EEBA High Performance Home Summit

Salt Lake City, UT

A Deep Dive into Heat Pump Water Heaters for Multifamily Buildings

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Pacific Northwest National Laboratory

EEBA
Energy & Environmental Building Alliance

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Special Thanks to the Experts

Image credits: Larson Energy Research; Ecotope

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

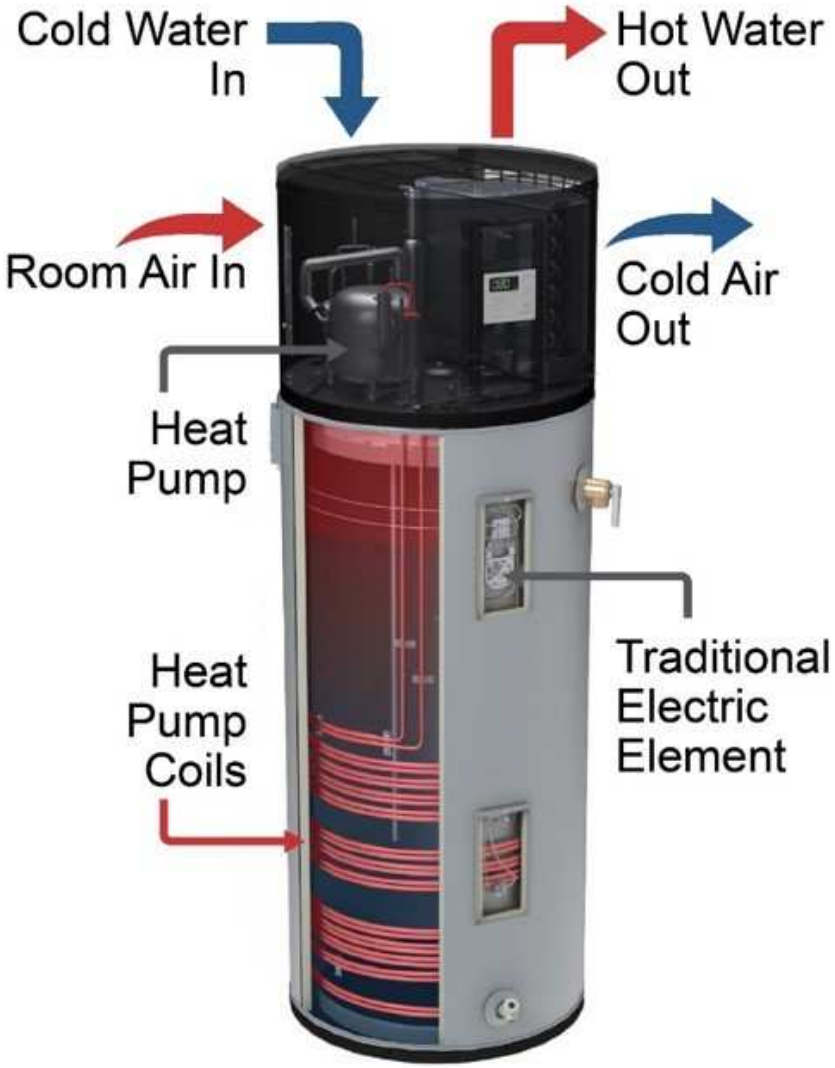
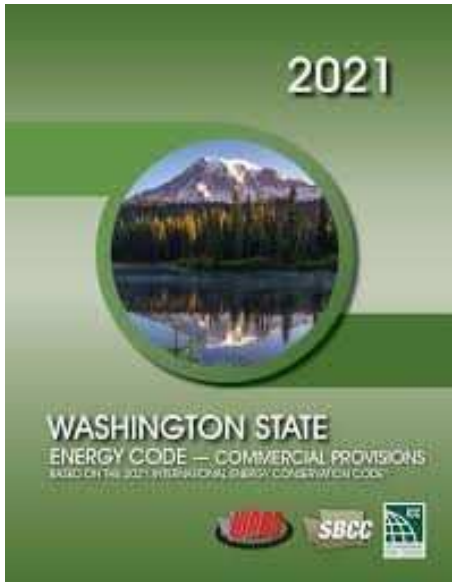


Image credit: ENERGY STAR

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



ZERO
ENERGY READY HOME
U.S. DEPARTMENT OF ENERGY

energy
ENERGY STAR

Image credits: DOE Zero Energy Ready Home; EPA ENERGY STAR; Washington State Building Code Council

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Heat Pump Water Heaters (HPWH)

Image credits: Larson Energy Research

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Heat Pump Water Heaters (HPWH)

Image credits: Ecotope

Implementation Approaches

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

Image credits; Ecotope; Larson Energy Research

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Distributed Systems

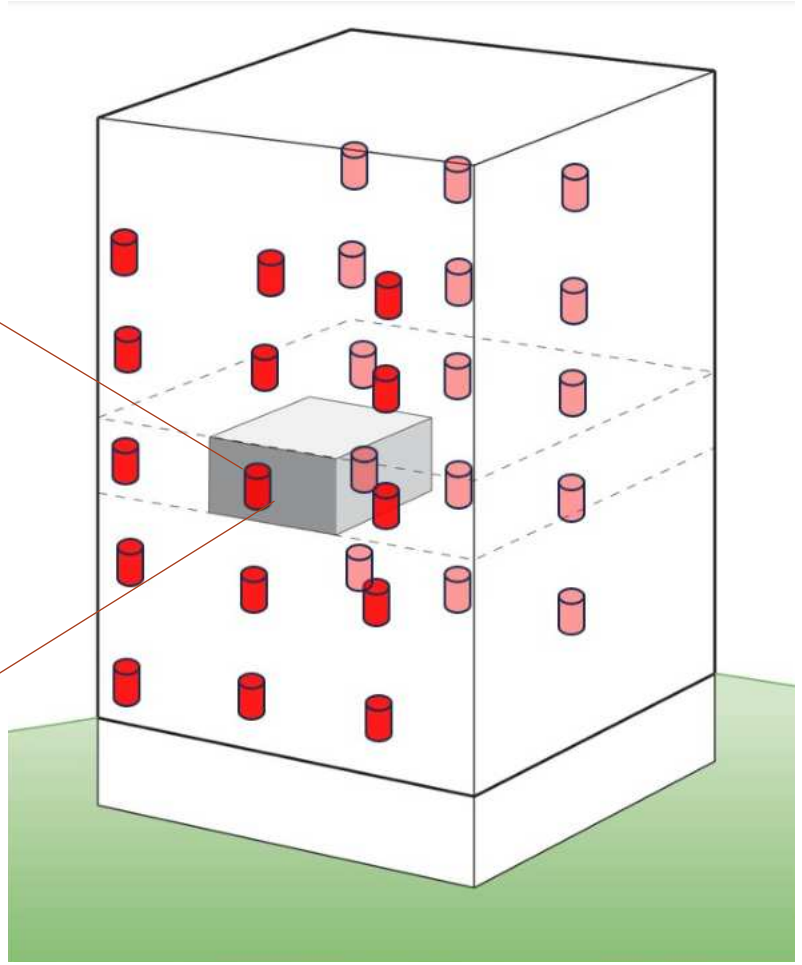


Image credits; Larson Energy Research; BSC modified by PNNL

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!**

Image credit: ENERGY STAR

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

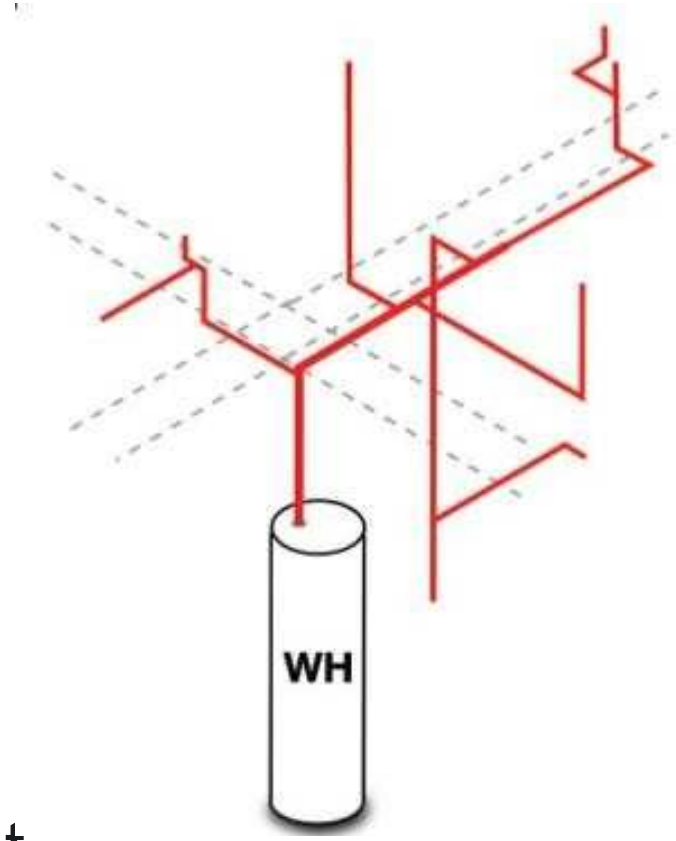


Image credit: International Association of Plumbing and Mechanical Officials

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?

Image credits: NEEA via ENERGY STAR; Larson Energy Research

Distributed Systems: Small-Space Installation

Image credit: Larson Energy Research

Distributed Systems: Small-Space Installation

Passive Ventilation

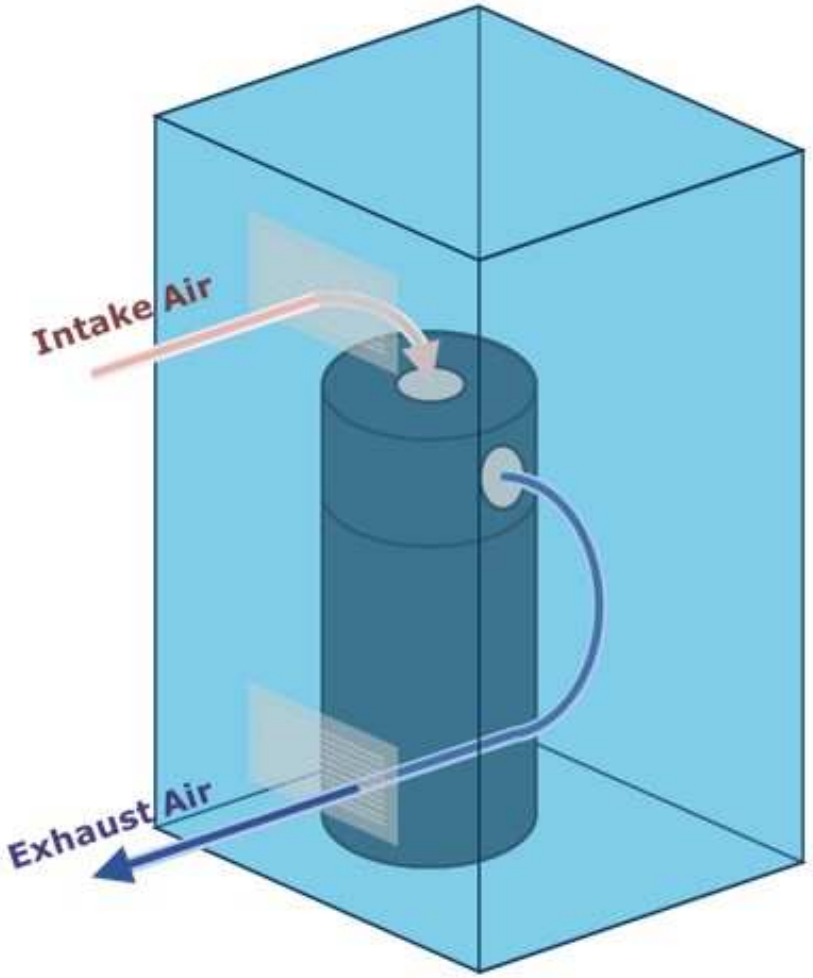


Image credits; ENERGY STAR; Larson Energy Research

Distributed Systems: Small-Space Installation

Passive Ventilation

- Fully louvered door
  - Min net free area = 300 in²

Image credits; ENERGY STAR

Distributed Systems: Small-Space Installation

Passive Ventilation

- Fully louvered door
  - Min net free area = 300 in²
- Two door louvers
  - One, high, one low
  - Equal size
  - Min net free area = 192 in² total

Image credits; ENERGY STAR

Distributed Systems: Small-Space Installation

Forced (ducted) Ventilation

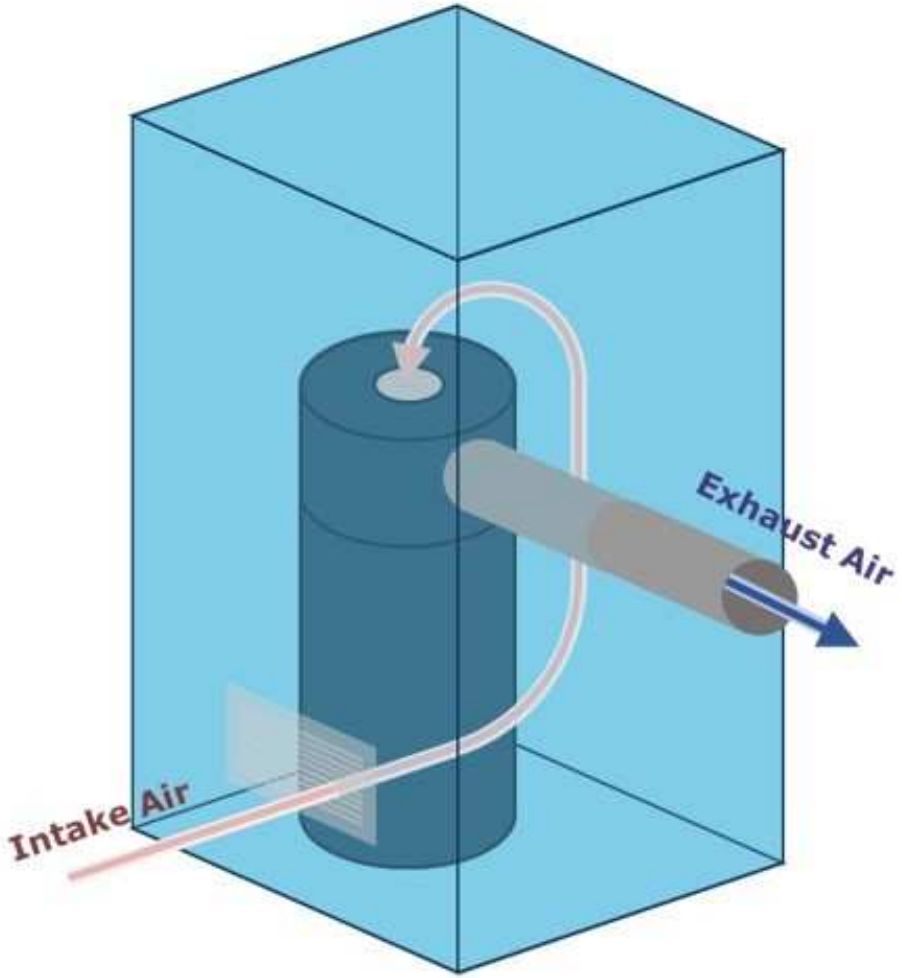


Image credits; US DOE/FSEC; Larson Energy Research

Distributed Systems: Small-Space Installation

Forced (ducted) Ventilation

- Short, straight, rigid duct runs
- Provide transfer grille or undercut door
  - Min net free area = 18 in²
- Or duct both intake and exhaust
- Intake and exhaust must both be ‘inside’ or both ‘outside’
- Insulate exhaust duct

