Example 3: MF Water Source Heat Pumps with Cooling Tower and Boiler

SYSTEM TAG: MF-ISUP-CEXH-Water-Source-HPs

PROJECT VISION

California Title 24 compliance modeling requires translating mechanical system designs into CBECC 2025 software objects, a process for which little practical guidance exists. Developed as part of the *Addressing Complex HVAC Systems in Code Compliance* project, funded by Southern California Edison through the CalBEM working group, each example walks through how a recognizable HVAC system type translates into CBECC objects, what Title 24 2025 Part 6 requires, and what assumptions were made.

PREPARED FOR
Southern California Edison
CalBEM Working Group 3

PREPARED BY
A2 Efficiency & West Monroe

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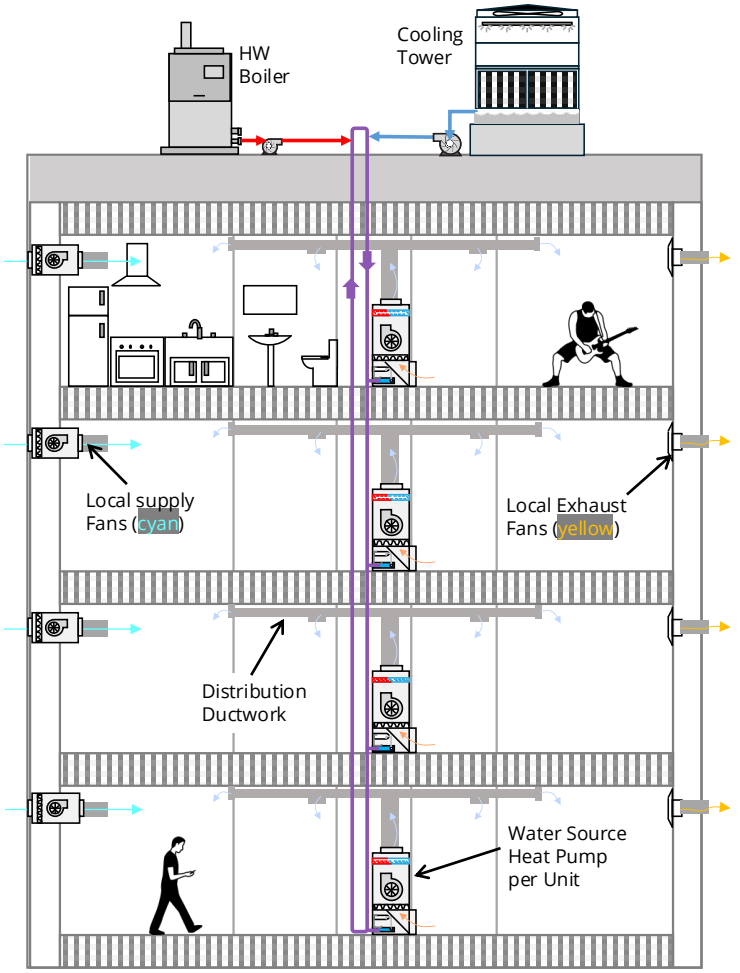
Mechanical Description

Each of the eight residential dwelling units in the 2-story MF08 prototype is conditioned by an in-unit water source heat pump (WSHP). Every WSHP exchanges heat with a shared condenser water loop held in a moderate temperature band year-round, so each compressor works against a smaller temperature lift than an air-source equivalent. A gas-fired condensing boiler adds heat only when the loop falls below its heating setpoint; a cooling tower rejects heat only when the loop rises above its cooling setpoint. Indoor fans are single-speed and ducted, with ducts located in conditioned space.

Ventilation is handled separately from conditioning by balanced individual supply and exhaust fans. Each dwelling has a dedicated balanced ventilator supplying outdoor air and exhaust at matched airflow sized by bedroom count for 1-bed and 2-bed unit types. Domestic hot water is provided by a central heat pump water heater plant.

