TITLE 24, PART 6 | 2025 CODE CYCLE

Multifamily Domestic Hot Water

Codes and Standards Enhancement (CASE) Proposal

Jingjuan "Dove" Feng, TRC
February 17, 2023

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

TITLE 24, PART 6 | 2025 CODE CYCLE

Central Heat Pump Water Heater Clean-up

Codes and Standards Enhancement (CASE) Proposal
Multifamily Domestic Hot Water

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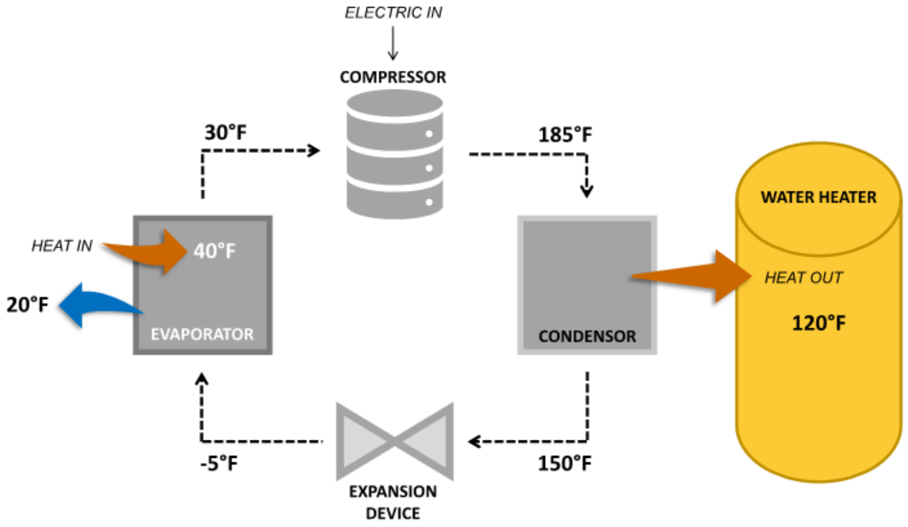
Background

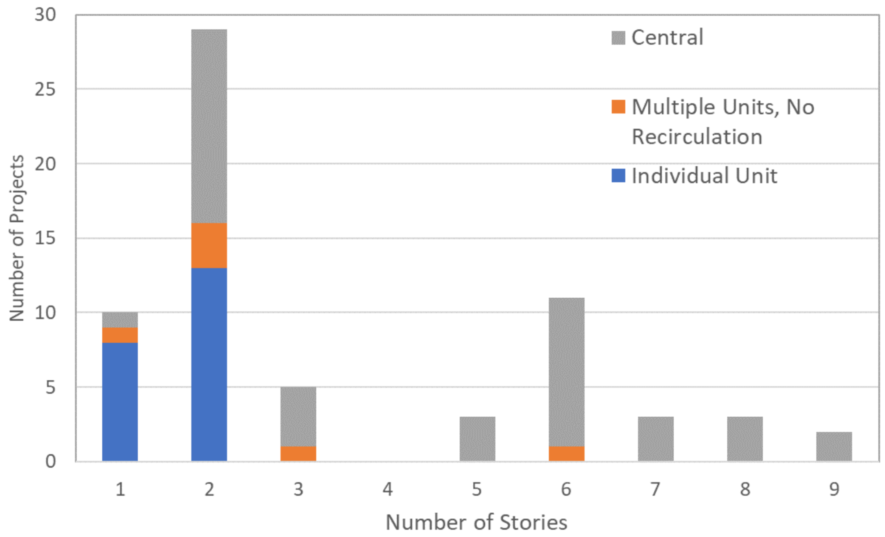
- Context and History
- 2022 Code Requirements
- Code Change Proposal

Context and History

- Heat pump water heaters (HPWHs) are a key component in decarbonization
  - Water heating accounts for 40% of natural gas consumption in residential sector
  - Heat pumps are refrigerant based devices that use electricity to move heat from a cool place to a warm place
  - Central domestic hot water (DHW) systems are common in multifamily buildings
  - Prescriptive compliance pathway for central HPWH introduced in the 2022 code cycle



Heat Pump Water Heater Operation[1]



HPWH Project Design[2]

1. ECOTOPE. A review of New Construction HP DHW Products and Gaps
2. Source: Consultant Projects collected by the CASE Team

Context and History

National and regional efforts to advance the knowledge, understanding and performance of central heat pump water heater systems

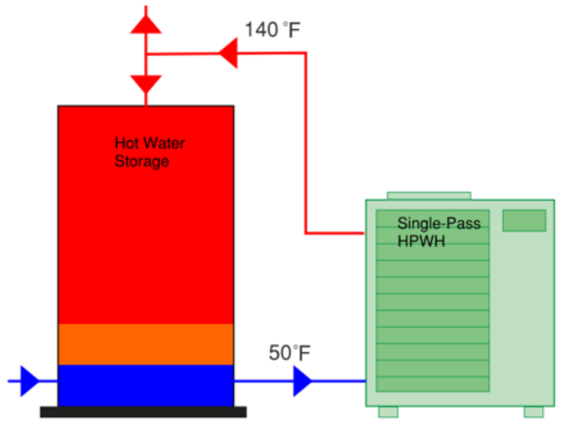
- Northwest Energy Efficiency Alliance (NEEA) effort to develop Advanced Water Heating Specification (AWHS)[1]
- Laboratory testing to support development of simulation of central HPWHs[2]
- California Energy Commission (CEC) funded research projects

1. https://neea.org/img/documents/Advanced-Water-Heating-Specification.pdf
2. https://title24stakeholders.com/support-for-energy-modeling-advancements/

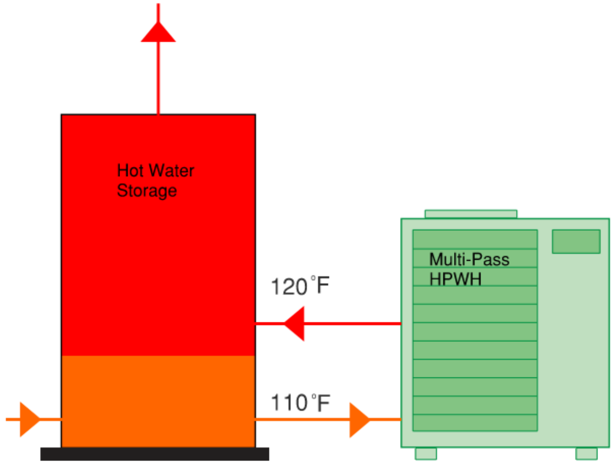
Central HPWH System Approach

System performance and applications vary by:

- Primary HPWH equipment types
  - Single-pass vs. Multi-pass
  - Refrigerant type
  - Capacity
- Temperature maintenance system (TMS) for maintaining hot water temperature in recirculation loop
  - Decoupled from primary system
  - Direct return to primary system



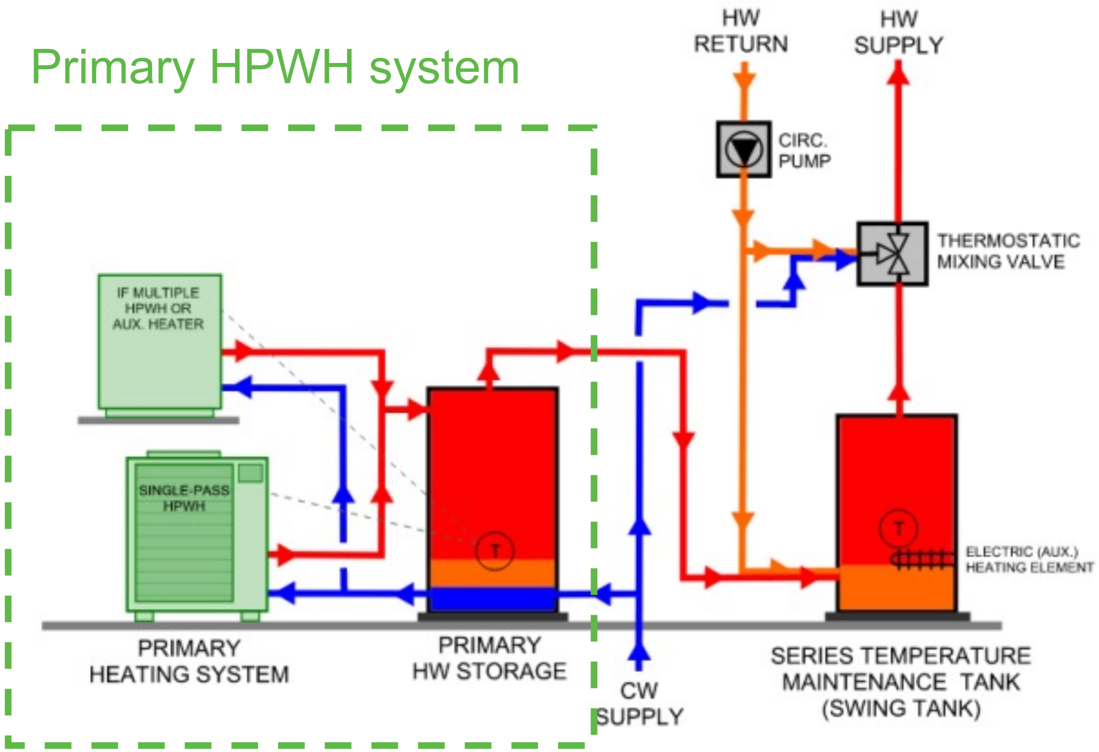
Single-Pass
Heats up water to working temperature in single pass



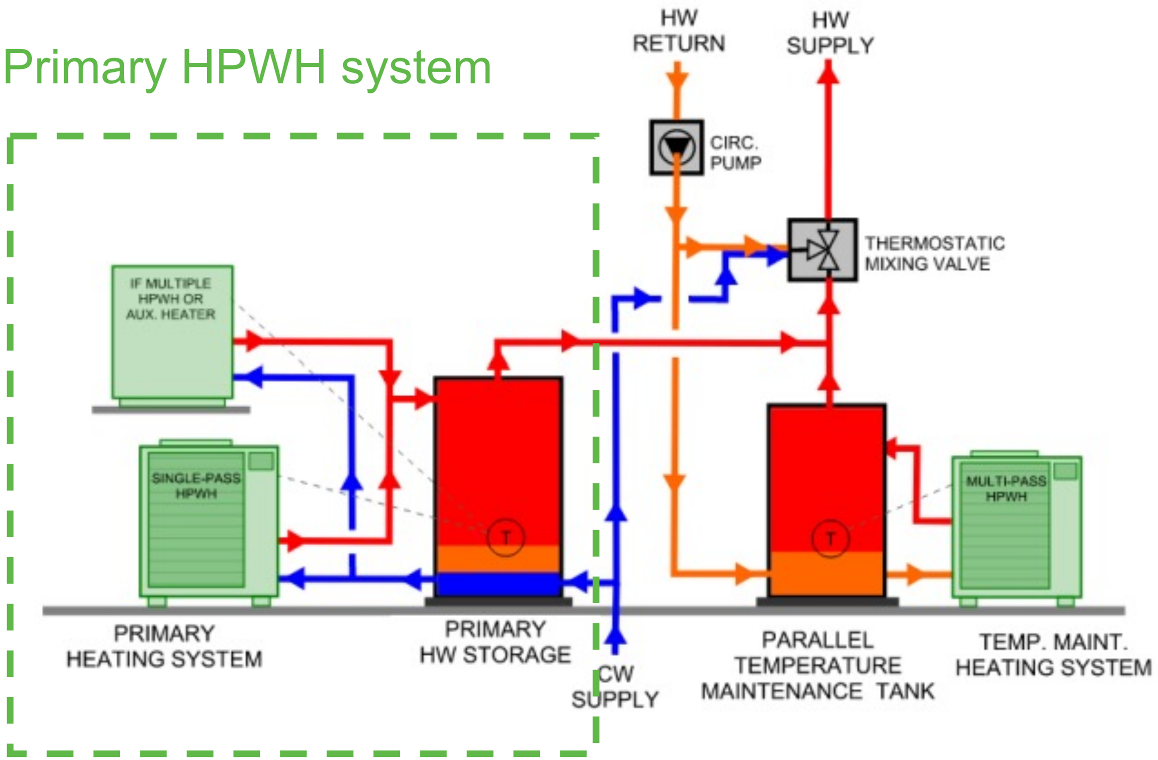
Multi-Pass
Heats up water to working temperature in multi pass

Recirculation Loop Decoupled from Primary System

Both configurations align with 2022 Title 24 prescriptive requirements



Single-pass primary with electric resistance water heater in series for temperature maintenance system **(HPWH_SPST)**

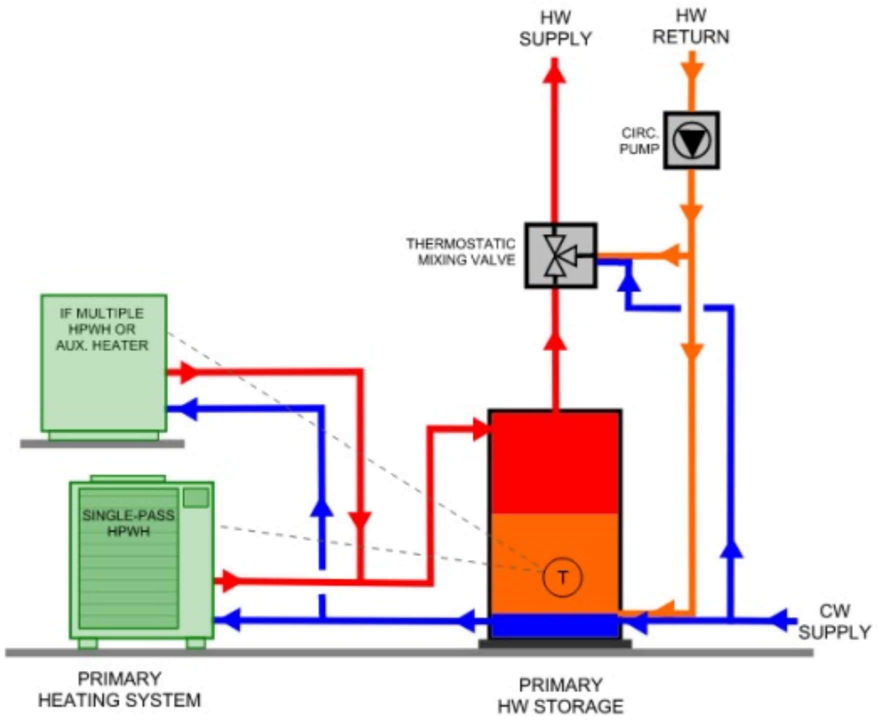


Single-pass primary with multi-pass in parallel for temperature maintenance system (**HPWH_SPwMPTM**)

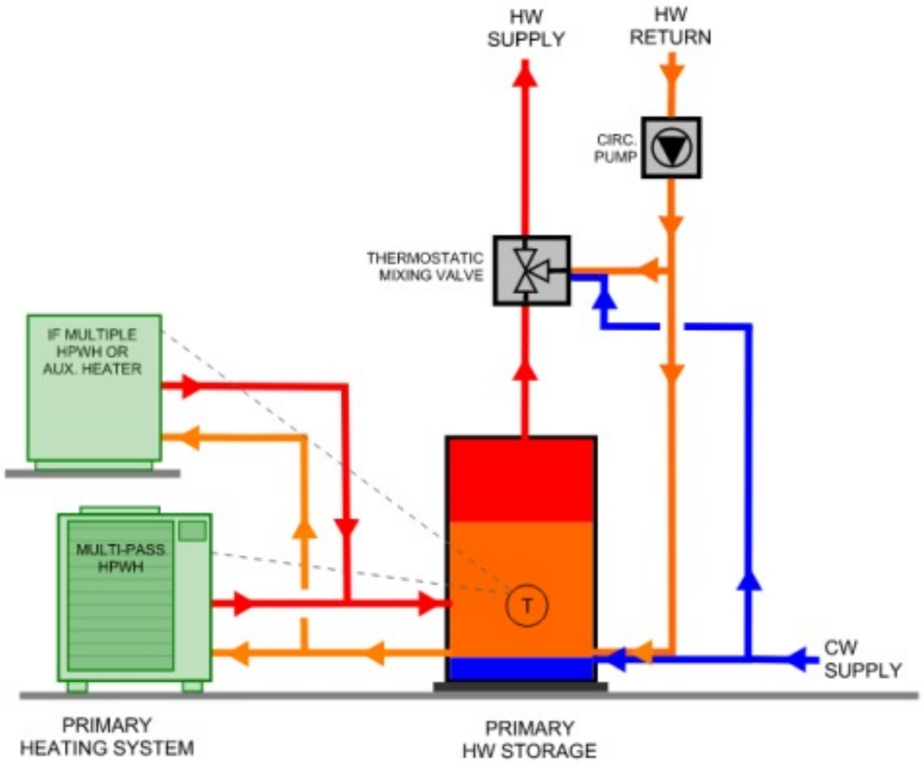
Source: NEEA, Dec 2022, https://neea.org/img/documents/advanced-water-heating-specification-v8.0.pdf

Temperature Maintenance System Return to Primary Configurations

Both configurations **DO NOT** align with 2022 Title 24 prescriptive requirements



Single-pass return to primary (**HPWH_SPRetP)**



Multi-pass return to primary **(HPWH_MPRetP)**

Source: NEEA, Dec 2022, https://neea.org/img/documents/advanced-water-heating-specification-v8.0.pdf

Current Code Requirements

Existing requirements in Title 24, Part 6 Section 170.2(d)2

- Allows both single-pass and multi-pass primary equipment
- Requires recirculation loop decoupled from primary HPWH systems
- Plumbing configurations to ensure stratification in primary tanks
- Control requirements to achieve minimal efficiency
- Requires heat pump compressor cut-off to be 40° F or lower
- Design documentation of specified operating conditions of the system according to Joint Appendix 14.4

Performance Requirements: Joint Appendix 14

- Qualification requirements for a performance pathway for central HPWH
- Includes product performance testing requirements, as well as design documentation requirements

Source: 2022 Building Efficiency Standards for Residential and Nonresidential Buildings

Proposed Code Change

- Updates prescriptive requirements in Section 170.2(d)2 for central HPWH to allow more design options
  - Updates primary prescriptive requirement to ensure system efficiency and operation reliability
  - Adds alternative prescriptive pathways that aligns with NEEA's AWHS for commercial HPWHs
- Updates standard design in performance approach to be consistent with primary prescriptive requirements

Draft code language for this measure is available in the handouts.

Proposed Code Change

System Configurations		Prescriptive Compliance Pathway		
		2022	2025	
			Primary path	Alternative path
Single-Pass Primary	with HW Circulation Returned to Primary Storage	No	No	NEEA AWHS Commercial HPWH Tier 3 or higher
	with Series Temperature Maintenance Tank System (Swing Tank)	Yes	Yes	
	with Parallel Temperature Maintenance Tank System with multi-pass HPWH	Yes	Yes	
Multi-Pass Primary	with HW Circulation Returned to Primary Storage	No	No	
	with Series or Parallel Temperature Maintenance Tank System (Swing Tank)	Yes	No	

All configurations can use the performance pathway

Poll Request (Example)

- **Measure Name:** Central HPWH
- **Type of Poll:** Open ended
- **Question:** Are there other central HPWH configurations we should investigate?
- **Answers:**.
- **Placement:** Proposed Code Change
- **Broadcast results to attendees as they respond:** Y
- **Make poll public during presentation:** Y

Market Overview

- Current Market Conditions
- Market Trends

Market Overview and Analysis

Current Market

Although market share of central HPWH is relatively small compared to central gas systems, central HPWH installations are increasing

Market Trend

Utility programs, federal, and state government funding to encourage market adoptions. Examples include:

- California Energy Smart Homes CEC California Electric Homes Program
- CEC Building Initiative for Low-Emissions Development (BUILD)
- California Public Utility Commission (CPUC) Energy Savings Assistance Program
- CEC Technology and Equipment for Clean Heating (TECH)
- Advanced Water Heating Initiative (AWHI)

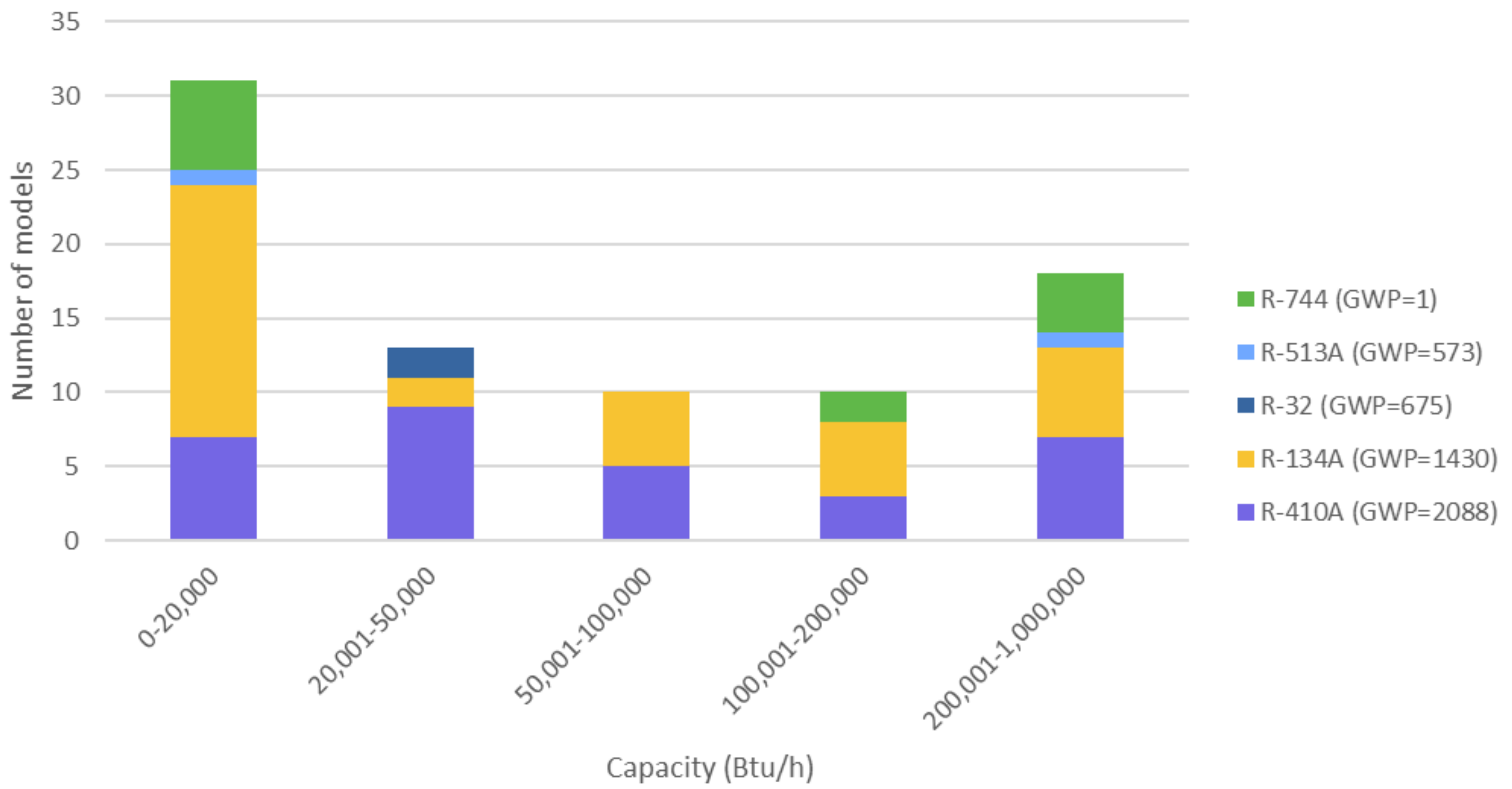
Poll Request (Example)

- **Measure Name:** Central HPWH
- **Type of Poll:** Open ended
- **Question:** What percentage of your projects are gas vs. HPWH?
- **Answers:**.
- **Placement:** After market overview and analysis
- **Broadcast results to attendees as they respond:** Y
- **Make poll public during presentation:** Y

Commercial HPWH Products

Wide range of HPWHs products:

- Product research shows 57 central HPWH models with current or near-term availability in CA
- Major manufacturers include Colmac, Nyle, Sanden, Aermec, AO Smith, Mitsubishi, Lync, etc.