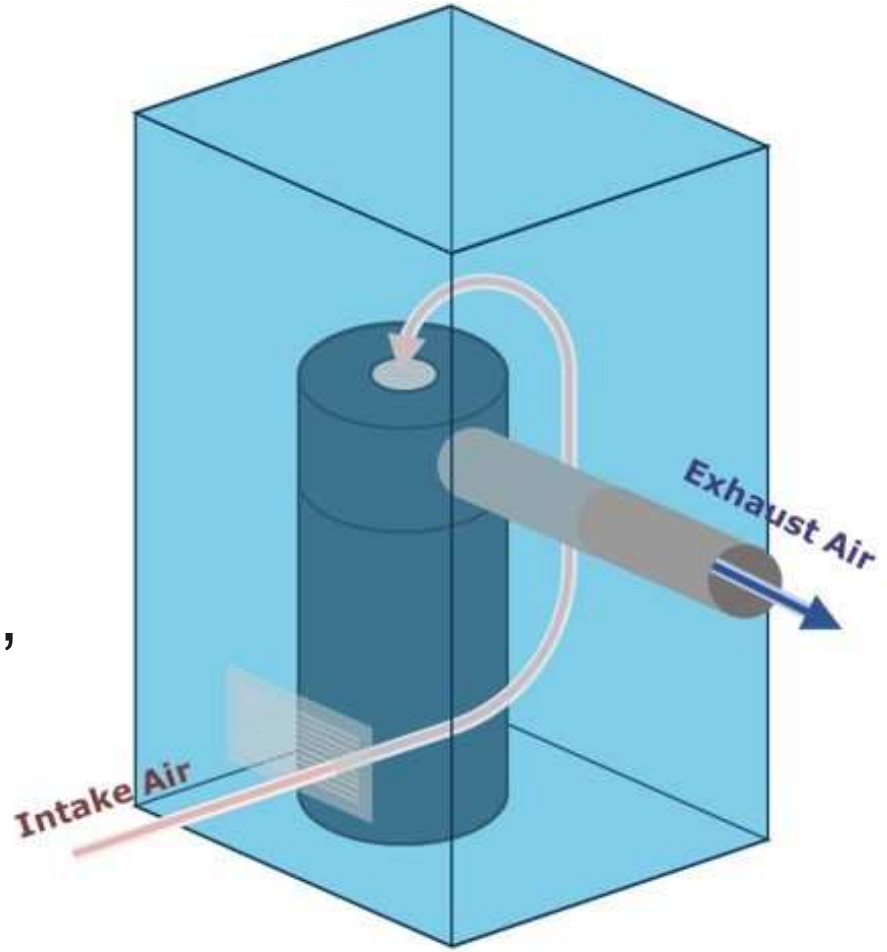


Image credit; Larson Energy Research

Distributed Systems: Potential Locations

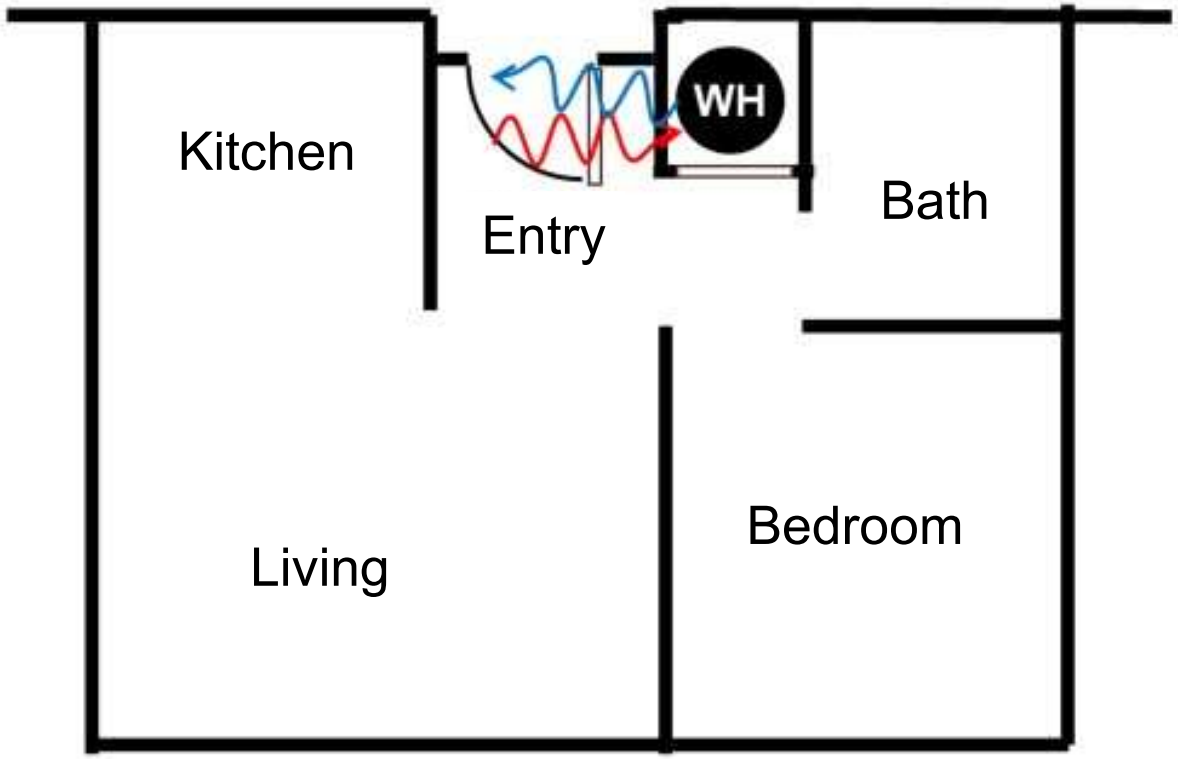
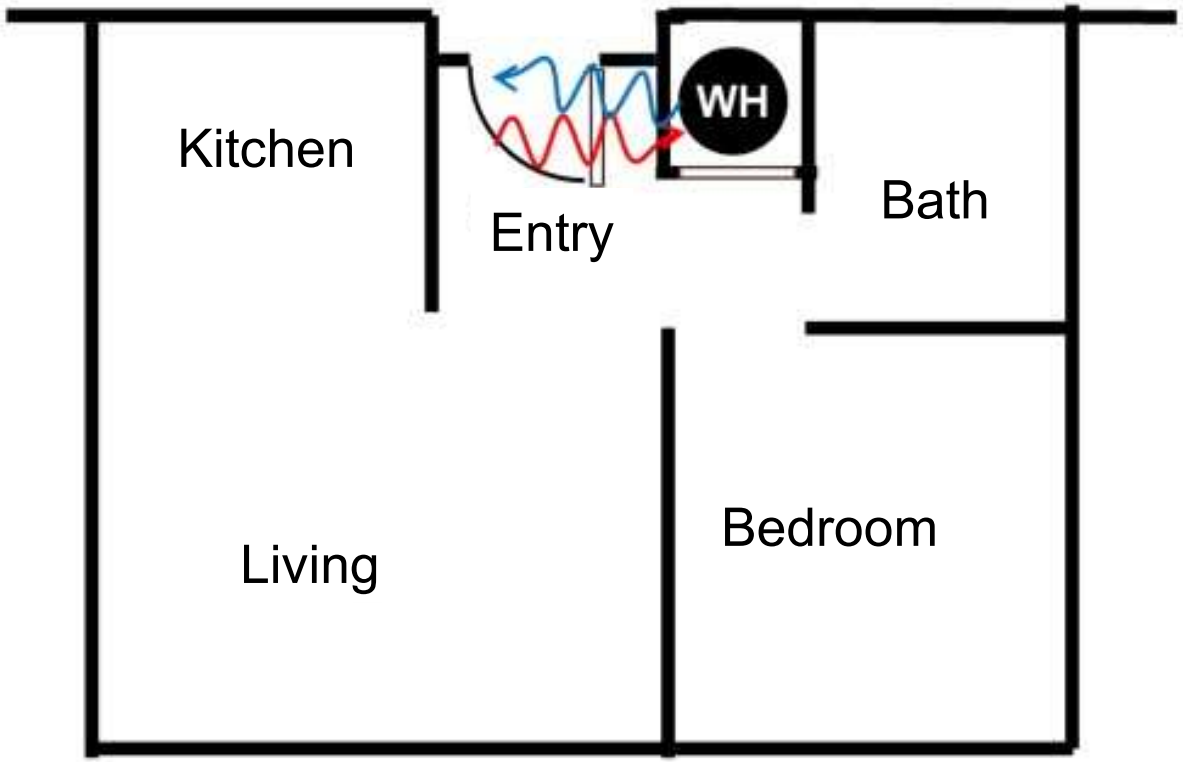


Image credit; Larson Energy Research

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



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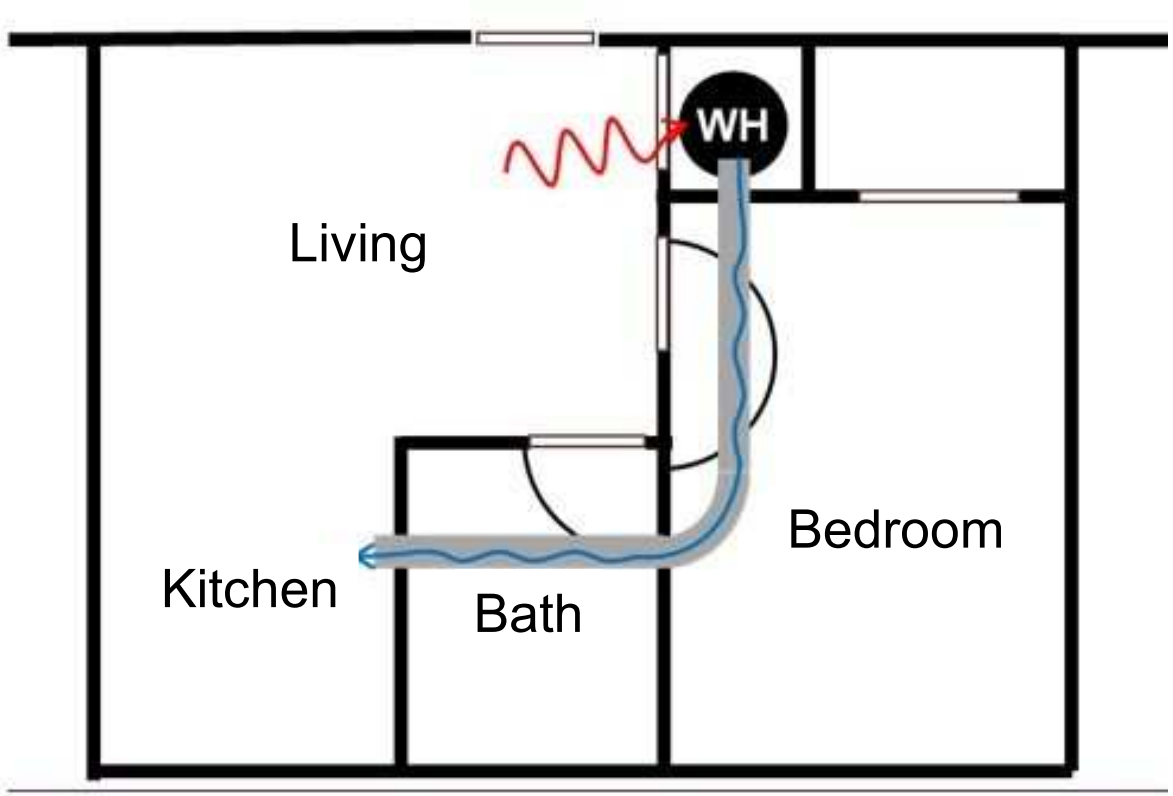