Diagram

The diagram shows a sample of four residential floors, each with a balanced ventilator (individual supply and exhaust, cyan and yellow arrows) and a ducted WSHP with distribution ductwork per unit. A shared condenser water loop (purple) connects to the condensing gas boiler and cooling tower on the rooftop.



Mechanical Details

The water source heat pump system was applied to the MF08 prototype, with eight in-unit WSHPs sharing a common condenser water loop maintained by a central cooling tower and gas-fired condensing boiler.

Ventilation: Balanced ventilator per dwelling unit; no central vent shaft

Ventilation control: Fixed flow, no DCV

Cooling: WSHP at the unit; heat rejected to a shared condenser water loop with open cooling tower

Heating: WSHP at the unit; loop topped up by a gas-fired condensing boiler when needed

Capacity control: Constant volume, fixed supply air temperature

Economizing: None

All WSHP share the same rated cooling and heating efficiencies, found in the equipment table below. The condenser water loop boiler and cooling tower are sized for the loop served. The boiler is enabled only when the loop temperature drops below the heating setpoint; the tower's variable-speed fan modulates when the loop needs to reject heat.

Mechanical Capacities and Sizing

WSHP indoor units are autosized per zone by the simulation engine. The condenser water loop and its boiler and cooling tower are hard sized for the loop served.

Residential Ventilation Fans

Unit Type	OA (cfm)	Supply W/cfm
1-Bed	37.5	0.4
2-Bed	54.9	0.4

Water Source Heat Pump

Parameter	Value
Object	ResCentralHtgClgSys - WSHP System
Type	Water Source Heat Pump
Rated COP (heating)	4.8
Rated EER (cooling)	17
CW Loop Inlet Reference	CW Supply Segment
CW Loop Outlet Reference	CW Return Segment

Indoor Fan and Distribution

Parameter	Value
Indoor Fan Object	ResFanSys - HVAC Fan, WSHP Indoor
Fan Type	Single Speed
W/cfm (cooling)	0.45
Distribution Object	ResDistSys - Air Distribution System, Res
Duct Location	Entirely in conditioned space

Dwelling Unit Templates and Instances

Template	Bedrooms	Area (sf)	Instances Referencing	Total Units
1-Bed Type Z1	1	750	1BR First Floor, 1BR Second Floor	4
2-Bed Type Z1	2	1,080	2BR First Floor, 2BR Second Floor	4

Per-Zone Autosized Capacities

Zone	Floor Area (sf)	Clg Cap (kBtu/h)	Htg Cap (kBtu/h)	Rated EER	Rated COP @ 47 F
Zone1 (First Floor)	3,660	25.8	32.2	17	4.8
Zone2 (Second Floor)	3,660	39.1	48.9	17	4.8

Condenser Water Loop (Plant)

Parameter	Value
Object	FluidSys - CW Loop
Loop Type	Condenser Water
Design Supply Temperature (F)	79
Pump Object	CW Loop Pump (on Return Segment)

Cooling Tower

Parameter	Value
Object	HtRej - CW Loop Cooling Tower
Tower Type	Open Tower
Fan Type	Axial
Fan Control	Variable Speed Drive
Rated Capacity (Btu/h)	70,000
Total Fan Horsepower (hp)	0.334
Air Flow Capacity (cfm)	1,389
Water Flow Capacity (gpm)	14.1
Low Speed Air Flow Ratio	0.5
Minimum Speed Ratio	0.5

Boiler

Parameter	Value
Object	Blr - CW Loop Boiler
Boiler Type	Hot Water
Fuel	Gas
Draft Type	Condensing
Rated Capacity (Btu/h)	22,000
AFUE	0.91

Domestic Hot Water Plant

Parameter	Value
Object	ResDHWSys - DHWHeatpump
System Type	Standard (Single Pass Primary)
Compressor	Sanden GS3-45HPA-US (4 kW at 40 F)
Compressor Quantity	2
Primary Tank Volume (gal)	160
Loop Tank Volume (gal)	80
Loop Tank Type	Electric Resistance
Recirculation Type	Non-Central
Source Air / Tank Location	Outside