Commercial HPWH Products

Increased product offering for low global warming potential (GWP) heat pumps

One manufacturer in 2019, and five more manufacturers by 2022/2023

Lync Watt AEGES CO2 units

Nyle E360 (R513a)

SANCO2 (CO2)

Mitsubishi QAHV (CO2)

Mayekawa unimo AW/WW/AWW-CO2 HP

Transom Hatch Air Sourced HP (CO2 available in 2023)

Technical Considerations

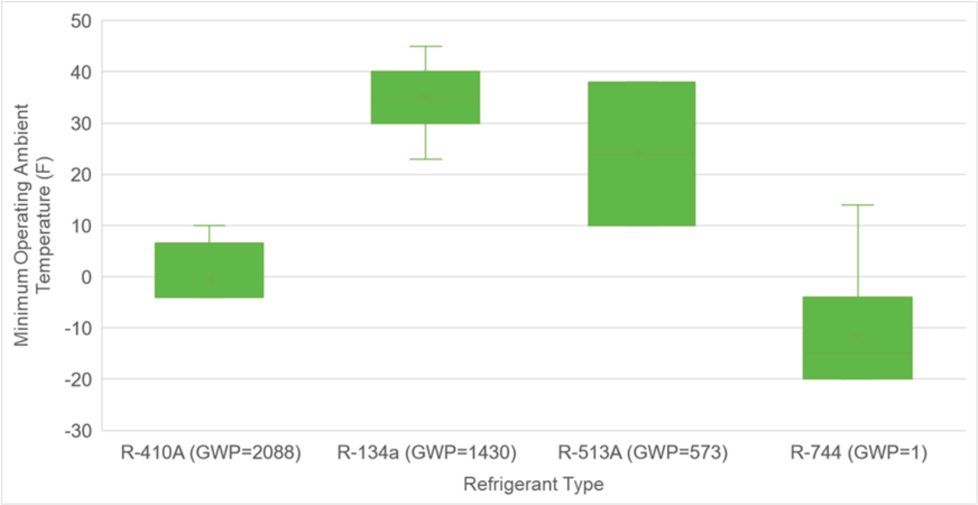
- Technical Considerations
- Potential Barriers and Solutions

HPWH Equipment Characters

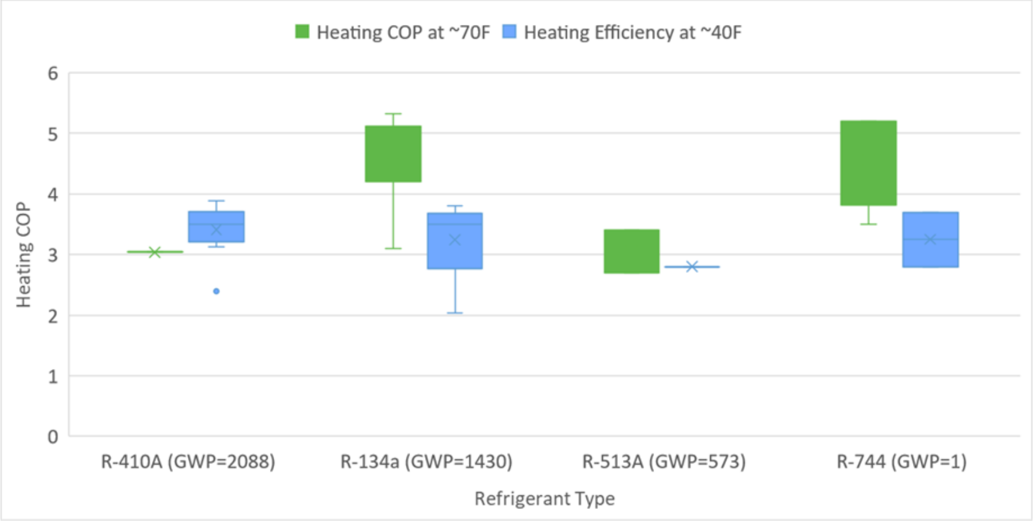
Design approaches should consider HPWH equipment characteristics to ensure **energy performance** and **system reliability**

- Minimum operating temperature impacts equipment location and efficiency
- Heating efficiency and capacity at lower ambient temperature impacts efficiency and first cost
- Some single-pass equipment cannot handle high inlet water temperature, i.e., may fail when configured as return-to primary-configuration

Minimum operating ambient temperature



Heating COP at ~40F ambient air temperature and at ~70F ambient air temperature for different refrigerants



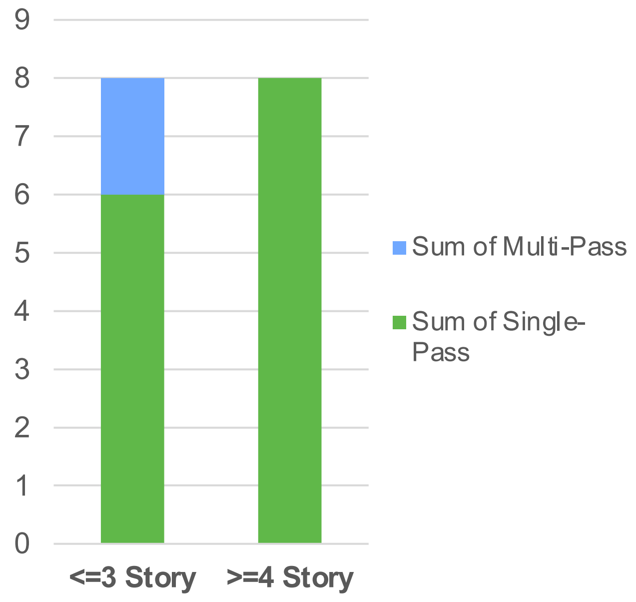
Source: HPWH product review, The CASE Team

Central HPWH Design Approaches

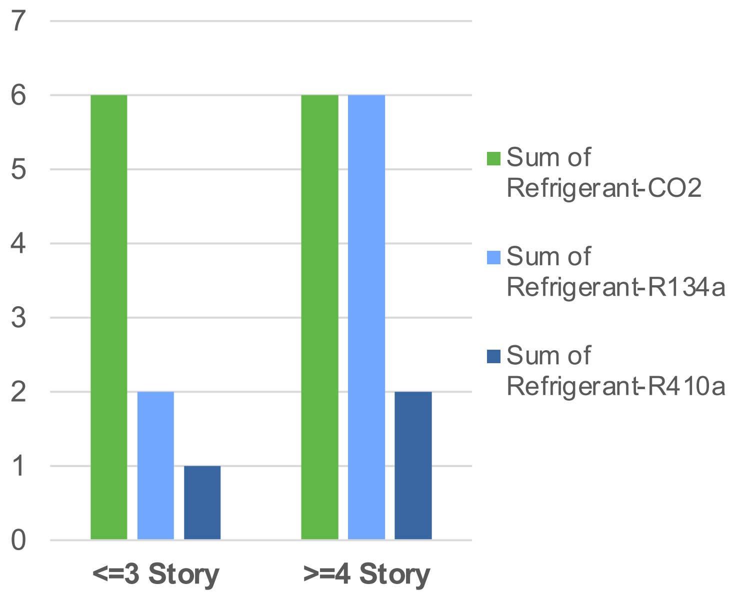
Design approaches vary by applications:

- Most projects reviewed use single-pass equipment
- Equipment using R-744 (CO2) refrigerant are increasing
- Most projects reviewed have primary system decoupled from TM system

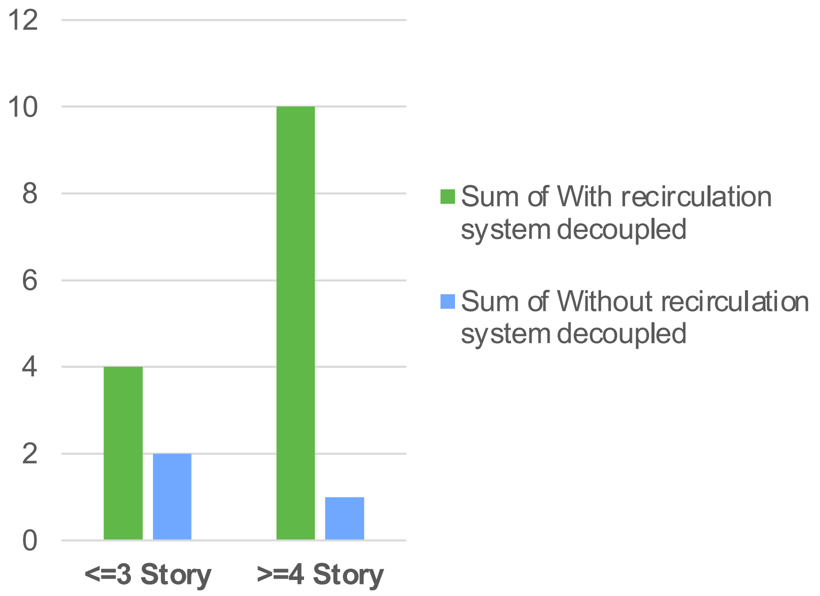
Number of projects that use single-pass vs. multi-pass HPWHs



Number of projects that use HPWHs with different refrigerants



Number of projects that have primary HPWH systems decoupled vs. not decoupled from the temperature maintenance system



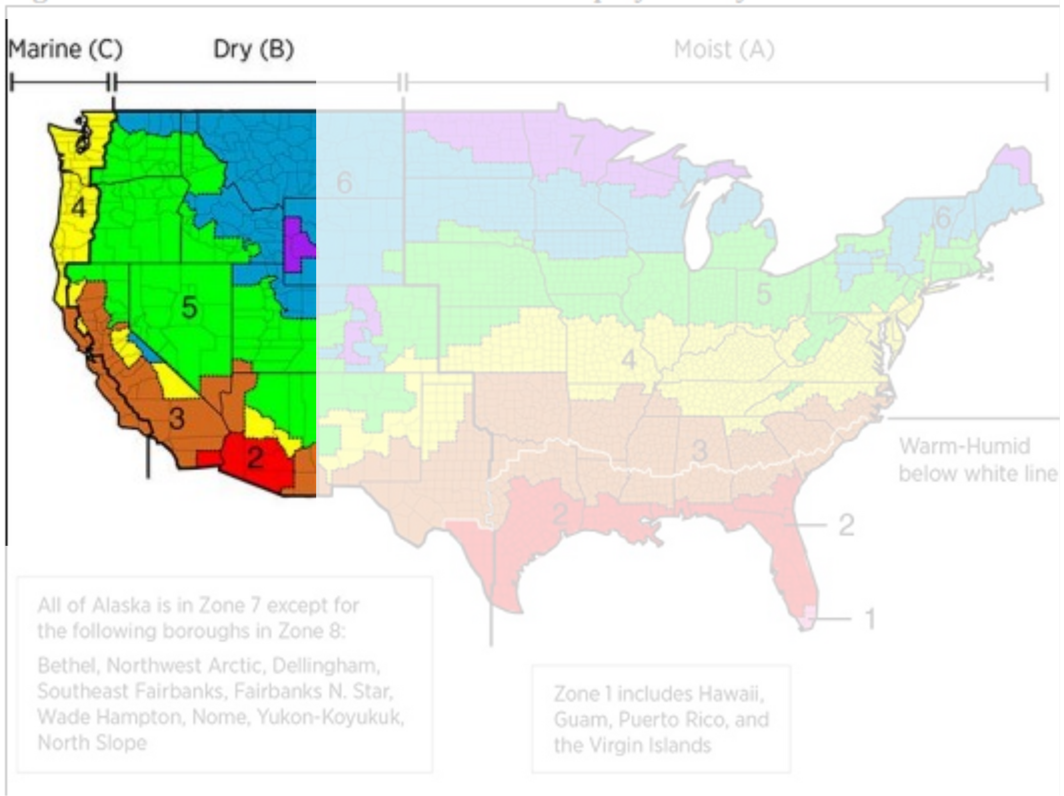
Source: Plan Review of central HPWH projects from Utility Programs, The CASE Team

Technical Considerations

Current Title 24 central HPWH standard design requirements need to be updated to reflect latest understanding of how central HPWH system performance is impacted by equipment type, refrigerants, and plumbing configurations.

Leverage NEEA V8.0 Efficiency Tiers approach for alternative prescriptive pathway

- Evaluate the predicted annual system coefficient of performance (COP)
- Categorize system design into efficiency tiers
- Develop qualified product list that includes HPWH product and piping configuration



	Minimum SysCOP			
	Hot Climate (IECC Zones 1-2)	**Mild Climate (IECC Zones 3-4)**	**Cold Climates (IECC Zones 5-6)**	**Extremely Cold Climates (IECC Zones 7-8)**
Tier 1	1.75	1.50	1.25	1.15
Tier 2	2.25	2.00	1.60	1.50
Tier 3	2.75	2.50	2.25	2.15
Tier 4	3.50	3.00	2.75	2.50

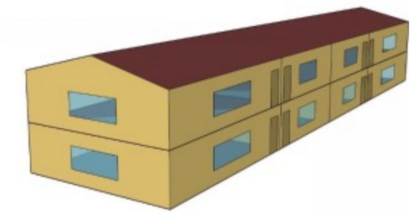
NEEA Advanced Water Heating Specification 8.0.
https://neea.org/resources/advanced-water-heating-specification-v8.0

Energy and Cost Impacts Per Dwelling Unit

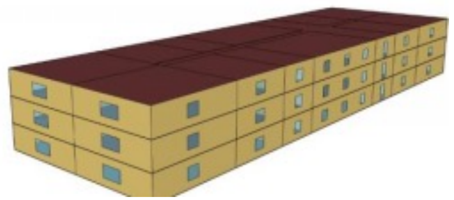
Methodology and Assumptions

- Energy Savings Methodology and Results
- Cost Impacts Methodology and Results
  - Incremental costs
  - Energy cost savings

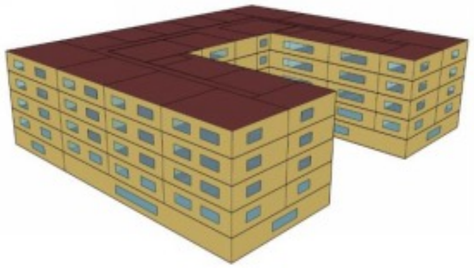
Methodology for Energy Impacts Analysis



Low-Rise Garden Style
2 Story



Low-Rise Loaded Corridor
3 Story



Mid-Rise Mixed-Use
5 Story

High-Rise Mixed-Use
10 Story

Building Type	Unit Counts				
	Studio	1-Bed	2-Bed	3-Bed	Total
Low-Rise Garden Style	0	4	4	0	8
Low-Rise Loaded Corridor	6	12	12	6	36
Mid-Rise Mixed-Use	8	40	32	8	88
High-Rise Mixed-Use	18	54	45	0	117
Occupancy Rate (ppl/apt)	1.37	1.74	2.57	3.11	

Methodology for Energy Impacts Analysis (cont.)

Methodology for per-dwelling unit energy and demand impacts

- Experienced plumbing engineers provided basis of design (BOD) for baseline and proposed cases
- Used 2022 multifamily prototypes

Energy analysis: California Building Energy Code Compliance (CBECC) -2025

Climate zones modeled: All climate zones

Assumptions for Standard and Proposed Designs

Central HPWH system components	Standard Design	Proposed Design-1	Proposed Design-2	Proposed Design-3	Proposed Design-4 (Only applicable for 4-story and higher)
	HPWH Base	HPWH_SPST	HPWH_SPRetP	HPWH_MPRetP	HPWH_SPwMPTM
Primary HPWH type	Single-pass	Single-pass	Single-pass	Multi-pass	Single-pass
Primary system refrigerant, 3-story and lower	R-410a	R-744	R-410a	R-410a	N/A
Primary system refrigerant, 4-story and higher	R-134a	R-744	R-134a	R-134a	R-744
Primary to TMS configuration	In series	In series	N/A	N/A	In parallel
TMS heater	Electric Resistant Water Heater	Electric Resistant Water Heater	N/A	N/A	Split HP with Storage Tank

Note: Proposed Designs 4 is only applicable for multifamily buildings with 4-story or more

Preliminary Energy Savings Estimates Per Dwelling Unit

Example: Mid-Rise Mixed Use

Single-pass primary with ER water heater in series for TM system (SPST) – Baseline with conventional refrigerant

- Annual Electricity (kWh/yr):414,578~569,623
- Annual Systemwide Life Cycle Cost (SLCC) (2026 PV $): 33,978~50,276

HPWH- SPST (Proposed with low-GWP refrigerant)

- Positive savings for electricity and SLCC for all climate zones

Single-pass return-to-primary (SPRetP)

- Positive savings for electricity and SLCC for all climate zones

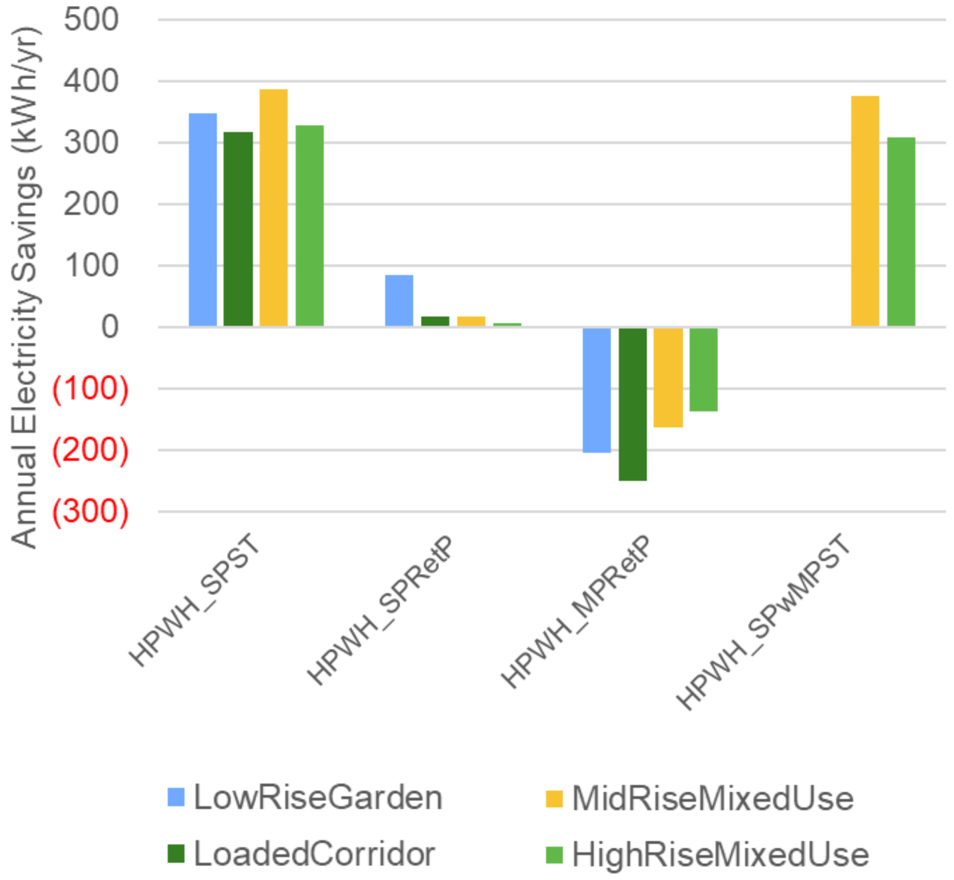
Multi-pass return-to-primary (MPRetP)

- Negative savings for electricity and SLCC for all climate zones

Single-pass primary with MP water heater in parallel (SPwMPST)

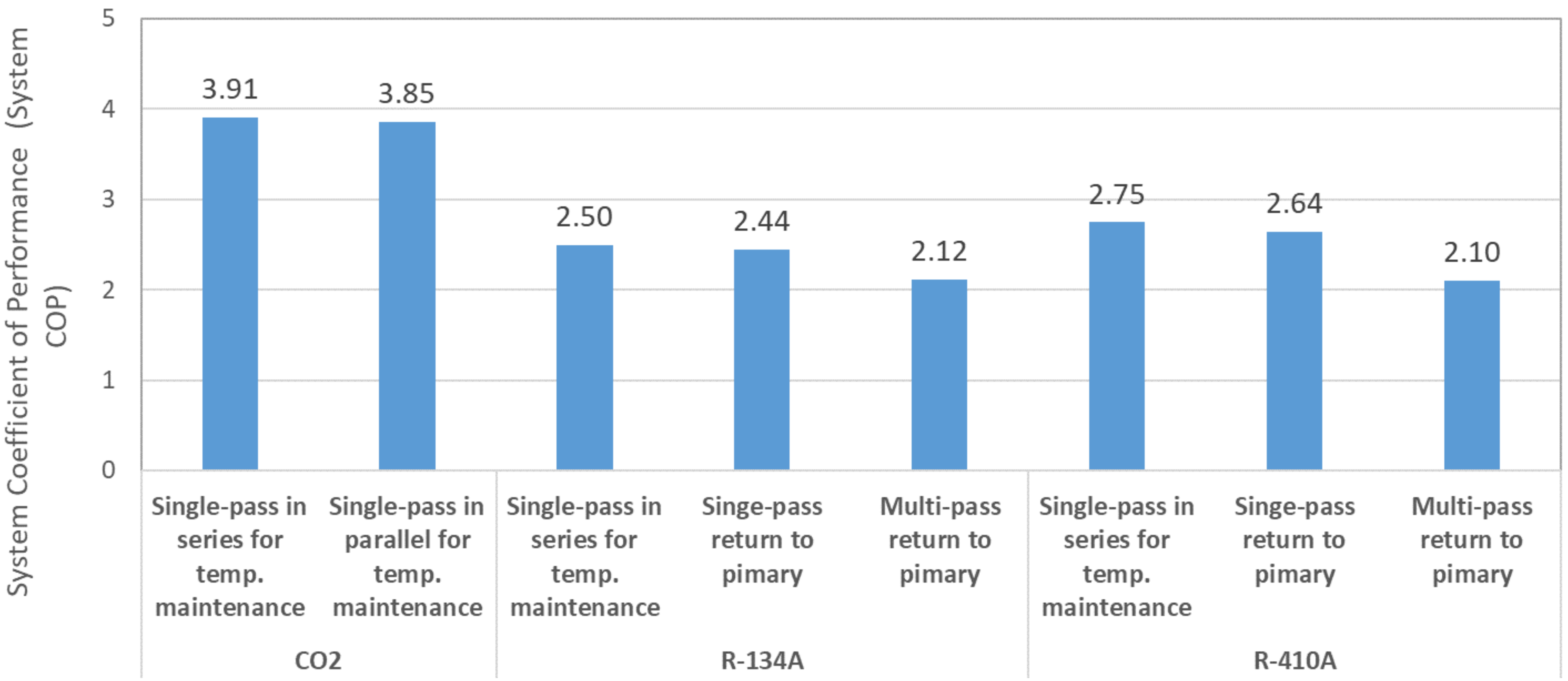
- Positive savings for electricity, SLCC and source energy for all climate zones

Example: Climate Zone 12



Central HPWH System Energy Performance

Example: Annual System COP for Climate Zone 12



NEEA Tier 3 System COP = 2.5 for most CA climate zones

Source: the DHW CASE Team

Incremental Cost Information

How we collected costs of base case and the proposed technology:

- Experienced plumbing engineers provided basis of design (BOD) for HPWH design for the four prototypes.
- Interviews with manufacturers, distributors or contractors confirmed the design concept.
- Design-build contractor provided cost estimation for the BOD

Incremental First Costs: Preliminary

Example : Climate Zone 12

Incremental First Cost	Low-Rise Loaded Corridor			
	HPWH Base	HPWH_SPST	HPWH_SPRetP	HPWH_MPRetP
Equipment total	$154,425	$56,050	$100,005	$285,290
Labor total	$12,425	$14,325	$8,720	$17,060
Total	$166,850	$70,375	$108,725	$302,350
Incremental Cost per Dwelling Unit	NA	**-$2,680**	**-$1,615**	**$3,764**

Incremental First Cost	Mid-Rise Mixed Use (5-Story)				
	HPWH Base	HPWH_SPST	HPWH_SPRetP	HPWH_MPRetP	HPWH_SPwMPTM
Equipment total	$366,455	$288,430	$187,379	$330,165	$262,744
Labor total	$20,715	$16,535	$13,875	$16,655	$15,395
Total	$387,170	$304,965	$201,254	$346,820	$278,139
Incremental Cost per Dwelling Unit	**NA**	**-$934**	**-$2,113**	**-$459**	**-$1,239**

Source: CASE Team

Poll Request (Example)

- **Measure Name:** Central HPWH
- **Type of Poll:** Open ended
- **Question:** **Do you have central HPWH cost data to help us cross check our assumptions?**
- **Answers:**.
- **Placement:** Proposed Code Change
- **Broadcast results to attendees as they respond:** Y
- **Make poll public during presentation:** Y

Statewide Energy Impacts

Methodology and Assumptions

- Statewide Energy Impacts Methodology

Statewide Energy Impacts Methodology

The Statewide CASE Team estimates annual statewide impacts by multiplying **A x B x C**:

A. per-dwelling unit energy impacts (discussed in previous section)
B. number of dwelling units of new construction/additions/alterations of each applicable building type
C. portion of affected dwelling units in each climate zone

Example:

Per Unit Impacts

Savings type	Savings Per Dwelling Unit
Electricity	[X] kWh
Peak demand	[X] Watts
Natural gas	[X] Therms
GHG emissions	[X] Tons CO_2e

×

Affected New Construction

Climate Zone	Multifamily Dwelling Units
1	100
2	1,000
…	
16	5,000

=

Statewide Energy Impacts

Climate Zone	Elec Savings (GWh)	…	GHG savings (MT CO_2e)
1	20		1,500
2	50		3,000
…			
16	100		2,000

Assumptions for Statewide Savings Estimates

- Percent of newly constructed dwelling units impacted = percent of buildings use central DHW systems x percent of buildings use electric DHW system
- Statewide savings will be developed pending release of final construction forecasts

Construction Forecast Building Type	Buildings with Central DHW System[1] (%)	Buildings Use electric DHW Systems in 2026[2] (%)	Newly Constructed Dwelling Units Impacted (%)
Low-rise Garden	45%	28%	13%
Loaded Corridor	65%	17%	11%
High-rise Multifamily	95%	14%	13%
Mid-rise Multifamily	66%	17%	11%

Do you have any data that can help us refine impact assumptions?

1. Source: Average of data from Evergreen Economics, Dodge Data& Analytics, and Utility programs
2. Source: Average of data from Evergreen Economics, California Residential Appliance Saturation Study RASS, and consultant projects collected by the CASE Team

Compliance and Enforcement

- Design
- Permit Application
- Construction
- Inspection
- Revisions to Compliance Software

Compliance and Verification Process

1. **Design Phase**
   - Plumbing designer provides sizing calculations, system approach and coordinate with manufacturers, distributors, or contractors to confirm the design concept and select equipment.
   - If using prescriptive approach, the plumbing designer confirms the design meeting updated code requirement. The plumbing designer verifies selected system meeting NEEA AWHS Tier 3 requirements.
   - Plumbing designer or energy consultant show compliance with energy code

2. **Permit Application Phase**
   - Design team submits plans, specifications, forms, and/or design drawings to the authority having jurisdiction (AHJ)
   - AHJ verifies building plans meet compliance criteria for local jurisdiction and new building codes

3. **Construction Phase**
   General contractor works with subcontractors to ensure design documents are carried out in construction

4. **Inspection Phase**
   AHJ verifies the type of systems in the approved permit have been installed

Software Updates

- Update standard design of the central HPWH system based on revised prescriptive requirements
- Add capability to calculate system COP for central HPWH system

Review of Code Language Markup

- Draft Code Change Language

Draft Code Change Language

- Draft code language available for review in the resources tab and downloadable.
- Provide feedback to CASE Author by March 3, 2023.
- **Updates prescriptive requirements in Section 170.2(d)2 to include two compliance paths**:

  (a) Single-pass primary HPWH meeting prescriptive requirements. Summary of revisions highlighted in red:
  - ~~Either single-pass and multi-pass primary equipment~~ Single-pass primary HPWH equipment
  - Requires recirculation loop decoupled from primary HPWH systems
  - Plumbing configurations to ensure stratification in primary tanks
  - Control requirements to achieve minimal efficiency
  - Requires heat pump compressor cut-off to be 40° F or lower
  - Design documentation of specified operating conditions of the system according to Joint Appendix 14.4

  (b) A system that meets requirement of NEEA Advanced Water Heating Specification for commercial HPWH system Tier 3 o higher.

Are there other existing requirements in Section 170.2(d)2 we should revisit for 2025 code cycle?

Poll Request (Example)

- **Measure Name:** Central HPWH
- **Type of Poll:** Open ended

Question: Are there other existing requirements in Section 170.2(d)2 we should revisit for 2025 code cycle?

- **Answers:**.
- **Placement:** Draft code change language
- **Broadcast results to attendees as they respond:** Y
- **Make poll public during presentation:** Y

Discussion and Next Steps

We want to hear from you!

- Provide **any last comments or feedback** on this presentation now verbally or over the chat
- More information on pre-rulemaking for the 2025 Energy Code at https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2025-building-energy-efficiency

Comments on this measure are due by March 3rd, 2023. Please send comments to info@title24stakeholders.com and copy CASE Authors (see contact info on following slide).

