

# EEBA High Performance Home Summit

Salt Lake City, UT

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## A Deep Dive into Heat Pump Water Heaters for Multifamily Buildings

Christian Kaltreider and Theresa Gilbride  
Pacific Northwest National Laboratory

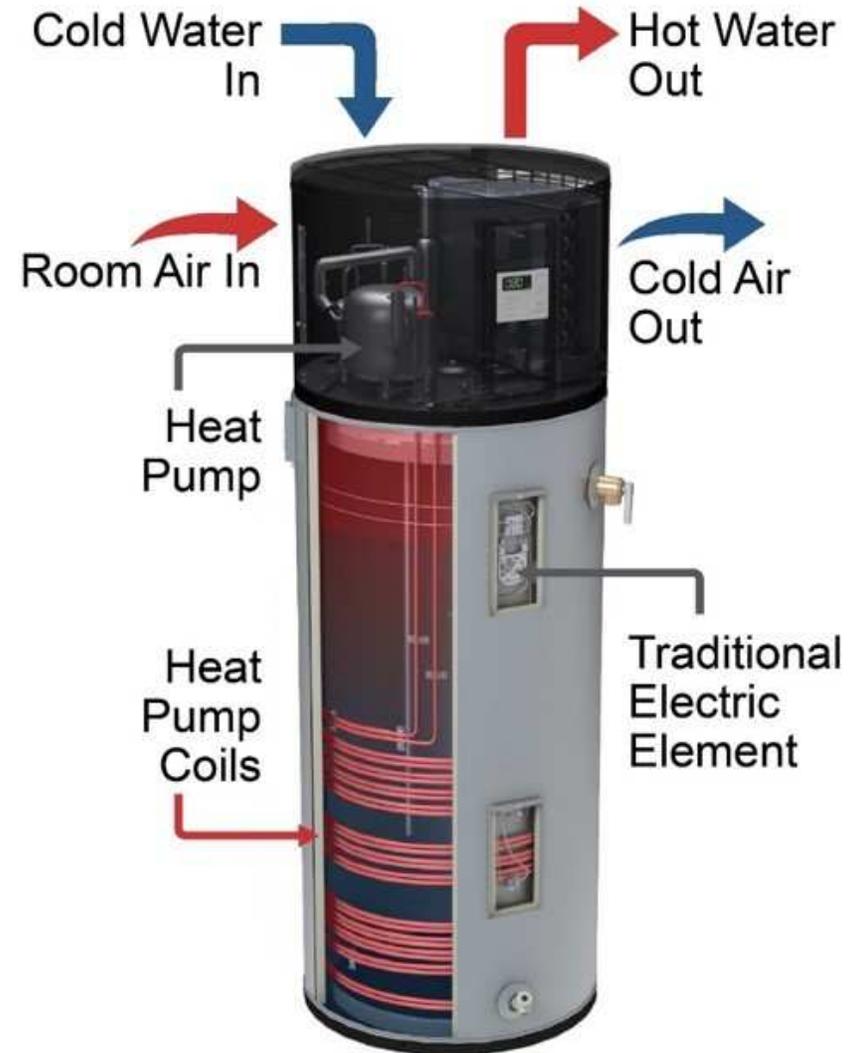


# Special Thanks to the Experts



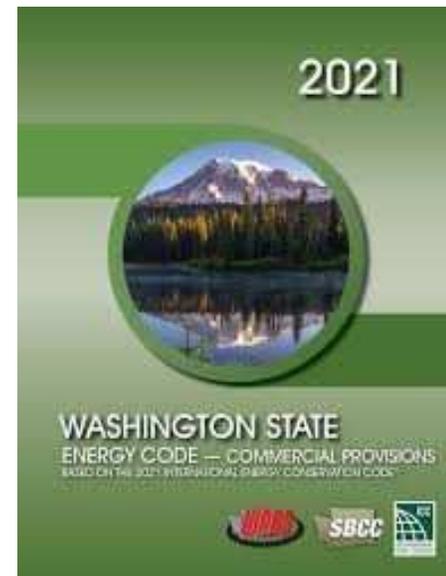
# Heat Pump Water Heaters (HPWH)

- Pump heat from air to water
- Highly efficient
- Integrated or split systems
- All air-source heat pumps:
  - Generate noise
  - Exhaust cold air
  - Generate condensate
  - Require space for airflow
  - Require sufficient warm air



# Why Use HPWHs in Multifamily Buildings?

- DHW is a high end-use in MF buildings
- Electrification
- ENERGY STAR
- Zero Energy Ready Home
- State and local codes



# Heat Pump Water Heaters (HPWH)



# Heat Pump Water Heaters (HPWH)

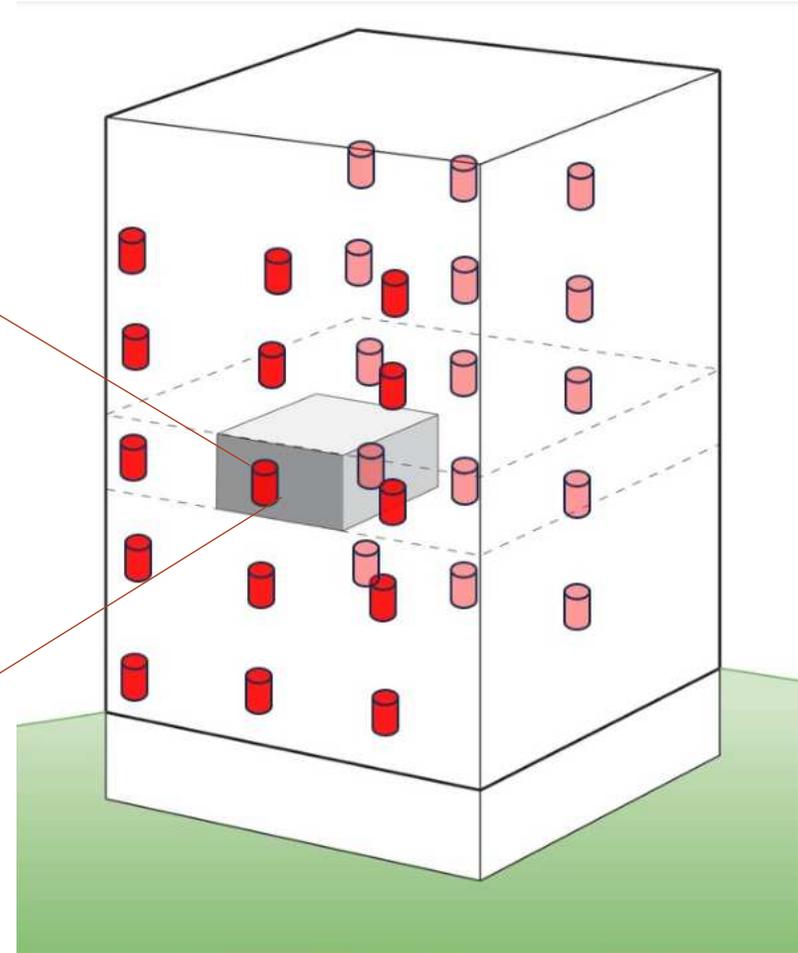


## Implementation Approaches

- Distributed HPWHs (integrated units)
  - 1 for 1
  - Clustered
- Central Systems



# Distributed Systems



## Distributed Systems: Advantages

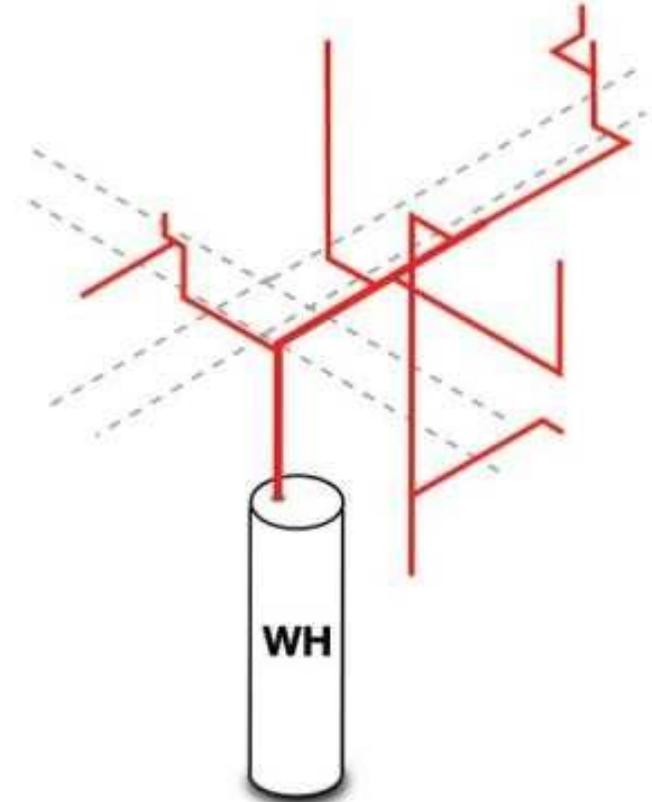
- Off-the shelf equipment
- Less complex design
- Simple install
- Familiar operation/maintenance
- Avoids complex controls



- **In short, residential plumbers can handle this job!**

## Distributed Systems: Advantages

- No recirculation loop (or small)
  - Energy waste
  - Potential failure points
- No central mechanical room required
- No exterior equipment
  - Exterior space, noise, aesthetics
- Simplified tenant billing
- Low likelihood of whole-building failure
- Applies well to smaller buildings that don't have dedicated maintenance staff



## Distributed Systems: Disadvantages

- Distributed maintenance
  - 100 units = 100 filter washes
- In-unit floor area
- In-unit noise
- In-unit cool air
- In-unit condensate
- Efficiency?
- Cost?

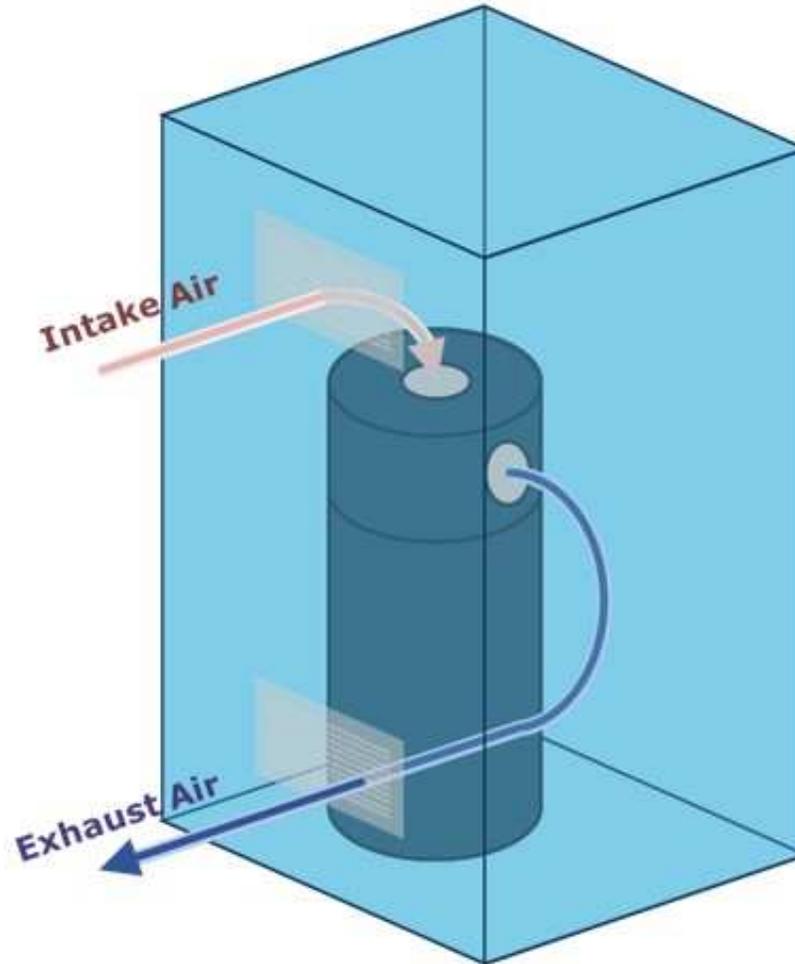


# Distributed Systems: Small-Space Installation



# Distributed Systems: Small-Space Installation

## Passive Ventilation



# Distributed Systems: Small-Space Installation

## Passive Ventilation

- Fully louvered door
  - Min net free area = 300 in<sup>2</sup>



# Distributed Systems: Small-Space Installation

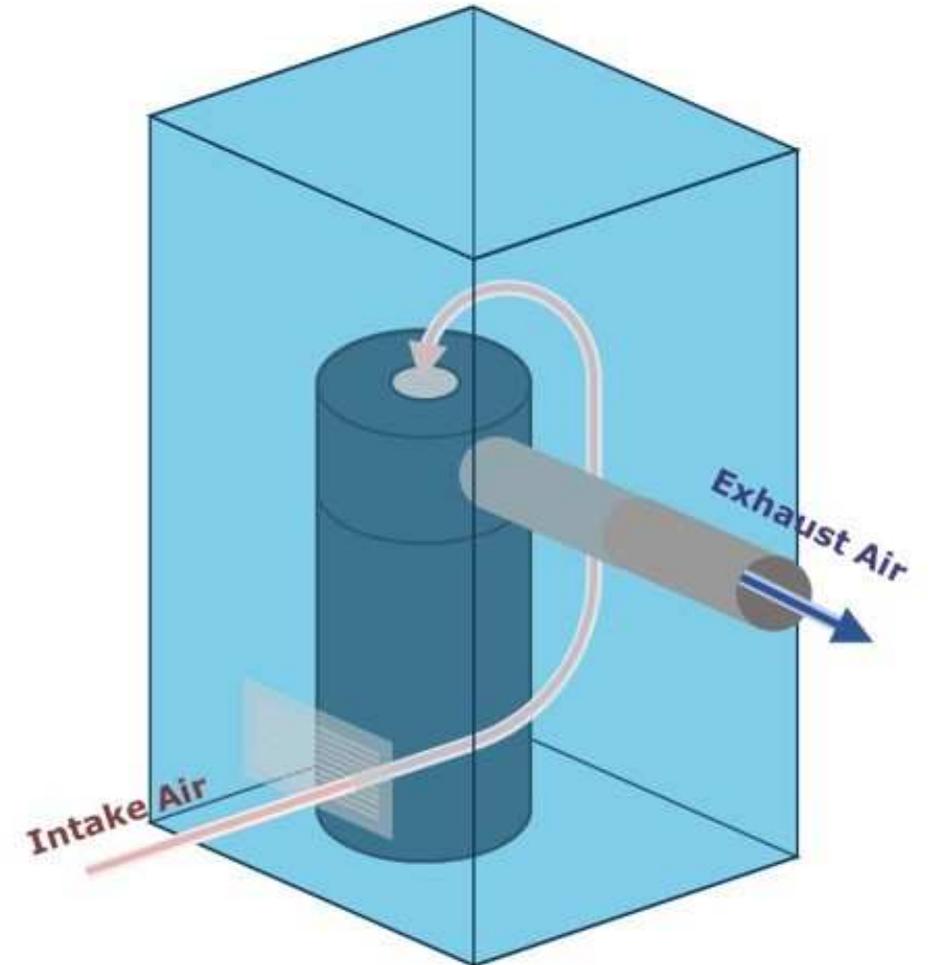
## Passive Ventilation

- Fully louvered door
  - Min net free area = 300 in<sup>2</sup>
- Two door louvers
  - One, high, one low
  - Equal size
  - Min net free area = 192 in<sup>2</sup> total



