	April 9, 2020	HEMS
Resideo	Arnold Meyer	May 4, 2020	HEMS
Alarm.com	Abe Kinney	May 4, 2020	HEMS
Natural Resources Defense Council	Pierre Delforge	August 1, 2019	LSHPWH
Northwest Energy Efficiency Alliance, Bonneville Power Admin., Portland Gen. Electric	Geoff Wickes, Tony Koch, Conrad Eustis (group call)	August 15, 2019	LSHPWH
Electric Power Research Institute (OpenADR Alliance, Energy Solutions, NEEA, BPA)	Chuck Thomas (also Rolf Bienert, Energy Solutions, NEAA, BPA, C.Eustis)	October 11, 2019	LSHPWH

Stakeholder Organization	Stakeholder Name	Date of Communication	Submeasure
A.O. Smith	Stephen Memory, Brian Branecky, Tim Rooney	October 23, 2019	LSHPWH
Rheem	Joe Boros, Ankur Maheshwari	December 10, 2019	LSHPWH
Natural Resources Defense Council	Pierre Delforge	May 28, 2020	LSHPWH
Energy350	Meg Waltner	June 30, 2020	LSHPWH
A.O. Smith	Ashley Armstrong	July 10, 2020	LSHPWH
Rheem	Joe Boros	July 10, 2020 August 21, 2020	LSHPWH
Skycentrics	Tristan de Frondeville	July 29, 2020	LSHPWH
EPRI	Ram Narayanamurthy	August 3, 2019	PreCooling
LBNL/UC Davis	Alan Meier	August 3, 2019	PreCooling
E3	Brian Conlon	September 4, 2019	PreCooling
Google/NEST	Serj Berlson	September 25, 2019	PreCooling
Google/NEST	Richard Counihan	December 2, 2019	PreCooling
E3	Brian Conlon	January 30, 2020	PreCooling
Natural Resources Defense Council	Meg Waltner	May 5, 2020	PreCooling
VCA Green	Wayne Alldredge	September 19, 2019	Battery Storage System
LBNL	Max Wei	October 9, 2019	Battery Storage System
E3	Brian Conlon	October 9, 2019	Battery Storage System
California Solar & Storage Association	Ben Davis, Scott Murtishaw	October 25, 2019 May 8, 2020 June 1, 2020 June 17, 2020 June 19, 2020	Battery Storage System
Tesla	Nick Armstrong	October 25, 2019	Battery Storage System
Solar Edge	Jason Bobruk	December 10, 2019	Battery Storage System
Sunpower	Megan Cordes, Daidipya Patwa, Matt Brost	December 11, 2019	Battery Storage System
Quality Logic	James Mater	February 11, 2020	Battery Storage System

Stakeholder Organization	Stakeholder Name	Date of Communication	Submeasure
PG&E	Albert Chiu	March 4, 2020	Battery Storage System
WattTime	Henry Richardson, Lekha Sridhar	April 10, 2020	Battery Storage System
Neil Kruis	Big Ladder Software	June 16, 2020	Battery Storage System
CBIA / HCD / Console	Chris Ochoa, Bob Ramyer, Kyle Krause	June 19, 2020	Battery Storage System

Homeowner Surveys

Evergreen Economics conducted two surveys to inform this CASE Report. The battery storage survey was targeted to homeowners with PV systems, while the survey addressing the other three submeasures targeted a broader cross-section of homeowners. The survey goals by topic area are listed below:

General:

- Gauge attitudes towards grid harmonization (harmonizing customer owned distributed energy resources with the grid while limiting the grid exports to periods beneficial to the grid and the ratepayer);
- Understand respondent values in the context of grid integration; and
- Understand preferences for demand response, time of use and critical peak pricing.

Battery Storage:

- Determine what benefits of batteries are most important to purchasers.
- Identify customer priorities when evaluating battery storage products
- Identify possible incentives to encourage battery purchases
- Identify major market barriers
- Identify quality assurance and persistence issues that can be addressed through code requirements
- Identify possible additional requirements for battery capabilities in JA12.

HPWH Load Shifting (for respondents with storage water heaters):

- Gauge familiarity with the technology
- Assess willingness to include controls
- Understand tolerance for controls and at which point they may disable controls

HVAC Load Shifting:

- Understand tolerance for discomfort or inconvenience of set point adjustments
- Categorize respondents into thermostat actors including “set it and forget it” and “tweakers”
- Understand tolerance for maximum thermostat set points (to inform eligibility for smart and occupancy controlled smart thermostats)
- Identify if there is value in developing voluntary requirements that may allow for additional credits
- Assess likelihood of disabling smart feature both permanently and temporarily, and how to reduce the likelihood

Home Energy Management:

- Gauge familiarity with home automation
- Assess interest in home automation systems
- Determine tolerance for remote decision making in the homeowner’s interest
- Determine persistence over time of automation feature

Key conclusions from the surveys (Evergreen Economics 2020) (Wudka 2020) are summarized below:

Battery Storage:

- Price is the largest barrier to purchasing batteries.
- Respondents with batteries reported higher incomes than respondents who only had solar.
- Both groups of respondents (with and without batteries) align in their values with regards to grid stability and increasing renewable energy reliance in California.
- Backup power for grid emergencies was a large motivator amongst those who decided to purchase a battery.
- Solar respondents reported that they may be more likely to consider purchasing a battery if Public Safety Power Shutoffs become more frequent.