Thank You

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CALIFORNIA ENERGY CODES & STANDARDS
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TITLE 24, PART 6 | 2025 CODE CYCLE

Ventilation Requirements for Heat Pump Water Heaters

Codes and Standards Enhancement (CASE) Proposal
Multifamily Domestic Hot Water

James Haile, Frontier Energy
February 17, 2023

CALIFORNIA ENERGY CODES & STANDARDS
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Background

- Measure Scope
- Manufacturer Requirements
- Understanding Net Free Area
- Current Practice
- Lab and Field Tests

Proposed Code Change Scope

This proposed code change involves:

- Mandatory ventilation air requirements for heat pump water heaters (HPWHs) in all occupancies.
- Only considering ventilation requirements for consumer integrated HPWHs as defined by federal code (CFR 430):
  - ≤ 120-gallon storage volume.
  - Electrical input < 24 amps at < 250 volts.

This proposed code change does not involve:

- Commercial integrated HPWHs.
- Split system HPWHs.
- Requiring HPWHs.

Draft code language for this measure is available in the **resources tab.**

Manufacturer Requirements

Options for providing sufficient ventilation include:

- Duct either inlet or exhaust, but exhaust nets best performance.
- Install in a large space (450 to 700 ft^3 minimum).
- In smaller spaces, ensure free air exchange using louvered doors, ventilation grilles, and door undercuts to net a large “free area” (approx. 240 in^2 minimum).

Heater: Not Ducted

Room size: Smaller than 700 ft^3 (e.g. 7' x 10' x 10').
Requirements: Full louvered door OR two louvers top and bottom. See below.

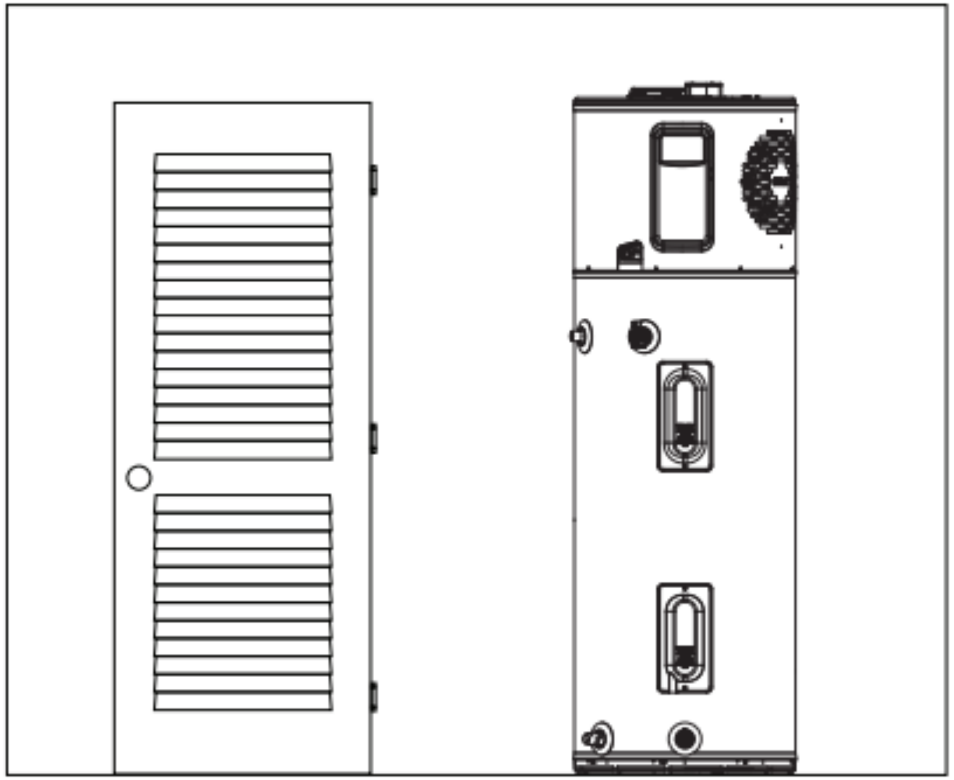


Image source: Rheem

What is Net Free Area (NFA)?

- The total area through which air can freely flow.
- Two components for total door NFA: louver gap and door undercut.
- Louver gap must be measured at the narrowest point.

$$NFA_{louvers} = (Louver\ Width) \times (Louver\ Gap) \times (\#\ of\ Louver\ Gaps)$$
$$= (26\ inches) \times (0.1875\ inches) \times (53) = \mathbf{258.375\ in^2}$$

$$NFA_{undercut} = (Door\ Width) \times (Undercut\ Height)$$
$$= (30\ inches) \times (0.75\ inches) = \mathbf{22.5\ in^2}$$

$$NFA_{total} = NFA_{louvers} + NFA_{undercut}$$
$$= 258.375\ \mathrm{in}^2 + 22.5\ \mathrm{in}^2 = \mathbf{280.875\ in^2}$$

Image source: Frontier Energy

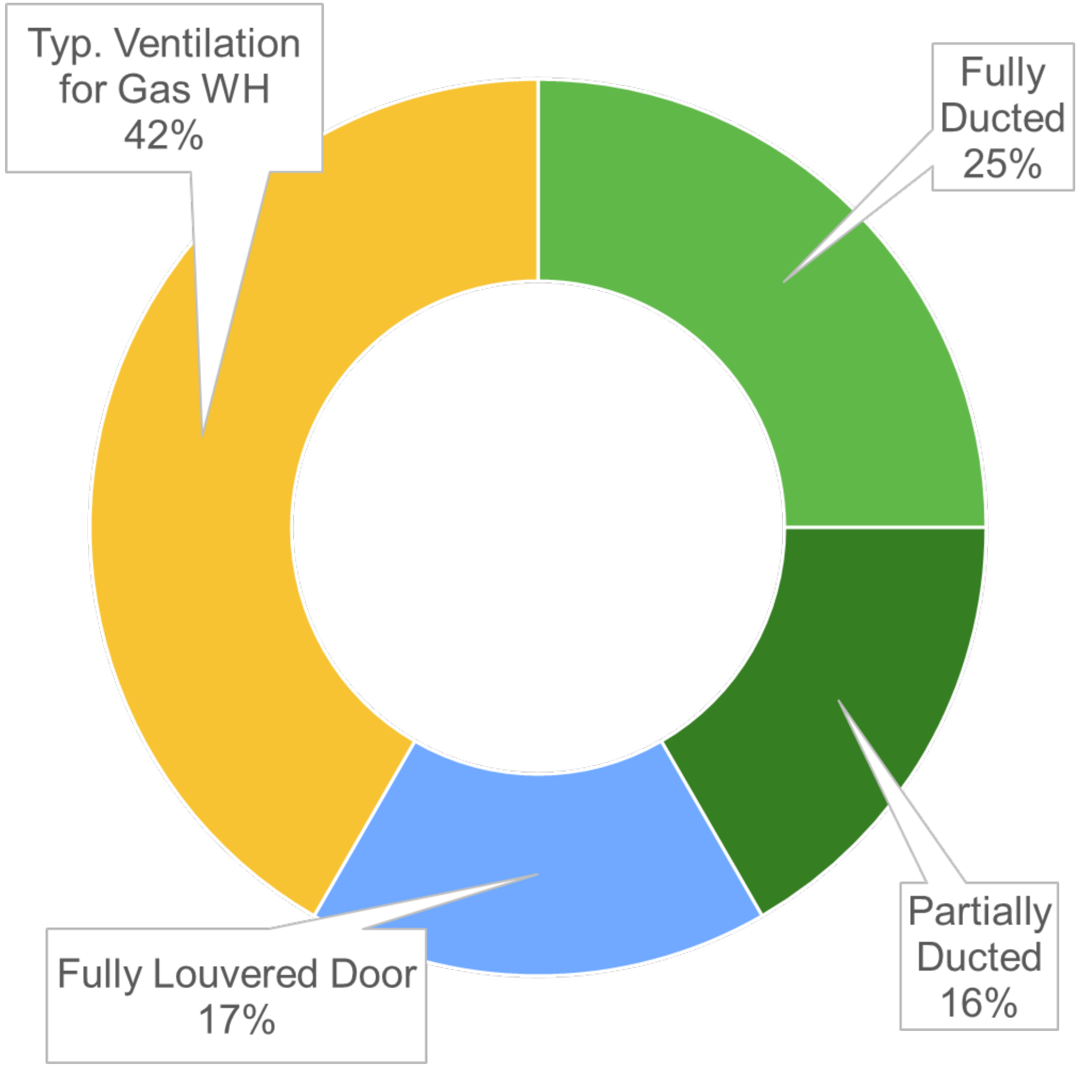
Poll Request

- **Measure Name:** Individual HPWH Ventilation
- **Type of Poll:** Multiple choice (1 answer)
- **Question:** In your experience, installers and designers are providing and specifying adequate ventilation air for HPWHs.
- **Answers:** Yes, No
- **Placement:** after slide 50 (What is NFA?)
- **Broadcast results to attendees as they respond:** (Y)
- **Make poll public during presentation:** (Y)

Current Practice

Despite manufacturer guidance, many designers are not specifying sufficient ventilation in plans.

- Plan review showed that only 42% specified ducting for small closets.
- 29% of unducted installs used fully louvered doors, though it is not clear whether these have sufficient NFA.
- 71% of unducted installs specified no more ventilation than typically provided a gas-fired water heater per plumbing code.



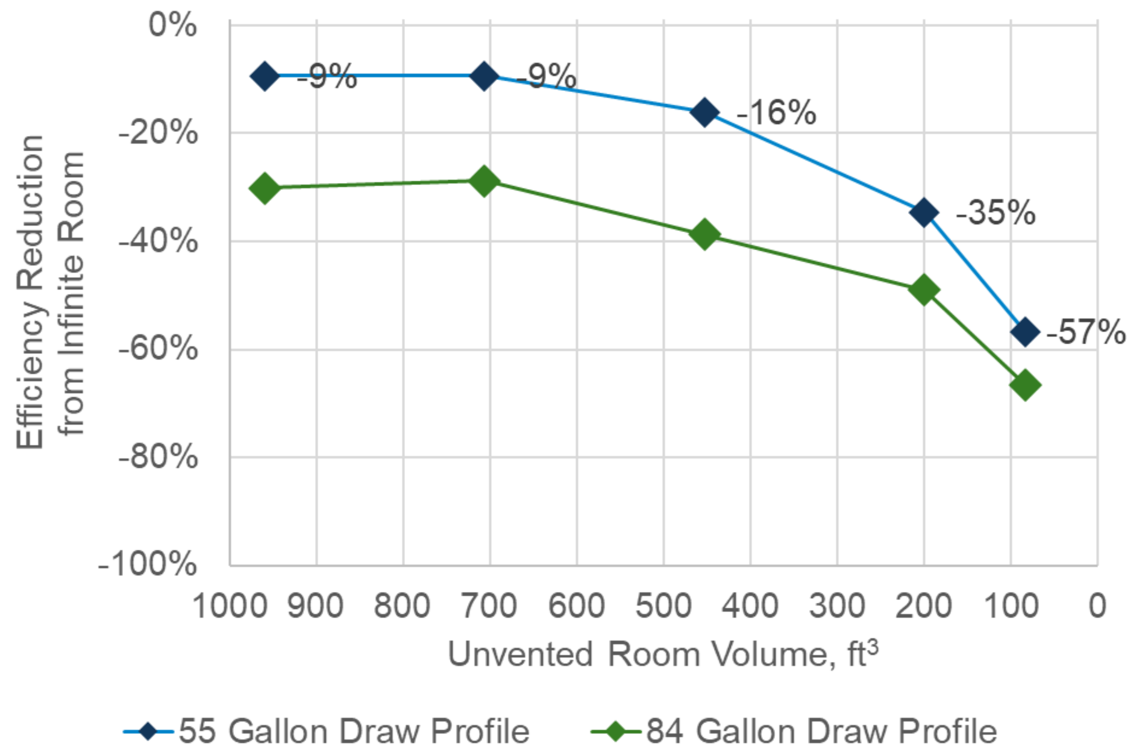
Current Practice Example: Creekside Multifamily Project

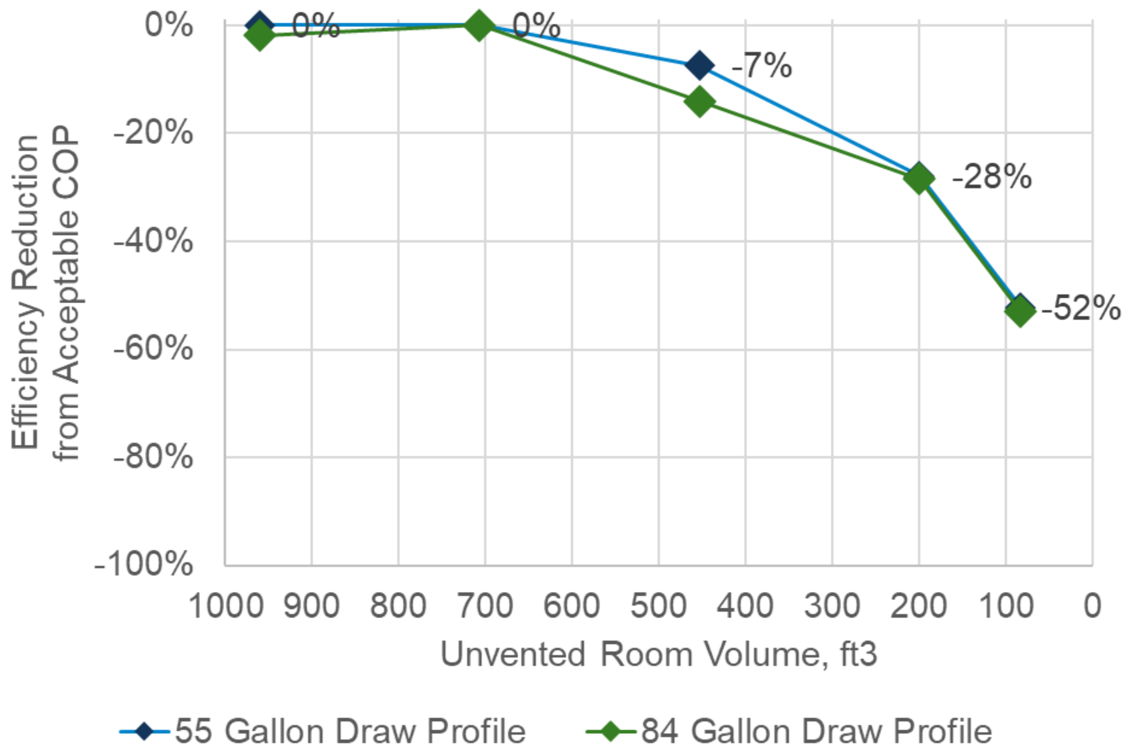
- Closet size ~81 ft^3.
- Used “fully louvered door” per manual, but NFA was 110 in^2.
- Exhaust not directed because not required with fully louvered door per manual, and installer claimed ports would be difficult to access.
- Compatible door with NFA 240 in^2 could not be found quickly enough, so exhaust was ducted through the door, saving 14% annual energy use.


Image Credits: Frontier Energy

Laboratory Testing: Unvented Interior Room Volume

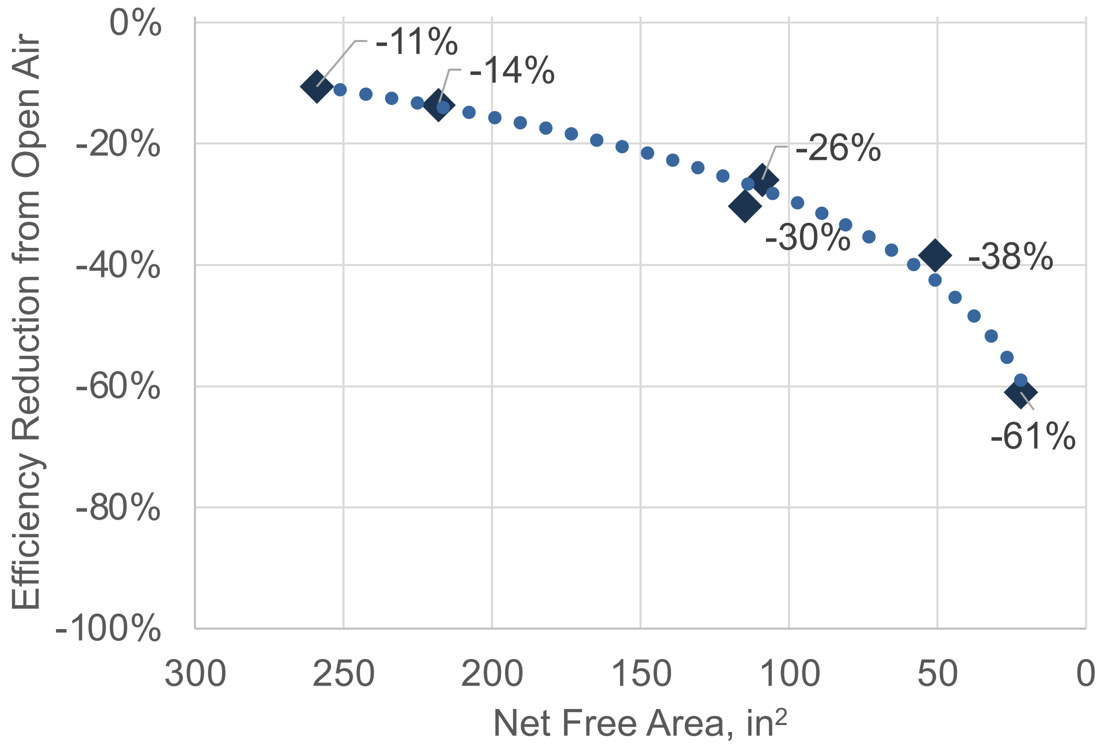
- "Acceptable" COP implied by manufacturer requirements is 3.21 at 700 ft^3, which is a 9% reduction from efficiency in an "infinite" room.
- 450 ft^3 still close to 3.0 COP (16% reduction from infinite room COP and 7% reduction from acceptable COP) and avoided resistance element use.

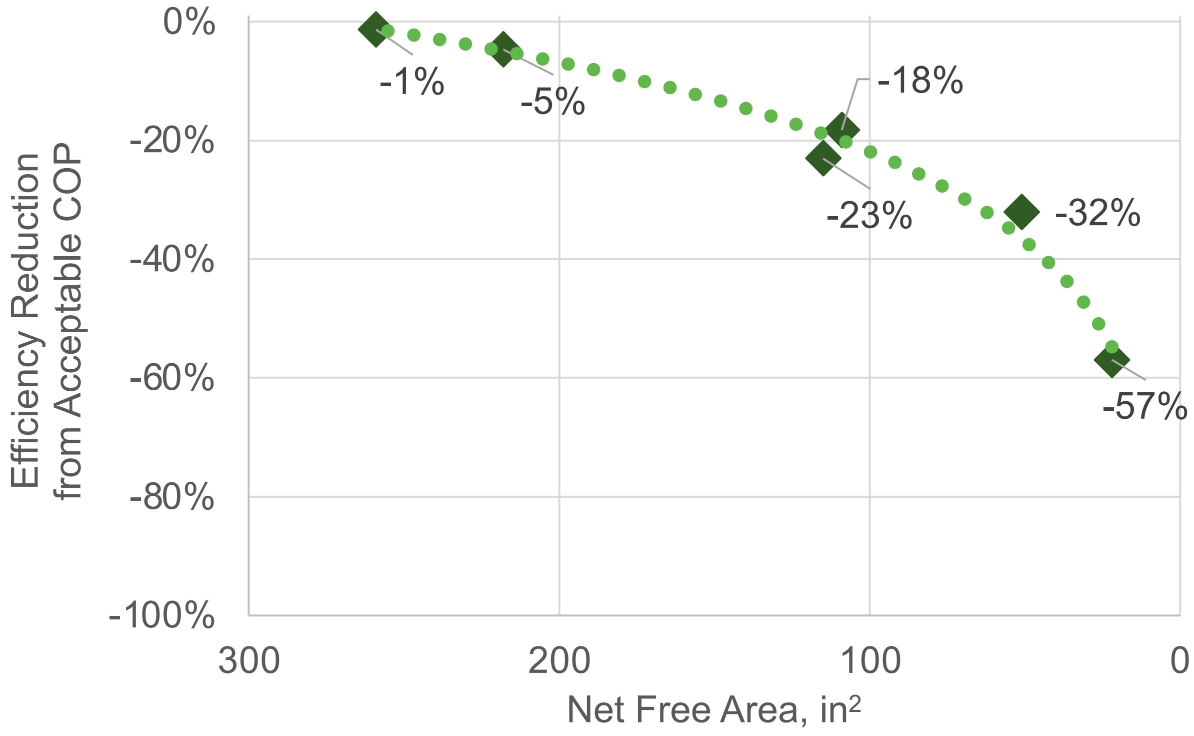




Laboratory Testing: Vented Interior Room NFA

- Manufacturer guidance on NFA (approx. 240 in^2) does not produce implied acceptable COP.
- Based on trend, 275 in^2 produces “acceptable” COP.



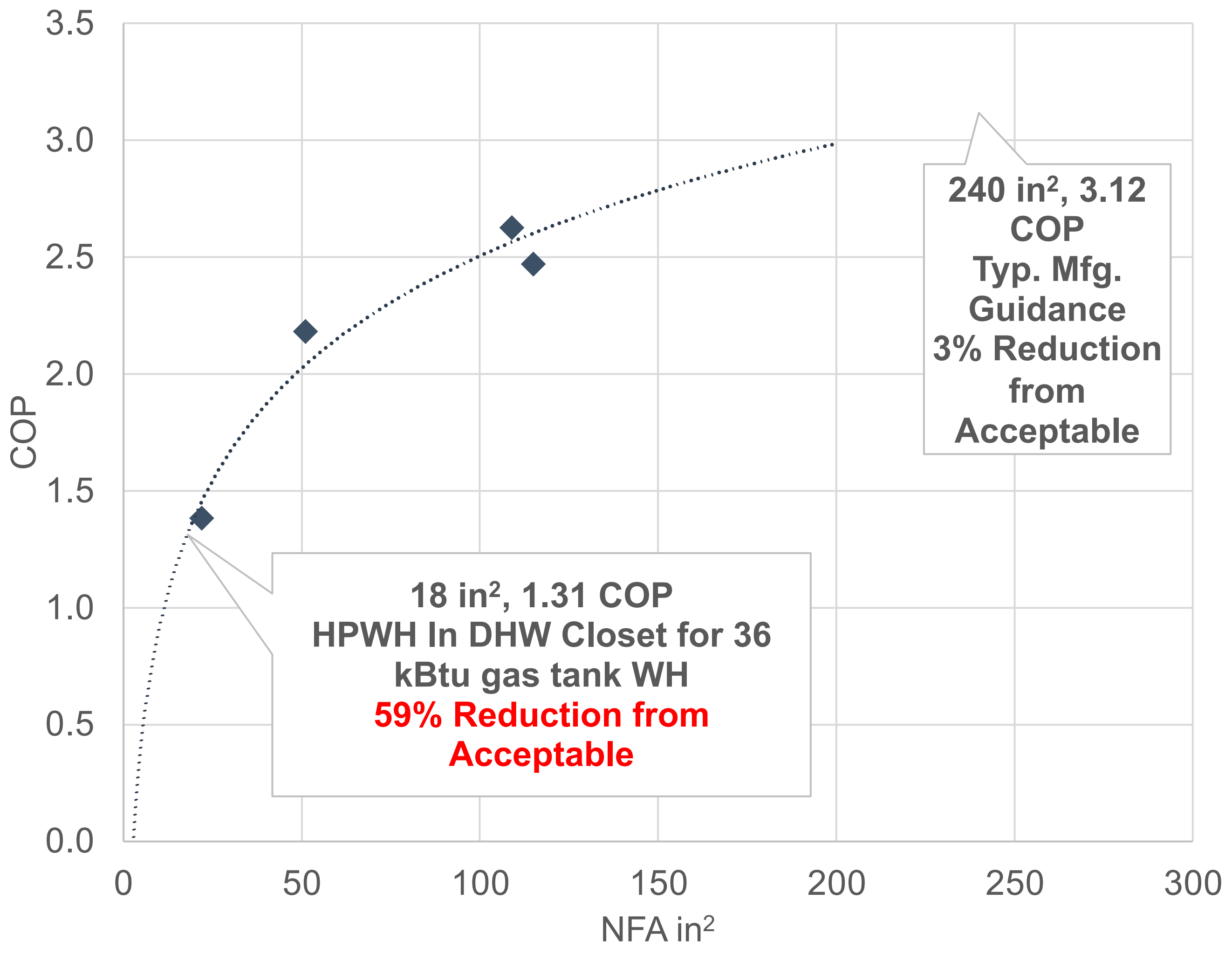


Lab Testing and Current Practice: A Sense of Scale

Reminder of plan review stats:

- 58% of multifamily HPWH installs are unducted in small closets
- 71% of unducted installs provided no more ventilation than that for a gas-fired storage water heater
- 29% of unducted installs used “fully louvered” doors, though these likely do not provide sufficient NFA or ventilation

Therefore: At least 42% of HPWH installs are likely operating below acceptable efficiency



Background Summary

- HPWH performance is heavily dependent on install location air volume and ventilation.
- Performance ceases to be “acceptable” in unvented rooms smaller than 450 ft^3, which is in line with manufacturer installation manuals.
- Manufacturer guidance generally agrees with lab results on vented rooms, but NFA requirements are below what lab results show to be sufficient.
- Despite guidance, most designs and installs do not provide adequate ventilation.
- 42% of HPWH installs are likely operating below acceptable COP.
- A majority of HPWH installs are likely not operating at acceptable efficiency levels.

Poll Request

- **Measure Name:** Individual HPWH Ventilation
- **Type of Poll:** Multiple choice (1 answer)
- **Question:** Is the apparent lack of attention to ventilation needs for heat pump water heaters a problem?
- **Answers:**
  - Yes! A big one!
  - Yes.
  - Maybe.
  - No.
- **Placement:** after slide 57 (Background Summary)
  - Present simultaneously with poll on Slide 59
- **Broadcast results to attendees as they respond:** (Y)
- **Make poll public during presentation:** (Y)

Poll Request

- **Measure Name:** Individual HPWH Ventilation
- **Type of Poll:** Free Response
- **Question:** If the apparent lack of attention to ventilation needs is a problem, what is the solution?
- **Answers:**
- **Placement:** after slide 57 (Background Summary)
    - Present simultaneously with poll on Slide 58
- **Broadcast results to attendees as they respond:** (Y)
- **Make poll public during presentation:** (Y)

Market Overview

- Current Market Conditions
- Market Trends
- Market Barriers

Market Overview and Analysis

Current Market

- 103 HPWH models certified by the California Energy Commission.
- 216 HPWH models certified by ENERGY STAR®.
- All use R-134a, which has a global warming potential (GWP) of 1430 and places compressor cutout around 40°F.
- All certified models can be ducted.
- All manufacturers have ventilation requirements.

Image credits (L to R): Bradford-White, A. O. Smith, Rheem, HTP

Market Overview and Analysis

Market Trends

- Due to availability, incentive programs, and a host of other factors, installs of HPWHs are increasing.
- Ducting seems to be the easiest and cheapest route for most installs.

