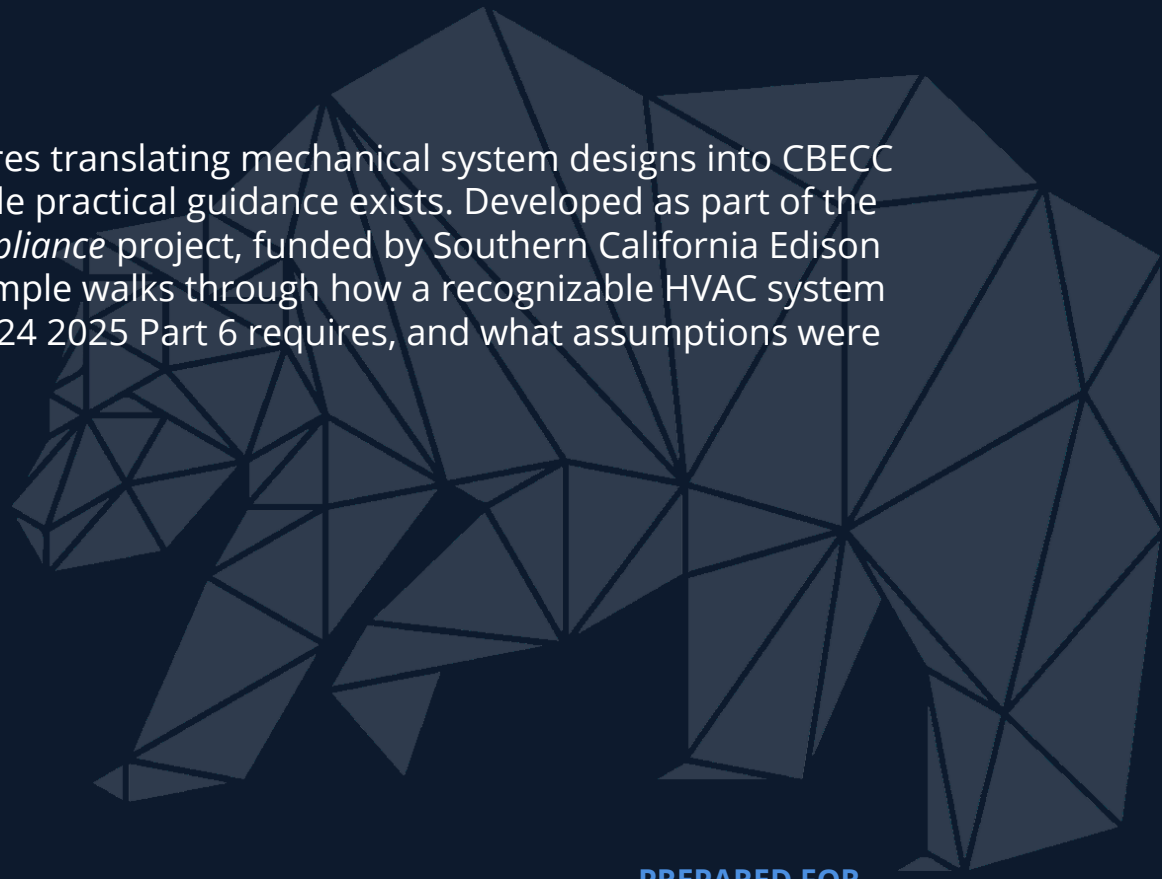
Example 2: MF Central VRF Heat Pump

SYSTEM TAG: MF-ISUP-CEXH-VRF-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

