ASSOCIATION FOR ENERGY AFFORDABILITY INC.

Heat Pump Water Heating

Technology Deep Dive

6/25/26

ASSOCIATION FOR ENERGY AFFORDABILITY INC.

Association for Energy Affordability

Dedicated to achieving clean, efficient, and equitable zero net carbon multifamily building stock in California

Presenters

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California Electric Homes

Agenda

- California Electric Homes Overview
- Heat Pump Water Heating Fundamentals
- Unitary Heat Pump Water Heating
- Central Heat Pump Water Heating
- Maintenance and Operations
- No Cost Technical Assistance
- Discussion

California
ELECTRIC
HOMES

INCENTIVE PROGRAM OVERVIEW

CALIFORNIA ELECTRIC HOMES

California ELECTRIC HOMES

Eligibility: All-electric residential new construction

- **Territory:** All of California
- **Building Type:** Single family, duplexes, triplexes, condominiums, low-rise and high-rise multifamily, ADUs, modular, and manufactured homes
- **Income Restrictions:** Market-rate

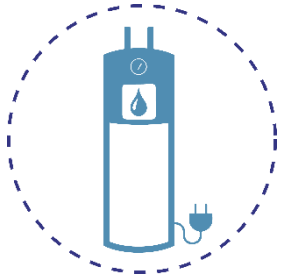
Incentives: Capped at $1.5M per builder/developer ($2M for first time all-electric builder/developer)

- **All-Electric New Construction**
- **Energy Storage**
- **Bonus Incentives:** Envelope and mechanical packages, DAC/HTR, load management, and more
- **Technical Assistance**

INCENTIVE ELIGIBILITY

100% all-electric residential buildings with the following:

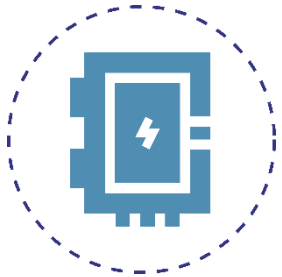
Heat Pump Space Heating



Heat Pump Water Heating

Induction Cooking

Thermostatic Mixing Valves



Segregated Circuits

Communicating Thermostats

These requirements must be met to qualify for any incentives in CalEHP, including both the base and bonus incentives.

California ELECTRIC HOMES

BASE ELECTRIFICATION INCENTIVES

California ELECTRIC HOMES

Incentive Levels per Participating Dwelling Unit[1]	2026	2027	2028
Market Rate			
SF/duplex/triplex/townhome	$2,500	$2,500	$2,500
MF/condo/ADU	$1,400	$1,400	$1,400
Manufactured Housing	$5,000	$5,000	$5,000
Disadvantaged Community (DAC) or Hard-to-Reach (HTR)			
SF/duplex/triplex/townhome	$3,000	$3,000	$3,000
MF/condo/ADU	$1,750	$1,750	$1,750
Manufactured Housing	$5,500	$5,500	$5,500

Eligibility Specification: Projects located in jurisdictions with active all-electric reach codes or ordinances that prohibit natural gas infrastructure are **not eligible** for base electrification incentives.

[1] Incentive level set by year the dwelling unit is completed

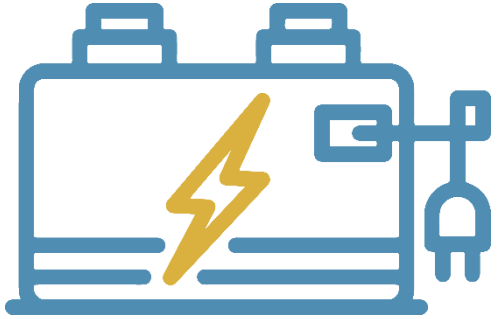
All projects must submit technical review documents for each completed lot or building by November 15 to receive that program year's incentives.

BASE ENERGY STORAGE INCENTIVES

California ELECTRIC HOMES

Incentives:

- $250/kWh for battery storage
- $300/kWh for battery storage in all-electric reach code jurisdictions



To qualify for the energy storage incentives, a project must still meet the program requirements

***CEC approved battery storage systems:**
https://solarequipment.energy.ca.gov/Home/EnergyStorage

Heat Pump Water Heating Fundamentals

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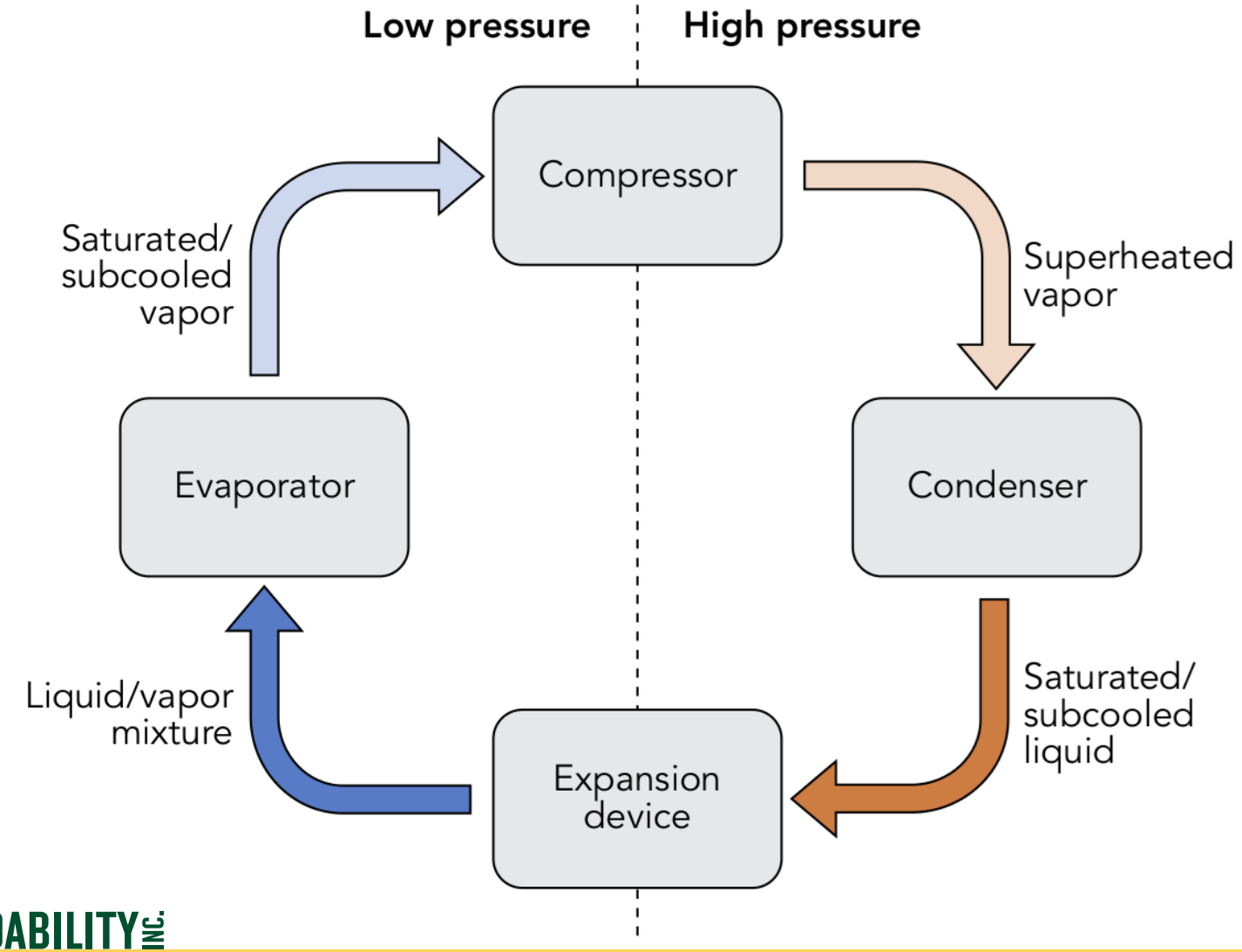
What is a Heat Pump?