# Distributed Systems: Small-Space Installation

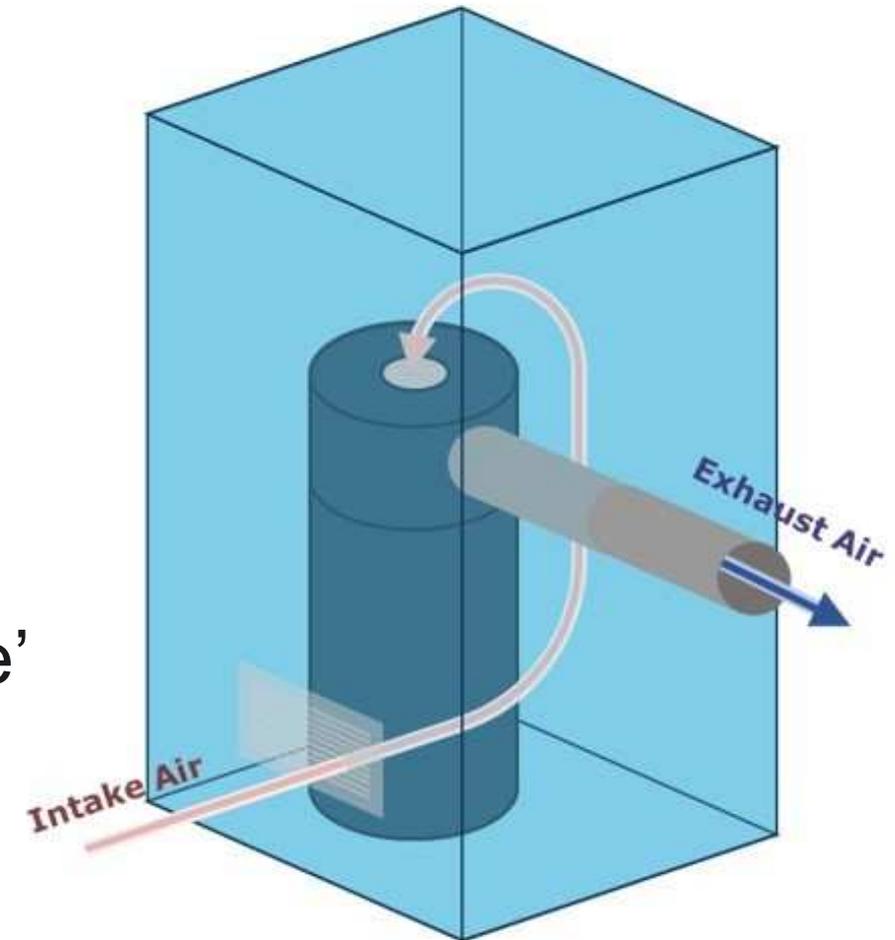
## Forced (ducted) Ventilation



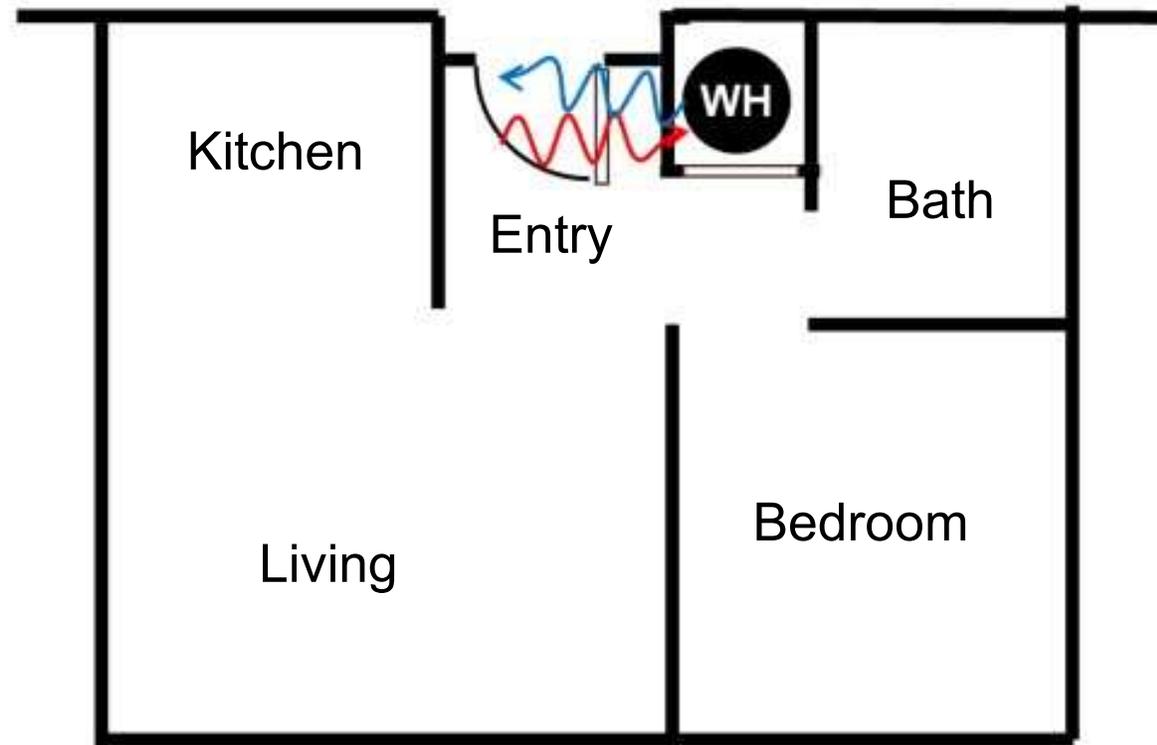
# Distributed Systems: Small-Space Installation

## Forced (ducted) Ventilation

- Short, straight, rigid duct runs
- Provide transfer grille or undercut door
  - Min net free area = 18 in<sup>2</sup>
- Or duct both intake and exhaust
- Intake and exhaust must both be 'inside' or both 'outside'
- Insulate exhaust duct



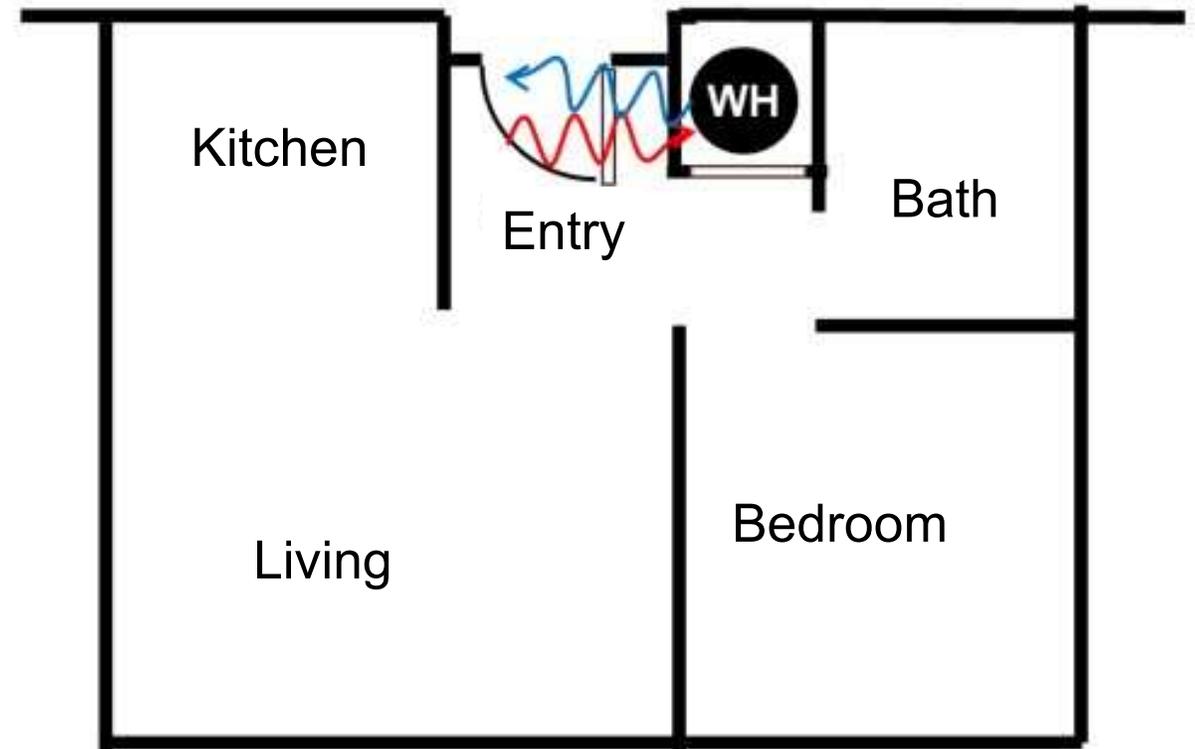
# Distributed Systems: Potential Locations



# Distributed Systems: Potential Locations

## In-Unit Closet

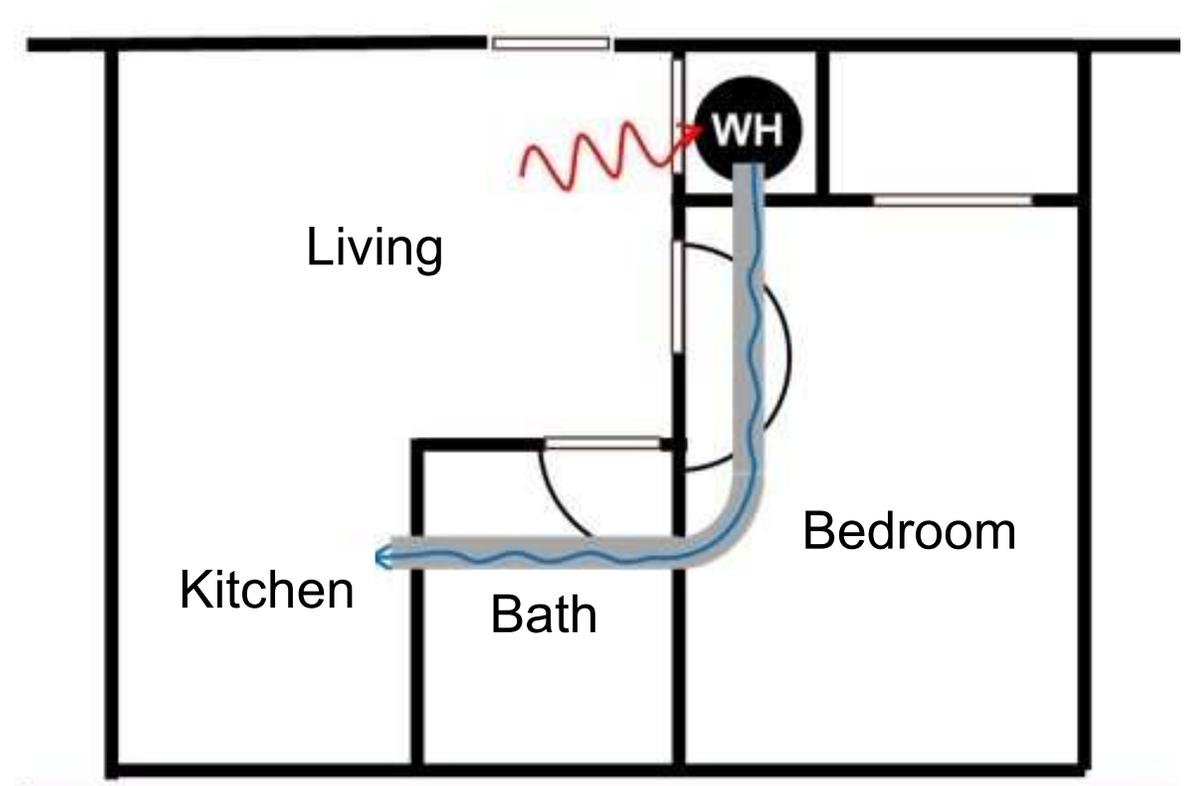
- Consider cool exhaust
  - Entryway good location
  - Ducted to kitchen or laundry
- Co-locate with laundry
- Maintenance staff must enter dwelling unit



# Distributed Systems: Potential Locations

## In-Unit Closet

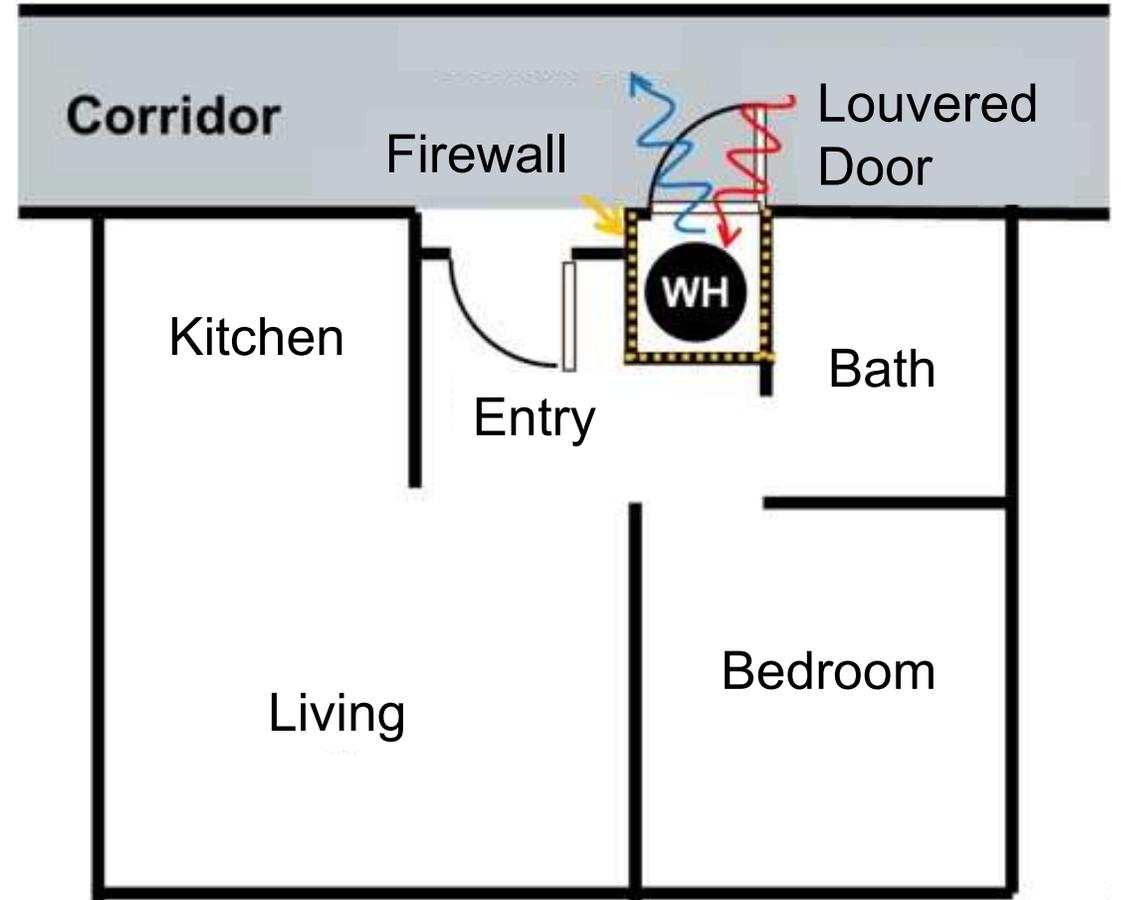
- Consider cool exhaust
  - Entryway good location
  - Ducted to kitchen or laundry
- Co-locate with laundry
- Maintenance staff must enter dwelling unit