Image credit; Larson Energy Research

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

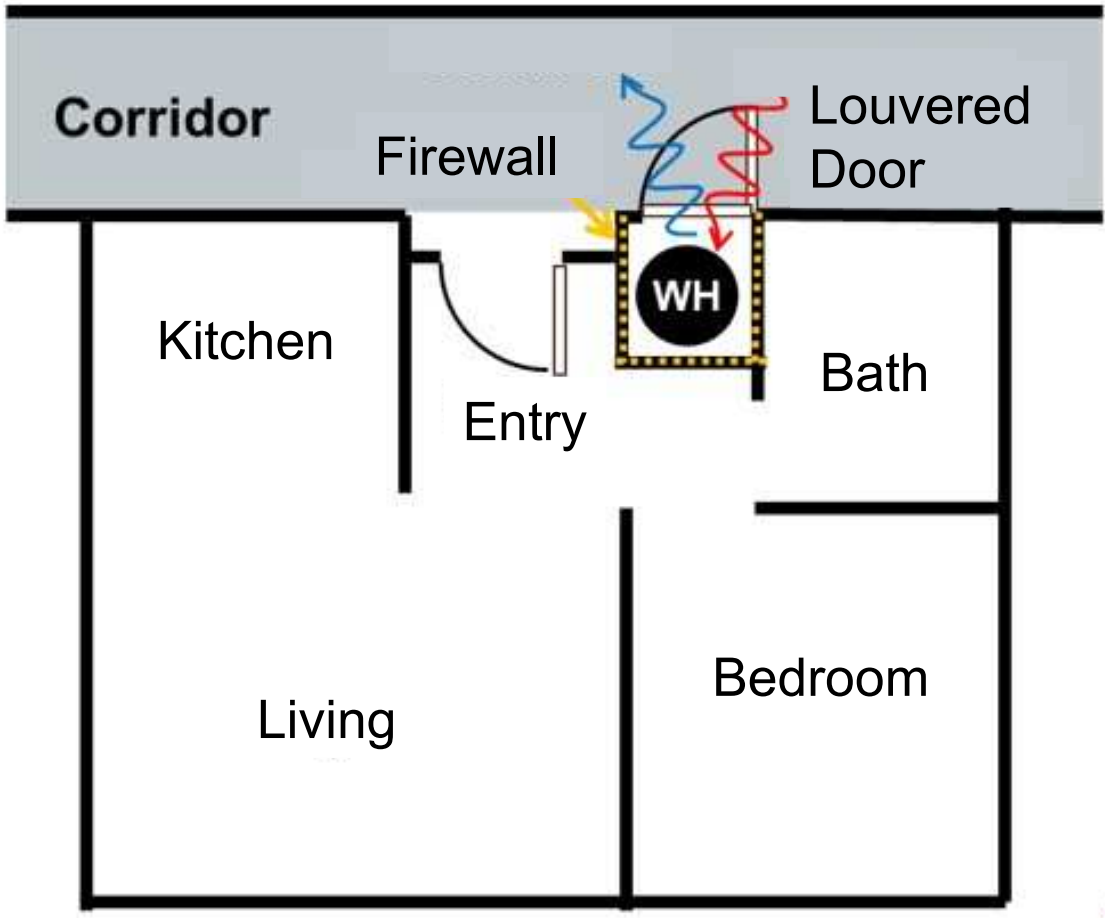


Image credit; Larson Energy Research

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

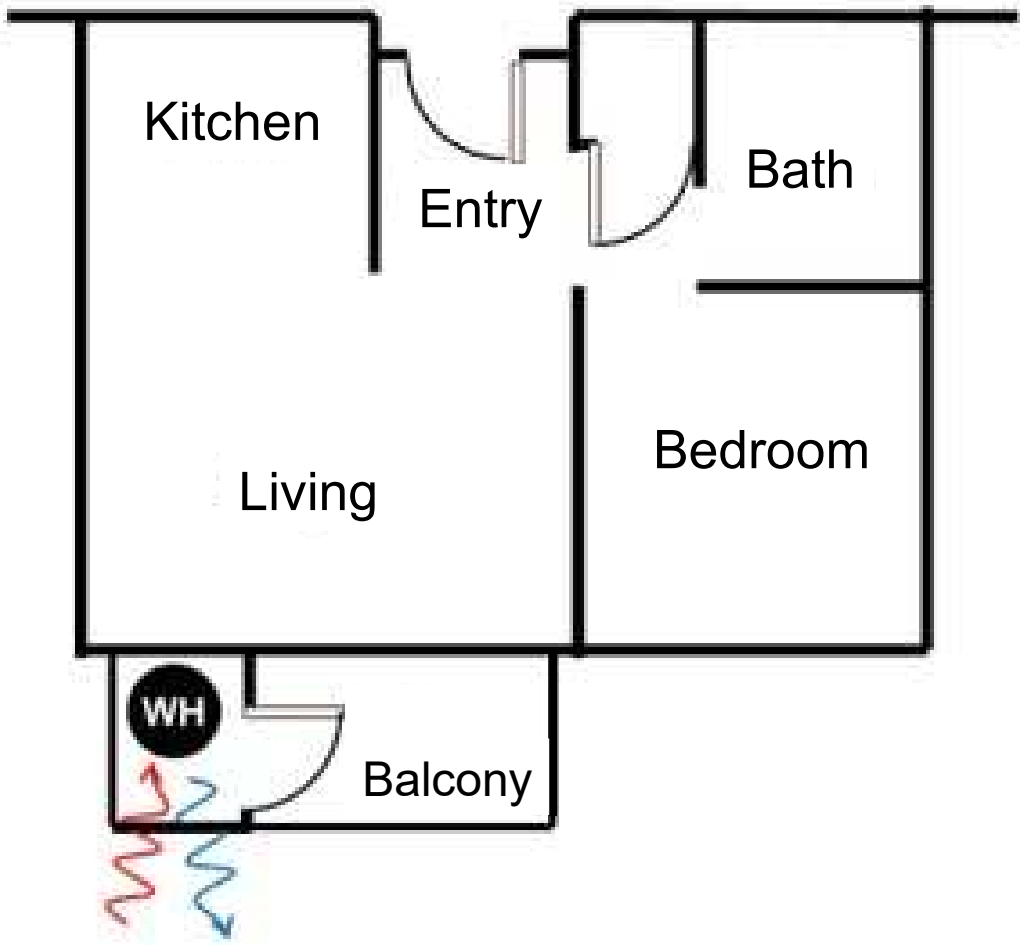


Image credit; Larson Energy Research

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

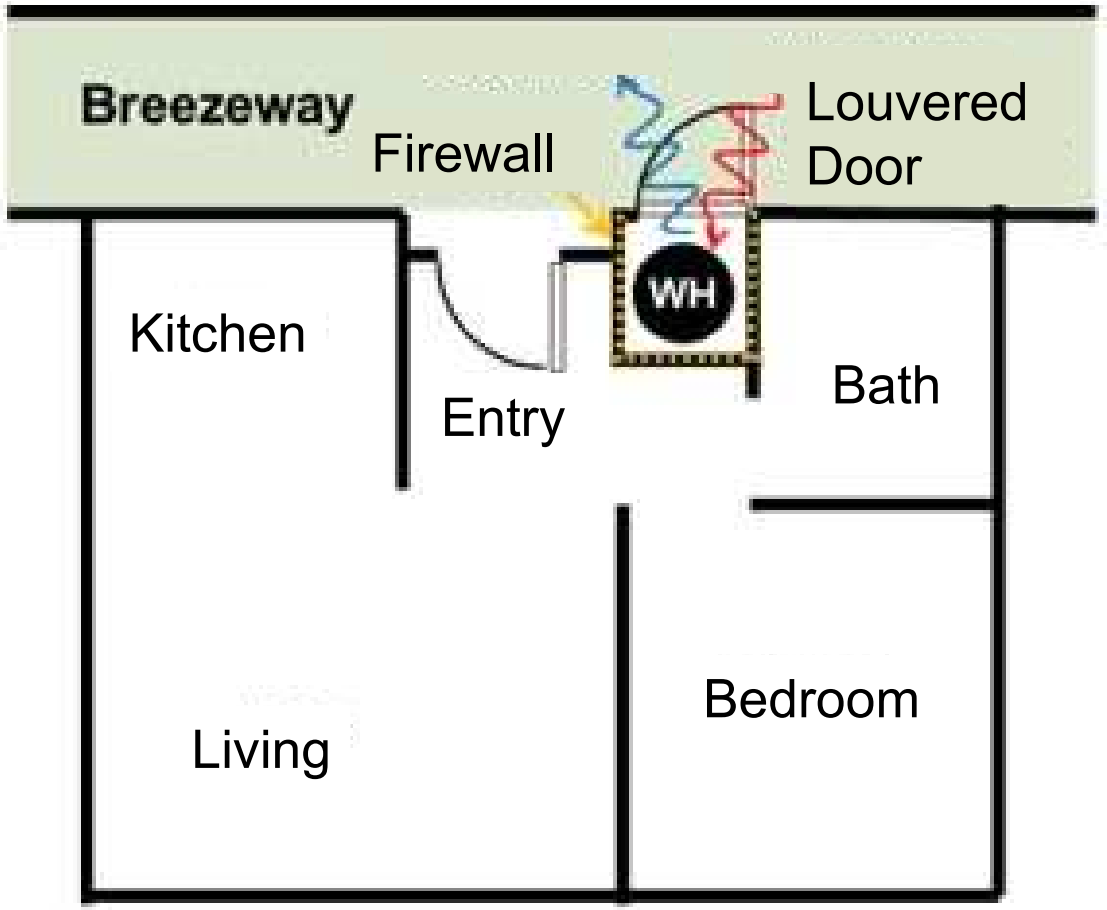
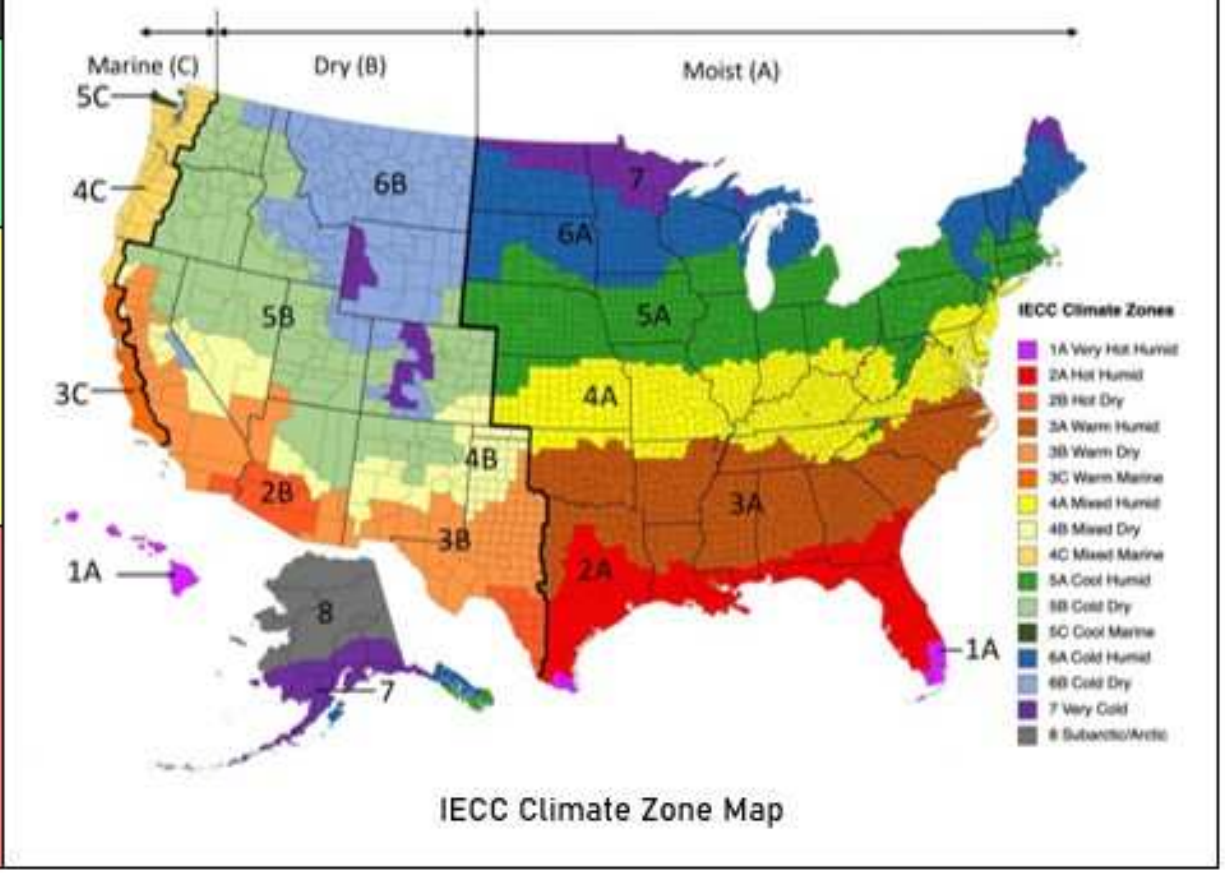


Image credit; Larson Energy Research

Distributed Systems: Potential Locations

Exterior Location Climate Implications

Climate Zone	Exterior Air Source…
1 A 2 A B	OK
3 A B C 4 A B C	Caution
5 A B C 6 A B 7	Inadvisable