Example 2: MF Central VRF Heat Pump

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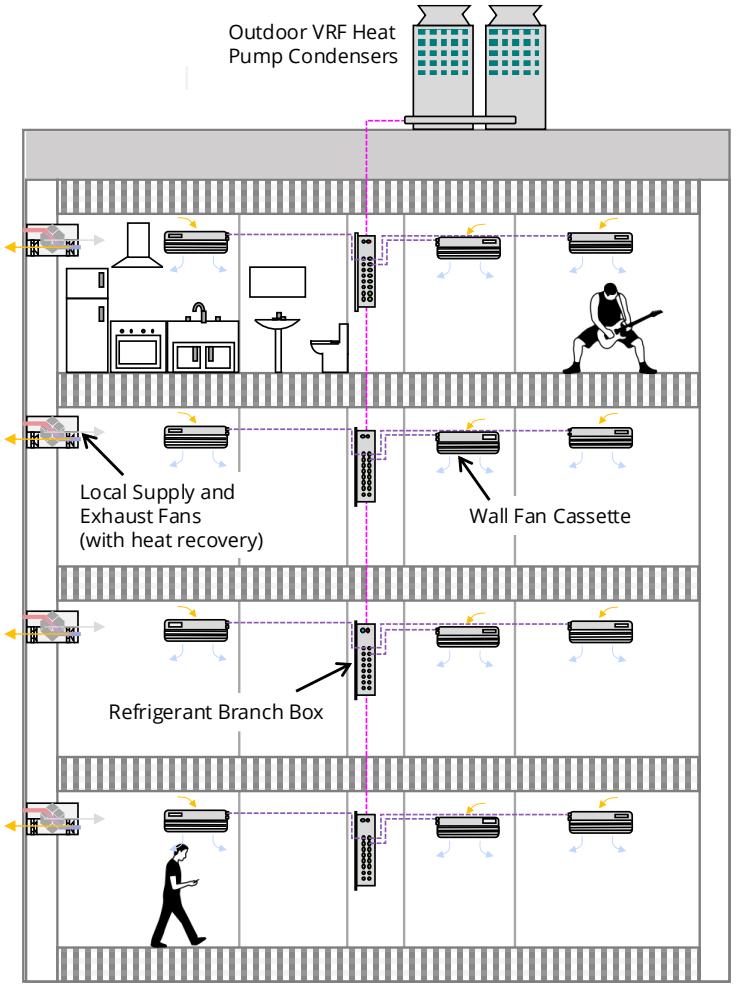
Mechanical Description

Each of the eight residential dwelling units in the 2-story MF08 prototype is conditioned by a central variable refrigerant flow (VRF) heat pump system. A single central outdoor unit serves all units through a refrigerant piping network, with indoor fan coils inside each dwelling. Each indoor unit modulates its refrigerant flow while the outdoor unit varies its speed to match the combined zone loads without reheat or mixing losses. All indoor units are in the same mode, heating or cooling, at any time.

Ventilation is handled separately from conditioning by balanced individual supply and exhaust fans with heat recovery. There is no central ventilation shaft, and the VRF system does not deliver outside air. 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 an individual supply and exhaust fan (left, grey and orange arrows) pushing outdoor air into the dwelling units and exhausting air back outside, and a ducted indoor fan coil per dwelling fed by refrigerant piping from the rooftop outdoor unit. A single VRF outdoor unit on the roof serves every dwelling in the building.



Mechanical Details

The central VRF system was applied to the MF08 prototype, with a single outdoor unit serving all eight dwelling units through a shared refrigerant distribution network and individual indoor fan coils in each unit.

Ventilation: Balanced ventilator per dwelling unit with heat recovery.

Ventilation control: Fixed flow, no DCV

Cooling: VRF heat pump, all-electric

Heating: VRF heat pump, all-electric, no supplemental electric resistance or gas

Capacity control: Variable refrigerant flow modulated at the outdoor unit, fixed supply temperature

Economizing: None

Mechanical Capacities and Sizing

Indoor fan coils and refrigerant capacity are autosized per zone by the simulation engine. The outdoor unit is hard-sized at the rated capacity. Both VRF methods use the same dwelling unit indoor fan, distribution, ventilator, and DHW objects.

Residential Ventilation Fans

Unit Type	Design OA (cfm)	Fan Power (W/cfm)	Fan Type	Heat Recovery
1-Bed	37.5	0.4	Balanced	HRV, 70% SRE
2-Bed	54.9	0.4	Balanced	HRV, 70% SRE

Residential Dwelling Unit Indoor Fan

Parameter	Value
Object	ResFanSys - HVAC Fan, VRF Indoor
Type	Single Speed Fan
W/cfm (Cooling)	0.45

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
Recirc Type	Non-Central
Source Air / Tank Location	Outside

Code Compliance Software Configuration

CBECC models VRF heat pump systems using one of two methods, determined by the outdoor unit's rated cooling capacity. The threshold is 65,000 Btu/h, which is where the AHRI test procedure changes: equipment below uses AHRI 210/240 (rated with SEER2 and HSPF2); equipment at or above uses AHRI 1230 (rated with EER, COP47, and IEER). CBECC requires the object type and efficiency metrics to match, so always verify the rated cooling capacity before selecting a method, using the wrong metrics produces inaccurate energy simulation results.

