Example 4: NR Small Office, Single Zone VAV, Dual Fuel Heat Pumps

SYSTEM TAG: T24ACM-SZVAVDFHP

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.

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Example 4: NR Small Office, Single Zone VAV, Dual Fuel Heat Pumps

System Tag: T24ACM-SZVAVDFHP
Title 24 2025 ACM: System c3

Mechanical Description

Each thermal zone is served by a dedicated packaged dual-fuel heat pump unit providing ventilation, heating, and cooling. The system uses a variable speed fan to modulate airflow while maintaining fixed supply air temperatures for heating and cooling modes.

Cooling is provided by the heat pump refrigerant circuit, with an economizer and multi-stage capacity control on larger units. Heating is staged between the heat pump and a secondary gas furnace, with two outdoor air temperature setpoints governing the transition: a supplemental heating coil limit, below which the furnace begins contributing, and a compressor lockout temperature, below which the heat pump is disabled, and the furnace takes over entirely.

In CBECC, each unit is modeled as a separate SZ-VAV-DFHP air system object assigned to its corresponding thermal zone.

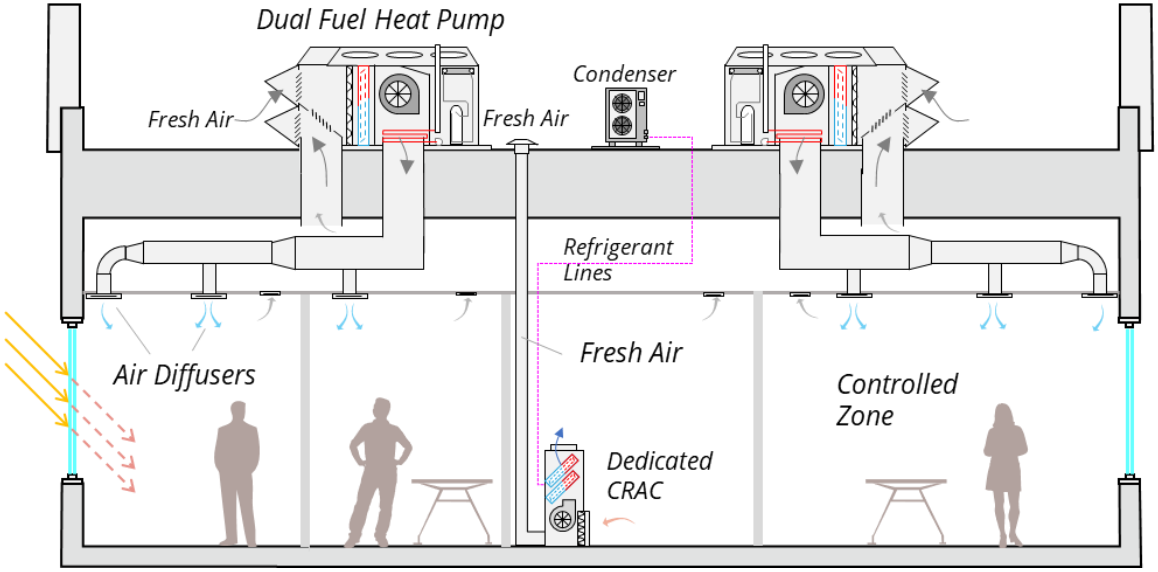


Figure 2: Non-Residential Small Office: SZ Variable Dual Fuel HPs

The diagram above shows dual fuel heat pump single zone rooftop packaged units serving the building. The left unit supplies two rooms via a shared duct run; in practice, each unit controls a single thermostat location.

Mechanical Details

The SZ-VAV-DFHP system was applied to the custom small office prototype, applying this to 7 thermal zones with an additional exhaust-only zone for the restroom and a computer room AC unit for the IT zone. For those 7 systems the following components are detailed below:

Ventilation: Mixed Air at each unit

Ventilation control: CO2 controls in 3 zones based on people density and flow.

Cooling: DX cooling (reversing heat pump)

Heating: heat pump and supplemental gas furnace

Capacity control: variable air flow with fixed air temperatures

Economizing: Yes, in units above 3.5 tons

Mechanical Capacities and Sizing

Equipment is sized based on the peak loads for each thermal zone calculated by CBECC when simulation is set to autosize based on 55°F supply air for cooling and 95°F supply air for heating. EnergyPlus evaluates the zone peak cooling, heating, and airflow rates. The results of those loads were used to specifically size the model components.

