8. Compliance Modeling Guidelines

The purpose of this section is to provide a guideline to CSU campuses, their design teams and energy modelers to aid with energy code compliance when installing decarbonized heating systems on campuses. Modeling decarbonized equipment using the existing performance method of energy code compliance encounters several issues, including the inability to model some equipment types in the state mandated compliance software, and the method in which compliance is calculated. This section will outline where these issues occur and provide state approved workaround and recommendations for alternate compliance approaches where necessary.

8.1 Background Information

The California Energy Commission (CEC) allows three methods to comply with the energy code. Two methods are typically adopted, either prescriptive or performance. A third, less common exceptional compliance approach can also be followed. The CSU system mandates that the performance approach to energy code compliance is adopted for all projects on CSU campuses, and therefore the remainder of this section focus on the performance approach, modeling guidelines and CEC approved workarounds where there are limitations in modeling software. Also included are recommendation for when prescriptive compliance may be an appropriate compliance approach

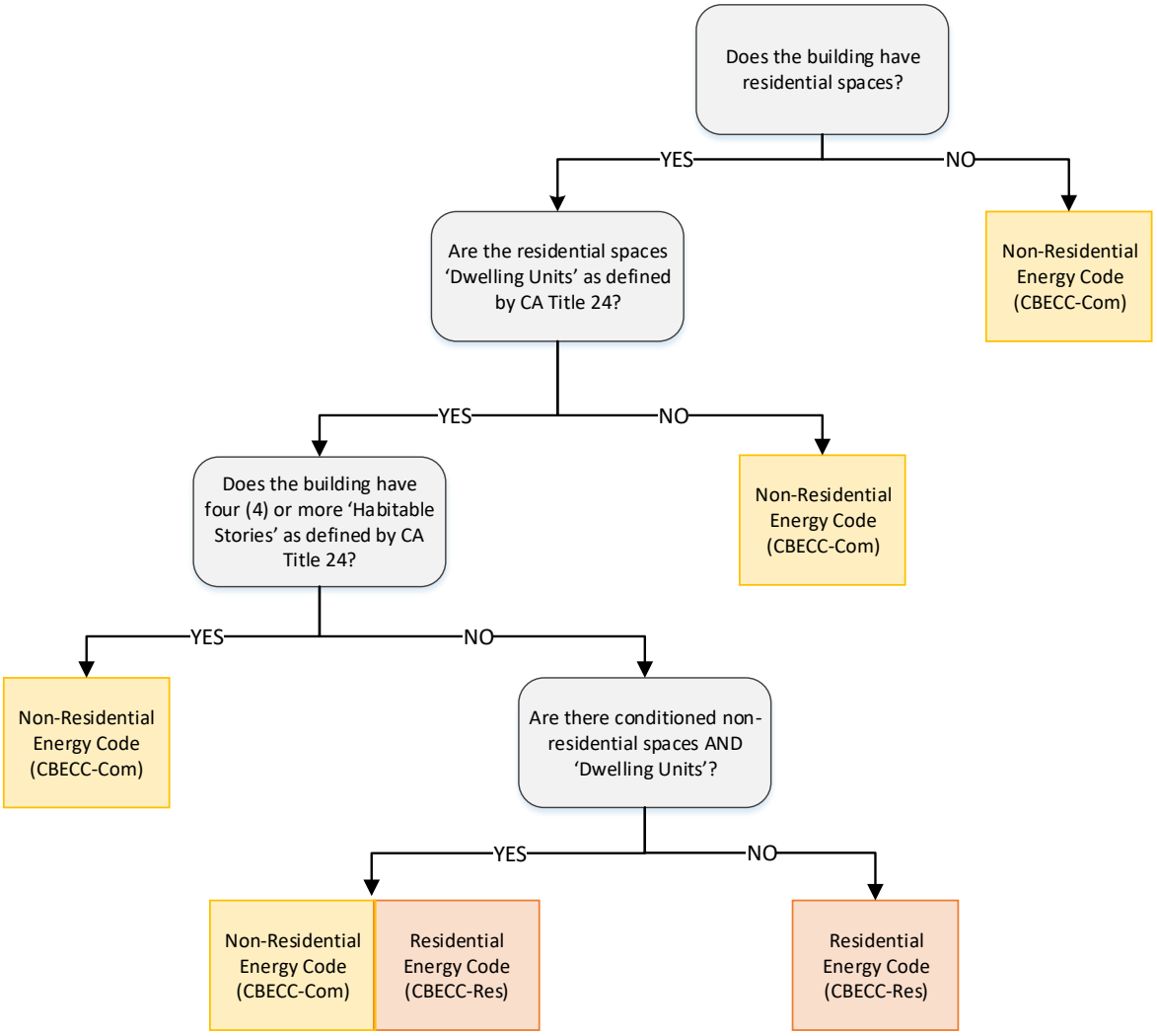
Performance Compliance

In order to allow for performance modeling the CEC has helped develop computer-based compliance simulation software that allows for a proposed building to be modeled and compared against a Title 24 prescriptive baseline building. CBECC-Com is used for the non-residential code and CBECC-Res for the residential code. Both compliance software allow users to input proposed building envelope, HVAC, DHW and lighting design information, along with building location and associated weather file, and determines the annual energy consumption on a Time Dependent Valuation (TDV) basis. This is compared to a Title 24 prescriptive baseline building, which is based on building systems and inputs as outlined in the CEC's Alternative Compliance Manual (ACM). To comply with energy code, a proposed building must at worst, equal the energy performance of a baseline building, resulting in a building being exactly 0% compliant, which is acceptable. In addition, performance modeling allows building systems to be analyzed either individually, a combination of different systems or as a whole, allowing the user to assess the performance of different building component against the Title 24 baseline.