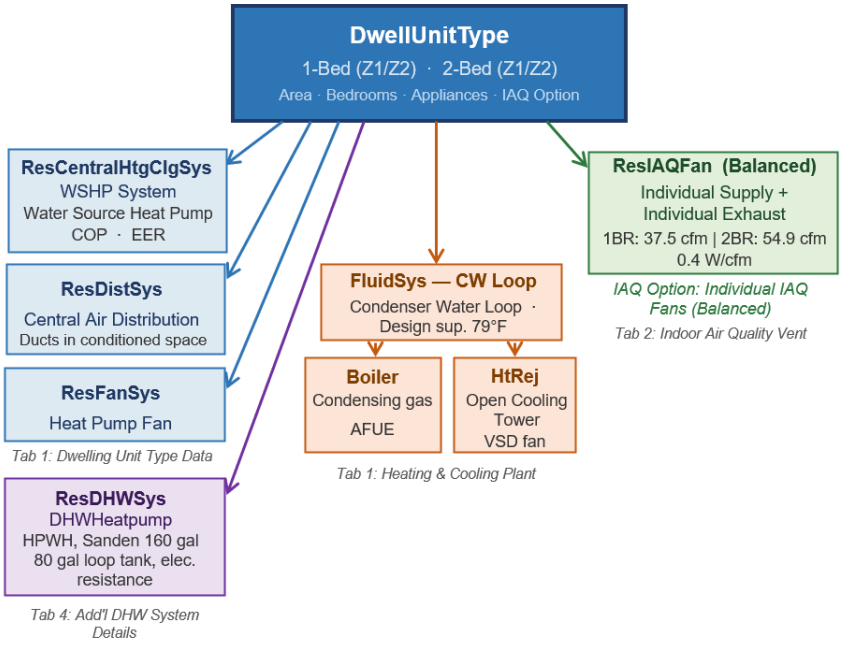
Code Compliance Software Configuration

In CBECC, the residential building is configured around the DwellUnitType object. Each unit type is an object holds references to the HVAC system, indoor fan, distribution, balanced ventilator, and DHW plant. DwellUnit instances point at a type and inherit its references. The WSHP example adds a plant: a FluidSys object that defines the condenser water loop, with a boiler and cooling tower as loop equipment.

The diagram below shows how the DwellUnitType assembles its components and how the WSHP system in turn references the condenser water loop. The blue branch covers HVAC conditioning on the Dwelling Unit Type Data tab. The orange branch covers the plant on the Heating and Cooling Plant tab. The green branch covers ventilation on the Indoor Air Quality Vent tab. The purple branch covers DHW.