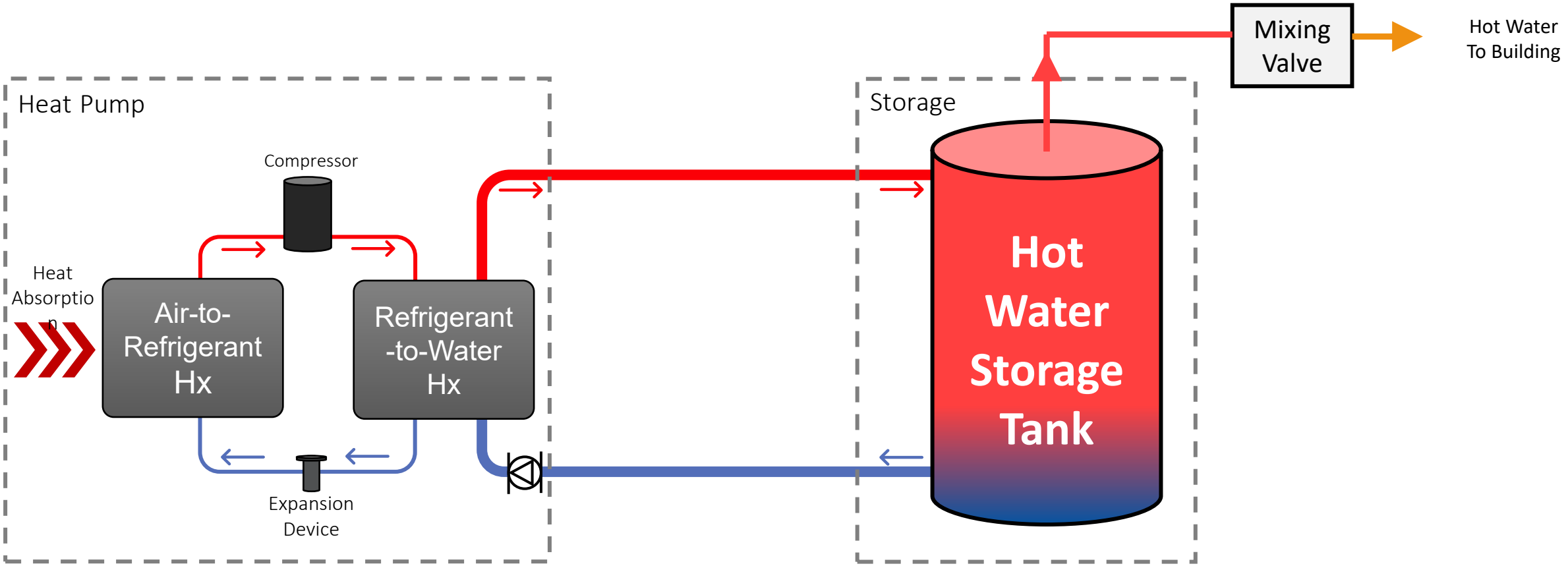
What's so great about heat pumps?

- Hyper-efficient (3-5x gas/electric resistance)
- Enable zero-emissions buildings via carbon-free electricity
- Improve air quality – no local emissions
- Improve safety – no gas lines
- Deliver heating and cooling with a single system
- Work in different climates

Refrigeration Cycle



Heat Pump Water Heater Components



Heat Pump Water Heaters - Unitary

Separate Tank

Integrated Tank

HPWH Equipment – Central

Monoblock / Separate Tank

Storage

Integrated Tank

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Recovery Rate & 1st Hour Rating

Recovery Rate

The amount of hot water a system can produce in one hour assuming a 90° F increase in water temperature.

First Hour Rating

The amount of hot water a system can deliver in one hour of continuous usage. It is a function of the storage capacity and the recovery rate.

For HPWH systems, first hour rating may approach comparable gas systems when starting with a fully heated tank. However, recovery rate will be slower.

Sizing Example

- Example Building Loads (ASPE):
- 1 hr: 440 gal
- 2 hr: 710 gal
- 3 hr: 960 gal

	Storage (gal)	Recovery (Btu/hr)	Recharge Time
Gas Tankless	0	600,000	-
Gas Tank-Type	200	400,000	0.5 hrs
Electric Heat Pump	**1,200**	**140,000**	**7 hrs**

- In a nutshell: Size storage to meet 3-hr peak demand; heat pumps to recharge tanks between peaks

Refrigerants in HPWHs

Name	GWP	Advantages	Disadvantages	Application
R134A	1430	- Low pressure - Maintains efficiency w/ warm incoming water - Can handle narrow ΔT	- Moderate low-ambient performance (down to 25-40°F OAT) - HFC refrigerant with high GWP	Most integrated HPWH and some split systems
R744 CO_2	1	- Excellent efficiency (COP 4+) - Excellent low-ambient performance (-13° F) - High output temp (up to 180°F)	- Needs wide ΔT - High pressure	Split systems – single pass
R513-A	573	- Lower GWP refrigerant compliant with refrigerant phase out	- Moderate low-ambient performance (down to 25-40°F OAT)	Split systems

With HPWHs, we face new challenges

- Ambient air temperature (heat source)
- Must manage cool air exhaust to maintain heat source
- Must size to accommodate longer recovery time
- Space and electrical capacity
- Inclusion of additional components

Heat Pump Water Heating

Unitary Systems

Unitary HPWH – Equipment Manufacturers

240V Systems

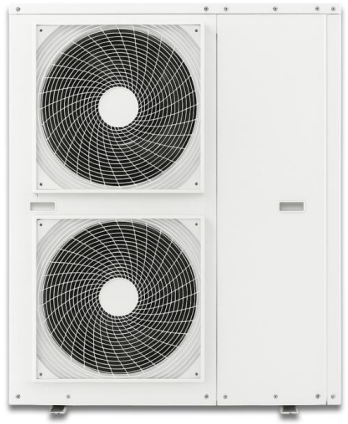
- Hard wired
- Includes electric resistance element
- Must install separate thermostatic mixing valve

120V Systems

- 120V plug in water heaters (shared or dedicated circuit)
- Integrated thermostatic mixing valve
- Not all models have electric resistance back-up