Market Barriers

- Barriers are difficult to analyze, as installers and designers are currently required to provide ventilation for HPWHs by manufacturers. Therefore, any measure requiring ventilation for HPWHs is simply making manufacturer requirements enforceable and forcing designers and installers to pay attention to the issue.
- Achieving NFA requirements with only a louvered door may be difficult with narrow closets, but this can be overcome by ducting over the door, through the door, or to another location.

Technical Feasibility

- Technical Feasibility
- Potential Barriers and Solutions

Technical Considerations and Feasibility

Things to Consider:

- Proper ventilation is necessary to avoid resistance element use for efficiency and grid stability.
- Ventilation may need to be adjusted post install—specify flex connections instead of solid pipe, so the HPWH can be repositioned if needed.
- Duct kits are available from every manufacturer for an average of $200, less if only exhaust is ducted.
- Louvered doors exist, at least down to 30 inches wide, that can provide >250 sq. in. NFA

Image credits (left to right): Rheem, A. O. Smith

Potential Barriers and Solutions

Potential Barrier:

Availability of high NFA louvered doors is low due to post-pandemic supply chain issues. What alternatives are there to doors?

Potential Solutions:

- Make sure undercut is included in the total NFA.
- Add retrofit louver sections to an existing or new solid door:
  - Relatively expensive (\$1.70 per in^2 NFA on average, or \$510 for 300 in^2 NFA), however;
  - Much higher free area ratio (35 to 50%, relative to 8-12% for most fully louvered doors).
- Duct the exhaust, through the ceiling, through the wall, or even through the door!

Regardless of the method, the performance difference is significant, payback is likely 1-2 years or less.

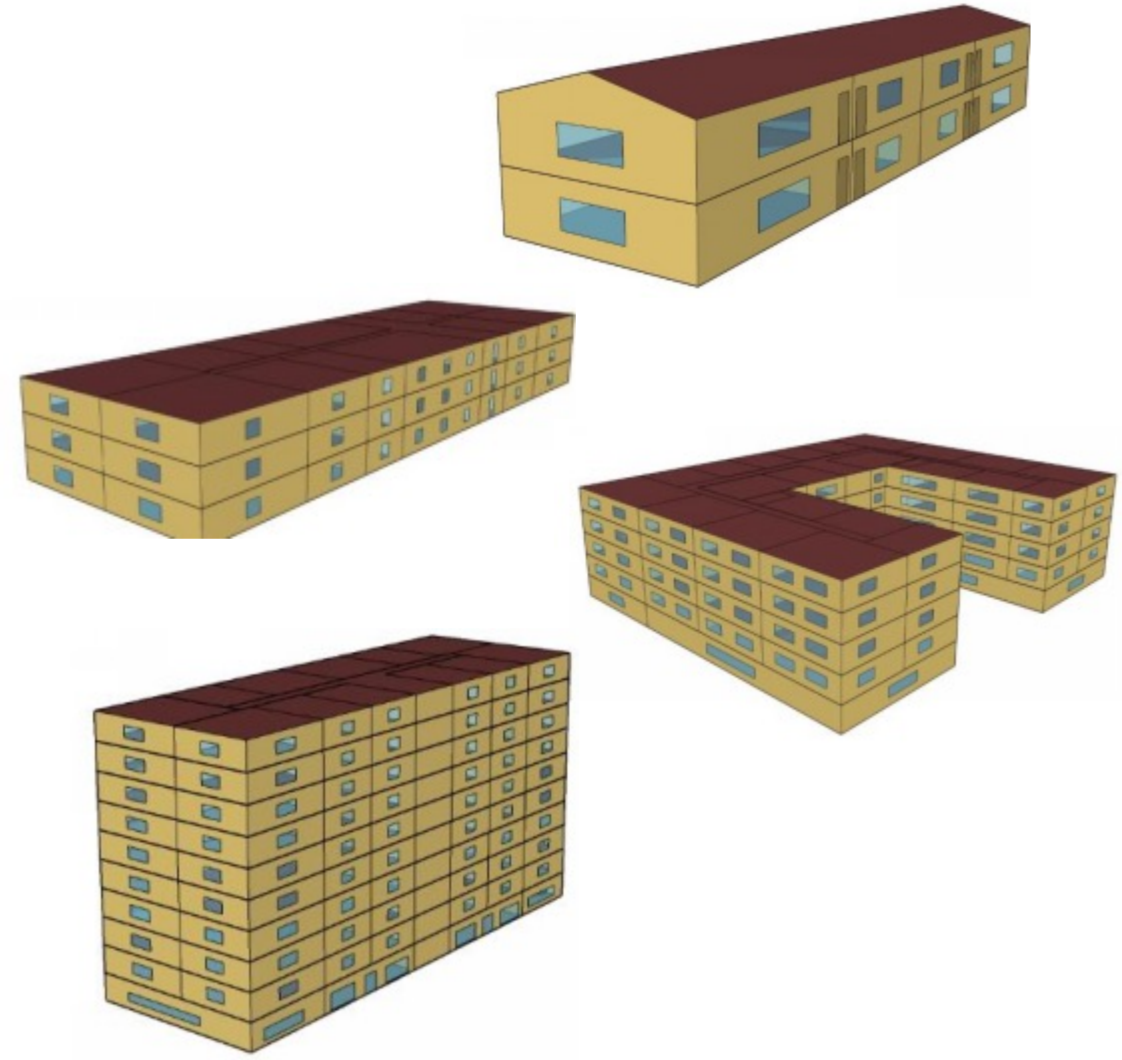
Energy and Cost Impacts Per Dwelling Unit

Methodology and Assumptions

- Energy Savings Methodology and Results
- Cost Impacts Methodology and Results
  - Incremental costs
  - Energy cost savings

Methodology for Energy Impacts Analysis

- Analysis will be conducted using standard California Building Energy Code Compliance (CBECC) prototypes for single family.
- Savings are expected to be the same for single family and multifamily, as water heating loads for individual units are dependent on the number of bedrooms, not other factors.
- Results from CBECC will be compared to lab test results, and savings will be calculated assuming heat pump water heater (HPWH) ventilation uses only the minimum NFA for a 36 kBtu gas-fired storage water heater as the baseline.
- CBECC assumes perfect ventilation, so lab test results will be used to adjust CBECC model outputs to non-ideal ventilation conditions.



Assumptions for Standard and Proposed Designs

Standard Design

- CBECC results adjusted to reflect poor ventilation using laboratory test results

Proposed Design

- Existing CBECC HPWH model

Incremental Cost Information

- How we collected costs of base case technology and proposed technology:
  - Collected data on costs of louvered doors and other ventilation methods.
  - Obtained contractor pricing for incremental labor cost to install adequate ventilation.
  - **Included first material costs and installation costs.**

- Equipment costs were found to range from <$100 to $2000 per dwelling unit, depending on the ventilation method and louvered door styling.
- Seeking additional cost data from additional designers and installers.

Ventilation Method	Sub Method	Materials Cost	Labor Hours
Large Space	NA	$0	0
Small Vented Space	Louvered Door	$200 to $2000	NC: 1 to 2 hours | Add/Alt: 0.5 to 1 hour
	Louver Sections	$1.70 per sq. in. NFA ($510 for 300 sq.in. NFA)	NC: 1 to 2 hours
	Grilles	< $100	NC: 1 to 2 hours | Add/Alt: 0.5 to 1 hour
Ducted Any Size Space	NA	$200	1 to 2 hours

Cost Effectiveness Example

Analysis not yet complete, but for example:

- Looking at a hypothetical HPWH installed in a 1-bedroom unit in Climate Zone 12 using current Pacific Gas and Electric Company time-of-use rates.
- This measure produces annual bill savings of **11.2%**, or **$248/year**.
  This is enough savings to cover the purchase of a new HPWH every ten years.

This is in line with findings from real-world HPWH ventilation interventions (for example, savings from ducting at Creekside were 14%).

Poll Request

- **Measure Name:** Individual HPWH Ventilation
- **Type of Poll:** Free response
- **Question:** Do you agree with this assessment of cost effectiveness? Why or why not?
- **Answers:**
- **Placement:** after slide 70 (Cost Effectiveness Example)
- **Broadcast results to attendees as they respond:** (Y)
- **Make poll public during presentation:** (Y)

Compliance and Enforcement

- Design
- Permit Application
- Construction
- Inspection
- Revisions to Compliance Software

Compliance and Verification Process

1. **Design Phase**
   Include the ventilation requirements in the design.

2. **Permit Application Phase**
   Building departments will follow existing process and check that ventilation requirements are met in the design.

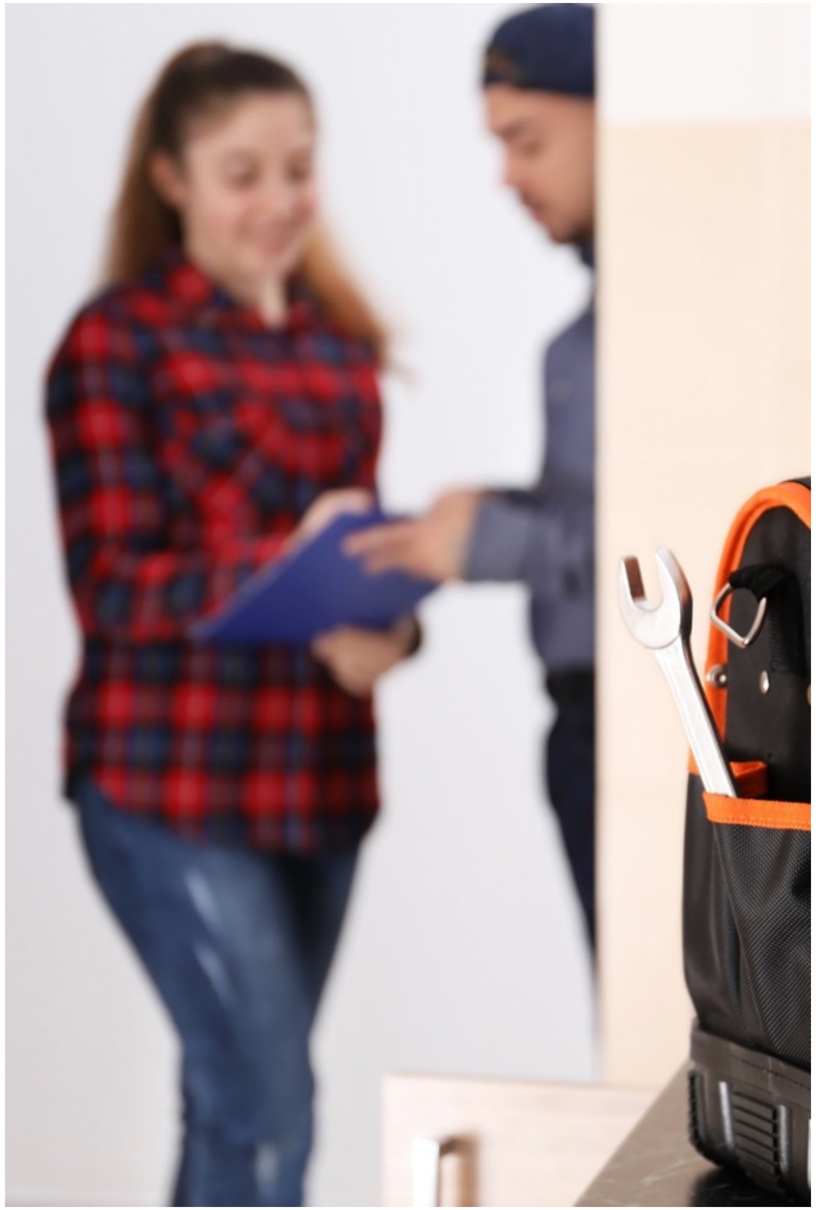
3. **Construction Phase**
   Build it according to the plan. If you are an installer and you note the design does not meet code, speak up as you would with any other code issue.

4. **Inspection Phase**
   Building departments will follow their existing enforcement process and check that the approved design was followed.

Market Actors

Do what you would do with any code requirement:

- **Manufacturers:** Make ventilation needs specific and clear, front and center, in installation manuals
- **Energy Consultants:** Make sure people are aware of ventilation needs when specifying or recommending HPWHs
- **Building Owners:** Be aware of ventilation needs of HPWHs
- **Architects/Designers:** Design for ventilation needs of HPWHs
- **Installers:** Install HPWHs with proper ventilation
- **Plans Examiners/Building Inspectors/HERS Raters:** Check for proper ventilation with HPWHs; Require installers to address any issues



Poll Request

- **Measure Name:** Individual HPWH Ventilation
- **Type of Poll:** Multiple choice (1 answer)
- **Question:** What steps do you think should be included in the compliance and enforcement process for this measure? Select all that apply.
- **Answers:**
  - Ventilation method should be included on compliance forms.
  - HPWH ventilation should have its own compliance forms.
  - HERS raters should verify compliance.
  - CBECC should have net free air (NFA) and room volume inputs, enabling it to de-rate HPWH efficiency for the performance compliance approach.
  - Simply requiring it is enough, at least for now.
- **Placement:** after slide 74 (Market Actors)
- **Broadcast results to attendees as they respond:** (Y)
- **Make poll public during presentation:** (Y)

Review of Code Language Markup

- Draft Code Change Language

Draft Code Change Language

- Add and adjust definitions in section 100.1(b) to differentiate different HPWH types.
- Add “Heat pump water heater” section to end of section 110.3(c):
  - Language is simple and based on California Plumbing and Mechanical code combustion air ventilation requirements for gas appliances.
  - Provide for four basic ventilation paths:
    1. Large unvented room: Minimum room volume of 100 ft3 / kBtu/h of compressor capacity or manufacturer provided requirements.
    2. Small vented room.
       - Minimum room volume of 20 ft3 / kBtu/h of compressor capacity or manufacturer provided requirements.
       - Larger of 125 in^2 plus 25 in^2 per kBtu of compressor capacity net free area or manufacturer provided requirements.
    3. Directly ducted in any size room: With some basic requirements like insulating the exhaust duct and sealing joints.
    4. Novel ventilation methods approved by the manufacturer and included in permit application.

Draft code language available for review in the resources tab and downloadable.

Provide feedback to CASE Author by March 3, 2023.

Discussion and Next Steps

We want to hear from you!

- Provide **any last comments or feedback** on this presentation now verbally or over the chat
- More information on pre-rulemaking for the 2025 Energy Code at https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2025-building-energy-efficiency

Comments on this measure are due by March 3rd, 2023. Please send comments to info@title24stakeholders.com and copy CASE Authors (see contact info on following slide).

Thank You

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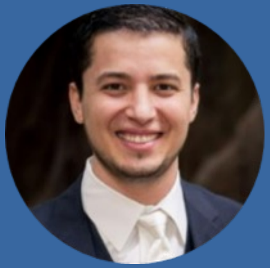
CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

TITLE 24, PART 6 | 2025 CODE CYCLE

Electric Ready Buildings Cleanup

Codes and Standards Enhancement (CASE) Proposal
Multifamily Domestic Hot Water



Jose Garcia, TRC
February 17, 2023

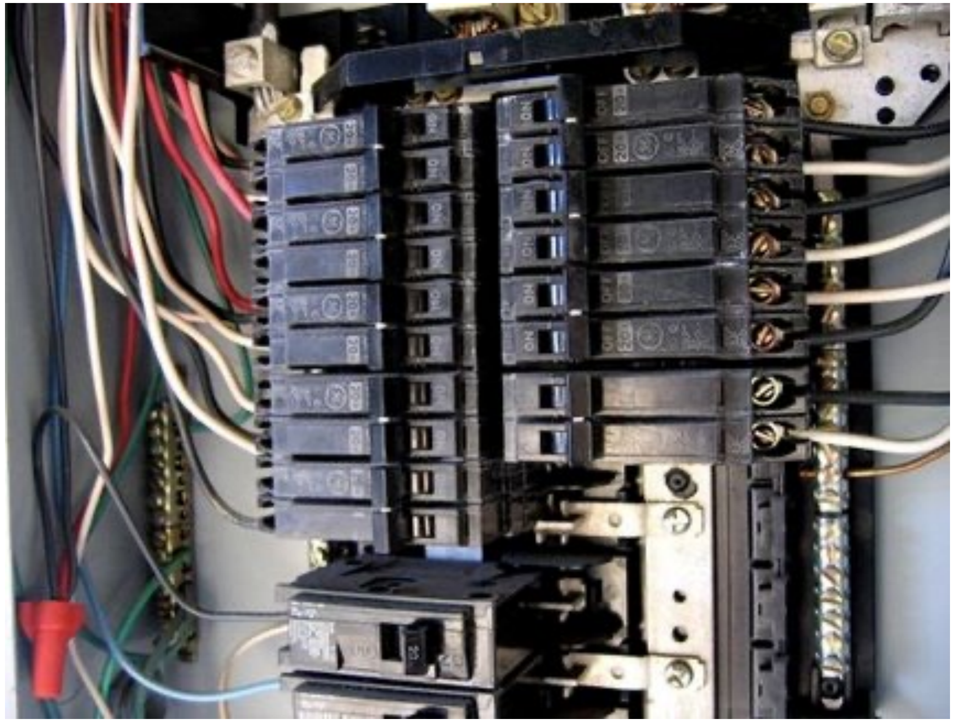
CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Context and History

The recommendations in this section would:

- Align the electric ready code language in Title 24 Part 6 Section 160.9 with standard design practice
- Improve the technical feasibility of the existing requirements

These recommendations were developed while developing two proposals for heat pump water heater (HPWH) electric readiness, which will be presented after this section.



Current Code Requirements

2022 Title 24, Part 6 Section 160.9
has the following existing electric ready requirements:

Electric Ready Requirements	Dedicated Branch Circuit Requirements	Breaker Requirements	Building Electrical System Requirements
Heat Pump Space Heater	240 volts, Rated at 30 amps	Reserved space for future double pole circuit breaker	No
Electric Cooktop	240 volts, Rated at 50 amps		No
Electric Clothes Dryer (Individual)	240 volts, Rated at 30 amps		No
Electric Clothes Dryer (Central)	208/240 volts, 24 amp capacity	Busbars and panels shall be sized for the future load	Required to be sized for future electric load to the point where the conductors serving the building connect to the utility distribution system

Proposed Code Requirements

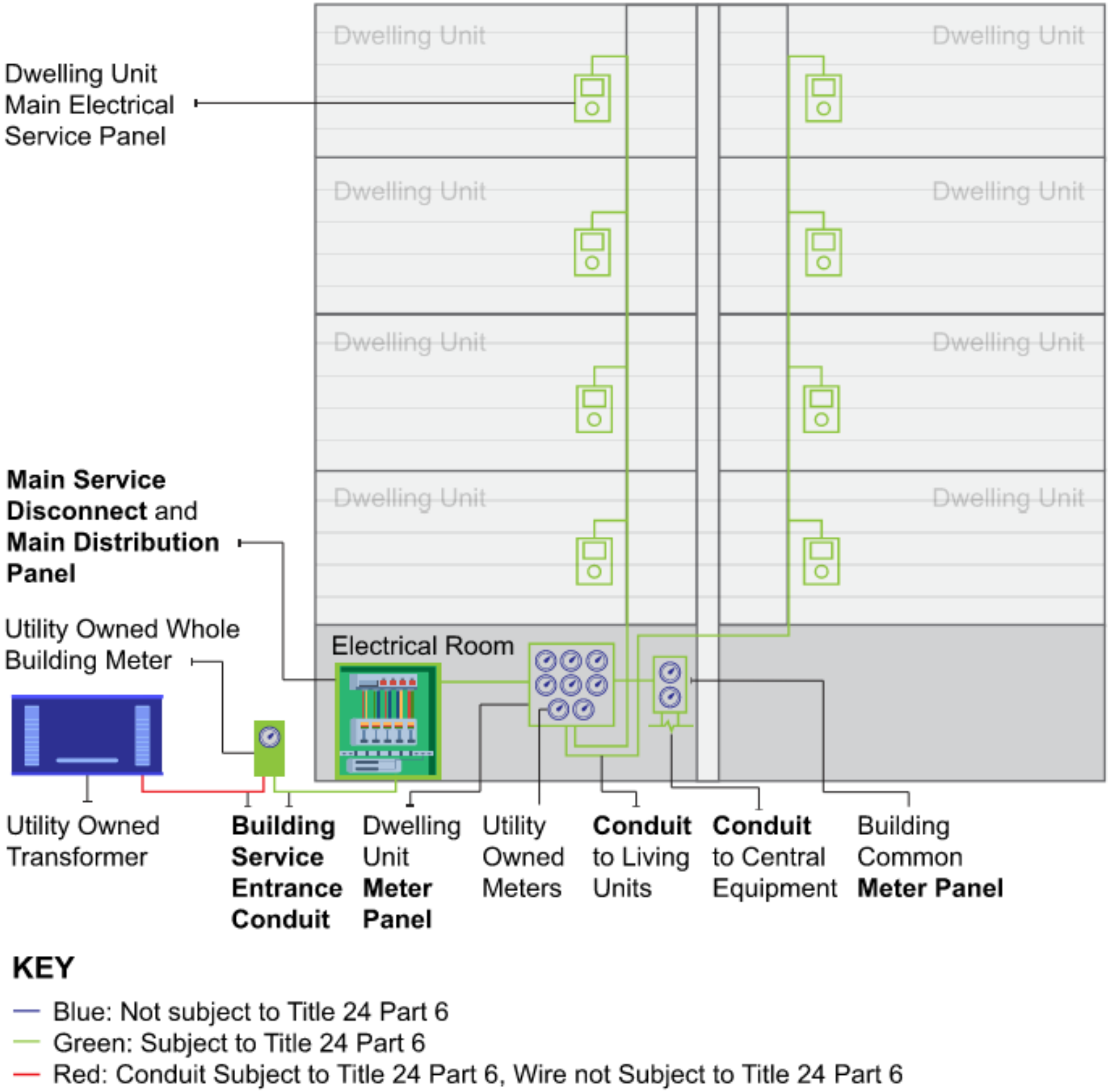
Improve the existing code requirements of section 160.9 by adding the following requirements:

<table>
<tr><th>Electric Ready Requirements</th><th>Proposed Additional Requirements</th></tr>
<tr><td>Heat Pump Space Heater</td><td rowspan="3">The following are required to be sized for the future electric load:
• The building electrical system to the point where the conductors serving the building connect to the utility distribution system, and
• The building service conduit</td></tr>
<tr><td>Electric Cooktop</td></tr>
<tr><td>Electric Clothes Dryer (Individual)</td></tr>
<tr><td>Electric Clothes Dryer (Central)</td><td>Make minor improvements to the existing language to clarify that the requirements apply to:
• The entire building electrical system, and
• The building service conduit</td></tr>
</table>

Technical Considerations

The recommendations are already standard practice because it is costly and challenging to retrofit major electrical components:

- Building service entrance conduit
- Meter panel(s)
- Main service disconnect
- Main distribution panel
- Conduit and wiring upstream of the dwelling unit



https://instrumentationtools.com/electrical-conduit/ ; https://www.evxperts.com/apartment-pics/meter-bank-area

Poll Request

- **Measure Name:** Electric Ready Buildings Cleanup
- **Type of Poll:** Open ended
- **Question:** Do you agree with our description, and if not what else should we know?
- **Answers:**
- **Placement:** After Technical Considerations
- **Broadcast results to attendees as they respond:** N
- **Make poll public during presentation:** N

Thank You

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CALIFORNIA ENERGY CODES & STANDARDS
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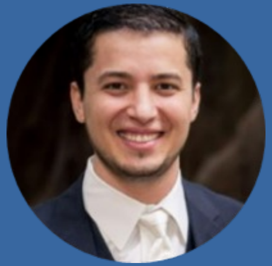
TITLE 24, PART 6 | 2025 CODE CYCLE

Individual Heat Pump Water Heater Electric Ready Cleanup

Codes and Standards Enhancement (CASE) Proposal

Multifamily Domestic Hot Water



Jose Garcia, TRC

February 17, 2023

CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Background

- Context and History
- Current and Proposed Code Requirements

Context and History

This mandatory measure would make future retrofits from gas or propane individual water heaters to individual heat pump water heaters (HPWH) more technically and financially feasible.

This measure is a cleanup of language developed under the 2022 Title 24, Part 6 update. **Cleanup is proposed to address the following factors:**

- Branch circuit sizing should be based on conductor current rating
- Individual HPWH require more space than individual gas or propane water heaters
- Individual HPWH require more ventilation than individual gas or propane water heaters

Current and Proposed Code Requirements

2022

Title 24 Part 6, Section 160.4(a)

- A reserved additional single pole circuit breaker space for future 240 volt use
- Conductor: 120/240 volt 3 conductor **10 AWG copper** branch circuit to future location
- Dedicated 125 volt 20 amp receptacle
- Condensate drainage

Proposed 2025

Title 24 Part 6, Section 160.9(d)

- A reserved additional single pole circuit breaker space for future 240 volt use
- Conductor: 120/240 volt 3 conductor branch circuit **rated at 30 amps min.** to future location
- **Entire building electrical system must be sized to meet future load**
- Dedicated 125 volt 20 amp receptacle
- Condensate drainage
- **Minimum space size: 39”x39”x96” (W,L,H)**
- **Ventilation**
  - **(a) Installed in space with minimum volume of 450 cu. ft., or**
  - **(b) Installed in a smaller space vented to a space 450 cu. ft. or larger via louvers with a total of 250 sq. in. net free area**
  - **(c) Installed with two 8” capped ducts, venting to exterior**

Draft code language for this measure is available in the resources tab.

