California Energy Commission

STAFF REPORT

CBECC-Res 2016 USER MANUAL

FOR CALIFORNIA BUILDING ENERGY CODE COMPLIANCE (CBECC-RES) PUBLIC DOMAIN SOFTWARE

Computer Performance Compliance with
the 2016 California Building Energy Efficiency Standards

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CALIFORNIA ENERGY COMMISSION

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The Building Energy Efficiency Standards (Standards) were first adopted and in effect in 1978 and periodically updated in the intervening years. The Standards are a unique California asset and have benefitted from the conscientious involvement and enduring commitment to the public good of many persons and organizations along the way. The 2016 Standards development and adoption process continued that long-standing practice of maintaining the Standards with technical rigor, challenging but achievable design and construction practices, public engagement and full consideration of the views of stakeholders.

The revisions in the 2016 Standards were conceptualized, evaluated and justified through the excellent work of Energy Commission staff and consultants. This document was created with the assistance of Energy Commission staff including Todd Ferris, Larry Froess, PE, Jeff Miller, PE, and Dee Anne Ross.

Other key technical staff contributors included Payam Bozorgchami, Bill Pennington, Michael Shewmaker, Alexis Smith, Maziar Shirakh, PE, Peter Strait, Danny Tam, RJ Wichert, and the Energy Commission's Web Team. Christopher Meyer, Building Standards Office Manager and Dave Ashuckian, PE, Deputy Director of the Efficiency Division, provided policy guidance to the Staff.

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ABSTRACT

The 2016 Building Energy Efficiency Standards for Low-Rise Residential Buildings allow compliance by either a prescriptive or performance method. Performance compliance uses computer modeling software to trade off efficiency measures. For example, to allow more windows, the designer will specify more efficient windows, or to allow more west-facing windows they will install a more efficient cooling system. Computer performance compliance is typically the most popular compliance method because of the flexibility it provides in the building design.

The Energy Commission is required by the Warren-Alquist Act to provide a public domain compliance program. The California Building Energy Code Compliance (CBECC-Res) software is the public domain software that will be certified by the Energy Commission in conformance with the *Residential Alternative Calculation Methods (ACM) Approval Manual*, which contains the process for approving compliance software. CBECC-Res must also comply with the modeling requirements of the *Residential Alternative Calculation Methods (ACM) Reference Manual*, which establishes the rules for the how the proposed design (energy use) is defined, how the standard design (energy budget) is established, and what is reported on the Certificate of Compliance (CF1R).

CBECC-Res 2016 Compliance Manager is the simulation and compliance rule implementation software. CBECC-Res is used to model all components that affect the energy performance of the building, as required for complying with the 2016 Building Energy Efficiency Standards. A Certificate of Compliance (CF1R), signed by a documentation author and a responsible party (either the building owner or designer), reports all of the energy features for verification by the building enforcement agency.

Keywords: ACM, Alternative Calculation Method, Building Energy Efficiency Standards, California Energy Commission, California Building Energy Code Compliance, CBECC, CBECC-Res, Certificate of Compliance, CF1R, compliance manager, computer compliance, energy budget, energy standards, energy use, performance compliance, public domain, Title 24, Title 24 compliance software.

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TABLE OF CONTENTS

Chapter 1. Overview

1.1 Approved for 2016 Compliance

California Building Energy Code Compliance (CBECC-Res 2016) is an open-source software program developed by the California Energy Commission for demonstrating compliance with the low-rise residential 2016 *Building Energy Efficiency Standards* (standards). The standards become effective for new construction on January 1, 2017.

CBECC-Res was originally approved on November 12, 2015. The low-rise residential standards apply to single-family dwellings (R-3 occupancy group) and to multi-family buildings (R-1 or R-2) with three stories or less. Duplexes and townhomes are single family. Hotels and motels (regardless of number of stories), and multi-family buildings with four or more stories, are outside the scope of the low-rise standards and cannot be modeled using CBECC-Res.

The 2016 compliance manager is the simulation and compliance rule implementation software specified by the Energy Commission. The compliance manager, called CBECC-Res, models features that affect the energy performance of the building. Mandatory requirements, as specified in Sections 110.0 through 110.11 and 150.0 of the standards, may or may not be modeled. For example, lighting requirements of Section 150.0(k) are not modeled as part of complying with Title 24, Part 6. An example of when mandatory requirements are modeled is insulation values. Section 150.0 includes mandatory minimum insulation levels for wood-framed walls, floors and ceilings. As implied by the name, mandatory requirements cannot be off by a more efficient feature elsewhere in the building. It is the responsibility of the program's user to be aware of the requirements of the standards.

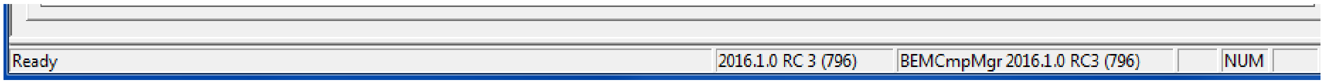
This manual is a guide to the program's use. It provides a description of software inputs and a guide to using the software. Knowledge of the standards is a pre-requisite. As the documentation author, you are responsible for the content of the compliance document produced by CBECC-Res, which is submitted to the enforcement agency as proof of compliance with the standards.

1.2 Transitioning to CBECC-Res 2016

As you begin using the 2016 software, some features make distinguishing between 2013 and 2016 easier. Historically, programs are for one standard and that continues. Each program has a separate desktop icon and name. Additionally,

A. The bottom of each screen displays the software version and the compliance manager version (see Figure 1-1) to make it easier to identify which version is in use. Please provide the software version when requesting software support (cbecc.res@gmail.com).
B. Input file extensions are .ribd16. If a 2013 .ribd file is opened in 2016 software, during the naming process the extension becomes .ribd16.

Figure 1-1: Identifying CBECC Version Number

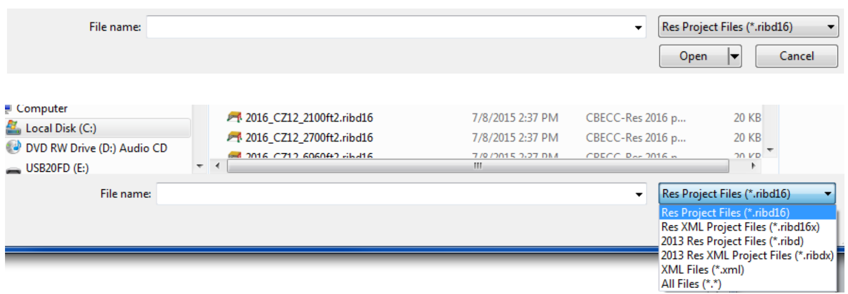


1.2.1 Opening 2013 project files

While it is strongly recommended to use the example files that come with the program (see Section 2.2), existing files can be converted to 2016 files using the following process:

1. Select File, open.
2. Change the default search from ***Res Project Files (*.ribd16)*** to ***2013 Res Project Files (*.ribd)*** (see Figure 1-2).

Figure 1-2: Opening 2013 *.ribd files



3. Find the file in the 2013 projects folder and open it. The program provides a warning message that you are opening a file that used a 2013 ruleset, and allowing an opportunity to cancel.
4. When saving the file, it is recommended that you select a 2016 projects folder.

1.3 What's Different in CBECC-Res 2016

NOTE: As of the June 2016 release of CBECC-Res 2016.2.0, no HERS providers are accepting projects for 2016. Expect programs for early adopters to be set up in late summer or early fall.

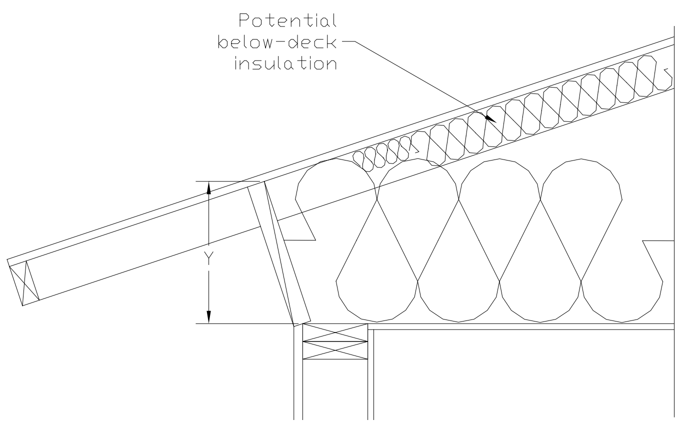
The *2016 Building Energy Efficiency Standards* were approved by the Energy Commission in June, 2015. Standards Section 150.1, Table 150.1-A (Package A) contains the features that are modeled to determine a building's energy budget. While not the only changes, the biggest changes to the standard design are attics, water heating, and additions (walls and attics).

1.3.1 Attics for 2016

The 2016 standards have three variations of attics allowable for prescriptive compliance. The standard design attic is option B, which may include below deck insulation (depending on the climate zone), with a tile roof surface. Where below deck insulation is included in the high performance attic a radiant barrier is not feasible (given the installation requirements). Because of below deck insulation, the radiant barrier requirements of Package A vary greatly. Even in zones that did not include a radiant barrier in the past, it may provide a benefit.

For purposes of illustrating the contrast between 2013 and 2016 standards, what might be considered a typical attic (with no above or below deck insulation) is option C. That option requires the ductwork be installed in the conditioned space. If the proposed design has ductwork in the attic with only ceiling below attic insulation, expect to notice a significant difference in compliance results for 2016.

Figure 1-3: Attic with Below Deck Insulation



NOTE: Above or below deck insulation is modeled in the attic construction (see Sections 5.3.1.6 and 6.7), while typical ceiling insulation is modeled in the conditioned zone as "ceiling below attic" insulation (see Section 6.8).

1.3.2 Water Heating for 2016

The standard water heater becomes a tankless gas water heater with 0.82 Energy Factor.

1.3.3 Addition Walls and Attics for 2016

The 2016 standard design wall in all additions is the same as new construction requirements in Section 150.1, Table 150.1-A ("Package A"). Previously, while an addition alone was compared to the Package A wall, an existing plus addition was compared to an R-13 wall (for additions up to 700 ft^2). For an explanation of the exception to the requirement for continuous insulation, see Section 10.1.

By contrast to the wall construction, the attic/ceiling is based on mandatory insulation only for additions up to 700 ft^2 (changed from R-30 to R-22 to accommodate spray foam insulation).

1.4 New in this Version of CBECC-Res

In addition to features added to CBECC-Res 2016.2.0 (Energy Design Rating (EDR) (Section 4.5), and a new heat pump water heater model (Section 9.8), CBECC-Res 2016.2.1 includes several new features and changes, including:

- Restores the ability to model multiple water heating systems in a single-family dwelling unit,
- Corrects special features and HERS reporting for multi-family water heating distribution systems,
- Improves the program's ability to model a duct system that deviates from Package A (standard design) when there is no cooling system, and
- Includes enhancements of HVAC system modeling to add wood heat, ductless multi-split, and ductless VRF.

1.5 Background

The standards allow compliance using either a prescriptive or performance compliance method. The prescriptive method is found in the *Residential Compliance Manual* (see Section 1.13, Related Publications). Performance compliance is an alternative calculation method (ACM) that uses building modeling software to demonstrate compliance with the standards. CBECC-Res is the public domain compliance manager, meaning it is the simulation and compliance rule implementation software specified by the Energy Commission.

The document 2016 *Residential Alternative Calculation Methods (ACM) Reference Manual* (ACM Reference Manual) (see Section 1.13 Related Publications) explains how the proposed and standard designs are determined. If you have questions about how the software models the energy use of a building feature refer to the ACM Reference Manual.

1.6 Program Updates

For software updates and valid version numbers check the link to the project website, accessible from www.energy.ca.gov/title24/2016standards/2016_computer_prog_list.html.

NOTE: Because submittals with outdated software will be rejected by the building department, sign up to receive notifications (http://www.energy.ca.gov/efficiency/listservers.html) from the Energy Commission. You can also sign up for CBECC-Res website updates and Frequently Asked Questions (FAQs) (http://www.bwilcox.com/BEES/BEES.html).

1.7 Watermarks and Forms

The only document produced by CBECC-Res is a Certificate of Compliance (CF1R). CBECC-Res generates a CF1R when you check the PDF option on the Analysis tab (accessible by double-clicking on Project), which requires an internet connection. The CF1R will have a watermark “This Certificate of Compliance is not yet registered” if HERS measures are required, and if using valid software. The documentation author and responsible person fields are completed during the registration process and are not program inputs. See Appendix A for a sample of the CF1R.

For more information about the process for removing the watermark, which requires registration with a HERS provider, see Section 1.7 below.

1.7.1 Not Useable Watermark

If a watermark shows “Not useable for compliance”, it was generated by using (a) the tools menu option Generate Draft T-24 Compliance Report rather than as part of the compliance calculations, (b) quick simulation rather than compliance mode, or (c) software that is not valid for compliance. This is a security feature. For a full explanation of the security features see the Frequently Asked Questions.

1.7.2 Mandatory Measures

In place of the MF-1R form, the Commission produced a summary document you can find at (http://www.energy.ca.gov/title24/training/2016_Residential_Mandatory_Measures_Summary.pdf).

CBECC-Res does not include space conditioning equipment load calculations required by Section 150.0(h). Mechanical contractors are expected to prepare these and other calculations as part of their responsibilities.

1.7.3 Forms

Prescriptive forms for either new construction or for additions and alterations are accessible from the Energy Commission’s web site: http://www.energy.ca.gov/2015publications/CEC-400-2015-032/appendices/forms/.

1.8 Registering the CF1R

When compliance requires HERS verification, the Certificate of Compliance (CF1R) produced by CBECC-Res must be registered with a HERS provider (such as CalCERTS) before applying for a building permit (see also *Residential Compliance Manual*).

NOTE: Every newly constructed building requires HERS verification. Indoor air quality (Section 150.0(o)) is a HERS verified mandatory requirement. Duct leakage testing is also a mandatory requirement. HERS verified requirements are summarized on page 2 or 3 of the CF1R (after the energy use and special features listings).

1.8.1 HERS Upload XML File

The file needed to upload a project to a HERS provider is created only when you check the box labeled "Full (XML)" on the Analysis tab (see also Section 4.4.1.5) before performing the compliance analysis.

The file is stored in the projects folder (CBECC-Res 2016 Projects). Only one of the files is valid for uploading to the HERS registry. Select the larger file, which contains the CF1R and is named:

<input file name> - AnalysisResults-BEES.xml

1.8.2 Registration Process

When HERS verification is required for a project, the watermark is only removed when the CF1R has completed the registration process at a HERS provider's web site, which includes the documentation author and the person who is authorized by the Business and Professions Code to take responsibility for the building design have electronically signed the CF1R.

For more information on registering a CF1R, find a HERS provider and visit their website for assistance in that process. Find approved HERS providers at the Energy Commission's website (www.energy.ca.gov/HERS/providers.html).

As construction progresses, follow-up documentation (certificates of installation (CF2R) and certificates of verification (CF3R) are required to confirm that the required measures are installed.

1.9 Special Features and Modeling Assumptions

The 2016 Reference Manual, Appendix A, identifies those features modeled in the building that are identified as special feature and modeling assumptions on the CF1R.

1.10 HERS Third-Party Verification

Appendix A of the ACM Reference Manual identifies the specific measures that require HERS verification or diagnostic testing. The CF1R produced by CBECC-Res identifies if a building includes any measures requiring field-testing or verification by a HERS rater as part of the compliance results. See also Section 1.7 and Section 1.14.8.

1.11 Fixed and Restricted Inputs

When the specified analysis type is compliance, fixed and restricted inputs cannot be changed by the user. Since example files may include assumptions that are not standard in a given climate zone, to determine the standard assumption for a given input, consult either standards, Section 150.1, Package A, or the ACM Reference Manual.

1.12 Preparing Basic Input

The software includes several example files, and the user manual provides a tutorial as well as a guide through program inputs. Required inputs include:

1. Building address, climate zone, front orientation, and availability of natural gas,
2. Conditioned floor area and average ceiling height,
3. Attic/roof details, roof pitch, roofing material, solar reflectance and emittance,
4. Ceilings below attic and vaulted ceiling R-values,
5. Wall areas, orientation, and construction details,
6. Door areas and orientation,
7. Slab or raised floor area and construction details,
8. Window and skylight areas, orientation, U-factor, Solar Heat Gain Coefficient,
9. Building overhang and side fin shading,
10. Mechanical heating and cooling equipment type and efficiency,
11. Distribution system location and construction details,
12. Method for providing mechanical ventilation, and
13. Domestic water heating system details, including type of water heating equipment, fuel type, efficiency, distribution system details.

1.13 Checklist for Compliance Submittal

The form needed for a compliance submittal includes a CF1R which is registered with a HERS provider if HERS verification is required (see Section 1.7).

Additional supporting documentation that may be required includes:

- NFRC certified U-factor and Solar Heat Gain Coefficient for windows and skylights,
- AHRI certified efficiency of cooling, heating and/or water heating equipment,
- Roofing material rating from the Cool Roof Rating Council,
- Solar water heating documentation to support a modeled solar fraction, or
- Any supporting documentation requested by the building department to verify modeled features.

1.14 Related Publications

In addition to this manual, users of the software need to have the following documents as a resource during the compliance process:

- *2016 Building Energy Efficiency Standards* contains the official standards adopted by the Energy Commission.

- *2016 Residential Compliance Manual* is the interpretive manual for complying with the standards (also contains sample compliance forms).
- *Reference Appendices for the 2016 Building Energy Efficiency Standards* is the source document for climate zones, HERS protocols for measures requiring verification by a HERS rater, as well as eligibility and installation criteria for energy efficiency measures.
- *2016 Residential Alternative Calculation Method (ACM) Reference Manual* (P400-2015-024, November 2015) contains the rules that the software follows to establish the standard and proposed designs for a proposed building.
- *2016 Appliance Efficiency Regulations* (P400-2015-021, July 2015) contains the standards applicable to appliances offered for sale in California.

These documents can be downloaded from the Energy Commission website (http://www.energy.ca.gov/title24/) or purchased from:

California Energy Commission
Publications Office
1516 9th Street
Sacramento, CA 95814
(916) 654-5200

1.15 Terminology

1.15.1 Compliance Manager

The compliance manager is the simulation and compliance rule implementation software specified by the Energy Commission, also known as the public domain compliance software. It is named CBECC-Res and it models the features of the building as specified in the standards, Section 150.1(c) and Table 150.1-A (Package A) to establish the energy budget for the building.

1.15.2 Report Manager

The report manager is a web-based application used to generate the Certificate of Compliance (CF1R). Although tools options contains a feature to check if the report generator is off line for maintenance, typically report generator problems have their source in the user's internet connection. Using wi-fi connections can result in timing errors because the CF1R can take several seconds to be created.

1.15.3 Package A

The term Package A refers to standards Section 150.1, Table 150.1-A. This table contains the features that are included in the standard design.

1.15.4 Standard Design

CBECC-Res creates a version of the proposed building that has the features of Section 150.1(c), Table 150.1-A in the specified climate zone to establish the standard design (also known as the energy budget). If the proposed design energy use is equal to or less than the standard design, the building complies and a Certificate of Compliance (CF1R) can be registered or submitted.

For newly constructed buildings, the standard design building is in the same location and has the same floor area, volume, and configuration as the proposed design, except that wall and window areas are distributed equally between the four main compass points, north, east, south and west. For additions and alterations, the standard design has the same wall and window areas and orientations as the proposed building.

The basis of the standard design is prescriptive Package A, which varies by climate zone. To find the climate zone for a given city, county or zip code, see *Reference Appendices for the 2016 Building Energy Efficiency Standards* (*Reference Appendices*), Joint Appendix JA2. Table 2-1 contains the representative city for each of the 16 California climate zones. Detailed information about how the standard design is established is included in the *Residential ACM Reference Manual* (see Section 1.13).

1.15.5 Proposed Design

The user-defined proposed building modeled in CBECC-Res is called the proposed design. The proposed design is compared to the standard design to determine if the building complies with the standards. The standard design minus proposed design must have an overall zero or positive margin to comply, although individual features (for example, space cooling) may be negative.

The building configuration is defined by the user through entries for floors, walls, roofs and ceilings, windows, and doors. The areas and performance characteristics, such as insulation R-values, U-factors, SHGC, are defined by the program user. The entries for all of these building elements must be consistent with the actual building design and configuration.

1.15.6 Mandatory Requirements

Mandatory requirements are found in Sections 100.0 through 110.10 and 150.0 of the standards. Any requirement that is mandatory (some are modeled, some are not) cannot be removed from the proposed building. For example, a building in climate zone 10 may show compliance without a whole house fan because that is a feature of Package A (Section 150.1). The requirement for duct leakage testing (Section 150.0(m)) is mandatory and cannot be removed. While the standard design building has all of the features of Package A, measures that are more efficient or less efficient can be modeled in the proposed design as long as the building meets the mandatory minimum requirements and the energy budget.

A partial list of the changes affecting the building envelope is a minimum of R-30 ceiling/roof insulation, R-19 raised floor insulation, and a maximum of 0.58 U-factor for window (see Section 150.0(q) for exceptions). Space conditioning system mandatory requirements include ducts with R-6 insulation that are sealed and have tested duct leakage, air-handler fan efficacy of 0.58 W/CFM or less, and cooling airflow of greater than 350 CFM/ton. These measures require a Home Energy Rating System (HERS) rater.

A four-page 2016 Low-Rise Residential Mandatory Measures Summary can be found by accessing http://www.energy.ca.gov/title24/training/2016_Residential_Mandatory_Measures_Summary.pdf.

1.15.7 Climate Zone

California has 16 climate zones. The climate zone can be found in the *Reference Appendices*, Joint Appendix JA2.1.1, by looking up the city, county, or zip code. The climate zone determines the measures that are part of the building's standard design (see Section 150.1, Table 150.1-A in the standards).

1.15.8 HERS Verification

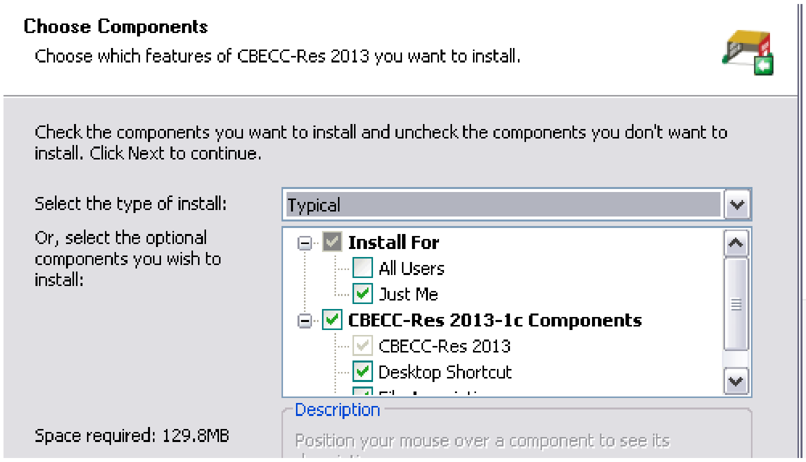
Some mandatory requirements and other optional compliance features require a Home Energy Rating Systems (HERS) rater to perform diagnostic testing or verify the installation. HERS raters are trained and certified by one of the HERS Providers. For a list of currently approved providers see www.energy.ca.gov/HERS/providers.html. HERS raters perform verification and testing requirements as specified in the *Reference Appendices*, Residential Appendices RA1 – RA4.

Chapter 2. Getting Started

2.1 Installing CBECC-Res

Click on the hyperlink for CBECC-Res or copy the link into your browser's address box. Follow the prompts and read/accept the license agreement. You can direct the software to a different drive, but do not change the names of the file folders. The software will create a desktop shortcut (if selected).

Figure 2-1: Setup



2.1.1 File locations

CBECC requires a file installation structure that has three locations – (1) executable, (2) data, and (3) projects folders. The default locations are:

Executable: c:\Program Files\CBECC-Res 2016

Data: c:\Documents and Settings\user\CBECC-Res 2016 Data

Projects: c:\Documents and Settings\user\CBECC-Res 2016 Projects

Installing CBECC-Res on a network may result in invalid path names. CBECC-Res should be installed on a local or mapped drive rather a name with "\\" as part of the path name. Input files are stored in the projects folder by default.

If the program will not run, consider uninstalling to reestablish the path names and reinstall.

2.2 Example Files

The first time you use CBECC-Res it is highly recommended that you spend a few minutes going through the tutorial in Chapter 3.

These example files demonstrate how to model a specific feature. They are tailored to a specific climate zone. Given that features that are beneficial in the San Joaquin Valley may not be appropriate in a Bay Area climate, users should review the CF1R thoroughly or tailor the example file to the climate zone in which your project is being built.

The following example files are included in the projects directory:

1. **1StoryExample3.ribd16.** Based on the Energy Commission's 2100 ft^2 single floor prototype in climate zone 12 with slab-on-grade floors, a tile high performance attic, cool roof, an attached garage, window dimension inputs, and overhangs.
2. **1StoryExample3BelowGrade.ribd16.** Based on the Energy Commission's 2100 ft^2 single floor prototype with a crawl space, and a separate 750 ft^2 basement with a wall furnace and no cooling system.
3. **1StoryExample3Cathedral.ribd16.** Same building as above with cathedral ceiling.
4. **1StoryExample3Crawl.ribd16.** Same as above with a crawl space.
5. **1StoryExample3CrawlMW.ribd16.** Same as above with a crawl space and with several wall types in the construction library (including concrete, ICF, Log, SIPs, below grade mass).
6. **1StoryExample3EDR.ribd16.** A 2100 ft^2 single family building, also with Energy Design Rating.
7. **1StoryExample3EDRPV.ribd16.** Same as above with Energy Design Rating and PV.
8. **1StoryExample3EDRZNE.ribd16.** Same as above with Energy Design Rating meeting Zero Net Energy (zero or negative energy design rating when PV is included).
9. **1StoryExample3EvapCond.ribd16.** Same as above with an evaporatively cooled condenser.
10. **1StoryExample3HPWH.ribd16.** Same as above 2100ft^2 prototype with a NEEA certified heat pump water heater.
11. **1StoryExample3HVAC.ribd16.** Same as above with ductless heat pump, ground source, and air to water heat pumps defined in the mechanical system library.
12. **1StoryExample3Multi.ribd16.** Same as above with multiple orientation.
13. **2Story Example3CombHydNoCool.ribd16.** Based on the 2700 ft^2 two-story prototype, set in climate zone 3, with a combined hydronic system with a boiler as the source of heating/water heating, and no cooling.
14. **2StoryExample3.ribd16.** Based on the 2700 ft^2 two-story prototype, set in climate zone 9, with a tile roof, and a whole house fan.
15. **2Story2ZoneExample3.ribd16.** Same building type as above but zoned 1st and 2nd story, each with its own HVAC system.
16. **2StoryZonalExample3.** Same building type as above with a zonally controlled heating credit (living and sleeping zones).
17. **AAExample3.ribd16.** An addition alone input file with existing HVAC and DHW in climate zone 9.

18. **EAAExample3.ribd16.** An existing plus addition input file with an existing HVAC system and an altered water heating system in climate zone 9.
19. **MFExample3.ribd16.** An eight-unit two-story multi-family 6960 ft^2 two-story building with each story as a separate zone with four dwelling units in each zone, served by individual water heaters, set in climate zone 12.
20. **MFExample3CentralSolarDHW.ribd16.** An eight-unit two-story multi-family 6960 ft^2 two-story building with each story as a separate zone with four dwelling units in each zone, served by central water heating with 35 percent solar contribution.

