Proposal Summary

2022 California Energy Code (Title 24, Part 6)

Multifamily Domestic Hot Water – Central Heat Pump Water Heater

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Introduction

The document summarizes proposed revisions to the California Energy Code (Title 24, Part 6) that will be discussed during Round 2 of the utility-sponsored stakeholder meeting on March 17, 2020. The Statewide Utility Codes and Standards Enhancement (CASE) Team is seeking input and feedback. To provide your comments, email info@title24stakeholders.com.

Measure Description

This measure will develop a prescriptive compliance pathway for central domestic water heating systems with heat pump technology serving multiple dwelling units by leveraging existing software algorithm development, lab testing, and design guide development. The CASE Team will perform additional market readiness research across a broad group of stakeholders and develop code and compliance manual language.

Central heat pump water heating (HPWH) is a key design strategy to decarbonize domestic water heating. Several successful designs have been implemented and are operational in Washington and California in field demonstrations. However, energy savings are highly dependent on design and not guaranteed. Heat pump water heaters require low entering water temperature to operate at high efficiencies. Design variables that must be considered include hot water draw schedules and volume throughout a multifamily building, and stratification strategies including tank sizing and piping configuration. Multiple water heaters can be designed to operate in parallel to increase overall capacity, and each heat pump water heater model has different performance characteristics.

Central HPWH is a relatively new design approach and no design guidelines exist to ensure appropriate design. This measure would integrate best practices into the code language for central HPWH design and operation to ensure energy savings. The CASE Team will gather the following information from various on-going research efforts:

- Heat pump water heater sizing and model selection in different climates
- Tank sizing and piping configurations that lead to beneficial stratification
- Control methods to maintain supply water temperature, reduce cycling, and optimize defrosting
- Location within the building and distribution piping, including impact on space heating and cooling loads.

The goal of this measure is to develop a prescriptive compliance pathway for central HPWH to encourage implementation in multifamily buildings. The CASE Team will collaborate and build upon the PG&E funded lab testing effort that include:

- Conduct performance testing of central HPWH systems and develop central HPWH model to be included in CBECC-Res and CBECC-Com
- Develop installation criteria for multifamily HPWH systems

There are several overlapping issues with accurately modeling central HPWH, which the CASE Team needs to coordinate with other domestic hot water (DHW) CASE topics and on-going research efforts:

- Recirculation loop modeling accounting for multiple loops or length of loops, solar thermal, or solar PV designs.
- Updating CBECC-Res to allow for central HPWH modeling in all multifamily buildings

Based on the outcome of the research, the CASE Team may recommend several alternate compliance pathways depending on the location, number of loops, and/or number of dwelling units being served by the central HPWH system.

Draft Code Language

The Energy Commission plans to create a multifamily chapter for inclusion in 2022 Title 24, Part 6. The multifamily chapter will draw from the appropriate sections of the 2019 residential and nonresidential Standards. The Statewide CASE Team uses the language and section numbering from residential and nonresidential Standards and Reference Appendices to show the proposed changes below. Changes to the 2019 documents are marked with red underlining (new language) and ~~strikethroughs~~ (deletions). Expected sections or tables of the proposed code (but not specific changes at this time) are highlighted in yellow. These changes are specific to multifamily buildings and not indicative of changes that apply to residential or nonresidential buildings.

Standards

SECTION 150.1 – PERFORMANCE AND PRESCRIPTIVE COMPLIANCE APPROACHES FOR LOW-RISE RESIDENTIAL BUILDINGS

[Item (c)8]

8. Domestic Water-Heating Systems. Water-heating systems shall meet the requirements of either A B or C. For recirculation distribution systems serving individual dwelling unit, only Demand Recirculation Systems with manual on/off control as specified in the Reference Appendix RA4.4.9 shall be used:

A. For systems serving individual dwelling units, the water heating system shall meet the requirement of either i, ii, iii, iv, or v:

i. One or more gas or propane instantaneous water heater with an input of 200,000 Btu per hour or less and no storage tank.

ii. 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 average U-factor no greater than 0.24, and in addition one of the following shall be installed:

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.