Both methods are demonstrated using the same prototype model. In each, the DwellUnitType object is the central organizing element: it holds references to all systems serving a unit type, and each DwellUnit instance inherits those references by pointing to a type. The diagram below shows how DwellUnitType assembles its components across three branches — HVAC conditioning (blue, Dwelling Unit Type Data tab), ventilation (green, Indoor Air Quality Vent tab), and DHW (purple). White boxes highlight where the Res Heat Pump System (ResHtPumpSys) configuration differs from the Res Central Heating and Cooling System (ResCentralHtgClgSys).

VRF Efficiency Rating Thresholds for CBECC Multi-Family Modeling

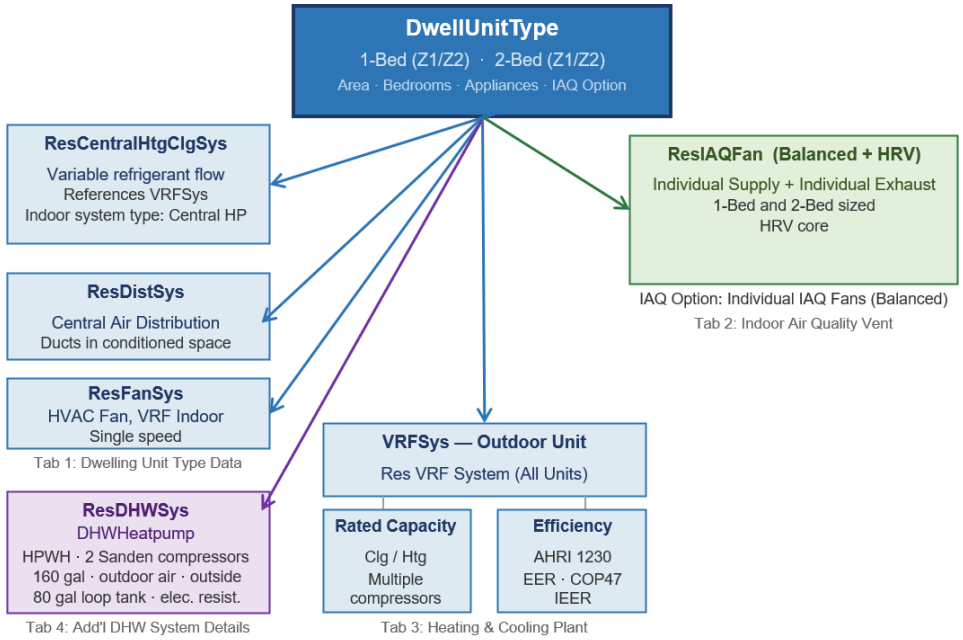
The appropriate efficiency metric for modeling VRF heat pump systems depends on the outdoor unit's rated cooling capacity, with 65,000 Btu/h serving as the dividing line.

- **Below 65,000 Btu/h:** Systems fall under the residential/light-commercial framework (AHRI 210/240-2023) and are rated using **HSPF2** for heating efficiency. These units should be modeled using HSPF2 input values consistent with the Appendix M1 test procedure.
- **At or above 65,000 Btu/h:** Systems fall under commercial equipment standards (AHRI 1230) and are rated using **COP** metrics — specifically **COP47** (coefficient of performance measured at 47°F) — along with IEER for cooling. These units should be modeled accordingly using COP-based inputs.

Figure 1: VRF central outdoor compressors

Method 1: Central VRF Above 65,000 Btu/h (AHRI 1230)

Applies when the outdoor unit's rated cooling capacity is at or above 65,000 Btu/h. The system is rated using EER, COP47, and IEER under AHRI 1230. In CBECC, the dwelling unit's HVAC system is set to Central Heating and Cooling System, and the ResCentralHtgClgSys object is set to variable refrigerant flow. That object references a separate VRFSys object holds the outdoor units capacity, efficiency, compressor count, and refrigerant piping geometry.