Combi Systems

- Hot water for DWH and hydronic heating
- Some systems even provide hot and chilled water



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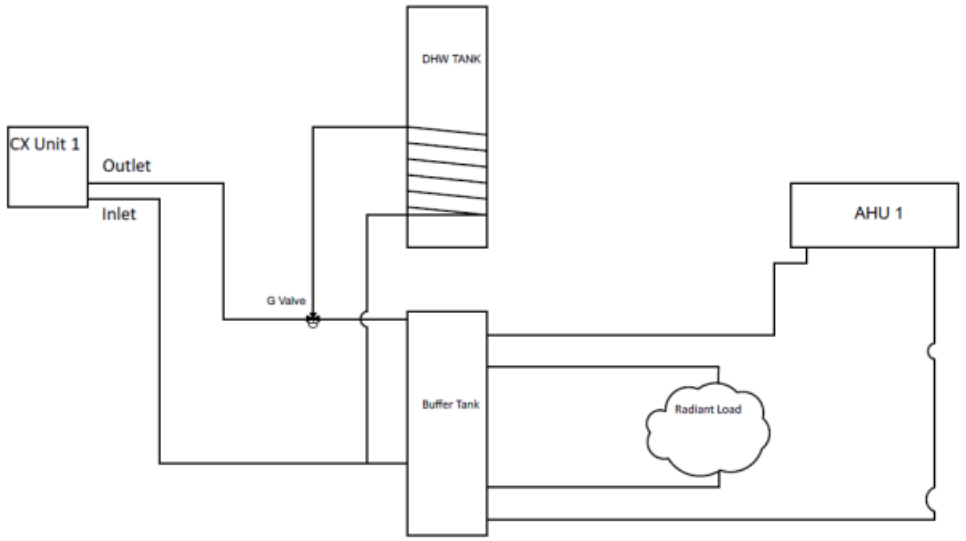

Example of a single heat pump supporting DHW (Domestic Hot Water) with radiant heating and a central air handler

Unitary HPWH – NEEA Ratings

- Northwest Energy Efficiency Alliance (NEEA)
- NEEA Advanced Water Heating Specification:

Table 1. Integrated HPWH Product Tier Overview

	Minimum Cool Climate Efficiency (CCE)*	Minimum Features	Sound Levels**	Demand Response-Enabled?
Tier 1.0	2.0	• ENERGY STAR compliance • Freeze protection	dBA < 65	Optional
Tier 2.0	2.3	Tier 1 plus: • Minimal use of resistance heating elements (see Section 5.1) • Compressor shut-down/notification • 10 year warranty • Condensate management	dBA < 60	Optional
Tier 3.0	2.6	Tier 2 plus: • Simultaneous intake and exhaust ducting capabilities • Air filter management • Override and default mode behavior as per Section 6.1	dBA < 55	Required
Tier 4.0	3.0	Tier 3 plus: • Physical design or default controls that limit resistance element heating to less than upper 50% of tank	dBA < 50	Required
Tier 5.0	3.5	Tier 4 plus: • No resistance element usage in default	dBA < 50	Required

** See Appendix B.1.2 for details on Cool Climate Efficiency definition and calculation method.*

Table 2. Split-System Product Tier Overview

	Minimum SCOP*	Minimum Features	Sound Levels Appendix B	Demand Response-Enabled?
Tier 1.0	2.1	• ENERGY STAR compliance • Freeze protection	dBA < 65	Optional
Tier 2.0	2.4	Tier 1 plus: • Minimal use of resistance heating elements (see Section 5.1) • Compressor shut-down/notification • 10 year warranty • Condensate management	dBA < 60	Optional
Tier 3.0	2.7	Tier 2 plus: • Override and default mode behavior as per Section 6.1	dBA < 50	Required
Tier 4.0	3.1	Tier 3 plus: • Physical design or default controls that limit resistance element heating to less than upper 50% of tank	dBA < 50	Required
Tier 5.0	3.6	Tier 4 plus: • No resistance element usage in default mode unless outside ambient air temperature is below -5°F	dBA < 50	Required

**SCOP (seasonal coefficient of performance) is a different quantity from CCE. SCOP applies to split-systems where the heat pump is subject to outdoor air conditions (see Appendix B.4). A blend of five Pacific Northwest cities was used as the reference climate for the SCOP.*

*** See Appendix D for details on Sound Level definition and calculation method.*

Unitary Heat Pump Water Heating Design Considerations

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Air Circulation

- Heat pumps produce cold air and need warm air
- **If delta T is more than 15F between inside and outside of closet, there is likely not enough air circulation**
- Ventilation is CRITICAL
  - Removes cold air and introduces warm, ambient air
  - Can be achieved with ducts, louvers, etc

Unitary HPWH - Ducting

Most integrated tank HPWH units can be ducted – intake, outlet, or both

When to duct?

- Strongly Recommended: When a HPWH is in a space that is very small and/or insufficiently vented.
- Often: Louvered door for intake and ducted exhaust

Why duct?

- If unit is inside an enclosed space that may get too cold, duct outlet air
- If unit is inside a conditioned space where you really don’t want to introduce cool air for tenant comfort

Why not duct?

- Adds cost
- Adds penetrations to envelope
- If unit is in conditioned space, ducting to outside increases air leakage.

Ducting not always necessary when locating in conditioned space. Added cooling load relatively minor.

Restricted vs. Unrestricted Ducting

Shrinking Room Study

- Duct Exhaust and Large Louver (NFA: 130 in^2)
- Duct Exhaust 50% Restricted and Large Louver (NFA: 130 in^2)
  - Designed to simulate flex ducts, turns and long runs
- 50% restricted duct = more electric resistance and lower overall COP (3.3 vs. 2.11)

Credit: Larson Energy Research

Do it Right

Not Very Good

Intake

Ok
Better

Exhaust

Ok

Intake

Residential HPWH Sizing

- CPC Table 501.1(2)
- "Best" - Match the required First Hour Rating to the Useful Storage Volume (80% of the Rated Storage Volume)
- "Good" - Match the required First Hour Rating with the Rated Storage Volume
- "Ok" - Match the required First Hour Rating with the HPWH's First Hour Rating Spec

TABLE 501.1(2)

FIRST HOUR RATING[1]

Number of Bathrooms	1 to 1.5			2 to 2.5				3 to 3.5			
Number of Bedrooms	1	2	3	2	3	4	5	3	4	5	6
First Hour Rating,[2] Gallons	38	49	49	49	62	62	74	62	74	74	74