iii. A single gas or propane storage type water heater with an input of 75,000 Btu per hour or less, rated volume of more than 55 gallons.

iv. A single heat pump water heater. The storage tank shall be located in the garage or conditioned space. In addition, one of the following:

a. 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

b. For Climate Zones 2 through 15, a photovoltaic system capacity of 0.3 kWdc larger than the requirement specified in Section 150.1(c)14; or

c. For Climate Zones 1 and 16, a photovoltaic system capacity of 1.1 kWdc larger than the requirement specified in Section 150.1(c)14.

v. A single heat pump water heater that meets the requirements of NEEA Advanced Water Heater Specification Tier 3 or higher. The storage tank shall be located in the garage or conditioned space. In addition, for Climate Zones 1 and 16, a photovoltaic system capacity of 0.3 kWdc larger than the requirement specified in Section 150.1(c)14 or a compact hot water distribution system as specified in the Reference Appendix RA4.4.6.

B. For systems serving multiple dwelling units, a central water-heating system that includes the following components shall be installed:

i. Gas or propane water heating system or

ii. Heat pump water heating system that is meeting the minimum requirements specified in Joint Appendix JA14 and field verified as specified in the Reference Appendix RA3.6.x.; and

~~ii.~~ iii A recirculation system that meets the requirements of Sections 110.3(c)2 and 110.3(c)5, includes two or more separate recirculation loops serving separate dwelling units, and is capable of automatically controlling the recirculation pump operation based on measurement of hot water demand and hot water return temperature; and

EXCEPTION to Section 150.1(c)8Biii: Buildings with eight or fewer dwelling units may use a single recirculation loop.

EXCEPTION to Section 150.1(c)8B-iii: Heat pump water heater serving eight or fewer dwelling units

~~iii~~ iv. A solar water-heating system meeting the installation criteria specified in Reference Residential Appendix RA4 and with a minimum solar savings fraction of either a or b below:

a. A minimum solar savings fraction of 0.20 in Climate Zones 1 through 9 or a minimum solar savings fraction of 0.35 in Climate Zones 10 through 16; or

b. A minimum solar savings fraction of 0.15 in Climate Zones 1 through 9 or a minimum solar savings fraction of 0.30 in Climate Zones 10 through 16. In

addition, a drain water heat recovery system that is field verified as specified in the Reference Appendix RA3.6.9.

EXCEPTION to Section 150.1(c)8B-iv: Central heat pump water heater system meeting requirements specified in ii.

C. A water-heating system serving multiple dwelling units determined by the Executive Director to use no more energy than the one specified in subsection B above.

Reference Appendices

JA14 Qualification Requirements for Central Heat Pump Water Heater System

JA14.1 Purpose and Scope

Joint Appendix JA14 provides the qualification requirements to meet the standards for Central Heat Pump Water Heater Systems set forth in Title 24, Part 6, Section 150.1(c)8 B.

JA14.2 Central Heat Pump Water Heater Requirements

Central heat pump water heater products shall be certified to the Energy Commission to meet the following requirements:

(a) Submit heat pump water heater test data in accordance with JA14.3 to the Energy Commission.

(b) Document defrost strategy, including the method of detecting frosting conditions (onset conditions), algorithm used for defrosting, and the defrost cycle length and process.

JA14.3 Test Procedure and Reporting

The test setup, installation, calculation procedure and instruments required for the test are as described in Title 10 CFR Appendix E to Subpart G of Part 431. The central HPWH shall be tested for the following performance specifications:

- Water heater input power
- Water heater output capacity
- Water heater COP

The central HPWH shall be tested at the following conditions

- Inlet ambient air temperature: Maximum, minimum, and two midpoint temperatures of the manufacturer specified operating range. Minimum shall be equal or lower than 40 °F.
- Inlet water temperature: Maximum, minimum, and two midpoint temperatures of the manufacturer specified operating range.
- Outlet water temperature: Maximum, midpoint, and minimum of outlet water (setpoint) temperatures of the manufacturer specified operating range. Maximum shall be equal to or greater than 140 °F.