TDV breaks the year into 8760 different hourly time periods and assigns a multiplier to both electrical and natural gas consumption during each time period. This multiplier is determined by hour of the year, energy type, climate zone and by building type. During periods of high demand on the electrical grid the TDV multiplier assigned to the electrical consumption is higher than during low periods, and therefore high electrical consumption in this time period is penalized. Additionally, as the California electrical grid is more strained than the natural gas grid, the multipliers assigned to natural gas consumption are typically less than and have lower peaks than electrical consumption. The ACM assigns carbonized systems as the baseline for most HVAC and DHW heating systems, typically resulting in a lower TDV energy usage for the baseline building. Therefore, electrifying building systems can have a negative impact on building compliance margin.

Residential vs. Non-Residential Code

Energy code in California is separated between Residential and Non-Residential codes. Residential energy code is applicable to all single-family and residential buildings three (3) stories or less. The non-residential code is applicable to all non-residential buildings, hotel/motels, and any residential buildings with four (4) or more habitable stories. The flowchart below should be used to determine which energy code and energy compliance software engine is applicable to a project.



The building is required to be split into two compliance models. One CBECC-Com model with the non-residential spaces and one CBECC-Res model with the dwelling unit spaces

DWELLING UNIT is a single unit providing complete, independent living facilities for one or more persons including access, permanent provisions for living, sleeping, eating, cooking and sanitation

HABITABLE STORY is a story that contains space in which humans may work or live in reasonable comfort, and that has at least 50% of its volume above grade

Figure 1: Residential vs Non-Residential Compliance Paths

Performance Modeling: CBECC-Com & CBECC-Res

CBECC-Com and CBECC-Res are free compliance software programs developed with CEC oversight that allows buildings under the non-residential code (CBECC-Com) and residential code (CBECC-Res) to be modeled and compared against a baseline. Currently the CEC allows one additional software program to be used for non-residential energy code compliance, EnergyPro and two additional software programs to be used for residential energy code compliance, EnergyPro and Right-Energy Title 24. EnergyPro and Right-Energy are third party license-based software that provide both energy modeling and compliance modeling capabilities. Both have a different user interface than that of either CBECC program, however when running Title 24 compliance models, both communicate with their respective CBECC programs and utilize the CBECC simulation engine to run compliance calculations. All inputs into EnergyPro and Right-Energy are therefore communicated into CBECC, and any limitations and workarounds for CBECC are also applicable to EnergyPro and Right-Energy. For this reason, the remainder of this section will focus on the direct version of the software, CBECC-Com and CBECC-Res.