2.3 Menu Bar

The menu bar at the top of the screen (see Figure 2-2) allows you to access many of the program's features.

Figure 2-2: Menu and Tool Bar

2.3.1 File

The file menu contains the standard functions for file management, opening and saving files, save as (to rename a file), and exiting the program.

2.3.2 Edit

Most users will use the right-click options to edit, rename, create and delete components which offer more control (see Section 2.6).

In addition to the standard cut, copy, and paste commands, the edit menu contains several commands for editing building descriptions. They are:

- Edit component
- Create component
- Delete component

NOTE: Use "delete component" carefully. The default condition is to delete the entire project.

2.3.3 Ruleset

CBECC-Res is designed to support multiple rulesets that implement the requirements of different codes. The ruleset menu will allow switching to a different compliance ruleset. Typically, changing to a different code requires changes to inputs. Users will need to pay special attention to instructions for performing accurate analysis under a different rulesets.

2.3.4 View

The view menu enables you to toggle on and off the display of the tool bar at the top of the screen and the status bar at the bottom of the screen.

2.3.5 Tools

The tools menu contains the following options:

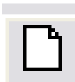
- Program and Analysis Options / *Proxy Server Settings*
- View T-24 Compliance Report / *opens the CF1R if available*
- View Project Folder / *opens the folder that contains the project files*
- View Project Log File / *contains file history, error messages*
- Delete Project Log File / *since this file contains the entire history of an input file, this tool deletes the log file to start fresh*
- Check Building Database / *checks for major errors*
- Check Report Generator Access / *checks for internet access to the report generator*
- Building Summary Report (input model) / *opens a .csv file in Excel*
- Building Summary Report (proposed/standard) / *opens two .csv files in Excel (one standard and one proposed)*
- Perform Analysis [same as short-cut key] / *runs file to determine if it passes or fails compliance*
- Review Analysis Results / *displays compliance results, if available*
- Generate Draft T-24 Compliance Report / *creates a draft CF1R which will have a watermark with "not useable for compliance" (for a "not registered" watermark see Section 1.6)*
- Generate CAHP/CMFNH Report / *generates a CAHP Incentive Report (C1R).*

2.3.6 Help

- Help Topics (*not enabled*)
- Quick Start Guide (opens an overview of the software and frequently asked questions)
- User Manual (opens this user manual document)
- Mandatory Requirements (requirements from standards section 150.0; for example, a steel framed wall with no rigid insulation does not comply with the minimum requirements)
- About . . . (to determine which version of CBECC-Res is installed)

2.4 Tool Bar

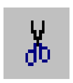
This section explains the program features accessed by clicking the icons on the tool bar at the top of the screen (see Figure 2-2).



New File
This button closes the current file (if one is open) and opens a new file.

Open File
This button launches the open dialog box to enable opening an existing file. If another file is open, a prompt to save that file before proceeding will appear.

Save
This button saves the file under its current name or launches the *save as* dialog to enable a new file name.

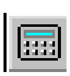


Cut
Not enabled (right-click and pick delete instead).

Copy
Copy the item (and any child components). If the *copy* button is not available from within program dialogs, use the keyboard shortcut Ctrl+C (to paste, use Ctrl-V).

Paste
Paste copied components. Typically the paste location is at the bottom, but can be moved up using the right-click/move up in list function. If the paste button is not available, use the keyboard shortcut, Ctrl+V.

Print
This tool is not used because the CF1R is produced and printed via Adobe Acrobat.



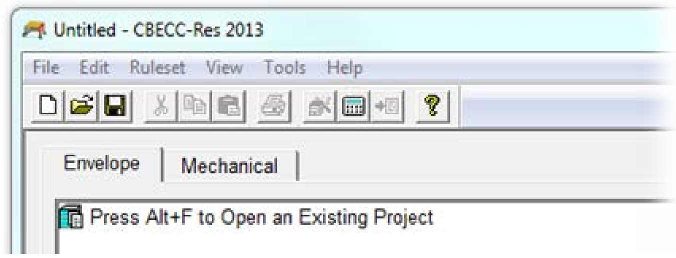
Perform Analysis
This button enables launching a compliance analysis using the currently loaded building description. You must save the current building description before performing the analysis.

About CBECC-Res 2016
View program license and version information.

2.5 Main Screen

The main screen (see Figure 2-3) is used for editing building descriptions. There are two tabs at the top of the main screen—Envelope and Mechanical. These tabs provide different views of the building description and provide access to two different subsets of building description data.

Figure 2-3: Main Screen



2.6 Right-Click Menu Options

CBECC-Res makes extensive use of menus accessible by right-clicking the mouse button (keyboard navigation options are shown in Section 2.7). The functions available through these menus depend on whether you are on the main screen or in an input dialog window.

Main Screen—Right-Click Menu. When clicked over a building component, the following choices are available:

- *Edit* – Opens the input dialog window for the selected component
- *Rename* – Enables renaming the selected component
- *Delete* – Deletes the selected component
- *Copy* – Copies the selected component with all of its associated ("children") components
- *Paste* – Adds copied components and children to the selected component
- *Move Up in list* – Moves a component up in the list of the same component type
- *Move Down in list* – Moves a component down in the list of the same component type
- *Expand/Contract* – Expands or contracts the list of children components (shortcut key is to use the + or – signs)
- *Create* – Enables you to create new child components for the selected component

Input Dialog—Right Mouse Menu. When clicked over an input value in the window, the following choices are available:

- *Item Help* – (not available)
- *Topic Help* – (not available)
- *Restore Default* – Returns the value of the field to its default value (if applicable)
- *Critical Default Comment* –(not available)

2.6.1 Analysis Types

Proposed Only: Simulates the proposed building's energy use using the 2016 compliance rules without establishing the standard design.

Proposed and Standard: In addition to simulating the proposed design, simulates the standard design building (one that complies with the 2016 prescriptive standards) to establish the energy budget for compliance.

2.6.2 Building Tree Controls (Parent/Child Relationships)

In order to analyze a building's energy use, it is necessary to track relationships among building components. CBECC-Res displays these relationships using the familiar tree control found in Windows™ Explorer and many other applications. For example, under the envelope tab, exterior walls are shown as parents to windows. Windows are connected to exterior walls and appear under walls as children to spaces. The tree controls vary in the components they display.

2.6.3 Rapid Editing

The tree control can be used to move and copy components or groups of components. To move a component, just drag and drop. If an association is not allowed, the program will prevent the move. To copy a component, place the cursor on the component, right click/copy, move to the destination and right-click/paste. Rename to maintain consistency. When parent components are moved, copied, or deleted, child components are included.

Components shown on the tree can be moved using a drag-and-drop technique provided it results in a compatible parent-child relationship.

Right-click edit commands are described in Section 2.6. Double-clicking opens the input dialog window.

2.7 Keyboard Navigation Without the Mouse

The following alternative procedures for getting from one field to another and to access the rick-click tools menu:

(1) Up/down arrow - moves up/down the tree

(2) <Alt> Enter - opens data for object highlighted / then tab to the field

(3) <Alt>F1 – opens the right mouse quick menu. Once open:

   a. Up/down arrows to highlight a selection and <enter> or type the letter, such as “E" to edit, “R” to rename
   b. When the bottommost "Create" item is selected - right/left arrow keys to open/close submenu of children to create
   c. <esc> key to close right mouse menu

(4) Left/right arrows - when on an object with children (i.e., a wall with windows), left arrow contract and right arrow expands (to show/hide the child objects).

2.8 Defining New Components

From the main program screen or at any point where you would like to create a component under (a child to the parent component):

- Right-click on the component to which you want to add the new component.
- Select *Create*, and the type of object you want to create. Only applicable component types will appear on the list. The components available will depend on where the cursor is placed (for example, a skylight can only be created under a cathedral roof).
- Accept the defaults or edit the name, parent, and existing component from which to copy, and click OK.
- Edit the input fields with white backgrounds to describe the new component, and click OK.

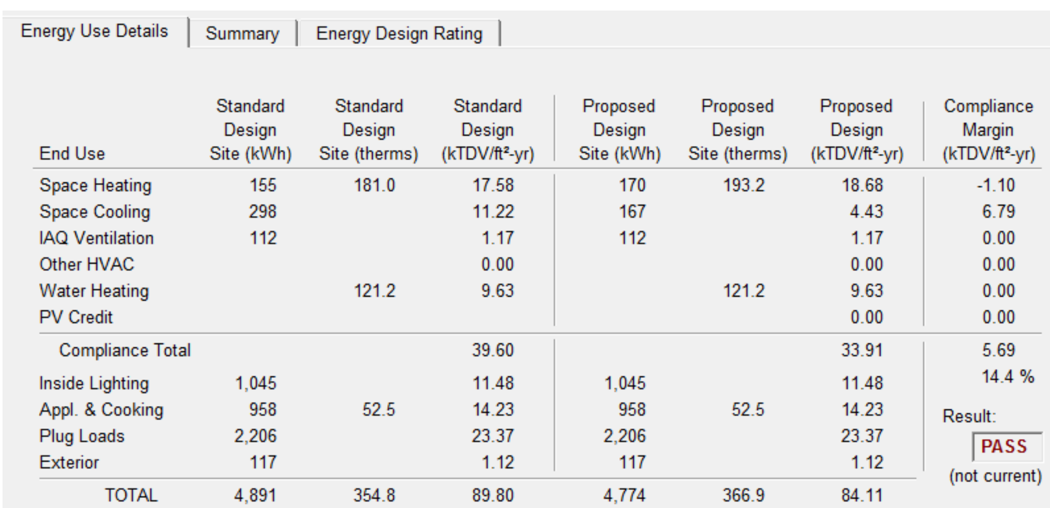
2.9 Analysis Results

Once an input file is created and the analysis performed (tools, perform analysis or ), the results can be viewed in several formats as shown below.

2.9.1 Energy Use Details

This is the typical results screen showing the detailed standard design and proposed design values in kTDV values (reported on the CF1R) as well as site energy.

Figure 2-4: Energy Use Detail Results

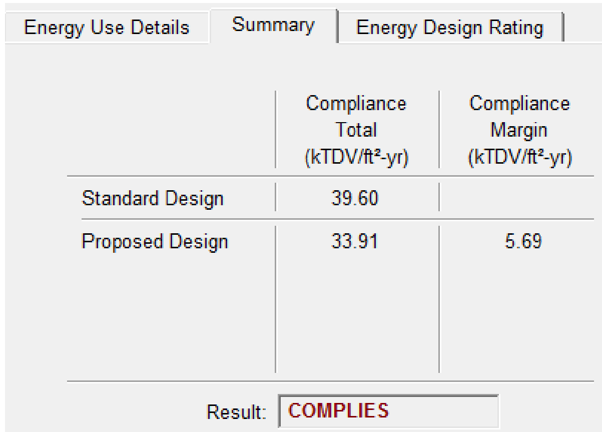


End Use	Standard Design Site (kWh)	Standard Design Site (therms)	Standard Design (kTDV/ft²-yr)	Proposed Design Site (kWh)	Proposed Design Site (therms)	Proposed Design (kTDV/ft²-yr)	Compliance Margin (kTDV/ft²-yr)
Space Heating	155	181.0	17.58	170	193.2	18.68	-1.10
Space Cooling	298		11.22	167		4.43	6.79
IAQ Ventilation	112		1.17	112		1.17	0.00
Other HVAC			0.00			0.00	0.00
Water Heating		121.2	9.63		121.2	9.63	0.00
PV Credit						0.00	0.00
Compliance Total			39.60			33.91	5.69
							14.4 %
Inside Lighting	1,045		11.48	1,045		11.48	
Appl. & Cooking	958	52.5	14.23	958	52.5	14.23	Result:
Plug Loads	2,206		23.37	2,206		23.37	PASS
Exterior	117		1.12	117		1.12	(not current)
TOTAL	4,891	354.8	89.80	4,774	366.9	84.11	

2.9.2 Summary

To view only the total compliance results (versus the individual heating, cooling, and water heating results), pick the summary tab.

Figure 2-5: Summary Results



Energy Use Details | Summary | Energy Design Rating

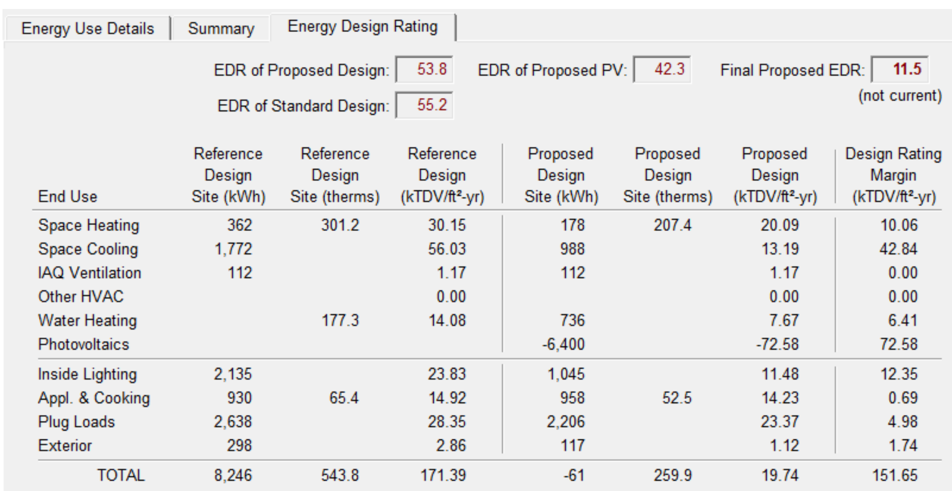
	Compliance Total (kTDV/ft²-yr)	Compliance Margin (kTDV/ft²-yr)
Standard Design	39.60	
Proposed Design	33.91	5.69

Result: COMPLIES

2.9.3 Energy Design Rating

The results of an analysis that includes an optional Energy Design Rating can be viewed on screen in greater detail than the results included on the Certificate of Compliance. To view results on screen, after performing a compliance analysis, select the appropriate tab (see Figure 2-6). For more information on the energy design rating, see Section 4-6.

Figure 2-6: Energy Design Rating Results



Energy Use Details | Summary | Energy Design Rating

EDR of Proposed Design: 53.8 EDR of Proposed PV: 42.3 Final Proposed EDR: 11.5 (not current)

EDR of Standard Design: 55.2

End Use	Reference Design Site (kWh)	Reference Design Site (therms)	Reference Design (kTDV/ft²-yr)	Proposed Design Site (kWh)	Proposed Design Site (therms)	Proposed Design (kTDV/ft²-yr)	Design Rating Margin (kTDV/ft²-yr)
Space Heating	362	301.2	30.15	178	207.4	20.09	10.06
Space Cooling	1,772		56.03	988		13.19	42.84
IAQ Ventilation	112		1.17	112		1.17	0.00
Other HVAC			0.00			0.00	0.00
Water Heating		177.3	14.08	736		7.67	6.41
Photovoltaics				-6,400		-72.58	72.58
Inside Lighting	2,135		23.83	1,045		11.48	12.35
Appl. & Cooking	930	65.4	14.92	958	52.5	14.23	0.69
Plug Loads	2,638		28.35	2,206		23.37	4.98
Exterior	298		2.86	117		1.12	1.74
TOTAL	8,246	543.8	171.39	-61	259.9	19.74	151.65

2.9.4 CAHP [not yet implemented]

The results of the CAHP or other incentive program analysis can either be viewed on screen or generated in a CAHP Incentive Report. To view results on screen, once a compliance report is run, select the appropriate tab (see Figure 2-7). For a printed report, select Generate CAHP/CMFNH Report from the Tools menu.

2.10 Error Message Resources

If you are using the program for the first time and the program will not run, see Section 2.1.1.

NOTE: If after (1) viewing the log file or (2) viewing the the .ERR files you cannot find the error, send your .ribd16 file (found in the CBECC-Res 2016 Projects folder) and contact information to cbecc.res@gmail.com.

Information helpful in determining the location of an error is found in two places – the log file, or one of the error files (for CSE errors).

2.10.1 Log File

If you would like to try to find the error yourself, select ***tools*** and pick the option "***view project log file***." This file provides clues as to what is wrong. It may contain repetitive information. Look for the word "error" and determine if you can see a clue as to where the error may be located:

```
2016-Mar-10 12:46:47 - Opening Project 'Smith.ribd'...
2016-Mar-10 12:46:47 - Model load successful into CBECC-Res 2013-4b (812)
2016-Mar-10 12:46:47 - Performing Building Database check...
2016-Mar-10 12:46:47 - Building Database check completed, no problems
found.
2016-Mar-10 12:46:51 - Performing Building Database check...
2016-Mar-10 12:46:51 - Error:  Data classified by the compliance ruleset
as Required not defined for Interior Ceiling 'Interior Ceiling 1':
InteriorCeiling:Outside.
2016-Mar-10 12:46:51 - Building Database check completed, 1 error(s)
found.
2016-Mar-10 12:46:51 - Analysis errant  Processing time:  Overall 0.2 /
CSE 0.0 / ModelPrep 0.03 / ResultsProcessing 0.00 / ReportGen 0.0 /
ResXMLWriting 0.01 / Model&SecurChks 0.10 / Model&HrlyCSVExports 0.00 /
DHWSim 0.00 / LoadModel 0.00 / Other 0.02
2016-Mar-10 12:47:03 - --------------------------------------------------
```

This identifies a problem with missing information on an interior ceiling.

2.10.2 CSE Errors

The project folder (tools, project folder) contains a folder with the same name as the input file. Inside that folder are several files including two error files (prop.err and std.err). Examining the contents of these files can provide additional clues as to what may be wrong with an input file. For example:

```
---------------
C:\CBECC-RES 2016 PROJECTS\TESTRUN2_2100 - COMP\TESTRUN2_2100 - PROP.CSE(1207):
Error:
  surface 'Zone1WallFront-Frm' of zone 'Zone1-zn':
    S0408: Wall sfTilt = 0: not 60 to 180 degrees
   S0214: No run due to error(s) above
---------------
```

This indicates that the wall tilt is incorrectly defined. This indicates that a tilt of 0 is entered for the front wall. Wall tilts are typically 90 degrees.

2.10.3 Potential Errors

Following is a list of potential error messages:

1 : pszCSEEXEPath doesn't exist
2 : pszCSEWeatherPath doesn't exist
3 : pszDHWDLLPath doesn't exist
4 : One or more missing files (CSE, ASHWAT or T24*(DHW/ASM32/TDV/UNZIP/WTHR) DLLs)
5 : pszBEMBasePathFile doesn't exist
6 : pszRulesetPathFile doesn't exist
7 : Error initializing BEMProc (database & rules processor module)
8 : Error initializing compliance ruleset
9 : Invalid project log file name (too long)
10 : Error writing to project log file
11 : Building model input/project file not found
12 : Error reading/initializing model input/project file
13 : Error evaluating ProposedInput rules
14 : Error retrieving CSE weather file name (from Proj:WeatherFileName)
15 : Energy (CSE) simulation weather file not found
16 : Error retrieving DHW weather file name (from Proj:DHWWthrFileName)
17 : DHW simulation weather file not found
18 : Error retrieving required data: Proj:RunID and/or Proj:RunAbbrev
19 : Analysis processing path too long
20 : Error evaluating ProposedInput rules
21 : Error evaluating PostProposedInput rules
22 : Error evaluating BudgetConversion rules
23 : Error evaluating CSE_SimulationPrep rules
24 : Unable to create or access analysis processing directory (see Section 2.1)
25 : Unable to open/delete/write simulation output file (.csv or .rep)
26 : Unable to open/delete/write simulation weather file
27 : Error copying simulation weather file to processing directory
28 : Unable to open/delete/write simulation input (.cse) file
29 : Error writing simulation input (.cse) file

30 : CSE simulation not successful - error code returned
31 : DHW simulation not successful
32 : Error encountered loading CSE DLL(s)
33 : Error evaluating ProposedModelCodeCheck rules
34 : Error evaluating ProposedModelSimulationCheck rules
35 : Error evaluating ProposedModelCodeAdditions rules
36 : User aborted analysis via progress dialog 'Cancel' button
37 : Error evaluating ProposedInput rules
38 : Error performing range and/or error checks on building model
39 : Error evaluating CSE_SimulationCleanUp rules
40 : Analysis aborted by calling application (via analysis callback function)
41 : Error evaluating ProcessResults rules
42 : Error evaluating ProposedCompliance rules
43 : Error(s) encountered reading building model (project) file
44 : Error(s) encountered evaluating rules required analysis to abort
45 : Invalid results object types encountered when copying results between models
46 : Error copying results objects from a previous model
47 : Error setting up check of weather file hash
48 : Input model contains one or more objects with the same name
49: Missing Zone CSE include file
50: Error evaluating OneTimeAnalysisPrep rules
51: Invalid results object types encountered when copying final results to user model
52: Error copying results objects from the final run into the user model
53: Unable to open/delete/write CSE include file
54: Error copying CSE include file to processing directory
200: (was 40) Error generating model report
201: (was 45) Unable to write compliance report file (.pdf or .xml)
202: (was 46) Error(s) encountered generating compliance report file (.pdf or .xml)
203: (was 48) Error evaluating CheckFileHash rules
204: (was 49) Weather file hash failed consistency check
205: Attempt to save project inputs (including results) following analysis failed

2.11 Managing Project Files

By default, project files are stored at C:\Users\<your username>\My Documents\CBECC-Res-2016-*\Projects, although this depends on where the program is installed.

Because CBECC stores a lot of information in folders on your computer, you may want to delete folders for older files. To retain a project in the most efficient manner, keep the file name with extension “.ribd16” (residential input building design) and the file for uploading a project to the HERS provider (<input file name> - AnalysisResults-BEES.xml). Other files are created when an analysis is performed.

2.12 Input Dialog Windows

The attributes of each building component can be edited by opening the input dialog window for the component. The dialog can be opened by double-clicking on the component on the tree control, using the edit option on the right mouse menu, or using the edit component option on the edit menu. (The tree control does not appear until you have created a project description or loaded an existing project file [Ctrl+O]).

2.13 Background Colors

The following background color convention is used in displaying data on the dialogs:

- White background = available for user input
- Gray background = not user editable

2.14 Status Bar

The status bar at the bottom of the screen provides useful information about each input field. There are three panes on the status bar which provide context-sensitive information. This same information is displayed in the tool tips if you allow the mouse to linger over an input field.

1. Input Description Pane – Concise descriptions of the selected input field are displayed at the far left of the status bar.
2. Input Classification Pane – The next pane to the right on the status bar displays a set of labels that indicates whether an input is required, optional, or unavailable for input (see Table 2-1).
3. Data Source Pane – The pane at the far right of the status bar displays a set of labels that identify the source of the information (if any) contained in the field. This distinguishes between information that is dictated by the compliance checking process and the information entered, for which you are responsible. The data source labels are explained in Table 2-2.

Table 2-1: Input Classification Explanations

TEXT DISPLAYED	EXPLANATION
No field selected	No building data field is currently selected.
Input is compulsory	Data is required; the program cannot perform a compliance analysis without this input.
Input is required	Data is required if the field is applicable to your project.
Input is optional	If applicable to your project, you may enter a value; a default value is always acceptable.
Input is Critical Default	You may overwrite the data with a more appropriate entry. You must be prepared to provide documentation substantiating the input value.
Field is not editable	The data in this field cannot be edited either because it is defined by the compliance ruleset, is not applicable to the selected compliance ruleset, or is an intermediate calculated parameter (meaning it is only referenced in this location and must be edited at the source of the input).
Navigation input	The purpose of the selected field is to enable you to select a component for editing without having to exit the current component and choose the next component from the tree

Table 2-2: Data Source Explanations

TEXT DISPLAYED	EXPLANATION
No field selected	No building data field is currently selected.
Value from user	The data shown is defined by the user either by direct input or through a wizard selection.
Value from simulation	The data shown is defined by an energy simulation.
Value undefined	No data is defined for the field.
Value from program	The data in this field is defined by the program either to implement requirements and procedures specified in the standards or to conform to building energy modeling conventions.

Chapter 3. Tutorial

Note: This tutorial is specific to CBECC-Res 2016.2.0.

This is a step-by-step tutorial for modeling a simple single-family residence in *CBECC-Res 2016.2.0.* The tutorial, completed in a few minutes, will help you become familiar with how components are created. The tutorial begins with a blank project. The example files included with the program are described in Section 2.2 and are found in the CBECC-Res "Projects" directory.

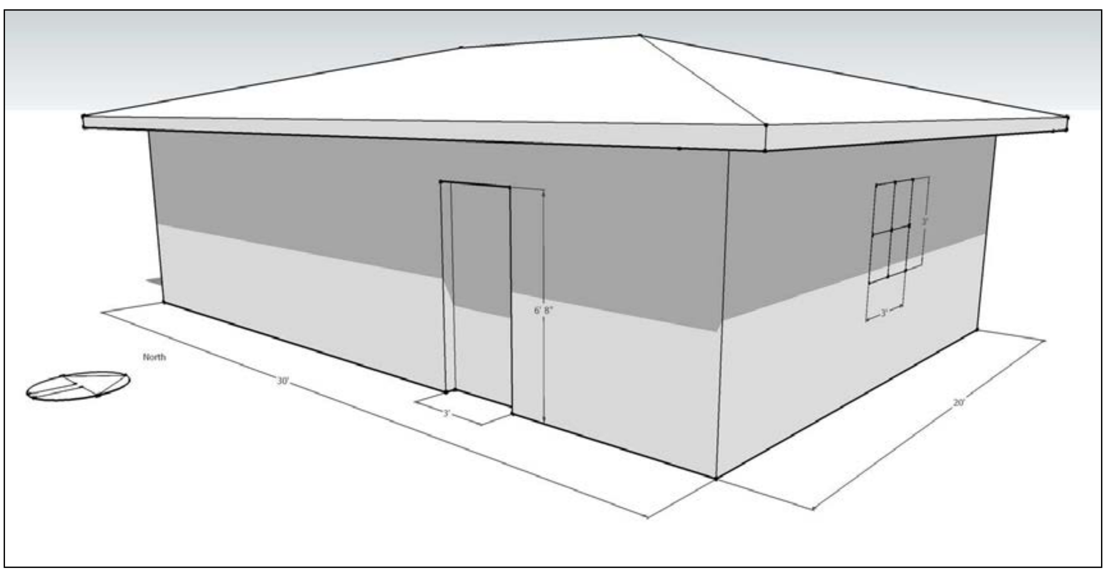
Not every input field will be discussed in this tutorial, but every input has a description in the appropriate chapter of this manual. Use the Table of Contents or the Index to find specific information (or use control-F to search). Additional information may also be found in the 2016 Residential ACM Reference Manual, which describes how the standard design is determined. These descriptions may provide insight to your compliance results.

TIP: As you are progress through the tutorial, look around the screens and fields so you get an idea where changes are made when you are working on a project.

3.1 Simple House Example

The house pictured in Figure 3-1 has a 30 ft by 20 ft living area, 8-ft ceilings with an attic above, and a slab-on-grade floor.

Figure 3-1: Simple House Example



On the south façade (front) is a single 3'-0" x 6'-8" front door. The west (left) has two 6'0" x 4'0" windows, east (right) has a 3'0" 3'0"window and north (back) facades has two 3'0" 3'0"windows and a 6'0" 6'8" sliding glass door with insulated glazing.

To model this home:

1. Download, install and start the CBECC-Res program. (The program can be downloaded from www.bwilcox.com/BEES/BEES.html). At the opening (main) screen dialog box, activate the button "Start with a Blank Project" and click <OK>.