## Distributed Systems: Potential Locations

### Internal Corridor Closet

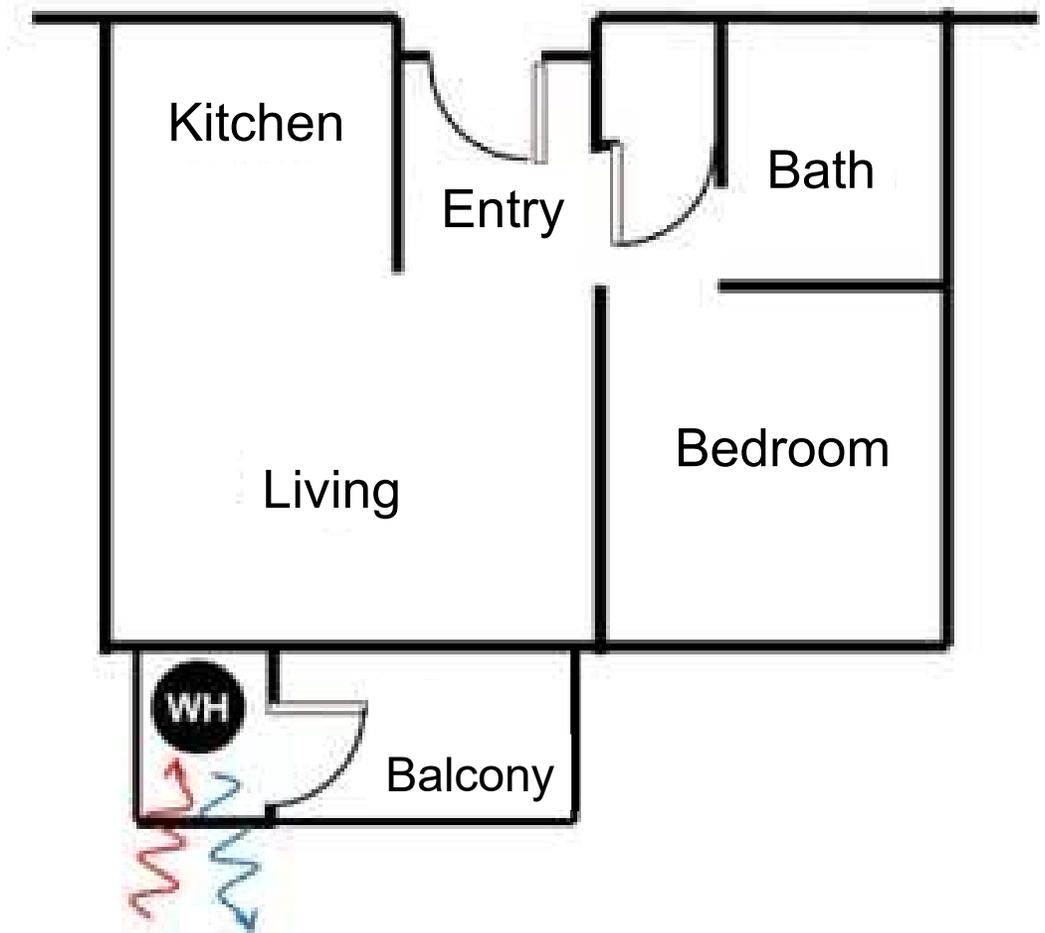
- Closet walls must provide:
  - Air barrier
  - Fire rating
  - Sound proofing
- Avoids in-unit cool exhaust
- Reduces in-unit noise
- Non-invasive maintenance



## Distributed Systems: Potential Locations

### Exterior Closet

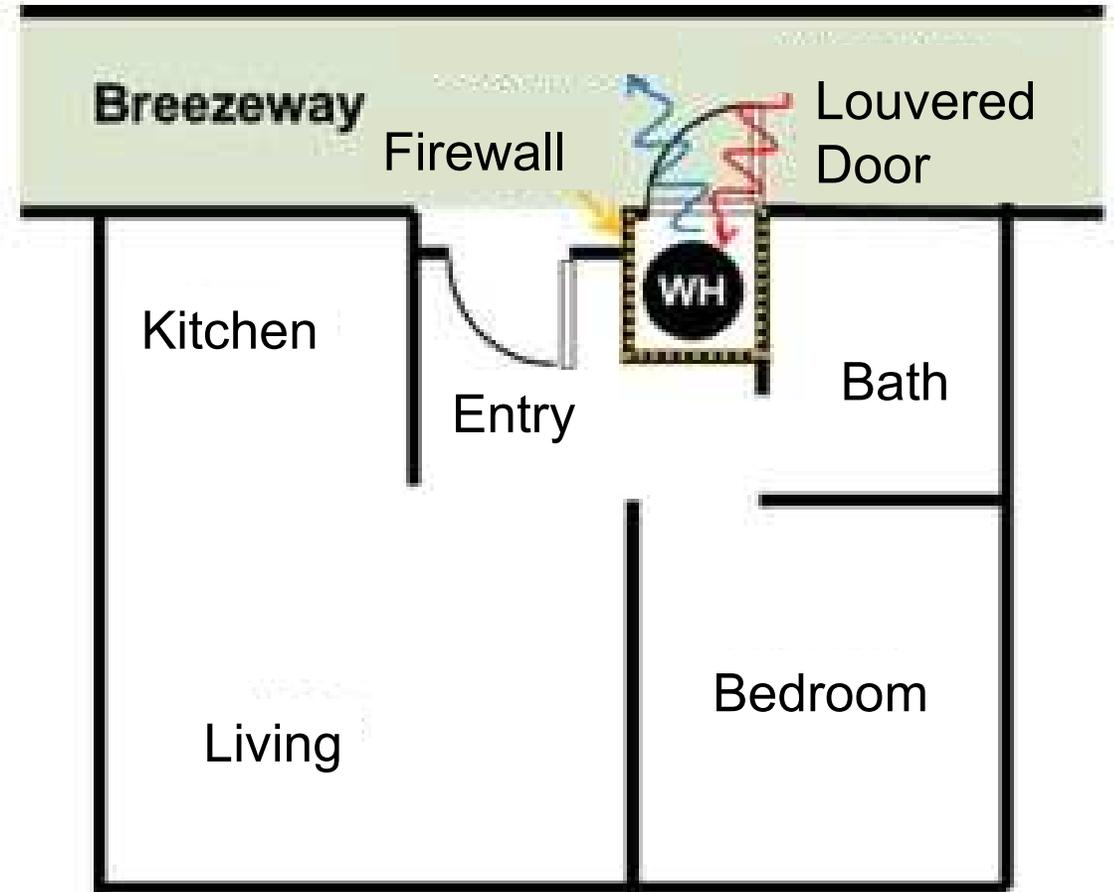
- Hot/warm climates only
- Avoids in-unit cool exhaust
- Reduces in-unit noise
- Maintenance staff must access balcony/patio



## Distributed Systems: Potential Locations

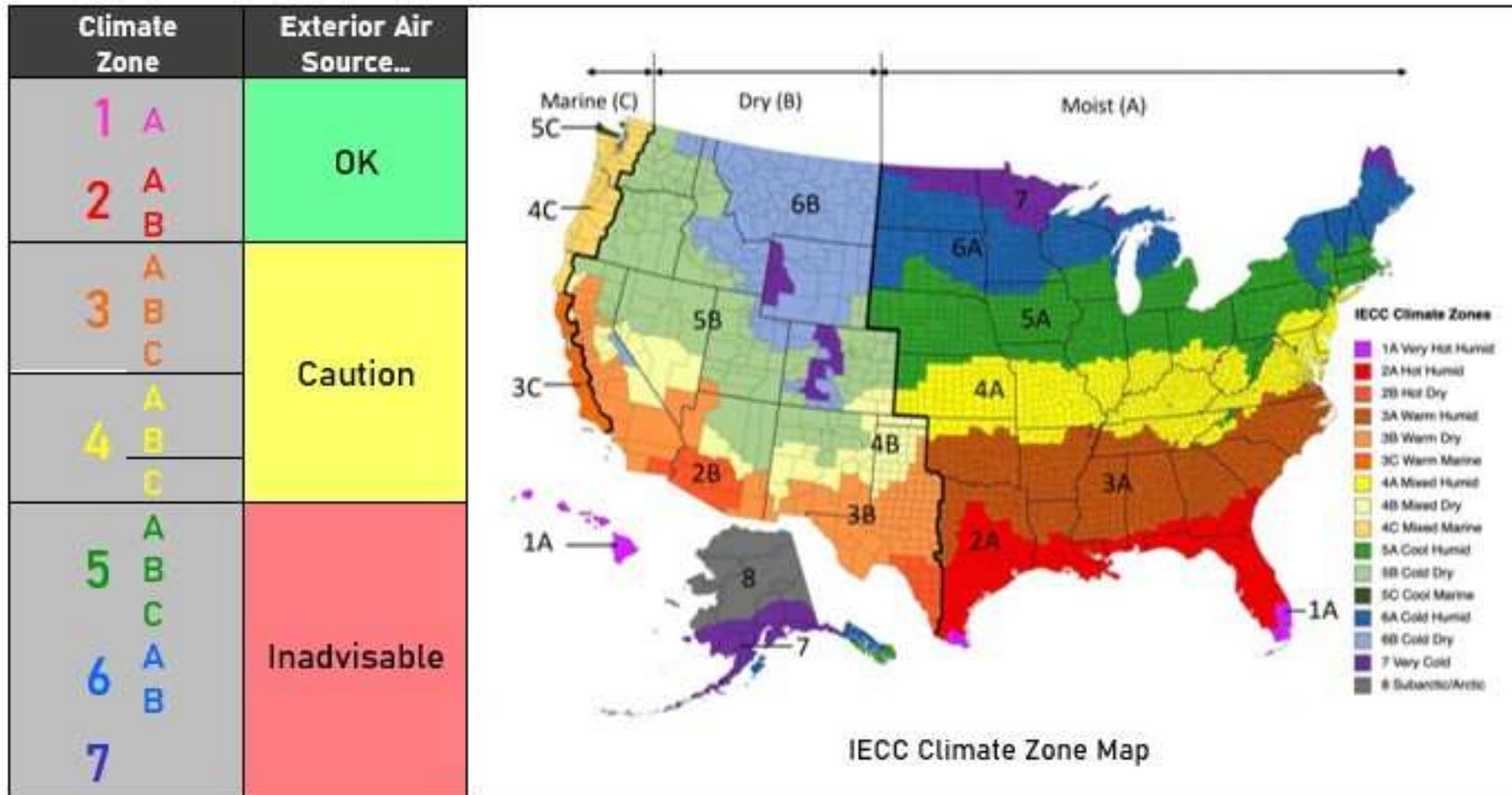
### Breezeway Closet

- Hot/warm climates only
- Closet walls must provide:
  - Air barrier
  - Thermal insulation
  - Fire rating
  - Sound proofing
- Avoids in-unit cool exhaust
- Reduces in-unit noise
- Non-invasive maintenance



# Distributed Systems: Potential Locations

## Exterior Location Climate Implications



## Distributed Systems: Potential Locations

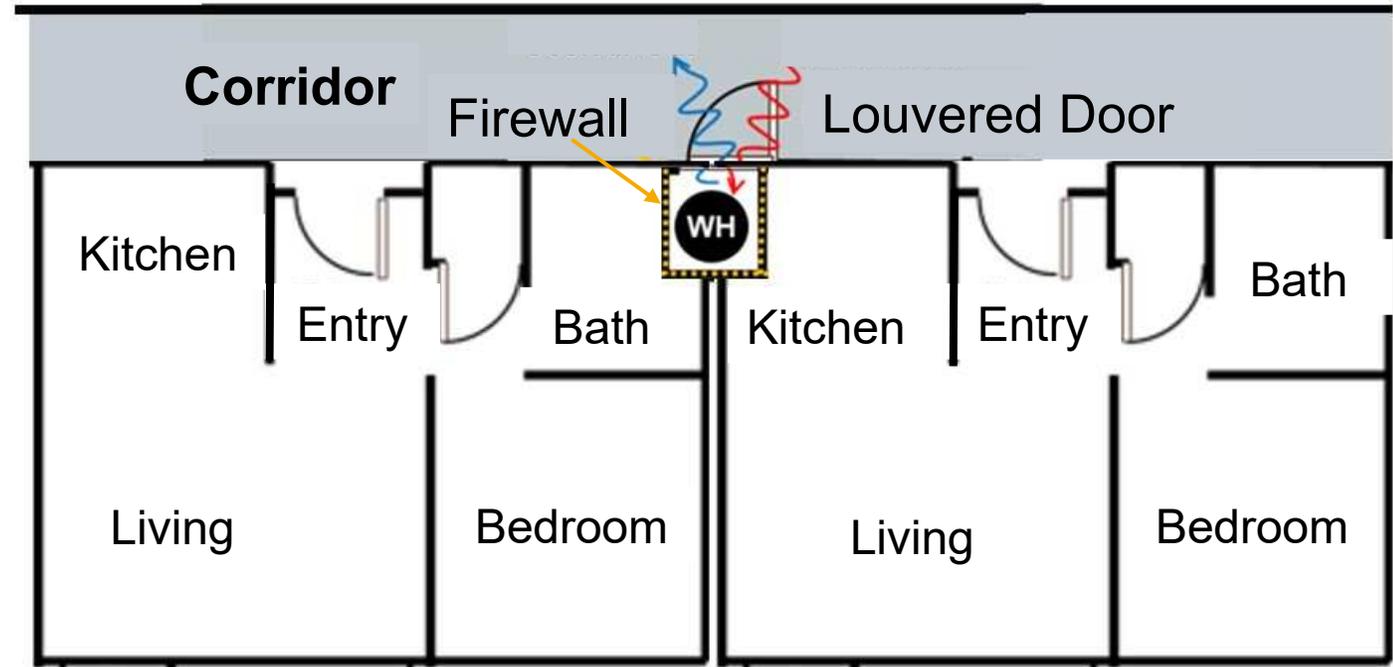
### Utility Rooms and Dead Space

- Mechanical rooms
- Laundry rooms
- Tops and bottoms of stairwells
- Good accessibility for maintenance
- Reduced noise and comfort concerns



## Distributed Systems: Clustered Deployments

- Allows fewer HPWHs
- Frees up floor space
- May lead to longer HW runs and recirculation loops
- Tenant billing not as simple



## Distributed Systems: Sizing and Selecting

- Sizing is essentially the same as single-family sizing
- 1 to 1 installation:
  - HPWH FHR > dwelling unit FHR requirement
- Clustered installation:
  - HPWH FHR > combined dwelling unit FHR requirements