IECC Climate Zone Map

Image credit; Larson Energy Research

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

Image credit: EPA WaterSense

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

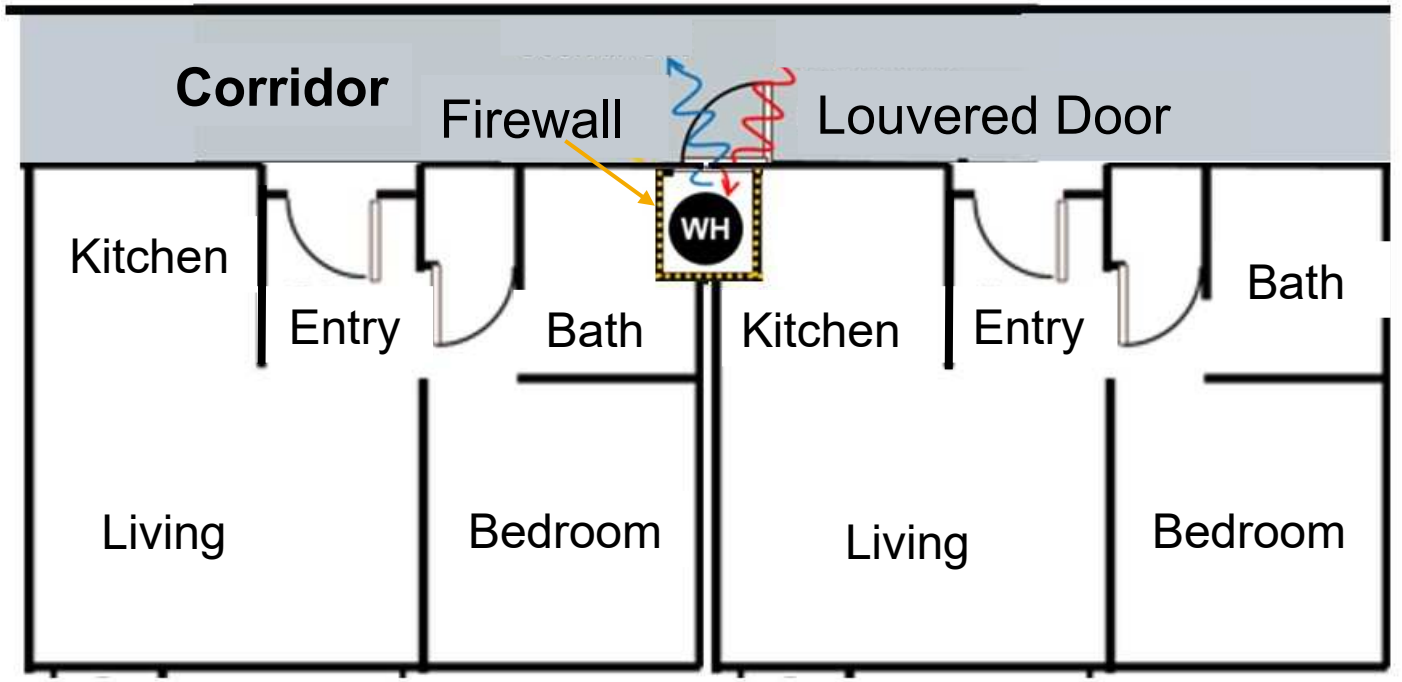


Image credit; Larson Energy Research, modified by PNNL

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

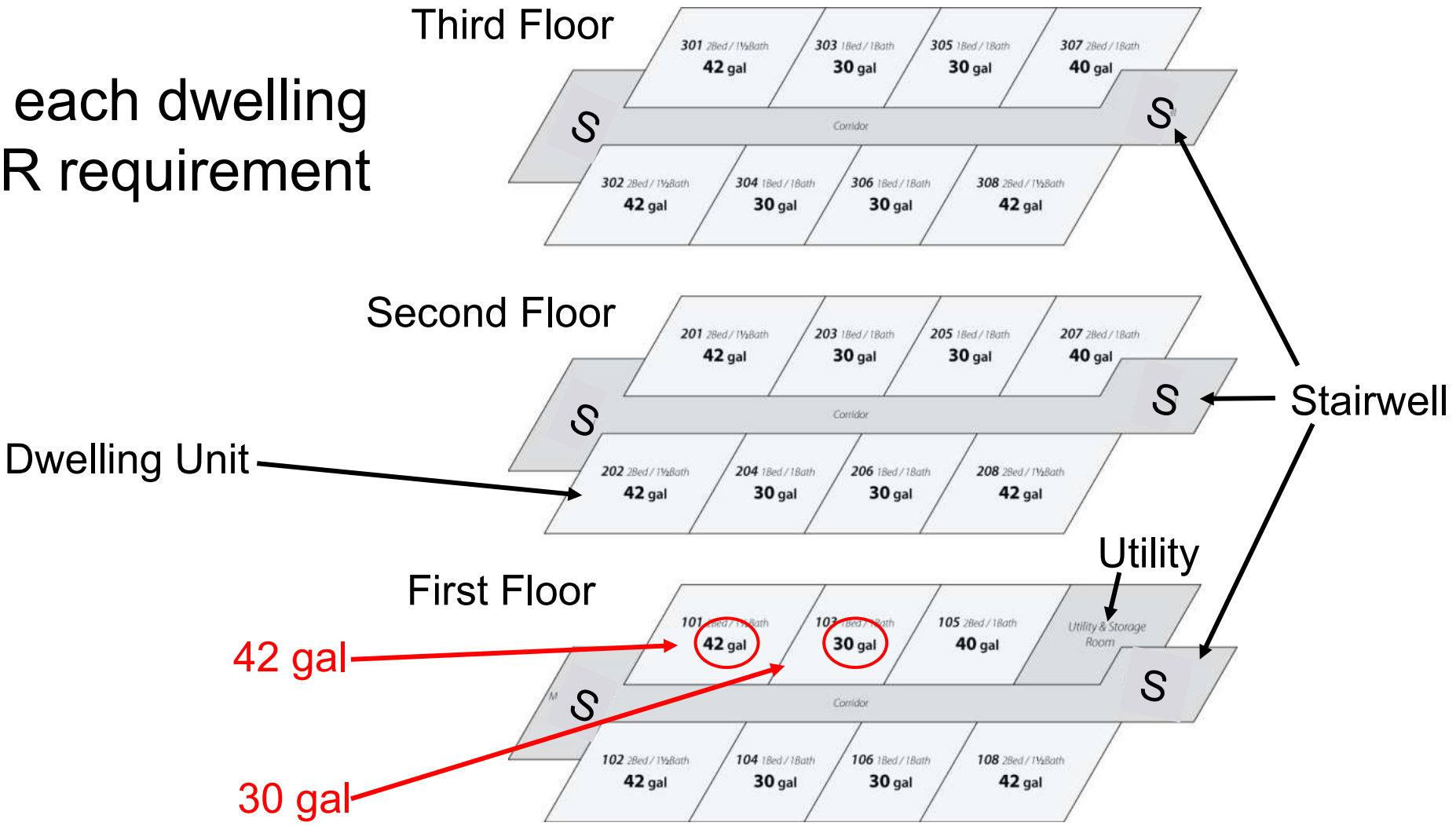


Image credit; Larson Energy Research, modified by PNNL

Distributed Systems: Clustered Deployments

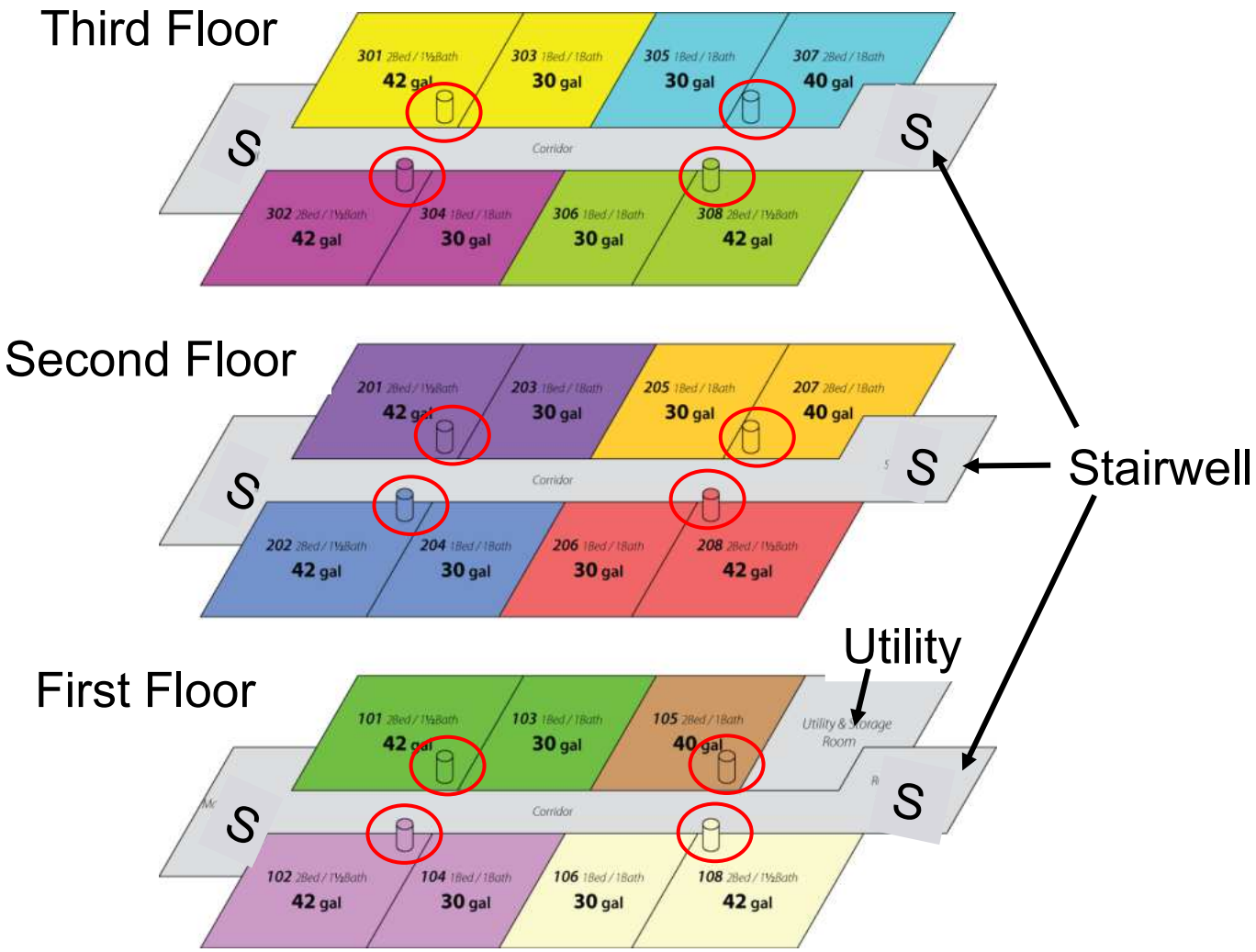
Match cluster requirements to HPWH models

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



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Distributed Systems: Clustered Deployments

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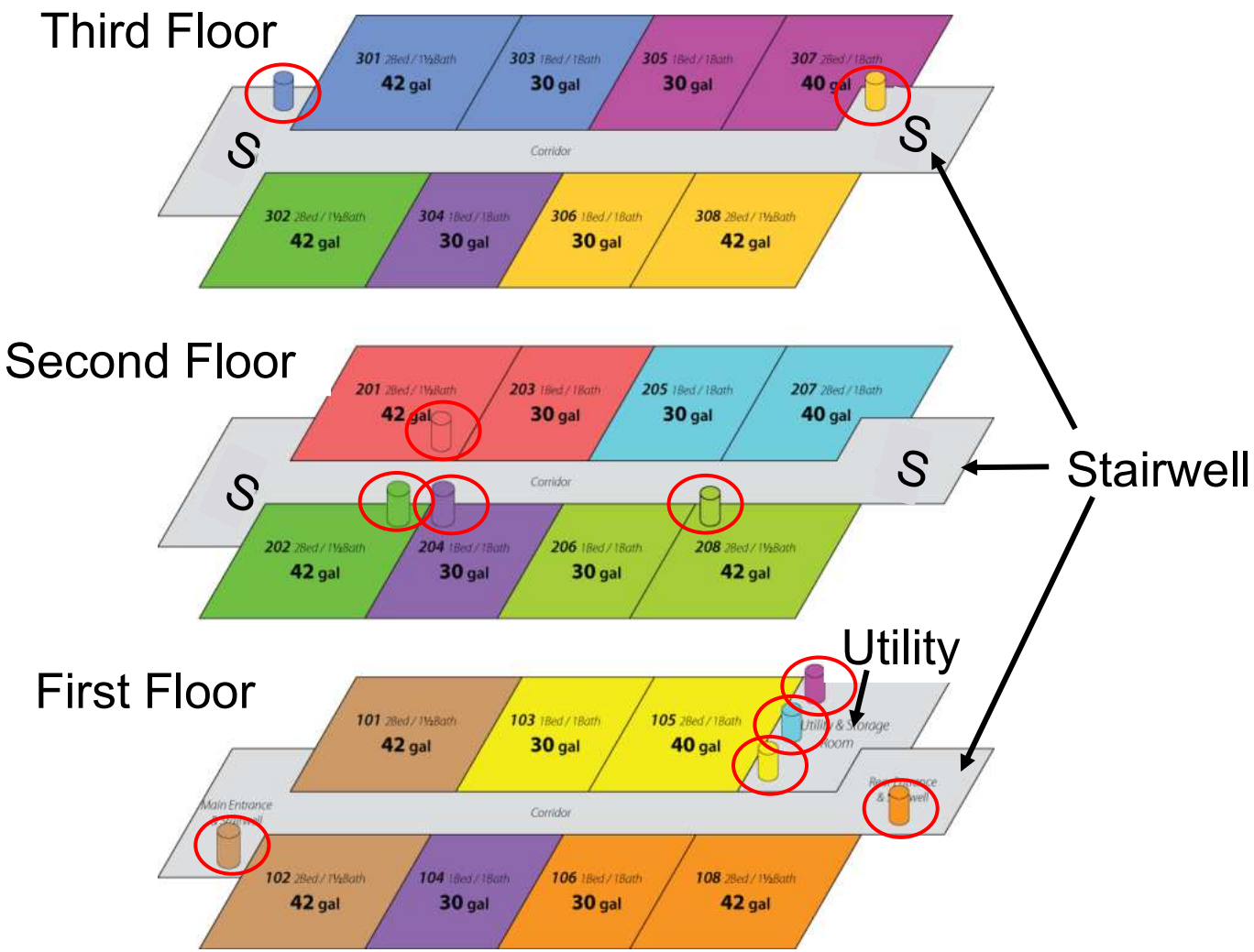


Image credit; Larson Energy Research, modified by PNNL

Central HPWH Systems

Image credit: Ecotope

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

Image credit: Ecotope

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

Image credits; Ecotope; Larson Energy Research

Central HPWH Systems: Market Delivery

Fully Packaged / Skid System

Image credit: Ecotope

Central HPWH Systems: Market Delivery

Fully Packaged / Skid System

Image credit; Larson Energy Research

Central HPWH Systems: Market Delivery

Fully Packaged / Skid System

Image credit: Ecotope

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

Image credits: Ecotope

Central HPWH Systems: Market Delivery

Fully Specified Built-Up System

Image credit: Ecotope

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

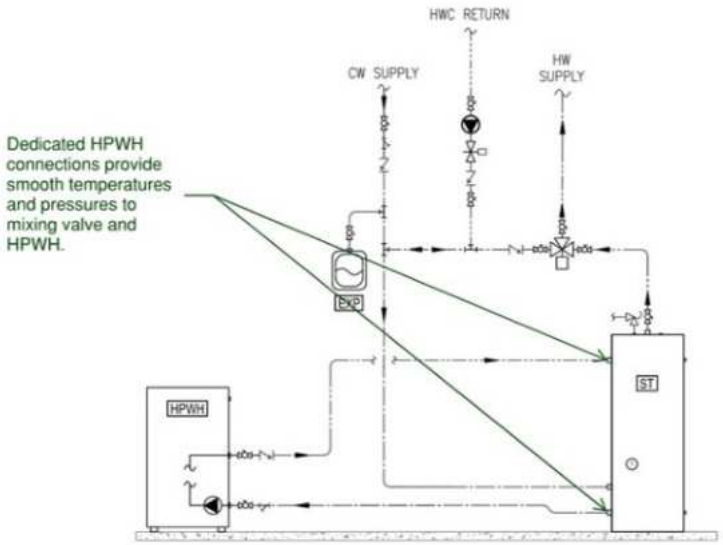


Image credits: Ecotope

Central HPWH Systems

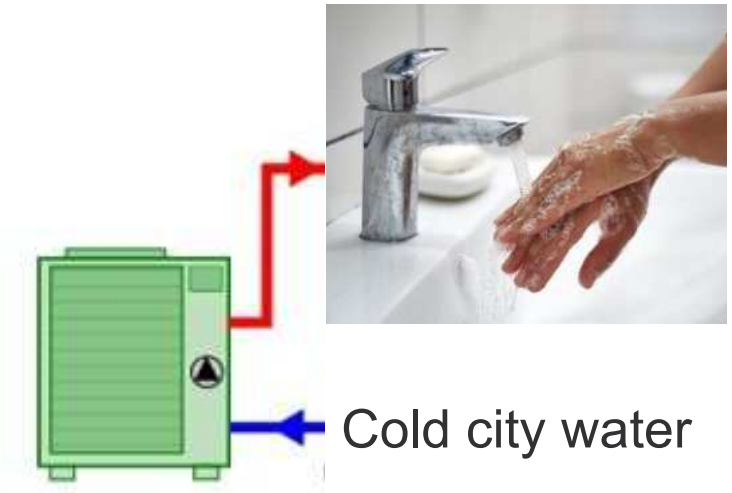
Caution

Enginerdy Material Ahead

Central HPWH Systems: Hot Water Loads

Primary hot water load

- Caused by hot water usage
- Mains water temp >>> 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 >>> DHW delivery temp
- Warm incoming water = Inefficient HP operation
- Smaller, constant load