2. Right click on the "Press Alt+F…" text line and choose create project from the drop-down menu, and enter the project name "Simple House" and click <OK>.

3. Select the climate zone of CZ12 (Sacramento). (You can select any climate zone, however program defaults are based on Package A so your results for this tutorial may be different.)

4. You will now be at the ***Project*** tab of the building model data. The name "Simple House" is filled in, and becomes the default name for the input file. Enter the address:

   1450 25th Ave.
   Sacramento, CA
   95811
   <Select> CZ12 (Sacramento)

5. Rather than clicking OK (which will take you out of the building model data) click the ***Analysis*** tab to enter a run title. Run title appears on the CF1R and can be used for information such as a compliance variable (e.g., w/ tankless water heater). Enter Compliance for the run title.

6. Check the boxes to Generate Report(s) ☑ PDF and ☑ Full (XML) (this will generate both a CF1R and the file that will get uploaded to the HERS provider). Most of the remaining inputs are kept as defaults. At the bottom is the run scope, which will stay as newly constructed.

7. Skip over the tabs for EDR and Notes. Any notes you provide will appear on the CF1R above the signature page.

8. Pick the tab ***Building*** and enter a description such as "Single Family Residence." Skip over the next couple of fields and enter a front orientation as "180" (based on the north arrow in above figure) and number of bedrooms as "2." For this example, we will assume the building has natural gas and we will not model an attached garage. NOTE for future reference: If attached garage is checked, you cannot delete the garage zone until you uncheck this option.

9. For now we will leave the Indoor Air Quality (IAQ) and Cool Vent tabs alone. IAQ will model an appropriately sized default exhaust fan. Cool vent (for example, a whole house fan) will be set based on the climate zone and the presence of an attic. If using sample files be sure to check for the presence of a whole house fan, which can have a negative effect in some climate zones.

10. Click "OK". Either click on the save button or Select <File>, <Save As> and name the file Simple House.ribd16.

NOTE: Dwelling unit types are used only for multi-family buildings.

11. **TIPS FOR GETTING AROUND**

    a. The project is called Simple House (so that is the default name for the input file). This name appears at the head of the project tree of the main CBECC-Res screen.

    b. To add components, right click on the parent component and choose <create>.

    c. To edit an existing component, either double click on the contents of the field to change the information, or right click and pick <edit>.

    d. If you need to edit or check a project component (address, climate zone, front orientation, IAQ ventilation, etc.) double click on the word project and it brings up the initial screen with the project tabs running across the top of the screen.

    e. Items in the project tree Construction Assemblies and Material Layers are not project components, but are a library of assemblies and materials. At this point the folders are empty but will be populated by the time the input file is fully created.

12. To continue, right click on the ***Project*** title. From the drop-down menu choose <create> then choose <zone>. Change the name Zone 1 to "House" and click <OK>.

13. At the next dialog box, the ***zone type*** is "Conditioned". Enter "600" for the floor area and "8" for the average ceiling height. Click <OK>.

14. On this screen (***Zone Data***), the number of stories in the zone is 1. The value "Bottom" is defining the floor level above grade. For a slab floor it is a value such as 0.33 and a floor over a crawl space is a value such as 2. Set this value to 0.33.

15. Next we will add an HVAC system to the conditioned zone.

    a. Click the drop-down menu arrow at the ***HVAC System*** box and choose to <Create new HVAC System>. At the next dialog box accept the default name by clicking <OK>.

    b. At the ***HVAC System Type***, pick from the drop down menu "Other Heating and Cooling System" and click <OK>.

    c. This opens the ***HVAC System Data*** fields where you will define the system, starting with the ***Heating Unit***.

    d. On the Heating Unit field, click on the pull-down arrow and pick <create new heating system>. Name this Furnace and click <OK>. Pick the equipment type as "CntrlFurnace." Change the efficiency to 80 AFUE and click <OK>.

    e. Now move to ***Cooling Unit*** and follow the same process – pick <create new cooling system>, rename it Split 14, select split system type. The efficiencies are minimum and the AC charge (refrigerant charge) default settings is based on the climate zone. Since this example is in a hot climate, we have the option of conducting the HERS test to verify refrigerant charge. For now, to avoid an energy penalty, keep it as verified. The 11.7 default EER does not require HERS verification. When a value higher than 11.7 is desired, check the option to "☑ Use this EER in compliance analysis". HERS verification is required as explained in Section 8.2.2.7. Click <OK>.

f. In the ***Distribution*** field follow the same procedure— keep the default name, select ducts located in attic and keep the default values (a check box sets the default values based on the climate zone). Click <OK>.

g. Next create the ***Fan*** data. Pick the single speed furnace fan and click <OK>. Accept the W/CFM cooling value of "0.58" and click <OK>.

h. You are now back at the ***HVAC System Data*** tab. Click <OK> to return to the ***Zone Data***. Although in this exercise we will not further edit the HVAC system, to do so you would access it by clicking on the ***Mechanical*** tab at the CBECC-Res main screen where a tree similar to the ***Envelope*** tree appears.

i. Next we will define the domestic water heating (***DHW System***) by selecting "create new DHW System" and keep the default system name and click ,OK.

j. Keep the Dwelling Unit Distribution as "Standard".

k. Pick from the drop-down menu for ***Water Heater(s) 1*** "create/import new Water Heater".

l. Set the name to tankless and cick <OK>.

m. Keep the heater element as gas. In the tank type field, select small instantaneous. Note that the Energy Factor changed to the default 0.82, tank volume is 0, input rating is 195,000. Accept these default characteristics for a tankless water heater system. Click <OK>.

n. Keep the water heater count as 1. Click <OK> again to accept the building details for floor area, stories, HVAC and DHW systems.

NOTE: In this tutorial we often accept the default names. You may wish to name your components something more descriptive since you will likely use a previous project to begin a new project and the names will help you identify the characteristics of that component.

16. Next we will add components from the top down, beginning with a 600 square foot ceiling. With your cursor on House, right click and choose <create> and then "Ceiling (below attic)." The list is not in alphabetical order. Accept the default name and click <OK>.

17. Follow the prompts to create a 600 square foot ceiling area and pick create a new construction assembly. Change the assembly name to "Ceiling R38" and click <OK>. Pick R 38 for the Cavity/Frame column and pick 2x4 Bottom Chord of Truss @ 24 in. O.C. for the Frame Path. Click <OK> three times. Notice that in addition to the ceiling, the program has created an attic zone with 600 square feet.

18. To create exterior walls

a. Move the cursor to the ***House*** row again. Choose <create> and then pick <exterior wall>. Change the Exterior Wall Name to "Front Wall" and click <OK>.

b. Enter a gross area of 240 square feet of wall area, and for the construction assembly create a new construction. Call it R19 + R4 Wall. Pick R-19 cavity insulation, change the framing to 2x6 @ 16 in. O.C. and an Exterior Finish of R4 Synthetic Stucco (this is the appropriate method for modeling 1-coat stucco). Since the rest of the inputs are correct, click <OK> twice.

c. Leave the wall ***tilt*** as 90.

d. Set the ***Orientation*** to front. This value is the plan orientation. For walls that are an angle, you must read and check the CF1R before printing. (Resist the urge to use numbers for the plan orientation unless the wall is at an angle and you have read section 7.1.) Click <OK>.

e. From the ***House*** row, repeat step b. through d. three more times for a "Left Wall," "Back Wall" and "Right Wall" remembering to enter the correct gross wall area (160 for left and right walls, 240 for back wall) and change the orientation to <Left>, <Back> or <Right>. **NOTE:** The program will let you copy data from any of the previous ***Exterior Wall*** or you can choose "none" at the <Copy Data From> dialog box. It is a time saver.

f. Return to the main screen by clicking <OK> after entering the last wall.

19. Before creating any windows, first set up the ***Window Types*** library. On the Window Types row, pick create and window type.

20. Name the window Oper and select OK. We will only change the U-factor and Solar Heat Gain Coefficient (SHGC) fields. Be sure to type in the U-factor and SHGC values, even if you wish to accept the default values. This ensures the time-saving feature built into the program works. In the U-factor field type in 0.32, tab to the SHGC field and type 0. 25 (the fields changed from blue to redish-brown).

    Repeat this step to create a window type called SGD with 0.30 and 0.20 values for U-factor and SHGC. Doors with glass are windows.

    NOTE: This set up allows you to change only the U-factor and SHGC values on a project in the window types list without having to go back and edit every window entry (see also Section 6.12). When adding the windows to the given walls, the fields will be blue indicating they are connected to the Window Type library correctly.

21. Now you can move the cursor to the front wall to add a door and windows to the envelope, starting with the front door.

    a. Right click on the ***Front Wall***, choose <create> and then click on <InputDoor>.

    b. Follow the prompts, naming it Entry. The door is 20 square feet. Use the default U-factor (0.50). Click <OK> to return to the main screen.

22. Now move to the ***Left Wall*** and right click o <create> a window. Name it L1 and click <OK>.

23. The next dialog box asks you to choose between ***window dimensions*** and ***overall window area***. Choose window dimension so an overhang can be modeled and click <OK>.

24. You are now at the ***Window Data*** tab. Select the ***Window Type*** from the library types just added (e.g., Oper) and enter the window height "3" and width "3" and. Set the multiplier to 1.

25. To add an overhang, click on the ***Window Overhang*** tab at the top of the screen. You will see an illustration of the inputs. Enter a ***Depth*** of "2" feet, a ***Dist Up*** of "1" foot, and an ***Extends Left*** and ***Extends Right*** of "7" feet each. Leave the ***Flap Height*** as "0." Complete the overhang by clicking <OK>.

26. Now right click on the ***Back Wall*** to <create> a window. Name it B1, pick copy data from L1, and click <OK>.

27. Keep the window height "3" and width "3" and set the multiplier to 2 since we will model identical overhangs for the two windows. Edit the overhang ***Extends Left*** and ***Extends Right*** values to 3 feet.

28. Still on the back wall, create a 6'x6'8" sliding glass door by right-clicking, picking <create> a window named B2 SGD, copy window B1. Change Window type to SGD from library (notice that it picked up the 0.30 and 0.20 efficiencies). Enter the width as 6 and a height of 6.67. Change the multiplier to 1. Change the overhang to have a left distance of 3 and a right distance of 10.

29. Finally, right click the ***Right Wall*** using the same method to create a window. Tell the program to copy the data from the first window (B1), changing the window height to "6" and width to "4" and keep the multiplier as 2. Change the overhang ***Extends Left*** and ***Extends Right*** values to "10.5" each. All other data remain the same. Click <OK>.

30. Next move back up to House (600 SqFt) and add a slab floor. Right click and choose <create> and then pick <Slab on Grade.> Enter an area of 600 square feet, a floor elevation of 0.33 (or the level of the surface of the floor above grade) and a perimeter equal to the length of the four sides exposed to the exterior (100). Note: If there was a garage, the edge no longer includes the length of the edge adjacent to the garage, but only adjacent to the exterior. Keep the surface set to default (80% covered, 20% exposed).

31. The last step is to check the characteristics of the attic zone that was created when the ceiling was defined. Move to the attic and double-click. This is where the roof pitch (roof rise) is defined. Change the 5 to a 3. Notice that the construction is asphalt shingle roof and the reflectance and emittance values are default (not a cool roof). Click <OK>.

32. Move to the construction assemblies and click on the plus (+) sign. Find Asphalt Shingle Roof and double click on it. We can add a radiant barrier, or add above deck roof insulation. Since the 2016 standards have roof deck insulation, we will add R-13 cavity/frame insulation.

33. To perform an analysis, save your input file using the ***Save*** shortcut key, and the ***Perform Analysis*** shortcut key (see page 2-5) (also accessible under the menu for ***Tools***). This will perform the simulation of the current model, which takes about 2 minutes or less. For comparison, Figure 3-2 shows the output screen for the model built in this tutorial. You will be able to view the CF1R since we checked the box to create the PDF. The PDF is generated using a web-based application.

Figure 3-2: Output for Simple House in Climate Zone 12

Energy Use Details | Summary | Energy Design Rating

End Use	Standard Design Site (kWh)	Standard Design Site (therms)	Standard Design (kTDV/ft²-yr)	Proposed Design Site (kWh)	Proposed Design Site (therms)	Proposed Design (kTDV/ft²-yr)	Compliance Margin (kTDV/ft²-yr)
Space Heating	39	45.2	15.45	52	58.6	20.01	-4.56
Space Cooling	352		38.75	345		37.79	0.96
IAQ Ventilation	62		2.28	62		2.28	0.00
Other HVAC			0.00			0.00	0.00
Water Heating		90.7	25.36		90.7	25.36	0.00
PV Credit						0.00	0.00
Compliance Total			81.84			85.44	-3.60
Inside Lighting	206		7.93	206		7.93	-4.4 %
Appl. & Cooking	721	37.8	37.40	719	37.8	37.33	Result:
Plug Loads	1,680		62.66	1,680		62.66	FAIL
Exterior	40		1.42	40		1.42	
TOTAL	3,101	173.7	191.25	3,104	187.1	194.78	

34. The project fails. The margin is negative on heating, slightly negative on cooling, and equivalent to the standard design on water heating. As part of this tutorial, we will try trading off some features.

35. Click on the **Mechanical** tab and double click on the Heating or Cooling System to change the efficiencies. Change the heating system AFUE to 92 (not 0.92).

36. Click on the envelope tab and we'll upgrade the windows. Double click on Oper and change the efficiency from 0.32 and 0.25 to 0.29 and 0.18.

37. Click <OK>. At this point if you wanted to rename the file you can select file/save to rename the file or pick "calculate" and the program will require saving the file as part of running the calculation. While CBECC-Res is running, be sure to close the PDF of the CF1R.

38. The project complies. Included in the user manual are all of the things you need to know to change your project details.

Figure 3-3: Updated Output for Simple House

Energy Use Details | Summary | Energy Design Rating

End Use	Standard Design Site (kWh)	Standard Design Site (therms)	Standard Design (kTDV/ft²-yr)	Proposed Design Site (kWh)	Proposed Design Site (therms)	Proposed Design (kTDV/ft²-yr)	Compliance Margin (kTDV/ft²-yr)
Space Heating	39	45.2	15.45	53	53.2	18.31	-2.86
Space Cooling	352		38.75	314		34.71	4.04
IAQ Ventilation	62		2.28	62		2.28	0.00
Other HVAC			0.00			0.00	0.00
Water Heating		90.7	25.36		90.7	25.36	0.00
PV Credit						0.00	0.00
Compliance Total			81.84			80.66	1.18
Inside Lighting	206		7.93	206		7.93	1.4 %
Appl. & Cooking	721	37.8	37.40	718	37.8	37.29	Result:
Plug Loads	1,680		62.66	1,680		62.66	PASS
Exterior	40		1.42	40		1.42	
TOTAL	3,101	173.7	191.25	3,074	181.7	189.96	

(Results may vary)

Chapter 4. Project

It is often best to start with an existing input file for a similar project, which will have the structure of the building set up (example files included are listed in Section 2.2). However, you have the option of starting with a blank project as demonstrated during the tutorial.

Once familiar with the program, you can set up a file template for projects that have a library of assemblies and equipment common to your projects. For example, R-30 cathedral ceilings; R-30 and R-38 ceilings below attic; tile roofs and asphalt/comp roofs, with or without radiant barriers; typical 2x4 and 2x6 wall construction assemblies; furnaces with 80% and 92% AFUE; and various water heater types and efficiencies, as appropriate for your clients.

4.1 Tool Tips/Automated Features

- **Right-Click.** The tools on the right-click menu are described in Section 2.6.
- **Tool Tips**. Some fields have tool tips that are activated by hovering over the field.
- **File Save**. If a file was not saved before you choose to perform an analysis, you are prompted to save it before performing the analysis. If you select the default save, the file will be saved over the existing file. Thus, if your intention is to create a new version of the file, be sure to pick <cancel> and select <file> and <save as> from the file menu.
- **Window Types**. You can set up window types in such a way that you can easily update all of the windows in a project with very few steps.

  Creating a list of window types, entering only the window U-factor and SHGC. If a project requires a change of brand or grade of windows, change the efficiencies in the window types and all window entries are revised. Please read the detailed instructions to ensure you've enabled this flexibility correctly (see Section 6.12)
- **EER verified**. When modeling an EER for typical HVAC equipment, you can accept the default EER and no verification is required. If however, you wish to take credit for the verified EER or a higher than default EER, you will need to check the box directing the program to use the specified EER in the compliance analysis.
- **Duct R-value**. When the "defaults" for ducts are used, if you change the climate zone and the new zone has a different Package A basis, the minimum will be updated (e.g., zone 7 is R-6 while zone 10 is R-8).
- **Automated Defaults Based on Climate Zone**. When a field such as duct R-value, window U-factor or SHGC is blue rather than red the value will update based on the default for the selected climate zone. If the field is red and you wish to enable this feature, swipe the cursor

across the field, right-click and select "Restore Default." The field will change from red to blue to indicate that it will change if a climate zone with a different standard design assumption is selected. To prevent unintended changes on window efficiencies, see also Window Types in Section 7.7.1.4.

4.2 Defining Surfaces Surrounding a Zone

CBECC-Res applies logic that requires a modeled space to have a ceiling/roof, floor and sometimes four walls. If a space/zone is adjacent to another space being modeled, the connection between these two zones is achieved by modeling an interior surface (wall, floor or ceiling) in one of the zones. When this connection is missing an error message appears which indicates that there are not enough surfaces. If the adjacent or connecting zone is not modeled, see Section 4.2.1.

There are too many variables to cover every situation you may encounter, but the general concept is that if an adjacent space is modeled, there must be some connection between the two zones. This can be an interior wall, floor, or ceiling.

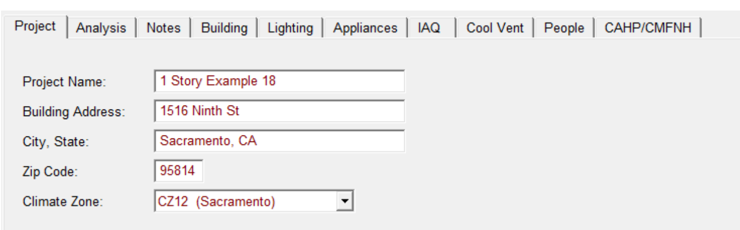
4.2.1 Addition Alone Connecting Surfaces

If the adjacent space is not modeled, an interior surface is modeled where the new space connects to the existing space. Check the option for a "party surface" when the adjacent zone is not being modeled. Interior surfaces are how CBECC-Res identifies that either conditioned space or an enclosed unconditioned space is on the other side of the surface, and that there are no solar gains.

4.3 Project Information

Double click on the project to access the tabs illustrated in Figure 4-1.

Figure 4-1: Project Information



4.3.1.1 Project Name

The project name is user-defined project information that will appear as the first piece of general information on the CF1R.

4.3.1.2 Building Address

Enter a building address, APN or legal description to identify the location of the proposed building project.

4.3.1.3 City, State

Enter the city or town in which the proposed building is located.

4.3.1.4 Zip Code

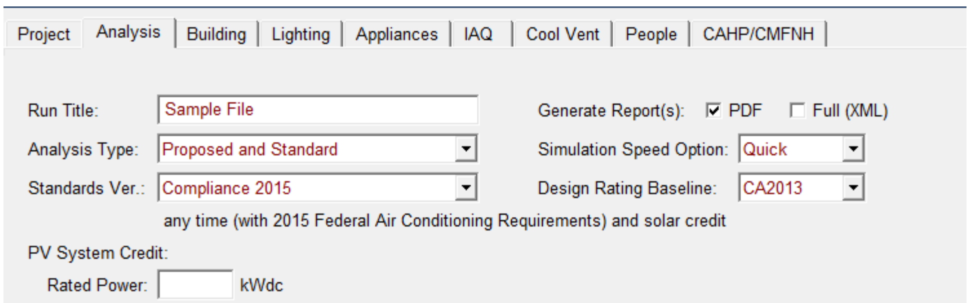
The zip code is used to establish the correct climate zone.

4.3.1.5 Climate Zone

Use the zip code and *Reference Appendices*, JA2.1.1. to determine the correct climate zone.

4.4 Analysis

Figure 4-2: Analysis Information



4.4.1.1 Run Title

Run title is a field for the software user's own notes or project information. The information will not appear on the CF1R. It can be used to identify information such as a compliance variable being considered (e.g., "w/ tankless water heater").

4.4.1.2 Analysis Type

The two types of analysis are ***proposed and standard design*** (typical for compliance), and ***proposed only***.

4.4.1.3 Standards Version

Default Compliance 2017.

4.4.1.4 Generate Report PDF (the CF1R)

To generate a PDF of the Certificate of Compliance (CF1R) at the end of the analysis, check the PDF box. The PDF automatically generated when this box is checked will have a watermark identifying that the CF1R is not registered. This watermark cannot be removed. Once the project is uploaded to a HERS provider and signed by the appropriate responsible persons, a CF1R with a registration number can be printed and submitted to the building department to obtain a building permit.

NOTE: If the CF1R has a watermark stating that it is not useable for compliance, this is an indication of one of three situations:

(1) The CF1R was generated via the tools option "Generate Draft T-24 Compliance Report" rather than as part of the compliance run (as explained in the frequently asked questions, this is a security feature),
(2) The compliance was run using the quick simulation speed option, or
(3) The software is out of date.

If the CF1R does not open at the end of a compliance run, the PDF file can be found in the CBECC-Res 2016 Projects folder.

4.4.1.5 Generate Report Full (XML) (the HERS Upload File)

An XML file gets uploaded to the HERS provider. Once a project is ready to complete, be sure to check the option to generate the full (XML) before performing the compliance analysis. This will create a file located in the My Documents\CBECC-Res 2016 Projects folder named:

<input file name> - AnalysisResults-BEES.xml

(**NOTE:** the smaller xml file, without "BEES" as part of the name, will result in an error when uploaded to the HERS provider as it does not contain the CF1R).

Although XML files are easily modified, the HERS providers have in place security measures to reject files that are modified. You can read more about this in the frequently asked question.

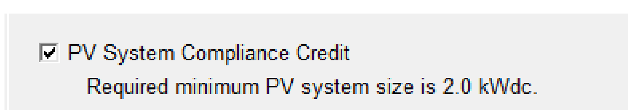
4.4.1.6 Simulation Speed Option

Options include Compliance and Quick. Quick allows results approximately 40 percent faster. Results are typically within 5% of the more detailed and lengthy Compliance simulation. To obtain a CF1R that can be registered, results must be from a simulation run in Compliance mode.

4.4.1.7 PV System Compliance Credit

To include energy compliance credit for a photovoltaic (PV) system, check the box on the analysis tab (see Figure 4-3).

Figure 4-3: PV Compliance Credit



This optional compliance credit for projects in climate zones 1-5 and 8-16 requires a minimum of 2 kWdc for single family and town house projects, and 1 kWdc per dwelling unit in a multi-family building. There is no compliance credit for PV systems in climate zones 6-7. Depending on the climate zone and conditioned floor area, a larger system may be required. The software will offer screen feedback as to the minimum system size required. The calculations upon which the credit is based can be found in the 2016 *Residential ACM Reference Manual*, Section 2.2.3.

The energy code compliance credit is reflected in the energy use summary as photovoltaic offset and is reported as a *Special Feature* on the CF1R. Systems must meet the eligibility criteria specified in Residential Reference Appendix RA4.6.

NOTE: For an energy design rating for compliance with CALGreen (Title 24, Part 11) see Section 4.5.2.

4.4.1.8 Analysis Report

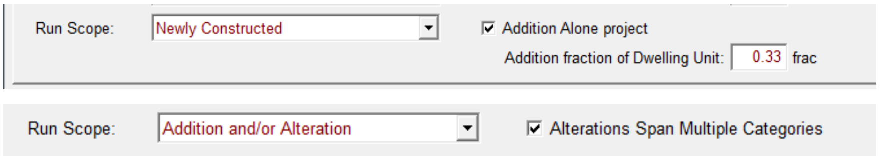
The default report type is Building Summary (csv).

4.4.1.9 Run Scope

The two types of projects are ***Newly Constructed*** or ***Addition and/or Alteration***. Do not select Addition and/or Alteration unless modeling the existing building.

Newly constructed includes an ***addition alone*** (see additional input described in Section 4.4.1.10).

Figure 4-4: Run Scope



Addition and/or alteration includes an input for a project that is an alteration only (no addition) (see additional input described in Section 4.4.1.10).

4.4.1.10 Addition Alone project or Alterations Span Multiple Categories

When applicable, check the Addition Alone project and enter the fraction of a dwelling unit (Addition Area / (Existing + Addition) = Fraction).

When the run scope is addition and/or alteration, and the project is an alteration alone, the user is required to verify that there are two or more alterations categories included in the project (not required for an Existing plus Addition plus Alteration). The categories are based on Table 150.2-B of the standards, and include:

Ceiling insulation
Wall insulation
Raised floor insulation
Fenestration
Window film
Space heating and/or cooling equipment
Duct sealing
Duct insulation
Water heating system
Roofing products
Others

4.5 Energy Design Rating and PV System Credit

The software includes the ability to calculate an energy design rating (EDR) as required in the CALGreen energy provisions (Title 24, Part 11).

The EDR is an alternate way to express the energy performance of a home using a scoring system where 100 represents the performance of a building meeting the envelope requirements of the 2006 International Energy Conservation Code (IECC). A score of zero or less represents the energy performance of a building that combines high levels of energy efficiency and/or renewable generation to “zero out” its TDV energy use.

The EDR is similar to the energy rating index in the 2015 IECC and the 2014 Residential Energy Services Network (RESNET) standards. The lower the score, the more efficient the building.

Buildings complying with the current standards are more efficient than the 2006 IECC, so most newly constructed buildings will have EDR scores below 100 (if an EDR were calculated for an older, inefficient home, the score could go above 100). Buildings with renewable generation such as photovoltaics (PV) can have a negative score.

When the user requests an EDR calculation, more detail is needed for the PV system(s). These inputs only affect the EDR calculation.

4.5.1 Energy Design Rating Calculation

To calculate an EDR, check the box next to detailed energy design rating inputs. The details of the calculations are included in the 2016 Residential ACM Reference Manual, Section 3.2.

4.5.2 PV System (EDR only)

EDR credit is available for PV systems complying with CALGreen. The PV credit in the EDR uses calculations based on PVWatts. If information beyond that found here or in the Reference Manual is needed, consult PVWatts technical documentation.

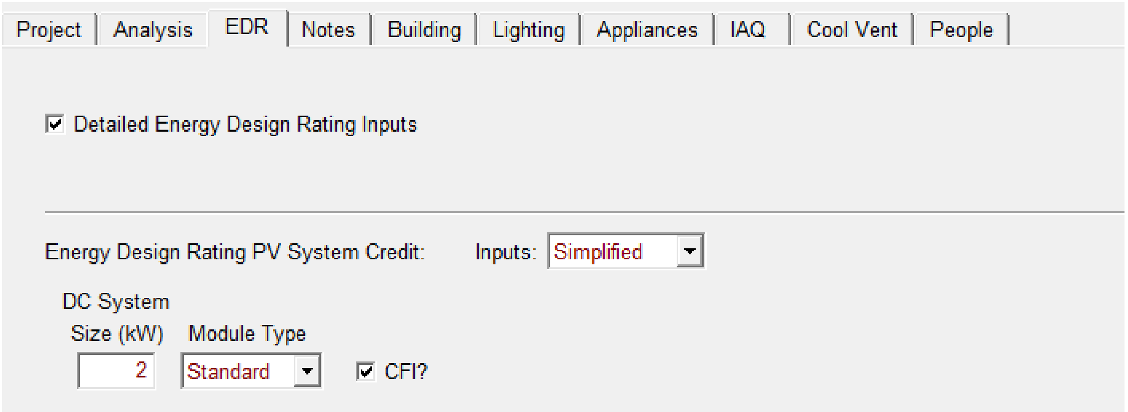
The PV system size and module type are required inputs. Users may select simplified or detailed inputs. With detailed inputs, the inverter efficiency must be included. The user can select either detailed installation information for the orientation and angle/tilt of the array or select California flexible installation.