HPWH Load Shifting

- 66 percent of respondents were somewhat to extremely interested in a technology that would preheat their water to avoid peak hours before mentioning any incentive.
- When the survey described that respondents may see $50 in bill savings, interest in

participation increased slightly, with an additional 4 percent of respondents saying they would be somewhat to extremely likely to adopt this technology.

- To better understand what level of inconvenience respondents would be willing to accept in exchange for an even higher amount of bill savings ($100 instead of $50), respondents were asked about the likelihood of disabling preheating if they ran out of hot water once a month. This did not significantly shift their willingness to participate.

HVAC Load Shifting:

- 79 percent of respondents said they were somewhat to extremely likely to participate in a program that would offer them $30 per summer month to pre-cool their home. An additional 9 percent said they are somewhat to extremely likely to adopt precooling when the incentive doubles.
- The most likely scenario respondents would override AC controls would be a day where warmer temperatures made household members uncomfortable, or if guests are over, suggesting comfort is the most likely trigger for disabling precooling.
- The most effective levers to encourage respondents to not override are either monetary (they see bill savings, or they risk losing a bill credit) or if they are able to remain comfortable.

Home Energy Management:

- 59 percent of respondents reported being somewhat to extremely likely to allow utilities to control certain items in their home for $20 a month. When asked about $40, there was a 6 percent increase.
- Low income respondents (<$35K/year) were about 13% more likely to give up some control of their appliances and home electronics in exchange for a utility incentive of $20/month. At $40/month, income level was a less important driver.
- Customers who were unlikely to sign up for the program were asked why. Over half of respondents were concerned about loss of control of their own living environment, service disruptions that require manual override, and intrusion on privacy.

Appendix G: Parametric Analysis of Pre-Cooling

Light shading shows parameters that meet TDV or kWh criteria (kWh Penalty ≤ 5 percent, TDV Savings > 0 percent). Dark shading shows climate zones that meet criteria for all sets of parameters). The first column is the scenario that is modeled in the savings calculations.

Table 54. Results of Parametric Analysis for SF 2100 Prototype: TDV Percent Savings

CZ	PC-Temp 75°F Lo Mass 4 HRS	PC-Temp 75°F Lo Mass 6 HRS	PC-Temp 75°F Hi Mass 4 HRS	PC-Temp 75°F Hi Mass 6 HRS	PC-Temp 72°F Lo Mass 4 HRS	PC-Temp 72°F Lo Mass 6 HRS	PC-Temp 72°F Hi Mass 4 HRS	PC-Temp 72°F Hi Mass 6 HRS
1	0%	0%	0%	0%	0%	0%	0%	0%
2	0%	0%	0%	0%	-1%	-1%	-1%	-1%
3	0%	0%	0%	0%	0%	0%	0%	0%
4	0%	0%	0%	0%	-2%	-2%	-2%	-2%
5	0%	0%	0%	0%	0%	0%	0%	0%
6	0%	0%	-1%	-1%	-5%	-6%	-6%	-6%
7	-1%	-1%	-1%	-1%	-5%	-6%	-3%	-4%
8	0%	0%	-2%	-2%	-4%	-5%	-5%	-7%
9	3%	3%	3%	2%	-1%	-2%	-2%	-3%
10	4%	4%	4%	3%	2%	1%	1%	0%
11	8%	9%	8%	9%	8%	8%	7%	8%
12	1%	1%	0%	0%	-2%	-2%	-3%	-3%
13	12%	13%	12%	12%	11%	11%	11%	10%
14	5%	6%	4%	5%	4%	4%	3%	3%
15	13%	19%	14%	19%	12%	17%	13%	17%
16	-1%	-1%	-1%	-1%	-2%	-2%	-2%	-2%

Table 55. Results of Parametric Analysis for SF 2100 Prototype: kWh Percent Penalty