Market Overview

- Current Market Conditions
- Market Trends
- Potential Market Barriers and Solutions

Market Overview and Analysis

Current Market

- Market share of individual HPWH is currently small
- 240 volt and 120 volt options are available

Market Trends

- As market adoption of HPWH increases, building owners will consider retrofitting from gas to HPWH
- Retrofit to HPWH are increasing, driven by programs and reach codes

Market Barriers

- The infrastructure and space requirements for HPWH are different than for gas water heaters
- Solution: Requiring some "electric ready" infrastructure and space reserved at new construction can greatly reduce the overall cost of future electrification

Technical Considerations

- Code Concept Development
- Branch Circuit, Space, and Ventilation
- Building Level Electrical Impacts

Code Concept Development

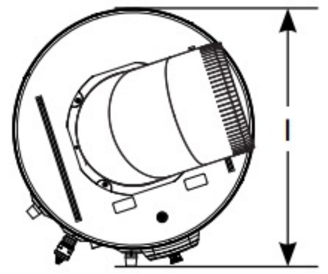
- Electric ready components identified in stakeholder interviews and plans review
- Prioritize flexibility for 240 volt or 120 volt options
  - Higher upfront costs of electrical infrastructure vs:
    - No ambient temperature limitations
    - Higher capacity compared to 120 volt options
    - Lower ventilation requirements in some cases
  - Future projects can choose 120 volt options if preferred
  - More challenging to retrofit from 120 volt circuit to 240 volt circuit

Image Credits (L to R):
Bradford-White, A. O. Smith, and Rheem

Poll Request

- **Measure Name:** Individual HPWH Electric Ready Cleanup
- **Type of Poll:** Open ended
- **Question:** Do you agree that the requirements should enable the future retrofit of 240 volt and 120 volt options? If not, what should we know?
- **Answers:**
- **Placement:** After Technical Considerations Slide 1
- **Broadcast results to attendees as they respond:** Y
- **Make poll public during presentation:** Y

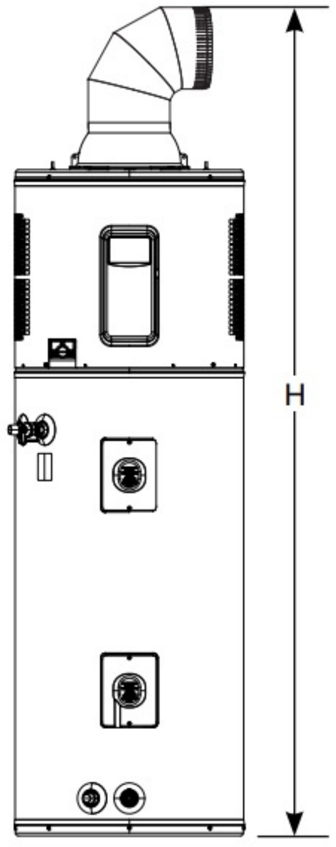
Branch Circuit, Space, and Ventilation



- **Branch circuit:** 30 amp rating is adequate for products on the market
- **Space requirements:**
  - HPWHs are typically larger, as illustrated in the product comparison table below
  - Ducting can require up to 16" additional vertical space required
  - Service access is important

WH Product Type	Length	Width	Height
Gas Instantaneous	18"	18"	28"
HPWH	28"	28"	70"

- **Ventilation requirements:**
  - Installing HPWH in spaces with a total volume of 450 cubic feet results in an acceptable COP, or
  - Installing HPWH in a smaller space communicating to a larger space via louvers with a net free area of at least 250 inches results in an acceptable COP



https://rmc-cdn.s3.amazonaws.com/media/uploads/iat/sites/36/2022/06/RH-PIHP-DC_Plug-in-Heat-Pump-Dedicated-Circuit_0610.pdf

Poll Request (Example)

- **Measure Name:** Individual HPWH Electric Ready Cleanup
- **Type of Poll:** Open ended
- **Question:** Do you agree with the technical justification and minimum requirements for space? If not, please explain and reach out to us with any data.
- **Answers:**
- **Placement:** After Technical Considerations Slide 2
- **Broadcast results to attendees as they respond:** Y
- **Make poll public during presentation:** Y

Building Level Electrical Impacts

- The entire building electrical system, including building service conduit needs to be sized for the future electrical load
- This is already standard practice for existing electric ready requirements
- Preliminary calculations indicate a non-negligible impact on building service size. These values are undergoing minor revisions, and they will likely change slightly.

Prototype (Service Voltage)	Building Service Size with Individual Gas (Amps)	Building Service Size with Individual HPWH (Amps)	Increase (%)
LRGS (240 V)	272	311	14%
LRLC (240 V)	984	1096	11%
MR (480 V)	1543	1655	7%
HR (480 V)	1539	1688	10%
Results are preliminary. HR base load is less than MR base load due to less commercial space			

Cost Impacts Per Dwelling Unit

Methodology and Assumptions

- Cost Impacts Methodology and Results
  - Incremental cost and future cost information

Incremental Cost and Future Cost Information

How we collected costs of base case technology and proposed technology:

- Experienced plumbing engineers provided basis of design (BOD) for HPWH design for the four prototypes
- Experienced electrical engineers provided BOD and retrofit cost estimates for the building electrical system for each prototypes considering:
  - Retrofit of electric ready building
  - Retrofit of not electric ready building
- Interviews with designers, design consultants, or contractors confirmed the design concept
- Additional cost data collection from a cost database with guidance from contractor interviews

Compliance and Enforcement

- Design
- Permit Application
- Construction
- Inspection

Compliance and Verification Process

1. **Design Phase**
   - Plumbing engineer determines if the electric ready requirements apply to the project, performs design activities to meet plumbing requirements, and coordinates the space and other infrastructure requirements to the design team.
   - Architect, mechanical engineer, and electrical engineer coordinate with the plumbing engineer to ensure that the electric ready requirements are met.
   - Energy compliance professional coordinates with design team to verify and document compliance.
2. **Permit Application Phase**
   Authority having jurisdiction (AHJ) verifies construction documents meet compliance criteria for local jurisdiction and building codes, including the new electric ready requirements.
3. **Construction Phase**
   General contractor works with subcontractors to ensure construction documents are carried out in construction and to document compliance.
4. **Inspection Phase**
   AHJ verifies the type of systems in the approved permit have been installed.

Review of Code Language Markup

- Draft Code Change Language

Draft Code Change Language

- Draft code language available for review in the resources tab and downloadable.
- Provide feedback to CASE Author by March 3, 2023.
- **Moves mandatory requirements in Section 160.4 to Section 160.9(d) and updates as shown below**:

1. A dedicated 125 volt, 20 amp electrical receptacle that is connected to the electric panel with a 120/240 volt 3 conductor~~, 10 AWG copper~~ branch circuit rated to 30 amps, within 3 feet from the water heater and accessible to the water heater with no obstructions. In addition, all of the following:

   A. Both ends of the unused conductor shall be labeled with the word "spare" and be electrically isolated; and

   B. A reserved single pole circuit breaker space in the electrical panel adjacent to the circuit breaker for the branch circuit in A above and labeled with the words "Future 240V Use"; and

2. Adds the following
   - The entire building electrical system shall be sized to meet the future electrical load
   - The HPWH must be installed in a space at least 39"x39"x96"
   - The HPWH shall be provided adequate ventilation by being installed in a sufficiently large room, having sufficient louvering, or via ducting

Discussion and Next Steps

We want to hear from you!

- Provide **any last comments or feedback** on this presentation now verbally or over the chat
- More information on pre-rulemaking for the 2025 Energy Code at https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2025-building-energy-efficiency

Comments on this measure are due by March 3rd. Please send comments to info@title24stakeholders.com and copy CASE Authors (see contact info on following slide).

Thank You

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CALIFORNIA ENERGY CODES & STANDARDS
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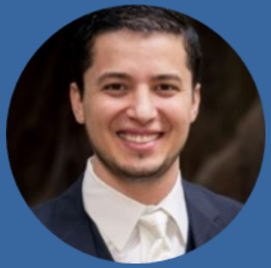
TITLE 24, PART 6 | 2025 CODE CYCLE

Central Heat Pump Water Heater Electric Ready

Codes and Standards Enhancement (CASE) Proposal
Multifamily Domestic Hot Water



Jose Garcia, TRC
February 17, 2023

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Background

- Context and History
- 2022 Code Requirements
- Proposed Code Change

Context and History

This mandatory proposal would make future retrofits from gas or propane central water heaters to central heat pump water heaters (HPWH) more technically and financially feasible. It applies to **new projects with central gas water heaters**.

- Retrofitting to HPWH can be technically challenging in existing buildings
- New construction would be installed with the infrastructure required to enable the retrofit to central HPWH in the future

The Statewide CASE Team previously pursued central water heating electric ready requirements for 2022 Title 24 Part 11.

https://www.broomhallbrothers.com/hot-water-boilers

Current Code Requirements

Existing requirements in Title 24, Part 6:

- **No electric ready requirement for central water heaters** in multifamily buildings
- Electric ready requirements for the following appliances in multifamily buildings:
  - Section 160.4(a):
    - Individual water heaters
  - Section 160.9:
    - Space heaters
    - Cooktops
    - Clothes dryers

Proposed Code Change

The proposal would add requirements for new construction multifamily dwelling units with central gas water heaters.

There are two pathways for compliance:

- The plumbing designer can use the prescribed design factors, or
- The plumbing designer can perform an engineered design

Draft code language for this measure is available in the **resources tab**

https://usframing.com/multifamily/

Proposed Code Change

Provide the following to ensure the building can accommodate a future HPWH system:

- Electrical
  - Dedicated raceway and/or conduit from the panel to the planned location of the future HPWH
  - The entire building electrical system upstream of the panel must be sized to meet the future load
- Condensate drainage piping installed
- Physical space including for required service clearances
- Ventilation
  - Install louver or duct penetrations through the building envelope and document the design air flow, or
  - Reserve space for the future heat pump outdoors

Poll Request

- **Measure Name:** Central HPWH Electric Ready
- **Type of Poll:** Open ended
- **Question:** Should the code require a route for future piping from the HP to the tanks be identified on the plans and constructed, or is this a detail that can be feasibly addressed at retrofit?
- **Answers:**
- **Placement:** After Proposed Code Change Slide 2
- **Broadcast results to attendees as they respond:** Y
- **Make poll public during presentation:** Y

Proposed Code Change

Preliminary prescribed sizing factors:

Sizing Factor	Minimum Requirement
Heat Pump – Physical Space*	3.6 sq. ft. per 10 MBH gas or propane input
Tank – Physical Space	4.4 sq. ft. per 10 MBH gas or propane input
Air Flow**	420 CFM per 10 MBH gas or propane input
Tons of Refrigeration for Condensate Pipe Sizing	0.7 tons refrigeration per 10 MBH gas or propane input
Heat Pump – Electrical***	1.1 kVA per 10 MBH gas or propane input
Temperature Maintenance Tank – Electrical***	1.0 kVA per 10 MBH gas or propane input

*To ensure adequate service and air flow clearance, minimum linear dimension of space reserved shall be

- 48” for systems with up to 125 MBH gas or propane input
- 84” for systems over 125 MBH gas or propane input

**Only used for indoor installations

Poll Request

- **Measure Name:** Central HPWH Electric Ready
- **Type of Poll:** Open ended
- **Question:** Would it be acceptable to have two sets of sizing factors, one for smaller gas systems and one for larger gas systems?
- **Answers:**
- **Placement:** After Proposed Code Change Slide 3
- **Broadcast results to attendees as they respond:** Y
- **Make poll public during presentation:** Y

Market Overview

- Current Market Conditions
- Market Trends

Market Overview and Analysis

Current Market

Although market share of central HPWH is relatively small compared to central gas systems, central HPWH installations are increasing

Market Trends:

Utility programs, federal, and state government funding to encourage market adoption including:

- California Energy Smart Homes CEC California Electric Homes Program
- CEC Building Initiative for Low-Emissions Development (BUILD)
- California Public Utility Commission (CPUC) Energy Savings Assistance Program
- CEC Technology and Equipment for Clean Heating (TECH Clean California)
- Advanced Water Heating Initiative (AWHI)

Technical Considerations

- Sizing Factor Development
- Design Process
- Building Service Impacts

Sizing Factor Development

- Required electric ready components determined through stakeholder interviews and plans review
- Prescribed sizing factors for each proposed electric ready component developed by analyzing designs from an experienced plumbing engineer
- **Critical aspects of the design include:**
  - Single pass primary CO^2 HP with electric resistance temperature maintenance tank in series
  - No dedicated backup electric resistance heating
  - Solar thermal heating included in existing gas system
  - Explored two recovery options:
    - Standard recovery (16 hours per day HP operation)
    - High recovery (13 – 13.5 hours per day HP operation)

Poll Request

- **Measure Name:** Central HPWH Electric Ready
- **Type of Poll:** Open ended
- **Question:** Do you agree with these assumptions? If not, what would you improve?
- **Answers:**
- **Placement:** After Technical Considerations Slide 1
- **Broadcast results to attendees as they respond:** Y
- **Make poll public during presentation:** Y

Design Process

The proposal would impact standard design practices:

- Plumbing engineer would coordinate the space and infrastructure needs for the future HPWH early in the design process
- Electrical engineer needs to plan for higher electrical loads
- Architecture and structure could be affected:
  - To meet space requirements for HPWH HP, or
  - For new building envelope penetrations to serve future ventilation needs (louvers and ductwork)

https://b2electrification.org/orion-real-life-performance-step-4-all-electric-building

Building Service Impacts

Standard Recovery

Prototype (Service Voltage)	Central Gas Service (Amps)	Central HPWH Service (Amps)	Increase (%)
LRGS (240 V)	272	305	12%
LRLC (240 V)	984	1023	4%
MR (480 V)	1543	1615	5%
HR (480 V)	1539	1622	5%

High Recovery

Prototype (Service Voltage)	Central Gas Service (Amps)	Individual HPWH Service (Amps)	Increase (%)
LRGS (240 V)	N/A	N/A	N/A
LRLC (240 V)	984	1060	8%
MR (480 V)	1543	1615	5%
HR (480 V)	1539	1656	8%

Results are preliminary. HR base load is lower than MR base load due to less commercial space.

Cost Impacts Per Dwelling Unit

Methodology and Assumptions

- Cost Impacts Methodology
  - Incremental costs

Incremental Cost Information

How we collected costs of base case technology and proposed technology:

- Plumbing engineers provided basis of design (BOD) for HPWH design for the four prototypes.
- Electrical engineers provided BOD and retrofit cost estimates for the building electrical system for each prototypes considering
  - Retrofit of electric ready building
  - Retrofit of not electric ready building
- Interviews with designers, design consultants, or contractors confirmed the design concept

Compliance and Enforcement

- Design
- Permit Application
- Construction
- Inspection

Compliance and Verification Process

1. **Design Phase**
   - Plumbing engineer determines if the electric ready requirements apply to the project, performs design activities to meet plumbing requirements, and coordinates the space and other infrastructure requirements to the design team
   - Architect, mechanical engineer, and electrical engineer coordinate with the plumbing engineer to ensure that the electric ready requirements are met
   - Energy compliance professional coordinates with design team to verify and document compliance

2. **Permit Application Phase**
   Authority Having jurisdiction (AHJ) verifies construction documents meet compliance criteria for local jurisdiction and building codes, including the new electric ready requirements

3. **Construction Phase**
   General contractor works with subcontractors to ensure design documents are carried out in construction and to document compliance

4. **Inspection Phase**
   AHJ verifies the type of systems in the approved permit have been installed

Review of Code Language Markup

- Draft Code Change Language

Draft Code Change Language

- Draft code language available for review in the resources tab and downloadable.
- Provide feedback to CASE Author by March 3, 2023.
- **Adds mandatory requirements to Section 160.9(e)**:
  - Central gas water heaters shall be electric ready for future HPWH
  - Future HPWH system shall be engineered, or sized with prescribed sizing factors
  - Meet the following:
    - Physical space reserved for heat pump and tanks
    - Ventilation: Plan for building envelope penetrations or reserve physical space for HP outside
    - Condensate drainage shall be installed
    - The entire electrical system shall be adequately sized for the future HP and TM tanks

Discussion and Next Steps

We want to hear from you!

- Provide **any last comments or feedback** on this presentation now verbally or over the chat
- More information on pre-rulemaking for the 2025 Energy Code at https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2025-building-energy-efficiency

Comments on this measure are due by March 3rd, 2023. Please send comments to info@title24stakeholders.com and copy CASE Authors (see contact info on following slide).

Thank You

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CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

TITLE 24, PART 6 | 2025 CODE CYCLE

Appendix M Pipe Sizing

Codes and Standards Enhancement (CASE) Proposal
Multifamily Domestic Hot Water Distribution

Amin Delagah, TRC
February 17, 2023

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Background

- Code Change Proposal
- 2022 Code Requirements
- Context and History

Existing Plumbing Code

- California Plumbing Code (CPC) Appendix A pipe sizing:
  – Uses the water supply fixture units approach
  – Based on estimated demand curves, referred to as Hunter’s curve

- CPC Appendix M added to Uniform Plumbing Code (UPC) in 2018 as an alternative pipe sizing procedure:
  – Uses the International Association of Plumbing & Mechanical Officials (IAPMO) Water Demand Calculator
  – Accounts for California code-required, low-flow fixtures
  – Uses a large dataset of flow diversity in real buildings for more accurate prediction of peak flow

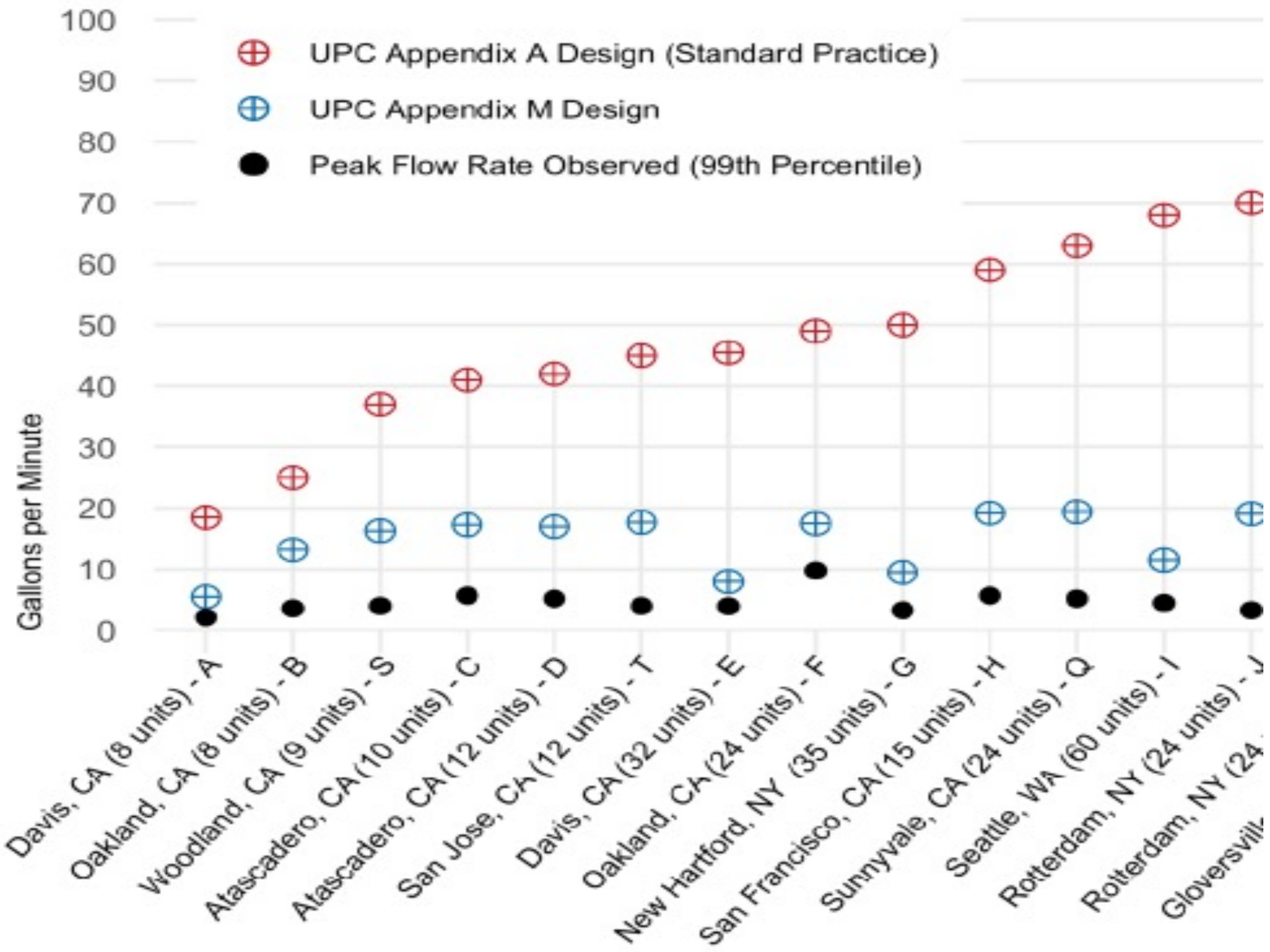
- The California Department of Housing and Community Development (HCD) must adopt CPC Appendix M for statewide implementation
- Local jurisdictions can adopt Appendix M

Peak Water Demand Presentation, 2016, Peak Water Demand Study: Development of Metrics and Method for Estimating Design Flows (aceee.org)
Peak Water Demand Study, 2017, peak-water-demand-study-executive-summary.pdf (iapmo.org)
Water Demand Calculator Study, 2020, water_demand_calculator_studyrev0.pdf (iapmo.org)

Context and History

Comparing Design Predictions to Actual Peak Flow Rates

- Appendix M design estimate is conservative versus observed peak flow rates
- Appendix M estimates are 2-6 times higher than observed flow rates
- Typically, a 1”-diameter pipe size reduction



Alternative Methodology for Sizing Water Pipes.2022. https://localenergycodes.com/content/reach-codes/energy-plus-water-1

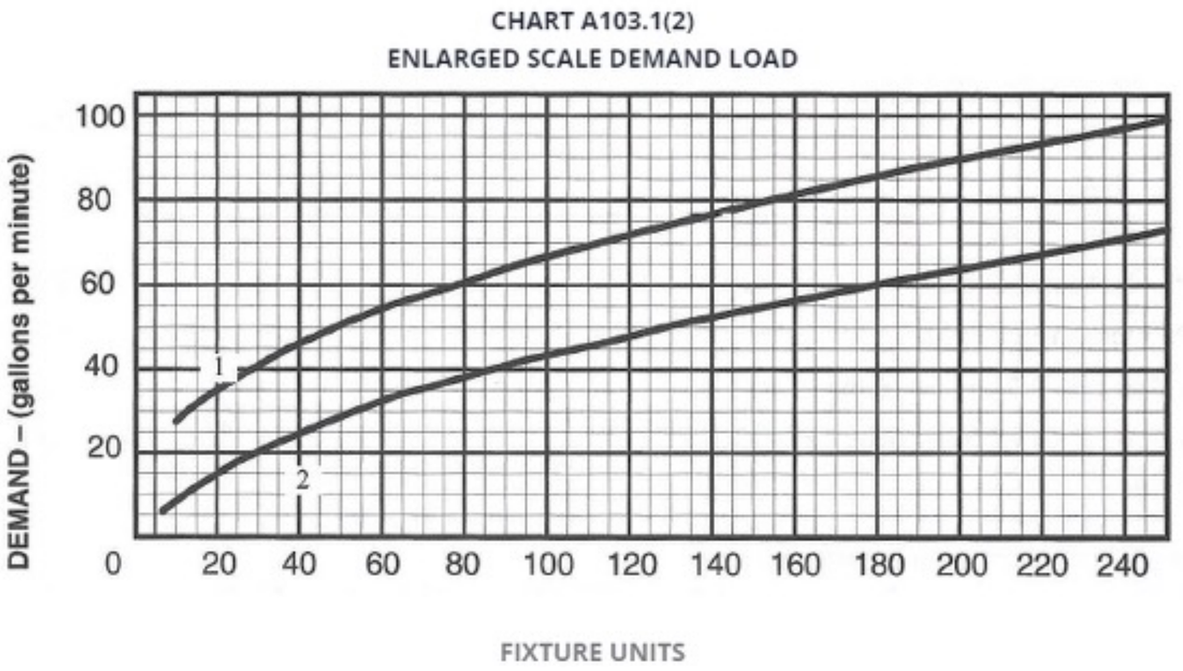
Existing Energy Code

- Prescriptive baseline model assumes standard practice CPC Appendix A pipe sizing
- CPC Appendix M is a compliance credit in the 2022 California Building Energy Code Compliance (CBECC) software

Current Practice

Appendix A pipe sizing includes

- Hunters' curve to estimate water demand in gallons per minute (gpm) based on total number of fixtures
- Each pipe section is sized based on water velocity and pressure drop



An established process results in streamlined calculation time and plan examiner approval time.

Context and History

- Several jurisdictions and states have adopted CPC Appendix M in municipal code and plumbing code
- Included in Appendix M of the 2021 UPC and in Appendix C of the 2020 Water Efficiency and Sanitation Standard (WE-Stand)

Context and History

CPC Appendix M sizing results in:

- **Lower material and installation costs**
  - Reduced cold water, reclaimed water, and hot water piping diameter in the distribution loop and heating plant
  - Potentially reduced developer cost related to water and wastewater capacity charges based on mains meter size
- **Lower utility costs**
  - Reduced hot water pipe heat loss
  - Smaller mains water meter and associated utility service charges
- **Reduced health risks and improved water quality** due to shorter dwell times in distribution systems
- **Water and embedded energy savings**

Alternative Methodology for Sizing Water Pipes.2022. https://localenergycodes.com/content/reach-codes/energy-plus-water-1
SF Water Power Sewer. 2022. Rates_Schedule_Booklet_031522.pdf (sfpuc.org)

Proposed Code and CBECC

- Section 170.2(d) – Prescriptive Approach for Water Heating Systems would incorporate code language requiring the use of CPC Appendix M for distribution systems serving individual and multiple dwelling units
- This measure would not add field verification or acceptance tests

Market Overview

- Current Market Conditions
- Market Trends
- Potential Market Barriers and Solutions

Market Overview and Analysis

Current Market

- Based on review of 25 project drawings, none used CPC Appendix M for MF buildings
- Designers indicate that they have not used CPC Appendix M for California projects
- In California jurisdictions that allow CPC Appendix M, building inspectors responded that there is limited to no uptake in submitted building plans
  - Several designers interviewed were not aware of these California cities that allow CPC Appendix M
- Some designers that we have interviewed that work outside of California have started using Appendix M

Poll Request

- **Measure Name:** Pipe Insulation Enhancement
- **Type of Poll:** Open Response
- **Question 1:** Does this market overview inside California align with your experience?
- **Answers:**
- **Question 2:** Is Appendix M pipe sizing methodology known and understood by the design community?
- **Answers:**
- **Placement:** After Existing Code 1st Content Slide
- **Broadcast results to attendees as they respond:** Y
- **Make poll public during presentation:** Y

Technical Considerations

- Technical Considerations
- Potential Barriers and Solutions

Technical Considerations

Existing calculator for Appendix M is available.