4.5.2.1 Inputs

Select either simplified or detailed inputs. Simplified will limit the module type options.

NOTE: When entering data for the first time, fields are revealed one at a time. Once you’ve entered the DC system size, tab to the next field.

Figure 4-5: Initial PV Screen



4.5.2.2 DC System Size (kW)

Enter the system size (in kW) of the PV system. If the PV system is also being used for compliance credit with Energy Code (Part 6), the value must be 2 or greater (see the minimum shown on the analysis tab or Section 4.4.1.7).

4.5.2.3 Module Type

Select the module type from the pull-down options as standard, premium, or thin film.

Select the most appropriate option based on information on the module data sheet:

- Standard is a typical poly- or mono-crystalline silicon module, with efficiencies of 14-17 percent.
- Premium is appropriate for modeling high efficiency (approximately 18-20 percent) monocrystalline silicon modules that have anti-reflective coatings and lower temperature coefficients.
- Thin film assumes a low efficiency (about 11 percent), and a significantly lower temperature coefficient which is representative of most installed thin film modules as of 2013.

4.5.2.4 CFI

When California Flexible Installation (CFI) is selected, inputs are simplified and specific orientation, tilt and shading conditions are not required. The performance of the PV system is estimated based on a range of module orientations and tilts. For a more complete explanation of CFI see Section 4.5.3.

4.5.2.5 Azimuth (degrees)

Enter the direction the PV array faces.

4.5.2.6 Tilt Input

Select either pitch or tilt from the pull-down menu for the entry of the array.

4.5.2.7 Array Angle (degrees) / Tilt (x in 12)

Based on whether degrees or pitch was selected in the previous input, enter the degrees at which the array is installed or the pitch (such as 5 in 12).

4.5.2.8 Inverter Effectiveness (%)

Nominal value for DC to AC conversion efficiency (rated AC divided by DC). Value must be greater than 0.

4.5.3 California Flexible Installation (CFI)

With CFI selected, the performance is based on a PV system installed with an azimuth ranging from 150° and 270° and with all modules at the same tilt as the roof (for roof pitches between 0:12 and 7:12).

When performance of the PV system is based on CFI, the HERS rater will verify that the modules are installed with any azimuth and any tilt within the acceptable range. Additionally, each system on each site must meet the “minimal shading” criterion.

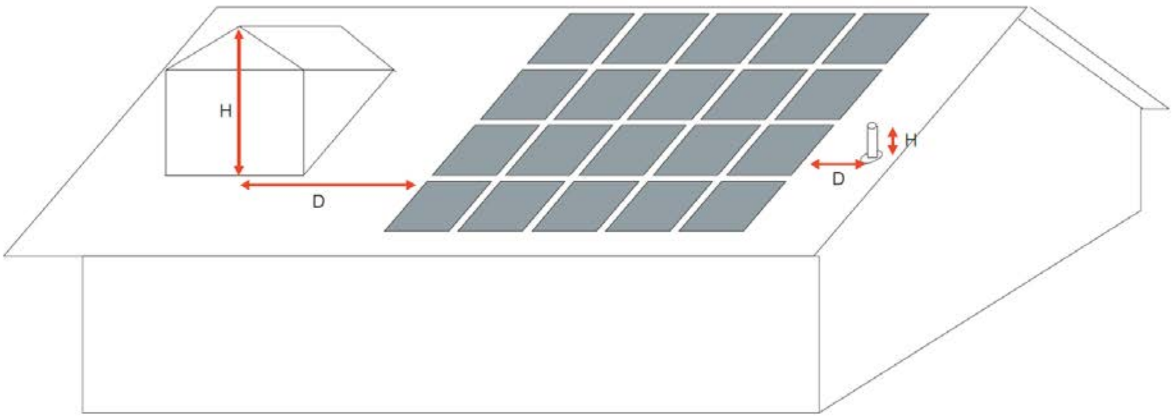
4.5.3.1 Minimal Shading

The “minimal shading” criterion is that no obstruction is closer than a distance (“D”) of twice the height (“H”) it extends above the PV modules (see Figure 4-6 for a depiction of “H” and “D”). As the figure illustrates, the distance “D” must be at least two times greater than the distance “H.” Any obstruction that projects above any portion of the PV array must meet this criterion for the PV array to be considered minimally shaded.

Obstructions that are subject to this criterion include any:

1. Vent, chimney, architectural feature, mechanical equipment or other obstruction that projects above the roof of the residential building with the installed solar system,
2. Part of the neighboring terrain that projects above the roof of the residential building,
3. Tree that is mature at the time of installation of the solar system or any tree that is planted or planned to be planted as part of the landscaping for the residential building (the expected performance must be based on the expected mature height of any tree planted or planned to be planted as part of the landscaping for the residential building),
4. Existing or planned residential building or other structure neighboring the residential building with the solar system and
5. Telephone or other utility pole that is closer than thirty feet from the nearest point of the array.

Figure 4-6: Minimal Shading Criterion



4.5.4 EDR Analysis Results

Once the options for the EDR are set and the building is run, the results may be viewed on the analysis results screen as shown in Figure 4-7.

Figure 4-7: Energy Design Rating Results

Energy Use Details | Summary | Energy Design Rating

EDR of Proposed Design: 51.6 EDR of Proposed PV: 31.3 Final Proposed EDR: 20.3

EDR of Standard Design: 62.1

End Use	Reference Design Site (kWh)	Reference Design Site (therms)	Reference Design (kTDV/ft²-yr)	Proposed Design Site (kWh)	Proposed Design Site (therms)	Proposed Design (kTDV/ft²-yr)	Design Rating Margin (kTDV/ft²-yr)
Space Heating	50	41.4	4.18	14	14.2	1.41	2.77
Space Cooling	10,108		156.60	4,121		71.49	85.11
IAQ Ventilation	112		1.12	112		1.12	0.00
Other HVAC			0.00			0.00	0.00
Water Heating		150.0	12.09		90.0	7.25	4.84
Photovoltaics				-6,979		-75.49	75.49
Inside Lighting	2,135		22.73	1,045		10.94	11.79
Appl. & Cooking	930	65.4	14.54	958	52.5	13.82	0.72
Plug Loads	2,638		27.12	2,206		22.32	4.80
Exterior	298		2.76	117		1.08	1.68
TOTAL	16,270	256.8	241.14	1,593	156.7	53.94	187.20

An EDR report is generated at the end of a calculation and on the CF-1R after the Part 6 compliance results. Results are displayed with and without PV. The CF1R will not enforce Zero Net Energy (ZNE) or tier prerequisites, but will report if CALGreen requirements are met (see Figure 4-8).

Figure 4-8: EDR Results on the CF1R

ENERGY DESIGN RATING			
Energy Design Rating (EDR) is an alternate way to express the energy performance of a building using a scoring system where 100 represents the energy performance of the Residential Energy Services (RESNET) reference home characterization of the 2006 International Energy Conservation Code (IECC). A score of zero represents the energy performance of a building that combines high levels of energy efficiency with renewable generation to"zero out" its TDV energy. Because EDR includes consideration of components not regulated by Title 24, Part 6 (such as domestic appliances and consumer electronics), it is not used to show compliance with Part 6 but may instead be used by local jurisdictions pursuing local ordinances under Title 24, Part 11 (CALGreen). As a Standard Design building under the 2016 Building Energy Efficiency Standards is significantly more efficient than the baseline EDR building, the EDR of the Standard Design building is provided for Information. Similarly, the EDR score of the Proposed Design is provided separately from the EDR value of installed PV so that the effects of efficiency and renewable energy can both be seen			
EDR of Standard Design	EDR of Proposed Design	EDR Value of Proposed PV	Final EDR of Proposed Design
48.1	42.0	51.5	-9.4

☒	Design meets Tier 1 requirement of 15% or greater code compliance margin (CALGreen A4.203.1.2.1) and QII verification prerequisite.
☒	Design meets Tier 2 requirement of 30% or greater code compliance margin (CALGreen A4.203.1.2.2) and QII verification prerequisite.
☒	Design meets ZNE Tier requirement for Single Family in climate zone CZ12 (Sacramento) for compliance with Calgreen section A4.203.1.3 including on-site photovoltaic (PV) renewable energy generation sufficient to achieve a Final Energy Design Rating (EDR) of zero or less. The PV System must be verified.

ENERGY DESIGN RATING PV SYSTEM INPUTS - DETAILED

DC System Size (kW)	Module Type	CFI	Azimuth (deg)	Tilt Input	Array Angle (deg)	Tilt: (x in 12)	Inverter Eff. (%)
2	Standard	☐	200	pitch	22.6	5.0	96
3	Standard	☐	180	deg	22.6	5.0	96

4.6 Notes

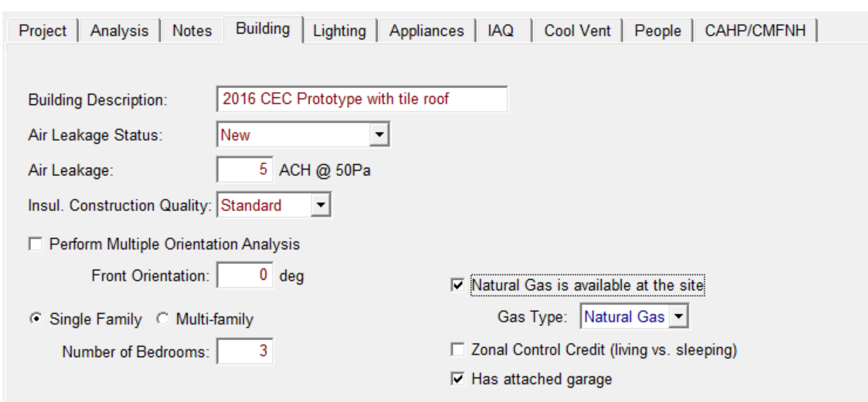
Include any project notes to appear on the Certificate of Compliance (CF1R). Information will appear prior to the signature page. The maximum space available is 10 lines. The font size allows for about 155-160 characters per row. To paste text from another document, use Control-V.

The project remarks field is for the program user. Text in this field is not printed on the CF1R.

4.7 Building

The ***Building*** tab (see Figure 4-9) is used to provide basic information about the building.

Figure 4-9: Building Information



4.7.1.1 Building Description

The building description will appear as the second line of general project information on the CF1R. It is a user-defined label and is different from the project name.

4.7.1.2 Air Leakage Status

Valid options are New and Altered. New construction is new. For an addition and/or alteration where infiltration testing will be performed for compliance credit, use altered.

4.7.1.3 Air Leakage

Input as Air Changes per Hour @ 50 Pascal (ACH50), the CF1R reports CFM50.

Default value (no blower door test) for single family buildings with space conditioning ducts in unconditioned space, and the default condition for no cooling, is 5 ACH50. When there are no heating and/or cooling system ducts in unconditioned space, the default is 4.4 for single-family buildings and townhomes. If a single family or town home will have HERS verified infiltration testing (blower door test), model an achievable target leakage area value.

For multi-family buildings there is no compliance option for infiltration testing. The default value that is assumed by CBECC-Res is 7 ACH.

This input represents the air flow through a blower door at 50 Pascal (Pa) of pressure measured in cubic feet per minute, called CFM50 or ACH50. CFM50 x 60 minutes divided by the volume of conditioned space is the air changes per hour at 50 Pa, called ACH50. When a value lower than default is modeled, diagnostic testing for reduced infiltration, with the details and target values modeled, is reported as a HERS Required Verification on the CF1R.

4.7.1.4 Insulation Construction Quality

Also known as Quality Insulation Installation (QII), valid options are standard and improved. The default value is standard. Improved means a HERS rater will verify insulation installation complies with RA3.5 (which requires multiple inspections). Credit for verified quality insulation installation is applicable to all insulated assemblies in a newly constructed building or the entire building of an existing plus addition analysis—ceilings/attics, knee walls, exterior walls and exterior floors. See *Reference Appendices*, Residential Appendix RA3.5.

4.7.1.5 Front Orientation

This field defines the front orientation in degrees and must be accurate within 5 degrees. This value is from the site plan. North is 0, east is 90, south is 180, and west is 270 degrees. While this input is typically the side of the building where the front door is located, if the front door, front façade, or the side of the building facing the street are different, any choice is acceptable as long as the end result is a CF1R with windows facing the correct actual azimuth.

NOTE: The front orientation or actual azimuth establishes the orientation of walls and windows, which are modeled using either labels such as “front” or “left,” or the orientation with respect to the front and not the actual orientation. See Orientation in Section 7.1 and review the CF1R carefully to ensure the correct information appears for azimuth of opaque surfaces and windows.

Multiple orientation (or cardinal compliance) is a valid selection for subdivisions where homes may be built in any orientation. The building must comply with the same energy features in all orientations. A single CF1R will display the compliance results for the four cardinal orientations—north, east, south and west.

4.7.1.6 Single Family or Multi-family

Use the check box to indicate if the building is a single-family dwelling (R-3 occupancy group), or is a multi-family building (R-1 or R-2 occupancy group) with three stories or less.

NOTE: A duplex or townhome (an R-3 occupancy) must be modeled as multiple single-family buildings. Each dwelling unit will be a separate input file rather than modeling a building with multiple dwelling units.

For more on modeling a multi-family building, see Sections 5.2 and 5.6.

4.7.1.7 Number of Bedrooms

For single family dwellings, indicate the number of bedrooms to establish mechanical ventilation requirements and determine if a building qualifies as a compact building for purposes of incentive programs.

4.7.1.8 Natural Gas Availability

Check the box if natural gas is available. Whether natural gas is available determines the fuel type used as the basis for time dependent value (TDV) in the standard design (see *Reference Appendices*, Joint Appendix JA3).

4.7.1.9 Gas Type

Select whether the fuel type being used in the building for heating, cooking, or water heating is natural gas or propane.

4.7.1.10 Zonal Control

Checking this box enables modeling a building that meets the criteria for zonal control requirements of the heating system, including separately modeled living and sleeping zones. This compliance option is not available with heat pump or combined hydronic space conditioning. Zonal control credit requires compliance with several eligibility criteria (see *Residential Compliance Manual*, Chapter 4, Section 4.5.2 for the complete list). This credit requires that the living and sleeping areas are modeled and conditioned separately. The conditioning is either with zonally-controlled equipment or separate space conditioning equipment with separate thermostat settings for living and sleeping zones. See Section 8.1.3 for more information on modeling zonal control.

CBECC-Res also has modeling capabilities for zonal cooling (see Section 8.3.3).

4.7.1.11 Has Attached Garage

This check box is used to indicate if there is an attached garage, which must be modeled. While there are no minimum requirements for the garage construction, it is modeled to accurately represent the building to be constructed and typically improves compliance due to the buffering effects of an enclosed attached space.

4.7.1.12 Central Laundry

If modeling a multi-family building, indicate if the laundry facilities are in a central location rather than within each dwelling unit. If the laundry facilities are central, define the zone in which the facilities are located.

4.8 Lighting/Appliances

For compliance with the standards, lighting is fixed.

The appliance information is not a compliance variable.

For single-family buildings, check the box to indicate if an appliance is located within a conditioned zone of the dwelling unit. The fuel type choices for the clothes dryer and cooking appliances is gas (gas is assumed to be natural gas, if available, otherwise it is propane) or electricity.

For multi-family buildings, this information is provided as part of the dwelling unit type (see Section 5.6.1.4).

4.9 IAQ Ventilation

For single-family dwelling units, the mandatory indoor air quality (IAQ) ventilation is specified here. The minimum required ventilation rate is displayed based on the conditioned floor area and number of bedrooms in the dwelling unit. See Section 8.6 for more information on the specific IAQ fan details. For more information on this mandatory requirement, see *Residential Compliance Manual*, Section 4.6.

For multi-family dwelling units, see Section 5.6.1.6.

4.9.1.1 Model as

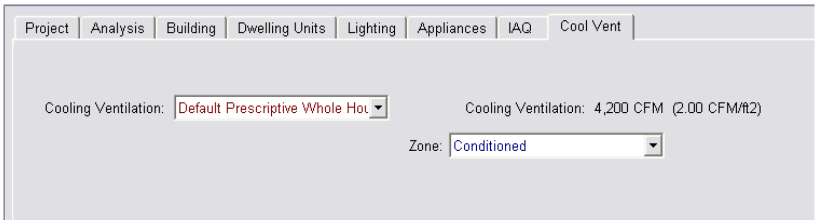
Select method of ventilation as either default minimum IAQ fan or specify individual fans (as described in Section 8.6).

4.9.1.2 Zone

Assign to one of the conditioned zones.

4.10 Cooling Ventilation

Figure 4-10: Cooling Ventilation



Cooling ventilation systems use fans to bring in outside air to cool the house when this could reduce cooling loads and save energy. The simplest approach is a whole house fan, which is the basis of the standard design in climate zones 8-14 where the evenings may cool down enough provide an effective means of cooling the house. The types of cooling ventilation are shown in Table 4-1. Additional inputs are discussed in Section 8.7.

4.10.1.1 Cooling Ventilation

Default value is none. Other options are a default prescriptive whole house fan (set to exactly 1.5 CFM/ft^2), specify individual fans, or a central fan integrated system which uses the space conditioning duct system to provide outside air for cooling (additional inputs are discussed in Chapter 8). Whole house fan operation requires that the building have an attic.

Table 4-1: Cooling Ventilation Fans

Measure	**Description**
Whole House Fan	Traditional whole house fan is mounted in the ceiling to exhaust air from the house to the attic, inducing outside air in through open windows. Whole house fans are assumed to operate between dawn and 11 PM only at 25% of rated CFM to reflect manual operation of fan and windows by occupant. Fans must be listed in the California Energy Commission's Whole House Fan directory. If multiple fans are used, enter the total CFM.
CFI (Central Fan Integrated) cool vent (fixed or variable speed)	These systems use the furnace or air handler fan to deliver outdoor air to conditioned space. With an automated damper, outside air duct, temperature sensors and controls, these systems can automatically deliver filtered outdoor air to occupant set comfort levels when outdoor conditions warrant the use of ventilation.

4.10.1.2 Zone

Assign to any conditioned zone that has a ceiling below an attic. Since a whole house fan uses attic venting to exhaust the hot air, an attic is required for this measure.

Chapter 5. Zones

5.1 Conditioned Zones

Decide in advance how many zones are needed to adequately define a building. A zone is typically an area with specific details that must be modeled separately from another area (a more complex building model does not necessarily yield better compliance results). Some cases where multiple zones are required are:

- Zonal control (with at least one living and one sleeping zone).
- Spaces served by different types of heating/cooling equipment (such as a heat pump and a gas furnace)
- Different duct conditions or locations.

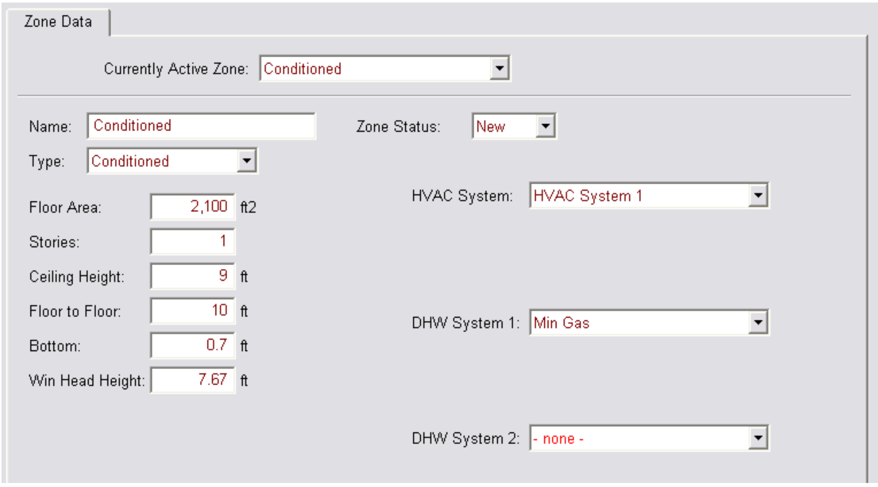
The simplest approach is to model the worst case in a single zone.

In addition to the conditioned zones, attics, crawl spaces, and garages/attached unconditioned spaces must be modeled. Attached unconditioned spaces should be modeled using the "attached garage" option (named as appropriate). The zone type "unconditioned" is not implemented.

To create the house or dwelling unit, right-click on project or edit an existing conditioned zone (see Figure 5-1).

5.1.1 Conditioned Zone Data

Figure 5-1: Conditioned Zone Data



5.1.1.1 Name

User-defined name. If the building plans have a unique identifier, that should be used here to assist in the plan checking and inspection processes.

5.1.1.2 Zone Status

The default is new for new construction or the added floor area of an addition. Other options include altered and existing.

5.1.1.3 Type

The default zone type is conditioned. If the building specifies zonal control (under the ***building*** tab), the type is defined as living or sleeping. For more information on zonal control see Section 8.1.3. Unconditioned is not implemented as a valid zone type. Any unconditioned zones can be modeled as a garage or as part of the garage (see Section 5.5).

5.1.1.4 Floor Area

Specify the floor area of the zone.

5.1.1.5 Number of Stories

Enter the number of stories in the zone (not the building). If each floor of a 2-story home is modeled as a separate zone, the number of stories is 1 for each zone. If the home is modeled as a single zone, then this value is the number of stories in the home (limited to 3).

5.1.1.6 Ceiling Height

Average ceiling height, in feet.

5.1.1.7 Floor to Floor

Distance between the floor being modeled and any floor above. Default value is average ceiling height plus one foot.

5.1.1.8 Bottom

The value input depends on how the building is zoned and whether there are below grade surfaces. It is the distance above grade of the surface of the floor (in feet), or below grade (negative value, in feet). A slab floor will be the height from the grade to the top of the slab (such as 0.7). A raised floor will be the height from grade to the top of the raised floor (if there is a crawlspace, this value is at least 2).

For multi-story buildings, if the upper floors are modeled as a separate zone, the bottom must be the total distance from grade to the bottom of the floor (e.g., if the first floor is at 0.7 feet, with 10 feet as the floor to floor height, the second floor bottom is 10.7).

5.1.1.9 Window Head Height

Default value is based on the average ceiling height (program will establish this value based on ceiling height.

5.1.1.10 HVAC System

Identify the name of the heating, ventilating and air conditioning (HVAC) system by picking a defined system or creating a new system. The system is made up of the heating, cooling and distribution systems, and a furnace fan. See more in Chapter 8, Mechanical Systems.

5.1.1.11 DHW System 1

Identify the name of the domestic water heating (DHW) system by picking a defined system or creating a new system. Multiple water heaters can be modeled as one system. See more in Chapter 9, Domestic Hot Water.

5.1.1.12 DHW System 2

If a water heater has a different distribution system, identify that as a second DHW system.

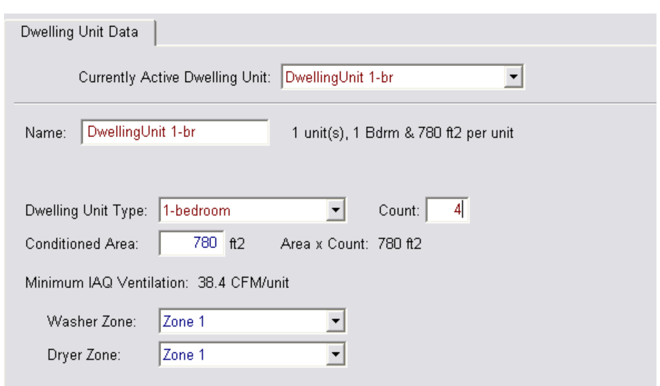
5.2 Multi-family Dwelling Unit Zone

Multi-family buildings (not duplexes or townhomes) with single story dwelling units can be modeled with each floor as a separate zone or with each dwelling unit as a separate zone. Because of the dwelling unit type structure, when a dwelling unit consists of two or three stories, each dwelling unit must be modeled as a separate zone. Two multi-family example files are included with the program using the less detailed approach. Both have 4 dwelling units per zone/floor, and one has central water heating.

When multi-family is selected, the zone data for HVAC and DHW are defined by creating the dwelling unit types (see Section 5.6). The dwelling unit type is one of the inputs used to build the zone information (see Figure 5-2).

NOTE: A duplex or townhome (an R-3 occupancy) must be modeled as multiple single-family buildings. Each dwelling unit will be a separate input file rather than modeling a building with multiple dwelling units.

Figure 5-2: Dwelling Unit Data



5.2.1.1 Name

This is a distinguishing piece of information to describe the zone or dwelling unit.

5.2.1.2 Dwelling Unit Type

Indicate which dwelling unit type contains the appliance data, HVAC, water heating and indoor air quality (IAQ) information for these dwelling units.

5.2.1.3 Count

This input is to specify how many of this dwelling unit type are included in this zone. If multiple dwelling units are included, this number is limited to one floor. In the above figure, the bottom floor has 780 x 4 = 3120 ft^2.

5.2.1.4 Conditioned Area

This data is captured from the dwelling unit type.

5.2.1.5 Washer Zone

This data is based on the input from the dwelling unit type indicating that this appliance is contained within the floor area of the dwelling unit.

5.2.1.6 Dryer Zone

This data is based on the input from the dwelling unit type indicating that this appliance is contained within the floor area of the dwelling unit.

5.3 Attic

The attic zone is where the roofing material (tile, asphalt shingles), radiant barrier, above and below deck insulation (as defined in the specified construction), as well as roofing characteristics (i.e., default or cool roof) are assigned.

NOTE: The 2016 standards assume an attic construction that meets prescriptive option B which has below deck insulation (modeled in the attic zone), and ducts installed in this high performance attic. The sample files include below deck insulation. The CF1R will include a special feature note if above or below deck insulation is modeled.

The compliance software models attics (up to two) as a separate thermal zone and includes the interaction with the air distribution ducts, infiltration exchange between the attic and the house, the solar gains on the roof deck and other factors. These interactions are illustrated in Figure 5-3.

5.3.1 Attic Zone Data

The software automatically creates an attic zone once you define a ceiling below an attic as part of the conditioned space or garage (see Figure 5-4).

If a second attic zone is needed, when defining the ceiling below attic in that zone, select create a new attic zone.