JA14.4 Design Condition Documentation Requirements

The central heat pump water heater system shall be capable of supplying hot water at design outlet water temperature under specified operating ranges for:

- minimum and maximum ambient air temperature
- minimum and maximum cold-water temperature
- minimum and maximum building demand at design draw and recovery conditions and duration.

Design documentation shall specify the operating conditions at which the primary heat pump water heater can supply hot water at design outlet water temperature without engaging auxiliary heating mechanism.

JA14.5 Plumbing Requirements

The central heat pump water heater system shall be configured as follows:

(a) Recirculation system configuration

- The hot water return from recirculation loop shall connect to a recirculation loop tank, and shall not directly connect to the primary HPWH inlet or the primary storage tanks
- The fuel source for the recirculation loop tank shall be electricity. The recirculation loop heater shall be capable of multi-pass water heating operation.

(b) Primary storage tank configuration

- For a single-pass system, multiple primary storage tanks shall be piped in series to maximize temperature stratification in the tanks. Hot water supply from the heat pump water heater shall connect to the top of the last tank and the heat pump water heater shall draw water from the bottom of the first tank.
- For a multi-pass system, multiple primary storage tanks shall be piped in parallel.

See Figure JA 14-1 for an example of a single-pass central heat pump water heater system schematic and Figure JA 14-2 for an example of a multi-pass central heat pump water heater system schematic.

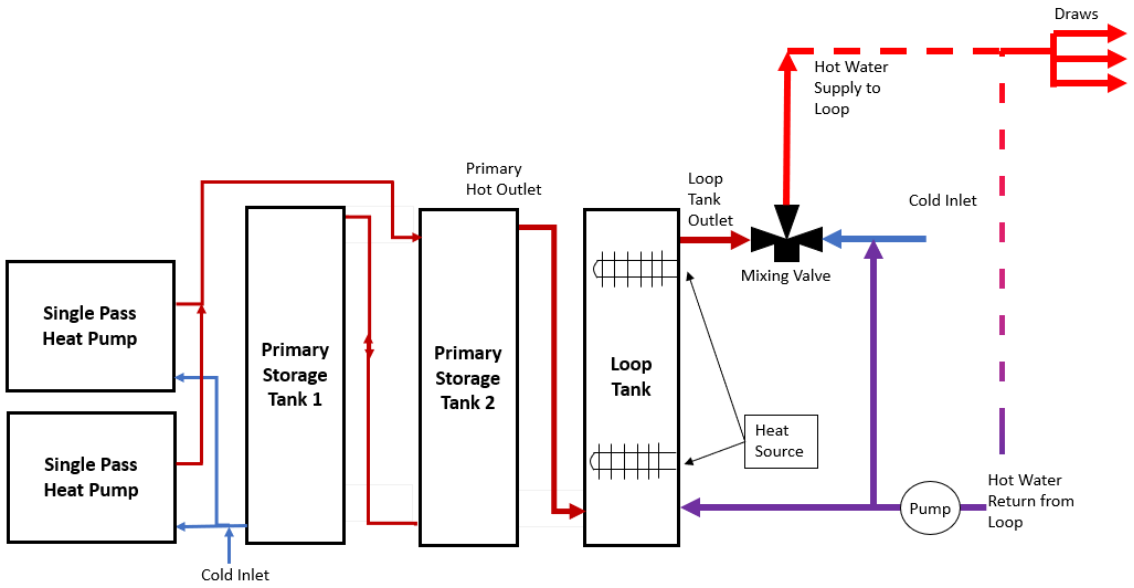

Figure JA 14 – 1: Example of Central Single-Pass Heat Pump Water Heater System Schematic