For SI units: 1 gallon = 3.785 L

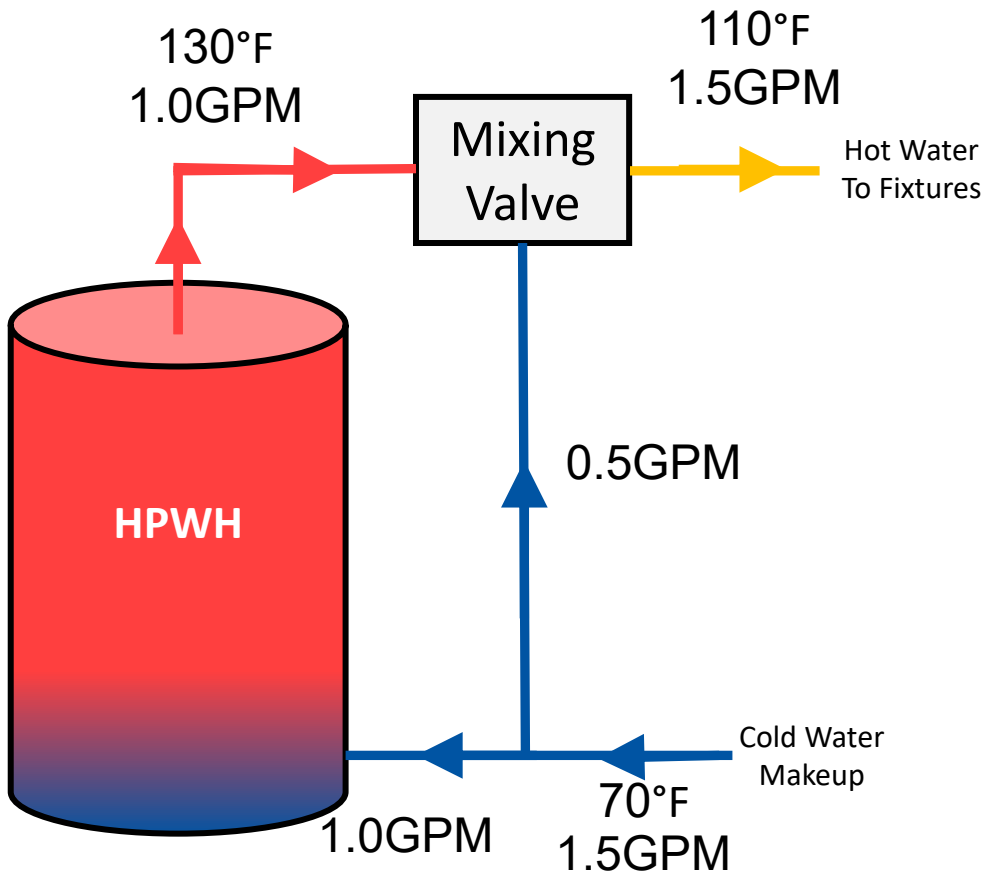
Notes:

[1] The first-hour rating is found on the "Energy Guide" label.

[2] Solar water heaters shall be sized to meet the appropriate first-hour rating as shown in the table.

Mixing valves

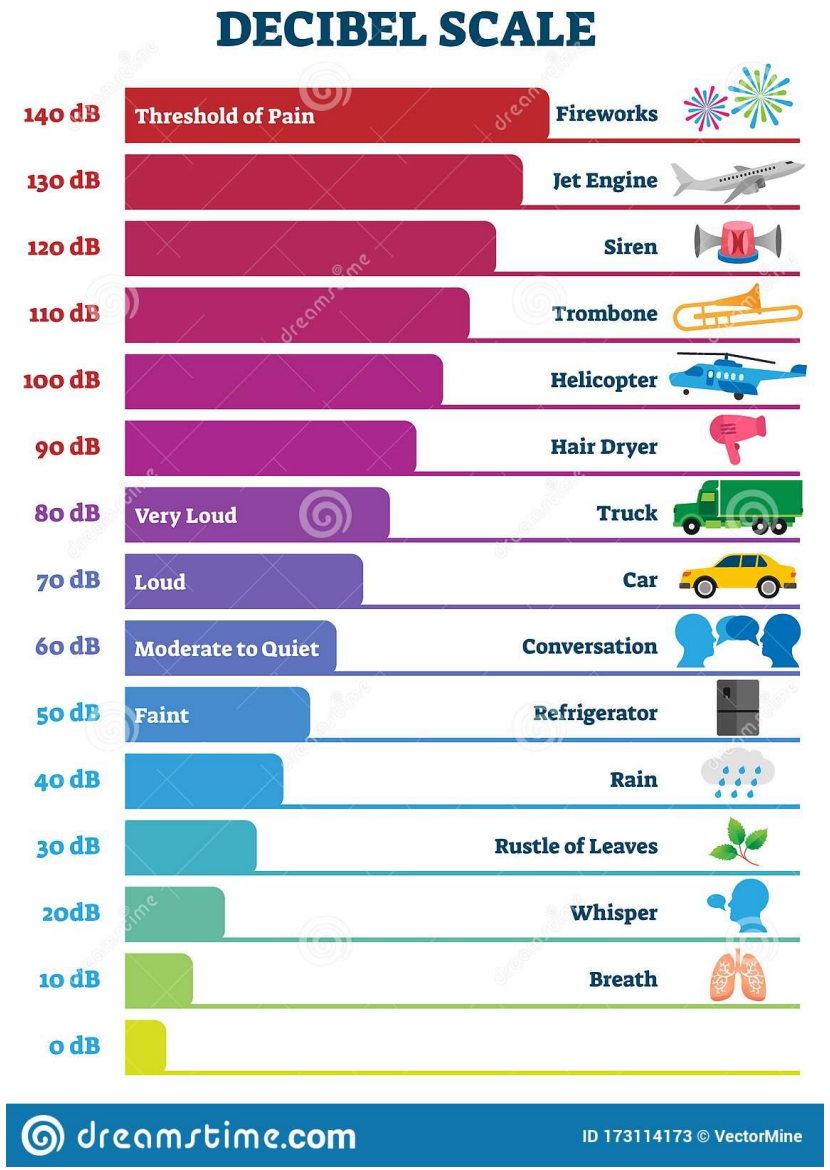
- Always include a mixing valve
- Increase storage volume without increasing footprint
- Ideal for space constrained installs
- Helps minimize electric resistance usage
- Load shifting potential
- Recovery rate decreases as temperature increases



Noise Considerations

Integrated HPWH	Split HPWH
• Do not install near bedrooms • Consider space usage and occupant sensitivities • Venting can reduce noise • Venting + Air Sealing	• Do not install near bedroom windows • Noise ordinance

NEEA Rated Tier 3 – below 50 dB



Unitary HPWH - Location

- **Garage** – Protected outdoor space w/ air circulation
  - Sound & air circulation not an issue
  - Low ambient performance should be considered
- **Outdoor Closet** – Enclosed unconditioned space
  - Sound not an issue
  - Must adequately louver door/wall or duct HP unit for air circulation
  - Low ambient performance should be considered
- **Indoor Closet**
  - Must consider sound & air circulation
  - No low-ambient concerns

Electrical Considerations

- Reduce power draw
  - Various models reduce power draw
  - Only when needed - must provide sufficient hot water availability to each apartment
  - Use mixing valve + larger storage volumes
- Infrastructure
  - 120v options available
  - Low power plug in 120v options

Water Heating	Panel Implications*
Low Power 120V heat pump	900W
240V 15 Amp Hybrid	2300W
Standard 240V 30Amp Hybrid	4500W
Sanden (compressor only)	1730W