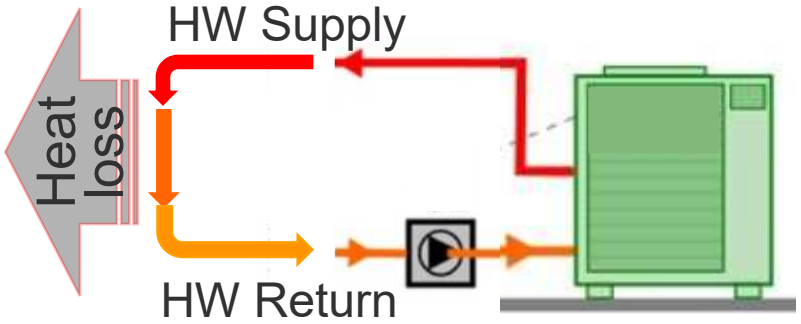


Image credit: Ecotope; CDC; modified by PNNL

Central HPWH Systems: Components

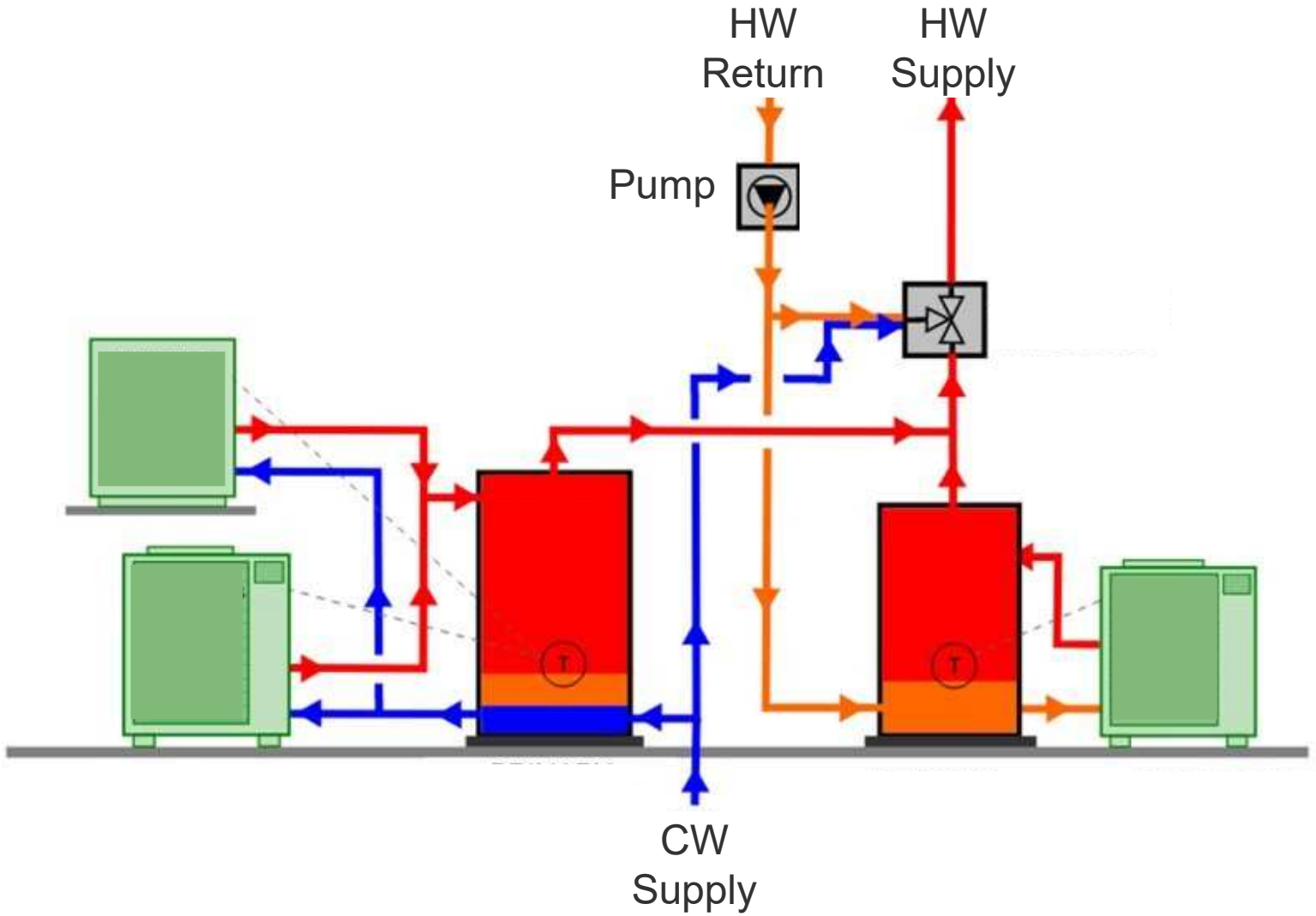


Image credit: Ecotope

Central HPWH Systems: Components

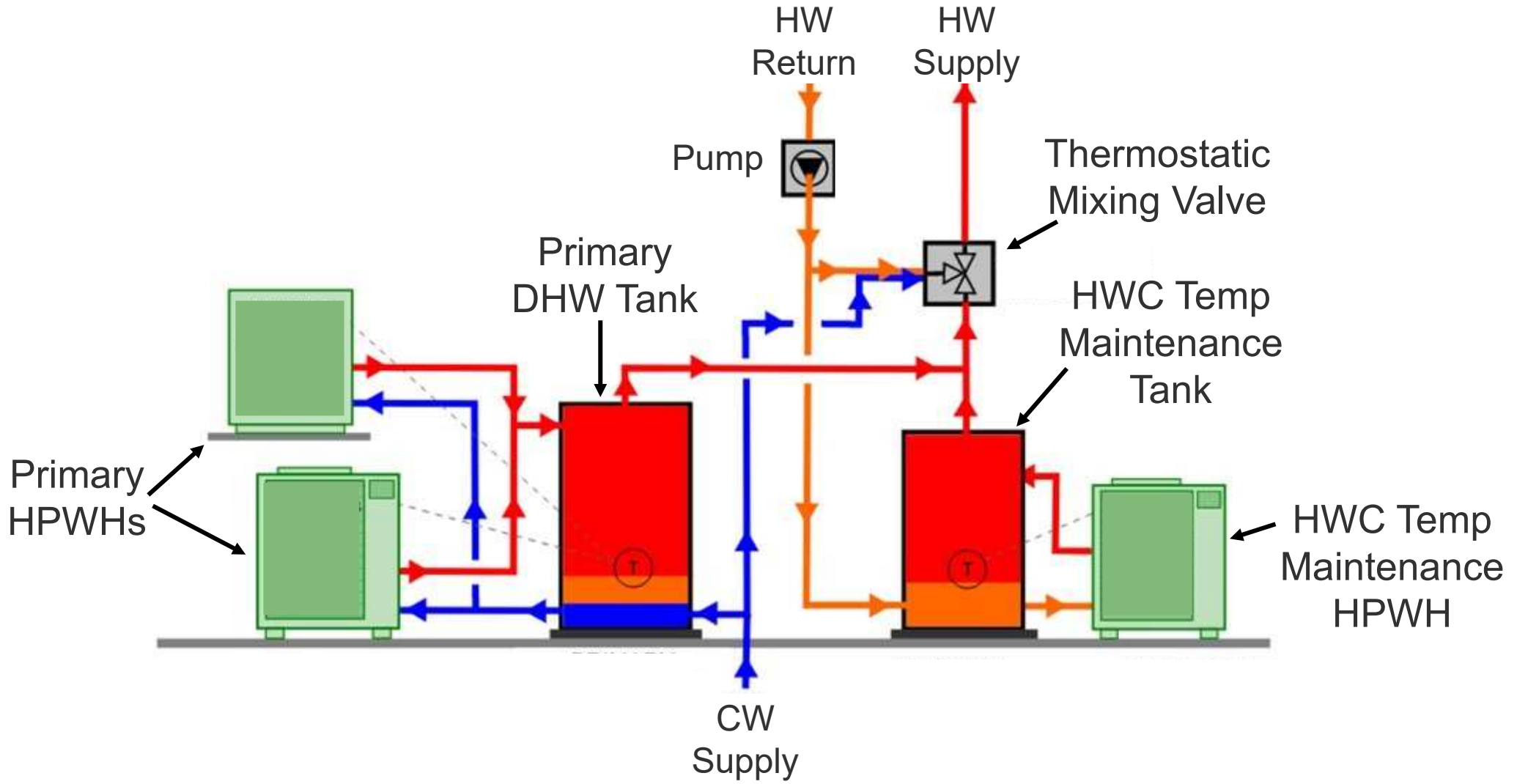
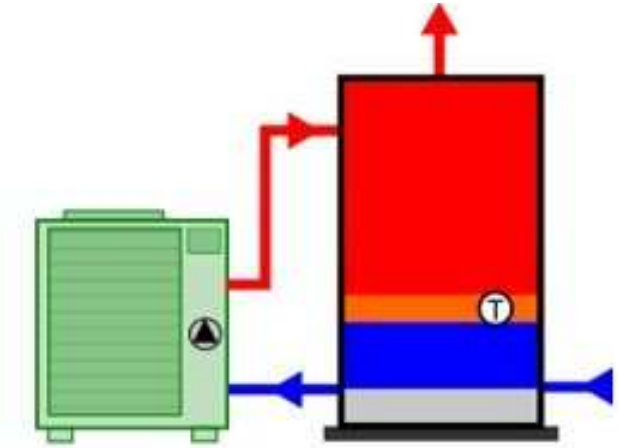