Coil Name	Nom Total Cap (Btu/h)	Nom Sensible Cap (Btu/h)	Max Air Flow Rate (CFM)	Heating Cap (Btu/h)
Zn Sys 1 Reception	51,545	37,068	1,363	51,545
Zn Sys 2 Conference	59,153	41,116	1,449	51,229
Zn Sys 3 Break Room	46,008	36,290	1,473	43,444
Zn Sys 4 Open Office	202,499	148,667	5,602	201,797
Zn Sys 5 Conference-Office	22,535	16,497	621	22,564
Zn Sys 6 Conference-Support	47,990	38,248	1,567	70,005
Zn Sys 7 Restrooms	0	0	0	0
Zn Sys 8 It And Elec	31,183	31,183	1,010	0
Zn Sys 9 Library	72,924	55,424	2,173	54,000
Zn Sys 10 Elec	0	0	0	0

Code Compliance Software Configuration

This section documents the HVAC system configuration as modeled in CBECC for Title 24 compliance. A summary diagram of the system architecture is provided, followed by detailed screenshots of key input screens.

The compliance model is organized around individual air systems (AirSys), one per conditioned thermal zone. Each air system contains a supply segment and a return segment. The supply segment hosts the cooling coil, heating coil, supplemental furnace, and supply fan as sequential components, along with an air terminal unit connecting the system to its zone and an outdoor air controller.

The SZVAVDFHP systems are modeled, each serving one conditioned zone. The systems are configured as follows:

- **Cooling coils** are modeled as direct expansion (DX) coils
- **Heating coils** are modeled as heat pump coils, serving as the primary heating source
- **Supplemental heating coils** are modeled as gas furnaces, activating as secondary heat when outdoor temperatures fall below the heat pump compressor lockout threshold
- **Supply fans** are modeled as variable speed drive (VSD) fans, reducing speed during low-load conditions to match zone ventilation demand
- **Outdoor air control** uses a fixed dry-bulb economizer with the high-limit shutoff temperature except System 10, which has no economizer due to its small capacity.

