CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Drain Water Heat Recovery

Draft Code Language

Last Updated: 03/10/2017

1. INTRODUCTION

The California Statewide Utility Codes and Standards Team actively supports the California Energy Commission in developing revisions to the 2019 California Building Energy Efficiency Standards (Title 24, Part 6). Our joint intent is to achieve significant energy savings through the development of reasonable, responsible, and cost-effective code change proposals for the 2019 Title 24 code change cycle.

The Statewide Utility Team is proposing code change for drain water heat recovery.

This measure adds drain water heat recovery (DWHR) to the standards as a prescriptive option for low-rise residential buildings. Drain water heat recovery (DWHR) is a double-walled heat exchanger that uses waste heat from shower drains to pre-heat the cold water that goes to the shower, water heater, or both. Only DWHR products designed to be installed vertically are included.

The Statewide Utility Team is requesting feedback on the draft code language presented in this document. Input we receive will inform the code change proposal that the Statewide Utility Team will be proposing to the California Energy Commission in April 2017.

To provide feedback, please email us at info@title24stakeholders.com or contact the measure lead at:

Bo White, bo@negawattconsult.com

For more information about the California Statewide Utility Codes and Standards Team's 2019 Title 24, Part 6 advocacy efforts, and the latest information on this code change proposal please visit: www.title24stakeholders.com.

2. DRAFT CODE LANGUAGE

The proposed changes to the Standards, Reference Appendices, and the ACM Reference Manuals are provided below. Changes to the 2016 documents are marked with underlining (new language) and ~~strikethroughs~~ (deletions).

2.1 Standards

ARTICLE 1 – ENERGY BUILDING REGULATIONS

10-102 – DEFINITIONS

DRAIN WATER HEAT RECOVERY (DWHR) consists of a double wall heat exchanger that recovers heat from the effluent in waste piping and uses it to preheat water in a domestic or service water-heating system in order to reduce water heating energy usage.

SUBCHAPTER 8 LOW-RISE RESIDENTIAL BUILDINGS – PERFORMANCE AND PRESCRIPTIVE COMPLIANCE APPROACHES

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

(c) Prescriptive Standards/Component Package.

8. Domestic Water-Heating Systems. Water-heating systems shall meet the requirements of either A~~,~~ or B~~, or C~~. For recirculation distribution systems serving individual dwelling unit, only Demand Recirculation Systems with manual control pumps as specified in the Reference Appendix RA4.4 shall be used:

A. For systems serving individual dwelling units, the water heating system shall meet the requirement of either i, ii, or iii:
   i. A single gas or propane instantaneous water heater with an input of 200,000 Btu per hour or less and no storage tank, and that meets the requirements of Sections 110.1 and 110.3 shall be installed.
   ii. A single gas or propane storage type water heater with an input of 105,000 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 meet all of the requirements for Quality Insulation Installation (QII) as specified in the Reference Appendix RA3.5, 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. All domestic hot water piping shall be insulated and field verified as specified in the Reference Appendix RA4.4.1, RA4.4.3 and RA4.4.14.~~ A drain water heat recovery unit compliant with CSA B55.1 and CSA B55.2 and with a minimum CSA rated effectiveness of 42 percent shall recover heat from at least the master bathroom shower and must at least transfer that heat either back to all the respective showers or the water heater.
   iii. A single gas or propane storage type water heater with an input of 105,000 Btu per hour or less, rated volume of more than 55 gallons, and that meets the requirements of Sections 110.1 and 110.3, 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. All domestic hot water piping shall be insulated and field verified as specified in the Reference Appendix RA4.4.1, RA4.4.3 and RA4.4.14~~ A drain water heat recovery unit compliant with CSA B55.1 and CSA B55.2 and with a minimum CSA rated effectiveness of 42 percent shall recover heat from at least the master bathroom shower and must at least transfer that heat either back to all the respective showers or the water heater.