CZ	PC-Temp 75°F Lo Mass 4 HRS	PC-Temp 75°F Lo Mass 6 HRS	PC-Temp 75°F Hi Mass 4 HRS	PC-Temp 75°F Hi Mass 6 HRS	PC-Temp 72°F Lo Mass 4 HRS	PC-Temp 72°F Lo Mass 6 HRS	PC-Temp 72°F Hi Mass 4 HRS	PC-Temp 72°F Hi Mass 6 HRS
1	0%	0%	0%	0%	0%	0%	0%	0%
2	0%	0%	0%	0%	2%	2%	1%	1%
3	0%	0%	0%	0%	0%	1%	0%	0%
4	0%	1%	0%	0%	3%	3%	2%	3%
5	0%	0%	0%	0%	0%	0%	0%	0%
6	2%	2%	1%	2%	8%	9%	8%	9%
7	1%	1%	1%	1%	6%	8%	4%	6%
8	3%	3%	3%	3%	7%	10%	7%	9%
9	2%	3%	2%	3%	6%	8%	6%	9%
10	2%	3%	2%	3%	5%	7%	5%	7%
11	1%	1%	1%	2%	2%	4%	2%	4%
12	1%	1%	1%	2%	5%	6%	5%	6%
13	1%	1%	1%	2%	3%	5%	3%	5%
14	1%	2%	1%	2%	3%	5%	3%	5%
15	1%	2%	1%	2%	4%	6%	4%	6%
16	1%	1%	1%	1%	3%	3%	3%	3%

Table 56: Results of Parametric Analysis for SF 2700 Prototype: TDV Percent Savings

CZ	PC-Temp 75°F Lo Mass 4 HRS	PC-Temp 75°F Lo Mass 6 HRS	PC-Temp 75°F Hi Mass 4 HRS	PC-Temp 75°F Hi Mass 6 HRS	PC-Temp 72°F Lo Mass 4 HRS	PC-Temp 72°F Lo Mass 6 HRS	PC-Temp 72°F Hi Mass 4 HRS	PC-Temp 72°F Hi Mass 6 HRS
1	0%	0%	0%	0%	0%	0%	0%	0%
2	1%	1%	0%	0%	-1%	-1%	-2%	-2%
3	0%	0%	0%	0%	-1%	-1%	0%	0%
4	0%	0%	0%	0%	-2%	-2%	-2%	-2%
5	0%	0%	0%	0%	-1%	-1%	0%	0%
6	0%	0%	0%	0%	-4%	-5%	-4%	-5%
7	-1%	-2%	-1%	-1%	-5%	-6%	-5%	-6%
8	1%	1%	0%	0%	-2%	-4%	-3%	-5%
9	4%	4%	4%	4%	0%	-2%	-1%	-2%
10	5%	5%	4%	5%	2%	2%	2%	2%
11	9%	11%	9%	10%	8%	9%	8%	9%
12	3%	3%	2%	2%	1%	0%	-1%	-1%
13	14%	14%	13%	14%	13%	13%	12%	13%
14	7%	8%	6%	7%	6%	6%	5%	5%
15	14%	20%	14%	20%	13%	18%	13%	18%
16	0%	-1%	0%	-1%	-1%	-2%	-1%	-2%

Table 57: Results of Parametric Analysis for SF 2700 Prototype: kWh Percent Penalty

CZ	PC-Temp 75°F Lo Mass 4 HRS	PC-Temp 75°F Lo Mass 6 HRS	PC-Temp 75°F Hi Mass 4 HRS	PC-Temp 75°F Hi Mass 6 HRS	PC-Temp 72°F Lo Mass 4 HRS	PC-Temp 72°F Lo Mass 6 HRS	PC-Temp 72°F Hi Mass 4 HRS	PC-Temp 72°F Hi Mass 6 HRS
1	0%	0%	0%	0%	0%	0%	0%	0%
2	0%	0%	0%	0%	3%	3%	2%	2%
3	0%	0%	0%	0%	1%	1%	1%	1%
4	1%	1%	1%	1%	3%	3%	3%	3%
5	0%	0%	0%	0%	1%	1%	1%	1%
6	2%	2%	2%	2%	8%	9%	7%	9%
7	2%	2%	1%	2%	6%	8%	6%	8%
8	3%	3%	3%	3%	7%	10%	7%	10%
9	2%	3%	2%	3%	7%	9%	7%	9%
10	2%	3%	2%	3%	5%	8%	5%	8%
11	1%	1%	1%	1%	2%	4%	2%	4%
12	1%	2%	1%	2%	5%	6%	5%	6%
13	0%	1%	1%	1%	2%	4%	2%	4%
14	1%	2%	1%	2%	2%	4%	2%	4%
15	1%	2%	1%	2%	3%	5%	3%	6%
16	1%	2%	1%	2%	3%	4%	3%	4%

Appendix H: Nominal Savings Tables

This code change proposal would not modify the stringency of the existing Title 24, Part 6 Standards, so the Energy Commission does not need a complete cost-effectiveness analysis to approve the proposed change. Therefore, nominal savings calculations were not performed for this measure.