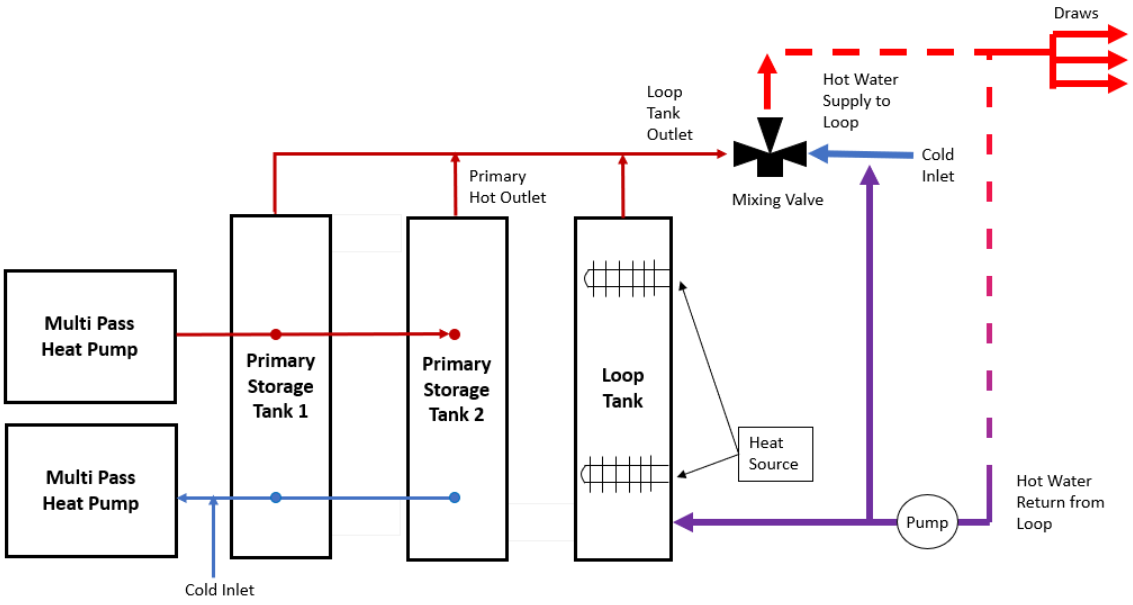

Figure JA 14 – 2: Example of Central Multi-Pass Heat Pump Water Heater System Schematic

JA14.6 Control Requirements

The following control requirements shall apply to the heat pump water heating system:

- The primary storage tank temperature setpoint shall be at least 140°F
- The recirculation loop tank temperature shall be at least 20°F lower than the primary storage tank temperature setpoint such that hot water from the recirculation loop tank is used for temperature maintenance load before engaging recirculation loop tank heater.
- The minimum heat pump water heater compressor cut-off temperature shall be equal or lower than 40°F.

RA2.2 Measures that Require Field Verification and Diagnostic Testing

Table RA2-1 describes the measures that require installer certification and HERS Rater field verification and diagnostic testing and identifies the protocol or test procedure in the Reference Residential Appendices that shall be used for completing installer and HERS Rater field verification and diagnostic testing.

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

Multi Family Domestic Hot Water Heating Measures		
~~Multiple Recirculation Loop Design for DHW Systems Serving Multiple Dwelling Units~~	~~Inspection that a central DHW system serving a building with more than eight dwelling units has at least two recirculation loops, each serving roughly the same number of dwelling units. These recirculation loops may serve the same water heating equipment or be connected to individualependent water heating equipment.~~	~~RA3.6.8~~
Verified Drain Water Heat Recovery System (DWHR-H)	Inspection to verify that the DWHR unit(s) and installation configuration match the compliance document and the DWHR(s) is certified to the Commission to have met the requirements.	RA3.6.9
Central Heat Pump Water Heating Systems Serving Multiple Dwelling Units	Testing and inspection to verify a central HPWH system serving multiple dwelling units meets the minimum equipment specifications, design, installation and performance requirements.	RA3.6.x

RA3.6.X – HERS-Verified Central Heat Pump Water Heater Systems Serving Multiple Dwelling Units

The visual inspection shall verify that the central heat pump water heating system is installed per requirements in JA14. Unless otherwise dictated by JA14, central heat pump water heater systems shall be installed according to manufacturer design and installation guidelines.

Visual inspection shall include the following:

(a) HPWH equipment's minimum compressor operation temperature is lower than 40°F based on manufacturer equipment specifications.

(b) Multiple storage tanks are piped in series for a single-pass system, and multiple storage tanks are piped in parallel for a multi-pass system.

(c) Verify that recirculation loop return water is connected to a recirculation loop tank or heater, and no recirculation return water is plumbed directly back to the primary storage tank or primary water heater.