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 heaters, boilers or other water heating equipment that meet the minimum efficiency requirements of Sections 110.1 and 110.3; and
   ii. A water heating recirculation loop that meets the requirements of Sections 110.3(c)2 and 110.3(c)5 and is equipped with an automatic control system that controls the recirculation pump operation based on measurement of hot water demand and hot water return temperature and has two recirculation loops each serving half of the building; and
      a. **EXCEPTION 1 to Section 150.1(c)8~~C~~Bii**: Buildings with eight or fewer dwelling units are exempt from the requirement for two recirculation loops.

iii. A solar water-heating system meeting the installation criteria specified in Reference Residential Appendix RA4 and with 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. The solar savings fraction shall be determined using a calculation method approved by the Commission.

a. **EXCEPTION 1 to Section 150.1(c)8Biii**: Buildings that install a drain water heat recovery compliant with CSA B55.1 and CSA B55.2 and with a minimum CSA rated effectiveness of 42 percent can reduce the required solar fraction of the solar water-heating system to 0.15 in Climate Zones 1 through 9 or 0.30 in Climate Zones 10 through 16. The drain water heat recovery system shall recover heat from at least half the showers located above the first floor and must at least transfer that heat either back to all the respective showers or the water heater.

2.2 Reference Appendices

There are no proposed changes to the Reference Appendices.

2.3 Residential ACM Reference Manual

APPENDIX B – WATER HEATING CALCULATION METHOD

B3. Hot Water Consumption: …In cases where a drain water heat recovery system is installed, T_{inlet} at the cold-side of the shower mixing valve and/or T_{inlet} at the water heater makeup water connection is recalculated during every showering event instead of equaling the result of Equation 9 from section B4.2. Which temperature(s) are affected depends on where the recovered heat is delivered. Regardless, the heat transfer of the drain water heat recovery system is calculated first using Equation 11 in section B4.2, then the pre-heated water temperature is calculated using Equation 12.

If only some shower fixtures within a single family home or multifamily dwelling unit are part of a DWHR system, savings are assumed to be directly proportional to the percentage of included shower fixtures.

B4.2. Cold Water Inlet Temperature: In cases where a drain water heat recovery system is installed, T_{inlet} is calculated differently during showering events. First, the heat transfer of the drain water heat recovery system is calculated using Equation 11, then the pre-heated water temperature is calculated using Equation 12. If the recovered heat is only delivered to the shower mixing valves, then iteration is required since the heat transfer is dependent on potable flow rate and that flow rate is dependent on the pre-heated water temperature.

$$\dot{Q}_{Avg} = \varepsilon_{Draw} * \min(\dot{V}_P, \dot{V}_D) * \rho * c_p * (T_{D,I} - T_{P,I}) * 60 \qquad \textit{Equation 11}$$

$$T_{P,O} = [\dot{Q}_{Avg} / (\dot{V}_P * \rho * c_p * 60)] + T_{P,I} \qquad \textit{Equation 12}$$

where

$\dot{Q}_{Avg}$ = Average heat transfer rate (Btu/hr)

ε_{Draw} = Overall effectiveness of the DWHR unit (unit-less)

$\dot{V}_P$ = Flow rate through potable side of the unit (gallons/minute)

$\dot{V}_D$ = Flow rate through drain side of the unit (gallons/minute)

ρ = Water density (lb/gallon)

c_p = Specific heat capacity at constant pressure for water (Btu/(lb·^{0} F))

$T_{D,I}$ = Drain inlet temperature (^{0} F)

$T_{P,I}$ = Potable inlet temperature (^{0} F)

$T_{P,O}$ = Potable outlet temperature (^{0} F)

60 = Unit conversion from minutes to hours (minutes/hour)

2.4 Residential Compliance Manual

Sections 5.4.1 and 5.9.2.1 of the Residential Compliance Manual will need to be revised.

5.4.1 Single Dwelling Units §150.1(c)8

There are three options to comply with the prescriptive water heating requirements for newly constructed single dwelling units. For all three options, the water heater must comply with the mandatory requirements for water heaters (See Section 5.3). If a recirculation distribution system is installed, only demand recirculation systems with manual control pumps are allowed. The three options are described below.

Option 1: Install a natural gas or propane instantaneous water heater with an input rating of 200,000 BTU per hour or less.