- Barrier: Increased calculation time in the short term with new approach
  - IAPMO Water Demand Calculator (WDC) takes longer to run than the CPC Appendix A Fixture Unit calculation approach
- Solution: Process will mature with a streamlined CPC Appendix M design application
  - Custom spreadsheets can save time
  - Potential for automation to eventually become a faster process

Water Demand Calculator (WDC v2.1)

PROJECT NAME : - - - - -

Click for Drop-down Menu → Single-Family Residence

FIXTURE GROUPS		FIXTURE	ENTER TOTAL NUMBER OF FIXTURES	PROBABILITY OF USE (%)	ENTER FIXTURE FLOW RATE (GPM)	MAXIMUM RECOMMENDED FIXTURE FLOW RATE (GPM)
Bathroom Fixtures	1	Bathtub (no Shower)	0	1.00	5.5	5.5
	2	Bidet	0	1.00	2.0	2.0
	3	Combination Bath/Shower	0	5.50	5.5	5.5
	4	Faucet, Lavatory	0	2.00	1.5	1.5
	5	Shower, per head (no Bathtub)	0	4.50	2.0	2.0
	6	Water Closet, 1.28 GPF Gravity Tank	0	1.00	3.0	3.0
Kitchen Fixtures	7	Dishwasher	0	0.50	1.3	1.3
	8	Faucet, Kitchen Sink	0	2.00	2.2	2.2
Laundry Room Fixtures	9	Clothes Washer	0	5.50	3.5	3.5
	10	Faucet, Laundry	0	2.00	2.0	2.0
Bar/Prep Fixtures	11	Faucet, Bar Sink	0	2.00	1.5	1.5
Other Fixtures	12	Fixture 1	0	0.00	0.0	6.0
	13	Fixture 2	0	0.00	0.0	6.0
	14	Fixture 3	0	0.00	0.0	6.0

DOWNLOAD RESULT | RESET WDC | ↓ Select Units for Water Demand ↓ GPM | LPM | LPS | RUN WDC | ← CLICK BUTTON ←

Poll Request

- **Measure Name:** CPC Appendix M
- **Type of Poll:** Open Response
- **Question 1:** What has been your experience in using the Water Demand Calculator?
- **Answers:**
- **Question 2:** Are there any other technical considerations that we should be aware of?
- **Answers**
- **Placement:** After Technical Considerations Content Slide
- **Broadcast results to attendees as they respond:** Y
- **Make poll public during presentation:** Y

Energy and Cost Impacts Per Dwelling Unit

Methodology and Assumptions

- Energy Savings Methodology
- Cost Impacts Methodology and Results
  - Incremental costs
  - Energy cost savings

Assumptions for Standard and Proposed Designs

Utilized basis of design developed from the 2022 CASE cycle for the **hot water distribution system**

- Pipe diameter and length shown
- New for 2025 cycle is appurtenance counts for both hot, cold, and heating plant distribution systems as they are similarly reduced in size from Appendix A to M

	Pipe Lengths Using CPC Appendix A Sizing (Hunters Curve) (ft)				**Pipe Lengths Using CPC Appendix M Sizing (IAPMO WDC) (ft)**			
Pipe Diameter (inches)	Low-Rise	Loaded Corridor	Mid-Rise	High-Rise	Low-Rise	Loaded Corridor	Mid-Rise	High-Rise
4	0	0	53	9	0	0	0	0
3	0	25	91	130	0	0	0	5
2.5	0	90	73	165	0	0	121	129
2	20	24	85	58	0	80	66	80
1.5	58	153	939	782	52	107	254	148
1	29	182	338	313	55	287	1,158	1,095
0.75	168	449	744	1018	168	449	724	1,018
Percent Surface Area Reduction					**9%**	**14%**	**19%**	**20%**

TRC. 2020. CASE 2022 Multifamily Domestic Hot Water Distribution. Final CASE Report.

Assumptions for Standard and Proposed Designs

BOD for the Domestic Hot Water heating plant is upcoming to include pipe lengths and equivalent pipe lengths based on the estimated heat loss from various appurtenances.

	Pipe Lengths Using CPC Appendix A Sizing (Hunters Curve) (ft)				Pipe Lengths Using CPC Appendix M Sizing (IAPMO WDC) (ft)			
Pipe Diameter (inches)	Low-Rise	Loaded Corridor	Mid-Rise	High-Rise	Low-Rise	Loaded Corridor	Mid-Rise	High-Rise
6	0	0	0	24	0	0	0	0
5	0	0	0	0	0	0	0	36
4	0	0	68	76	0	0	0	0
3	0	56	12	24	0	0	80	64
2.5	0	0	0	0	0	0	0	0
2	56	12	12	76	56	68	12	24
1.5	12	0	12	36	12	0	12	12
1	0	12	24	0	0	12	24	48
0.75	12	12	0	0	12	12	0	0
0.50	24	48	0	0	24	48	0	0

Assumptions for Standard and Proposed Designs

Developed BOD for the **cold water distribution system** for cost saving purposes. Pipe diameter and length shown.

	Pipe Lengths Using CPC Appendix A Sizing (Hunters Curve) (ft)				Pipe Lengths Using CPC Appendix M Sizing (IAPMO WDC) (ft)			
Pipe Diameter (inches)	Low-Rise	Loaded Corridor	Mid-Rise	High-Rise	Low-Rise	Loaded Corridor	Mid-Rise	High-Rise
4	0	0	19	43	0	0	0	0
3	0	18	107	54	0	0	0	0
2.5	0	72	66	47	0	0	0	0
2	23	59	115	160	0	0	0	93
1.5	32	48	81	227	0	0	68	0
1.25	26	119	720	598	0	18	161	4
1	29	154	220	260	23	131	139	226
0.75	54	135	200	260	141	456	1,160	1,326

Methodology for Energy Savings Analysis

- Hot water distribution savings based on 2022 CASE energy modeling
  - Greater number of pipes with large diameter equals greater length of pipe affected by code change, thus higher energy savings for larger prototypes buildings
- Modeling includes distribution loop and heating plant
  - Based on gas and heat pump heating plants for the four prototype buildings for pipe lengths and appurtenance counts
  - Equivalent pipe length calculated to model pipe heat loss at each appurtenance at the heating plant
  - An average 24-h pipe water temperature at the heating plant of 125°F

Appendix M Pipe Sizing: Incremental Cost Information

Material and labor installed costs from a mechanical contractor

- Labor hours vary for vertical vs. horizontal piping since horizontal piping requires hanger installation
- Labor rate for insulation cost savings included (smaller pipes require less insulation)

Compliance and Enforcement

- Design
- Permit Application
- Construction
- Inspection
- Revisions to Compliance Software

Compliance and Verification Process

1. **Design Phase**
   - Designer shows Appendix M sizing on plumbing drawings.
   - Energy consultant assists building designer in preparing energy compliance documentation LMCC/NRCC.
2. **Permit Application Phase**
   - Builder submits compliance documents with the building permit application.
   - Local enforcement agencies check plans to ensure compliance with California Energy Code and health and safety requirements, and they verify that the information on the construction documents is consistent with the requirements specified on the compliance documents.
   - Enforcement agency issues the building permit.
3. **Construction Phase**
   - Contractor begins construction, including installation of cold and hot water distribution piping.
   - Contractor completes the related LMCI/NRCI form.
   - Builder or installing contractor provides a copy of the completed, signed, and dated LMCI/NRCI form at the building site and requests building inspection.
4. **Inspection Phase:**
   Local enforcement agency inspects to ensure compliance.

Review of Code Language Markup

- Draft Code Change Language

Draft Code Change Language

SECTION 170.2 – PERSCRIPTIVE APPROACH

Section 170.2(d) Water Heating Systems.

For hot water distribution piping serving individual and multiple dwelling units, verify pipe sizing is in accordance to CPC Appendix M.

Draft code language available for review in the resources tab and downloadable.

Provide feedback to CASE Author by March 3, 2023.

Discussion and Next Steps

We want to hear from you!

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Thank You

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CALIFORNIA ENERGY CODES & STANDARDS
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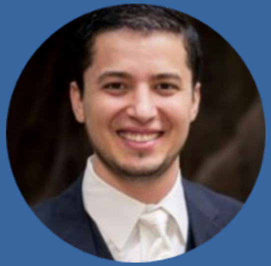
TITLE 24, PART 6 | 2025 CODE CYCLE

Recirculation System Demand Control Cleanup

Codes and Standards Enhancement (CASE) Proposal

Multifamily Domestic Hot Water



Jose Garcia, TRC

February 17, 2023

CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Proposed Code Change

- This proposal is intended to remove the prescriptive requirement for demand recirculation systems (demand control) for recirculation systems serving multiple dwelling units

- **Updates prescriptive requirements in Section 170.2(d):**
  For recirculation distribution systems serving individual dwelling units, only Demand Recirculation Systems with manual on/off control as specified in the Reference Appendix RA4.4.9 shall be used. Recirculation system serving multiple dwelling units shall meet the requirements of Sections 110.3(c)2 and 110.3(c)5~~, and shall be capable of automatically controlling the recirculation pump operation based on measurement of hot water demand and hot water return temperature.~~

Draft code language available for review in the resources tab and downloadable.

Provide feedback to CASE Author by March 3, 2023.

Context and History

- Demand control for recirculation systems serving multiple dwelling units was removed from the compliance software in 2020, based on concerns related to technical feasibility in this application
- The Statewide CASE Team identified the following technical concerns in interviews with stakeholders
  - Multifamily buildings need to be able to provide hot water at any time
  - Designers and design consultants were concerned about increased risk of legionella growth at temperatures below roughly 117 °F - 120 °F, although there was not consensus on an exact cutoff temperature
  - In practice, demand control systems are often turned off to avoid complaints

https://www.supplyhouse.com/Grundfos-59896341-UPS15-58FC-3-Speed-Circulator-Pump-1-25-HP-115-volt-4701000-p?utm_source=google_ad&utm_medium=Shopping_tm&utm_campaign=Shopping_TM_New_users&gclid=EAIaIQobChMIkPGDvY6H_QIV4gB9Ch0JIALPEAQYAiABEgK41fD_BwE

Poll Request

- **Measure Name:** Recirculation Demand Control Cleanup
- **Type of Poll:** Multiple Options
- **Question:** Please select any of the following that you agree are technical concerns:
  - (1) Providing adequate hot water 24 hours/day
  - (2) Increased risk of legionella growth
  - (3) Demand control systems are often turned off
  - (4) None of the above
- **Answers:** Any combination of the options available—Display as bar chart showing percent of respondents who picked each option
- **Placement:** After Context and History
- **Broadcast results to attendees as they respond:** Y
- **Make poll public during presentation:** Y

Poll Request

- **Measure Name:** Recirculation Demand Control Cleanup
- **Type of Poll:** Open response
- **Question:** Do you have any other feedback for us?
- **Answers:**
- **Placement:** After Poll 1
- **Broadcast results to attendees as they respond:** Y
- **Make poll public during presentation:** Y

Thank You

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TITLE 24, PART 6 | 2025 CODE CYCLE

Pipe Insulation Enhancement

Codes and Standards Enhancement (CASE) Proposal
Multifamily CASE Domestic Hot Water

Amin Delagah, TRC

February 17, 2023

CALIFORNIA ENERGY CODES & STANDARDS

A STATEWIDE UTILITY PROGRAM

Background

- 2022 Code Requirements
- Code Change Proposal
- Context and History

Existing Code

SECTION 160.4 – MANDATORY REQUIREMENTS FOR WATER HEATING SYSTEMS

(f) Insulation for piping and tanks

1. Piping for multifamily domestic hot water systems shall be insulated to meet the requirements of Table 160.4-A

TABLE 160.4-A PIPE INSULATION THICKNESS—MULTIFAMILY DOMESTIC HOT WATER

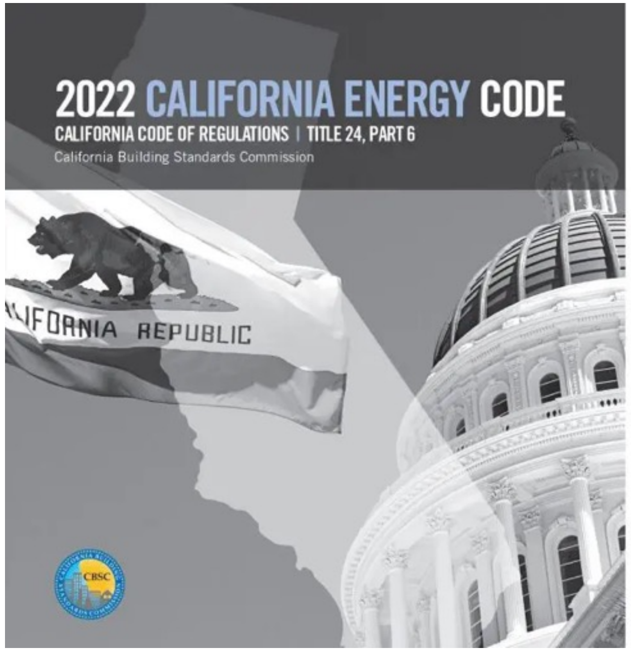
FLUID OPERATING TEMPERATURE RANGE (°F)	INSULATION CONDUCTIVITY			NOMINAL PIPE DIAMETER (in inches)				
	Conductivity (in Btu•in/h•ft^2•°F)	Mean Rating Temperature (°F)		< 1	1 to <1.5	1.5 to < 4	4 to < 8	8 and larger
Multifamily Domestic Hot Water Systems				Minimum Pipe Insulation Required (Thickness in inches or *R*-value)				
105—140[1]	0.22—0.28	100	Inches	1.0	1.5	2.0	2.0	2.0
			R-value	R7.7	R12.5	R16	R12.5	R11

1. Multifamily and hotel/motel domestic hot water systems with water temperature above 140°F shall use the row in Table 120.3-A for the applicable water temperature.

Existing Code

Requirements are unclear in Section 160.4:

- Not explicit that **all** hot water piping are insulated to thickness requirements
  - 2022 California Plumbing Code (CPC) definition: A **plumbing appurtenance** is a manufactured device, a prefab assembly, or in the field assembly of component parts that is an adjunct to the basic piping system and plumbing fixtures.
    - It demands no additional water supply or add discharge load
    - It performs a function in the operation, maintenance, servicing, economy, or safety of the plumbing system
    - Examples for hot water piping include flanges, pumps, valves (isolation, mixing, balancing, check, etc.), strainers, hose bibs, meters, sensors, heat exchangers and air separators
- No language requiring:
  - Continuous insulation across loop
  - Pipe supports to be thermally isolated and insulated
  - Specific installation techniques to further reduce heat loss



Poll Request

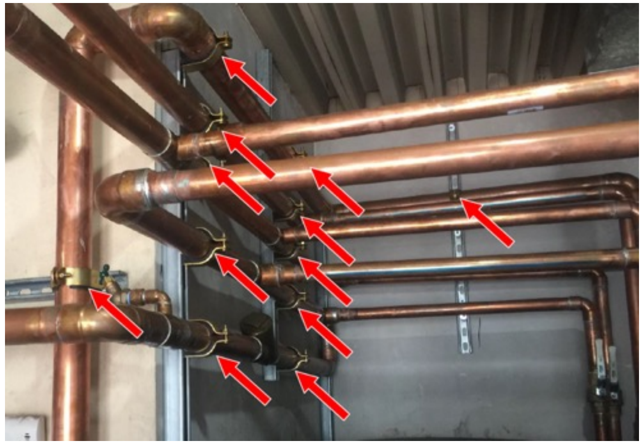
- **Measure Name:** Pipe Insulation Enhancement
- **Type of Poll:** Open Response
- **Question:** Does existing code related to pipe insulation extend to appurtenances and pipe supports in series with hot water piping?
- **Answers:**
- **Placement:** After Existing Code 1st Content Slide
- **Broadcast results to attendees as they respond:** Y
- **Make poll public during presentation:** Y

Existing Code

- Currently Title 24, Part 6 has no requirements for field verification
- Photos of pipe insulation in buildings show portions of pipes, fittings, valves and pumps are not insulated
  - Portions of insulation poorly installed
  - Portions of pipe supports are not thermally isolated from pipe and properly insulated
- The unclear or lack of pipe insulation language relating to appurtenances in CPC and ASHRAE 90.1 for domestic hot water systems may have influenced Title 24, Part 6 language:
  - Design requirements on project drawings are inconsistent and subject to interpretation
  - Outcome is most hot water piping related to the heating plant and distribution loop end up only partially insulated

Uninsulated Fittings and Valves

Uninsulated Pipe Supports



Association for Energy Affordability Inc

Current Practice

The most common practice is to insulate hot water piping to the minimum insulation thicknesses in code.

Interviews with designers indicate that they:

- Use code minimum requirements in their pipe insulation specification.
- Tees and elbows get insulated as they are considered part of the piping.
- Sometimes isolation valves get insulated.

Several designers commented that contractors will do nothing more than what the inspector is checking, which is usually tees and elbows.

- One designer commented that they get push back on above code or voluntary pipe insulation requirements from contractors.

In summary, this Pipe Insulation Enhancement Measure has two components:

- **Code Language Cleanup**
- **Field Verification**

Context and History

- Best practice design specifications are well known, but infrequently implemented, explicit language in code can result in:
  - Much simpler specification information provided by the designer
  - Less confusion and more consistency for contractors
  - Less pushback from contractors to meet voluntary insulation specifications
- To achieve continuous insulation across piping, in absence of explicit code language, designers have to provide comprehensive specifications and drawings in project documents

Example of continuation pipe insulation requirements:

Pipe Insulation Requirements

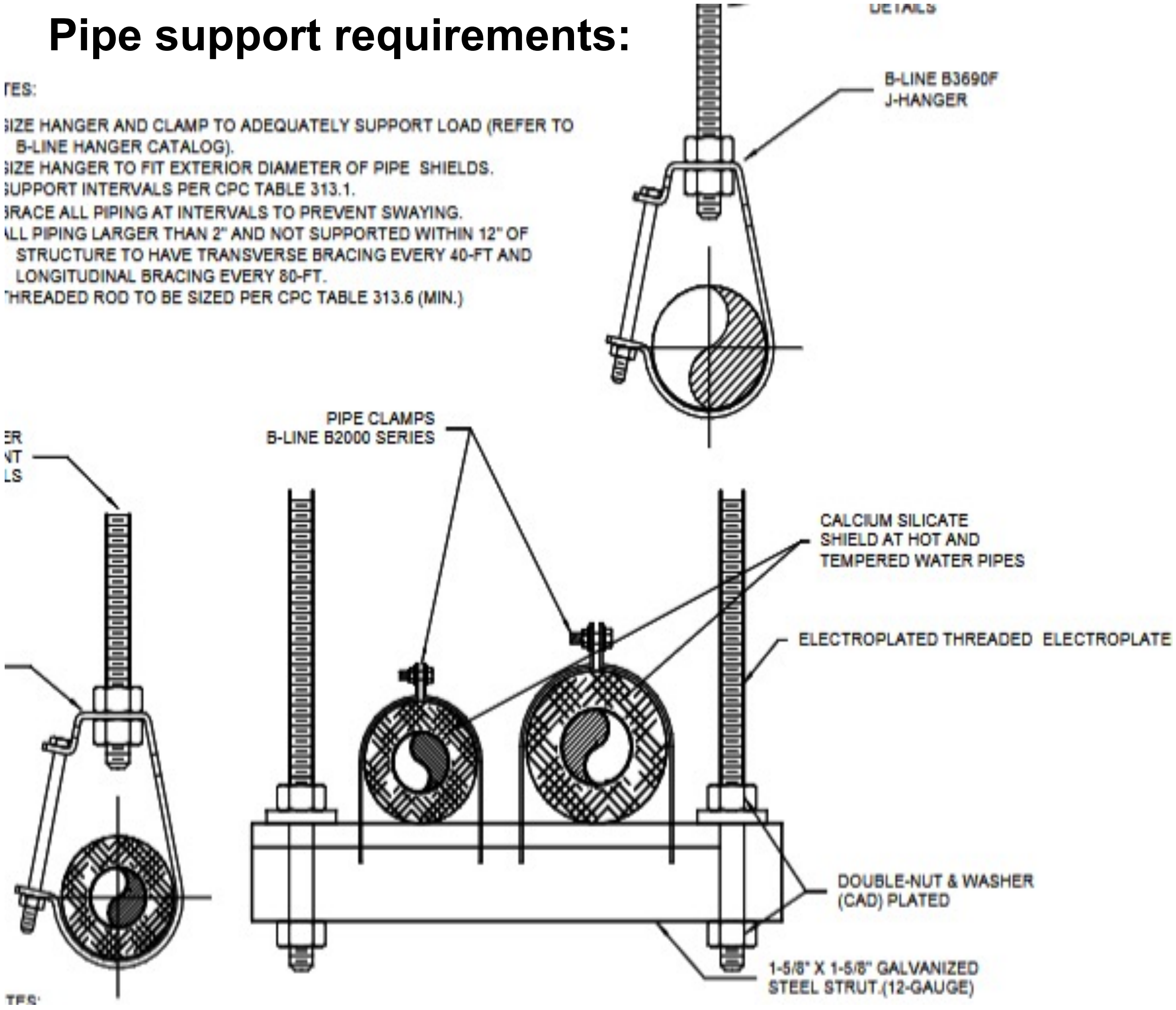
Pipe Insulation:	All hot water supply and return piping in the boiler rooms are to be insulated to Title 24 requirements noted below. In addition to hot water pipes, all fittings, valves, hangers are to be insulated. Fittings attached to domestic hot water storage tanks (cold, T&P, etc.) are to be insulated for a minimum of 3' away from tank.
Installation:	Insulation must be continuous across piping, including all piping components such as fittings, joints, flanges, elbows, and valves. **Where insulated piping is attached to hangers, the attachment shall be outside the insulation,** with the insulation remaining in place between the hanger and the pipe, with no break in the insulation.
Hangers:	All new piping must be supported using thermally broken calcium silicate or rigid phenolic foam and metal pipe shield or approved equal.
Material:	Jacketed fiberglass with PVC elbows for interior application; fiberglass with metal clam shell shielding and metal elbows for all exterior piping.
Thickness:	All new pipe insulation work must meet current Title 24 requirements noted below. All existing piping must be insulated either to current Title 24 requirements or to the maximum thickness allowed based on existing conditions.

For Fluids 105-140°F (DHW)	
Nominal Pipe Diameter	**Insulation Wall Thickness**
< 1inch	1 inch
≥ 1 inch	1.5 inches

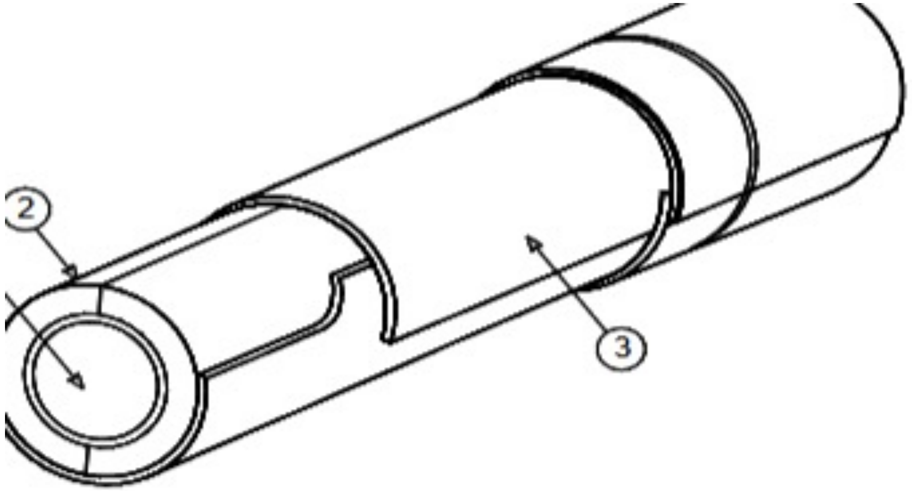
Association for Energy Affordability Inc

Detailed Project Drawings

Pipe support requirements:



Pipe insulation requirements:



GLASS INSULATION WITH ALL SERVICE JACKET.
E PIPING IS NOT CONCEALED IN WALL OR CEILING SPACES, PROVIDE PVC JACKETING O
S & ALUMINUM JACKETING ON PIPING OUTDOORS. SILICONE CAULK PVC JACKETING SE
ATERTIGHT WITH APPROVED ADHESIVE. INSIDE BUILDINGS LOCATE JACKET SEAMS IN L
ON. OUTSIDE, WHERE EXPOSED TO WEATHER, LOCATE JACKET SEAMS ON BOTTOM OF

INSULATION THICKNESS (1)

SERVICE	TEMPERATURE RANGE	NOMINAL PIPE DIAMETER (In Inches)			
		< 1	1 to < 1.5	1.5	2 to <4
HOT WATER	141F - 200F	1.5	1.5	2.0	2.0

Illustration from Advanced Build Energy Program Plan Review Sketches Form Multifamily Building in Santa Rosa.

Proposed Code

Pipe insulation language cleanup to section 160.4(f)1, adding:

- “All” piping for multifamily domestic hot water systems shall be insulated, including first 8 feet of inlet cold water piping to heating plant.
- Adding that appurtenances at heating plant and distribution loop shall be insulated to specific requirements:
  - Insulation thickness to be flush with pipe insulation or minimum 1”-thick if appurtenance is bulkier.
  - Removable and re-installable for maintenance or replacement.
- Insulation on the piping and appurtenances shall be continuous.
- Pipe supports, hangers, and clamps shall be attached on the outside of rigid pipe insulation.
- Installation Quality: All pipe insulation seams sealed, specific insulation installation practices for tees and elbows, extended stem isolation valves
- Definition of hot water piping and plumbing appurtenances.
- Space cooling and heating pipe insulation language incorporated from 120.3

Uniform Pipe Insulation Across Piping, Valves and Fittings

Proposed Code

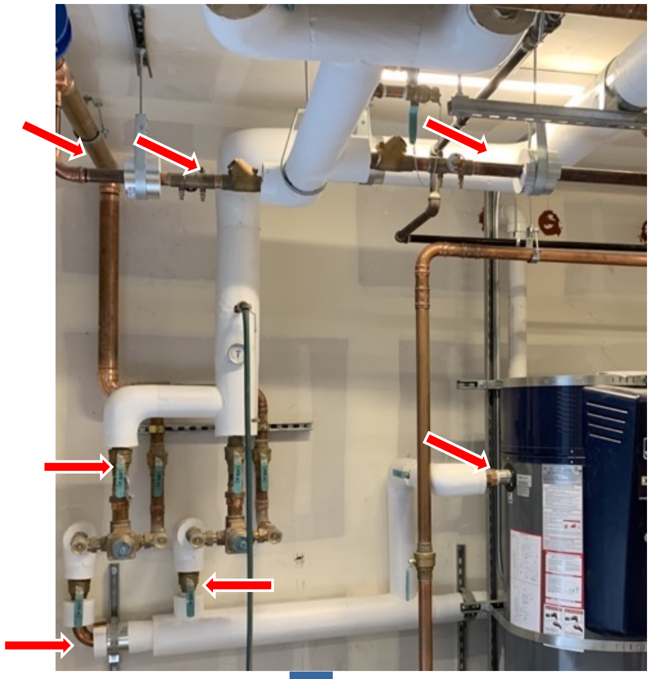
- Mandatory Installer CI form that inspection was performed in accordance to applicable procedures
- Low-rise and nonresidential Certificates of Inspection forms will be updated
- Pipe Insulation Third-Party Field Verification
  - Prescriptive language in section 170.2(d), RA3.6.10 for 3rd Party Verification
  - Low-rise and Nonresidential HERS Inspection forms will be updated
    - Performance option would need to be updated to penalize building design if third-party verification is not completed

Energy Code Ace. 01.26.23. https://energycodeace.com/LowriseMultifamilyForms/2022

Context and History

The prevailing electric heating plant design is the single-pass heat pump placed upstream in series with an electric resistance water heater, known as the “swing tank” configuration.