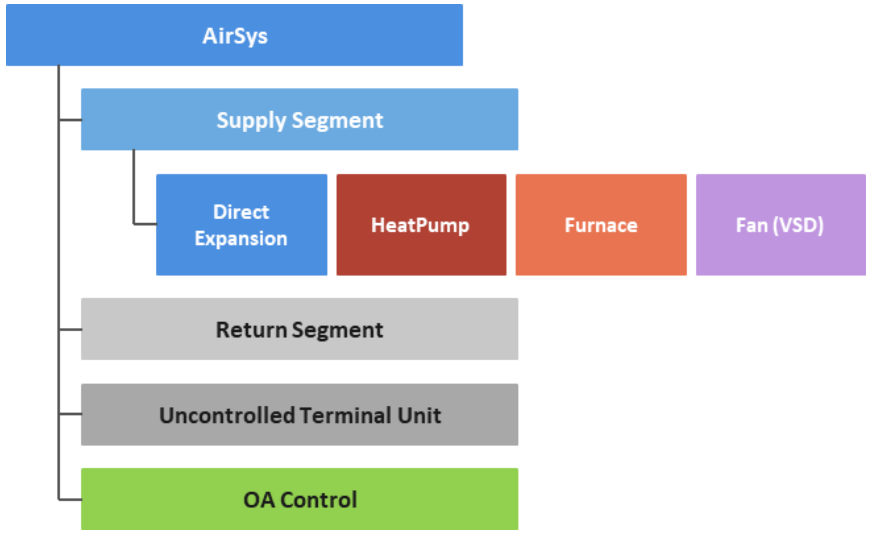


Figure 3: Component Diagram for SZVAVDFHP

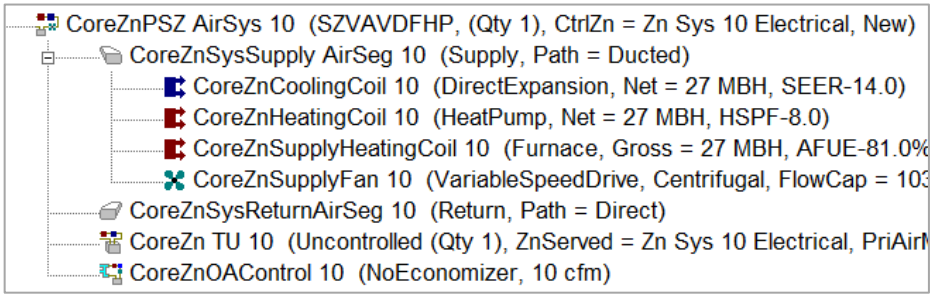


Figure 4: SZVAVDFHP Components in CBECC

CBECC Object Locations

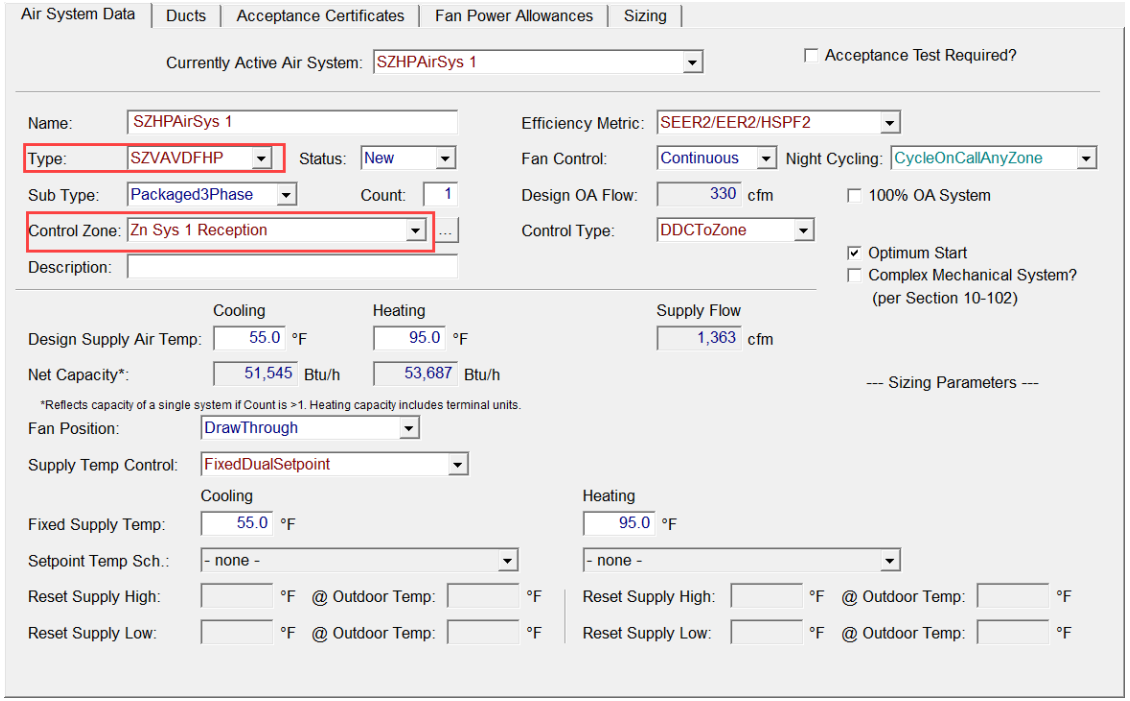
Included are screenshots of the air systems used to specify the SZVAVDFHP and the cooling coil elements for each.

Air Systems and Zone Systems

The primary HVAC system, SZVAVDFHP, is configured with 7 air systems in CBECC. The air system component enables variable speed fans as well as economizer controls which zone systems do not have configured.

Secondary systems, serving the restroom, the IT/Elec and computer rooms are configured with Zone Systems respectively.