Heat Pump Water Heating
Central Systems

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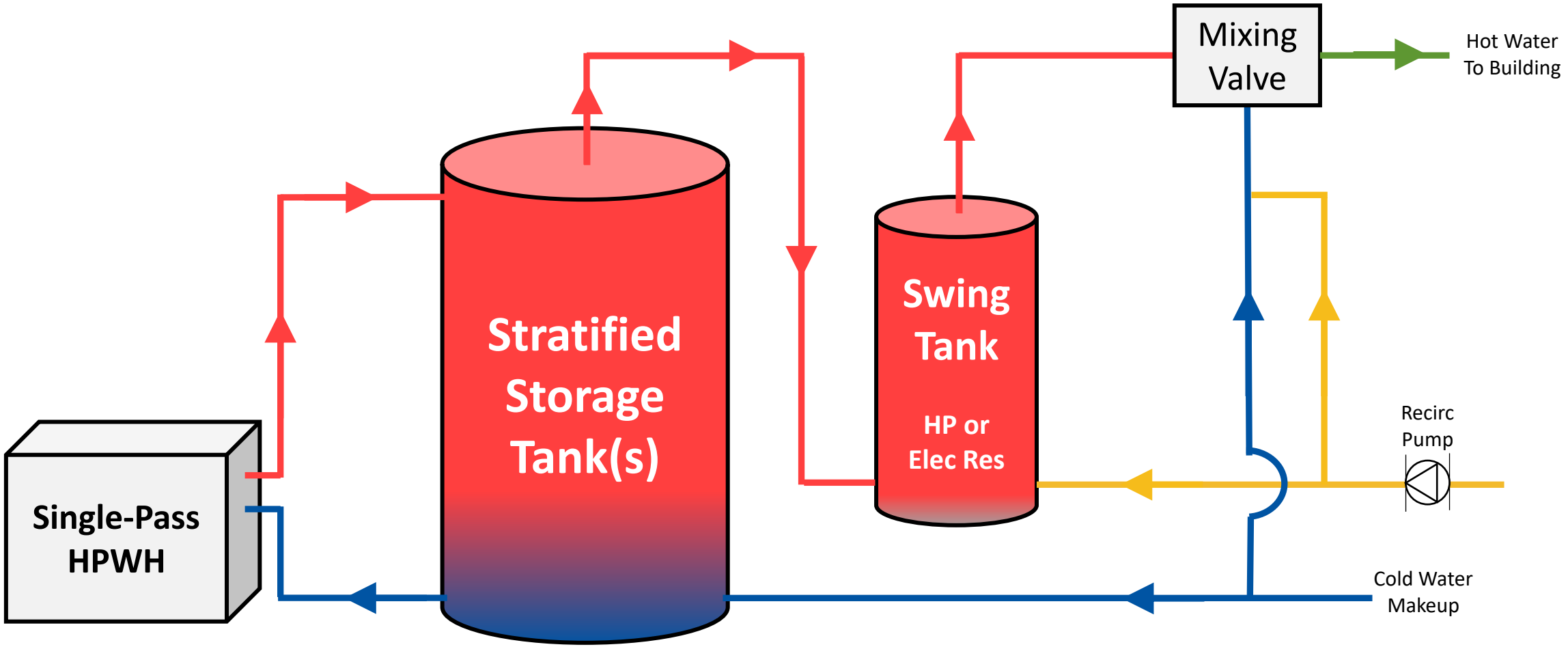
Single-Pass w/ Swing Tank (prescriptive baseline)



Certification to the CEC

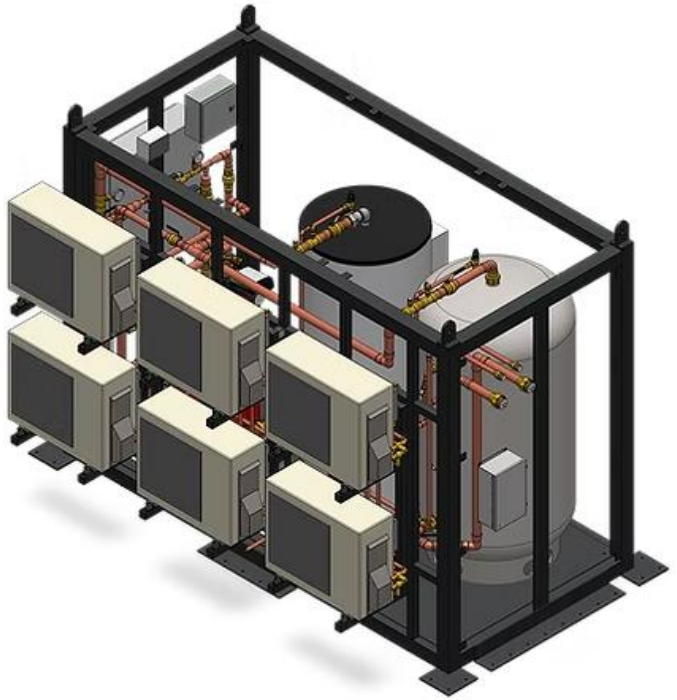
CALIFORNIA ENERGY COMMISSION

- To qualify as a JA14 central heat pump water heater system for compliance, with applicable performance compliance credits, the system shall be certified to the California Energy Commission, according to the requirements contained in JA14.
- This submission is completed by the manufacturer.

Central HPWH Equipment

Skid Hot Water Plants

- Plant is built in a factory and shipped to the site, reducing on-site complexity
- Skid manufacturers also engineer the plant, and often offer extended warranty
- Waterdrop Systems using Sanco heat pumps
- Steffes Origin using Mistubishi Heat2O
- Colmac skid
- Other contractors may be able to build the plant in a factory setting and ship to site



Other CHPWH equipment

- Manufacturers not JA14 certified (yet)
  - Transom Hatch
  - Phase change thermal battery storage “tankless” - Intellihot
  - Others

Water source heat pumps, less common for multifamily

TRANSOM

JA14 HPWH Equipment Details

Make and model	Refrigerant	Rated capacity MBH	Efficiency COP	Min ambient operating temp	Max water outlet temp
Eco2 Sanco	R744 (CO2)	15.4	Up to 5.5	-25F	150F
Colmac CxA	R-134a or R513a	25 to 76	Up to 3	35F	140F
Rheem HPHD	R134a	60/135	Up to 4	40F	150F
AO Smith C-series (Packaged hybrid)	R-134a	82	4.3	20F	150F
Nyle HPA (Lochinvar/State/AO Smith)	R513a	66 to 340	Up to 4.6	23F	160F
Nyle C-series	R513a	90/125/185	Up to 3	35F	160F
Mitsubishi Heat2O	R744 (CO2)	136.5	Up to 4.5	-13F	160F
Lync Aegis A	R744 (CO2)	210/329/425	Up to 3.8	-4F	170F
Laars Etherm	R744 (CO2)	322	Up to 4	0F	180F

Central Heat Pump Water Heating Design Considerations

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Central HPWH Sizing

Large Storage Tanks + Small Heat Pumps

Advantages

- Reduces overall hot water system cost, since tanks are cheaper than heat pumps.
- Reduces building electrical service requirements including wiring, panels, and service
  - Reduces owner exposure to high peak demand (kW) charges
  - Reduces heat pump equipment short cycling
  - Improves resiliency in event of power outage – thermal battery
  - Enables load shifting & demand response – can rely on storage and lock out heat pumps during peak pricing periods or demand response events