It should be noted that the guidance provided in this report is applicable to the current code cycle only. The 2022 energy code, which will come into effect on January 1st, 2023 may impact the overall recommendations outlined below. One key item the 2022 code cycle may adjust are the TDV rates that CBECC-Com and CBECC-Res use to calculate compliance. These are under review by the CEC and may be updated for the 2022 cycle to enhance the compliance margins of decarbonized equipment. However, these have yet to be formally agreed upon and are not applicable with the current version of CBECC-Com or CBECC-Res, and therefore have not been assessed for this report.

Performance Modeling: Standard HVAC Systems[1]

The following tables show the Title 24 HVAC System Maps. These tables define the standard (or baseline) HVAC systems that a project is compared against in a performance energy model. This is meant to be representative of a typical construction in California meeting baseline code mandated efficiencies and requirements. These tables are important for design teams to consider as they will be compared against that building system in the performance model.

[1] 2019 Nonresidential Alternative Calculation Method Reference Manual for the 2019 Building Energy Efficiency Standards https://ww2.energy.ca.gov/publications/displayOneReport_cms.php?pubNum=CEC-400-2019-006-CMF

Table 2: HVAC System Map

Building Type	Standard Design
Residential or hotel/motel guestrooms in a building with seven or fewer floors above grade	System 1 - SZAC
Residential or hotel/motel guestrooms in a building with eight or more floors above grade	System 2 - FPFC
Retail building 2 floors or fewer	System 7 - SZVAV*
Warehouse and light manufacturing space types (per the Appendix 5.4A Schedule column) that do not include cooling in the proposed design	System 9 - HEATVENT
Covered process	See Table 4: System Map for Covered Processes
Healthcare Facilities	Same as the Proposed Design
All other space types	See Table 3: Nonresidential Spaces (Not Including Covered Processes)

Table 3: Nonresidential Spaces (Not Including Covered Processes)

Building Area	Floors	Standard Design	Description
< 25,000 ft^2	≤ 3 floors	System 7 - SZVAV*	Single Zone VAV
	4 or 5 floors	System 5 - PVAV	Packaged VAV Unit
	> 5 floors	System 6 - VAVS	Built-up VAV Unit
25,000 ft^2–150,000 ft^2	≤ 5 floors	System 5 - PVAV	Packaged VAV Unit
	> 5 floors	System 6 - VAVS	Built-up VAV Unit
>150,000 ft^2	Any	System 6 - VAVS	Built-up VAV Unit

Table 4: System Map for Covered Processes

Building Type or Space Type	Floors	Standard Design System
Total computer room design cooling load is over 3,000,000 Btu/h Note: if the user chooses computer room for the space type and enters a receptacle load less than 20 W/ft^2, then the proposed and standard design shall use a receptacle load of 20 W/ft^2.	Any	System 10 – CRAH Unit
Computer rooms that do not meet the conditions for System 10, CRAH	Any	System 11 – CRAC Unit
Laboratory Space	Any	System 12 – LAB
Restaurant Kitchen	Any	System 13 – KITCH

Table 5: System Descriptions

System Type	Description	Detail
System 1 – SZAC	Residential Air Conditioner	Single zone system with constant volume fan, no economizer, DX cooling and furnace
System 2 – FPFC	Four-Pipe Fan Coil	Central plant with terminal units with hot water and chilled water coils, with separate ventilation source
System 3 – SZAC	Packaged Single Zone	Single-zone constant volume DX unit with gas heating
System 4 – RESERVED		
System 5 – PVAV	Packaged VAV Unit	VAV reheat system; packaged variable volume DX unit with gas heating and with hot water reheat terminal units
System 6 – VAVS	Built-up VAV Unit	Variable volume system with chilled water and hot water coils, water-cooled chiller, tower and central boiler
System 7 – SZVAV	Packaged Single-Zone VAV Unit	Single-zone variable volume DX unit with variable-speed drive and gas heating
System 8 – RESERVED		
System 9 – HEATVENT	Heating and Ventilation Only	Gas heating and ventilation
System 10 – CRAH	Computer Room Air Handler	Built-up variable volume unit with chilled water, no heating
System 11 – CRAC	Computer Room Air Conditioner	Packaged variable volume DX unit with no heating
System 12 – LAB	Laboratory HVAC System	Laboratory spaces in a building having a total laboratory design maximum exhaust rate of 15,000 cfm or less use Table 3, Nonresidential System Map. Laboratory spaces in a building with building floor area < 150,000 ft²: System 5 – PVAV Laboratory spaces in a building with building floor Area ≥ 150,000 ft²: System 6 – VAVS
System 13 – KITCH	Kitchen HVAC System	Dedicated single-zone makeup air unit (MAU) with dedicated exhaust fan. If the building is VAVS per Table 3, the cooling source is chilled water and the heating source is hot water. Otherwise, cooling source is DX and heating source is a gas furnace.