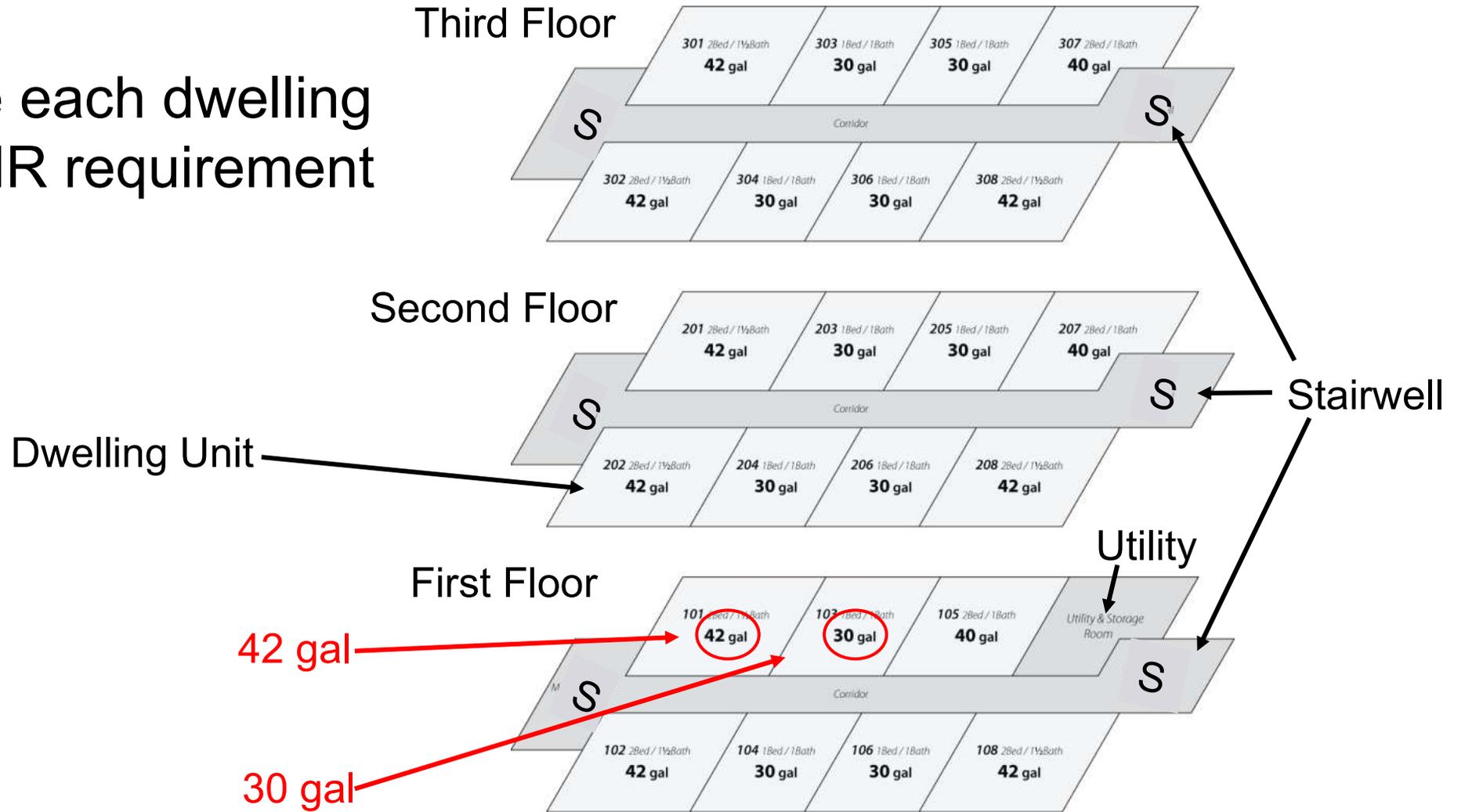
## Distributed Systems: Clustered Deployments

Identify HPWH models with a range of FHRs

HPWH Size	First Hour Rating
Extra Small 40-gallon tank	58 gallons
Small 50-gallon tank	66 gallons
Medium 64-gallon tank	78 gallons
Large 80-gallon tank	92 gallons

# Distributed Systems: Clustered Deployments

Estimate each dwelling unit's FHR requirement



## Distributed Systems: Clustered Deployments

Match cluster requirements to HPWH models

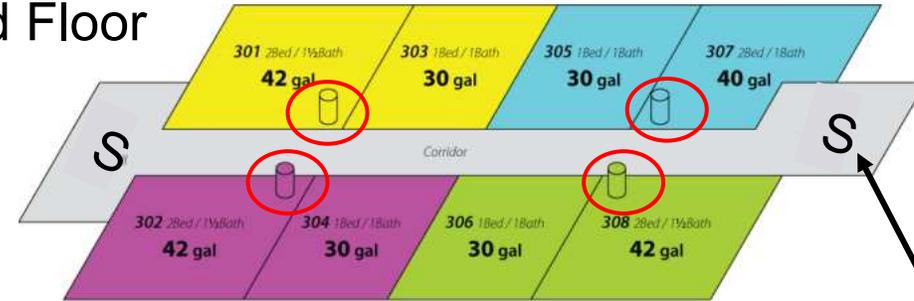
HPWH Size	First Hour Rating	Suitable Clusters
Extra Small 40-gallon tank	58 gallons	- Any one unit
Small 50-gallon tank	66 gallons	- Two 1/1 units
Medium 64-gallon tank	78 gallons	- One 1/1 unit + one 2/1 unit - One 1/1 unit + one 2/1½ unit
Large 80-gallon tank	92 gallons	- Three 1/1 units - One 2/1 unit + One 2/1½ unit - Two 2/1½ unit

# Distributed Systems: Clustered Deployments

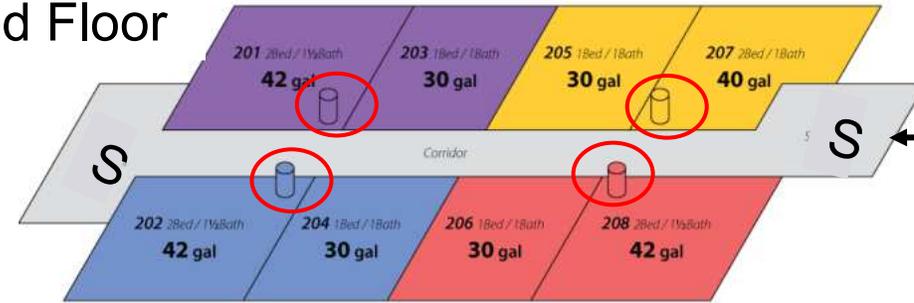
Try to cluster units to:

- Minimize total number of HPWHs
- Place units to mitigate sound and exhaust issues
- Minimize HW runs and avoid recirc loops

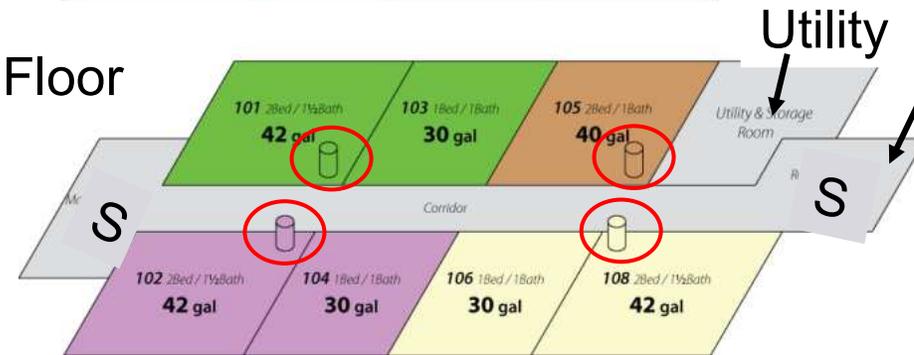
Third Floor



Second Floor



First Floor



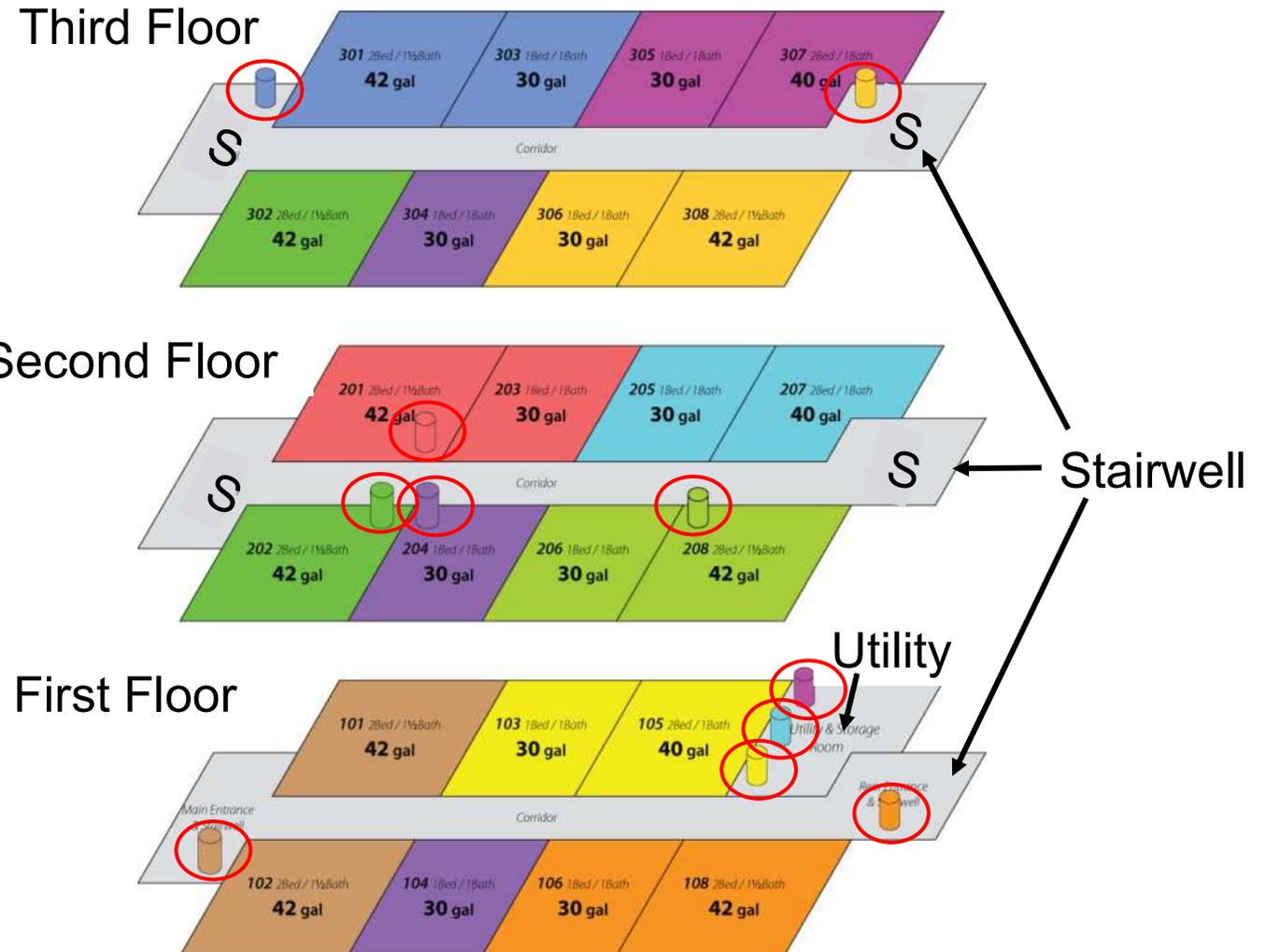
Stairwell

Utility

# Distributed Systems: Clustered Deployments

Try to cluster units to:

- Minimize total number of HPWHs
- Place units to mitigate sound and exhaust issues
- Minimize HW runs and avoid recirc loops



# Central HPWH Systems



## Central HPWH Systems: Advantages

- All equipment outside of units
  - Easy maintenance access
  - No in-unit noise
  - No in-unit exhaust
  - No in-unit condensate
- Centralized maintenance
- Applies well to larger buildings with dedicated maintenance staff



## Central HPWH Systems: Disadvantages

- More complex design, installation, operation
- Recirculation loop
  - Energy waste
  - Potential failure points
- Central mechanical room required
- Exterior space, noise, aesthetic considerations
- Tenant billing
- Potential whole-building failure

# Central HPWH Systems: Market Delivery

## Fully Packaged / Skid System

- All major components pre-assembled and piped at the factory
- Manufacturer provides design info to site engineer for permitting
- Manufacturer provides installation and operation instructions
- Generally least prone to design and installation error



# Central HPWH Systems: Market Delivery

## Fully Packaged / Skid System



# Central HPWH Systems: Market Delivery

## Fully Packaged / Skid System



# Central HPWH Systems: Market Delivery

## Fully Packaged / Skid System



# Central HPWH Systems: Market Delivery

## Fully Specified Built-Up System

- Engineer provides building characteristics to CHPWH provider
- CHPWH provider designs the system
- CHPWH provider provides installation and operation instructions
- More flexible but more prone to error



# Central HPWH Systems: Market Delivery

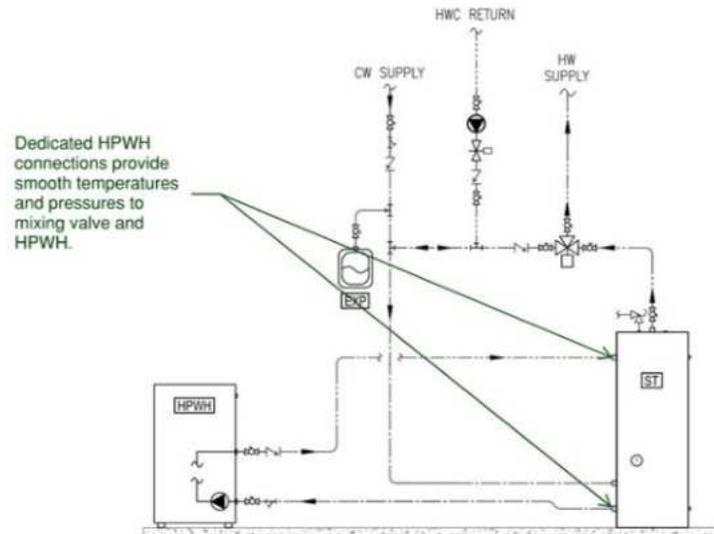
## Fully Specified Built-Up System



# Central HPWH Systems: Market Delivery

## Custom Engineered System

- Designed by engineer of record
- Engineer specifies and sizes all components
- Plumbing installer sources components
- Most flexible option but more prone to error



# Central HPWH Systems

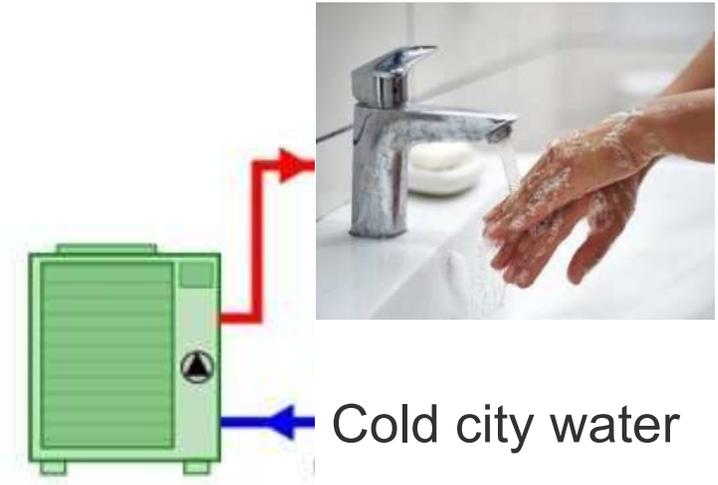
**Caution**

Enginerdy Material Ahead

# Central HPWH Systems: Hot Water Loads

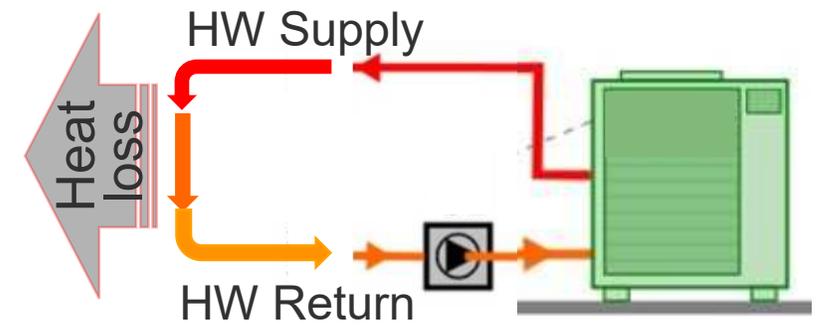
## Primary hot water load

- Caused by hot water usage
- Mains water temp  $\ggg$  DHW delivery temp
- Cold incoming water = Efficient HP operation
- Large, fluctuating load