- The resistance heater is used to make up recirculation loop heat losses in the temperature maintenance system.
- A poorly insulated recirculation loop can have a pipe heat loss of 200 Watts/dwelling unit.
- The best insulated recirculation loop is at 50 Watts/dwelling unit.
- The electric resistance elements in the swing tank must make up most of the heat losses in the recirculation loop for fair to poorly insulated systems at 70-200 Watts/dwelling unit.

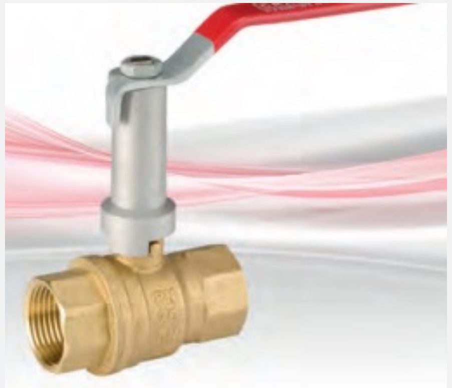


Pipe insulation gaps lead to more resistance use

Market Overview

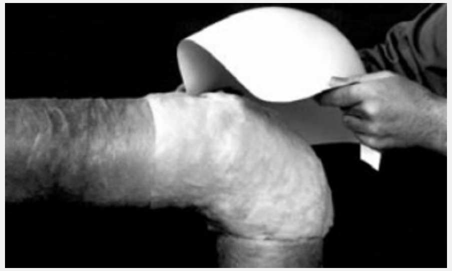
- Current Market Conditions
- Market Trends
- Potential Market Barriers and Solutions

Market Overview and Analysis



Products that support proposed language cleanup measure include:

- Extended stem isolation valves at 2 ¼” to support pipe insulation
- PVC insulated fitting covers and installation instructions
- OEM valve and pump clamshell insulation
- Aftermarket reusable valve wraps for valves, flanges, elbows, tees, seam covers from 1” to 3.5” thickness



The California pipe insulation market is mature and has a wide range of products and fabrication techniques to support this code measure.

Market Overview and Analysis

Review of project plans using 2016 and 2019 Title 24, Part 6 code:
The Statewide CASE Team reviewed pipe insulation language in detail on 23 new construction project drawings, of which 7 provided additional language, as follows—

- 6 pipe jacketing (26%)
- 3 pipe hanger/support insulation (13%)
- 4 sealed seams (17%)
- 5 PVC fitting covers (22%)
- 2 appurtenances (9%)
- 7 heating plant pipe insulation (30%)

Building plans analysis shows designers and developers are not voluntarily incorporating comprehensive pipe insulation requirements into their building plans indicating the need for mandatory language.

Market Overview and Analysis

Market Trends

Stakeholders: What has been your experience with DHW pipe insulation as a designer, contractor, developer, or building inspector?

Market Barriers

- Current design specifications are limited and inconsistent on plans
  → *Solution: A training that details best practice pipe insulation instructions and supporting detailed drawings and the impact on system efficiency would inform the design community*
- Lack of general contractor knowledge to install continuous pipe insulation
  → *Solution: Training for general and subcontractors on the importance of complete and proper pipe insulation and installation techniques.*
- Lack of incentives to comprehensively insulate piping voluntarily in advance of code improvements

Technical Considerations

- Technical Considerations
- Potential Barriers and Solutions

Technical Considerations

Technical Considerations

- The proposal changes standard design specifications and adds field verification

Technical Barriers and Potential Solutions

- Barrier: Contractors typically do not prioritize insulating piping and may take shortcuts to speed up installation; thus, costs are minimized associated with planning, procurement, labor, and materials
  - → *Solution: The proposal explicitly states requirements for pipe insulation. Verification will force contractors to plan for procuring the correct materials and utilize more labor-intensive fabrication techniques to insulate piping comprehensively*

Technical Considerations

Technical Considerations

- The proposal adds field verification of pipe insulation quality installation

Technical Barriers and Potential Solutions

- Barrier: Insulation installation quality has been a problem due to lack of clear requirements and lack of field verification

  → *Solution: Field verification ensures that contractors complete work consistent to mandatory code requirements*

- Barrier: While pipe insulation subcontractors have the training and fabrication techniques to comprehensively insulate piping, additional subcontractors will be needed in the marketplace to meet demand

  → *Solution: Training program development and implementation in comprehensive pipe insulation techniques will build workforce and also train HERS raters for the new requirements*

Energy and Cost Impacts Per Dwelling Unit

Methodology and Assumptions

- Energy Savings Methodology and Results
- Cost Impacts Methodology and Results
  - Incremental costs
  - Energy cost savings

Methodology for Energy Impacts Analysis

Methodology for per-dwelling unit energy and demand impacts

- Plumbing engineers provided basis of design (BOD) recirculation and heating plant piping configurations for the four prototypes based on CPC Appendix A sizing procedure
- Assess distribution pipe heat loss using a custom recirculation loop heat loss model based on pipe heat loss calculation method defined in Title 24 ACM Reference Manual
  - Base case code requirements
  - Proposed code requirements
- Assess heating plant pipe heat loss using heat loss calculation formula defined in Title 24 ACM Reference Manual
- Spreadsheet analysis was conducted to estimate DHW system energy impact
  - Apply code minimum plant operating efficiency to heat loss results
  - Apply long-term systemwide cost factors to hourly energy results

Assumptions for Base Case and Proposed Designs

Base Case Design

All piping is required to be insulated

- Straight pipes are not perfectly insulated based on standard practice
- A portion or all appurtenances and pipe hangers are not insulated

Proposed Design

Improved insulation through code clarification and field verification

- All piping, appurtenances, pipe hangers are required to be insulated
- Installation best practices must be followed
- Insulation field verification is required

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Energy Savings Analysis Assumptions

- Overall pipe insulation quality is determined by three factors
  - The pipe surface area not being insulated
  - Pipe that is insulated but with poor quality
  - Accounts for heat loss from recirculation loop to the branch piping
- Overall pipe insulation quality is represented as the percentage of pipe surface area that is not insulated
- The 2022 Statewide CASE team estimated the pipe insulation quality improvement potential

	Low-Rise Garden	Low-Rise Loaded Corridor	Mid-Rise Mixed Use	High-Rise Mixed Use
Base Case	52%	43%	38.5%	43%
Proposed Case	37%	28%	23.5	28%
Improvement (Based on 2022 DHW CASE Study Report)	15%	15%	15%	15%

Incremental Cost Information

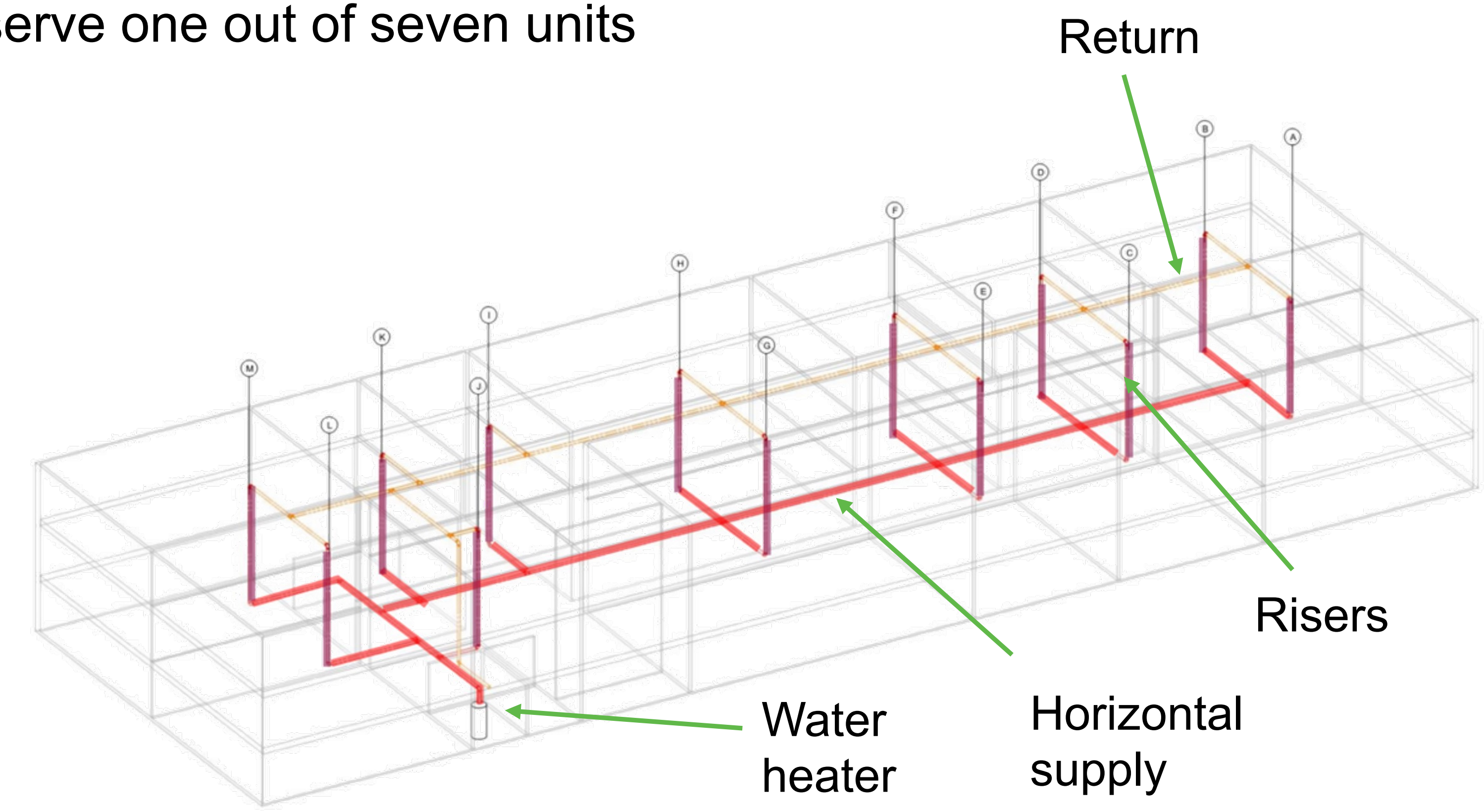
- Cost analysis for recirculation system pipe insulation
  - Recirculation loop configurations are based on 2022 CASE Study report
- Cost analysis for heating plant pipe insulation
  - Heating plant configurations are newly developed for 2025 CASE Study report
    - Documented a list of common appurtenances including pipe supports along with quantity and pipe size
    - Experienced plumbing engineers provided basis of design (BOD) for the four prototypes.
- Design build contractor provided cost estimation for the BOD
  - Obtained pricing for the baseline and proposed pipe-insulation measure to cover procurement, installation, commissioning, maintenance and replacement over 30-year period

Field Verification: Incremental Cost Assumption

HERS inspection sampling assumption (proposed requirement):

- Inspect 100% mechanical room and first level of horizontal piping and;
- Inspect a sample of risers that serve one out of seven units

Most designs have horizontal piping on the same floor as the hot water heater, or offset one floor, that functions as a header for risers that run up or down the building.



Field Verification: Incremental Cost Information

- Data collected through interview with HERS Rater manager
  - 10,000 square feet of floor area can be covered in 3.5 hours
  - Labor rate of $250/hour
- Travel cost includes 100 miles at $0.55/mile
- Number of trips based on 5 hour maximum spent on site per trip
- No baseline cost

Floor area to be verified → hours spent on site → number of trips required

Compliance and Enforcement

- Design
- Permit Application
- Construction
- Inspection
- Revisions to Compliance Software

Compliance and Verification Process

1. **Design Phase**
   Ensure that the correct section of code is referenced or copied into the drawings

2. **Permit Application Phase**
   Plan examiner reviews and approves project pipe insulation and hanger drawings and requirements to ensure they meet code requirements

3. **Construction Phase**
   - Contractors insulate pipe to code requirements following designer requirements
   - Contractor communicates with HERS/Acceptance Test Technician (ATT) inspector to come onsite and review insulation work prior to sheetrock being places on walls and ceilings

4. **Inspection Phase**
   - HERS/ATT inspector approves work
   - Builder inspector inspects drawings, inspection forms, and visible pipe insulation

Review of Code Language Markup

- Draft Code Change Language

Draft Code Change Language

SECTION 160.4 – MANDATORY REQUIREMENTS FOR WATER HEATING SYSTEMS

(f) Insulation for piping and tanks

1. All piping for multifamily domestic hot water systems shall be insulated to meet the requirements of Table 160.4-A.

All plumbing appurtenances on hot water piping from a heating source to heating plant, at the heating plant, and distribution supply and return piping shall be insulated.

Pipe supports, hangers, and pipe clamps shall be attached on the outside of rigid pipe insulation to prevent thermal bridging.

SECTION 170.2 – PERSCRIPTIVE APPROACH

Section 170.2(d) Water Heating Systems.

For hot water piping serving individual and multiple dwelling units, heating plant and recirculation system piping insulation quality shall be field verified and shall meet the criteria specified in Reference Appendix RA36.10.

SECTION 180.2 – ALTERATIONS

Draft code language available for review in the resources tab and downloadable.

Provide feedback to CASE Author by March 3, 2023.

Discussion and Next Steps

We want to hear from you!

- Provide **any last comments or feedback** on this presentation now verbally or over the chat
- More information on pre-rulemaking for the 2025 Energy Code at https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2025-building-energy-efficiency

Comments on this measure are due by March 3rd. Please send comments to info@title24stakeholders.com and copy CASE Authors (see contact info on following slide).

Thank You

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CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

TITLE 24, PART 6 | 2025 CODE CYCLE

Automatic Balancing Valves

Codes and Standards Enhancement (CASE) Proposal
Multifamily Domestic Hot Water Distribution

Jose Garcia, TRC
February 17, 2023

CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Background

- Context and History
- 2022 Code Requirements
- Code Change Proposal

Context and History

This proposal saves energy and reduces first costs in multifamily buildings with smaller circulation systems by improving on common design and installation practices

Thermal balancing valves:

- Do not require manual balancing
- Result in lower pipe surface temperatures on average, saving energy
- Improves delivery performance of the hot water system, resulting in reduced risk of:
  - Hot water supply set point increase
  - Scalding
  - Legionella
- Work best with variable speed pumps

This proposal was previously investigated, but not proposed, by the 2022 Statewide CASE Team

- Savings were limited due to the baseline implementation of circulation pump demand control
- The Statewide CASE Team is proposing a new baseline without circulation pump demand control. See the Recirculation System Demand Control Cleanup section of this slide deck.

Current Code Requirements

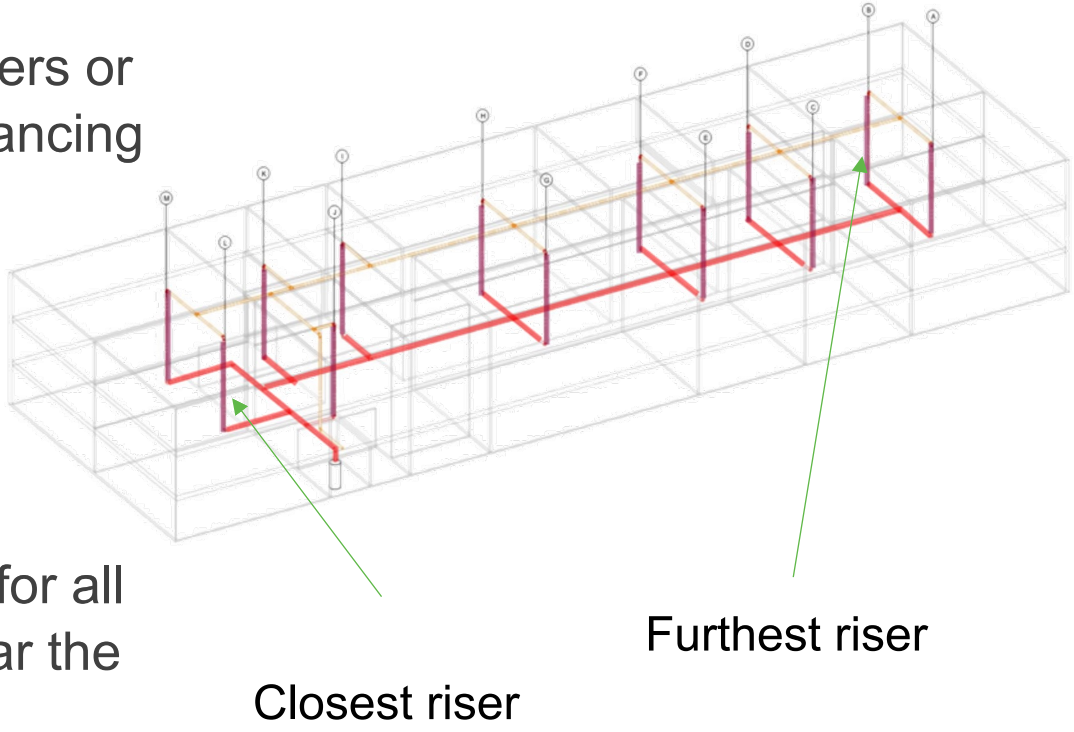
- Currently **2022 Title 24, Part 6** does not have specific requirements for balancing of multi-riser systems
- Related **industry standards** that impact the design of multi-riser systems include ASHRAE Guideline 12 and ASHRAE Standard 188
- **Other jurisdictions:** Washington state energy code requires “means for balancing the flow rate through each individual hot water supply riser or piping zone” for multi-riser systems

Poll Request

- **Measure Name:** Automatic Balancing Valve
- **Type of Poll:** Open Response
- **Question:** Are there other relevant code requirements, including for jurisdictions outside of California, that you are aware of?
- **Answers:**
- **Placement:** After Current Code Requirements
- **Broadcast results to attendees as they respond:** Y
- **Make poll public during presentation:** Y

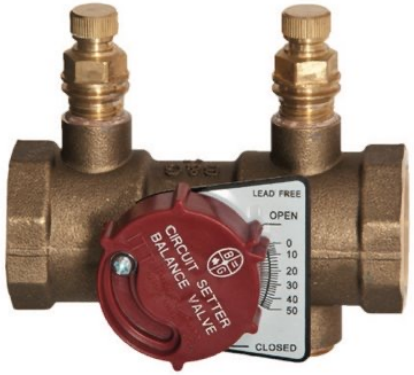
Current Practice

- Multifamily buildings typically include multiple return risers or return piping zones (multi-riser), which require flow balancing at each riser to work properly
- Riser flow rates are not always clearly specified
  - Example from plans review: “Set balancing valves partly open to restrict but not stop flow.”
- When specified, riser flow rates are typically the same for all risers, resulting in higher temperatures at the risers near the water heater
- Manual valves are often poorly balanced or not balanced
- Instrumentation is rarely used to verify flow rates

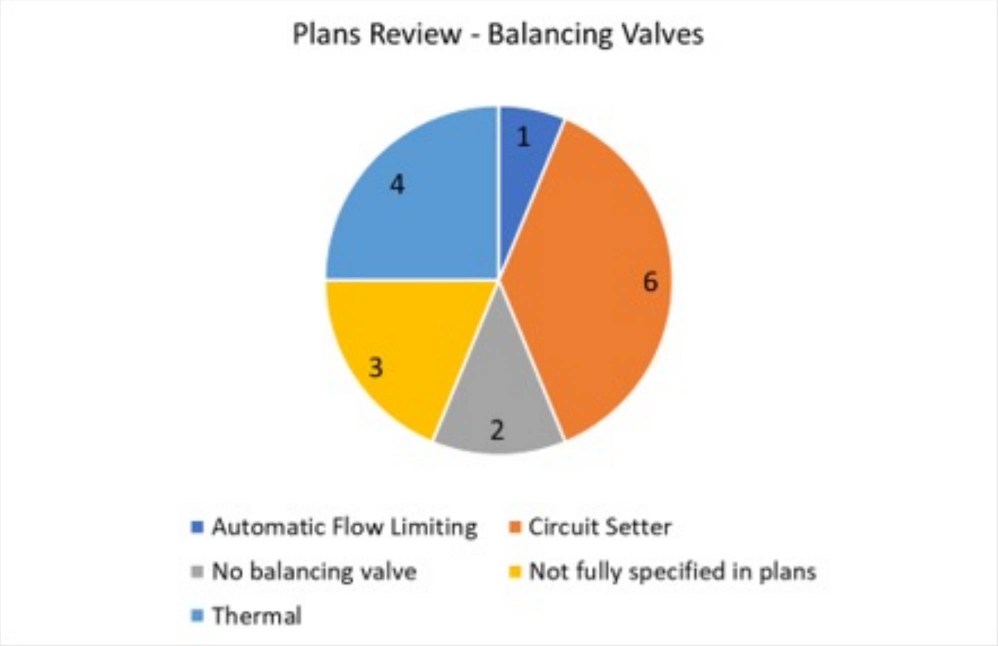


National Pump Supply, 01/24/2023, https://cdn11.bigcommerce.com/s-lej68b8h/images/stencil/1280x1280/products/505/11182/bell--gossett-circuit-setter-plus-balance-valve-bg__73688.1586049231.png?c=3?imbypass=on

Current Practice



- "Circuit setter" type valves are the most common product, being specified in 6 of 16 project reviewed
- Thermal balancing valves are increasing in adoption
  - 3 of 7 interviewees use thermal balancing valves
  - Thermal balancing valves were specified in 4 of 16 projects reviewed
- Variable speed pumps were specified in 7 of 16 projects reviewed



Proposed Code Change

This proposed measure is a compliance option.

- Applies to new construction, additions, and alterations
- Applies to central hot water systems with more than one riser

For a compliance credit, the project shall include:

- Thermal balancing valves set to a maximum temperature set point of 120 °F at the last branch from each riser
- A variable speed pump with differential pressure control
- Hot water return piping total developed length (TDL) that does not exceed a specified length
  – Lab testing is currently being performed to determine an appropriate TDL cutoff

Caleffi Hydronic Solutions, 01/24/2023, https://www.caleffi.com/usa/en-us/catalogue/thermosettertm-thermal-balancing-valve-116140a

Market Overview

- Current Market Conditions
- Market Trends
- Potential Market Barriers and Solutions

Market Overview and Analysis

Current Market

- Plans review indicated two common thermal balancing valve products
  - Caleffi 116
  - Thermomegatech circuit solver
- Bell and Gossett has a thermal balancing valve product
- Rated turndown ratios range from 4 - 13,
  with minimum Cv of 0.2 being most common

Market Trend: Interviews and plans review indicate increasing adoption

Market Barriers

- Barrier: Designers and contractors have to learn how to correctly implement the product
- Solution: Manufacturers often provide engineers and contractors with training on new products

Thermomegatech, 02/26/2023, https://www.thermomegatech.com/product/circuit-solver/

Poll Request

- **Measure Name:** Automatic Balancing Valve
- **Type of Poll:** Multiple choice
- **Question:** Designers, design consultants, and contractors: What balancing valve products are you specifying or installing in your multi-riser projects?
  - (1) Mostly or all manual balancing valves
  - (2) Mostly or all thermal balancing valves
  - (3) Other (Please type your response in the chat)
  - (4) It depends (Please type your rationale in the chat)
- **Answers:**
- **Placement:** After Market Overview and Analysis
- **Broadcast results to attendees as they respond:** Y
- **Make poll public during presentation:** Y

Technical Considerations

Technical Considerations

- Balancing valves may not always meet temperature set point due to system hydraulics
  - Valve Cv and distribution system layout determine the resultant minimum valve flow rate
  - Based on preliminary lab data, pressure drop in the return piping is an important driver of overall pressure drop
  - To receive compliance credit, the return piping TDL needs to be below a specified value
  - Plumbing engineers are familiar with calculating TDL to size the domestic distribution system

- System performance is reliant on variable speed circulation pump selection and set up
  - To receive compliance credit, the plumbing designer needs to specify a variable speed circulation pump with some form of differential pressure control
  - Variable speed circulation pumps are common

Energy and Cost Impacts Per Dwelling Unit

Methodology and Assumptions

- Energy Savings Methodology and Results
- Cost Impacts Methodology and Results
  - Incremental costs
  - Energy cost savings

Methodology for Energy Impacts Analysis

Methodology for per-dwelling unit energy and demand impacts

- Plumbing engineers provided basis of design (BOD) for the four prototypes.
  - Manual balancing valve with constant speed pump
  - Thermal balancing valve with variable speed pump
- Spreadsheet analysis was conducted to estimate the system performance
  - Advanced capabilities to capture DHW distribution system heat loss
  - Estimate energy savings due to reduced DHW distribution system heat loss
  - Apply plant efficiency
  - Experienced plumbing engineer gives input to spreadsheet analysis to verify valve performance is realistic based on rated valve performance (Cv)
- Apply Long-term Systemwide Cost factors to hourly energy results

Assumptions for Base Case and Proposed Designs

Base Case Design

Manual balancing valve with constant speed pump

- Riser temperature is not specified, rather riser flow rate is set to 0.5 GPM per riser
- Constant speed pump

Proposed Design

Thermal balancing valve with variable speed pump

- 120°F hot water temperature at last riser branch
- Variable speed pump with constant pressure control
- Minimum flow rate is limited by minimum valve Cv (0.23)
- Pump energy savings are not currently estimated

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Incremental Cost Information

- Plumbing engineers provided BOD for the four prototypes
  - Manual balancing valve with constant speed pump
  - Automatic balancing valve with variable speed pump
- Design build contractor provided cost estimation for the BOD
- Interviews with manufacturers, distributors, or contractors confirmed the design concept

Costs results are pending but preliminary data shows cost savings due to lower balancing costs.

Seeking maintenance costs from stakeholders.

Poll Request

- **Measure Name:** Automatic Balancing Valve
- **Type of Poll:** Multiple choice
- **Question:** Designers, design consultants, and contractors: Do you agree that thermal balancing valves cost less up front due to reduced balancing costs?
  - (1) Yes
  - (2) No, the labor savings are not that significant
  - (3) No, there are no labor savings
  - (4) I don't know
- **Answers:** One of the options available: Display as bar chart showing percent of respondents who picked each option
- **Placement:** After Incremental Cost Information
- **Broadcast results to attendees as they respond:** Y
- **Make poll public during presentation:** Y

Preliminary Energy Savings Estimates Per Dwelling Unit

Savings Estimate	Low Rise Garden Style		Low Rise Loaded Corridor	
	HPWH System	Gas System	HPWH System	Gas System
Annual Electricity Savings (kWh/yr)	34 to 48	0	11 to 12	0
Peak Demand Reduction (W)	4 to 6	0	~1	0
Annual Natural Gas Savings (Therms/yr)	0	144 to 204	0	46 to 53
Annual Systemwide Life Cycle Cost Savings (2026 PV $)	226 to 324	171 to 244	73 to 83	55 to 63

Compliance and Verification Process

1. **Design Phase**
   - Plumbing engineer specifies the thermal balancing valve product and circulation pump product, the thermal balancing valve temperature set point, and pump control method
   - Energy compliance professional coordinates with the plumbing engineer and documents that the requirements to receive compliance credit are met

2. **Permit Application Phase**
   Authorities having jurisdiction (AHJ) verifies that construction documents match the energy compliance forms, and meet the criteria for compliance credit

3. **Construction Phase**
   General contractor works with plumbing subcontractor to ensure construction documents are carried out in construction, and to document compliance

4. **Inspection Phase**
   AHJ verifies the type of systems in the approved permit have been installed

Review of Code Language Markup

- Draft Code Change Language

Draft Code Change Language

Adds language to Section 170.1 describing the compliance option.