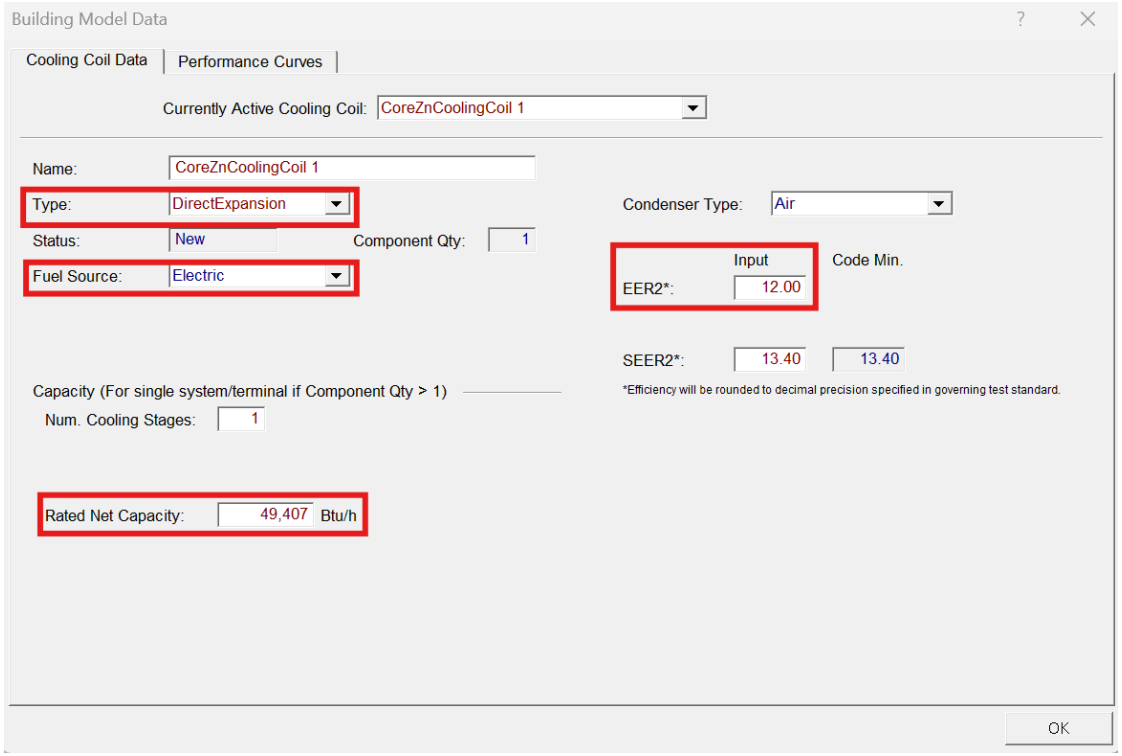
Zone Name	Sys Type	Floor Area (sf)
Zn Sys 1 Reception	SZVAVDFHP	1392.2
Zn Sys 2 Conference	SZVAVDFHP	928.9
Zn Sys 3 Break Room	SZVAVDFHP	1414.3
Zn Sys 4 Open Office	SZVAVDFHP	5962.3
Zn Sys 5 Conf-Office	SZVAVDFHP	578.3
Zn Sys 6 Conference-Support	SZVAVDFHP	1359.2
Zn Sys 7 Restrooms	Exhaust	245.5
Zn Sys 8 IT and Elec	SZAC	131.9
Zn Sys 9 Library	SZVAVDFHP	1818



DX Cooling Coils

The cooling coils are modelled as direct expansion with the fuel source being electric. The restroom zone type has no cooling coil modeled since it just consists of an exhaust fan.

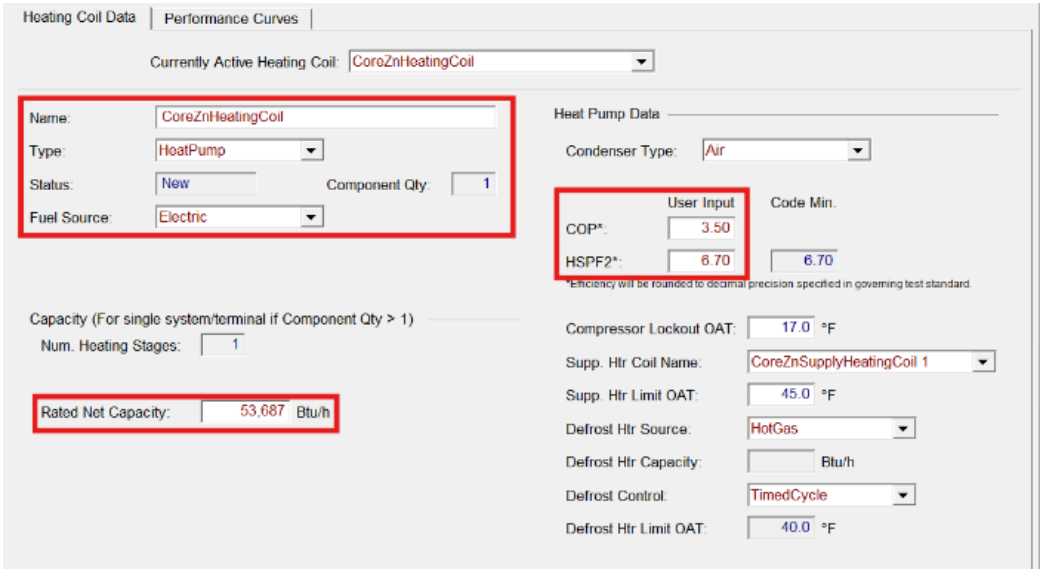
Zone Name	Clg Net (kBtu/hr)	Clg EER2
Zn Sys 1 Reception	49.4	12
Zn Sys 2 Conference	56.7	12
Zn Sys 3 Break Room	44.1	12
Zn Sys 4 Open Office	194.1	10.4
Zn Sys 5 Conf-Office	21.6	12
Zn Sys 6 Conf-Support	46	12
Zn Sys 7 Restrooms	-	-
Zn Sys 8 IT and Elec	70	-
Zn Sys 9 Library	69.9	10.8