Disadvantages

- Large tanks need space and structural support
- Increase replacement costs
- More susceptible to distribution issues/high recirculation loads

Central HPWH Sizing

- Example Building Loads (ASPE):
- 1 hr: 440 gal
- 2 hr: 710 gal
- 3 hr: 960 gal

	Storage (gal)	Recovery (Btu/hr)	Recharge Time
Gas Tankless	0	600,000	-
Gas Tank-Type	200	400,000	0.5 hrs
Electric Heat Pump	**1,200**	**140,000**	**7 hrs**

- In a nutshell: Size storage to meet 3-hr peak demand; heat pumps to recharge tanks between peaks

Image: AEA

Central HPWH Location

- **Outside** – roof, ground, or garage
- **Inside** – w/ large louvers & ducting – be careful!!!
- Consider distance between heat pumps and tanks
  - Water that cools in pipes between cycles can dilute tank
  - Longer runs may require additional booster pump
- Sound – ok or need to mitigate?
  - Wide range of dBA ratings (40 to 90+ dBA)
  - What are jurisdictional noise requirements?
  - May also need isolators to dampen vibration

Impact of ambient air temperature

Rated capacity vs needed capacity

PAY ATTENTION WHEN SIZING AND SELECTING EQUIPMENT, AND BE CAREUL AND READ FOOT NOTES ASSOCIATED WITH NOMINAL OUTPUT CAPACITY.

Veritus AHP-140

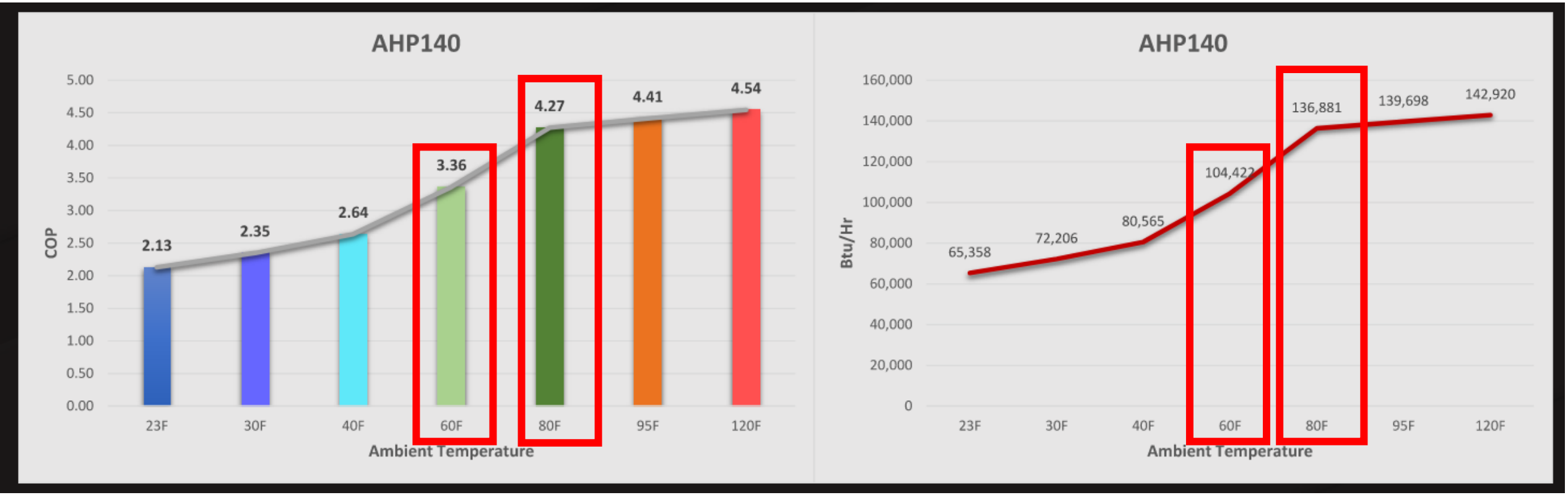
AIR SOURCE HEAT PUMP	DIMENSIONS AND SPECIFICATIONS				
Model Number	COP*	Maximum Output BTU/Hr*	A	Shipping Weight	Total # Modules
AHP060	4.61	66,688	30-5/8"	1,155	1
AHP140	4.27	136,881	41-5/8"	1,370	1
AHP200***	4.38	203,069	72-1/4"	2,505	2 (60 + 140)***
AHP280***	4.27	272,762	83-1/4"	2,721	2 (2 x 140)***
AHP350***	4.34	339,450	113-7/8"	3,854	3 (2x 140 + 60)***

** DOE test standard, 80°F ambient with 63% humidity, inlet water temperature at 70°F, outlet water temperature at 120° F.*
***The field installed piping manifold will increase the depth of the units to 63"*
**** Packaged Separately (Models AHP200-350)*

Impact of ambient air temperature

Rated capacity vs needed capacity

PAY ATTENTION WHEN SIZING AND SELECTING EQUIPMENT, AND BE CAREUL AND READ FOOT NOTES ASSOCIATED WITH NOMINAL OUTPUT CAPACITY.