Provide feedback to CASE Author by March 3, 2023.

Discussion and Next Steps

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Thank You

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CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

TITLE 24, PART 6 | 2025 CODE CYCLE

Master Mixing Valves

Codes and Standards Enhancement (CASE) Proposal
Multifamily Domestic Hot Water

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CALIFORNIA ENERGY CODES & STANDARDS
A STATEWIDE UTILITY PROGRAM

Introduction

- The California Plumbing and Energy Codes do not require the use of master mixing valves (MMV) for centralized domestic hot water (DHW) distribution systems with recirculation
- Measure will require builders to use thermostatic MMV in the mechanical room prior to piping leading to the hot water distribution system
- Will result in energy savings from reduced pipe heat loss from lower temperature recirculation loops
- Yields additional savings at the heating plant by diverting most of the recirculation loop return water back to the mixing valve versus going back to the storage tank to maximize water temperature stratification in the tank

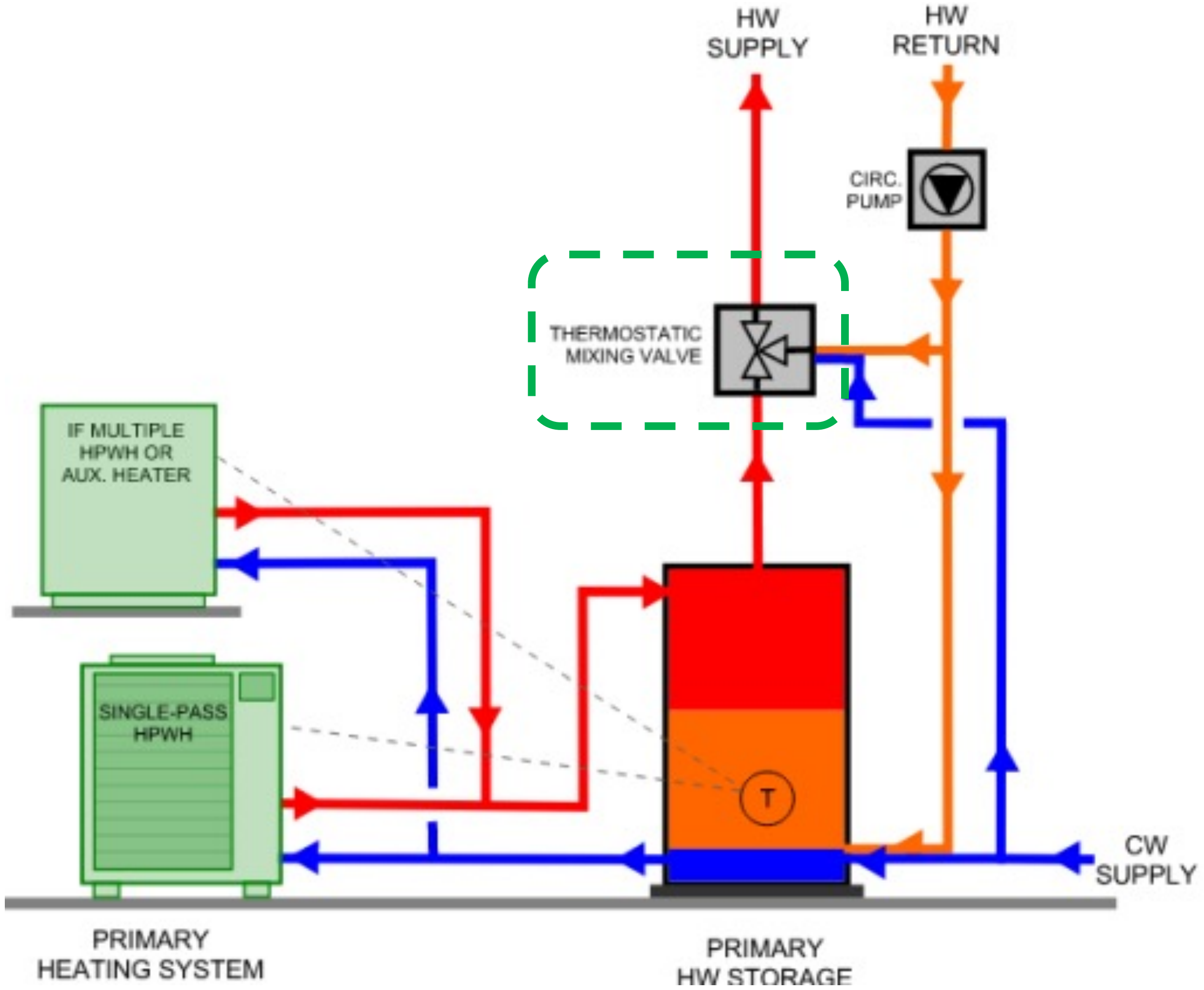


Photo Credit NEEA. 2/2023. https://neea.org/img/documents/Advanced-Water-Heating-Specification.pdf

Background

- Context and History
- Current Practices
- Code Change Proposal

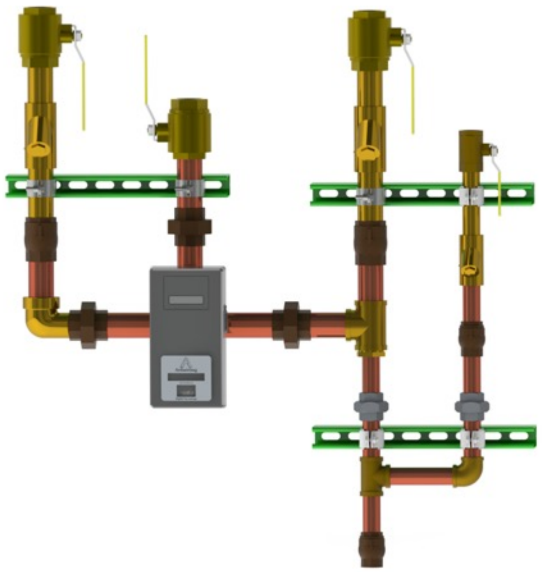
Context and History

Mixing valves are used to mitigate pathogen growth and scalding risk:

- MMVs offer the simplest solution to controlling the temperature in a centralized DHW system distribution loop
- Correct sizing is needed to ensure the valve is responsive and minimizes pressure loss by meeting the maximum design water flow rate

The broader industry has started advocating for MMV use:

- Recommended by several leading HP manufacturers' installation guidelines
- The Northwest Energy Efficiency Alliance's (NEEA) *Advanced Water Heating Specification 8.0* defines four major components of a central heat pump water heating (HPWH) system including temperature maintenance system (TMS)
  - Thermostatic MMV are a required component of the TMS



Context and History

Use of MMVs to precisely control the distribution supply and return temperatures has become ubiquitous with central HPWH systems.

MMV at the heating plant offer energy benefits:

- Higher heating plant operating efficiency
- Lower centralized distribution loop heat losses versus mixing at the dwelling unit
- Load shifting capabilities
- Ability to safely increase storage heating capacity

PHCP Pros. When Does Digital Mixing Make Sense? | 2021-02-01 | phcppros

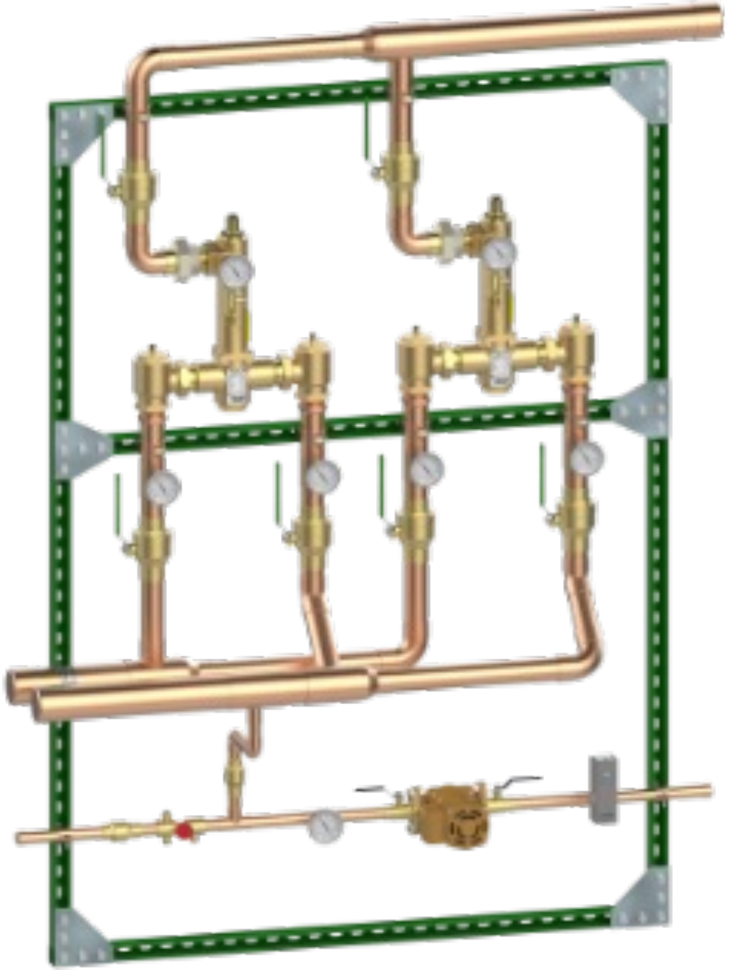
Current Practices

Central DHW systems with recirculation designs:

- Mechanical MMV are commonly specified
- Install multiple MMV in parallel for multifamily buildings four habitable stories or more for better mixing control

ASSE 1017 standard cannot differentiate the performance of various MMV types for central DHW

- No requirements to verify that the device performs thermostatic mixing
- Temperature control requirement is not stringent
- Valves are not tested to operate with continuous recirculation



PM Engineer. 12/2022. https://www.pmengineer.com/articles/93940-julius-ballanco-the-demise-of-asse-1070

Proposed Code Change

Mandatory requirements for Water Heating Systems:

Centralized water heating plants with continuous recirculation system(s) shall install a digital or mechanical thermostatic MMV on each distribution loop that conforms to ASSE 1017-2009

1. MMV shall be:
    - installed on the heating plant hot water supply outlet header leading to the recirculation loop.
    - installed and commissioned in accordance with manufacturer's instructions and applicable reference appendix.
2. The plumbing plans shall provide MMV installation details and specifications indicating water mixing parameters, if this exceeds the mixing capability of the specified MMV, the designer shall provide valve commissioning instructions to prevent temperature creep.

A compliance option to install digital MMV in lieu of mechanical MMV for central DHW systems

Market Overview

- Current Market Conditions
- Market Trends
- Potential Market Barriers and Solutions

Market Overview and Analysis

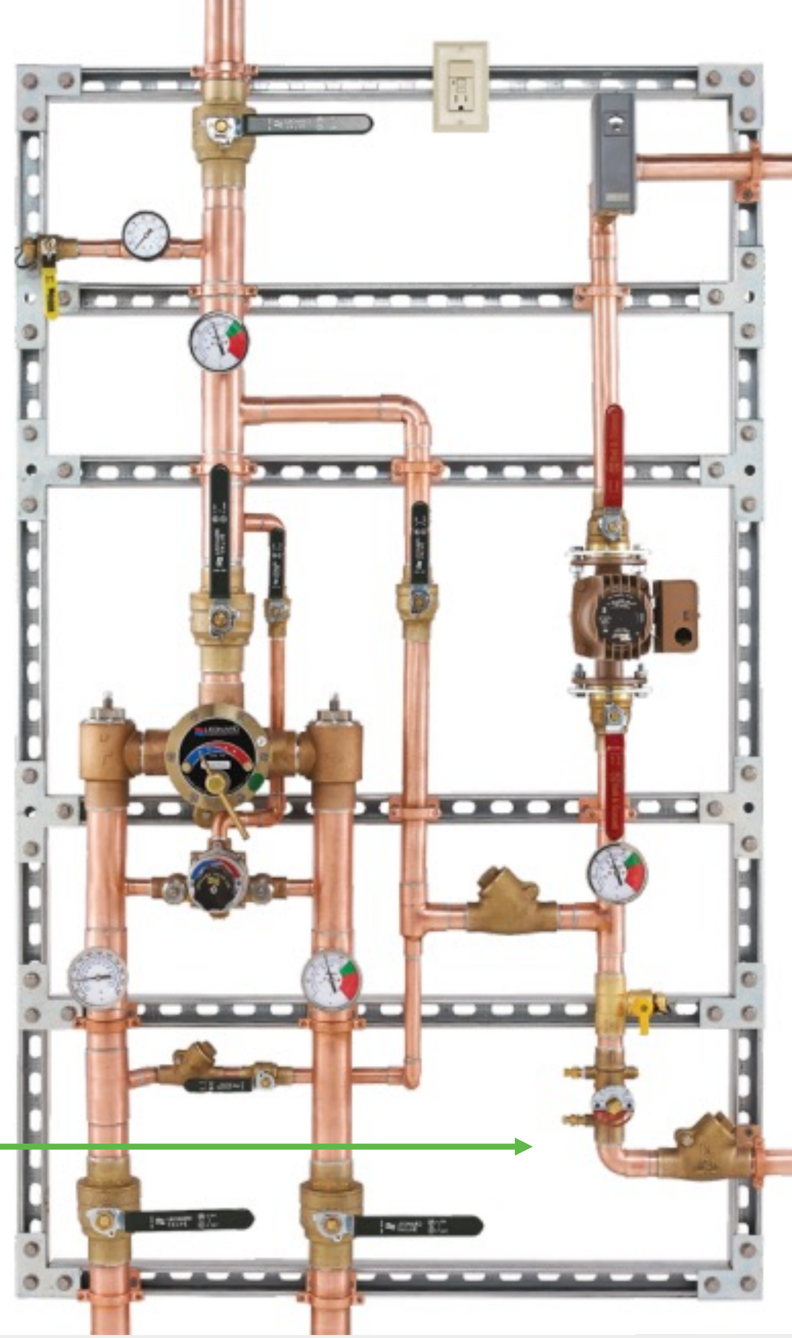
Mechanical MMVs

Benefits of mechanical MMV:

- Standard practice, lower cost to install

Drawbacks of mechanical MMV:

- Originally designed to mix hot and cold water with greater than 20°F temperature difference
- Many are not designed or rated for operation of variable water draw distribution systems with recirculation return loop
- They regulate the heater outlet water temperature less accurately
- Slower response, impacted more by pressure fluctuations
- Most manufacturers require installation with balancing valve



Market Overview and Analysis

Digital MMVs

Benefits of digital MMV

- Energy saving benefits
  - Promotes greater stratification in gas-fired or heat pump-based indirect storage tank systems or integrated water heaters leading to higher efficiency operation
  - Regulates the heater outlet water temperature more accurately
  - Minimizes energy waste by limiting cold water intrusion into the distribution loop
- Better handles pressure fluctuations
- Some units have monitoring, remote adjustment, and night setback
- Low commissioning costs

Drawbacks of digital MMV

- More expensive to purchase
- Sensors can malfunction
- Requires power

Poll Request

- **Measure Name:** Master Mixing Valves
- **Type of Poll:** Open Response
- **Question:** Can you share your experience with mechanical or digital MMVs?
- **Answers:**
- **Placement:** After Market Overview and Analysis Slide
- **Broadcast results to attendees as they respond:** Y
- **Make poll public during presentation:** Y

Market Overview and Analysis

Current Market by Hot Water System Type

Based on new building project drawings in California:

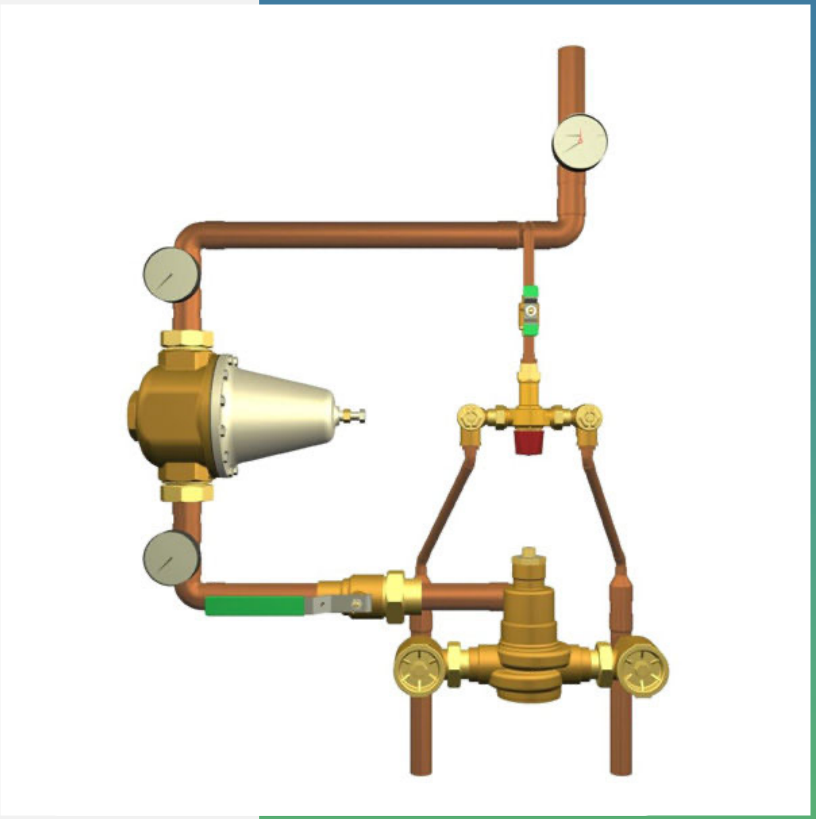
- 34 multifamily buildings with MMV (82%)
- 2 central heating plants with MV at dwelling unit (9%)
    - 1 heat pump and 1 gas-fired heating plants
- 2 central heating plants with no MV (9%)
    - 2 gas-fired heating plants

18% of centralized systems do not use MMV at the outlet of the heating plant and either mix downstream, at the dwelling unit, or none.

Market Overview and Analysis

Current Market by MMV Type

- Based on 25 project drawings
  - 23 mechanical MMV (92%)
    - 16 Paraffin (64%)
    - 5 Bi-metal High-Low (20%)
    - 2 Unknown (8%)
  - 2 digital MMV (8%)
- Paraffin or Bi-metal High-Low are the most popular
- Factory built mixing stations found in 4 projects



Designer Interview Results

3 of 5 building designers state they only or predominately specify digital MMV.

MMV Sizing and setup widely varies between designers:

2 designers size the MMV using Appendix A

- One uses multiple mechanical MMV in parallel to meet higher maximum flow requirements, not for redundancy reasons
- The other designer uses digital only and typically sizes using a single MMV

2 others size the MMV using Appendix M

- One uses parallel mechanical MMV for redundancy in larger buildings
- The other designer uses single digital MMV for most buildings, unless redundancy is necessary or maximum flow requirements dictate parallel MMV

Designer Interview Results

Rank the factors that influence MMV specification	Average of 5 Designers
Reliability	High
Regulate the heater outlet water temp. more accurately	High
MMV promotes load shifting by storing water at higher temps	High
MMV reduces the use of ER or NG supplemental heating by storing water at elevated temps	High
Pathogen mitigation	Medium/High
Minimum inlet to outlet temp. differential	Medium/High
Increased storage energy capacity with the aid of MMV to reduce storage volume needs	Medium
Scalding mitigation	Medium
Pressure loss rating	Medium
Zero demand temperature creep mitigation	Medium
Cost	Medium/Low

Technical Considerations

- Technical Considerations
- Potential Barriers and Solutions

Technical Considerations

- MMVs have to meet a product standard (ASSE 1017) for thermal compliance for once through applications
- A common practice to size MMV using Appendix A methodology for maximum flow rate causes oversizing of MMV and reduced valve responsiveness
  - The proposed Appendix M measure will support right sizing
  - Several designers interviewed use alternative sizing methodologies close to Appendix M to ensure MMV are sized appropriately

Research required to understand how often digital valves fail in field applications

- What happens when the power goes out?
- In the lab, other failure modes were observed such as faulty temperature sensors, unit locked up, and required rebooting after a 1-hour period of pump nonoperation.

Poll Request

- **Measure Name:** Master Mixing Valves
- **Type of Poll:** Open Response
- **Question:** What have you observed in the field with the commissioning or operation of mechanical or digital master mixing valves?
- **Answers:**
- **Placement:** After Technical Considerations 1st Content Slide
- **Broadcast results to attendees as they respond:** Y
- **Make poll public during presentation:** Y

Technical Considerations

Technical Barriers and Potential Solutions

Market Barriers:

- "If its not broke, don't fix it." Hard to overcome business-as-usual mentality; specify mechanical MMV and ignore temperature creep mitigation
  - After factoring in addition of balancing valve per manufacturer's guidelines and extensive commissioning for mechanical MMVs, digital valves are cost competitive
- Lack of familiarity with digital MMV
  - Valve manufacturers are promoting digital
  - Lab and field-testing, case studies, and testimonials by peers (designers and contractors and operators) would support transition

ACEEE 2021 Hot Water Forum Session 16. March 18, 2021. https://drive.google.com/file/d/1UkUXWGldtqUFMHjcJIDs2_GXdrmCTrjr/view

Poll Request

- **Measure Name:** Master Mixing Valves
- **Type of Poll:** Open Response
- **Question:** Are there any other market observations or technology considerations with MMVs that we should be aware of?
- **Answers:**
- **Placement:** After Technical Considerations 2nd Content Slide
- **Broadcast results to attendees as they respond:** Y
- **Make poll public during presentation:** Y

Lab Testing of MMVs

Lab testing at Pacific Gas and Electric Applied Technology Services, where heat pump-based DHW systems operate to mimic real world operation in multifamily buildings.

24-hour DHW system testing was conducted

- With no MMV
- With mechanical MMV
- With digital MMV

Testing is limited but provides a window into the impact of MMV:

- Preliminary electricity savings at the heating plant of 8.9% from using a MMV versus no MMV and mimicking mixing at the dwelling unit
- Existing testing has shown 1.2% savings from using digital versus mechanical MMV at 120°F supply and 110°F return temperatures
  - Plan to test MMV with low heat loss rates of 50 watts/DU and elevated return temperatures above 120°F
  - High flow rate low delta T distribution loop designs will demonstrate performance variation between MMV technologies

	SAVINGS FROM		
Heating Plant Design	Mechanical MMV from no MMV	Digital MMV from no MMV	Digital MMV from Mechanical MMV
Single Pass HP with Series Electric Resistance Heater			
Single Pass HP with Parallel Multi Pass HP/Tank		10.8%	
Single Pass HP Return to Primary	8.7%	10.0%	1.2%
Multi Pass HP Return to Primary		11.2%	

Energy and Cost Impacts Per Dwelling Unit

Methodology and Assumptions

- Energy Savings Methodology and Results
- Cost Impacts Methodology and Results
  - Incremental costs
  - Energy cost savings

Methodology for Energy Impacts Analysis

Methodology for per-dwelling unit energy and demand impacts

- The lab testing was completed for the four main heating plant designs in:
  - 44-unit medium draw profile which is half of the 88-unit prototype multifamily building
  - Energy savings can be extrapolated for the various other prototypes and heating plant types
- Lab testing results will be used to calculate heating plant energy savings per dwelling unit
- California Building Energy Code Compliance (CBECC) modeling and post processing will be used to calculate energy use in all 16 climate zones for the proposed case with thermostatic MMV (Mandatory requirement)
- Base case assumes no MMV and additional plant energy use
- For gas heating plants, the heat loss savings in the loop remain unchanged, the savings at the heating plant are estimated

Incremental Cost Information

- Plumbing engineers provided BOD for the four prototypes.
- Interviews with manufacturers, distributors or contractors confirmed the design concept.
- Design build contractor provided cost estimation for the BOD
  - Obtained pricing for the baseline and proposed MMV to cover procurement, installation, commissioning, maintenance and replacement over 30-year period

Proposed mandatory measure

- Base case: no MMV
- Proposed case: mechanical or digital MMV

Performance option

- Base case: mechanical MMV
- Proposed case: digital MMV

Compliance and Enforcement

- Design
- Permit Application
- Construction
- Inspection

Compliance and Verification Process

1. **Design Phase**
   - Designer ensures that MMV specification, mixing parameters, and instructions are provided in plans and meets code requirements.
   - Energy consultant in preparing compliance documentation and optional performance compliance form.
2. **Permit Application Phase**
   - Compliance documents are submitted with the building permit application to verify compliance.
   - Plan examiner checks plans to ensure the building conforms to energy standards, health and safety requirements, and verifies that info on construction documents is consistent with requirements on the compliance documents.
   - After the plans examiner has approved the plans, the enforcement agency will issue the building permit.
3. **Construction Phase**
   - Upon receiving a building permit, the contractor begins construction, including installation and commissioning of specified MMV.
   - The contractor is required to complete the related LMCI/NRCI form and post a copy of inspection forms at the building site for review by the enforcement agency in conjunction with requests for final inspection for the building.
4. **Inspection Phase**
   - Local enforcement agency representatives inspect new buildings to ensure compliance and verify construction.
   - The inspector will verify LMCI/NRCI forms have been completed and signed.

Review of Code Language Markup

- Draft Code Change Language

Draft Code Change Language

SECTION 160.4 – MANDATORY REQUIREMENTS FOR WATER HEATING SYSTEMS

(j) Master Mixing Valves. Centralized water heating plants with recirculation system(s) shall install thermostatic master mixing valve on each distribution loop that conforms to ASSE 1017-2009 standard.

1. The master mixing valve shall be installed on the heating plant hot water supply outlet header leading to the recirculation loop.
2. The master mixing valve shall be installed and commissioned in accordance with manufacturer's instructions and applicable reference appendix.
3. The plumbing plans shall provide MMV installation details and specifications indicating water mixing parameters

SECTION 180.1 – ADDITIONS

SECTION 180.2 – ALTERATIONS

Anytime additions or alterations to the distribution system or water heater in a central water heating system with continuous recirculation are made, the contractor shall verify the existence of, or install, a thermostatic master mixing valve on each distribution loop.

Draft code language available for review in the resources tab and downloadable.

Provide feedback to CASE Author by March 3, 2023.

Discussion and Next Steps

We want to hear from you!

- Provide **any last comments or feedback** on this presentation now verbally or over the chat
- More information on pre-rulemaking for the 2025 Energy Code at https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2025-building-energy-efficiency

Comments on this measure are due by March 3rd. Please send comments to info@title24stakeholders.com and copy CASE Authors (see contact info on following slide).

Thank You

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