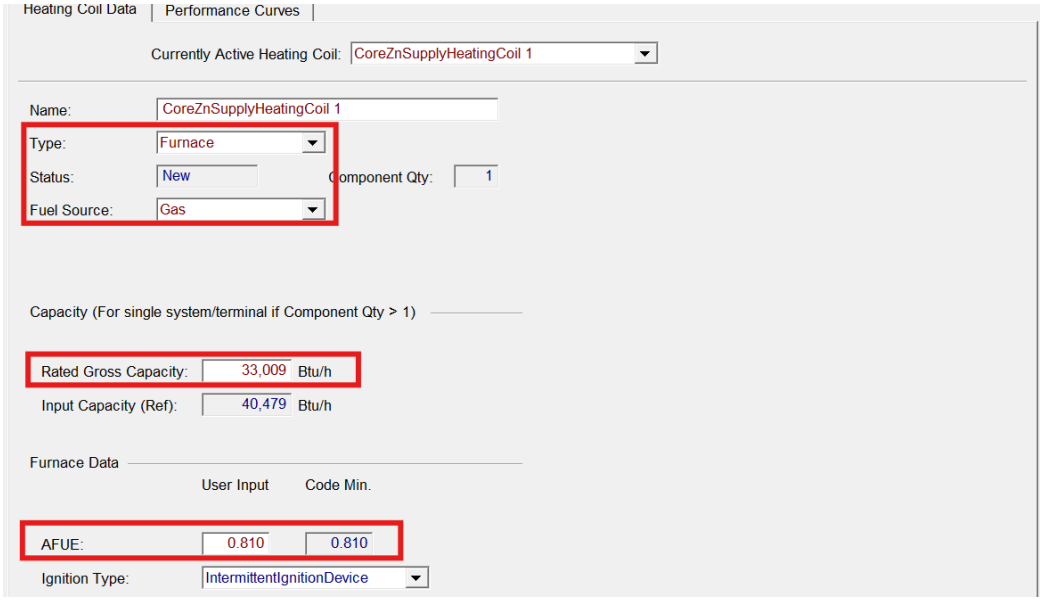


HP and Gas Backup Heating Coils

Two heating coil objects are modelled. The primary which is the heat pump type and the secondary which is the furnace type. Both the restroom and IT/Elec systems do not have heating. Heat pumps were designed at a COP of 3.5 and an HSPF2 of 6.7. Furnaces were designed at a minimum efficiency of 81%.

Zone Name	Htg HP (kBtu/hr)	Gas Furnace (kBtu/hr)
Zn Sys 1 Reception	53.7	33.0
Zn Sys 2 Conference	53.7	43.7
Zn Sys 3 Break Room	45.4	53.1
Zn Sys 4 Open Office	210.2	132.0
Zn Sys 5 Conf-Office	23.5	15.7
Zn Sys 6 Conf-Support	72.0	58.8
Zn Sys 9 Library	46.9	46.9