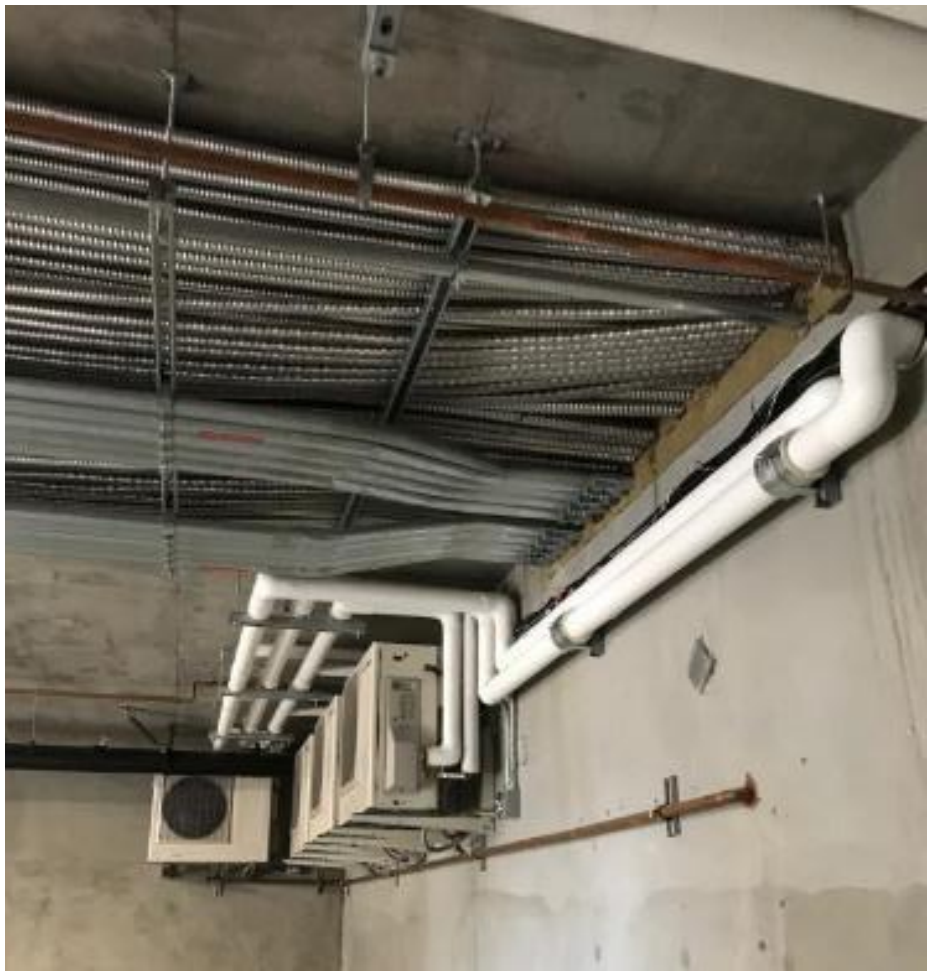


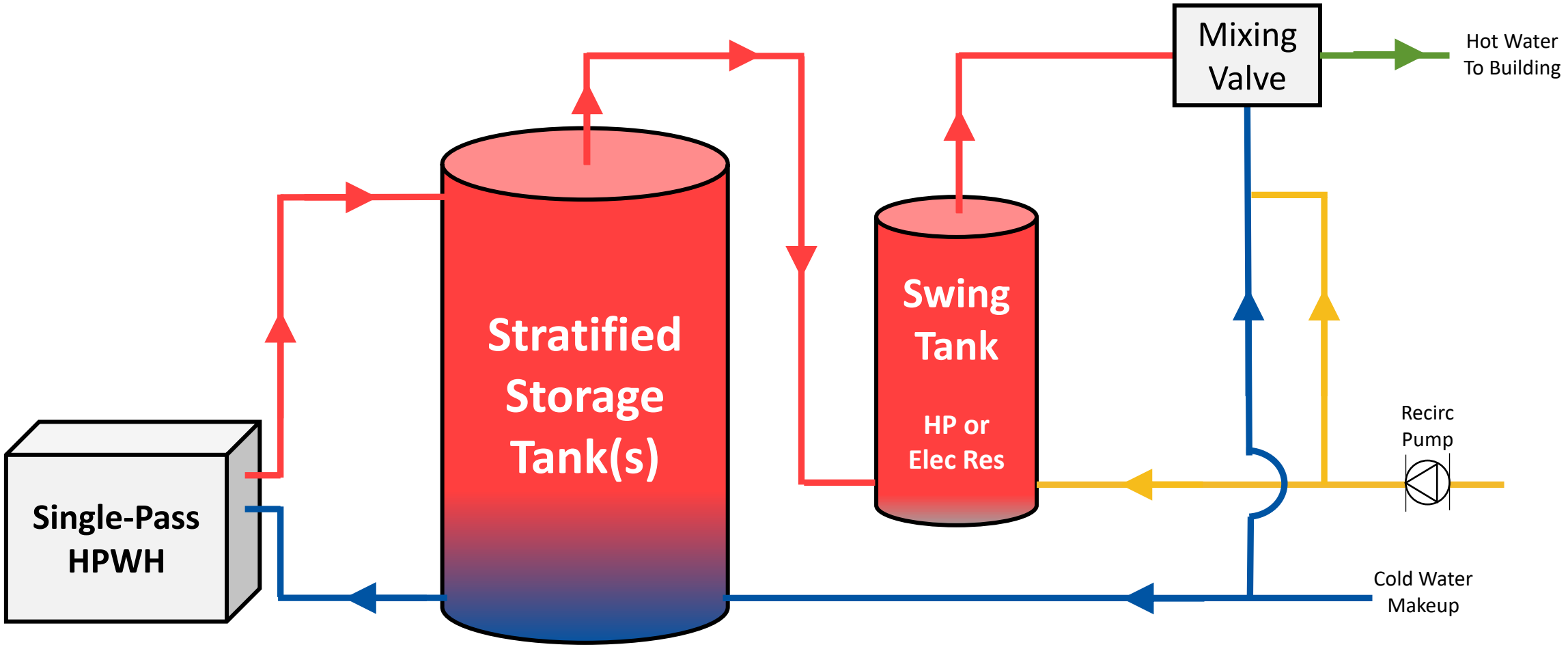
Image: AEA

Image: AEA

Central HPWH – Single-Pass vs Multi-Pass

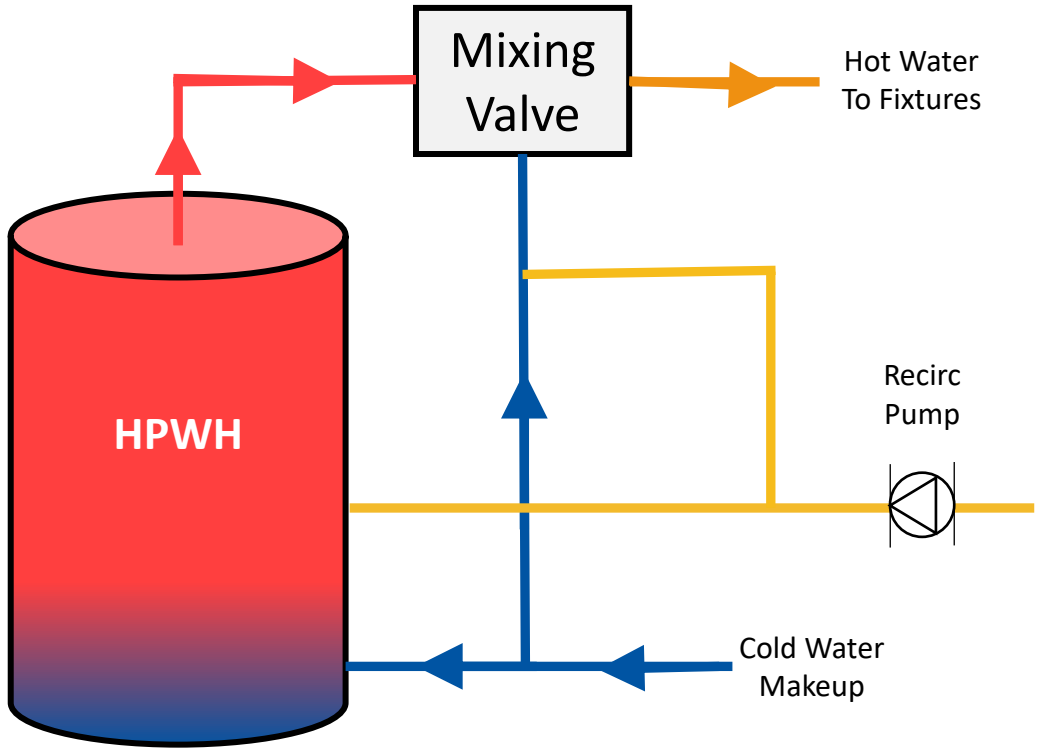
- **Single-Pass**
  - Most efficient
  - Better stratification = larger effective storage volume
  - Somewhat more complex design
  - Probably need separate recirc/swing heater
  - Becoming standard practice for central HPWH
- **Multi-Pass**
  - Less efficient
  - Less stratification = smaller effective storage volume
  - Simple system design and piping

Where does recirc go?