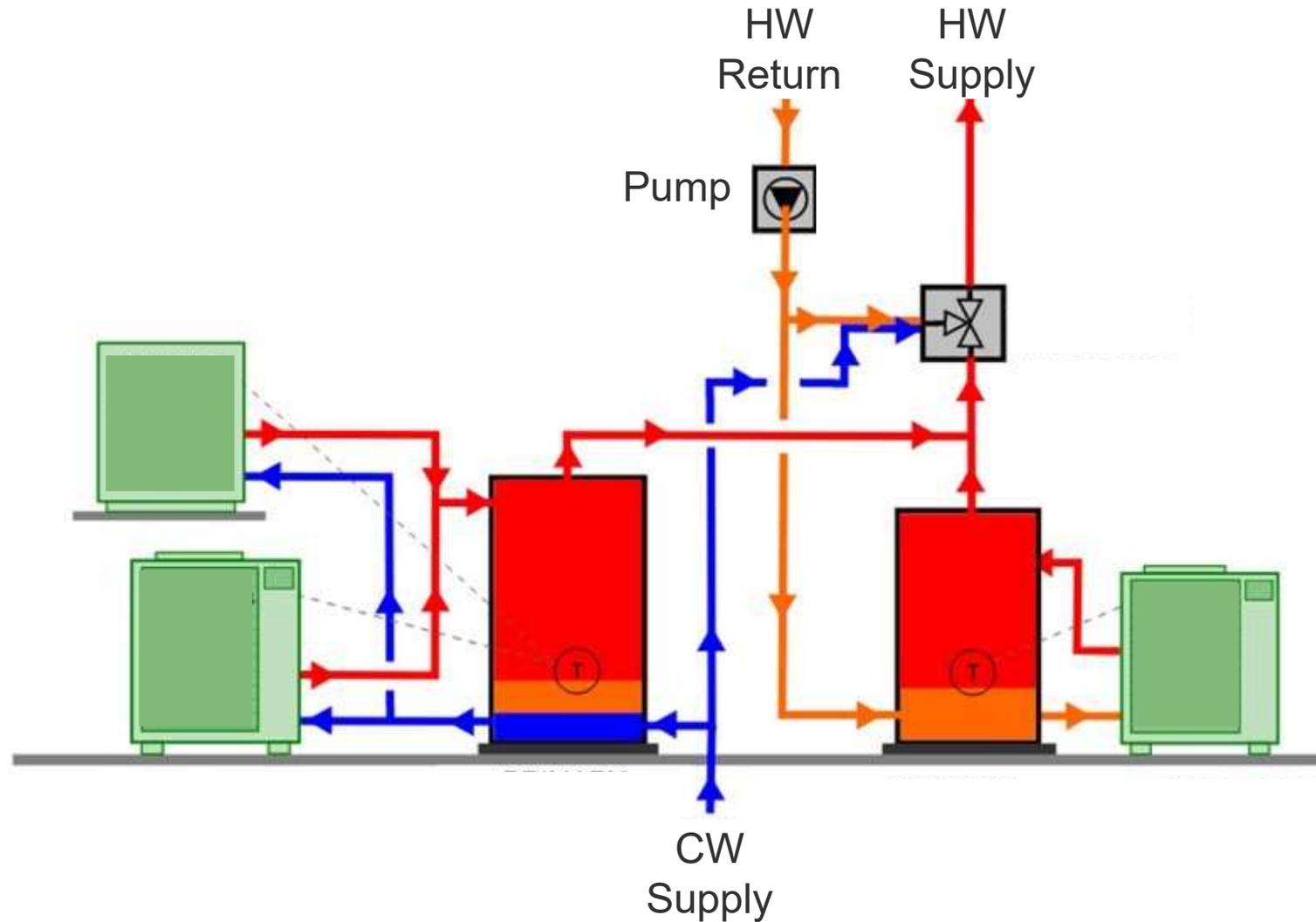


## HW circulation temperature maintenance

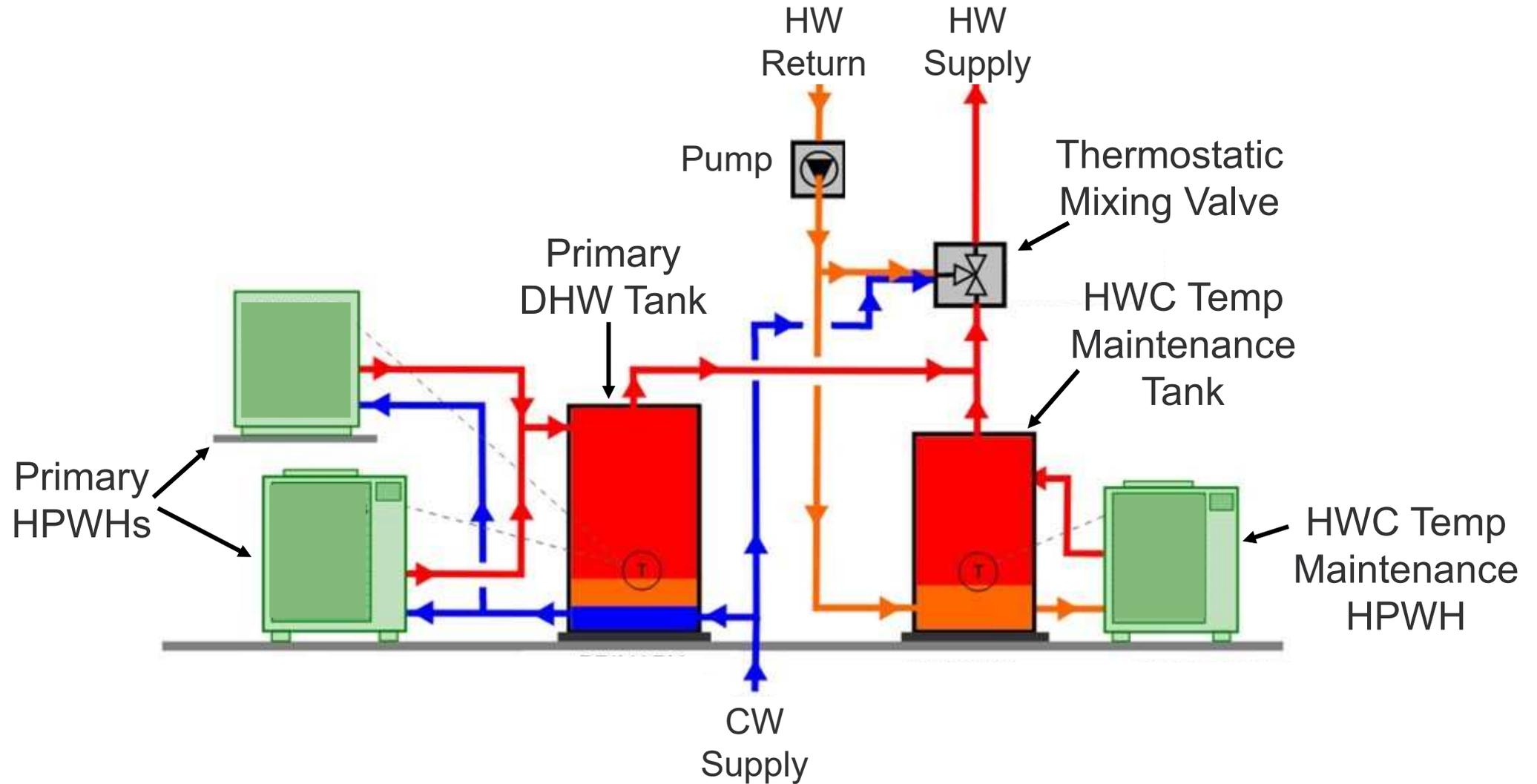
- Caused by recirculation pipe heat loss
- HWC return temp  $\ggg$  DHW delivery temp
- Warm incoming water = Inefficient HP operation
- Smaller, constant load



# Central HPWH Systems: Components

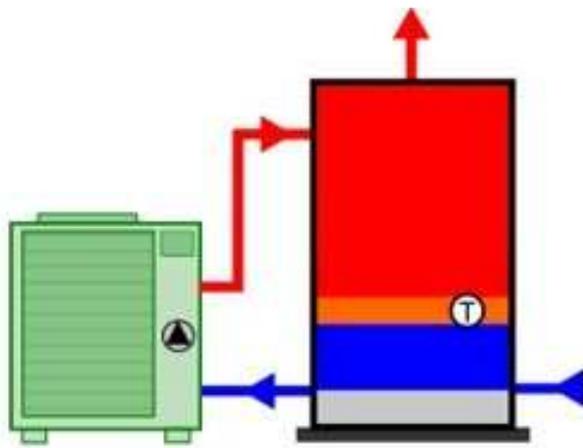


# Central HPWH Systems: Components

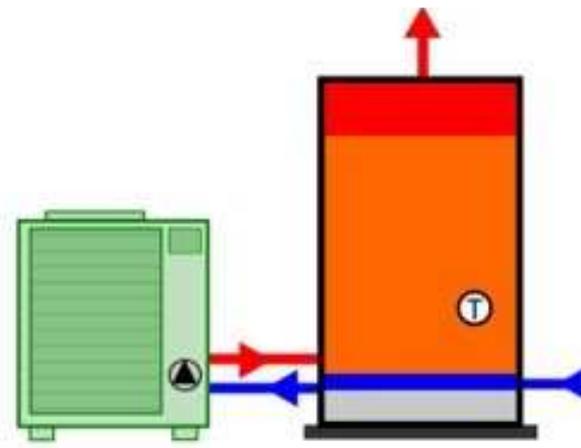


# Central HPWH Systems: Types of HPWHs

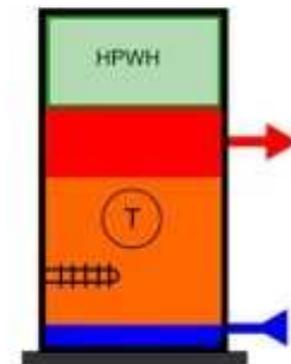
Single Pass HPWH



Multi-Pass HPWH



Integrated HPWH

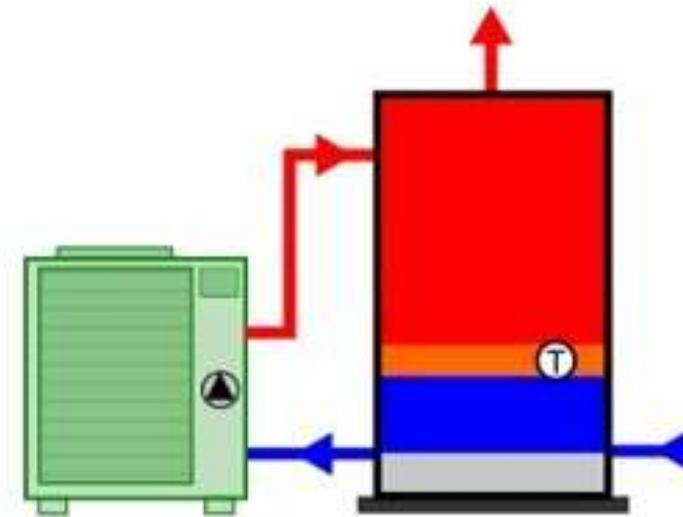


## Central HPWH Systems: Types of HPWHs

### Single-Pass HPWH

- Heat pump and tank are separate
- Adjusts flow to meet target outlet temp
- Maximizes HP efficiency
- May require separate heater for HWC temp maintenance

Single-Pass HPWH

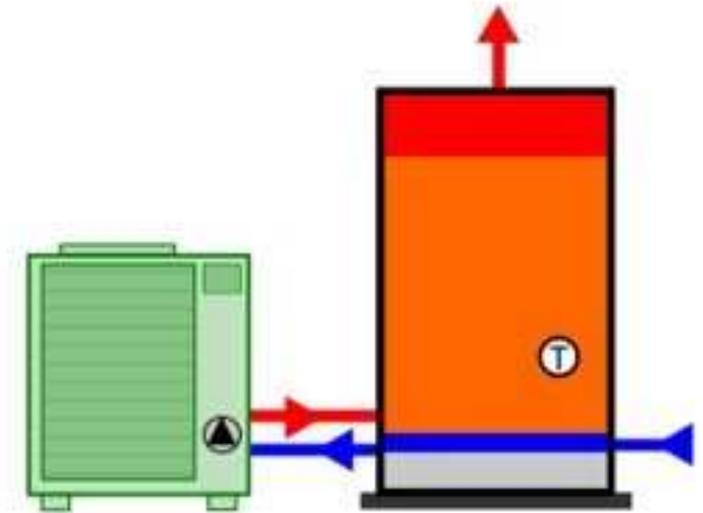


## Central HPWH Systems: Types of HPWHs

### Multi-Pass HPWH

- Heat pump and tank are separate
- Constant flow
- Heats by 5-10°F each pass
- Can provide HWC temp maintenance
- Similar to gas water heater installation
- Lower HP efficiency
- More storage required

Multi-Pass HPWH

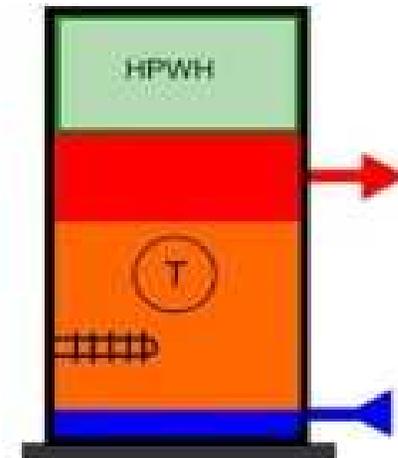


# Central HPWH Systems: Types of HPWHs

## Integrated HPWH

- Heat pump and tank are combined in a single unit
- Larger commercial units available
- Cost-effective for smaller loads
- Controls are proprietary; can be difficult to control when auxiliary heat is used