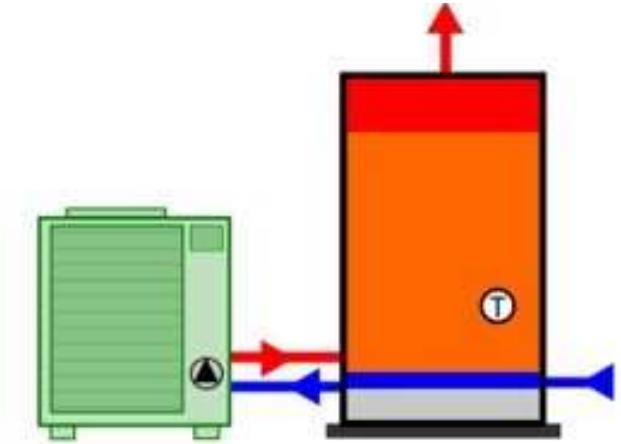
Image credit: Ecotope

Central HPWH Systems: Types of HPWHs

Single Pass HPWH



Multi-Pass HPWH



Integrated HPWH

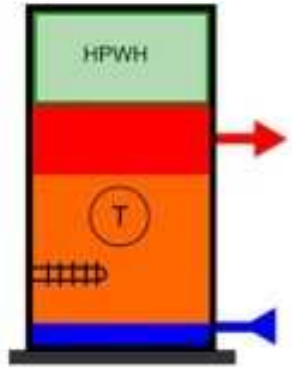


Image credits: Ecotope

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

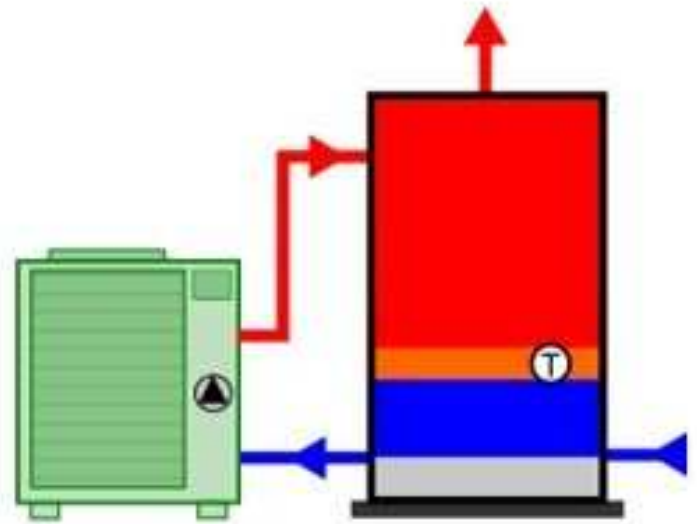


Image credit: Ecotope

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

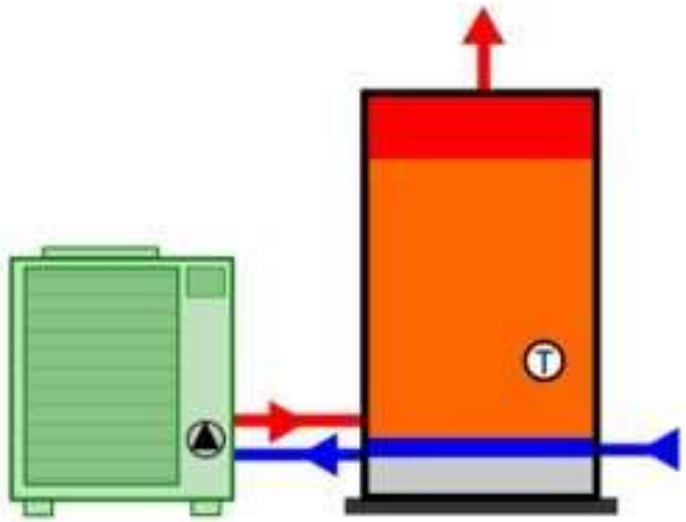


Image credit: Ecotope

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

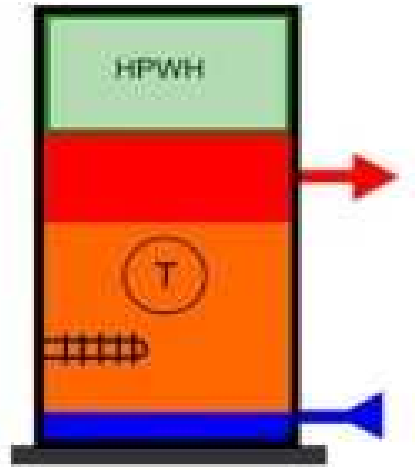


Image credit: Ecotope

Central HPWH Systems

WARNING

Potentially Disturbing Engineering Material Past This Point

Central HPWH Systems: System Configurations

HWC Return to Parallel Temperature Maintenance Tank

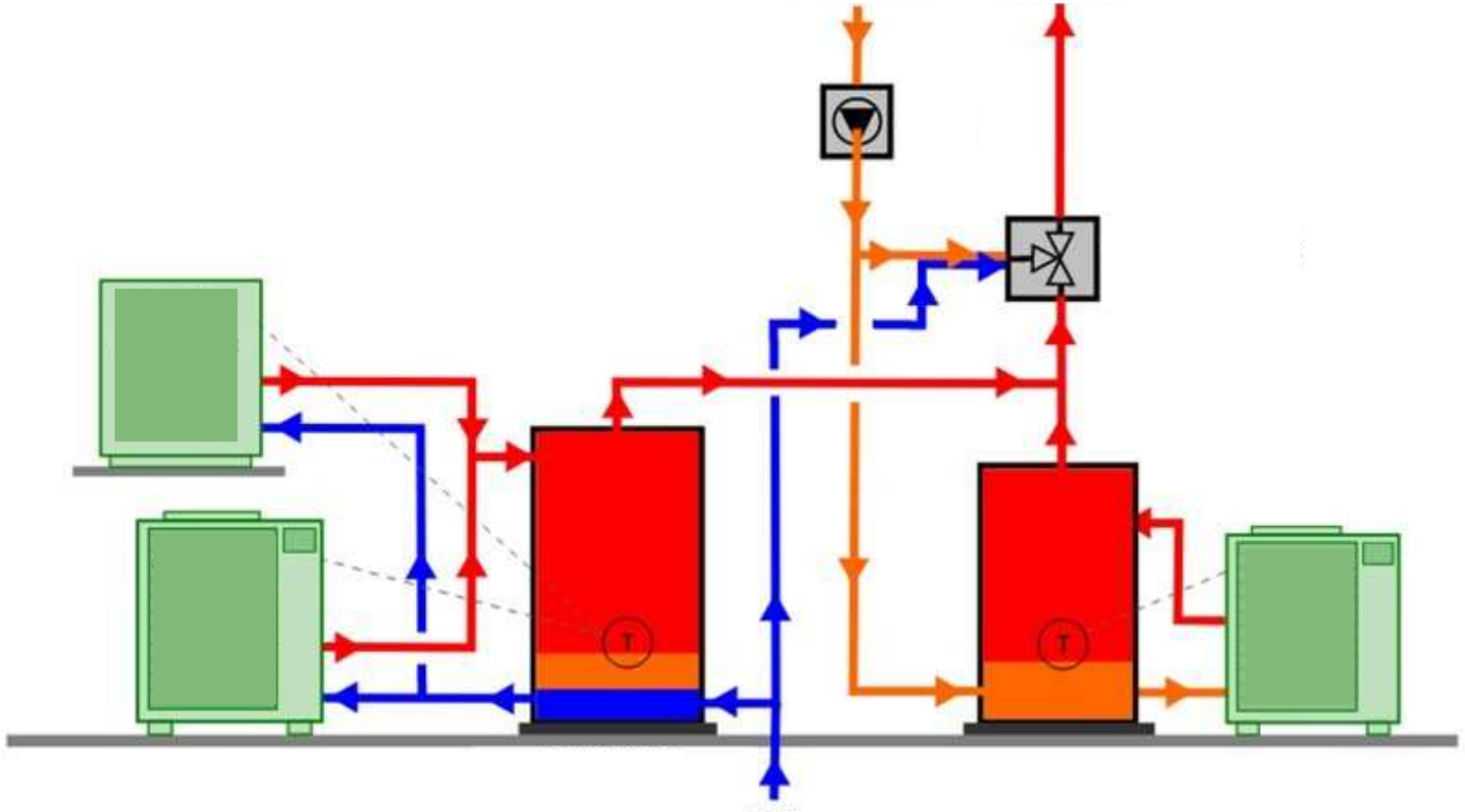


Image credit: Ecotope

Central HPWH Systems: System Configurations

HWC Return to Parallel Temperature Maintenance Tank

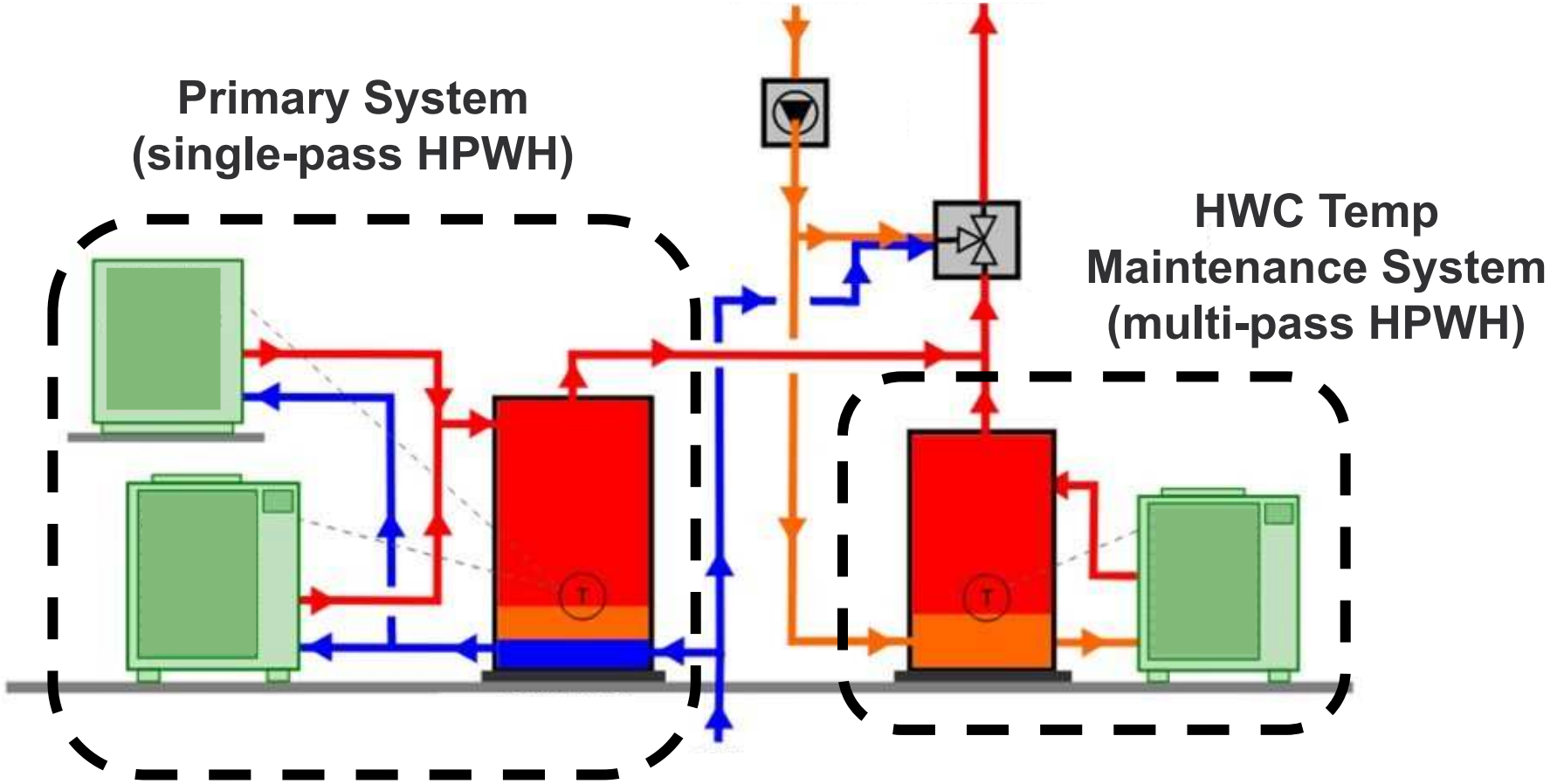
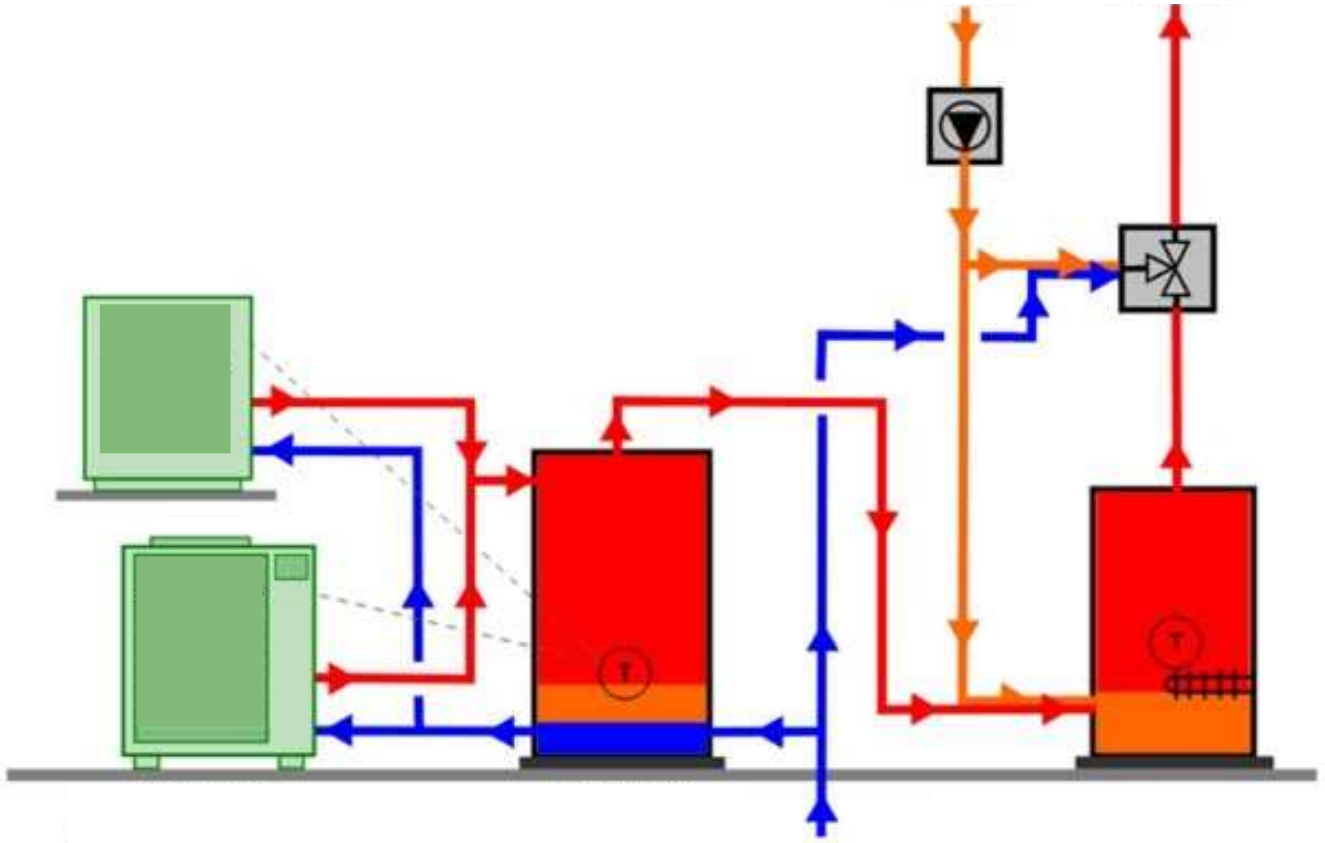


Image credit: Ecotope

Central HPWH Systems: System Configurations

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



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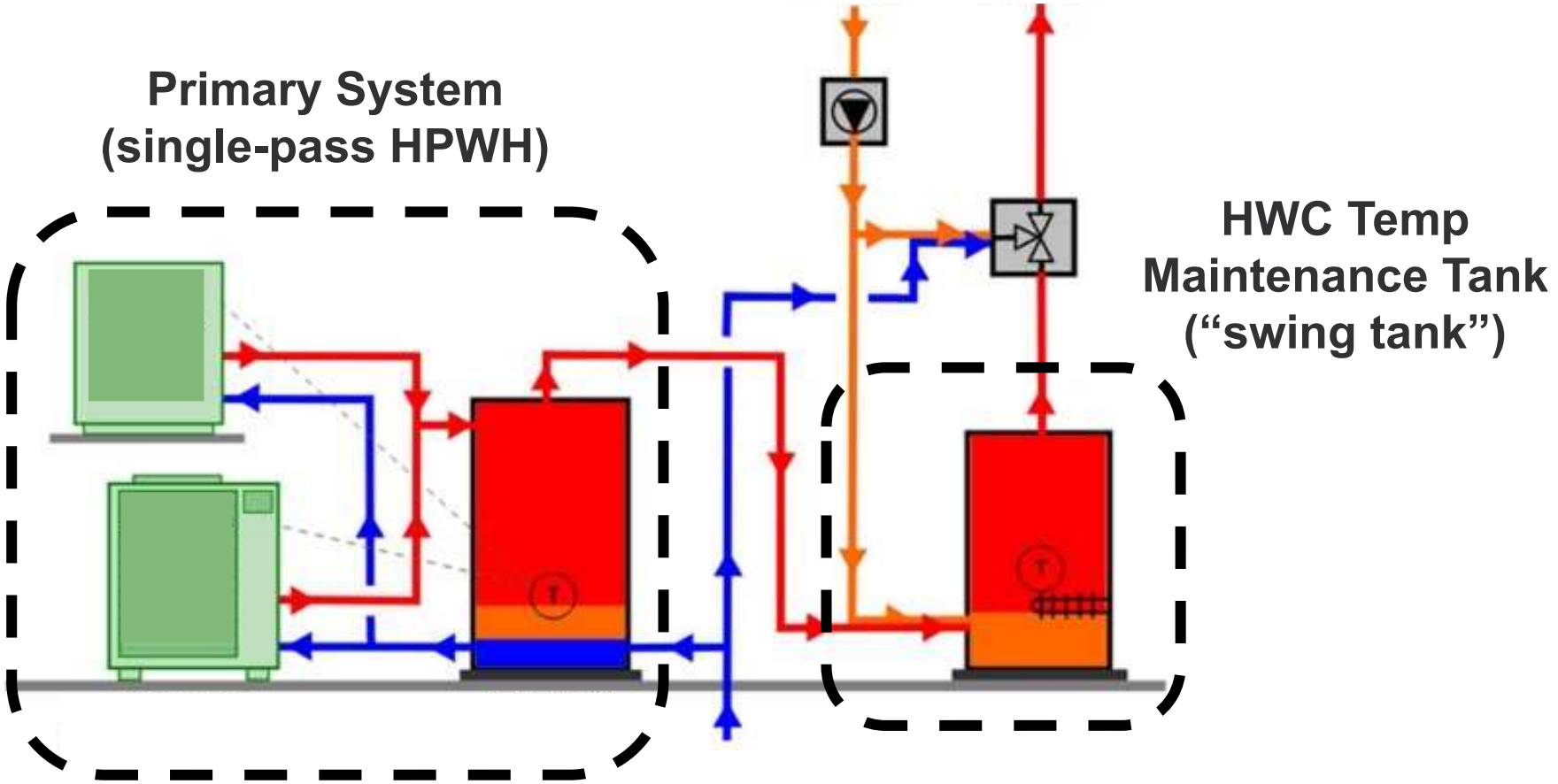
Central HPWH Systems: System Configurations

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



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Central HPWH Systems: System Configurations