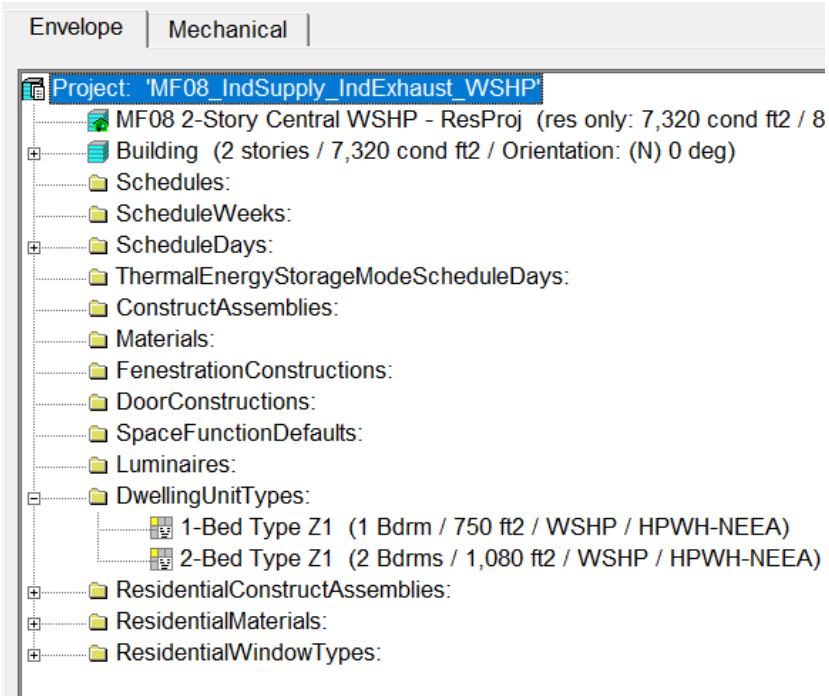
Key Modeling Points

- **The DwellUnitType is a template**, it defines equipment assignments once. Two templates are defined (1-Bed Type Z1 and 2-Bed Type Z1). Four DwellUnit instances each include a count of two, resulting in eight total dwelling units across the two floors.
- **The WSHP system object** is shared across all unit types. Rated COP and EER are set once and apply to every unit. Indoor capacity is autosized per zone. Each unit's ResCentralHtgClgSys references the CW loop supply and return segments so unit-level conditioning is tied to plant loads.
- **The condenser water plant** is configured onec on the Heating and Cooling Plant tab as a single FluidSys CW Loop. The boiler and the open cooling tower are child equipment of the loop, referenced through the loop's inlet and outlet segments.
- **The IAQ approach** is set per unit type on Tab 2: Individual IAQ Fans (Balanced). Each type references its own balanced ventilator sized by bedroom count.
- **The balanced ventilators** are set to IAQ Fan Type = Balanced with no heat recovery in this example.

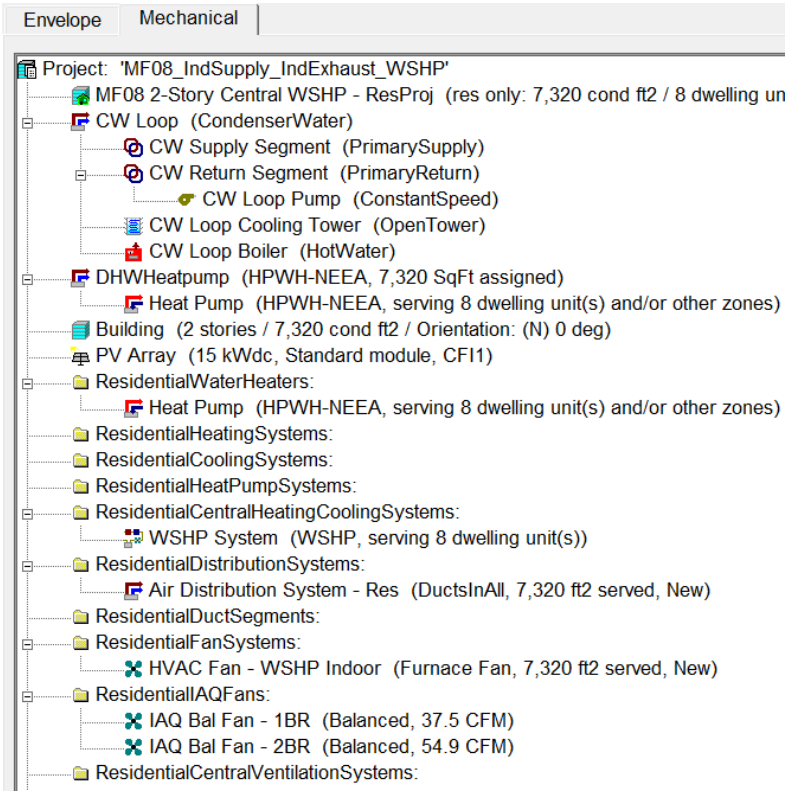


CBECC Object Locations

For multifamily buildings in CBECC the key objects for configuring the HVAC are on the envelope and the mechanical tab. The envelope tab as shown below is where dwelling units live. These are the integration points for all multifamily dwellings where all the components for each dwelling type are defined and linked to mechanical systems.