Figure 5-3: Attic Model Components

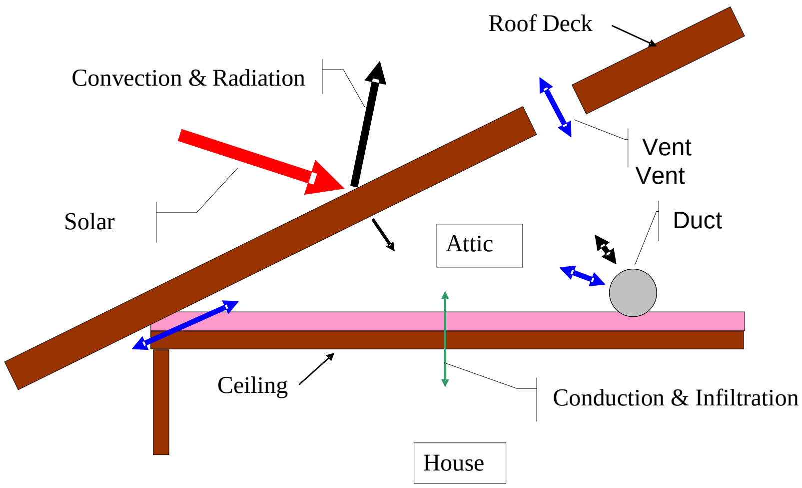
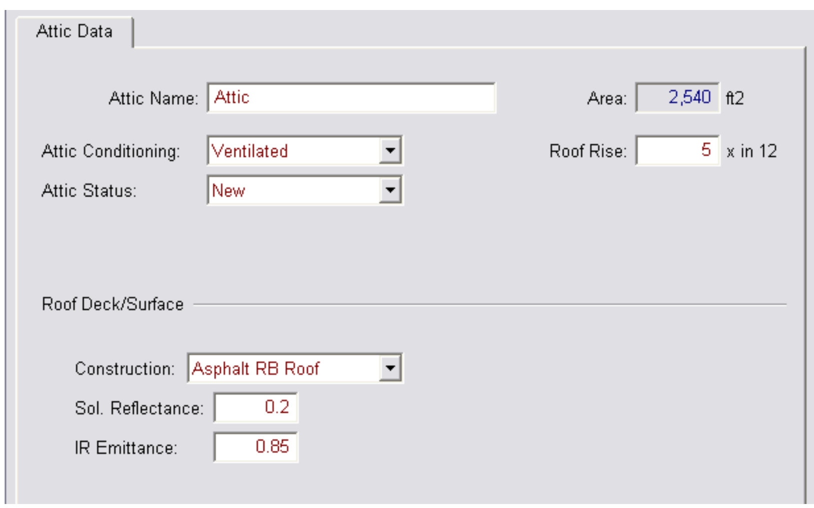


Figure 5-4: Attic Zone Data



5.3.1.1 Name

User-defined name. If the building plans have a unique identifier, that should be used here to assist in the plan checking and inspection processes.

5.3.1.2 Attic Conditioning

The conditioning type is set to either ventilated (typical attic) or unventilated. Ventilated or vented attic is typical construction. An unvented attic is sometimes called a sealed attic.

5.3.1.3 Roof Rise

Specify the roof rise or roof pitch, which is the number of feet the roof rises in a span of 12 feet (shown on elevations as 4:12 or 4 in 12). If there are multiple pitches you can enter the roof rise of the largest area of roof.

5.3.1.4 Area

The area is not a user input. The area is derived from the combination of ceilings below attic modeled as part of the conditioned and unconditioned zones.

5.3.1.5 Attic Status

Default is new. Other options include altered and existing for Existing+Addition+Alteration analysis.

5.3.1.6 Construction

The roof construction is the connection to an assembly that contains the roofing material (such as tile or asphalt shingles), radiant barrier, and other construction details, including above and below deck insulation, but not typical ceiling insulation (see more in Chapter 6, Construction Assemblies).

5.3.1.7 Solar Reflectance

The default aged solar reflectance is 0.10 for all roof types. The aged solar reflectance for a roof product published by the Cool Roof Rating Council (CRRC) (www.coolroofs.org) or calculated from the initial value using the equation in 3.7.1 of the 2016 Residential Compliance Manual. The aged solar reflectance measures the roofing product's ability to reflect solar heat. A higher value is better for warmer climates, so if a specific product color is unknown use a lower value among options to avoid having to recalculate compliance during construction.

If the roof membrane has a mass of at least 25 lb/ft^2 or any roof area that incorporates integrated solar collectors, the roof may assume the Package A solar reflectance value (see Section 5.3.2).

If the roof is a cathedral ceiling or rafter roof, the solar reflectance is defined as part of the ceiling (see Chapter 7, Building Envelope).

The roofing material and roof structure is specified via the ***Roof Deck/Surface: Construction***, which is accessed under ***construction assemblies*** or by creating a new ***roof construction assembly*** as discussed in Chapter 6, Construction Assemblies.

5.3.1.8 IR Emittance

The default infrared or thermal emittance (or emissivity) for all roofing materials is 0.85. Otherwise, enter the emittance value published by the Cool Roof Rating Council (CRRC) (www.coolroofs.org).

If the roof membrane has a mass of at least 25 lb/ft^2 or for any roof area that incorporates integrated solar collectors, the roof may assume the Package A emittance value (see Section 5.3.2).

If the roof is a cathedral ceiling or rafter roof, the emittance is defined as part of the roof/ceiling rather than an attic (see Chapter 7, Building Envelope).

The roofing material and roof structure is specified via the ***Roof Deck/Surface: Construction*** which is accessed under ***construction assemblies*** or by creating a new ***roof construction assembly*** which is discussed in Chapter 6, Construction Assemblies.

5.3.2 Cool Roof

Cool roof is a term that refers to the ability of roofing materials to both reflect and absorb solar heat. It typically means a high solar reflectance and a high emittance, but can also be a low emittance and a very high solar reflectance.

Although specific values are not mandatory, Package A (the basis of the standard design) contains a minimum requirement for solar reflectance and emittance that varies by climate zone and roof slope. A low slope roof has a ratio of rise to run (or pitch) of 2 in 12 or less (≤9.5 degrees from the horizontal). In climate zones 13 and 15 a low slope roof is compared to a roof with 0.63 aged solar reflectance and 0.85 emittance. A steep slope roof has a ratio of rise to run of greater than 2:12 (>9.5 degrees from the horizontal). In climate zones 10 through 15 a steep slope roof is compared to a roof with 0.20 aged solar reflectance and 0.85 emittance.

The CF1R reflects that a cool roof is modeled when a reflectance of 0.20 or greater is modeled. If a reflectance value greater than 0.10 but less than 0.20 is modeled, the CF1R reflects a special features message that the building contains a non-standard roof reflectance.

5.3.3 Low Slope Aggregate Roof

Although more common in nonresidential applications, aggregate is a roofing product made up of stone or gravel material that is used as a finish surface for low-sloped roofing. A compliance option (see Publication CEC-400-2012-018-SF) allows for default efficiencies when the material is tested to the initial solar reflectance value shown in Table 5-1. The compliance option allows compliance using the default values for aged solar reflectance and emittance values shown in the table.

Table 5-1: Solar Reflectance and Emittance for Aggregate Materials

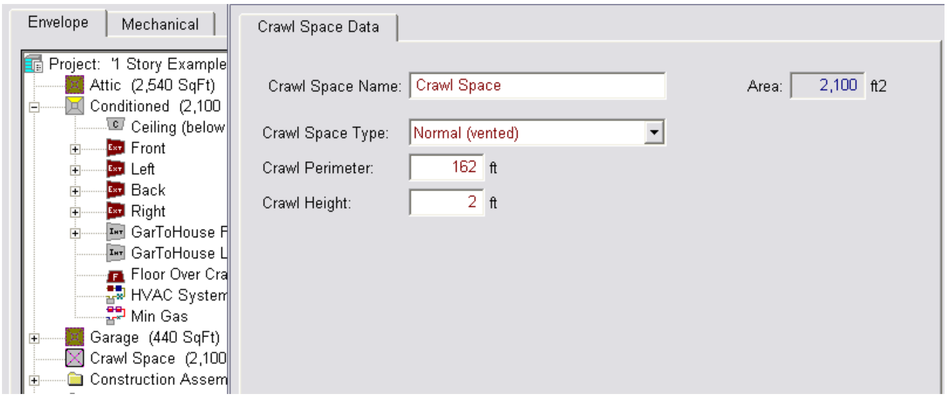
Aggregate Size	Tested Initial Solar Reflectance	Default Aged Solar Reflectance	Default Emittance
Built-Up Roofs Size 6-8 confirming to ASTM D448 and D1863	0.50	0.48	0.85
Ballasted Roofs Size 2-4 confirming to ASTM D448	0.45	0.40	0.85

5.4 Crawl Space

The software automatically creates a crawl space zone when a floor over crawl space is defined. The floor characteristics are more fully discussed in Chapter 6, Construction Assemblies.

The crawl space zone (see Figure 5-5) is created using the area specified for the raised floor above the crawl space and the floor elevation to set the area and height of the crawl space.

Figure 5-5: Crawl Space Zone



5.4.1 Crawl Space Zone Data

5.4.1.1 Crawl Space Name

User-defined name. If the building plans have a unique identifier, that should be used here to assist in the plan checking and inspection processes.

5.4.1.2 Crawl Space Type

The default type (and only option implemented) is a vented crawl space. Of the three types: (1) normal vented crawl space (has a conditioned space above with raised floor insulation), (2) insulated with reduced ventilation [as used in the Building Code], or (3) sealed and mechanically ventilated crawl space (also called a controlled ventilation crawl space or CVC). For CVC credit installation requirements see *Reference Appendices*, Residential Appendix RA 4.5.1.

5.4.1.3 Crawl Perimeter

The length (in feet) of the perimeter (similar to the slab edge length for a slab on grade floor).

5.4.1.4 Crawl Height

The depth/height of the crawl space, in feet (minimum of 2 feet). The same value is used for the floor elevation and the zone bottom.

5.5 Garage

An attached unconditioned space is modeled as a separate unconditioned zone. If the garage is not attached to the building, it is not modeled. When the project was defined as having an attached garage, the software created an unconditioned zone (see Figure 5-6). The buffering effect of this zone is modeled to accurately represent the building.

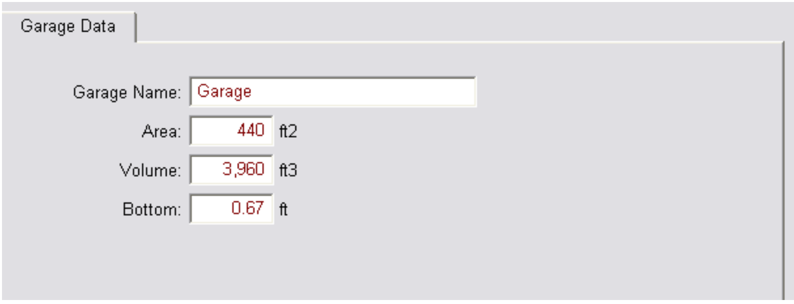
The walls between the house and garage are modeled as part of the conditioned space as an interior wall, not in the garage. For details on modeling the walls, ceiling, slab floor and garage door, see Chapter 6, Construction Assemblies and Chapter 7, Building Envelope.

To delete a garage zone, first uncheck that the building has an attached garage (on the Building tab), then the garage zone can be deleted.

When a multi-family building is modeled as having an attached garage, the software creates only one unconditioned garage zone. To represent a garage attached to each unit increase the size of the single garage zone to have the area and all the surfaces of all the garages combined.

5.5.1 Garage Zone Data

Figure 5-6: Garage Zone Data



5.5.1.1 Garage Name

User-defined name. If the building plans have a unique identifier, that should be used here to assist in the plan checking and inspection processes.

5.5.1.2 Area

The area of the garage or unconditioned space, in square feet (ft^2).

5.5.1.3 Volume

Volume of the space in cubic feet (ft^3) .The program defaults the volume based on the average ceiling height defined for the conditioned zone.

5.5.1.4 Bottom

Floor elevation or distance above grade of the surface of the floor (in feet). This can be a negative value for surfaces below grade.

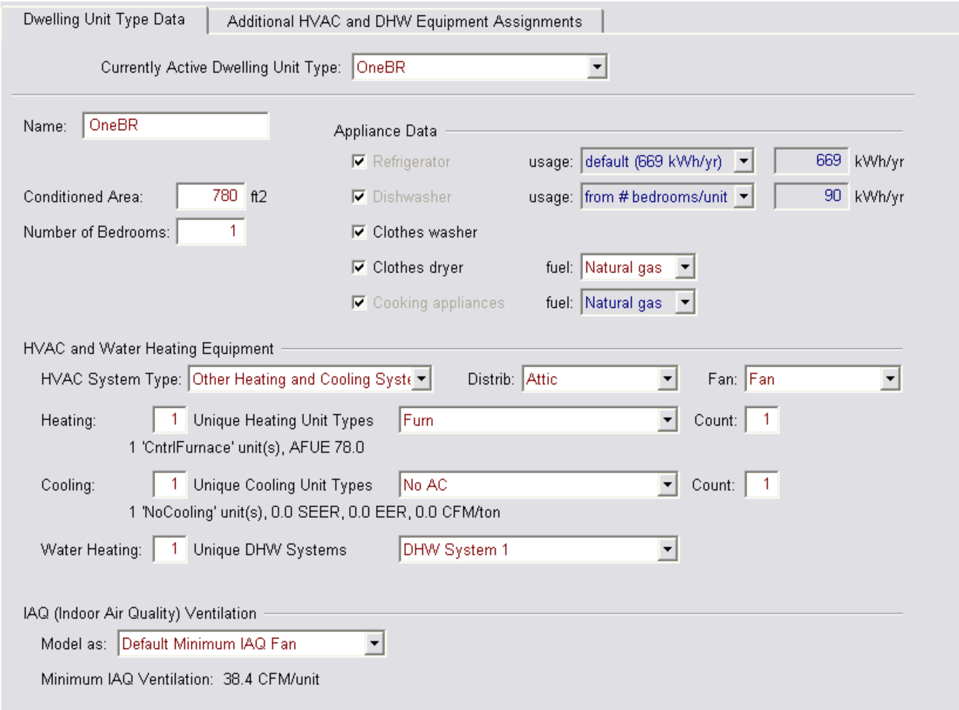
5.6 Dwelling Unit Types

Dwelling unit types are used only for buildings with multiple dwelling units, not for single-family construction.

NOTE: When defining the space conditioning system, please use short descriptive names. To meet the reporting requirements needed by HERS raters for each dwelling unit, the report created by the software uses a combination of the heating, cooling, distribution and fan system names to identify those systems and their associations with the dwelling unit.

Each dwelling unit type is created based on its characteristics (see Figure 5-7). For example, 1-bedroom units with 780 ft², 2-bedroom units with 960 ft² are created defining the HVAC equipment, water heating conditions, and IAQ ventilation. Once created, the dwelling unit types are used in defining the zone (see Section 5.2).

Figure 5-7: Dwelling Unit Type



5.6.1.1 Name

This is a distinguishing piece of information to describe the dwelling unit.

5.6.1.2 Conditioned Area

The number of square feet in the one dwelling unit type being defined.

5.6.1.3 # Bedrooms

Number of bedrooms in the dwelling unit used to establish the minimum ventilation requirements.

5.6.1.4 Appliance Data

The appliance information does not affect compliance with the standards but does affect the "appliances and miscellaneous energy use" as reported on the CF1R.

Check the box to indicate if an appliance is located within a conditioned zone of the dwelling unit. The fuel type choices for the clothes dryer and cooking appliances is gas (gas is assumed to be natural gas, if available, otherwise it is propane) or electricity.

5.6.1.5 HVAC and Water Heating Equipment

Space conditioning and water heating equipment is entered as described in Chapter 8 and 9. If multiple pieces of equipment with identical characteristics are used, enter that in the "count" field. If multiple pieces of different equipment are modeled (the worst case will be assumed), enter that as "unique . . ." types or systems and enter the specifications under the tab called Additional HVAC and DHW Equipment Assignments.

As noted at the beginning of Section 5.6, keep system names as short as possible to accommodate CF1R reporting requirements.

5.6.1.6 IAQ (Indoor Air Quality) Ventilation

Used to identify that a default minimum IAQ fan is being used or another method of meeting the mandatory ventilation requirement. Required minimum IAQ ventilation, in CFM/dwelling unit, is displayed based on conditioned floor area and number of bedrooms.

Chapter 6. Construction Assemblies

CBECC-Res does not use the assembly U-factors from the *Reference Appendices*, Joint Appendix 4. Instead, assemblies are created inside the program. As you build an assembly, the screen displays a U-factor and R-value only as a guide for the user to see how the assembly compares to the standard design assembly (standards, Section 150.1(c), Table 150.1-A "Package A"). Model the closest insulation R-value without exceeding the product's R-value.

In addition to typical wood-frame construction, CBECC-Res can model wood framed walls with advanced wall framing (AWF), steel-frame wall construction, concrete, masonry, insulated concrete form (ICF), brick, below grade, log, strawbale, and structurally insulated panels (SIPs). It does not yet model steel framed ceilings and floors.

6.1 Cavity R-Value

When completing assemblies, use the compressed product R-value for the cavity space (Table 6-1).

Table 6-1: Compressed Insulation R-values

Nominal Lumber Size	Cavity Depth	Compressed R-value Inside Cavity for Product Rated as…										
		R-38	**R-38C**	**R-30**	**R-30C**	**R-25**	**R-22**	**R-21C**	**R-19**	**R-15C**	**R-13**	**R-11**
2x12	11-1/4"	37	38	30								
2x10	9-1/4"	32	35	30	30	25						
2x8	7-1/4"	27	30	25	27	24	22	21	19			
2x6	5-1/2"			21	22	20	19	21	18			
2x4	3-1/2"						14	15	13	15	13	11
2x3	2-1/2"									11	10	8.9
2x2	1-1/2"										6.6	6.2
2x1	3/4"											
Standard Product Thickness		12"	10-1/4"	9-1/2"	8-1/4"	8"	6-3/4"	5-1/2"	6-1/4"	3-1/2"	3-1/2"	3-1/2"

6.2 Assembly Types

The types of assemblies that can be created in the program are:

Exterior wall
Interior wall (also used for demising walls or walls between house and garage)
Underground wall
Attic roof
Cathedral roof
Ceiling below attic
Interior ceiling

Slab on Grade
Exterior floor
Floor over crawl space
Interior floor
Underground floor

Also included are some typical assemblies:

T24-2016 exterior wall wood 2x4
T24-2016 R38 ceiling below attic
T24-2016 R30 ceiling below attic
T24-2016 R19 exterior floor
T24-2016 R19 floor over crawl
T24-2016 R15 interior wall
T24-2016 R19 interior floor

6.3 Mandatory Envelope Requirements

The mandatory insulation requirements (standards Section 150.0(a)-(d)) for new construction are based on a wood-framed assembly:

- Ceilings or rafter roofs with R-30, or a weighted average U-factor of 0.031 (formerly R-19).
- Raised floor insulation with R-19 or a weighted average U-factor of 0.037 (formerly R-13).
- Framed wall insulation is either (1) R-13 in a wood-framed 2x4 wall or an overall U-factor of 0.102, or (2) R-19 in a wood-framed 2x6 wall or an overall U-factor of 0.074.

Under the Help button is a summary of these minimum mandatory requirements which may be particularly helpful if building with steel framed walls. These walls require sheathing insulation in order to comply with the mandatory requirement.

Mass or unframed walls do not have a minimum mandatory insulation requirement.

6.4 Spray Foam Insulation (SPF)

The R-values for spray applied polyurethane foam insulation differ depending on whether the product is closed cell (default R-5.8/inch) or open cell (default R-3.6/inch). When completing a construction assembly for the roof/ceiling, walls, or floor, use the values shown in Table 6-2 to determine the default R-value for the cavity size. Alternatively, with HERS verification and additional documentation requirements, a higher than default value may be used, as indicated by checking the box for non-standard spray foam in cavity as part of the construction assembly (see *Reference Appendices*, Residential Appendix RA3.5.6).

Table 6-2: Required Thickness Spray Foam Insulation

Required R-values for SPF insulation	R-11	R-13	R-15	R-19	R-21	R-22	R-25	R-30	R-38
Required thickness closed cell @ R5.8/inch	2.00 inches	2.25 inches	2.75 inches	3.50 inches	3.75 inches	4.00 inches	4.50 inches	5.25 inches	6.75 inches
Required thickness open cell @ R3.6/inch	3.0 inches	3.5 inches	4.2 inches	5.3 inches	5.8 inches	6.1 inches	6.9 inches	8.3 inches	10.6 inches

To receive the most credit, spray foam insulation may be combined with improved construction quality, which is modeled at the project level (see Section 4.7.1.4) and requires HERS verification (*Reference Appendices,* Residential Appendix RA3.5).

6.4.1 Medium Density Closed-Cell SPF Insulation

The default R-value for spray foam insulation with a closed cellular structure is R-5.8 per inch, based on the installed nominal thickness of insulation. Closed cell insulation has an installed nominal density of 1.5 to less than 2.5 pcf.

6.4.2 Low Density Open-Cell SPF Insulation

The default R-value for spray foam insulation with an open cellular structure is calculated as an R-3.6 per inch, calculated based on the nominal required thickness of insulation. Open cell insulation has an installed nominal density of 0.4 to 1.5 pounds per cubic foot (pcf).

6.5 Advanced Wall Framing

Advanced wall framing (AWF) is applicable to wood framed walls that meet the installation criteria from *Reference Appendices*, Joint Appendix JA 4.1.6 to reduce the amount of wood used for framing. The construction technique, referred to as an advanced wall system, incorporates the following construction techniques:

- 24-inch on center framing,
- Eliminates intermediate framing for cripple and king studs,
- Uses single top plates, double stud corners, and in-line (i.e., stack) framing to maintain continuity of transferring live loads of roof framing to wall framing (which allows roof sheathing and exterior siding to be installed at full widths),
- Reduces framing for connections at interior partition walls (i.e., T-walls), and
- Reduces window and door header sizes.

6.6 Attic Roof Terminology

6.6.1 Attic

Attic is an enclosed space directly below the roof deck and above the ceiling beams. The attic component of the building contains the roof and attic, and any insulation that occurs at the roof deck. In CBECC-Res, the attic is a separate zone. A typical attic does not include the ceiling or ceiling insulation, which is modeled as part of the ceiling below attic. Up to two attics can be defined in a building.

6.6.2 Cathedral Ceiling

A cathedral ceiling or rafter roof is modeled when there is no attic above with a ceiling below. A cathedral ceiling typically has insulation installed between the rafters and may be flat or sloped. The insulation is in contact with the ceiling and there is typically a one-inch air gap above the insulation so that moisture can be vented. Whether there is an air space required above the insulation, or the entire cavity is filled with insulation with no venting, is up to the local building official.

6.6.3 Ceiling Below Attic

The ceiling is defined as the interior upper surface of a space separating it from an attic, plenum, indirectly or directly conditioned space or the roof assembly, which has a slope less than 60 degrees from horizontal (definition from *Reference Appendices*).

6.6.4 Knee Wall

A knee wall is a sidewall separating conditioned space from attic space under a pitched roof. Knee walls are modeled in CBECC-Res as an interior wall (although actually a demising surface) and are insulated as an exterior wall.

6.6.5 Low Slope Roof

A low slope roof has a ratio of rise to run (or pitch) of 2 in 12 or less (≤9.5 degrees from the horizontal). Although a specific value is not mandatory, the standard design for a low slope roof in climate zones 13 and 15 is a 0.63 aged solar reflectance.

If the roof membrane has a mass of at least 25 lb/ft^2 or the roof area incorporates integrated solar collectors, the roof may assume the standard design value for solar reflectance (exceptions to Section 150.1(c)11).

6.6.6 Radiant Barrier

A radiant barrier installed below the roof decking reduces radiant heat to any ducts and insulation below. While not a mandatory requirement, the standard design used to establish a building’s energy budget has a radiant barrier in climate zones 2-15. Installation requirements for a radiant barrier (see CF2R form) require the radiant barrier in the garage/unconditioned space if a radiant barrier is installed in the attic over conditioned space and that same attic is over the unconditioned space. The radiant barrier is modeled as part of the attic zone construction (see Section 6.7.2.7) Radiant barrier cannot be installed in a cathedral ceiling.

6.6.7 Roof

A roof is defined as the outside cover of a building or structure including the structural supports, decking, and top layer that is exposed to the outside with a slope less than 60 degrees from the horizontal.

When Package A (the basis of the standard design) contains a minimum requirement for solar reflectance and emittance, the values vary by roof slope. A low slope roof has a ratio of rise to run (or pitch) of 2 in 12 or less (≤9.5 degrees from the horizontal). A steep slope roof has a ratio of rise to run of greater than 2:12 (>9.5 degrees from the horizontal). Although there is no mandatory cool roof requirement, these are the characteristics used to establish the standard design, so there will be an energy penalty when default roof values are used.

6.6.8 Steep Slope Roof

A steep slope roof has a ratio of rise to run of greater than 2:12 (>9.5 degrees from the horizontal). Although a specific value is not mandatory, the standard design for climate zones 10 through 15 is an aged solar reflectance of 0.20.

If the roof membrane has a mass of at least 25 lb/ft^2 or the roof area incorporates integrated solar collectors, the roof may assume the standard design value for solar reflectance (exceptions to Section 150.1(c)11).

6.7 Attic Construction

Attic constructions are accessed by creating a new attic roof construction, or modifying an existing assembly in the list of ***Construction Assemblies***. The attic construction is the zone containing the roofing material (e.g., tile, asphalt), above or below deck insulation, and the radiant barrier. A typical attic does not include the ceiling or ceiling insulation modeled as the ceiling below attic. There is no orientation associated with an attic roof.

6.7.1 Attic Construction Data

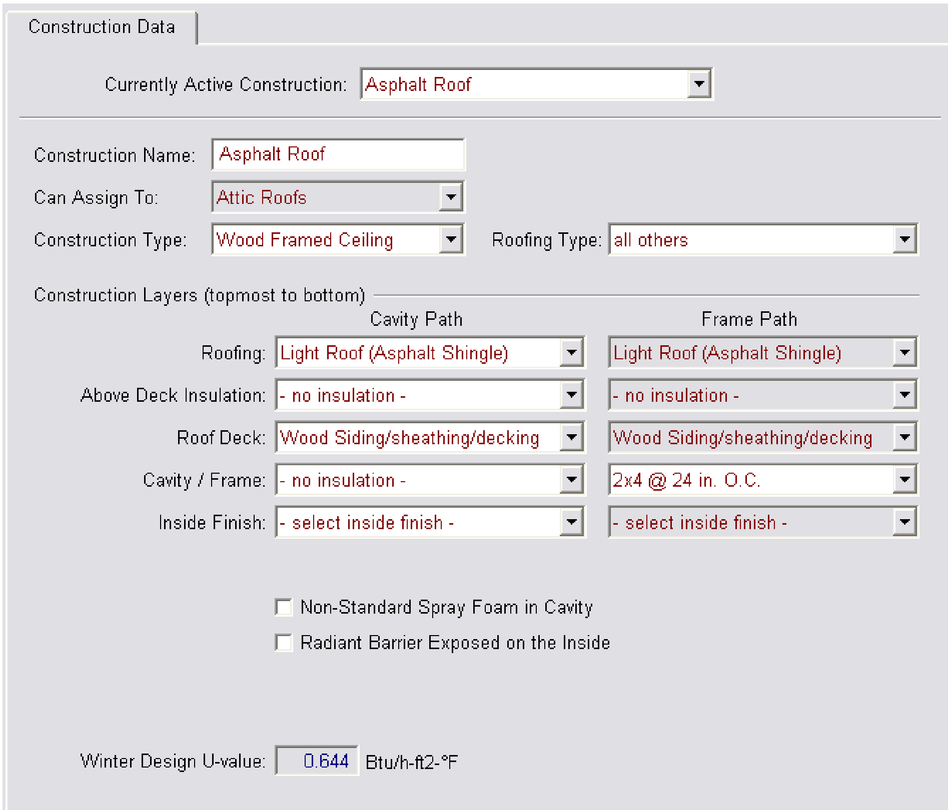
6.7.1.1 Construction Name

User-defined name. If the building plans have a unique identifier, that should be used here to assist in the plan checking and inspection processes.

6.7.1.2 Can Assign To

This is a fixed field. To create a new assembly type, at the zone level, select <create> and pick the appropriate construction assembly type.