Multi-Pass HWC Return to Primary

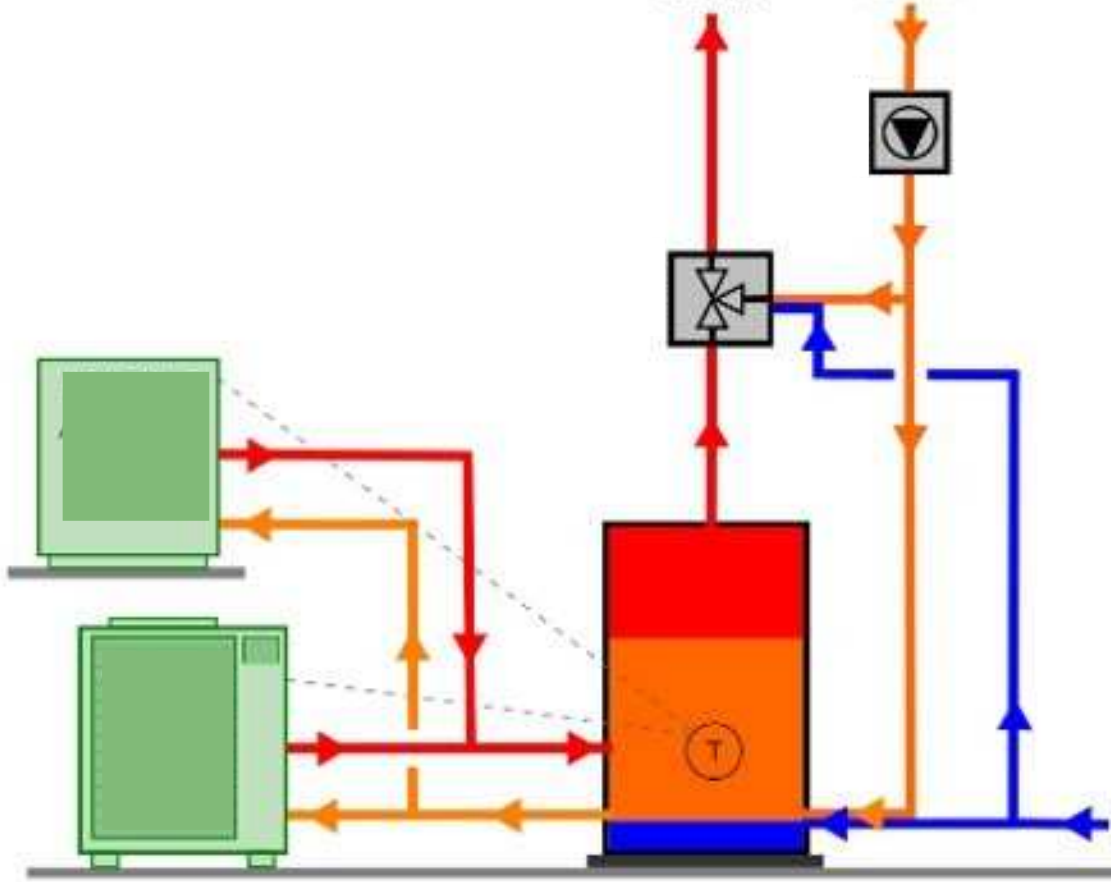

Image credit: Ecotope

Central HPWH Systems: System Configurations

Multi-Pass HWC Return to Primary

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

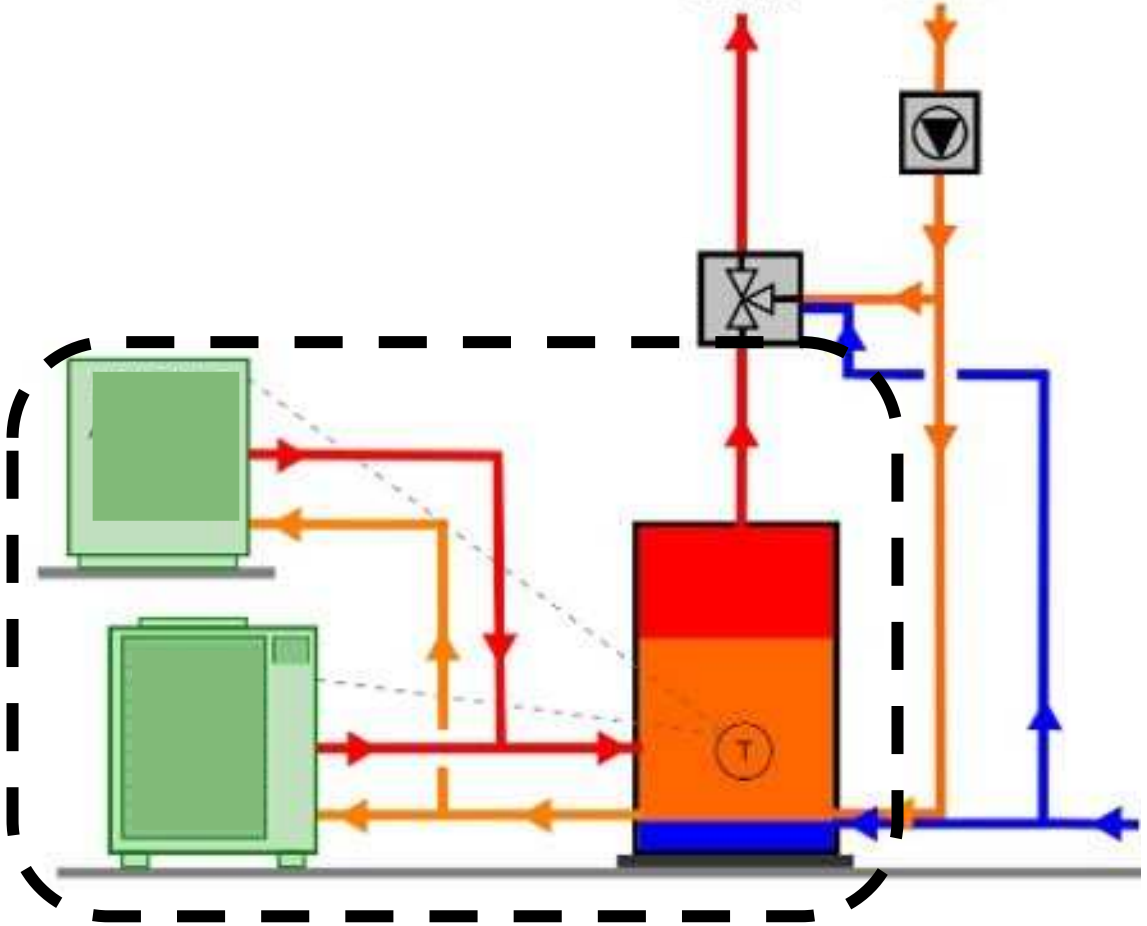

Image credit: Ecotope

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

Image credit: Ecotope

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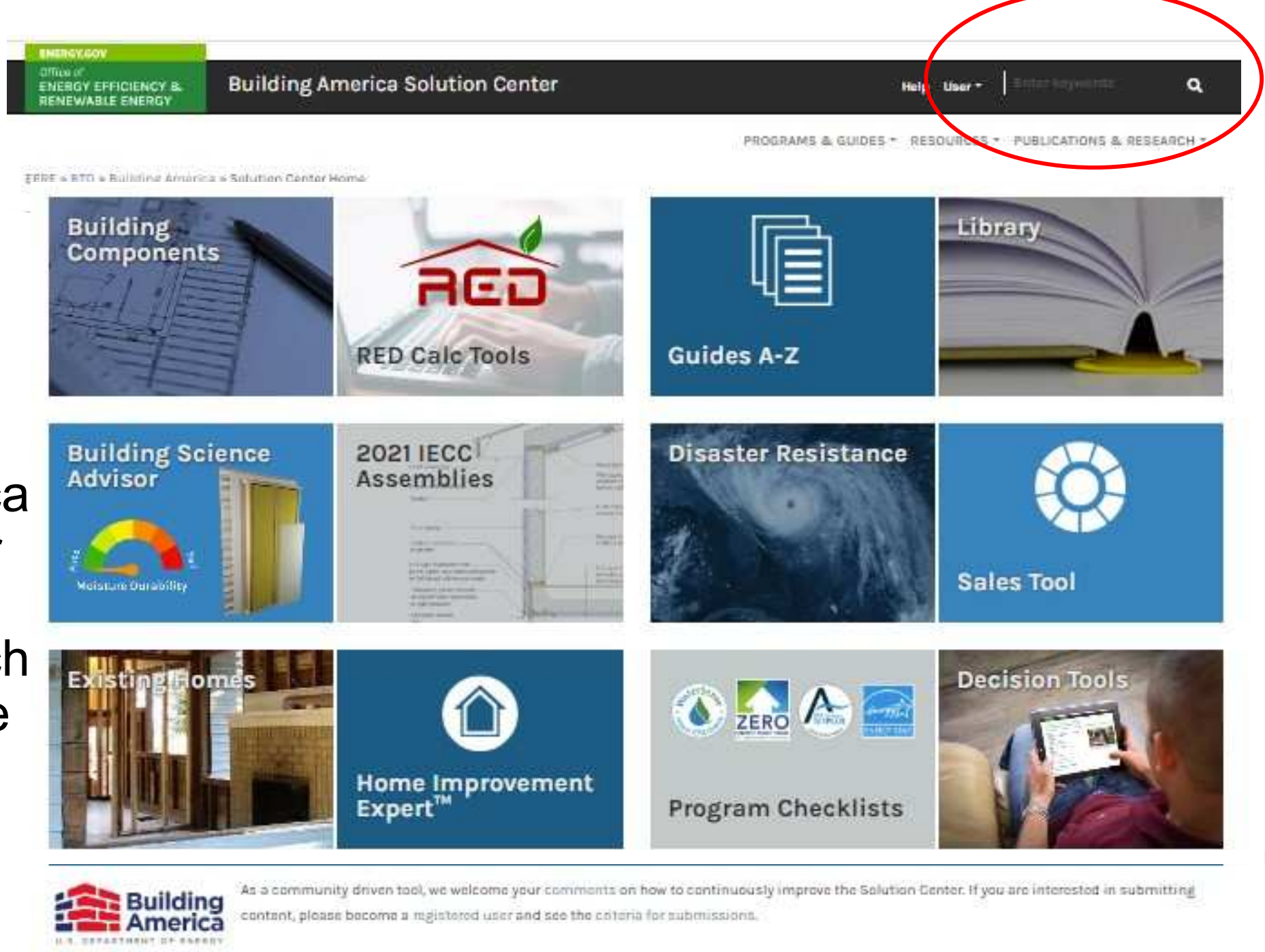
Where to Find HPWH Guides in the Building America Solution Center

From the Search Bar in the home page:



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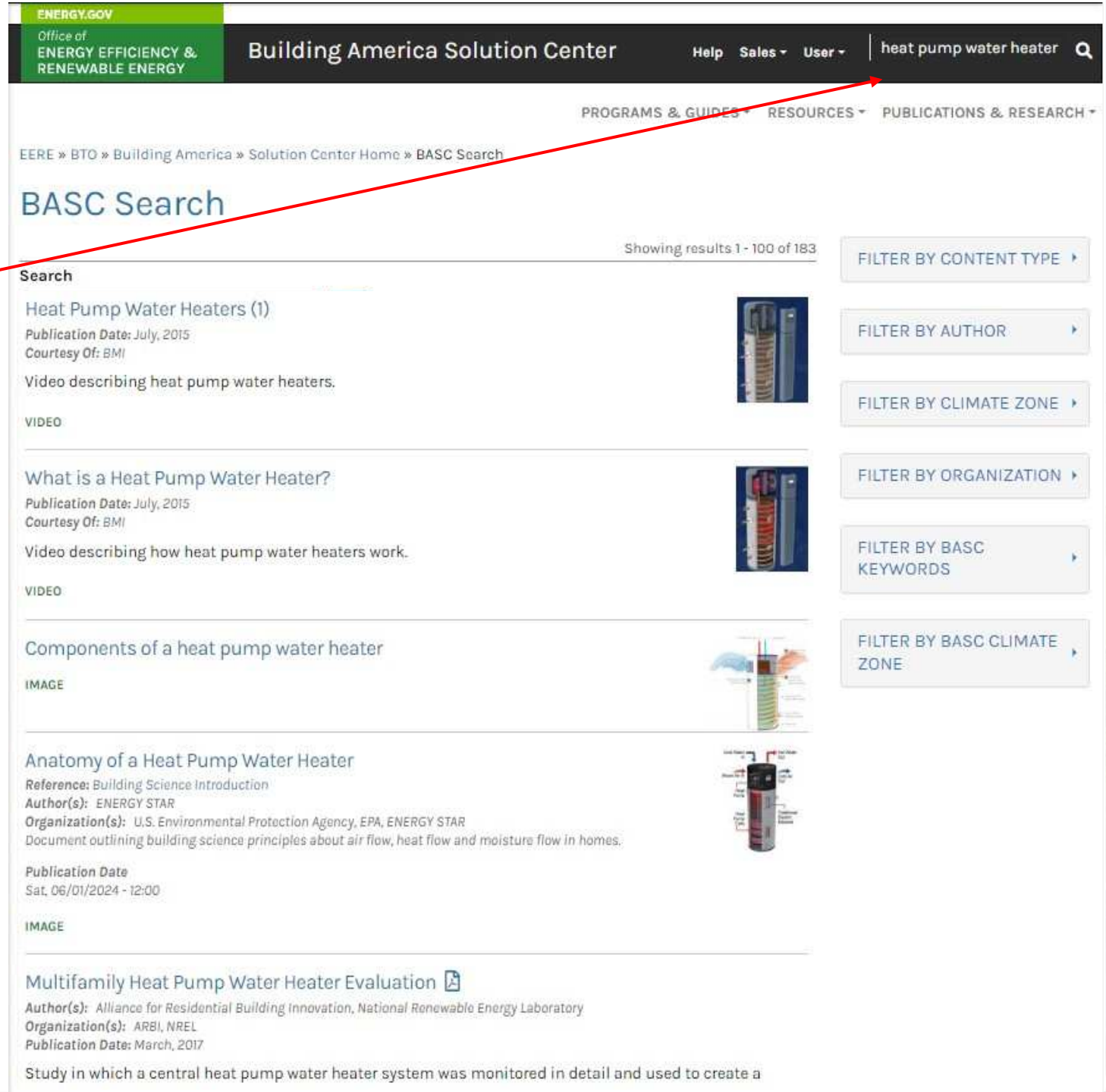
Type “heat pump water heater” in the search bar at the top right of the page.
Search results could include

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



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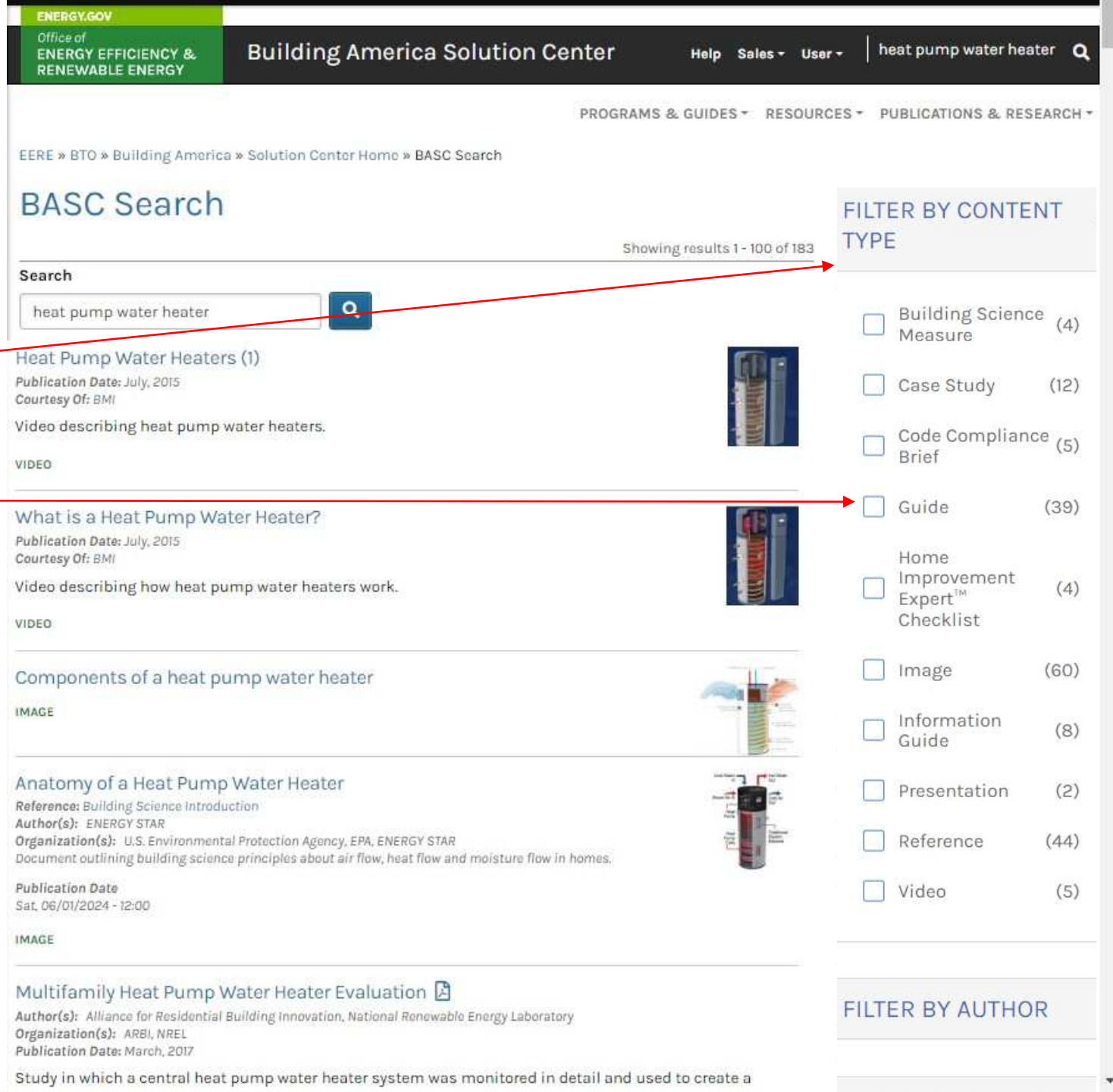
Select “Filter by Content Type.”

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



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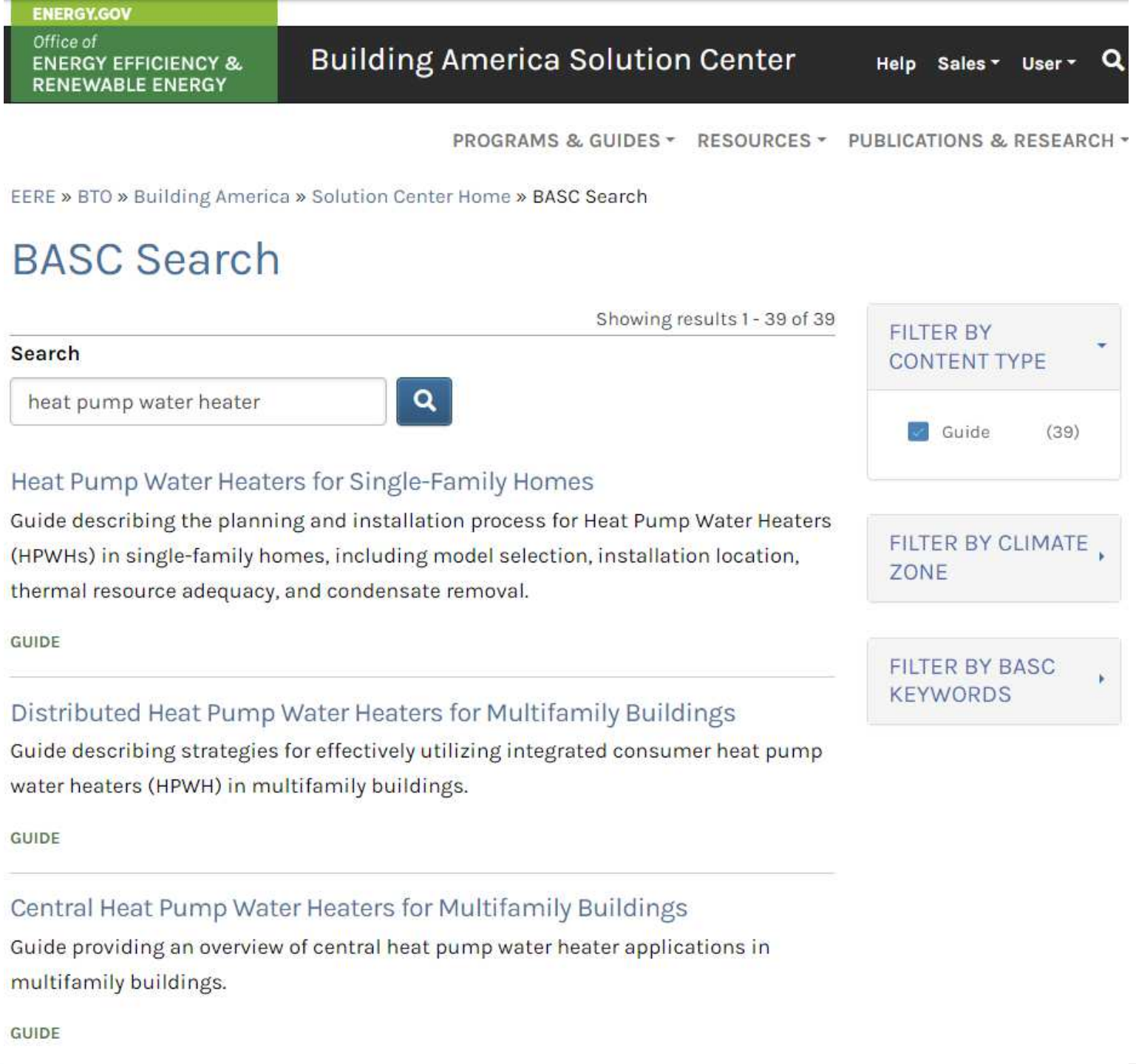
Results are sorted by relevance.