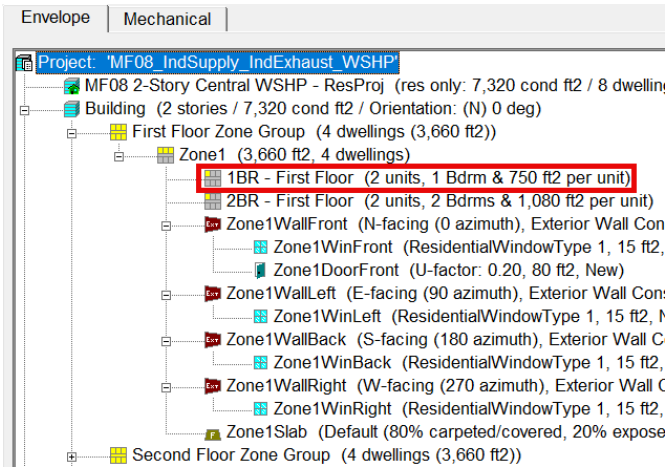
The mechanical tab is where those systems reside and where you can make multiple versions as needed of each system component. For example, this model uses a single WSHP System object to represent the water source heat pumps in every dwelling, however you could use several WSHP objects, one for each capacity or configuration of WSHP, on a project. Similarly, you can see in the residential IAQ fans there are two fans at specific air flow rates for fresh air based on the different number of bedrooms in each typical dwelling unit. The condenser water loop appears at the top of the Mechanical tab as a FluidSys object, with the CW Loop pump, open cooling tower, and gas-fired boiler configured as children of the loop.



Screenshots

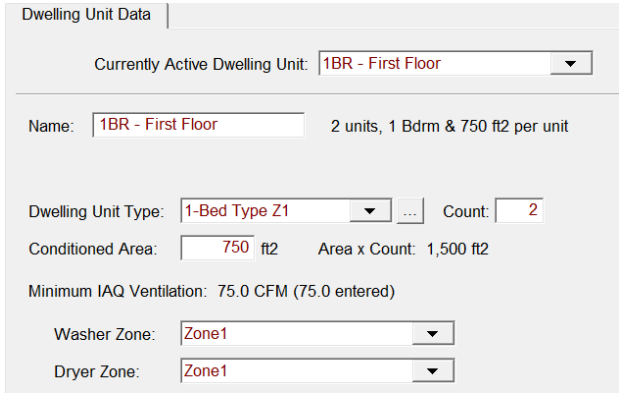
Thermal Space Dwelling Unit Data

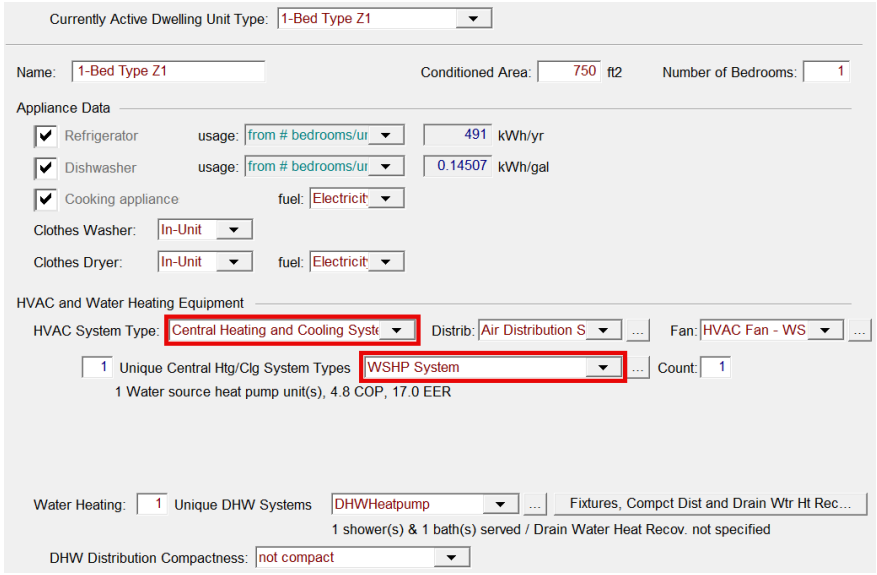
Each thermal space holds a Dwelling Unit Data object that records the count of unit instances of that type in the space and the in-unit appliances.