Figure 6-1: Attic Construction Data



6.7.1.3 Construction Type

Options are wood framed, built-up roof, steel framed ceiling [not yet implemented], and SIP ceiling.

6.7.1.4 Roofing Type

Pick the appropriate roof type as either: (1) steep slope roof tile, metal tile, or wood shakes; or (2) all other. Options available for the construction layer “Roofing” vary based on this selection.

6.7.2 Attic Construction Layers

Working from the top to the bottom of the construction layers:

6.7.2.1 Roofing

The available types will depend on the roofing type specified above. Types include light roof, roof tile, asphalt, gravel, tile, heavy ballast or pavers, very heavy ballast or pavers, metal tile, and green hybrid roofing tile.

6.7.2.2 Above Deck Insulation

If above deck insulation is shown as part of the attic details, model the R1 to R60 insulation.

6.7.2.3 Roof Deck

The default is wood siding/sheathing/decking.

6.7.2.4 Cavity/Frame

List the compressed R-value of cavity insulation (see Section 6.1) in the cavity column. This is the insulation that is installed at the roof. Typical insulation is modeled as part of the ceiling below attic. The framing column is to indicate the size and spacing of the framing. Options are 2x4 to 2x12 with 16- or 24-inch on center framing).

6.7.2.5 Inside Finish

This is the inside finish (if any), of the attic space, and does not include the ceiling below the attic. A layer of gypsum is not typically included.

6.7.2.6 Non-Standard Spray Foam in Cavity

This check box identifies additional documentation and HERS verification requirements due a claimed R-value that exceeds the default assumption of R-5.8 per inch for closed cell and R-3.6 per inch for open cell (see Section 6.4).

6.7.2.7 Radiant Barrier Exposed on the Inside

This check box identifies whether a radiant barrier is being installed in the attic.

6.8 Ceiling Below Attic and Interior Ceilings

The ceiling below attic is typically where insulation is installed when it separates conditioned space from the attic zone (Figure 6-2).

Interior ceilings are used to define surfaces separating conditioned space from another conditioned space or an enclosed unconditioned space.

6.8.1 Ceiling Construction Data

6.8.1.1 Construction Name

User-defined name. If the building plans have a unique identifier, that should be used here to assist in the plan checking and inspection processes.

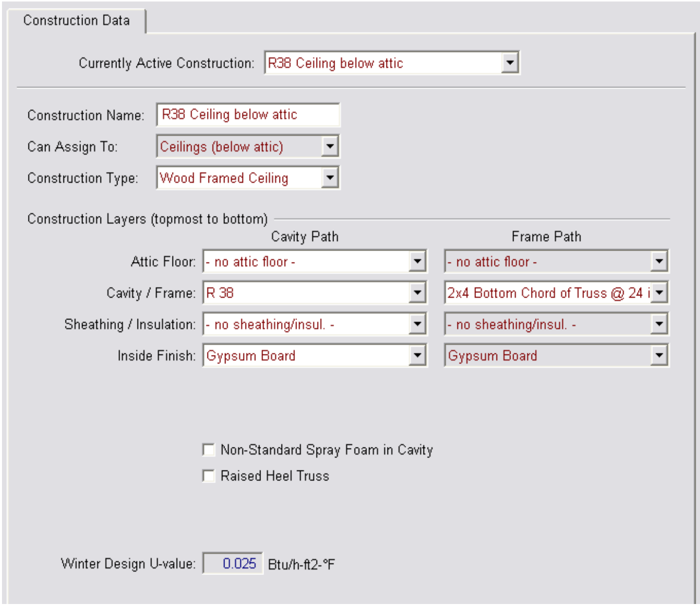
6.8.1.2 Can Assign To

This is a fixed field. To create a different assembly type, at the zone level, pick create and select the appropriate construction assembly type.

6.8.1.3 Construction Type

Options are wood framed or steel framed [not yet implemented].

Figure 6-2: Ceiling Below Attic Assembly



6.8.2 Ceiling Construction Layers

6.8.2.1 Attic Floor

The available types include no attic floor and wood siding/sheathing/decking.

6.8.2.2 Cavity/Frame

List the compressed R-value of cavity insulation (see Section 6.1) in the cavity column. In the framing column select the size of the framing and the spacing, such as 2x12 with 24-inch on center framing, or 2x4 roof truss at 24-inches on center.

6.8.2.3 Sheathing/Insulation

List the sheathing or insulation layer. Options are none, gypsum board, wood sheathing, and R1 to R60 insulation.

6.8.2.4 Inside Finish

This is the inside finish (if any), of the attic space. A layer of gypsum is typical.

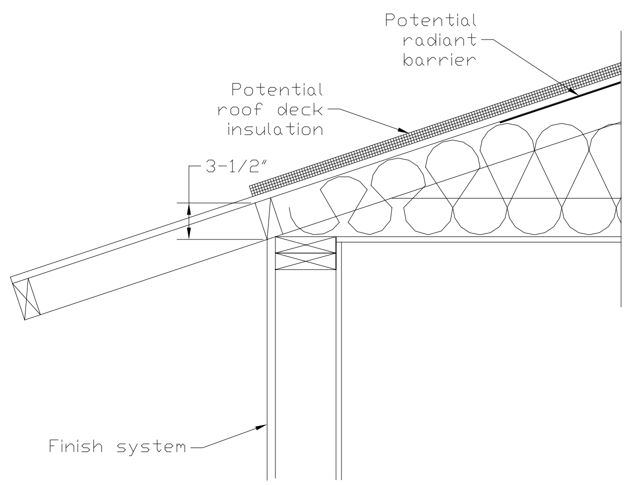
6.8.2.5 Non-Standard Spray Foam in Cavity

This check box identifies additional documentation and HERS verification requirements due a claimed R-value that exceeds the default assumption of R-5.8 per inch for closed cell and R-3.6 per inch for open cell (see Section 6.4).

6.8.2.6 Raised Heel Truss

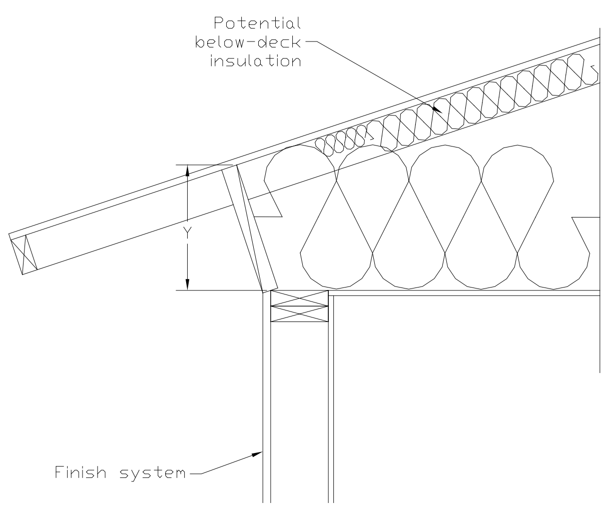
Check box to indicate if there is a raised heel truss and its height (in inches). With a standard roof truss (Figure 6-3) the depth of the ceiling insulation is restricted to the space left between the roof deck and the wall top plate for the insulation path and the space between the bottom and top chord of the truss in the framing path. If the modeled insulation completely fills this space, there is no attic air space at the edge of the roof. Heat flow through the ceiling in this attic edge area is directly to the outside both horizontally and vertically, instead of to the attic space.

Figure 6-3: Section at Attic Edge with Standard Truss



A raised heel truss (Figure 6-4) provides additional height at the attic edge that, depending on the height and the ceiling insulation, can either reduce or eliminate the attic edge area and its thermal impact.

Figure 6-4: Section at Attic Edge with a Raised Heel Truss

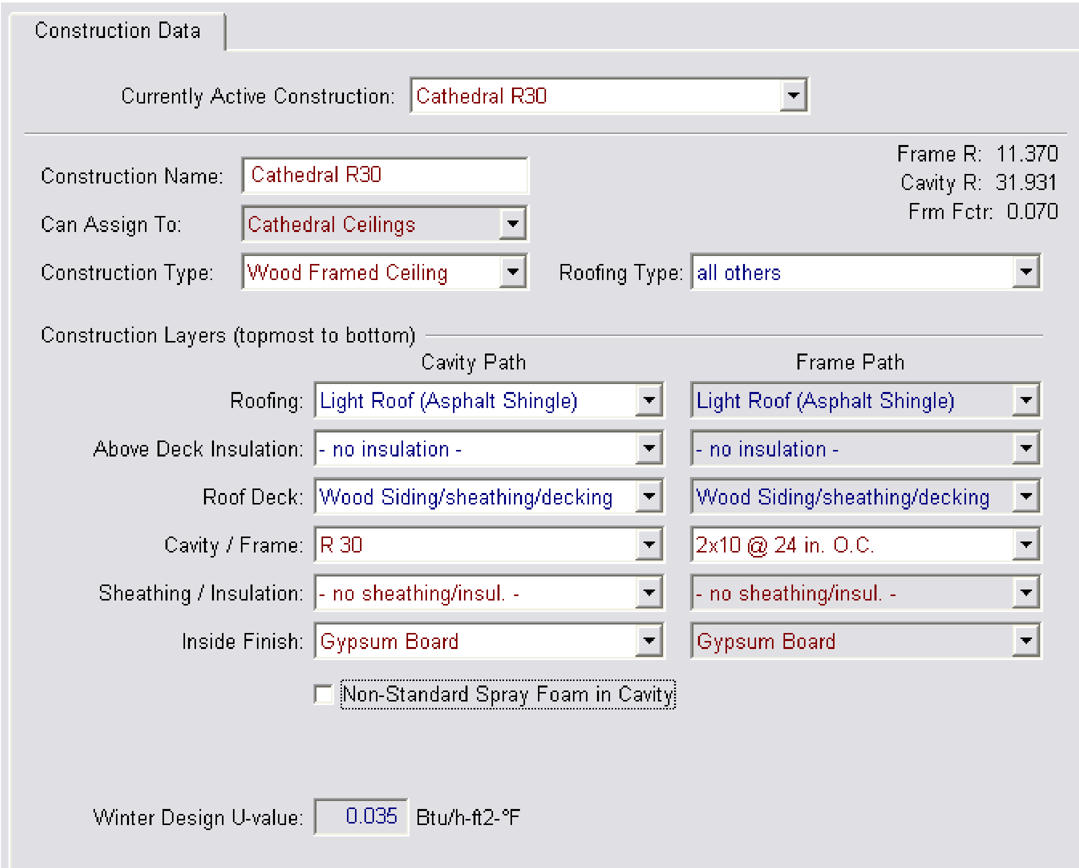


6.9 Cathedral Ceiling

6.9.1 Cathedral Ceiling Construction Data

Each surface facing a different orientation will be modeled as a separate surface (see Figure 7-3 and Section 7.2.2).

Figure 6-5: Cathedral Ceiling



6.9.1.1 Construction Name

User-defined name.

6.9.1.2 Can Assign To

This is a fixed field. To create a new assembly type, at the zone level, pick create and select the appropriate construction assembly type.

6.9.1.3 Construction Type

Options are wood framed, built up roof, steel framed [not yet implemented], and SIP ceiling.

6.9.1.4 Roofing Type

Pick the appropriate roof type as either: (1) steep slope roof tile, metal tile, or wood shakes; or (2) all other. Options available for the construction layer "Roofing" vary based on this selection.

6.9.2 Cathedral Ceiling Construction Layers

6.9.2.1 Roofing

The available types will depend on the roofing type specified above. Types include light roof, roof tile, asphalt, gravel, tile, heavy ballast or pavers, very heavy ballast or pavers, metal tile, and green hybrid roofing tile.

6.9.2.2 Above Deck Insulation

Options include no insulation, or R1 to R60.

6.9.2.3 Roof Deck

The default is wood siding/sheathing/decking.

6.9.2.4 Cavity/Frame

List the compressed R-value of cavity insulation (see Section 6.1) in the cavity column. The framing column is to indicate the size of the framing and the spacing (e.g., 2x12 with 24-inch on center framing). Also included is an option for a 2x4 bottom chord of truss at 24-inches on center.

6.9.2.5 Sheathing/Insulation

List the sheathing or insulation layer. Options are no sheathing/insulation, gypsum board, wood sheathing, and R1 to R60 insulation.

6.9.2.6 Inside Finish

This is the inside finish (if any), of the roof. A layer of gypsum is typically included.

6.9.2.7 Non-Standard Spray Foam in Cavity

This check box identifies additional documentation and HERS verification requirements due a claimed R-value that exceeds the default assumption of R-5.8 per inch for closed cell and R-3.6 per inch for open cell (see Section 6.4).

6.10 Walls

Wall constructions are accessed by creating a new wall inside the conditioned zone or creating/ modifying an assembly in the list of ***Construction Assemblies***. Walls (Figure 6-6) are defined from the inside surface to the outside. Interior walls are modeled the same as exterior walls. For a description of when a wall is modeled as interior (for example, demising or walls separating the house from the garage), see Section 6.10.6.

CBECC-Res can currently model wood or steel-framed, SIP, mass, straw bale and log walls, advanced wall framing and underground walls.

6.10.1 Interior and Exterior Wall Construction Data

6.10.1.1 Construction Name

User-defined name.

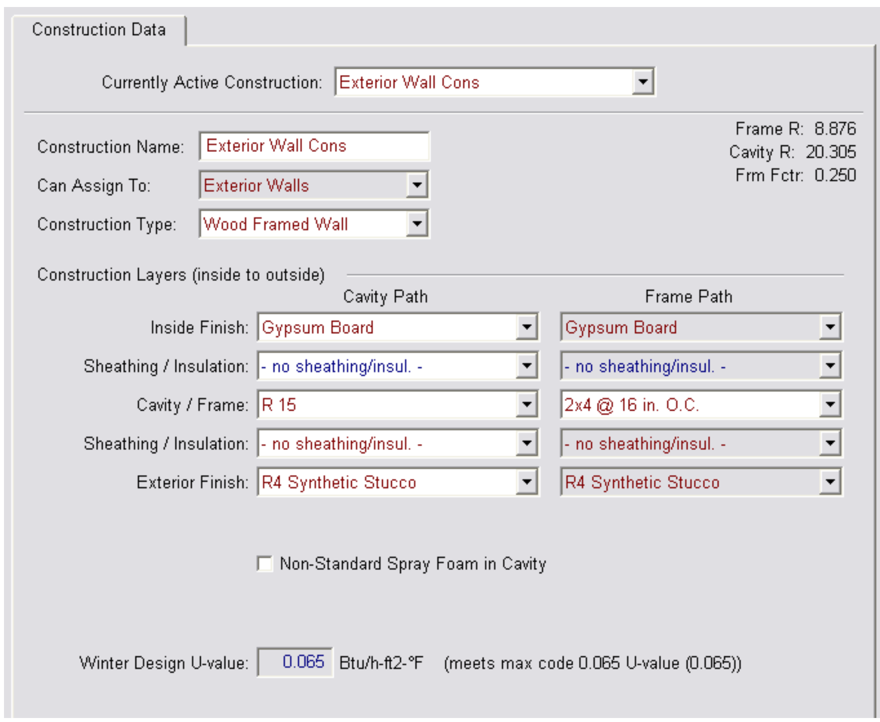
6.10.1.2 Can Assign To

This is a fixed field. To create a new assembly type, at the zone level pick <create> and select the appropriate construction assembly type.

6.10.1.3 Construction Type

Options available include wood framed and steel framed (Section 6.10.2), unframed wall types are concrete, Insulated Concrete Form (ICF), brick, hollow unit masonry, adobe, strawbale, log (Section 6.10.3) and structurally insulated panels (SIPs) (Section 6.10.4).

Figure 6-6: Wood-Framed Wall Construction Data



6.10.2 Framed Wall Construction Layers (inside to outside)

6.10.2.1 Inside Finish

Default value gypsum board.

6.10.2.2 Sheathing/Insulation

List the sheathing or insulation layer in a wall on the inside surface (conditioned space side) of the framed wall, or the size and material of furring on the inside surface. Options are none, gypsum board, wood sheathing, and R 1to R 60 insulation.

6.10.2.3 Cavity/Frame

List the compressed R-value of cavity insulation (see Section 6.1) in the cavity column. The framing column is to indicate the size of the framing and the spacing (e.g., 2x6 with 16-inch on center framing), or advanced wall framing (AWF), see Section 6.5.

6.10.2.4 Sheathing/Insulation

List the sheathing or insulation layer on the outside of the framing. Do not enter 1-coat stucco here. Options are none, gypsum board, wood sheathing, and R 1to R 60 insulation.

6.10.2.5 Exterior Finish

Exterior finish options are wood siding, 3 coat stucco, or R4 synthetic stucco (also known as 1-coat stucco).

6.10.2.6 Non-Standard Spray Foam in Cavity

This check box identifies that additional documentation and HERS verification requirements apply because the claimed R-value exceeds the default assumption of R-5.8 per inch for closed cell and R-3.6 per inch for open cell (see Section 6.4).

6.10.3 Mass or Other Unframed Walls

6.10.3.1 Inside Finish

Default value gypsum board.

6.10.3.2 Insulation/Furring

List the insulation installed if the walls are furred on the inside. Select the thickness and type of furring which is 0.5-inch to 5.5-inch thick wood or metal.

6.10.3.3 Mass Layer

List the material which varies based on the construction type and includes concrete, brick, light weight (LW), medium weight (MW) or normal weight (NW) concrete masonry units (CMU) with solid grout, insulated cores, or empty cores. Select the thickness.

6.10.3.4 Insulation/Furring

List the insulation installed if the walls are furred on the outside. Select the thickness and type of furring which is 0.5-inch to 5.5-inch thick wood or metal.

6.10.3.5 Exterior Finish

Exterior finish options are wood siding, 3 coat stucco, or R4 synthetic stucco (also known as 1-coat stucco) and wood siding/sheathing/decking.

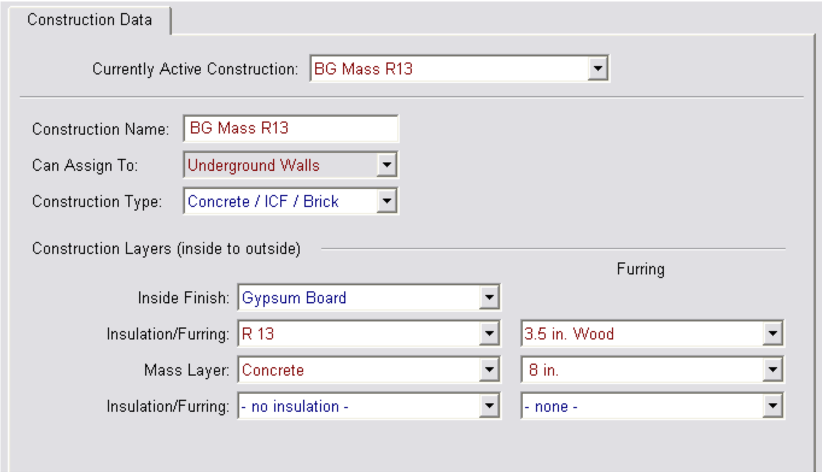
6.10.3.6 Non-Standard Spray Foam in Cavity

This check box identifies that additional documentation and HERS verification requirements apply because the claimed R-value exceeds the default assumption of R-5.8 per inch for closed cell and R-3.6 per inch for open cell (see Section 6.4).

6.10.4 Below Grade Walls

Underground or below grade walls that are concrete/ICF/Brick can be created using the right-click/create underground walls option on the construction assemblies list (see Figure 6-7). With the exception of the exterior surface (which is assumed to be soil), please see Section 6.10.3 above for wall inputs.

Figure 6-7: Below Grade Walls



6.10.5 Structurally Insulated Panels (SIPs)

6.10.5.1 Inside Finish

Default value gypsum board.

6.10.5.2 Sheathing/Insulation

List the continuous insulation layer on the inside surface (conditioned space side) of the SIP wall. Options are R1 to R60 insulation.

6.10.5.3 Panel Rated R (@ 75 F)

Specify the panel's rated R-value at 75 degrees in the cavity path (R14 to R55). In the frame path list the thickness of the panel and whether it is or is not OSB.

6.10.5.4 Sheathing/Insulation

List the continuous insulation layer on the outside surface of the SIP wall. Options are R1 to R60 insulation.

6.10.5.5 Exterior Finish

Exterior finish options are wood siding, 3 coat stucco, or R4 synthetic stucco (also known as 1-coat stucco) and wood siding/sheathing/decking.

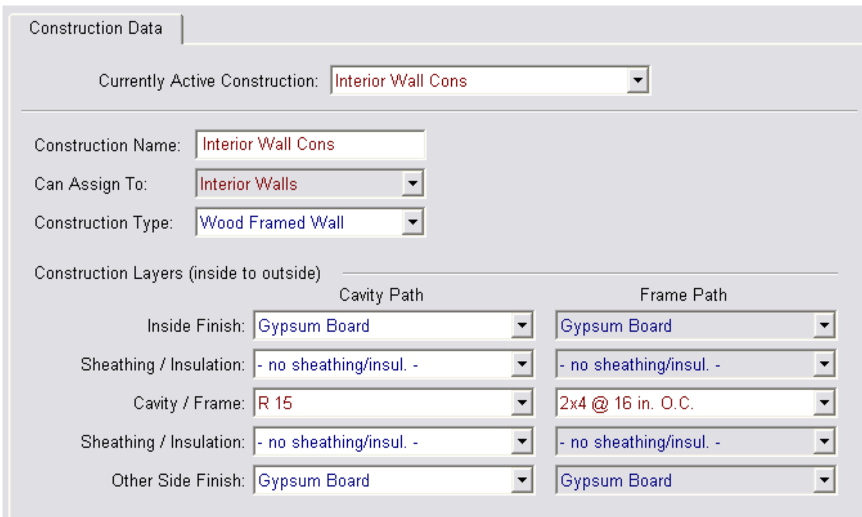
6.10.6 Demising and Interior Walls

Walls separating conditioned space from unconditioned space (e.g., from house to garage, knee walls) are modeled in the conditioned space as interior, although actually demising walls. In creating the building envelope, the wall will have conditioned space on one side and unconditioned space or zone on the other side.

When defining multi-family buildings, party walls separating zones are defined as part of both zones in which they occur. The box indicating that there is a dwelling unit on the other side is checked.

When the wall is an interior or demising wall, both the inside and outside surfaces are gypsum board, and there will be no solar gains on the unconditioned side. Knee walls are insulated as a wall.

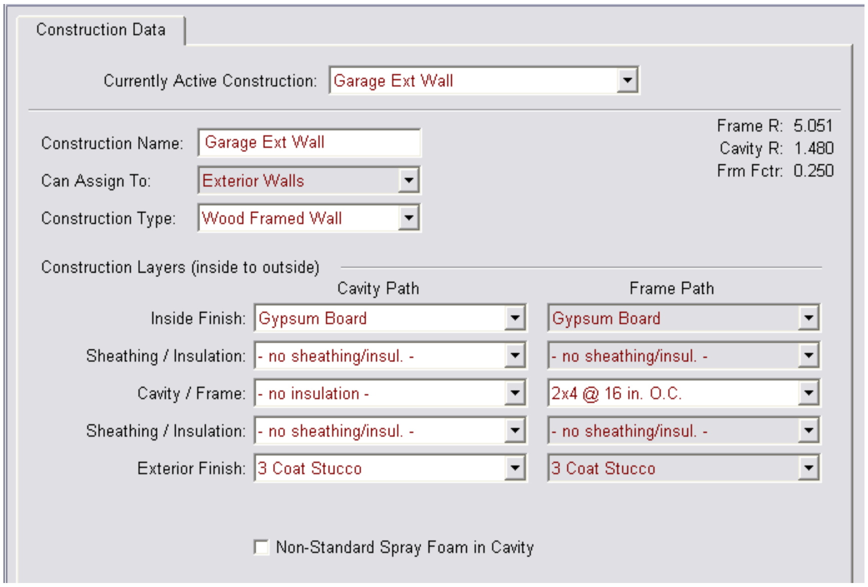
Figure 6-8: Interior Walls



6.10.7 Garage Exterior Walls

The outermost walls of the garage wall or unconditioned storage space, which are modeled as part of an unconditioned zone, typically do not have insulation (see Figure 6-9).

Figure 6-9: Uninsulated Exterior Wall



6.11 Floors

Raised floor types that can be created include wood framed, steel framed [not yet implemented], and SIPs over a crawl space (with a crawl space zone associated with the building), over exterior (no crawl space), or interior floor (which includes a floor over garage (although actually a demising surface)). See Figure 6-10 through Figure 6-12.

Figure 6-10: Floor over crawl space

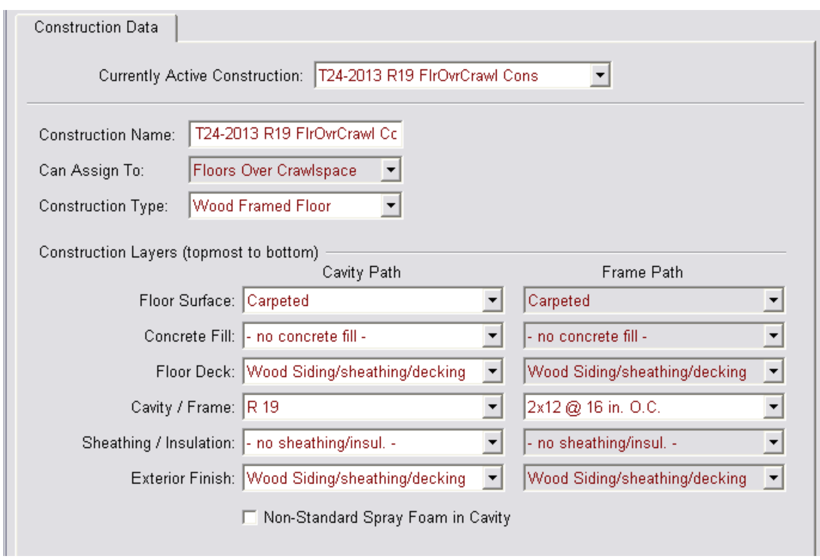
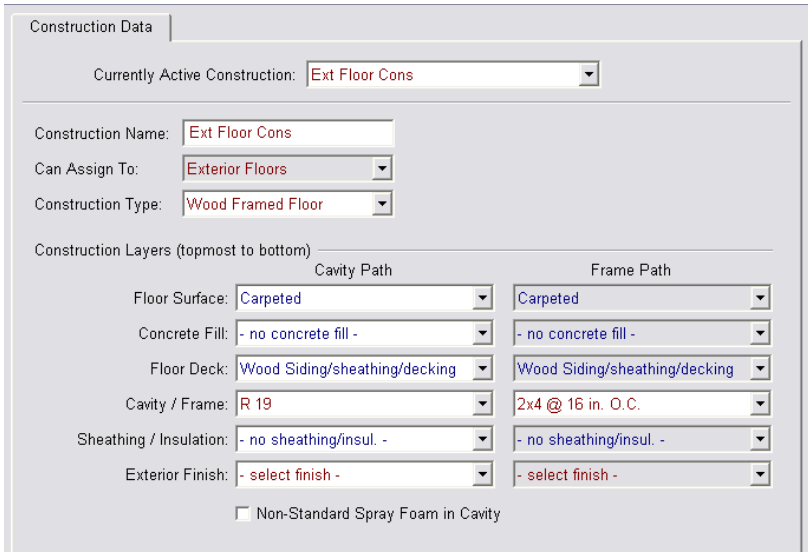


Figure 6-11: Floor over exterior



6.11.1 Raised Floor Construction Data

6.11.1.1 Construction Name

User-defined name.