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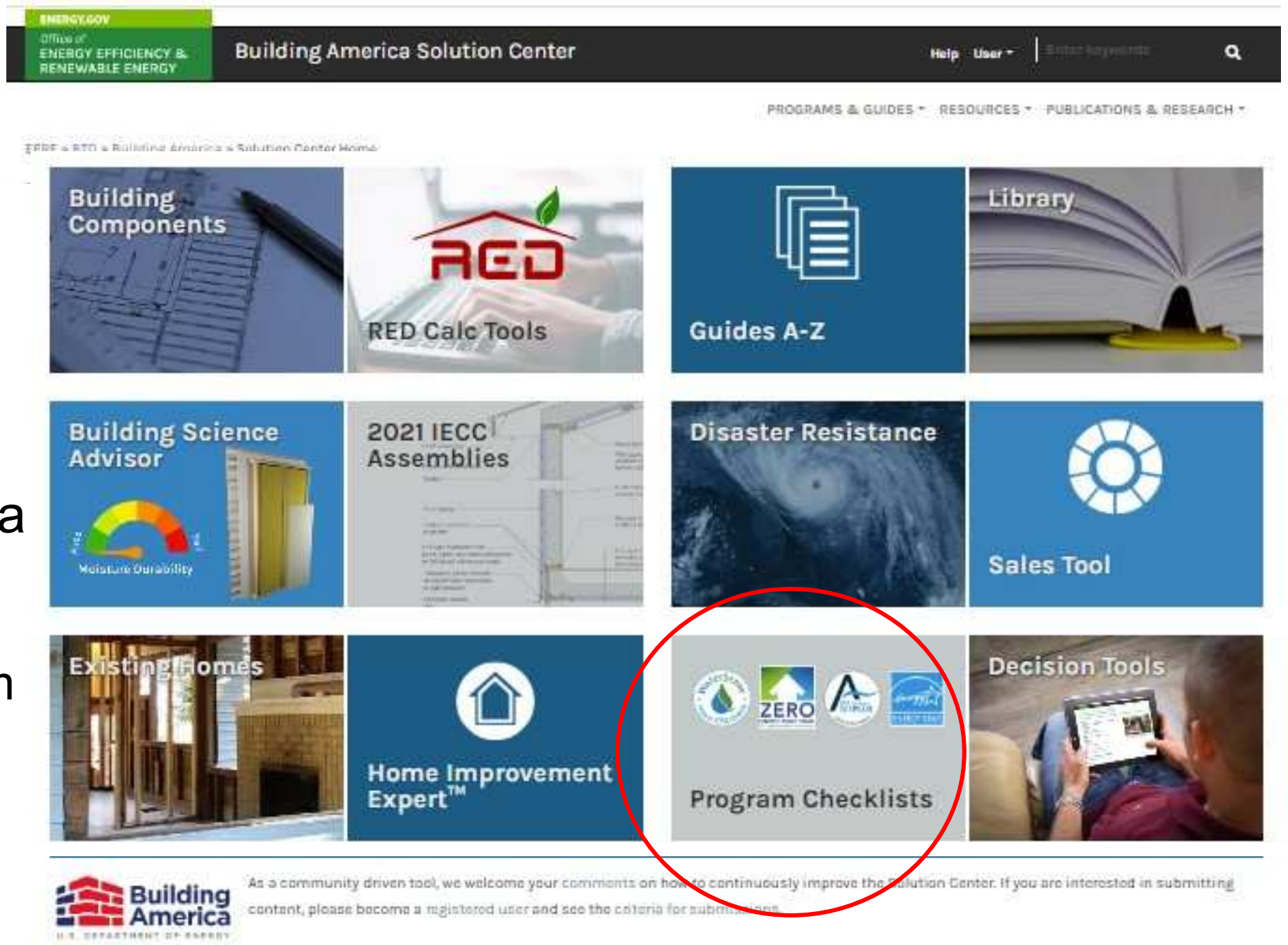
Where to Find HPWH Guides in the Building America Solution Center

from the Program Checklists in the home page:



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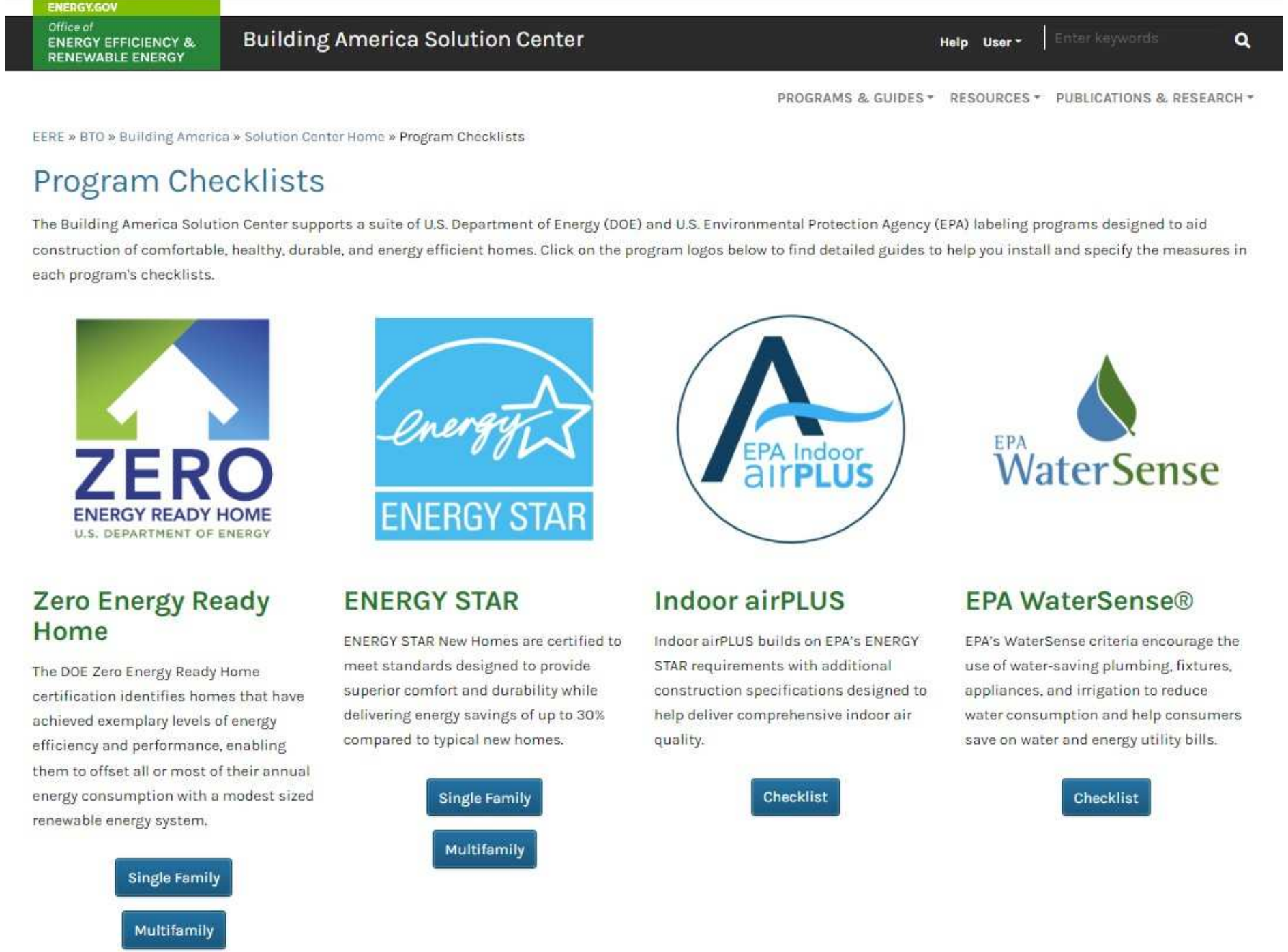
Program Checklists

Choose “Multifamily”



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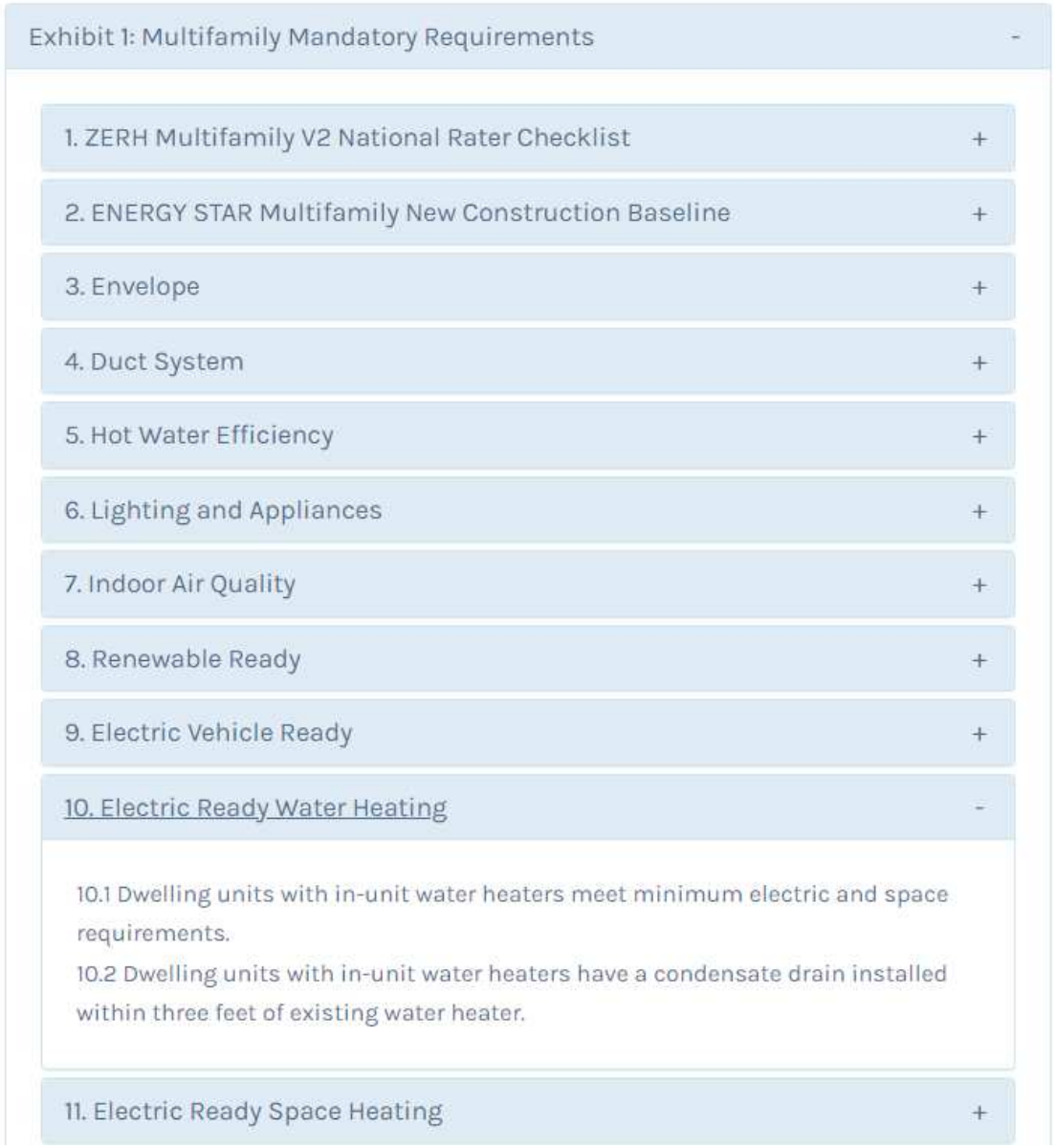
ZERO ENERGY READY HOME U.S. DEPARTMENT OF ENERGY

Open the new DOE Zero ENERGY Ready Home Multifamily Checklist.

Select Exhibit 1: Multifamily Mandatory Requirements.

Choose # 10. Electric Ready Water Heating



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ZERO ENERGY READY HOME U.S. DEPARTMENT OF ENERGY

Or, scroll down to the National Rater Checklist.

Select
#10. Heat Pump Water Heater Ready.

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ENERGY STAR

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.

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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

Scope

Plan a successful installation of integrated consumer heat pump water heaters (HPWH) to supply domestic hot water in a multifamily residential building.

- Learn why multifamily buildings present additional challenges for HPWHs and how to overcome those challenges.
- Choose between a one-to-one or clustered approach.
- Size the HPWHs appropriately.
- Use installation locations that will ensure a smooth installation, efficient water heater operation, and occupant comfort.

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.

Anatomy of a Heat Pump Water Heater

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Description

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

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Distributed Heat Pump Water Heaters for Multifamily Buildings

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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

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Other Tabs:

Success

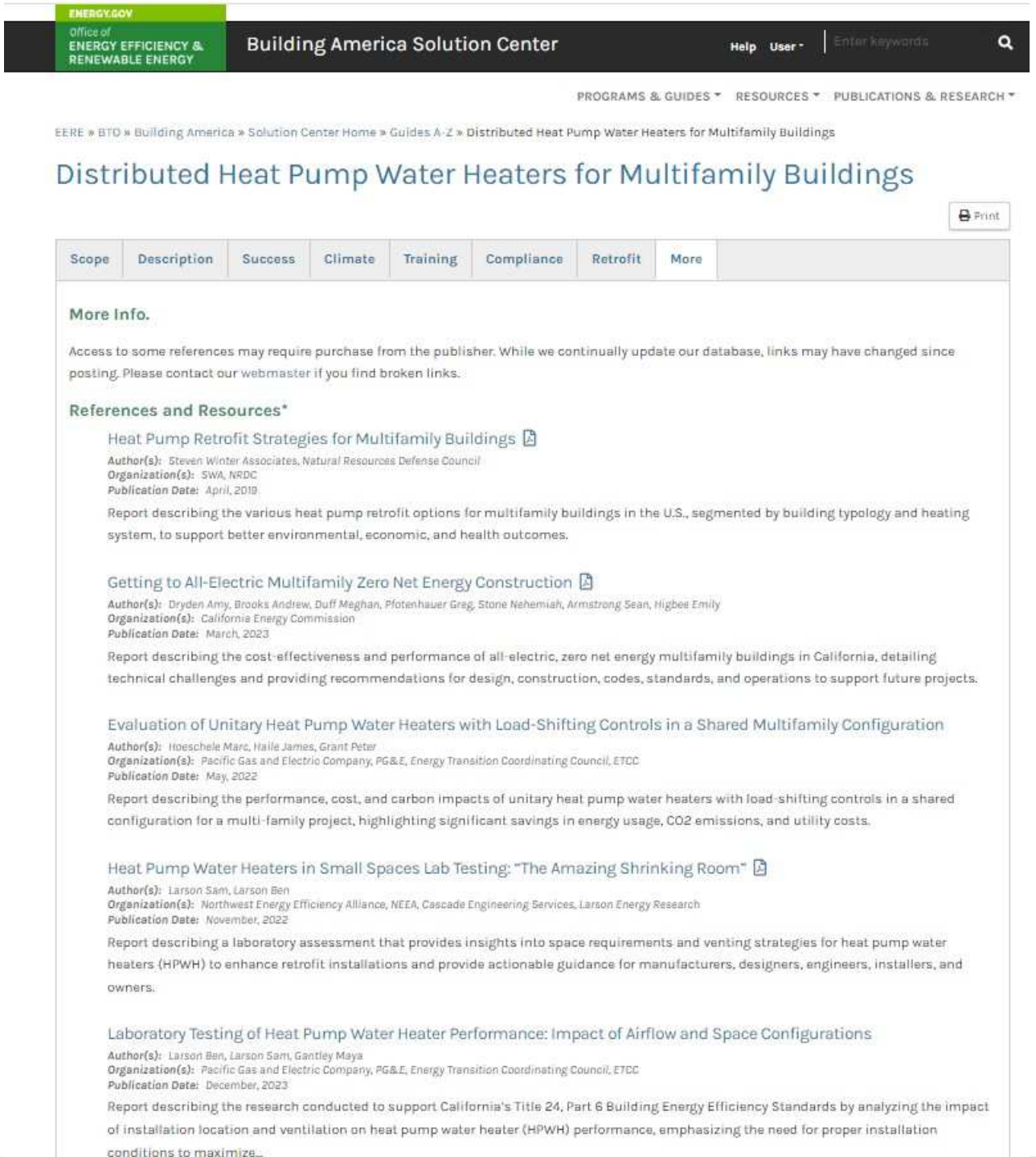
Climate

Training

Compliance

Retrofit

More



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Questions?

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