Dwelling Unit Type Data (1-Bed shown)

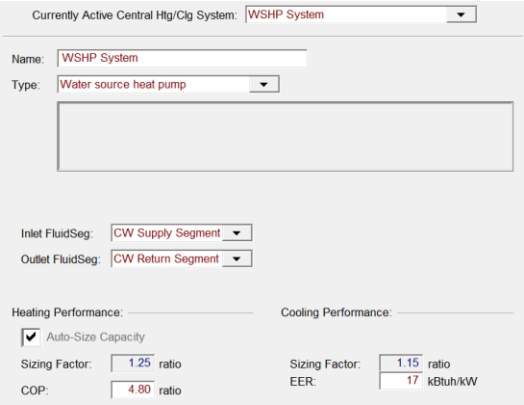
Sets unit area, bedrooms, appliances, HVAC System type set to Central Heating and Cooling System, the WSHP system reference, indoor fan, distribution, and DHW reference.





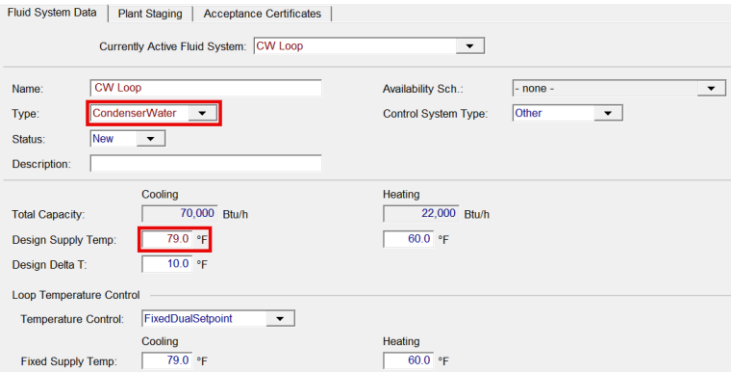
WSHP System Object

On the Mechanical tab. Sets the WSHP type, rated COP and EER, and the CW Loop supply and return segment references.



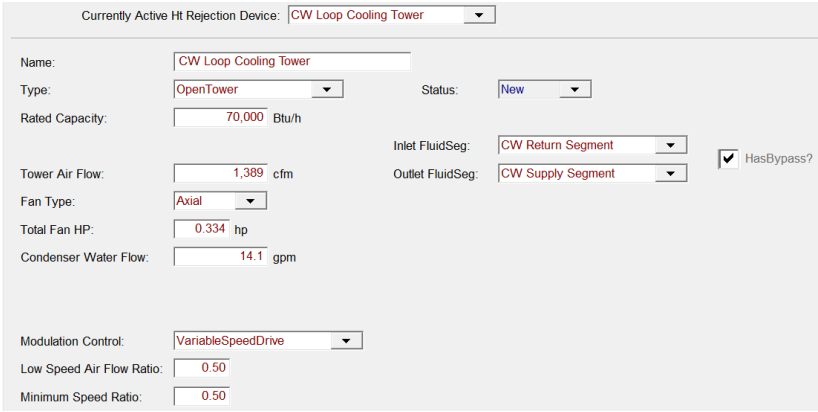
Condenser Water Loop (FluidSys)

On the Mechanical tab the CW loop is defined for the WSHP systems. The CW loop defines the type as Condenser Water, the design supply temperature. With the loop pump as a child of the return segment and the boiler and cooling tower added as child equipment of the CW Loop.