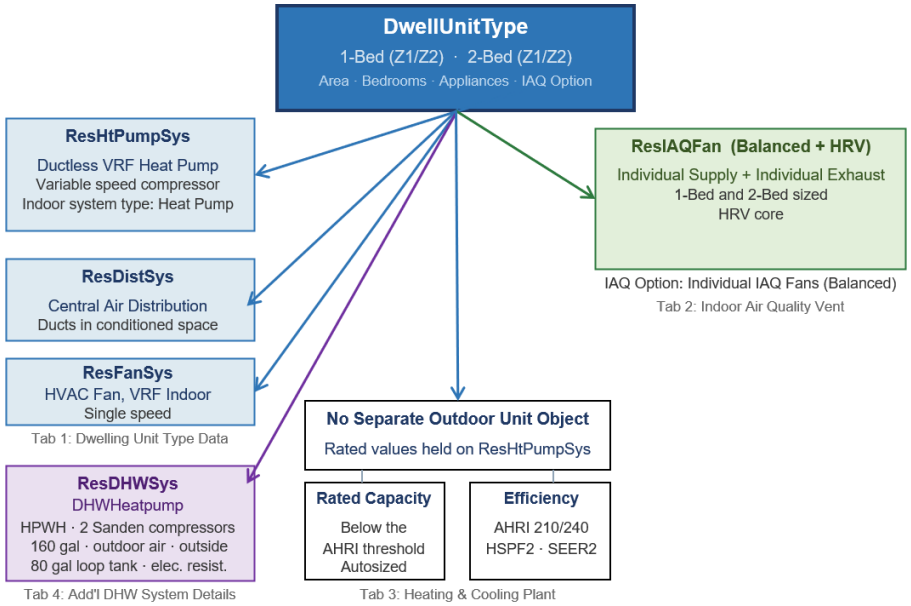
VRF Outdoor Unit (Method 1)

Parameter	Value
Object	VRFSys - Res VRF System (All Units)
Rated Cooling Capacity (Btu/h)	216,000
Rated Heating Capacity (Btu/h)	250,000
EER	10
COP47	3.2
IEER	17
Compressor Quantity	3
Equivalent Pipe Length (ft)	150
Maximum Vertical Separation (ft)	50
Control Priority	Load Priority

Method 2: Ductless VRF Below 65,000 Btu/h (AHRI 210/240)

Applies when the outdoor unit's rated cooling capacity is below 65,000 Btu/h. The system is rated using HSPF2 and SEER2 under AHRI 210/240-2023. In CBECC, the dwelling unit's HVAC system type is set to Heat Pump Heating and Cooling System, and a ResHtPumpSys object with the Ductless VRF Heat Pump type holds the rated efficiency values. There is no separate VRFSys outdoor unit object on this path.

This method is appropriate for smaller multifamily prototypes or for VRF systems sized to serve a single dwelling unit or a small group of units below the commercial capacity threshold.

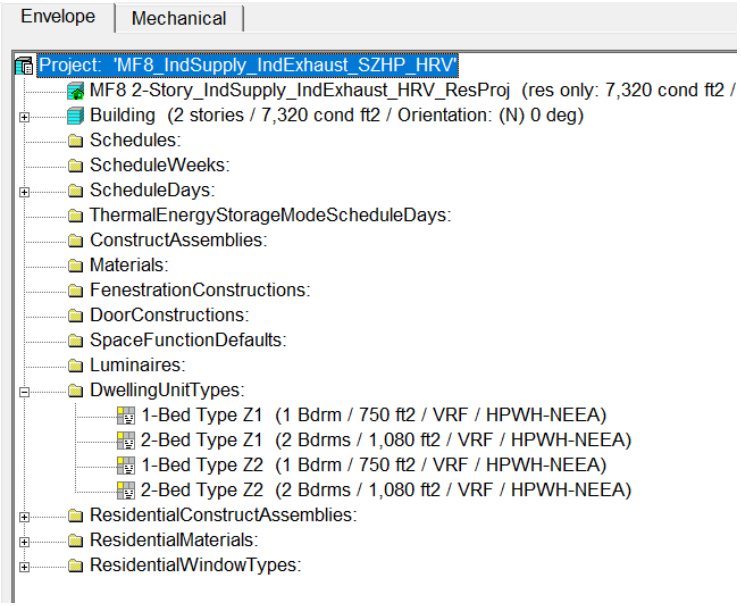


VRF Heat Pump (Method 2)