Option 2: Install a natural gas or propane storage water heater with a rated storage volume 55 gallons or less and an input rating of 105,000 BTU per hour or less. The dwelling unit must meet all of the requirements for Quality Insulation Installation (QII), which requires that a HERS Rater verify QII has been designed and installed in accordance with Energy Standards. The user must also do one of the following:

1. Use a compact hot water distribution design, which requires a HERS Rater to verify that the system has been designed and installed in accordance with the Energy Standards (See Reference Appendix RA4.4.16.)

2. ~~Insulate all domestic hot water pipes which requires that a HERS Rater verify that the pipe insulation is designed and installed in accordance to the Energy Standards.~~ A drain water heat recovery unit compliant with CSA B55.1 and CSA B55.2 and with a minimum CSA rated effectiveness of 42 percent shall recover heat from at least the master bathroom shower and must at least transfer that heat either back to all the respective showers or the water heater.

Option 3: Install a natural gas or propane storage water heater with a rated storage volume greater than 55 gallons and an input rating of 105,000 BTU per hour or less. The user must also do one of the following:

~~1. Insulate all domestic hot water pipes which requires that a HERS Rater verify that the pipe insulation is designed and installed in accordance to the Energy Standards.~~

1. Use a compact hot water distribution design, which requires a HERS Rater to verify that the system has been designed and installed in accordance with the Energy Standards (See Reference Appendix RA4.4.16.)

2. A drain water heat recovery unit compliant with CSA B55.1 and CSA B55.2 and with a minimum CSA rated effectiveness of 42 percent shall recover heat from at least the master bathroom shower and must at least transfer that heat either back to all the respective showers or the water heater.

If Option 2 is pursued, in which a gas storage water heater that is 55 gallons or less is installed instead of a gas instantaneous water heater, then QII will need to be considered at the start of the design process, and it must be coordinated with several players including the designer, the general and/or

insulation contractor, and the HERS Rater. QII will be included as part of the first building inspection, typically well in advance of the actual water heater being installed.

For more information on QII compliance requirements see Chapter 3 (Building Envelope) of this compliance manual and RA3.5 of the Reference Appendix. QII is required for Option 2 but not for Option 3. That is, if a natural gas or propane water heater less than 55 gallons is installed, the building must also comply with the QII requirements.

The minimum federal efficiency requirement for storage water heaters greater than 55 gallons is more stringent than storage water heaters that are 55 gallons or less.

For more information on HERS-verified domestic hot water pipe insulation requirements, see Section 5.6.2.5 of this chapter. The Reference Appendix contains the requirements for the proper installation of pipe insulation (see RA4.4.1, RA4.4.3 and RA4.4.14). ~~The compliance requirements in Reference Appendix RA4.4.3 state that all the piping in a hot water distribution system must be insulated from the water heater to each fixture or appliance following the proper installation provisions in Reference Appendix RA4.4.1.~~ RA 4.4.14 states that HERS inspection is needed to verify that all hot water piping in non-recirculating systems is insulated correctly. A summary of the mandatory pipe insulation requirements is described in Section 5.3.5.1. HERS-verified pipe insulation is included in Options 2 and 3 described above. ~~If a user does not want to insulate pipes, he or she can choose to use a compact hot water distribution design instead.~~

For more information on HERS-verified compact hot water distribution design, see Section 5.6.2.4. HERS-verified compact hot water distribution designs are included in Options 2 and 3 described above. If a user does not use a compact design, he or she can comply with HERS-verified pipe insulation requirements instead.

Any other water heating system that differs from the three options described in this section does not meet the prescriptive requirements. Other systems can be installed if using the performance approach as described in Section 5.5.

For additions, the prescriptive requirements described above apply only if a water heater is being installed as part of the addition. The prescriptive requirements apply only to the space that is added, not the entire building.

For alterations where an existing water heater is being replaced, the water heater must meet the mandatory equipment efficiency requirements. Pipe insulation requirements do not apply to alteration for portion of the pipes that are inaccessible. See Chapter 9 for more detailed explanation for the water heating alteration requirements.

§150.1(c)8

As mentioned, there are three options for users to comply prescriptively with the water heating requirements for newly constructed single dwelling units, including additions. All options must also comply with the applicable mandatory requirements in §110.3 and §150.0 (j and n).