(d) The recirculation loop tank uses electricity as the fuel source. These may be electric resistance element or a dedicated multi-pass HPWH.

ACM Reference Manual

Multiple Dwelling Units

When the proposed design is a central water heating system, the standard design consists of the water heating devices, a recirculation system, and solar systems as follows:

Water-heating device. The standard design consists of the same number of water-heating devices as the proposed design using the efficiencies required in the Appliance Efficiency Standards. The standard design is natural gas when the proposed device is natural gas. The standard design is propane if the proposed device is propane. Each water-heating device in the proposed system is examined separately. If the proposed water-heating device is gas or propane, the standard design is set to the same type and characteristics as the proposed design.

If the proposed water-heating device is electric resistance or heat pump with no recirculating loops (fewer than eight dwelling units), then the standard design is a heat pump water heater with 2.0 UEF with no recirculation loops. If the proposed central water-heating device is electric resistance or heat pump with recirculating loops, the standard design is ~~natural gas or propane~~ central heat pump water heater system with recirculating loop.

The appropriate efficiencies and standby losses for each standard water-heating device are then assigned to match the minimum federal requirements. The standards for consumer water heaters, as defined by 42 U.S.C 6291(16), are specified in 10 CFR 430.32(d); the standards for commercial water heaters, as defined by 42 U.S.C 6291(16), are specified in 10 CFR 431.110.

Central HPWH system. The standard central HPWH system uses a heat pump water heater meeting requirement specified in JA 14.

Recirculating system. The standard design includes a recirculation system with controls that regulate pump operation based on measurement of hot water demand and hot water return temperature, and capable of turning off the system as described in Appendix B4 Hourly Recirculation Distribution Loss for Central Water Heating Systems. The standard design has one recirculation loop.

Solar thermal water-heating system. The standard design has a solar water heating system meeting the installation criteria specified in Residential Reference Appendix RA4 and with a minimum solar savings fraction of 0.20 in Climate Zones 1-9, or 0.35 in Climate Zones 10-16.

VERIFICATION AND REPORTING

All modeled features and the number of devices modeled for the water heating system are reported on the CF1R. Electric resistance and heat pump water heaters indicate the location of the water heater. NEEA-rated heat pumps are identified by the brand and model, which must be verified by the building inspector. Where water heating system features or distribution systems specify or require HERS verification, those features are listed in the HERS required verification listings on the CF1R.

Compliance Manuals

Chapter 5 of the Residential Compliance Manual will need to be revised.

5.2.2.2 Heat Pump Water Heater (HPWH)

Central HPWH systems are DHW systems with recirculation loop designed to deliver hot water produced by HPWH equipment from a centralized location to multiple end users.

5.4.2 Multiple Dwelling Units: Multifamily, Motel/Hotels, and High-Rise Residential

The changes to the Residential ACM Reference Manual will be made dependent on the compliance pathway language. Section 2.9.3 of 2019 ACM Reference Manual would be edited as proposed below.

There are ~~two~~ three options for using the prescriptive approach to compliance for multifamily buildings:

1. A water heater must be installed in each unit that meets the requirements for a single family building.
2. A central gas or propane-fired water heater or boiler. The water heater must have an efficiency that meets the requirements in §110.1 and §110.3 (as listed in Table 5-5).
3. A heat pump water heater system meeting JA 14 and field verified as specified in the Reference Appendix RA3.6.x.

5.4.2.3 Central Heat Pump Water Heating Systems

Central HPWH systems are domestic hot water systems with recirculation loop designed to deliver hot water produced by HPWH equipment from a centralized location to multiple end users.

A key design feature of a central HPWH system is whether it is piped to be single-pass or multi-pass. In a single-pass HPWH system, the cold water passes through the heat pump(s) one time and is heated to the intended storage temperature. In a multi-pass HPWH system, the cold water passes through the heat pump(s) multiple times, each time gaining a 7-10°F temperature increase, until the tank reaches the intended storage temperature

This section will include:

- Equipment and system sizing best practice recommendation
- Plumbing configuration recommendations.
    - Describe the concept of using recirculation loop tank to improve HPWH efficiency
    - Plumbing configurations for primary storage tanks
- Control best practice