Integrated HPWH



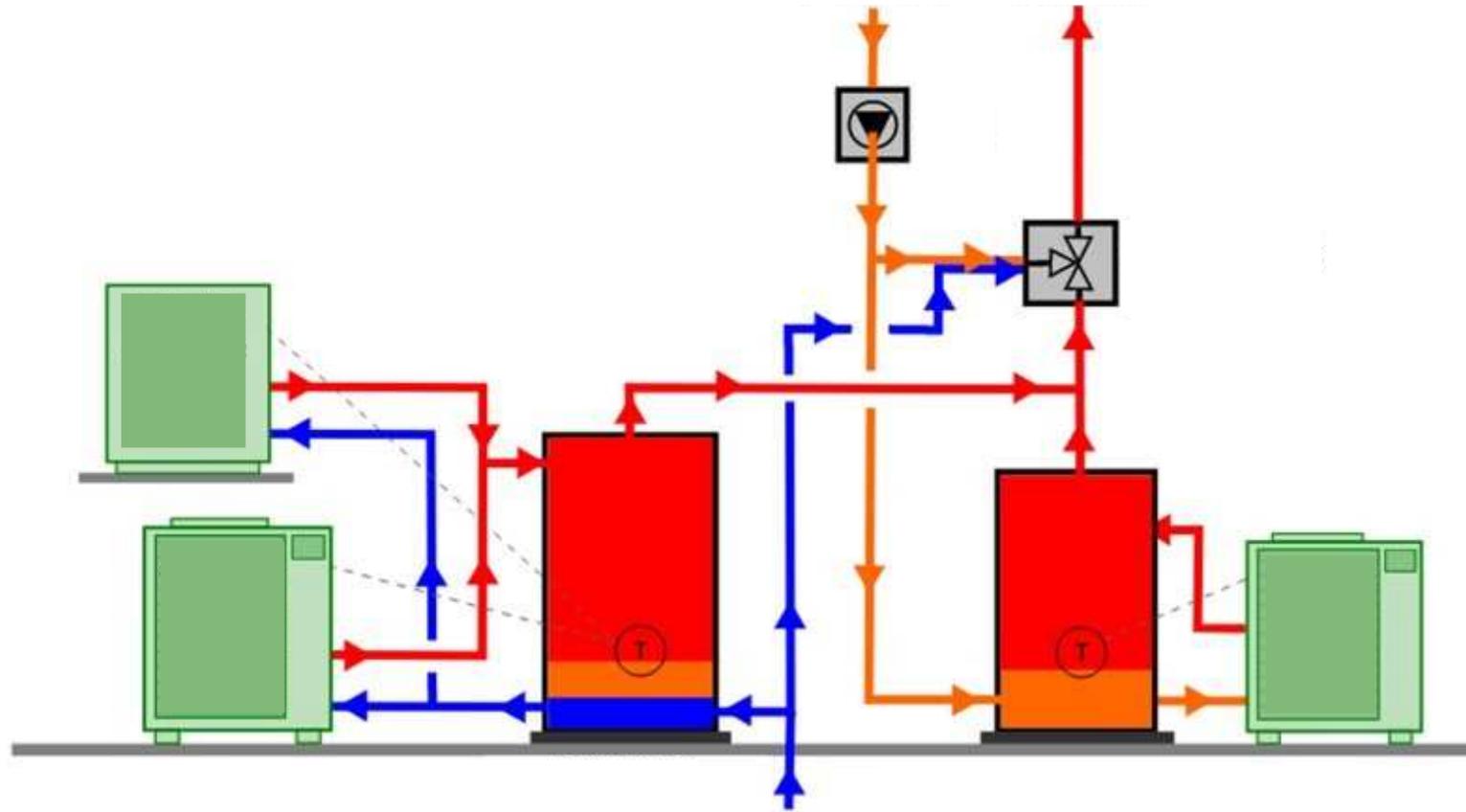
## Central HPWH Systems

**WARNING**

Potentially Disturbing Engineering Material Past This Point

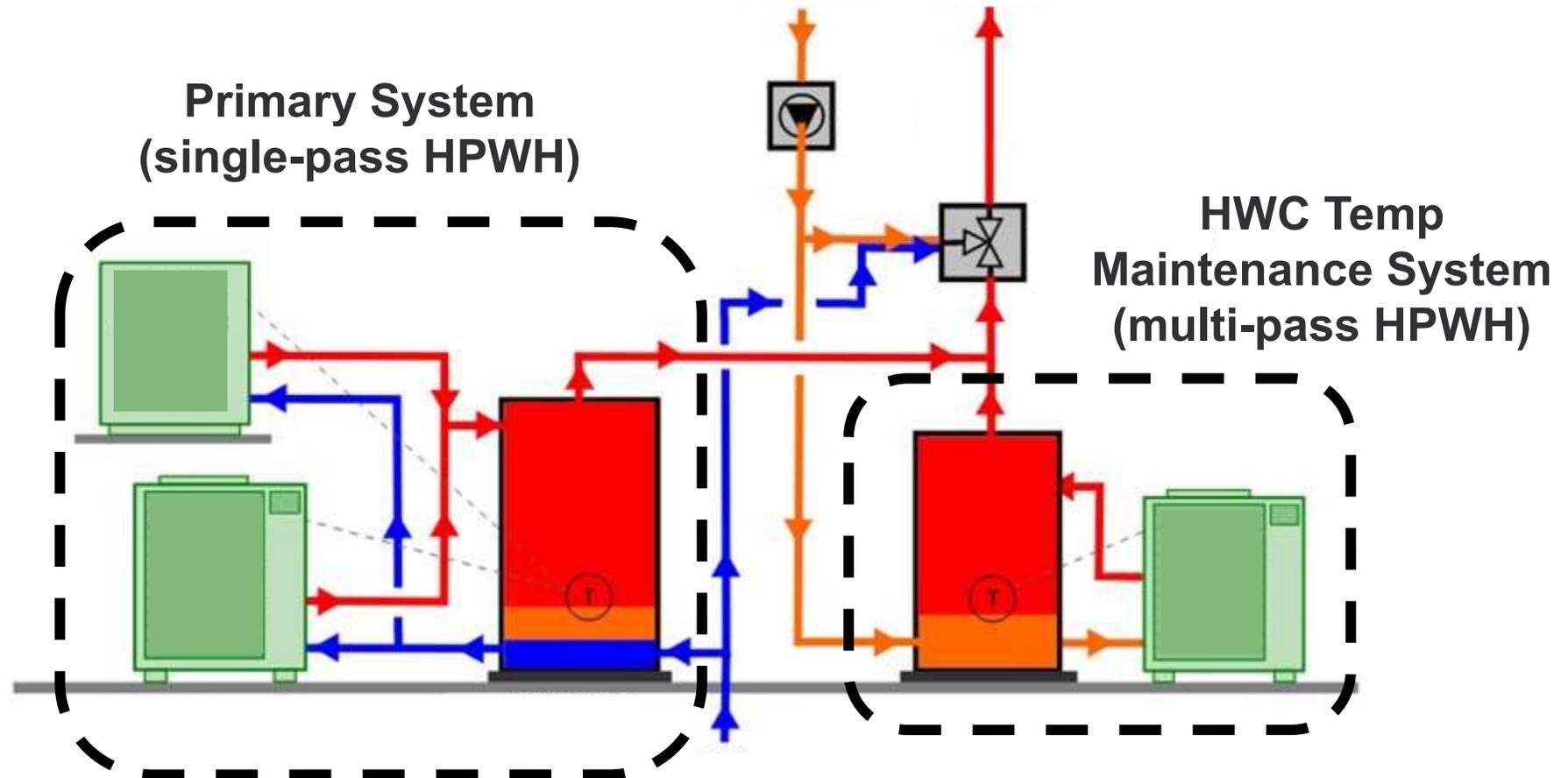
# Central HPWH Systems: System Configurations

## HWC Return to Parallel Temperature Maintenance Tank



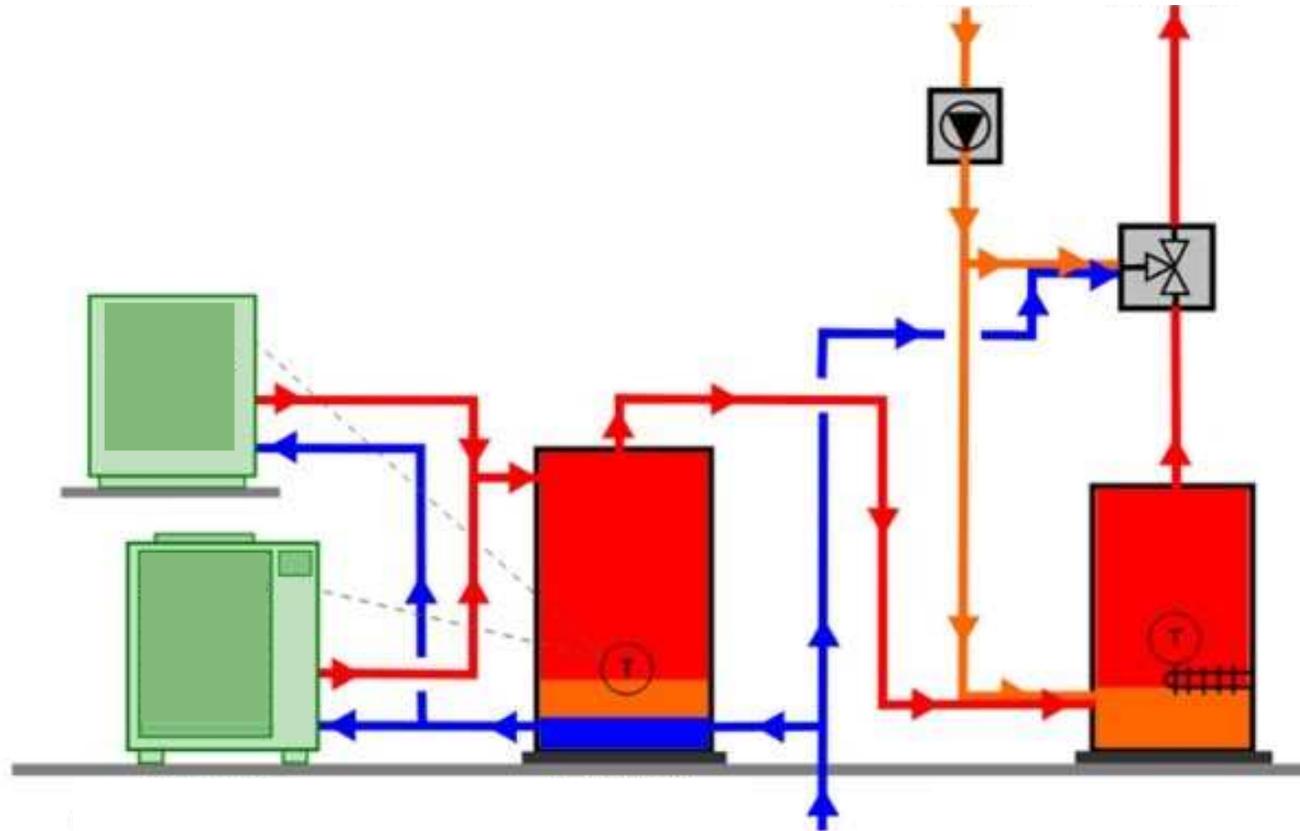
# Central HPWH Systems: System Configurations

## HWC Return to Parallel Temperature Maintenance Tank



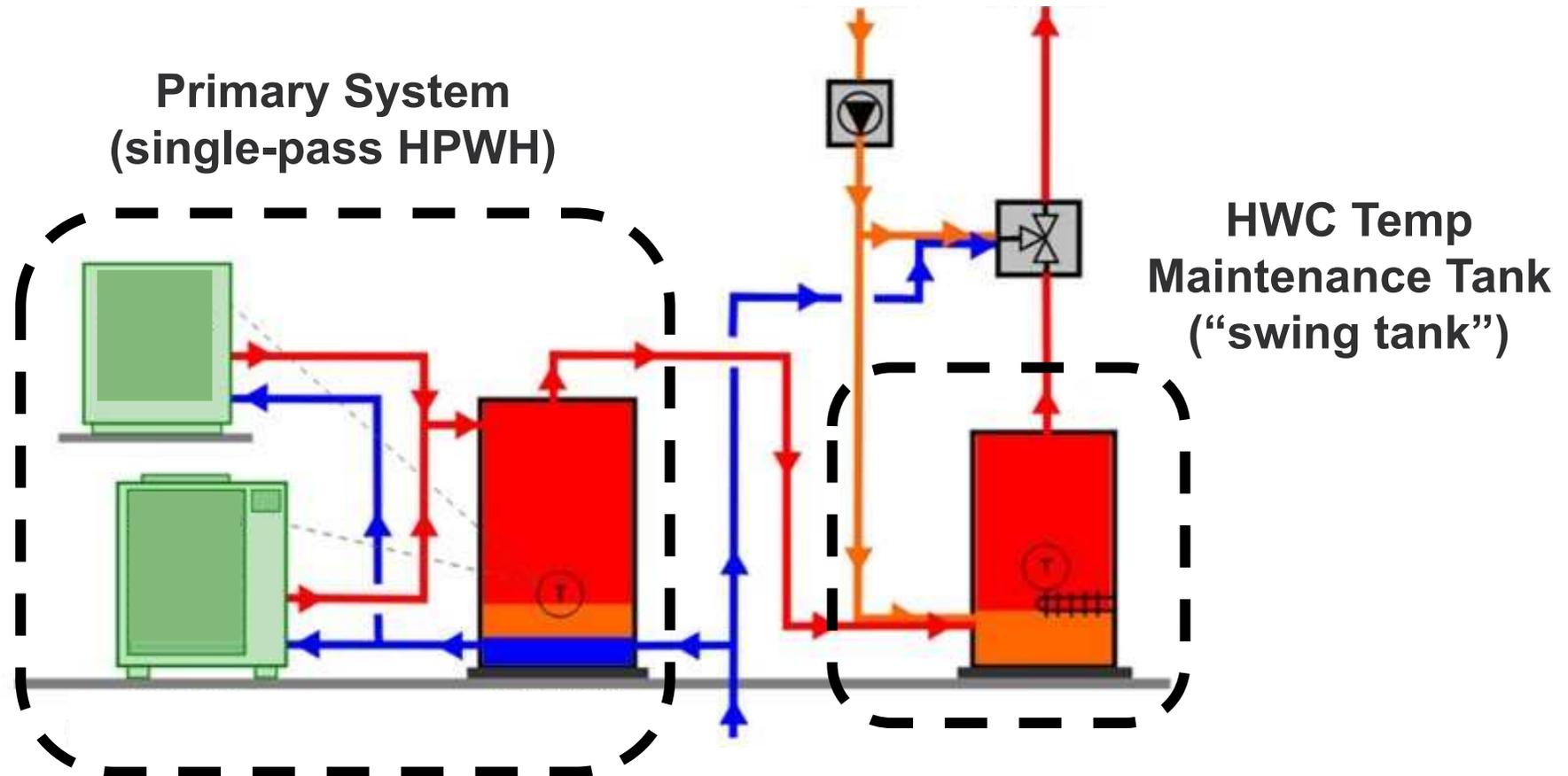
# Central HPWH Systems: System Configurations

## HWC Return to In-Series Temperature Maintenance Tank (Swing Tank)



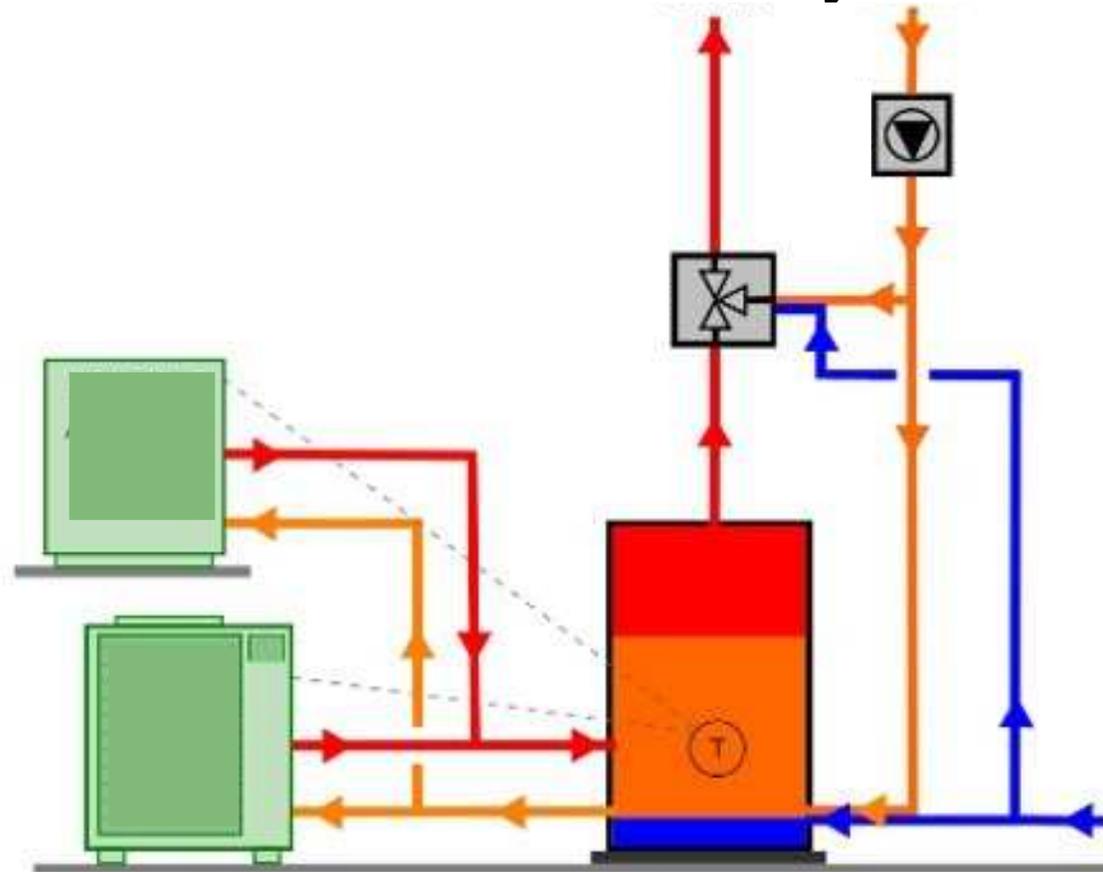
# Central HPWH Systems: System Configurations