6.11.1.2 Can Assign To

This is a fixed field. To create a new assembly type, at the zone level, pick create and make the appropriate construction assembly type.

6.11.1.3 Construction Type

Options include wood and steel frame [not yet implemented] construction, or SIPs.

6.11.2 Raised Floor Construction Layers (top to bottom)

6.11.2.1 Floor Surface

The available floor surface types are carpeted, hardwood, tile, and vinyl.

6.11.2.2 Concrete Fill

Default is no concrete fill. Select no concrete fill, or concrete fill.

6.11.2.3 Floor Deck

Select (1) no floor deck or (2) wood siding, sheathing, decking

6.11.2.4 Cavity/Frame

List the compressed R-value of cavity insulation (see Section 6.1) in the cavity column. The framing column is to indicate the size of the framing and the spacing (e.g., 2x6 with 16-inch on center framing) or panel size for SIPs.

6.11.2.5 Sheathing/Insulation

List the sheathing or insulation layer on the outside of the framing. Options are none, gypsum board, and R1 to R60 insulation.

6.11.2.6 Exterior Finish or Ceiling Below Finish

Optional input.

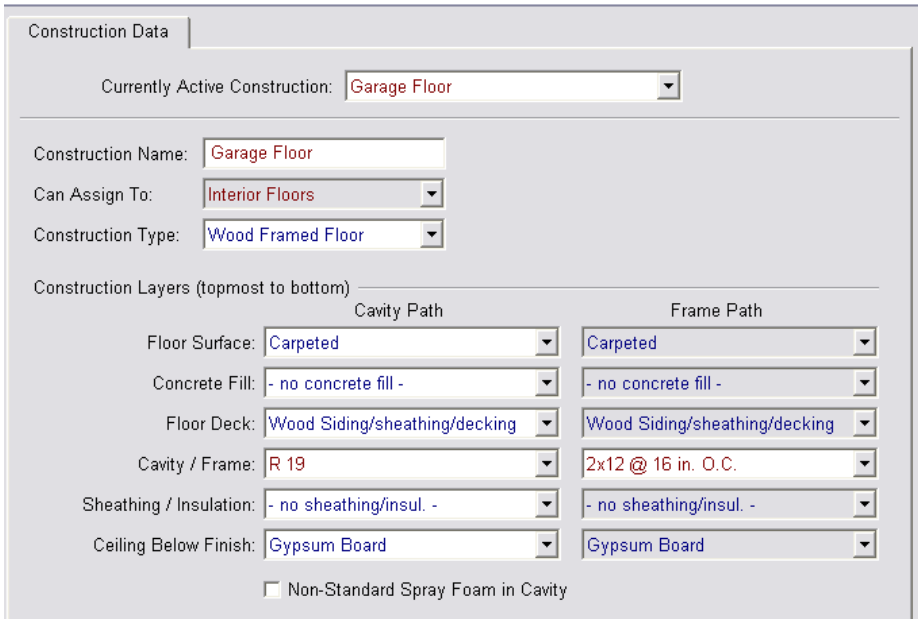
6.11.2.7 Non-Standard Spray Foam in Cavity

This check box identifies additional documentation and HERS verification requirements due a claimed R-value that exceeds the default assumption of R-5.8 per inch for closed cell and R-3.6 per inch for open cell (see Section 6.4).

6.11.3 Floor Over Garage

A floor over a garage is modeled as an interior floor. When defining the building envelope, the outside surface will be set to garage rather than another conditioned zone. By modeling it as an interior floor, the ceiling below can be set to gypsum board or be left undefined ("- select inside finish –").

Figure 6-12: Interior Floor



6.11.4 Slab and Below Grade Slab

There are no construction assemblies for slab and below grade slab floors. See Sections 7.5 and 7.6.

6.12 Window Types

This feature was designed to accommodate the need to easily update window efficiencies, should they change after they are input. To use it most productively, only the efficiencies in the window types library have to be changed to be reflected throughout the building model. Read carefully the first time setting up your windows or the program will override your inputs with default values.

Create a library of window types using product specific values for U-factor and SHGCs. Even if you wish to keep the default values, be sure to retype them (text changes from blue to red - this ensures the values will not change if you change to a climate zone with different window requirements). For the greatest flexibility, leave size, overhang or fin fields blank and create values for products with different values, such as operable, fixed, casement, glass block, doors, and existing windows.

When creating the windows on a given wall, you will specify the size and any overhang/fin details.

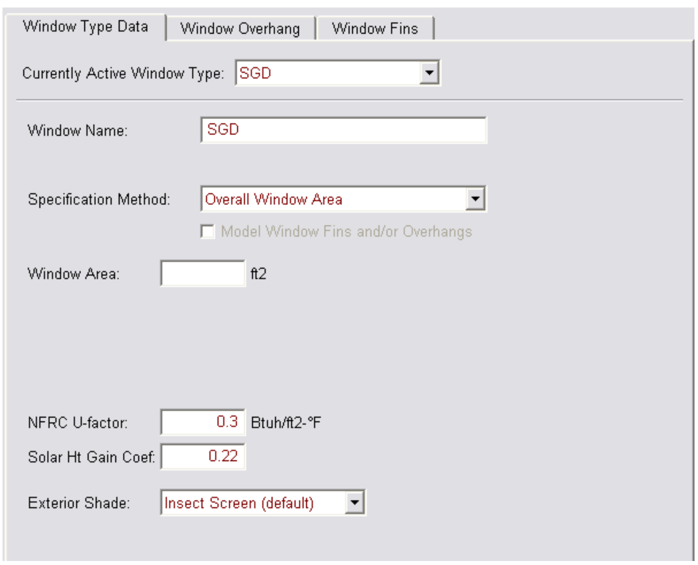
6.12.1.1 Window Name

User defined name. Use a brief description of the type of window.

6.12.1.2 Specification Method

This value can be specified when defining the individual windows in the building.

Figure 6-13: Window Type



6.12.1.3 Model Window Fins and/or Overhangs

This value can be specified when defining the individual windows in the building. Check box is available only when the previous field is set to window dimensions.

6.12.1.4 Window Area

Typically blank. This value can be specified when defining the individual windows in the building.

6.12.1.5 NFRC U-factor

Be sure to type in the value rather than accepting the default. U-factor from National Fenestration Rating Council (NFRC) for the window product (not the center of glass value) (www.nfrc.org). Alternatively, enter the default value from standards Section 110.6, Table 110.6-A.

6.12.1.6 Solar Heat Gain Coefficient

Be sure to type in the value rather than accepting the default. Solar Heat Gain Coefficient (SHGC) from NFRC for the fenestration product (www.nfrc.org). Alternatively, enter the default value from standards Section 110.6, Table 110.6-B.

6.12.1.7 Source of U-factor/SHGC

The three valid sources are NFRC, default, or Alternate Default Fenestration Procedure (ADFP). A rarely used provision in the standards is for unrated site-built fenestration, which requires use of Reference Appendix NA6 to calculate both the U-factor and SHGC. Whichever source is used, the standards require a temporary label on every window. See References Appendices (CEC-400-20012-005), p. NA6-1 through 6-5 for further information and responsibilities associated with this calculation procedure.

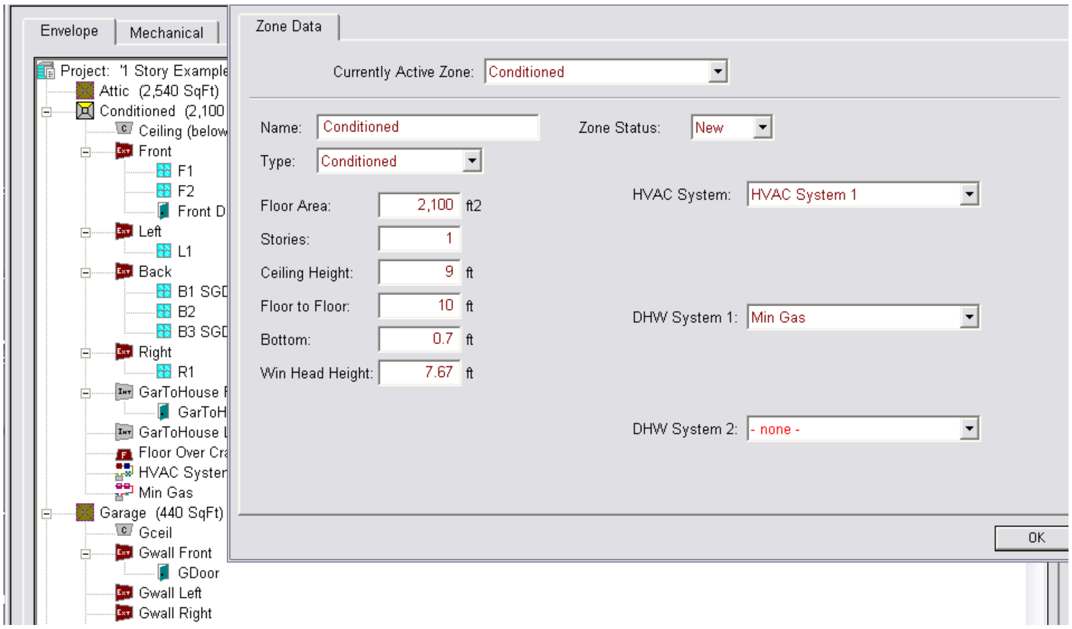
6.12.1.8 Exterior Shade

Default bug screens for windows, none for skylights.

Chapter 7. Building Envelope

Once the conditioned zone is defined (see Figure 7-1) the different components of the building envelope can be created or modified.

Figure 7-1: Conditioned Zone

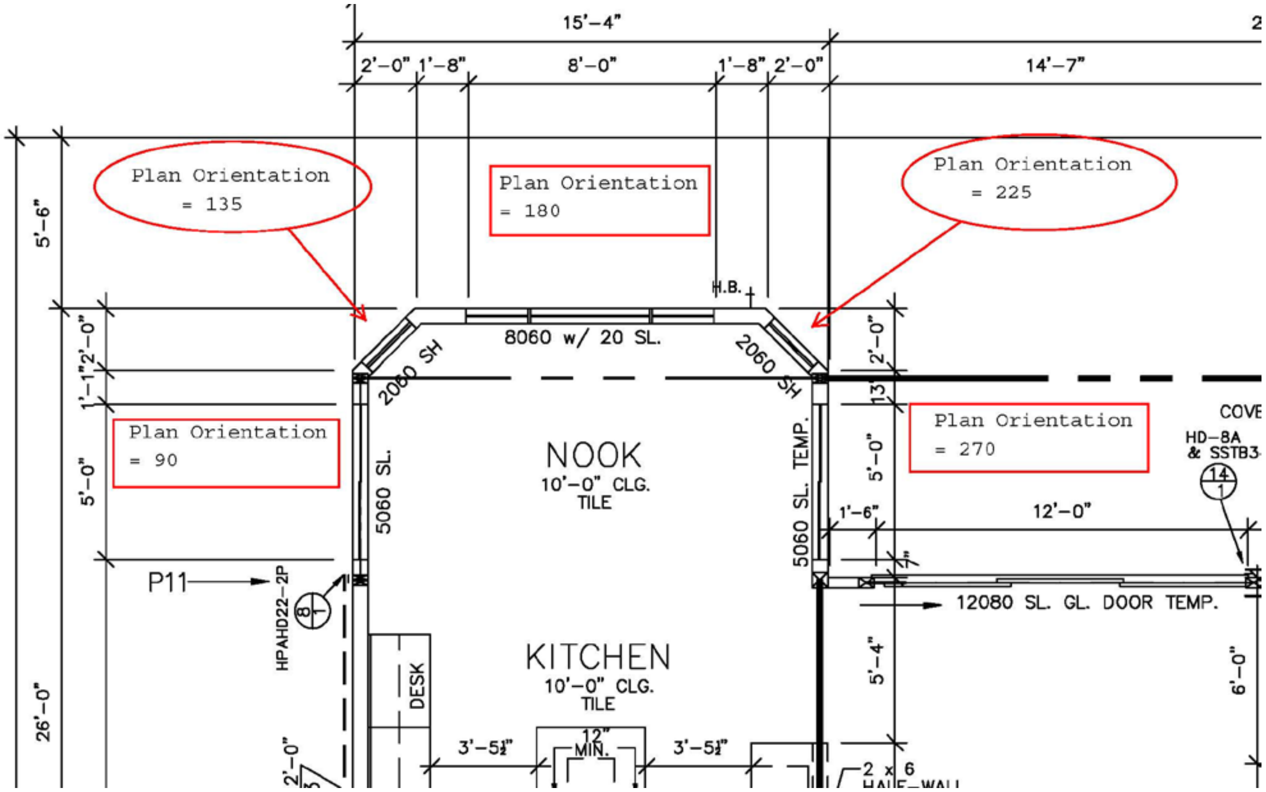


7.1 Orientation

The orientation of walls, windows, and any orientation other than front orientation is the plan orientation or plan view. It is the view looking at the plans (front, left, back, right) or as if standing outside and looking at the front of the building. The numeric value for the plan view of walls and windows is the same for every building—front is 0, left is 90, back is 180, and right is 270. When defining surfaces use the labels front, left, back and right, and only specify a value when the walls are at an angle, such as a bay or corner wall, in which case you will specify the orientation "relative to the front." If there is a bay off the back of a building (see Figure 7-2) the back angled walls are entered as 135 and 225. If the bay is off the front, the angled walls are at 315 and 45. The software adjusts these based on the value entered for ***Building***, ***Front Orientation***, and will report the actual azimuth.

NOTE: if you enter the actual orientation of walls, the software models the value entered plus the building front orientation, and the output will not match the proposed building. If you enter the actual orientation of the walls, the only way for the output to be correct would be to define the front orientation as 0 and most plan checkers will not understand why the site plan and your building front do not match. Additionally, to assist inspectors, the CF1R report was modified to include the side of the building or plan orientation.

Figure 7-2: Plan Orientation



7.2 Opaque Surfaces

Working from top down, add any ceilings below attic as well as any cathedral ceilings, followed by walls and floors.

7.2.1 Ceiling below attic

7.2.1.1 Ceiling Name

User-defined name. If the building plans have a unique identifier, that should be used here to assist in the plan checking and inspection processes.

7.2.1.2 Belongs to Zone

Select any appropriate zone already included in the building model. When copying components of one zone to another, this field automatically changes.

7.2.1.3 Surface Status

The default condition is new for new construction. Other options include existing and altered.

7.2.1.4 Attic Zone

Select any appropriate attic zone or define a new zone. A separate attic zone would be needed if any of the characteristics of the attic are different, including the roofing material, above or below deck insulation, or radiant barrier.

7.2.1.5 Construction

If an appropriate construction assembly is not available, right-click and pick create (discussed in depth in Chapter 6, Construction Assemblies).

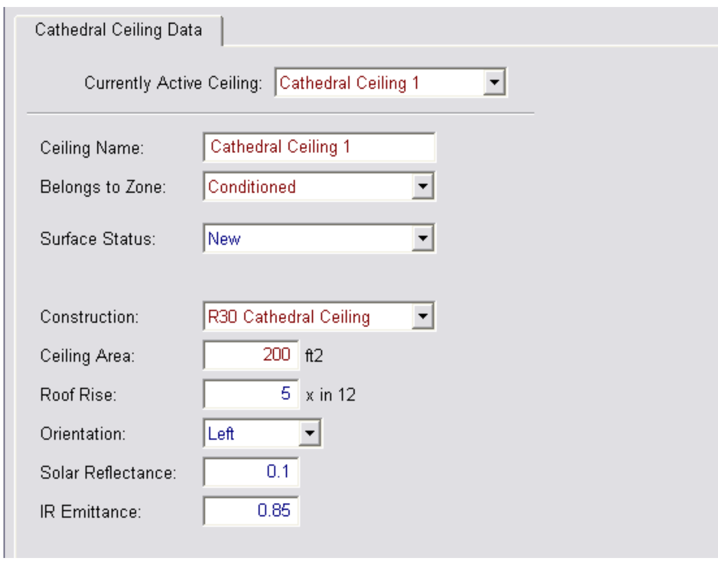
7.2.1.6 Ceiling Area

Area of the ceiling, in square feet.

7.2.2 Cathedral Ceiling

The information needed to define a cathedral ceiling is shown in Figure 7-3). Because the orientation is entered for cathedral ceilings, the ceiling will be modeled in multiple entries, with a typical cathedral ceiling having two or more parts (e.g., left and right).

Figure 7-3: Cathedral Ceiling



7.2.2.1 Ceiling Name

User-defined name. If the building plans have a unique identifier, that should be used here to assist in the plan checking and inspection processes.

7.2.2.2 Belongs to Zone

Select any appropriate zone already included in the building model. When copying components of one zone to another, this field automatically changes.

7.2.2.3 Surface Status

The default condition is new for new construction. Other options include existing and altered.

7.2.2.4 Construction

If no appropriate construction assembly is available, right-click and pick create (discussed in depth in Chapter 6, Construction Assemblies).

7.2.2.5 Ceiling Area

The area of the ceiling (in square feet) that meets all the same specified criteria. If parts of the roof face different orientations, they must be modeled separately.

7.2.2.6 Roof Rise

Specify the roof rise or roof pitch, which is the number of feet the roof rises in a span of 12 feet (e.g., shown on plans as 4:12 or 4 feet in 12 feet). If there are multiple pitches you can enter the roof rise of the largest area of roof

7.2.2.7 Orientation

The plan view using labels front, left back and right. If specifying a value, it is based on front = 0, left = 90, back = 180, and right = 270. If the cathedral ceiling is on a part of the building facing an angle, match the orientation of the walls. See Section 7.1.

7.2.2.8 Solar Reflectance

The default aged solar reflectance is 0.10 for all roof types. Alternatively, enter the aged solar reflectance for a roof product, as published by the Cool Roof Rating Council (CRRC) (www.coolroofs.org). A higher value is better, so if a specific product color is unknown use a lower value among options to avoid having to regenerate compliance documentation during construction. See also Section 5.3.1.7.

7.2.2.9 IR Emittance

The default thermal emittance (or emissivity) for all roofing materials is 0.85. Alternatively, enter the emittance value published by the Cool Roof Rating Council (CRRC) (www.coolroofs.org). See also Section 5.3.1.8.

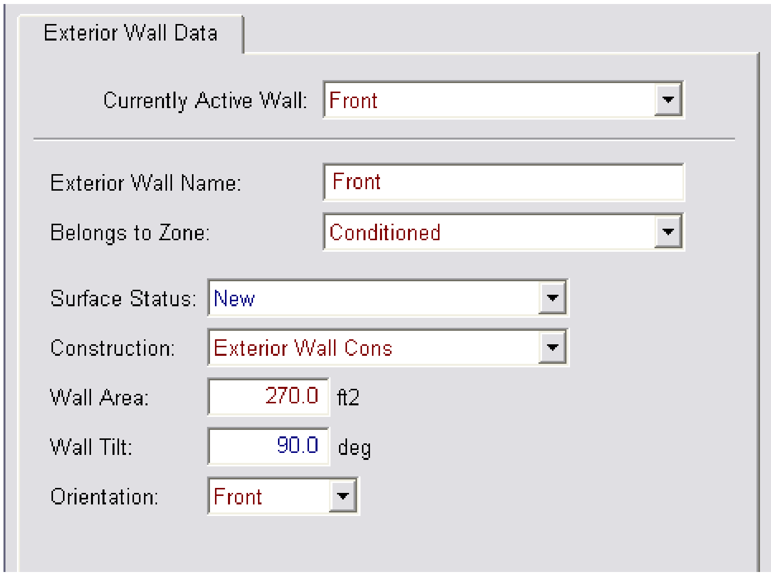
7.2.3 Knee Walls

Model any knee walls (a sidewall separating conditioned space from attic space under a pitched roof or where ceiling heights change), as an interior wall with the outside surface as attic, with insulation value typical for a wall.

7.2.4 Exterior Walls

Add the walls in a clockwise or counter-clockwise direction and in the order you would like them to appear because it is not possible to change the order. See Figure 7-4.

Figure 7-4: Exterior Wall



7.2.4.1 Exterior Wall Name

If the building plans use a unique tag or ID, use that for the name, otherwise a simple name such as front or front wall is sufficient. Each name within a zone or on a surface must be unique.

7.2.4.2 Belongs to Zone

The name of the zone in which the wall is being modeled.

7.2.4.3 Surface Status

Surface status is used to identify an existing, altered or new wall. Any surfaces that are part of a new building or addition are new.

7.2.4.4 Construction

Pick one of the construction assemblies or create a new construction assembly (see Section 6.10)

7.2.4.5 Wall Area

Gross wall area, in square feet (the area of windows and doors associated with the wall will be subtracted).

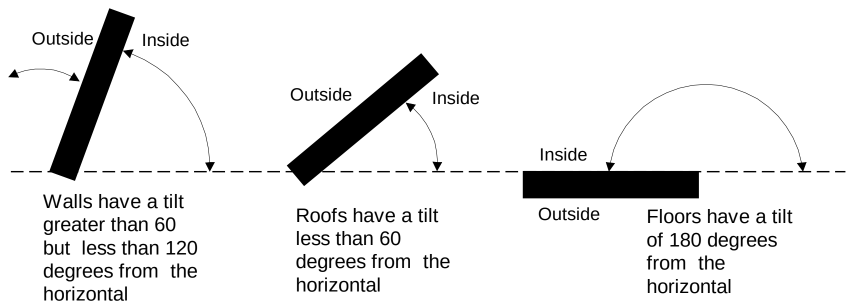
7.2.4.6 Wall Tilt

A wall typically has a tilt of 90 degrees but may range from greater than 60 degrees to less than 120 degrees (see Figure 7-5).

7.2.4.7 Orientation

The plan view orientation. Use front, left, back and right. If specifying a value, it is based on front being equal to 0, left is 90, back is 180, and right is 270, rather than the actual building orientation. The software will add the front orientation and this plan orientation to determine the actual orientation of the modeled surface. See Section 7.1.

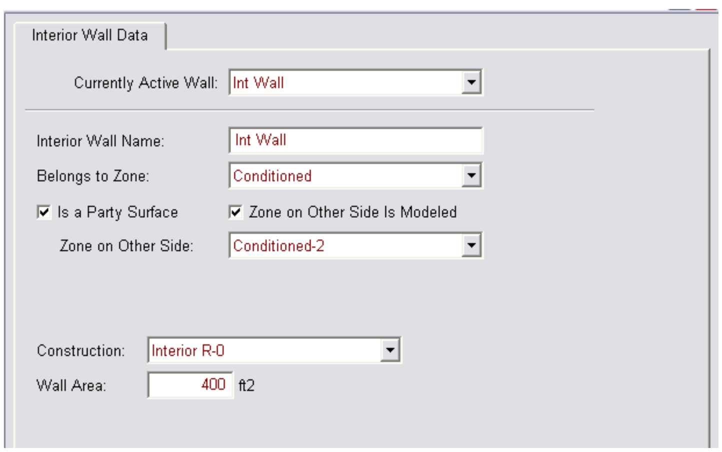
Figure 7-5: Surface Tilt



7.2.5 Party Walls and Surfaces

If each dwelling unit in a multi-family building is modeled as a separate zone, model any interior walls separating one dwelling unit from another as part of both dwelling units. Both zones are identified, as well as checking the box that the zone on the other side is modeled (see Figure 7-6).

Figure 7-6: Party Wall



When modeling an addition, the wall separating the addition from the house, garage, or other unconditioned space must be modeled. If the zone on the other side of the surface is not modeled (e.g., addition alone adjacent to garage), model the interior wall as a party surface.

7.2.6 Below Grade Overview

This is an overview of the inputs scattered throughout the user manual that are related to modeling below grade surfaces, also known as basements or underground surfaces.

In the zone information, if there are below grade surfaces, determine the depth of the below grade walls and floor and enter the zone bottom as the negative of that number. For example, if the walls are 6 feet 4 inches below grade, the wall and floor depths are 6.33 feet, and the zone depth is -6.33 feet.

Some modeling decisions to consider are that: (1) Since the orientation is not an input and it is not possible to have doors or windows, you could combine all of the walls into a single input. (2) If the ground is sloped, use your professional judgment as to how detailed to break out the surfaces. You could select an average, model all at the lowest level (conservative), or somewhere in between. (3) The zone type "unconditioned" cannot be modeled. An unconditioned basement could be modeled in place of a garage (rename the attached garage zone).

7.2.7 Below Grade Walls

Create below grade and slab floors using the right-click, create underground wall or floor. Below grade floors are described in Section 7.6.

7.2.7.1 Depth of Bottom of Wall Below Grade

Measurement from grade to the bottom surface of the wall (entered as a positive number, in feet).

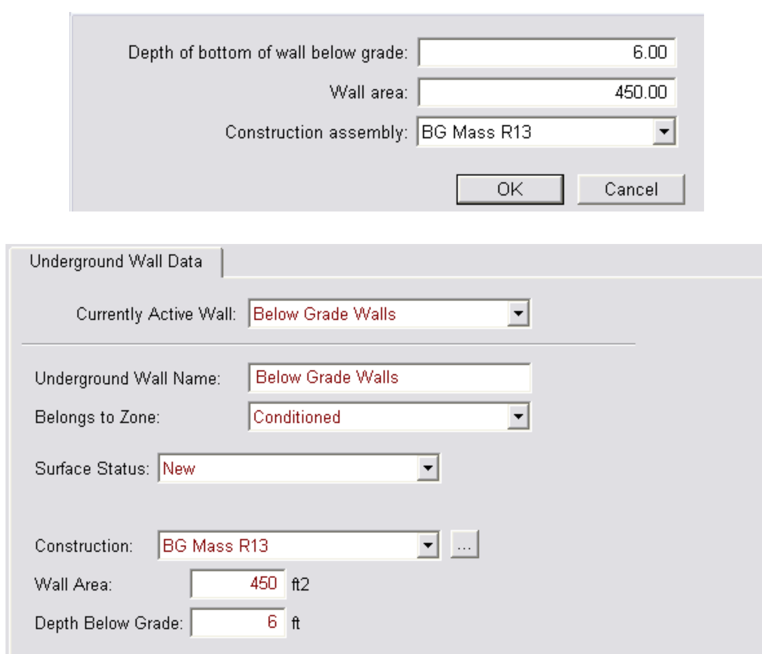
7.2.7.2 Wall Area

Since wall orientation is not an input, enter the combined area of walls that share the same characteristics (in feet).

7.2.7.3 Construction Assembly

Pick one of the construction assemblies or create a new underground wall assembly (see Section 6.10). Construction assemblies are limited to concrete/ICF/Brick. With the exception of the exterior surface (which is assumed to be soil), please see Section 6.10.3 for wall inputs.

Figure 7-7: Underground Walls



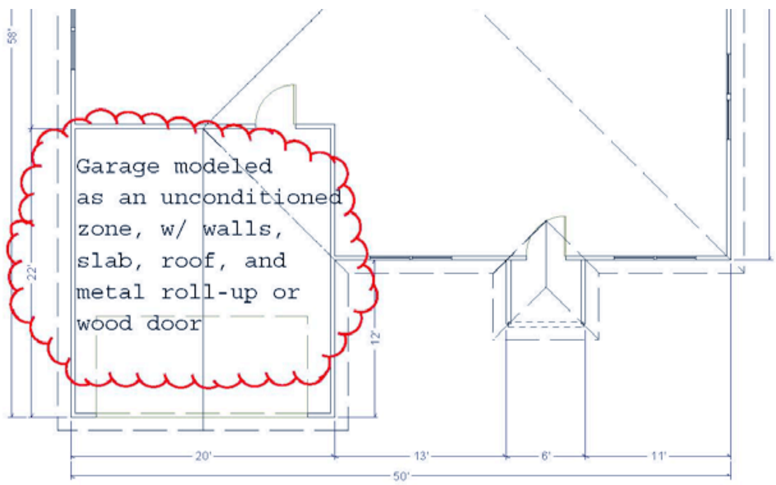
7.2.8 Garage Surfaces

In addition to the surfaces separating the house from the garage (which are modeled as part of the conditioned zone), also model attached unconditioned spaces (see Figure 7-8).