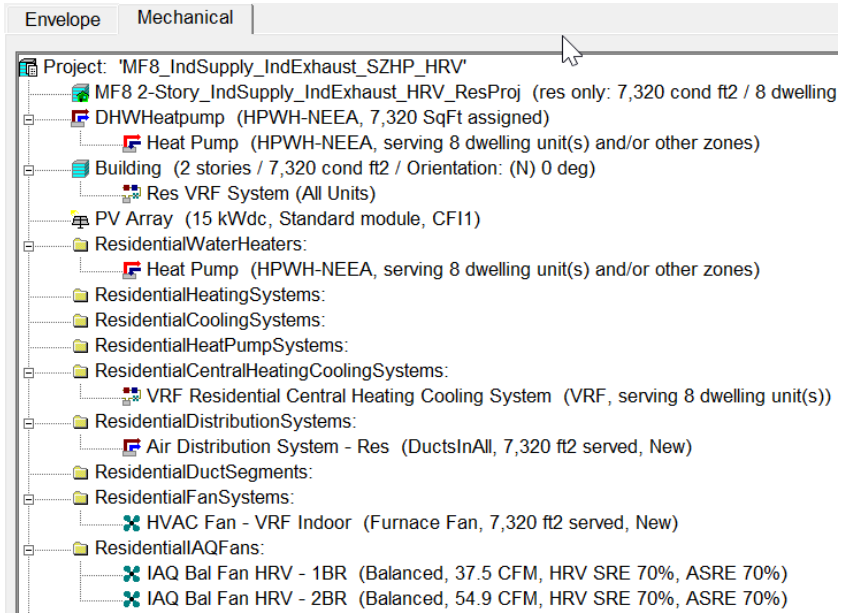
Parameter	Value
Object	ResHtPumpSys - VRF Type Heat Pump
Type	Ductless VRF Heat Pump
Compressor Speeds	Variable
HSPF2	7.0
SEER2	14
Backup	none
Capacity	Autosized

CBECC Object Locations

For multifamily buildings in CBECC, HVAC inputs live on two tabs: Envelope and Mechanical. Dwelling units and their type references are on the Envelope tab. System objects (the VRF outdoor unit or the Ductless VRF heat pump, the indoor fan, distribution, balanced ventilator, and DHW plant) are on the Mechanical tab.

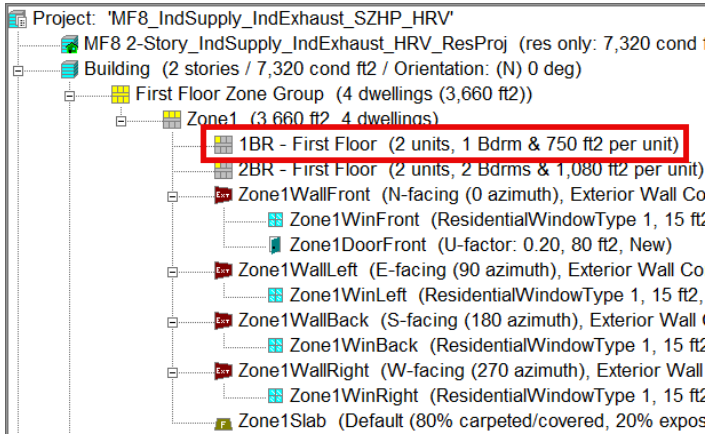


The mechanical tab is where those systems reside and where you can make multiple versions as needed of each system component. For example, this model uses a single heat pump system to represent the split heat pumps however you may end up with several of these one for each capacity of heat pump on a project. Similar you can see in the residential AQ fans there are multiple fans at specific air flow rates for fresh air based on the different number of bedrooms in each typical dwelling unit.