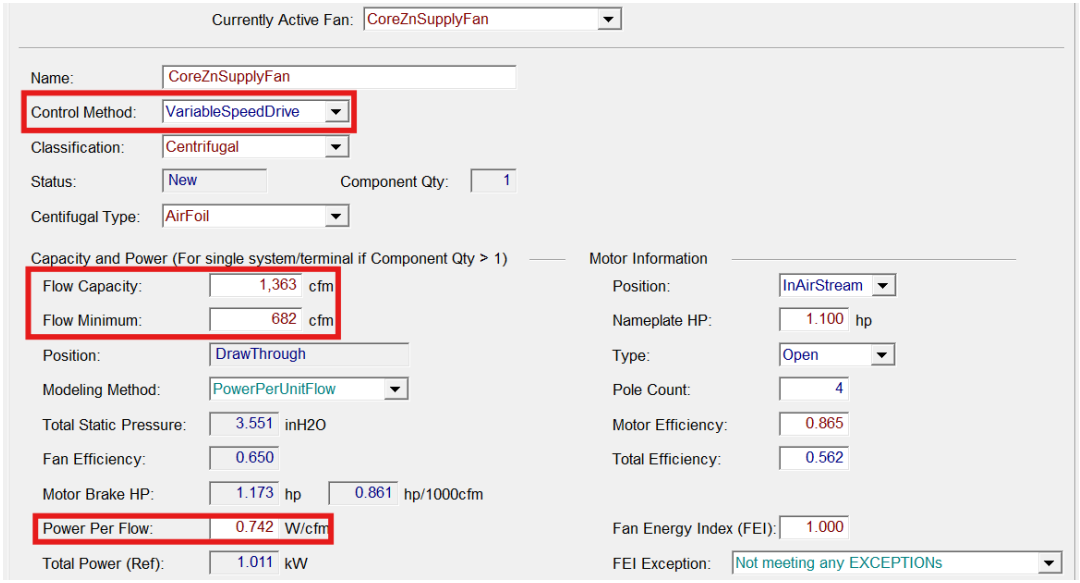


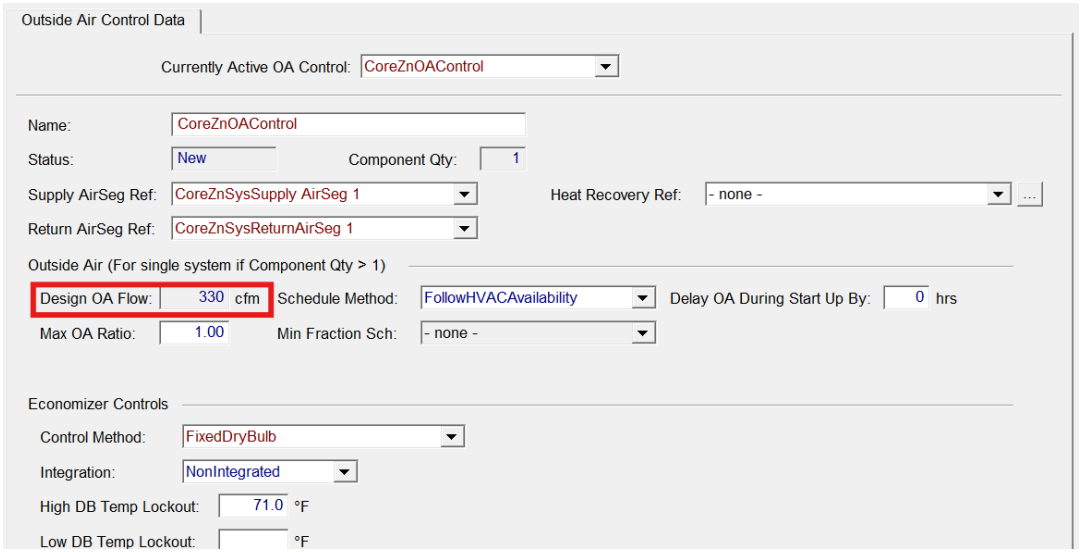


Fan Component

Each fan object includes maximum, minimum, fan power, motor horsepower, motor efficiency, and FEI. CBECC uses these inputs to calculate part-load fan power across the annual simulation. Zones are modelled as with fan control as variable speed drive expect for restrooms and Elec/IT rooms which are constant volume.

Zone	Supply (CFM)	Min (CFM) (50%)	Fan Eff (W/cfm)
Zn Sys 1 Reception	1363	682	0.742
Zn Sys 2 Conference	1449	725	0.742
Zn Sys 3 Break Room	1473	737	0.742
Zn Sys 4 Open Office	5603	2802	0.742
Zn Sys 5 Conf-Office	621	311	0.742
Zn Sys 6 Conf-Support	1567	784	0.742
Zn Sys 7 Restrooms	250	-	-
Zn Sys 8 IT and Elec	985	-	0.58
Zn Sys 9 Library	2173	1087	0.742





System Efficiency Tables

The table shows the system compared with the T24 2025 standard baseline system for this building and location.