## HWC Return to In-Series Temperature Maintenance Tank (Swing Tank)



# Central HPWH Systems: System Configurations

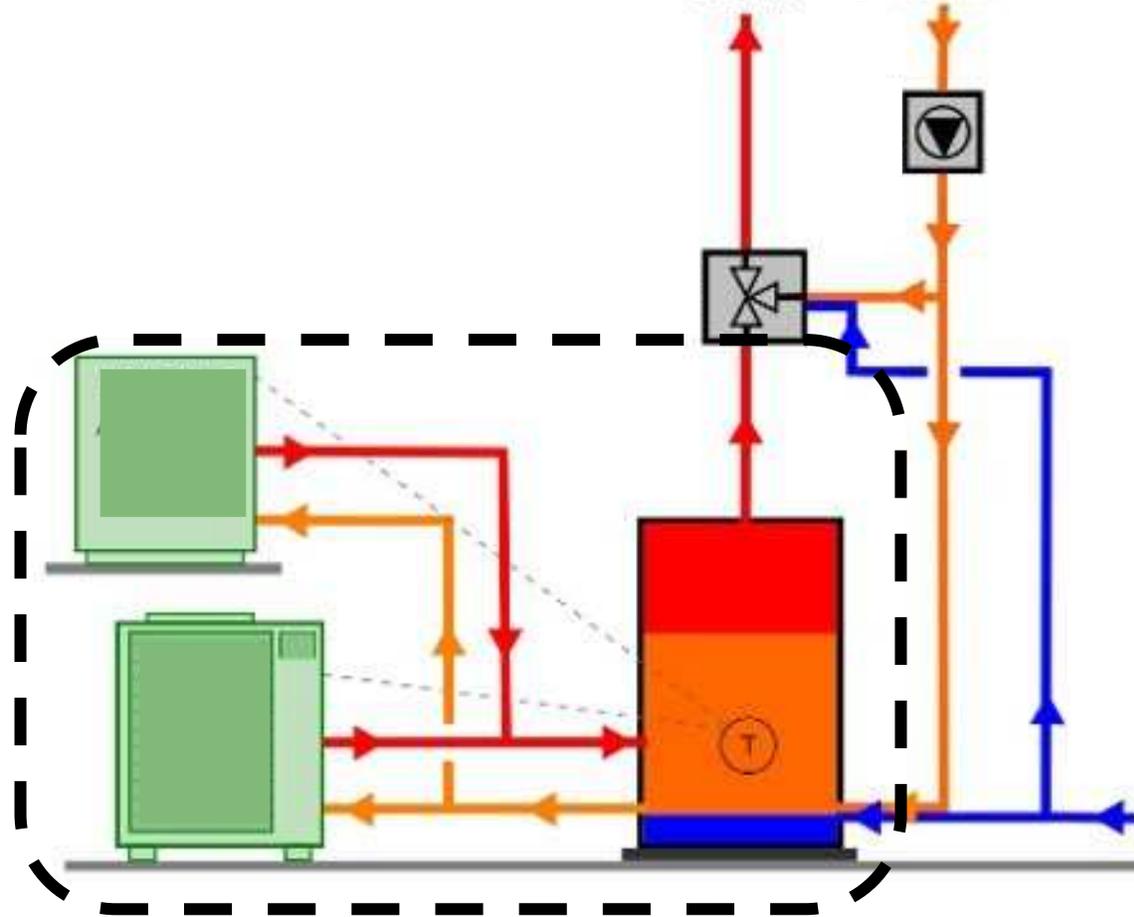
## Multi-Pass HWC Return to Primary



# Central HPWH Systems: System Configurations

## Multi-Pass HWC Return to Primary

Combined Primary  
System  
and  
HWC Temp Maintenance  
System  
(multi-pass HPWH)



# Central HPWH Systems: Additional Considerations

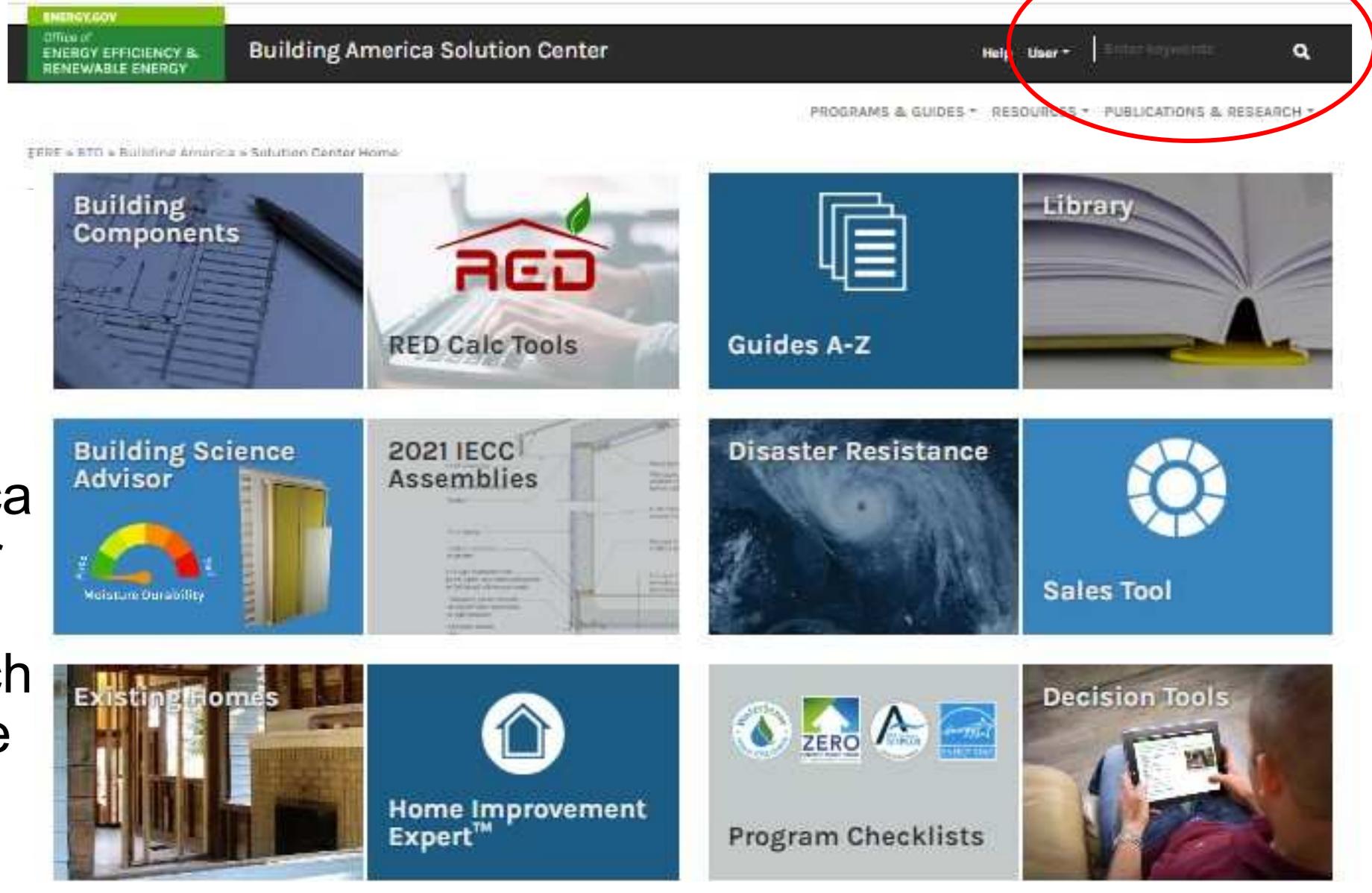
- Sizing
  - Go for larger storage, smaller HP capacity
- Condensate management
- Structural preparation for storage tanks
- Back-up heating
  - Redundancy
  - Cold temperature operation





Where to Find  
HPWH Guides  
in the  
Building America  
Solution Center

From the Search  
Bar in the home  
page:

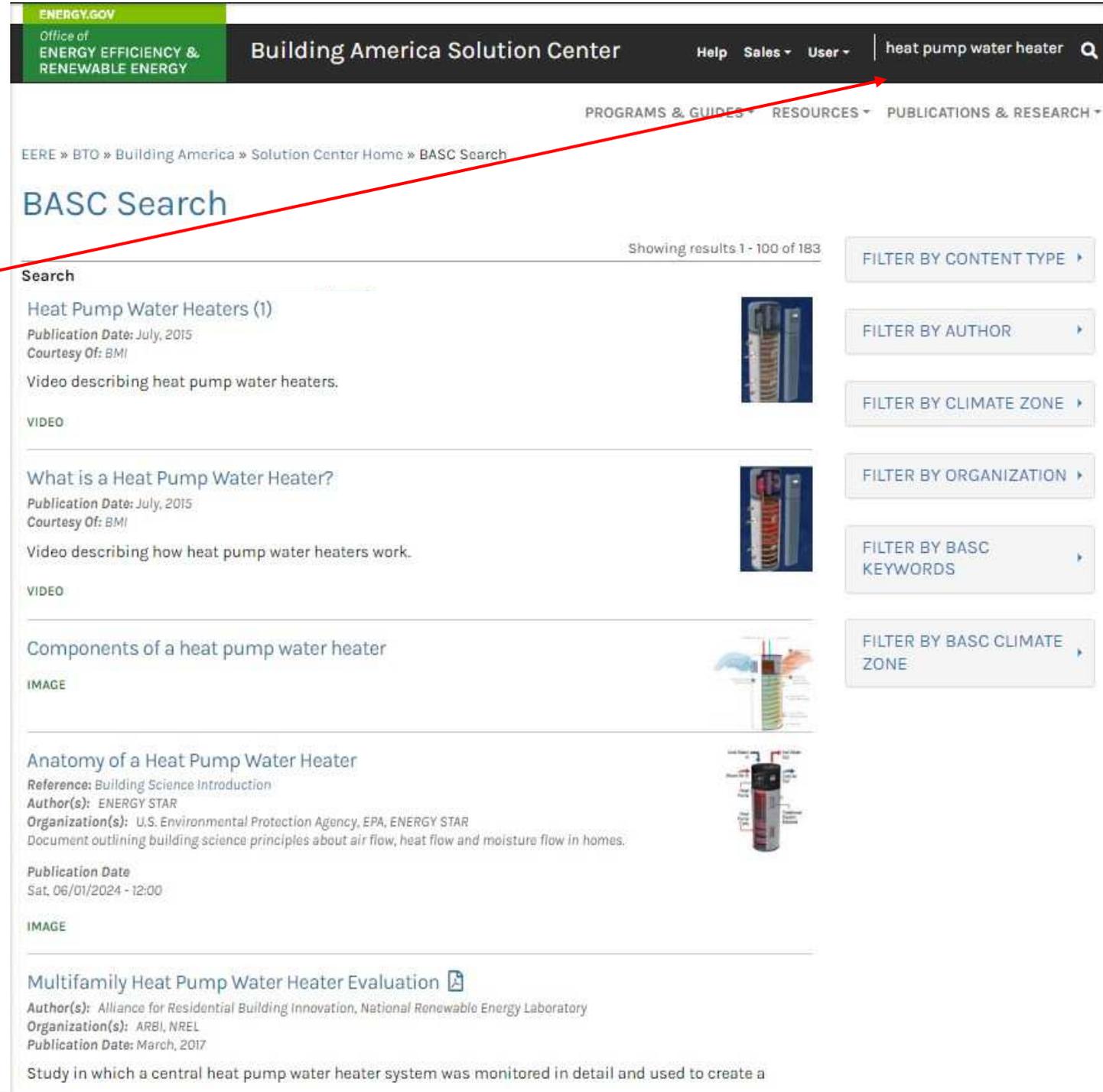


As a community driven tool, we welcome your comments on how to continuously improve the Solution Center. If you are interested in submitting content, please become a registered user and see the criteria for submissions.

Type “heat pump water heater” in the search bar at the top right of the page.

Search results could include

- guides
- images
- videos
- references
- CAD files
- presentations
- case studies



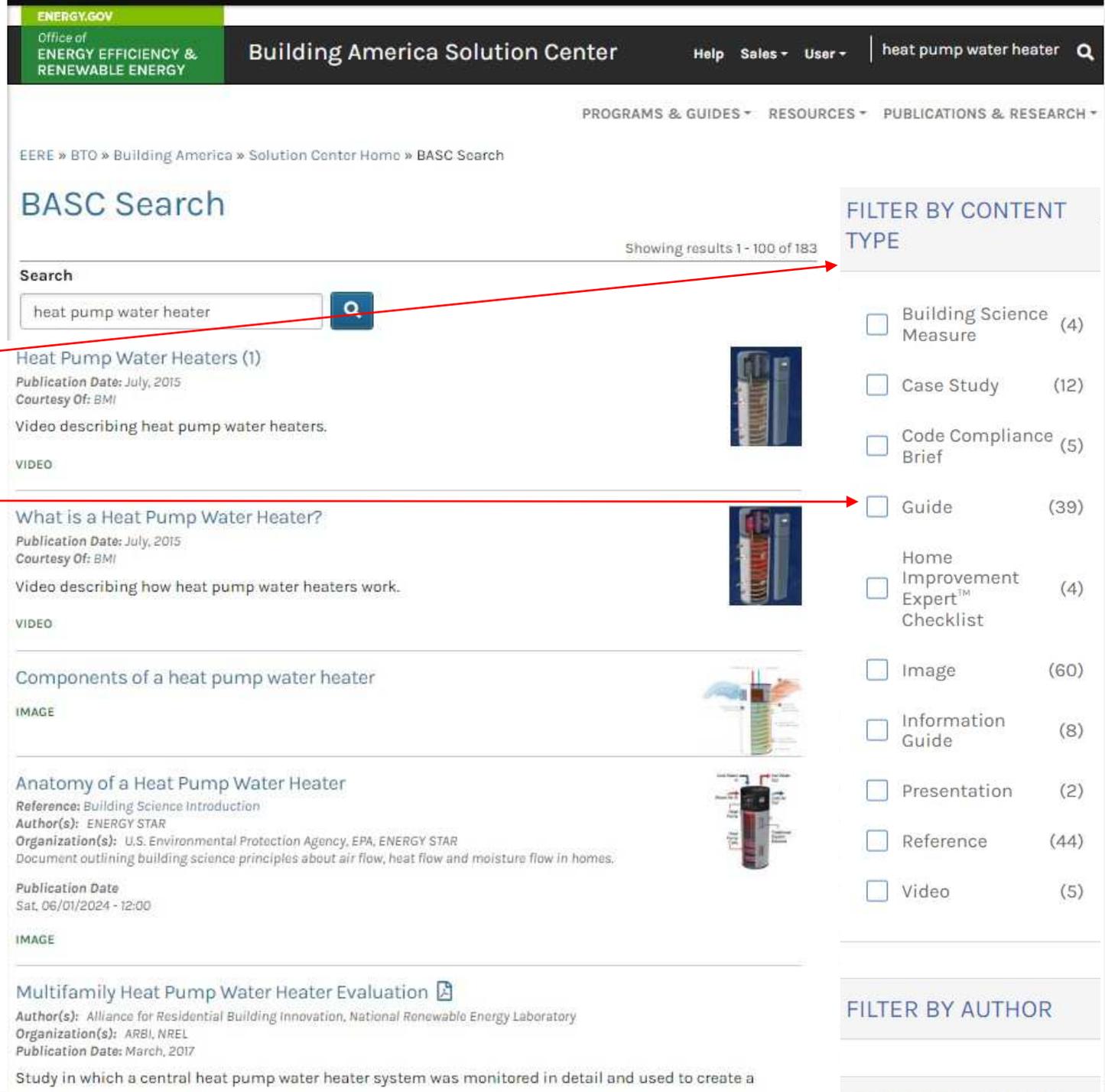
The screenshot shows the 'Building America Solution Center' website. At the top, there is a navigation bar with 'ENERGY.GOV', 'Office of ENERGY EFFICIENCY & RENEWABLE ENERGY', and 'Building America Solution Center'. A search bar on the right contains the text 'heat pump water heater'. Below the navigation bar, there are links for 'PROGRAMS & GUIDES', 'RESOURCES', and 'PUBLICATIONS & RESEARCH'. The main content area is titled 'BASC Search' and shows 'Showing results 1 - 100 of 183'. The search results are listed under the heading 'Search' and include:

- Heat Pump Water Heaters (1)**  
Publication Date: July, 2015  
Courtesy Of: BMI  
Video describing heat pump water heaters.  
VIDEO
- What is a Heat Pump Water Heater?**  
Publication Date: July, 2015  
Courtesy Of: BMI  
Video describing how heat pump water heaters work.  
VIDEO
- Components of a heat pump water heater**  
IMAGE
- Anatomy of a Heat Pump Water Heater**  
Reference: Building Science Introduction  
Author(s): ENERGY STAR  
Organization(s): U.S. Environmental Protection Agency, EPA, ENERGY STAR  
Document outlining building science principles about air flow, heat flow and moisture flow in homes.  
Publication Date: Sat, 06/01/2024 - 12:00  
IMAGE
- Multifamily Heat Pump Water Heater Evaluation**  
Author(s): Alliance for Residential Building Innovation, National Renewable Energy Laboratory  
Organization(s): ARBI, NREL  
Publication Date: March, 2017  
Study in which a central heat pump water heater system was monitored in detail and used to create a

On the right side of the search results, there are several filter buttons: 'FILTER BY CONTENT TYPE', 'FILTER BY AUTHOR', 'FILTER BY CLIMATE ZONE', 'FILTER BY ORGANIZATION', 'FILTER BY BASC KEYWORDS', and 'FILTER BY BASC CLIMATE ZONE'. A red arrow points from the search bar to the search results.

Select “Filter by Content Type.”

Choose “Guide” to sort the search results to guides only.



ENERGY.GOV  
Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Building America Solution Center

Help Sales User heat pump water heater

PROGRAMS & GUIDES RESOURCES PUBLICATIONS & RESEARCH

EERE » BTO » Building America » Solution Center Home » BASC Search

## BASC Search

Showing results 1 - 100 of 183

Search

heat pump water heater

Heat Pump Water Heaters (1)

Publication Date: July, 2015  
Courtesy Of: BMI

Video describing heat pump water heaters.

VIDEO

What is a Heat Pump Water Heater?

Publication Date: July, 2015  
Courtesy Of: BMI

Video describing how heat pump water heaters work.

VIDEO

Components of a heat pump water heater

IMAGE

Anatomy of a Heat Pump Water Heater

Reference: Building Science Introduction  
Author(s): ENERGY STAR  
Organization(s): U.S. Environmental Protection Agency, EPA, ENERGY STAR  
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Publication Date  
Sat, 06/01/2024 - 12:00

IMAGE

Multifamily Heat Pump Water Heater Evaluation

Author(s): Alliance for Residential Building Innovation, National Renewable Energy Laboratory  
Organization(s): ARBI, NREL  
Publication Date: March, 2017

Study in which a central heat pump water heater system was monitored in detail and used to create a

### FILTER BY CONTENT TYPE

- Building Science Measure (4)
- Case Study (12)
- Code Compliance Brief (5)
- Guide (39)
- Home Improvement Expert™ Checklist (4)
- Image (60)
- Information Guide (8)
- Presentation (2)
- Reference (44)
- Video (5)

### FILTER BY AUTHOR

## BASC Search

Showing results 1 - 39 of 39

### Search

heat pump water heater



#### Heat Pump Water Heaters for Single-Family Homes

Guide describing the planning and installation process for Heat Pump Water Heaters (HPWHs) in single-family homes, including model selection, installation location, thermal resource adequacy, and condensate removal.

GUIDE

#### Distributed Heat Pump Water Heaters for Multifamily Buildings

Guide describing strategies for effectively utilizing integrated consumer heat pump water heaters (HPWH) in multifamily buildings.

GUIDE

#### Central Heat Pump Water Heaters for Multifamily Buildings

Guide providing an overview of central heat pump water heater applications in multifamily buildings.

GUIDE

FILTER BY  
CONTENT TYPE

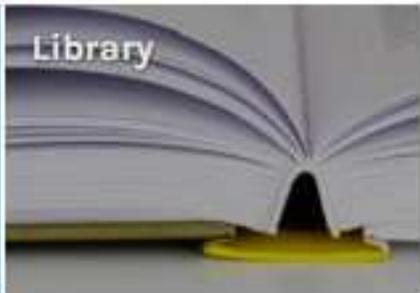
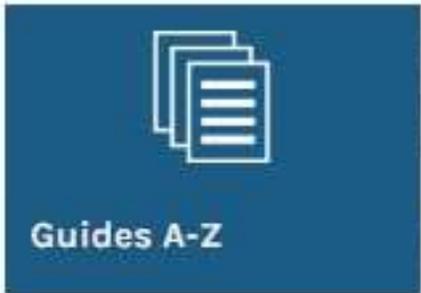
Guide (39)

FILTER BY CLIMATE  
ZONE

FILTER BY BASC  
KEYWORDS

Results are  
sorted by  
relevance.

EEER & BTO | Building America | Solution Center Home



Where to Find HPWH Guides in the Building America Solution Center

from the Program Checklists in the home page:

EERE » BTO » Building America » Solution Center Home » Program Checklists

## Program Checklists

The Building America Solution Center supports a suite of U.S. Department of Energy (DOE) and U.S. Environmental Protection Agency (EPA) labeling programs designed to aid construction of comfortable, healthy, durable, and energy efficient homes. Click on the program logos below to find detailed guides to help you install and specify the measures in each program's checklists.



### Zero Energy Ready Home

The DOE Zero Energy Ready Home certification identifies homes that have achieved exemplary levels of energy efficiency and performance, enabling them to offset all or most of their annual energy consumption with a modest sized renewable energy system.

Single Family

Multifamily



### ENERGY STAR

ENERGY STAR New Homes are certified to meet standards designed to provide superior comfort and durability while delivering energy savings of up to 30% compared to typical new homes.

Single Family

Multifamily



### Indoor airPLUS

Indoor airPLUS builds on EPA's ENERGY STAR requirements with additional construction specifications designed to help deliver comprehensive indoor air quality.

Checklist



### EPA WaterSense®

EPA's WaterSense criteria encourage the use of water-saving plumbing, fixtures, appliances, and irrigation to reduce water consumption and help consumers save on water and energy utility bills.

Checklist

# Program Checklists

## Choose "Multifamily"



# Zero Energy Ready Home: Multifamily Checklist

Open the new DOE Zero ENERGY Ready Home Multifamily Checklist.

Select Exhibit 1: Multifamily Mandatory Requirements.

Choose # 10. Electric Ready Water Heating

Exhibit 1: Multifamily Mandatory Requirements	
1. ZERH Multifamily V2 National Rater Checklist	+
2. ENERGY STAR Multifamily New Construction Baseline	+
3. Envelope	+
4. Duct System	+
5. Hot Water Efficiency	+
6. Lighting and Appliances	+
7. Indoor Air Quality	+
8. Renewable Ready	+
9. Electric Vehicle Ready	+
10. Electric Ready Water Heating	-
10.1 Dwelling units with in-unit water heaters meet minimum electric and space requirements.	
10.2 Dwelling units with in-unit water heaters have a condensate drain installed within three feet of existing water heater.	
11. Electric Ready Space Heating	+



## Zero Energy Ready Home: Multifamily Checklist

Or, scroll down to the National Rater Checklist.

Select #10. Heat Pump Water Heater Ready.

Exhibit 1: Multifamily Mandatory Requirements	+
National Rater Checklist	-
1. Partnership Status	+
2. ENERGY STAR Multifamily New Construction Baseline	+
3. Building Envelope	+
4. Duct System	+
5. Water Heating Efficiency	+
6. Lighting and Appliances	+
7. Indoor Air Quality	+
8. Renewable Ready	+
9. Electric Vehicle Ready	+
<u>10. Heat Pump Water Heater Ready</u>	-
10.1 Dwelling units with in-unit water heaters meet minimum electric and space requirements.	
10.2 Dwelling units with in-unit water heaters have a condensate drain installed within three feet of existing water heater.	
11. Heat Pump Space Heating Ready	+



# ENERGY STAR Multifamily Checklist

Or, open the new ENERGY STAR Multifamily Checklist.

Select Reference Design.  
Then select Water Heater.

Or, scroll down and select the National Rater Field Checklist. Heat pump water heater guides are under #11. Domestic Hot Water.

National Program Requirements Exhibit 1: ENERGY STAR Multifamily Reference Design -

Residential Cooling Equipment (Where Provided) in Dwelling Units or Common Spaces +

Residential Heating Equipment (Where Provided) in Dwelling Units or Common Spaces +

Envelope, Windows, & Doors +

Water Heater +

Thermostat & Ductwork +

Lighting, Appliances, & Fixtures +

National Rater Field Checklist +

Rater Design Review Checklist +

Water Management System Requirements +

Guides are the “heart” of the Solution Center

Guides have 8 to 10 tabs:

**Scope** – a scope of work for contractors.



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EERE » BTO » Building America » Solution Center Home » Guides A-Z » Distributed Heat Pump Water Heaters for Multifamily Buildings

## Distributed Heat Pump Water Heaters for Multifamily Buildings

Print

Scope	Description	Success	Climate	Training	Compliance	Retrofit	More
<p><b>Scope</b></p> <p>Plan a successful installation of integrated consumer heat pump water heaters (HPWH) to supply domestic hot water in a multifamily residential building.</p> <ul style="list-style-type: none"> <li>Learn why multifamily buildings present additional challenges for HPWHs and how to overcome those challenges.</li> <li>Choose between a one-to-one or clustered approach.</li> <li>Size the HPWHs appropriately.</li> <li>Use installation locations that will ensure a smooth installation, efficient water heater operation, and occupant comfort.</li> </ul> <p>See the Compliance Tab for related codes and standards requirements, and criteria to meet national programs such as DOE's Zero Energy Ready Home program, ENERGY STAR Certified Homes, and Indoor airPLUS.</p>							



Anatomy of a Heat Pump Water Heater

## Description

- a description of the technology or construction method
- Pros and cons of this option and other options.
- Installation considerations.

## Distributed Heat Pump Water Heaters for Multifamily Buildings



Scope	Description	Success	Climate	Training	Compliance	Retrofit	More
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### Description

This guide provides strategies for successfully using integrated consumer heat pump water heaters (HPWH) in multifamily buildings. In this guide, the term “integrated consumer HPWHs” refers to the standard HPWHs found in home improvement stores that are typically used in single-family homes (Figure 1). In multifamily applications, these HPWHs are installed either individually in each dwelling unit (one-to-one) or using a clustered approach where each individual HPWH serves just a few dwelling units. This guide builds on information about consumer HPWHs presented in the guide Heat Pump Water Heaters for Single-Family Homes. That guide provides a valuable background for using this guide. For guidance on using centralized heat pump water heating systems for multifamily buildings, see the Central Heat Pump Water Heaters for Multifamily Buildings.



Figure 1. A heat pump water heater is installed in the interior closet of a multifamily dwelling unit. (Source: Larson Energy Research)

Heat pump water heaters work by pulling heat from the surrounding air and moving it to the water stored in the tank to provide domestic hot water (DHW). Integrated refers to the fact that the heat pump’s compressor and heat exchanger are integrated into one unit attached to the water storage

# Other Tabs:

Success

Climate

Training

Compliance

Retrofit

More

## Distributed Heat Pump Water Heaters for Multifamily Buildings

Print

Scope	Description	Success	Climate	Training	Compliance	Retrofit	More
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### More Info.

Access to some references may require purchase from the publisher. While we continually update our database, links may have changed since posting. Please contact our webmaster if you find broken links.

### References and Resources\*

#### Heat Pump Retrofit Strategies for Multifamily Buildings

Author(s): Steven Winter Associates, Natural Resources Defense Council  
 Organization(s): SWA, NRDC  
 Publication Date: April, 2019

Report describing the various heat pump retrofit options for multifamily buildings in the U.S., segmented by building typology and heating system, to support better environmental, economic, and health outcomes.

#### Getting to All-Electric Multifamily Zero Net Energy Construction

Author(s): Dryden Amy, Brooks Andrew, Duff Meghan, Pfotenhauer Greg, Stone Nehemiah, Armstrong Sean, Higbee Emily  
 Organization(s): California Energy Commission  
 Publication Date: March, 2023

Report describing the cost-effectiveness and performance of all-electric, zero net energy multifamily buildings in California, detailing technical challenges and providing recommendations for design, construction, codes, standards, and operations to support future projects.

#### Evaluation of Unitary Heat Pump Water Heaters with Load-Shifting Controls in a Shared Multifamily Configuration

Author(s): Hoesechele Marc, Haile James, Grant Peter  
 Organization(s): Pacific Gas and Electric Company, PG&E, Energy Transition Coordinating Council, ETCC  
 Publication Date: May, 2022

Report describing the performance, cost, and carbon impacts of unitary heat pump water heaters with load-shifting controls in a shared configuration for a multi-family project, highlighting significant savings in energy usage, CO2 emissions, and utility costs.

#### Heat Pump Water Heaters in Small Spaces Lab Testing: "The Amazing Shrinking Room"

Author(s): Larson Sam, Larson Ben  
 Organization(s): Northwest Energy Efficiency Alliance, NEEA, Cascade Engineering Services, Larson Energy Research  
 Publication Date: November, 2022

Report describing a laboratory assessment that provides insights into space requirements and venting strategies for heat pump water heaters (HPWH) to enhance retrofit installations and provide actionable guidance for manufacturers, designers, engineers, installers, and owners.

#### Laboratory Testing of Heat Pump Water Heater Performance: Impact of Airflow and Space Configurations

Author(s): Larson Ben, Larson Sam, Gantley Maya  
 Organization(s): Pacific Gas and Electric Company, PG&E, Energy Transition Coordinating Council, ETCC  
 Publication Date: December, 2023

Report describing the research conducted to support California's Title 24, Part 6 Building Energy Efficiency Standards by analyzing the impact of installation location and ventilation on heat pump water heater (HPWH) performance, emphasizing the need for proper installation conditions to maximize...

# Questions?