1. A system with a single natural gas or propane instantaneous water heater:

    a. A gas input rating less than or equal to 200,000 BTU/h.

    b. No supplemental storage tank is installed.

    c. If using a recirculation distribution system, only demand recirculation systems with manual control pumps are allowed.

2. A system with a single gas or propane storage water heater with a rated storage volume of 55 gallons or less must have:

a. A gas input rating of 105,000 BTU/h or less.

b. The dwelling unit must meet all of the requirements for QII as specified in the Reference Appendix RA3.5, and either

i. ~~Have HERS-verified insulation on all domestic hot water piping (see RA4.4.1, RA4.4.3 and RA4.4.14)~~ A drain water heat recovery unit compliant with CSA B55.1 and CSA B55.2 and with a minimum CSA rated effectiveness of 42 percent shall recover heat from at least the master bathroom shower and must at least transfer that heat either back to all the respective showers or the water heater.

ii. Have a HERS-verified compact distribution system design (see RA4.4.16).

c. If using a recirculation distribution system, only demand recirculation systems with manual control pumps are allowed.

3. A system with a single gas or propane storage type water heater with a rated storage volume of greater than 55 gallons must have:

a. A gas input rating 105,000 BTU/h or less, and either

i. ~~Have HERS-verified insulation on all domestic hot water piping (see RA4.4.1, RA4.4.3 and RA4.4.14)~~ A drain water heat recovery unit compliant with CSA B55.1 and CSA B55.2 and with a minimum CSA rated effectiveness of 42 percent shall recover heat from at least the master bathroom shower and must at least transfer that heat either back to all the respective showers or the water heater.

ii. Have a HERS-verified compact distribution system design (see RA4.4.16).

b. If using a recirculation distribution system, only demand recirculation systems with manual control pumps are allowed.

5.9.2.1 Multifamily, Motel/Hotels, and High-Rise Nonresidential §150.1(c)8Ciii

Solar water heating is prescriptively required for water heating systems serving multiple dwelling units, whether they are multifamily, motel/hotels, or high-rise nonresidential buildings. The minimum solar fraction depends on the climate zone (CZ) and whether compliant DWHR is installed~~: 0.20 for CZ 1 through 9 and 0.35 for CZ 10 through 16~~. See Table 5-11 below. The drain water heat recovery shall be compliant with CSA B55.1 and CSA B55.2 and have a minimum CSA rated effectiveness of 42 percent. It shall recover heat from at least half the showers located above the first floor and must at least transfer that heat either back to all the respective showers or the water heater.

Table 5-11: Required Performance of Solar Systems Installed in Multifamily Buildings with Central Distribution Systems

Climate Zone	Minimum Solar Fraction if no DWHR	Minimum Solar Fraction if compliant DWHR installed
1-9	0.20	0.15
10-16	0.35	0.30

2.5 Compliance Forms

The Statewide CASE Team proposes that the following forms are modified:

- "CEC-CF2R-PLB-21-H, Certificate of Installation, HERS Verified Multifamily Central Hot Water System Distribution"

- "CEC-CF2R-PLB-22-H, Certificate of Installation, HERS Verified Single Dwelling Unit Hot Water System Distribution"

The proposed regulations add a table with content as shown in Table 1 to the multifamily form and content as shown in Table 2 to the single family form. This will help ensure that installations match the plans and energy model (where applicable) and that the system saves the expected amount of energy.

Table 1: DWHR Table for CEC-CF2R-PLB-21-H (multifamily central hot water systems)

Unit ID	DWHR-1	DWHR-2
Make & Model		
Diameter & Length		
CSA Rated Effectiveness		
Configuration (Equal, Unequal-Shower, or Unequal-Water Heater)		
Quantity of residential units with DWHR		
Total quantity of shower fixtures receiving recovered heat		
Total quantity of shower fixtures amongst all served residential unit(s) (i.e. fully ignore residential units without any DWHR)		

Table 2: DWHR Table for CEC-CF2R-PLB-22-H (single dwelling unit hot water systems)

Unit ID	DWHR-1	DWHR-2
Make & Model		
Diameter & Length		
CSA Rated Effectiveness		
Configuration (Equal, Unequal-Shower, or Unequal-Water Heater)		
Quantity of shower fixtures receiving recovered heat		
Total quantity of shower fixtures		