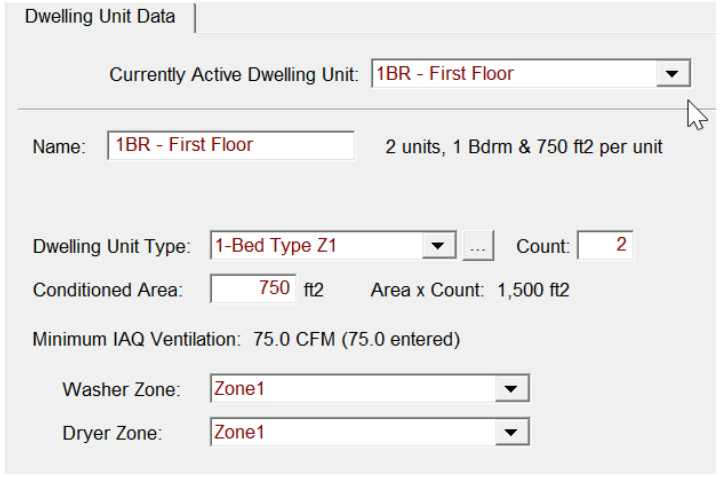
Thermal Space Dwelling Unit Data

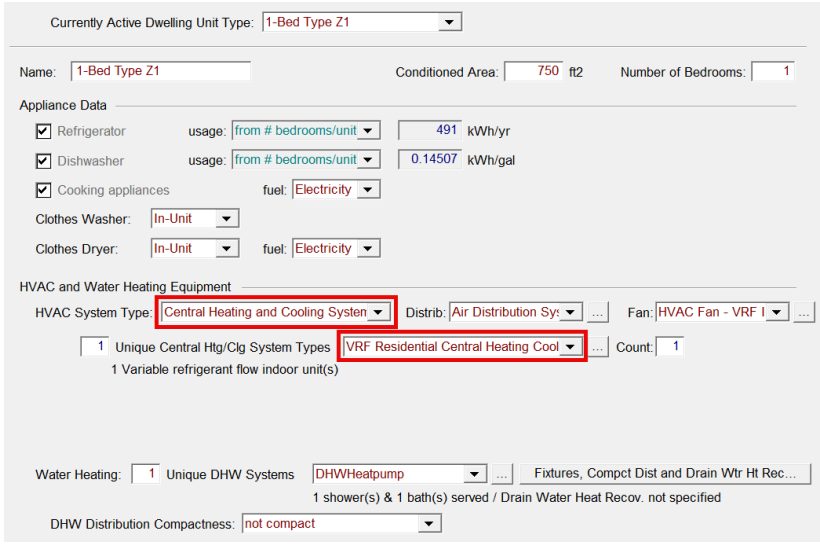
Each thermal space holds a Dwelling Unit Data object that records the count of unit instances of that type in the space and the in-unit appliances.



Dwelling Unit Type Data (Method 1, 1-Bed shown)

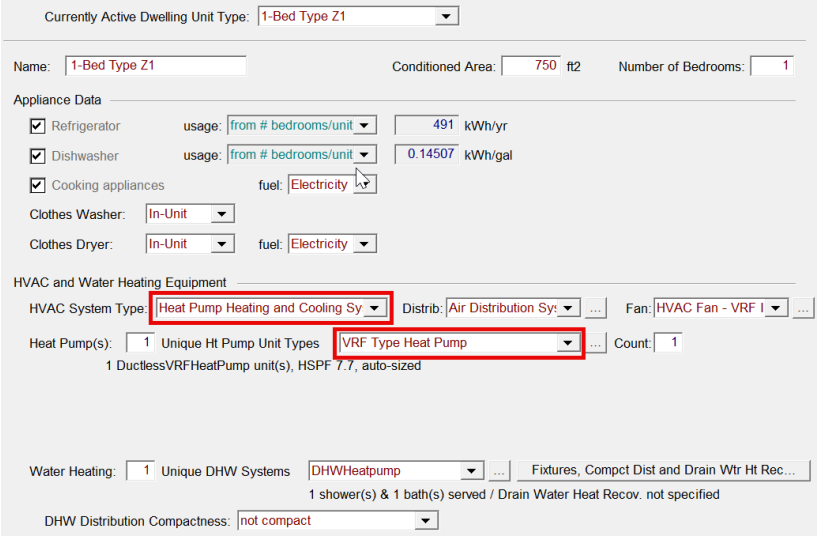
Sets unit area, bedrooms, appliances, HVAC system type to Central Heating and Cooling System, the ResCentralHtgClgSys reference, indoor fan, distribution, and DHW reference.