CSU Compliance Requirements

In addition to mandating that the performance approach is followed for all projects, the CSU system requires the following performance goals are achieved:

- 10% compliance margin for overall building
- Each system (envelope, HVAC, DHW) must be minimally compliant (0%).

8.2 Modeling Approach

Buildings Connecting to Central Distribution Loops

The 2019 CBECC-Com 2019 User Manual[2] recommends that the proposed waterside heating and cooling systems are modeled with similar characteristics to the District system, but with Title 24 minimum efficiency chillers and boilers, sized to meet the approximate load of the proposed building. Any pumps, supplemental local heating systems or equipment that will be installed as part of the construction project should be modeled as designed.

Building with Local Space Heating Equipment

Projects that are complying via the performance approach and are installing local heating and/or cooling systems must ensure that the systems are modeled within CBECC-Com or CBECC-Res. There are however several limitations within both softwares that restrict the ability to accurately model decarbonized HVAC and DHW systems. The following table outlines the decarbonized systems we have assessed in Section 4 and Section 5, and whether these systems are able to be modeled and if there are any CEC-approved workarounds.

Table 8.1: Decarbonized heating equipment – Performance Modeling Workarounds

System	Description	Ability to Model?	CEC Approved Workaround
Air-to-Water Heat Pump (AWHP)	Heating Only	No	Baseline Title 24 Heating System, as defined in the ACM
	Heating/Cooling Only	No	
	Heat Recovery	No	
Water-to-Water Heat Pump (WWHP)	Heating Only	No	Baseline Title 24 Heating System, as defined in the ACM
	Heating/Cooling Only	No	
	Heat Recovery	No	
Water/Ground Source Heat Pump (WSHP / GSHP)	Water-Source	Yes	N/A
	Ground-Source	No	Model as minimally compliant heat pump system
Air-to-Air Heat Pump	Single Zone Heat Pump or Packaged VAV Heat Pump	Yes	N/A
Variable Refrigerant Flow (VRF)	Air Cooled VRF	Yes	N/A
	Water Cooled VRF	No	Model as minimally compliant Water-Source Heat Pump system
Electric Boiler	N/A	Yes	N/A
Electric Resistance Heating	N/A	Yes	N/A

[2] https://ww2.energy.ca.gov/title24/2019standards/documents/computer_programs/CBECC-Com19_UserManual_2019_1_0.pdf

Building with Domestic Hot Water Heating

Within CBECC-Com, residential DHW systems and non-residential DHW systems must be modeled as individual and separate systems, regardless of their actual design. For residential spaces within CBECC-Com, the same simulation engine as that used for residential spaces in CBECC-Res is used, therefore the impacts on residential DHW decarbonization are shared between both residential and non-residential performance modeling. The table below outlines different strategies for modeling decarbonized DHW systems in both residential and non-residential applications and the typical impacts these have on compliance margins.