Mixing valves

- Increase storage volume without increasing footprint
- Ideal for space constrained installs
- Helps minimize electric resistance usage
- Load shifting potential
- Shift recirc water away from swing tank or primary storage



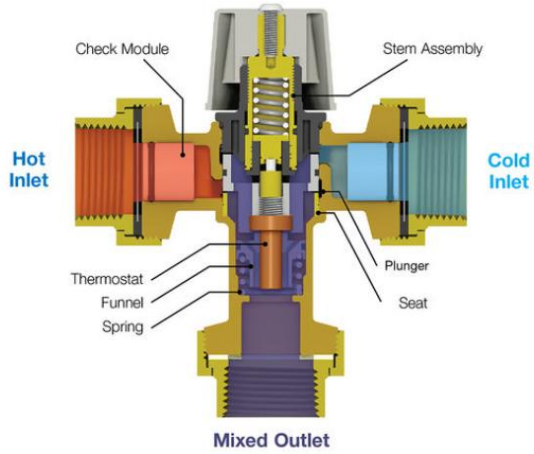
Mixing Valve Types

Electronic

- Digital Set Points
- Temperature Probes allow for Automatic changes
- Legionella Disinfection Options (recirc only)
- More precise, program schedules, better for commercial applications

Thermostatic

- Automatic
- No electrical connections needed
- Thermostatic element contracts and expands based on set point and temperature
- Commercial and residential



Static

- +/-10 Degrees
- Requires trial and error method to set it
- Residential

Recirculation

- Objective – Maintain temp with as little flow as possible
- BEST and Easiest – Thermally balanced variable speed
  - Thermal balancing valves – Caleffi Thermosetter, B&G Temp Setter, or equal
  - Pump – VS w/ proportional pressure – Grundfos Magna 1, B&G Ecocirc, or equal
  - Set and forget TBVs
  - Ensure valves and pumps are sized properly
- More difficult to commission and less efficient:
  - Demand control + constant speed pump
  - Aquastat + constant speed pump
- Don’t Do It – Constant speed no control

Pre-Occupancy Performance Testing

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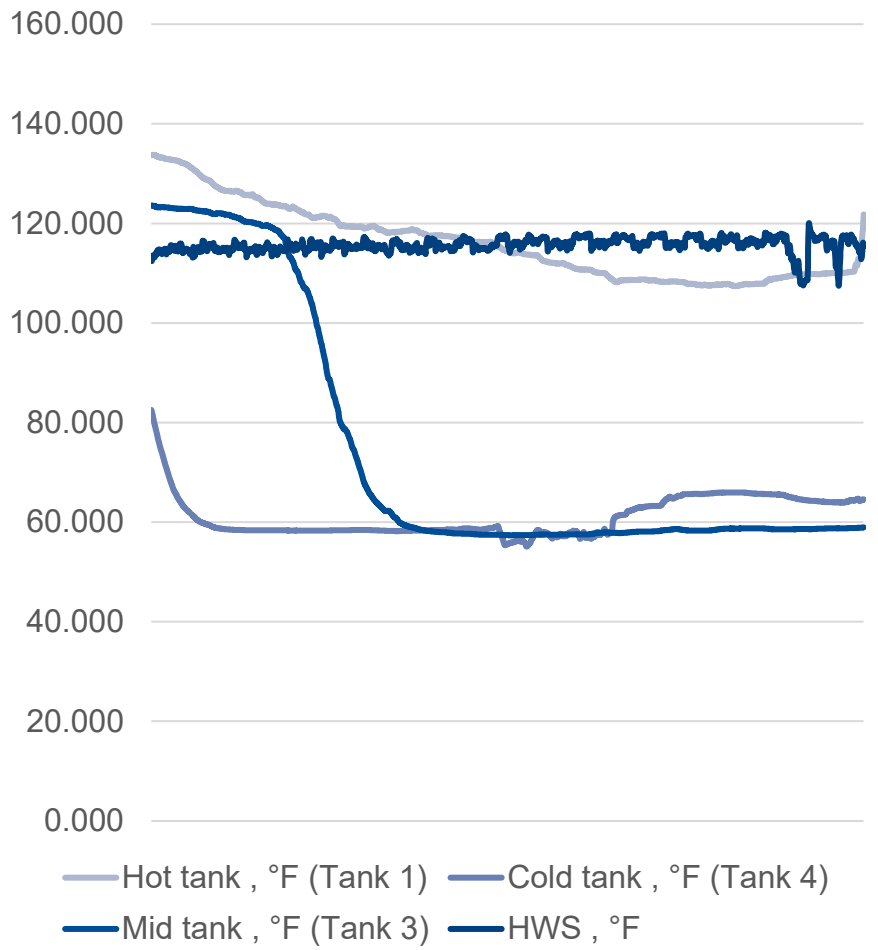
Pre-Occupancy Performance Testing

- Developments benefit from pre-occupancy performance testing of HPWH systems
  - Complex piping and controls for central systems
  - Manual settings for unitary water heaters and mixing valves
- Identify issues before occupants move in



California
ELECTRIC
HOMES

NO COST TECHNICAL ASSISTANCE

TECHNICAL ASSISTANCE ELIGIBILITY

California ELECTRIC HOMES

Technical assistance is available at NO-COST to:

- All-electric market rate residential housing project teams
- Mixed-fuel project teams interested in making the switch to all-electric

WHO CAN REQUEST TECHNICAL ASSISTANCE

California ELECTRIC HOMES

Technical assistance is available to:

Project team members who are <u>currently enrolled</u> in OR <u>interested in learning more about CalEHP</u> including:

- Residential developers
- Residential builders
- Architects
- Design teams
- Energy consultants
- HERS raters

WHEN IS TECHNICAL ASSISTANCE AVAILABLE

When is technical assistance available?

- From project conception to Certificate of Occupancy and all situations in between.
- Technical assistance can be utilized at any point of construction!

Design Phase: We can help your project to meet all program prerequisites and focus design on bonuses.

Construction Phase: We can help make minor changes to help the project receive some bonuses for future lots that have not yet received Certificate of Occupancy.

California ELECTRIC HOMES

HOW TO REQUEST TECHNICAL ASSISTANCE

California ELECTRIC HOMES

To request technical assistance:

1. Reach out to your CalEHP program contact (outreach, operations, or technical associate) at any point before construction is complete.

2. Next a technical team members will schedule an intake call to confirm how we can provide technical assistance for your project(s)!

CALIFORNIA ELECTRIC HOMES RESOURCES

Contact us:

- (833) 987-3935
- caelectrichomes@trccompanies.com
- caelectrichomes.com

Discussion

Thank You!

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