SYSTEM ARCHITECTURE COMPARISON - Proposed (SZVAVDFHP) vs. Standard (SZHP / SZVAVHP / SZAC)		
Category	**Proposed (SZVAVDFHP)**	**Standard (SZHP / SZVAVHP / SZAC)**
System Type	SZVAVDFHP - Single-Zone VAV Dual-Fuel Heat Pump all zones	SZHP; SZVAVHP; SZAC: Single-Zone Heat Pump (CV); Single-Zone VAV Heat Pump; Single-Zone Air Conditioner
Cooling Efficiency	EER 10.4 / EER 10.8 / EER 12.5 / IEER 13.3 (large zones) / SEER 13.9	EER 10.6 / 11.4 (all zones)
Heating Primary	Air-source HP, COP 3.5 (all zones)	Air-source HP, COP 3.2 / 3.3 (all zones)
Heating Supp.	Natural Gas Furnace (AFUE 0.81) - inline supply air furnace - switches on at 35°F	Electric - switches on at 35°F
Fan Type	VSD, CV on ALL zones (0.8804 / 0.9646 / 1.0191 W/cfm)	CV, VSD on most zones (0.58 / 0.72 / 0.742 W/cfm)
VAV Terminal	VAVNoReheatBox - min 50% of design flow (all zones)	Uncontrolled (most zones); VAVNoReheatBox on large zones only
Economizer	Fixed DB 71°F Non Integ + mixed (7 of 8 zones)	Fixed DB 71°F Integ
Supp Lockout	Gas furnace takes over from HP at 35°F OAT	Electric resistance adds to HP at 35°F OAT

Relevant Energy Code Citations

Required Demand Control Ventilation

401.2.1.2.3 [Section 120.1(d)3]

Three zones exceeded the occupancy density limit and were equipped with an airside economizer based on cooling capacity requirements, therefore requiring a modulating airflow of ventilation based on CO2 control.

Fan Control

401.3.14 [Section 140.4(m)]

Fans are equipped to modulate their flow rate to 50% of airflow at 30% of power in each model.

Duct Insulation - Ducts in Directly Conditioned Space

401.2.4.1 [Section 120.4(a)]

Supply-air ducts routed within the return air plenum are considered enclosed in directly conditioned space and are therefore exempt from the minimum duct insulation requirement. No insulation is required for these duct segments.

Duct Sealing and Leakage Testing

401.2.4.7 [Section 120.4(g)]

Duct systems are required to be sealed per the applicable UL 181 standards. Formal leakage acceptance testing per NA7.5.3 is not required, as the duct system does not meet the triggering criteria for systems located predominantly in conditioned space.

Direct Digital Controls to Zone

401.2.2.10 [Section 120.2(j)] and Table 401.2-D [Table 120.2-A]

Each air-handling system and all zones served are required to have DDC to the zone level for new construction where the system supplies more than three zones with a design heating or cooling capacity of 300 kBtu/h or greater.

Optimum Start/Stop Controls

401.2.2.11 [Section 120.2(k)] Systems equipped with DDC to the zone level are required to have optimum start/stop controls that calculate pre-conditioning time based on space temperature, occupied setpoint, outdoor air temperature, and time to occupancy.

Supply Air Temperature Reset Controls

401.3.8 [Section 140.4(f)] A fixed dual setpoint range of 55°F to 95°F is applied as the cooling minimum and heating maximum for supply air temperature reset.

Required Air-Side Economizer

401.3.7 [Section 140.4(e)] All cooling systems exceed 33,000 Btu/hr and are required to include an air economizer. For Climate Zone 9, the fixed dry-bulb high-limit shutoff is set at 71°F per Table 401.3-G [Table 140.4-G].

Heat Pump Supplementary Heating Controls

400.5.2 [Section 110.2(b)] Supplementary heat is locked out when the heating load can be met by the heat pump alone. The outdoor air compressor cut-off is modeled at 17°F with secondary heat availability beginning at 45°F. Supplementary heat operation is permitted during defrost.

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.