Table 2: Decarbonized domestic hot water equipment – Compliance Impacts

Fossil Fuel Free DHW Equipment	Application	Impact on TDV compliance margin
Centralized Electric Resistance	Residential	Baseline DHW system is carbonized, resulting in significant DHW TDV penalty.
Centralized Heat Pump (air/water-to-water)	Residential	Baseline DHW system is carbonized, resulting in significant DHW TDV penalty. See additional information below table
Decentralized Electric Resistance	Residential	Baseline DHW systems is decarbonized. No negative impact on TDV compliance margin
Decentralized Heat Pump (air/water-to-water)	Residential	Baseline DHW systems is decarbonized. No negative impact on TDV compliance margin
Electric Resistance	Non-Residential	Baseline DHW systems is decarbonized. No negative impact on TDV compliance margin
Heat Pump (air/water-to-water)	Non-Residential	Baseline DHW systems is decarbonized. No negative impact on TDV compliance margin

Centralized heat pump water heaters (CHPWH) serving residential spaces are compared against a baseline of natural gas DHW heater and are therefore impacted significantly in TDV compliance margin calculations. It is therefore recommended that if such a system is installed, a prescriptive path for DHW compliance is followed that is in compliance with the CEC Executive Director Determination Pursuant to Section 150.1(c)8C of the residential energy code dated December 19, 2019[3]. This determination allows the prescriptive compliance path to be followed for CHPWH provided certain criteria are met. The criteria include the following:

- Specific sizing and layout requirements
- The installation of a solar hot water (SHW) system sized with a minimum solar savings fractions depending on climate zone **or** installation of 0.1 kWdc per dwelling unit of additional solar photovoltaic (PV) system over and above the requirement specific in Section 150.1(c)14.
- Mandatory pipe insulation requirements depending on climate zone.

In addition to the system types outlined in the tables above, in certain circumstances it is recommended that the prescriptive approach is adopted. Both CBECC-Com and CBECC-Res require a building

[3] https://efiling.energy.ca.gov/GetDocument.aspx?tn=231318.

geometry to be modeled, with building envelope and space types within the building defined in order to develop a building load profile. For centralized systems that serve greater than one building, performance modeling is therefore not suitable as it is not feasible to model all buildings connected to a district loop. In these situations, such as replacements of chillers within a CUP, or the installation of a heat pump that serves a quadrant on campus consisting of multiple buildings, it is recommended that the prescriptive compliance approach is followed.

Exceptional Compliance

In certain circumstances, the workarounds outlined above may not result in a passing model. If this occurs, a design team may deem it necessary to follow an exceptional compliance approach with the CEC. The CEC allows buildings to follow this approach *"if a building permit applicant proposes to use a performance compliance approach, and the building design cannot be adequately modeled by an approved calculation method"*.

The exceptional compliance approach is not recommended due to the following reasons:

- Exceptional compliance models are required to be reviewed and approved by the CEC
- Review process can be extremely long and has the potential to delay project schedules
- Approval is not guaranteed, potentially causing redesign late in the project schedule
- Not commonly used and therefore potential for delayed during peer review and project approval

8.3 Compliance Recommendations

Due to the limitations of the abovementioned compliance approaches, the following approach is recommended for projects with decarbonized systems:

Building & Major System Retrofits:

1. Performance compliance utilizing a CEC-approved workaround for decarbonized HVAC & DHW systems.
2. Performance compliance for envelope and lighting systems only (this can be achieved by selecting Envelope and Lighting Only compliance in CBECC-Com). Comply prescriptively for HVAC & DHW systems.

Central Plant Systems:

1. Prescriptive compliance

New Construction:

1. Performance compliance utilizing a CEC-approved workaround for decarbonized HVAC & DHW systems.
2. Performance compliance for envelope and lighting systems only (this can be achieved by selecting Envelope and Lighting Only compliance in CBECC-Com). Comply prescriptively for HVAC & DHW systems.

8.4 Additional Resources

The CEC provides a range of additional resources for energy modelers and design teams. It is recommended these are used as a resource to aid design teams accurately model within the CBECC software programs.

- Alternative Compliance Manual
- Frequently Asked Questions
- Energy Code Reference Appendices

These resources can be found at the following location, which also include contact information for the CEC Title 24 hotline that should be used as a resource if there are questions when modeling decarbonized systems:

https://www.energy.ca.gov/programs-and-topics/programs/building-energy-efficiency-standards/2019-building-energy-efficiency