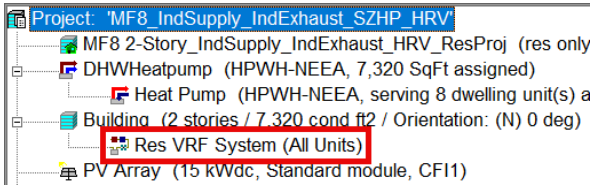
Dwelling Unit Type Data (Method 2, 1-Bed shown)

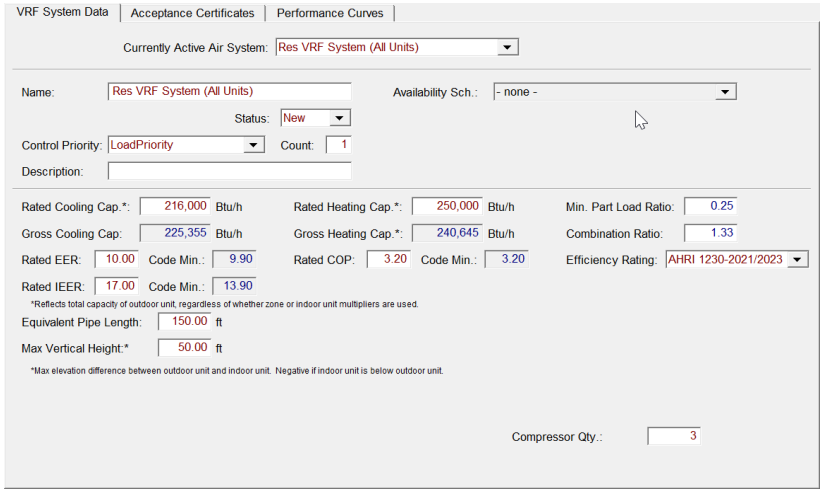
Sets unit area, bedrooms, appliances, HVAC system type to Heat Pump Heating and Cooling System, the ResHtPumpSys reference, indoor fan, distribution, and DHW reference.



VRF System Object (Method 1)

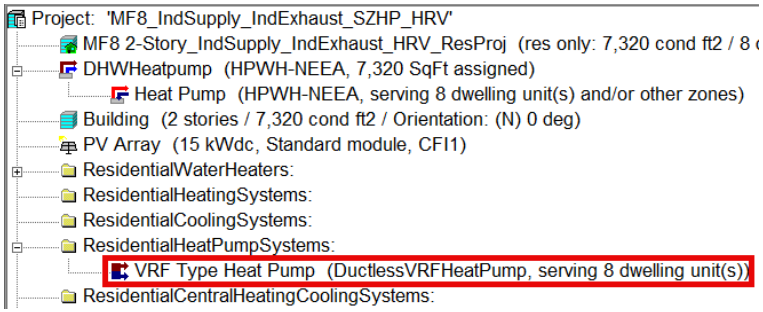
On the Mechanical tab. Sets the VRFSys rated capacity, AHRI 1230 metrics, compressor count, equivalent pipe length, and maximum vertical separation between indoor and outdoor units.