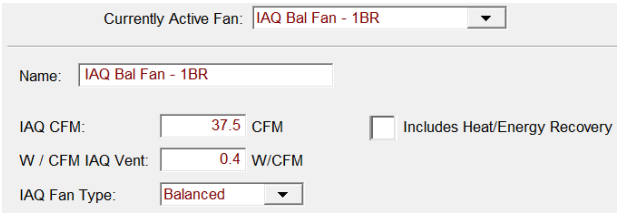
Cooling Tower (HtRej)

Opened from the CW Loop's heat rejection child on the Mechanical tab. Sets the tower type as Open Tower, the rated capacity, and links the tower to the loop through Inlet FluidSeg (CW Return Segment) and Outlet FluidSeg (CW Supply Segment). The axial fan and total fan horsepower set fan power; condenser water flow sets the design loop flow through the tower. Modulation Control is set to Variable Speed Drive, with low speed air flow ratio and minimum speed ratio capping the turndown range.



Indoor Air Quality (1-Bed shown)

Sets the IAQ approach to Individual IAQ Fans and references the unit's balanced ventilator. The heat recovery box is unchecked in this example.



Relevant Energy Code Citations

Restructured 2025 Title 24, Part 6 with section numbers shown with legacy cross-reference in brackets.

Ventilation & IAQ, Attached Dwelling Units

403.2.2.3 & 403.2.2.3.4 [160.2(b)2 & 160.2(b)2Aiv]:

The governing sections for MF dwelling unit ventilation. All attached dwelling units shall meet ASHRAE 62.2 as amended by the Code. ISUP/IEXH qualifies as balanced ventilation per item 2.1. Compartmentalization testing ≤ 0.30 cfm/sf at 50 Pa required per item 2.2.

Equipment Efficiency, WSHP and Boiler

400.5.1 [110.2(a)]:

Equipment shall meet the applicable federal minimum efficiency in Tables 400.5-A through 400.5-L. Water source heat pumps are covered by Table 400.5-B [110.2-B]. The boiler in this model is well below the 1 MMBtu/h system input that triggers Title 24's commercial boiler prescriptive requirements (401.3.13.8 [140.4(k)8] and related); federal minimum efficiency for residential-class gas hot water boilers applies via this section. Modeled WSHP COP and EER and boiler AFUE all exceed the federal minimum (see equipment tables).

Cooling Tower Mandatory Requirements

400.5.5 [110.2(e)]:

Open and closed-circuit cooling towers ≥ 150 tons shall meet conductivity-control and cycles-of-concentration requirements. The tower in this model is well below the 150-ton threshold and is exempt. NR prescriptive 401.3.10.1 [140.4(h)1] would require VSD fan control on motors ≥ 7.5 hp; the model tower fan is below that threshold. VSD control is used in the model to match design intent.

Ducts in Conditioned Space

402.2.6.1.1, under 402.2.6.1 [150.0(m)1]:

When all ducts are located entirely within conditioned space, duct insulation is not required. Must be confirmed through HERS field verification per RA3.1.4.3.8. All dwelling unit ducts modeled as entirely in conditioned space.

Single-Zone Ducted System Fan Efficacy

402.2.6.13.2 [150.0(m)13B]:

Single-zone ducted systems shall meet ≤ 0.58 W/cfm (non-gas AHU) at ≥ 350 cfm/ton airflow. WSHP indoor fans are non-gas. Modeled fan efficacy is below the code cap; see indoor fan table. HERS verification required.

Standard Design Mechanical Package, CZ9

403.3.1.1 [170.2(c)3A]:

For MF performance compliance in CZ9: HP SEER2 and HSPF2 at federal code minimum per 403.3.1.1; refrigerant charge verification required per 403.3.1.2.1. Individual supply fan efficacy for non-HRV balanced systems: ≤ 0.4 W/cfm per 403.3.1.2.5 in CZ 5-10 and CZ 15.

Standard design is a Split Heat Pump baseline. Proposed WSHP picks up compliance credit from the high WSHP COP and EER, offset by gas boiler heat input to the loop and the tower fan and loop pump energy that the Standard Design does not include.

This example is one of eight developed as part of the *Addressing Complex HVAC Systems in Code Compliance* project. The full guide includes additional HVAC system types, alternative configurations, and working CBECC model files. All resources are available through the CalBEM working group and EnergyCodeAce platform.