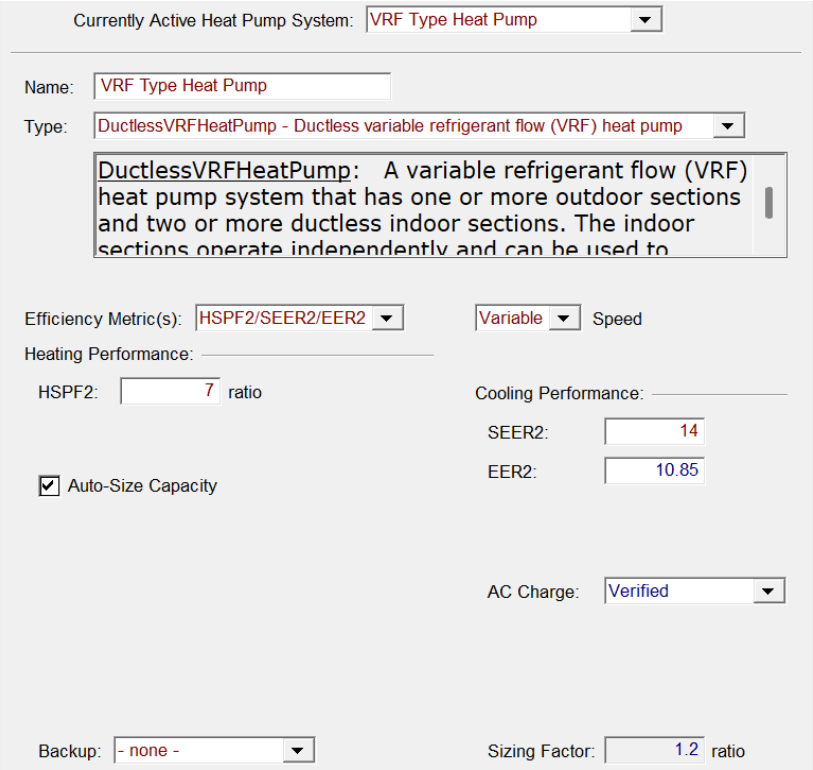


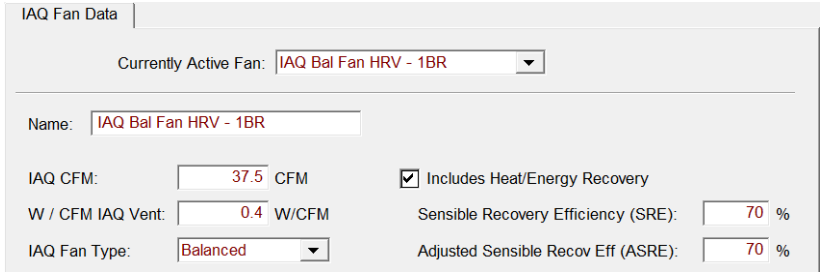


VRF Heat Pump Object (Method 2)

On the Mechanical tab. Sets the ResHtPumpSys type to Ductless VRF Heat Pump, with HSPF2, SEER2, and variable speed compressor.

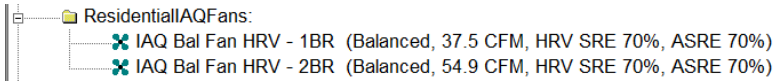






Indoor Air Quality Vent (1-Bed shown)

Sets the IAQ approach to Individual IAQ Fans, references the balanced HRV ventilator for the unit, and the FID accessibility checkboxes. Same configuration for both VRF modeling methods.



Relevant Energy Code Citations

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

Ventilation and 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.

VRF Efficiency Metric by Capacity

Section 400.5 / Table 400.5-G [110.2 / Table 110.2-G]:

Sets the size-vs-metric split for VRF. < 65,000 Btu/h: AHRI 210/240, rated SEER2 and HSPF2; model as ResHtPumpSys (Ductless VRF). ≥ 65,000 Btu/h: AHRI 1230, rated EER, COP47, and IEER; model as VRFSys referenced by a ResCentralHtgClgSys set to Variable refrigerant flow. Wrong metric for the system size produces inaccurate results.

Balanced Ventilation with Heat Recovery

403.2.2.3.4 [160.2(b)2Aiv], item 2.1:

Balanced ventilation systems with HRV or ERV serving a single dwelling unit shall have fan efficacy ≤ 1.0 W/cfm. Recovery effectiveness is credited through the HVI listing entered for the IAQ fan object. See also 403.3.1.2.5 [170.2(c)3Bv]: ≤ 0.4 W/cfm for balanced ventilation without HRV/ERV in CZ 5-10 and CZ 15.

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. HERS verification required at construction.

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. VRF indoor fan coils are non-gas. Model inputs 0.45 W/cfm for all dwelling unit HVAC fans. 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 VRF gains compliance margin from part-load performance, no supplemental resistance heat, and the HRV ventilator credit.

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.