No surface is modeled more than once, so if the garage ceiling is a floor in the conditioned space zone, it is not modeled in the garage zone. The garage surfaces are typically not insulated and it is not necessary to model any windows. Model the area and type of ceiling, slab floor (perimeter length is only to exterior), any walls (typically with R-0 insulation) and the large metal roll-up or wood door (U-factor 1.00) and the door to outside. In a one-story building, the attic is typically shared with the conditioned space (NOTE: this is why the attic area (which cannot be edited) is bigger than the conditioned space).

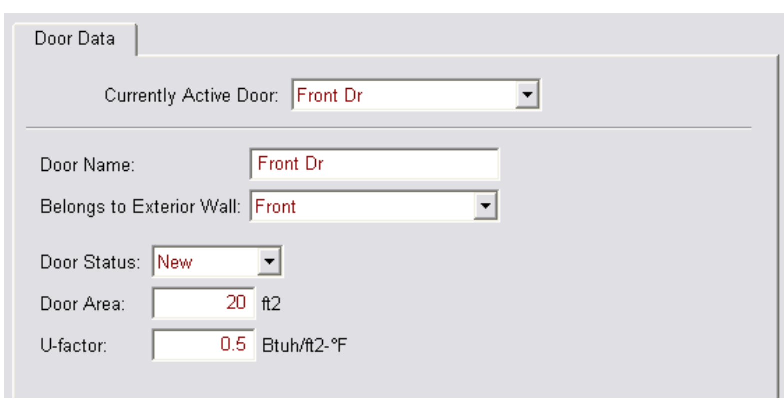
The surfaces that separate the house or conditioned zone from the garage are modeled with the conditioned zone as interior walls and interior floors (see Sections 6.10.3 and 6.11.3).

Figure 7-8: Attached Garage



7.2.9 Opaque Doors

Figure 7-9: Opaque Door



Doors and windows (fenestration) are modeled separately. For doors with glass, first determine if only part of the door or the entire door is a window. When a door is less than 50 percent glass, calculate the glass area plus two inches on all sides (to account for a frame) and model that as window (see Section 7.7.1). The opaque area of the door is the total door area minus the calculated glass area. For doors with 50 percent or more glass area see Section 7.7.4. The standard design building has the same area of opaque door as the proposed design building.

7.2.9.1 Door Name

User defined name. If the plans use a door schedule or unique identifier, that identifier can be used for the door name. Each surface must have a unique name.

7.2.9.2 Belongs to Exterior Wall

Default is the existing wall. When copying window data to another zone, the program changes this to the new exterior wall.

7.2.9.3 Door Status

The default is new for new construction or if part of an addition. Other options include altered and existing.

7.2.9.4 Door Area

Enter the door area, in square feet.

7.2.9.5 U-factor

Default value is 0.50 for opaque doors, 1.00 for the large garage doors (roll-up or wood). Other values allowed are from Joint Appendix 4, Table 4.5.1, only.

7.2.10 Garage Door

When modeling a garage zone, the large garage doors (metal roll-up or wood) are modeled with a 1.00 U-factor.

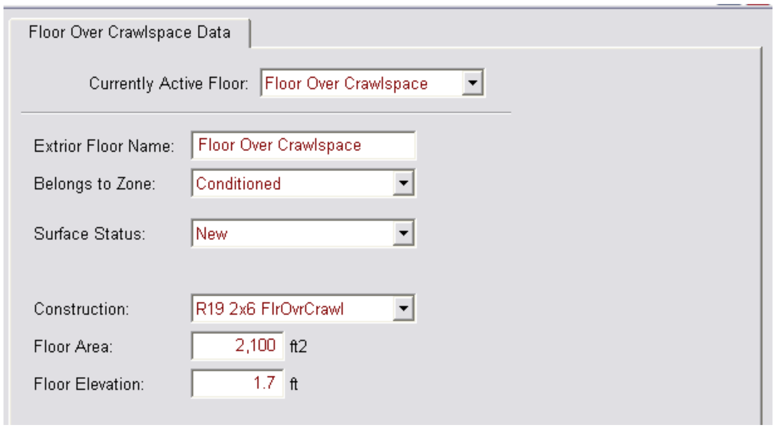
7.3 Raised Floor

When creating a raised floor over a crawl space, the software will create the associated crawl space zone. When a raised floor is over an unconditioned space, such as a garage, model this as an interior floor (with the adjacent zone being the garage).

A raised floor over exterior is when there is no crawl space and no unconditioned space underneath the floor (floor extends out beyond the first floor walls).

7.3.1 Floor over Exterior or Crawl Space

Figure 7-10: Raised Floor



7.3.1.1 Exterior Floor Name

User-defined name. If the building plans have a unique identifier, that should be used here to assist in the plan checking and inspection processes.

7.3.1.2 Belongs to Zone

Select any appropriate zone already included in the building model. When copying components of one zone to another, this field automatically changes.

7.3.1.3 Surface Status

Select New, Existing, or Altered.

7.3.1.4 Construction

Raised floor over crawl space, exterior floor, or interior floor. If an appropriate construction assembly is not available, right-click and pick <create> (discussed in depth in Chapter 6, Construction Assemblies).

7.3.1.5 Floor Area

Area of the floor, in square feet.

7.3.1.6 Floor Elevation

Height above grade or the depth of crawl space, in feet. This value must be consistent with the zone information. If the crawlspace height is 2 feet, this value is also 2. If this is a second floor and the zone identifies the bottom of the zone as 2 with a floor to floor height of 10, this value is 12.

7.3.2 Interior Floor/Floor Over Garage

A raised floor over a garage or over another conditioned space is modeled as an interior floor, but with either the garage or another zone on the other side.

Figure 7-11: Garage or Interior Floor

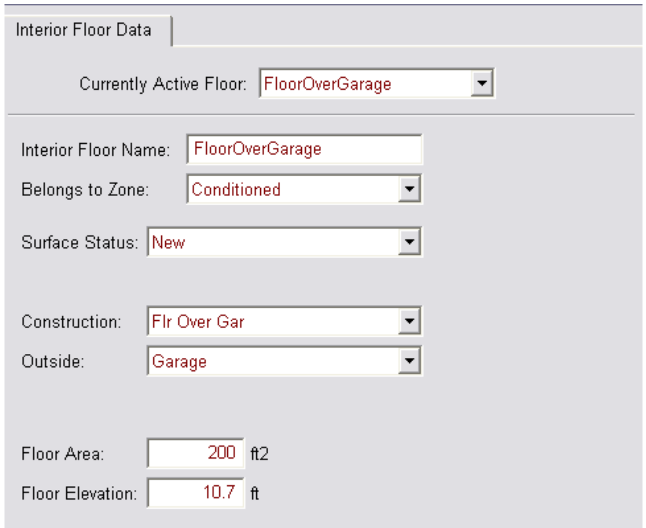
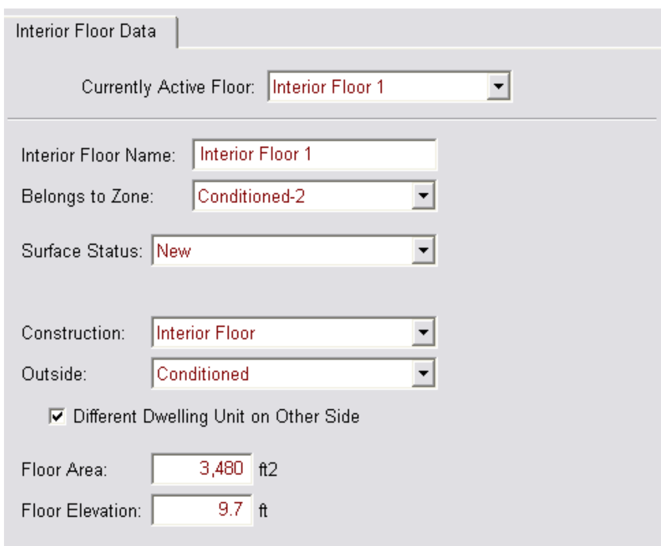


Figure 7-12: Multi-Family Interior Floor



7.3.2.1 Interior Floor Name

User-defined name. If the building plans have a unique identifier, that should be used here to assist in the plan checking and inspection processes.

7.3.2.2 Belongs to Zone

Select any appropriate zone already included in the building model. When copying components of one zone to another, this field automatically changes.

7.3.2.3 Surface Status

Select New, Existing, or Altered.

7.3.2.4 Construction

Interior raised floor. If an appropriate construction assembly is not available, right-click and pick create (discussed in depth in Chapter 6, Construction Assemblies).

7.3.2.5 Outside

The outside condition or adjacent zone.

7.3.2.6 Different Dwelling Unit on Other Side

A checkbox(see Figure 7-12) is included when the project is identified as multi-family to indicate whether another dwelling unit is on the other side of the surface being modeled.

7.3.2.7 Floor Area

Area of the floor, in square feet.

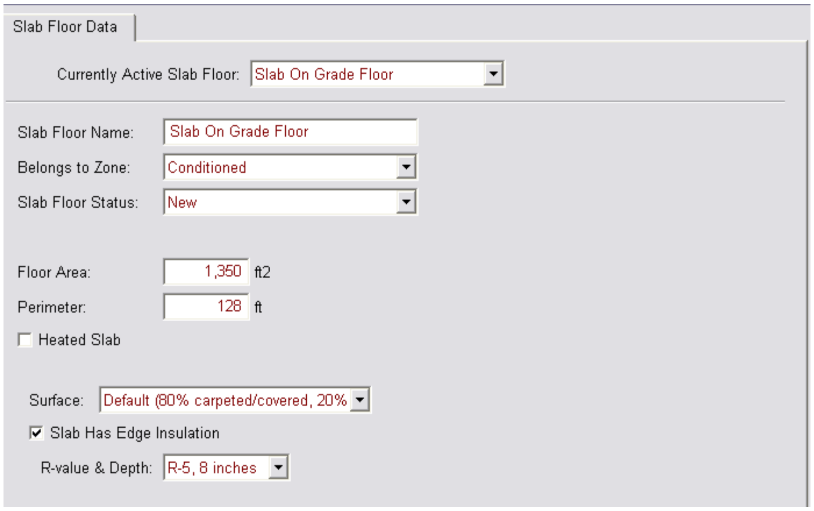
7.3.2.8 Floor Elevation

Height above grade, in feet. This value must be consistent with the zone information. If the bottom of the zone is 0.7 and the floor to floor height is 10, this value is 10.7.

7.4 Slab Floor

Slab on grade floors are modeled in conditioned spaces, unconditioned spaces, heated slab floors, slab floors with mandatory or optional slab edge insulation, floors with 20% exposed and 80% covered, or some other combination of exposed and covered slab.

Figure 7-13: Slab Floor Data



7.4.1.1 Slab Floor Name

If the building plans use a unique tag or ID, use that for the name. Each name within a zone or on a surface must be unique.

7.4.1.2 Belongs to Zone

The name of the zone in which the slab is being modeled.

7.4.1.3 Slab Floor Status

Select New, Existing, or Altered.

7.4.1.4 Floor Area

Area in square feet measured from the outside of the exterior surface of the zone.

7.4.1.5 Perimeter

Length of slab edge (in feet) between the space modeled and exterior only. Do not include the length of edge that occurs between the house and garage (an area that cannot be insulated if the edge is being insulated).

7.4.1.6 Heated slab

Check box to indicate that the slab is heated, in which case mandatory insulation requirements apply. See standards Section 110.8.

7.4.1.7 Surface

Default 20% exposed/80% covered, otherwise specify exposed or covered slab (modeled separately). Covered slab includes carpet, cabinets, and walls. No building has 100% exposed slab.

7.4.1.8 Slab Has Edge Insulation

Check box to indicate that the slab edge will be insulated.

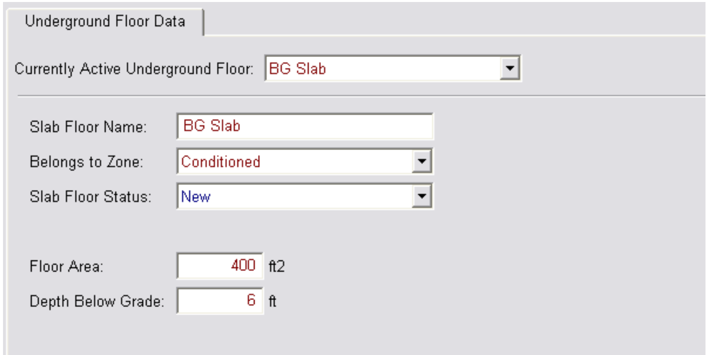
7.4.1.9 R-value & Depth

When slab edge insulation is indicated in the check box, the R-value and depth of the proposed slab edge insulation is identified. Depth of insulation installed vertically is specified in inches. Depth of insulation installed horizontally is specified in feet.

7.5 Below Grade Slab

When a slab floor is below grade, create an underground floor by right-clicking on the zone. There are no edge losses for the below grade slab.

Figure 7-14: Underground Floor Data



7.5.1.1 Slab Floor Name

If the building plans use a unique tag or ID, use that for the name. Each name within a zone or on a surface must be unique.

7.5.1.2 Belongs to Zone

The name of the zone in which the below grade slab is being modeled.

7.5.1.3 Slab Floor Status

Select New, Existing, or Altered.

7.5.1.4 Floor Area

Area in square feet measured from the outside of the exterior surface of the zone.

7.5.1.5 Depth Below Grade

This is the depth of the floor below grade (positive number, in feet). With the exception that this value is expressed as a positive number, this value should match the value for the zone bottom (see Section 5.1.1.8).

7.6 Windows

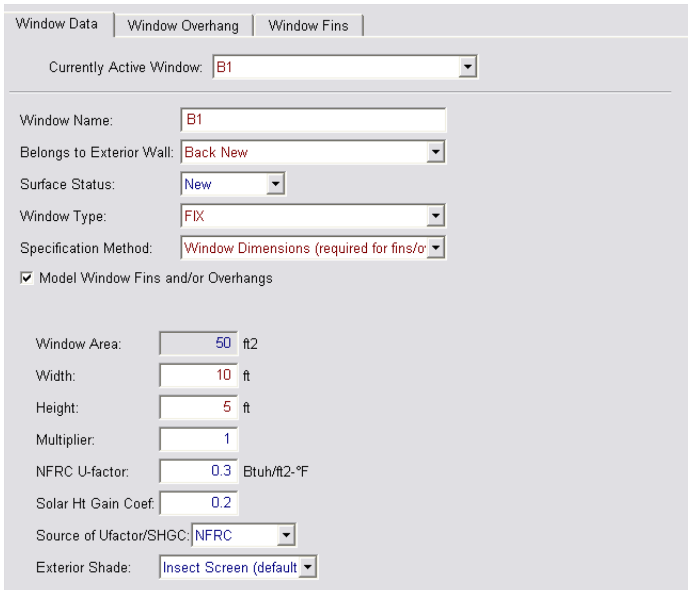
The standards establish a maximum weighted average U-factor of 0.58 (Section 150.0(q)) for fenestration, including skylights. The exception allows the greatest of 10 ft^2 or 0.5 percent of the conditioned floor area to exceed the maximum 0.58 U-factor.

Create a library of window types using either default values or product specific values for U-factor and SHGCs (see Section 6.12). Since you must model each window individually, this gives you the greatest flexibility by allowing you to update the window efficiencies with the least amount of effort. When you create a new window type, even if you wish to keep the default values, be sure to retype them so the values on the window type screen are red. Then when you pick the window type the window data screen picks up the values (in blue) from the window type fields.

7.6.1 Window Data

Right-click on the wall to which you will add windows and pick <create> and select window. The screen shown in Figure 7-15 is displayed.

Figure 7-15: Window Data



7.6.1.1 Window Name

User defined name. If the plans use a window schedule or unique identifier, that identifier can be used for the window name. Each window on a given surface must have a unique name.

7.6.1.2 Belongs to Exterior Wall

Defaults to the wall on which the window was created. When copying window data to another zone, the program changes this to the new exterior wall.

7.6.1.3 Surface Status

Select new, altered or existing.

7.6.1.4 Window Type

If using a window type from the library you created, select from the valid options. This field can also be set to “none.”

If this field is “none,” the window U-factor and SHGC of each window is entered directly, which eliminates a useful feature. If the window efficiencies need to change, using a window type allows this update to occur more efficiently (see Section 6.12).

7.6.1.5 Specification Method

Select either Window Dimensions (required for fins and overhangs) or Overall Window Area.

7.6.1.6 Model Window Fins and/or Overhangs

Check box is available only when Section 7.7.1.4 is set to window dimensions.

7.6.1.7 Window Area

If using the overall window area, enter the area of a window (in square feet) and the multiplier. For example, if there are three $3^0 5^0$ windows, enter window area “15” ft^2 and multiplier “3.”

7.6.1.8 Width

If using the window dimensions method, enter the window width (in feet).

7.6.1.9 Height

If using the window dimensions method, enter the window height (in feet).

7.6.1.10 Multiplier

The number of identical windows (NOTE: must also have identical overhang and fin conditions, if modeled).

7.6.1.11 NFRC U-factor

If a window type was selected above, this value is auto-completed using a U-factor from National Fenestration Rating Council (NFRC) for the window product (not the center of glass value) (www.nfrc.org). Alternatively, enter the default value from standards Section 110.6, Table 110.6-A.

7.6.1.12 Solar Heat Gain Coefficient

If using a window type was selected above, this value is auto-completed using a Solar Heat Gain Coefficient (SHGC) from NFRC for the fenestration product (www.nfrc.org). Alternatively, enter the default value from standards Section 110.6, Table 110.6-B.

7.6.1.13 Source of U-factor/SHGC

The three valid sources are NFRC, default, or Alternate Default Fenestration Procedure (ADFP). A rarely used provision in the standards is for unrated site-built fenestration, which requires use of Reference Appendix NA6 to calculate both the U-factor and SHGC. Whichever source is used, the standards require a temporary label on every window. See References Appendices (CEC-400-20012-005), p. NA6-1 through 6-5 for further information and responsibilities associated with this calculation procedure.

7.6.1.14 Exterior Shade

Default bug screens for windows, none for skylights.

7.6.2 Window Overhang

Under the Window Overhang tab (see Figure 7-16) enter the overhang dimensions and position.

7.6.2.1 Depth

Distance the overhang projects out from the wall (in feet).

7.6.2.2 Distance Up

The distance (as viewed from elevations) from the top of the window to the bottom of the overhang (in feet).

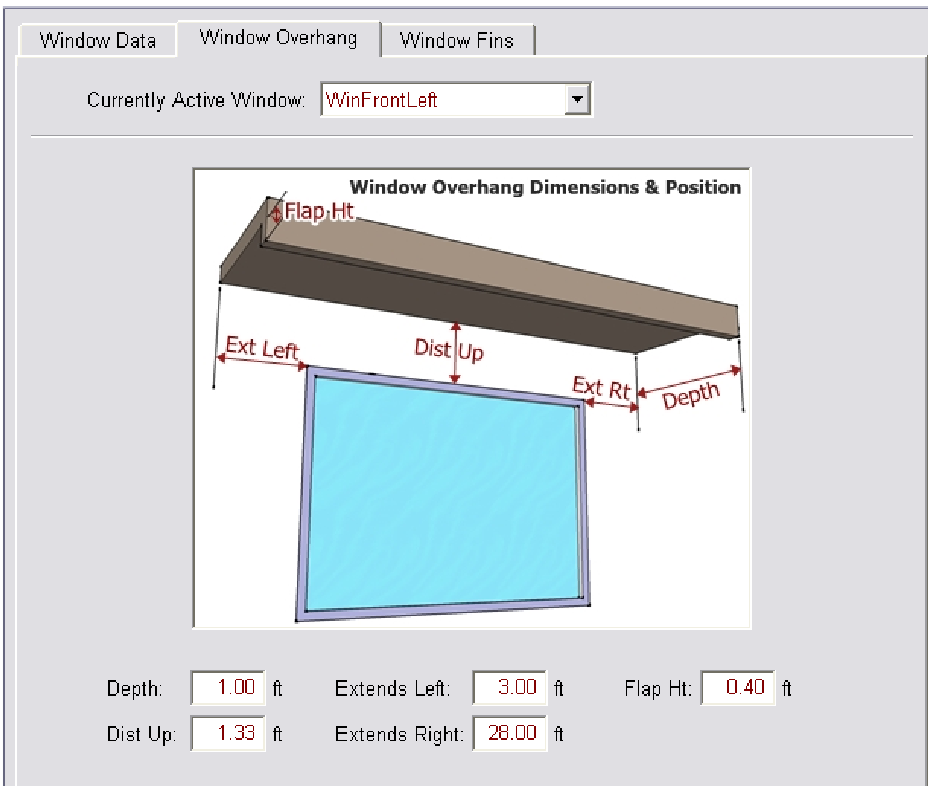
7.6.2.3 Extends Left

Distance (in feet) the overhang extends from the left edge of the window to the end of the overhang.

7.6.2.4 Extends Right

Distance (in feet) the overhang extends from the right edge of the window to the end of the overhang.

Figure 7-16: Overhang



7.6.2.5 Flap Height

Default 0 feet. If the overhang has a flap that extends lower than the bottom of the overhang, thereby increasing the potential shading of the overhang, this added length is modeled as the flap height.

7.6.3 Window Fins

A window fin is a building feature that provides shading benefit to a window (for example, a recessed entry area). Figure 7-17 shows inputs found in the Window Fins tab.

7.6.3.1 Left Fin Depth

Depth (in feet) of the wall (fin) to the left of the window that provides shading to the window.

7.6.3.2 Distance Left

Distance (in feet) from the left edge of the window to the left fin.

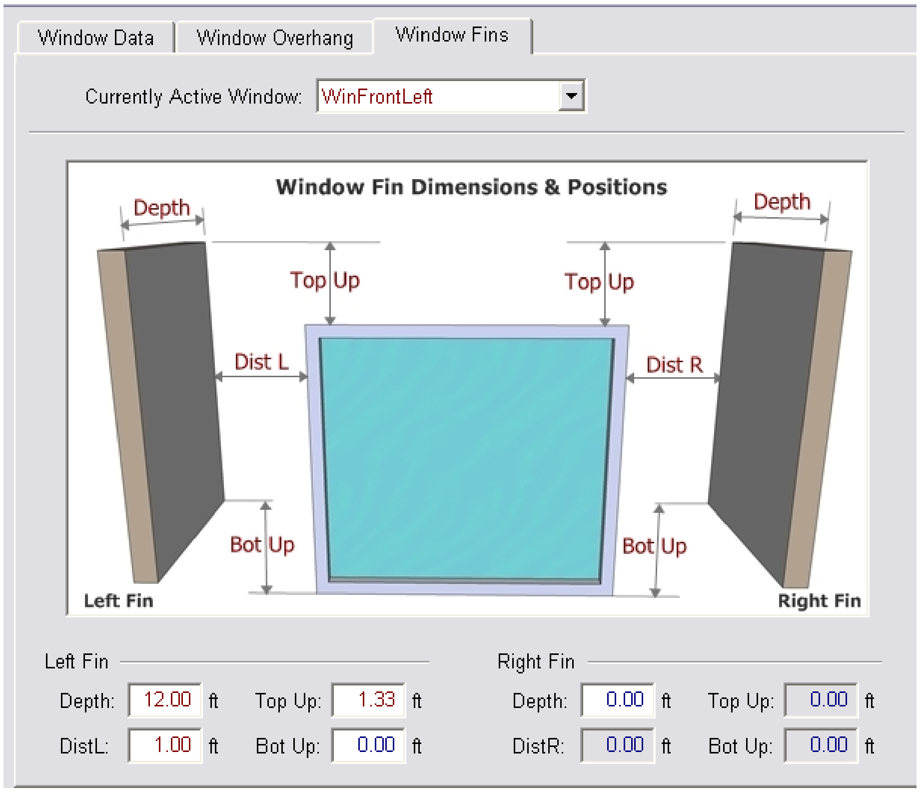
7.6.3.3 Top Up

Distance (in feet) from the top of the window to the top of the wall (fin).

7.6.3.4 Bottom Up

Distance (in feet) from the bottom of the window to the bottom of the left fin.

Figure 7-17: Window Fin



7.6.3.5 Right Fin Depth

Depth (in feet) of the wall (fin) to the right of the window that provides shading to the window.

7.6.3.6 Distance Right

Distance (in feet) from the right edge of the window to the right fin.

7.6.3.7 Top Up

Distance (in feet) from the top of the window to the top of the wall (fin).

7.6.3.8 Bottom Up

Distance (in feet) from the bottom of the window to the bottom of the right fin.

7.6.4 Glass Doors

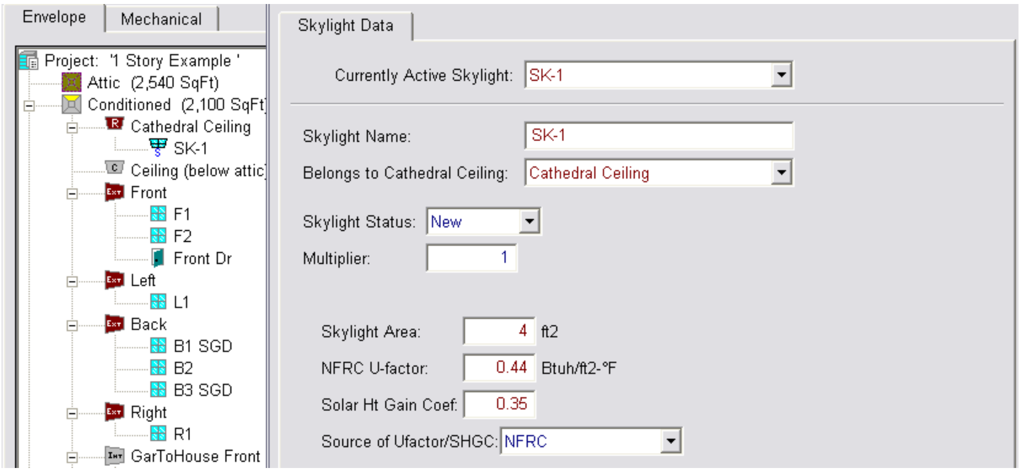
For a door with 50 percent or more glass area, or a door with an NFRC rating, the entire door area is modeled as a window.

The glass area (in square feet) of a door with less than 50 percent glass is the sum of all glass surfaces plus two inches on all sides of the glass (to account for a frame). This area is modeled as a window. The remaining area of the door is modeled as opaque door (see Section 7.2.5).

7.7 Skylights

To create a skylight, a section of cathedral ceiling with an area slightly larger than the skylight must be created. Right-click on the cathedral ceiling surface and pick <create> and select skylight (see Figure 7-18).

Figure 7-18: Skylight



7.7.1.1 Skylight Name

User defined name. If the plans use a window schedule or unique identifier, that identifier can be used for the window name. Each skylight on a given surface must have a unique name.

7.7.1.2 Belongs to Cathedral Ceiling

Defaults to the cathedral ceiling on which you picked create.

7.7.1.3 Skylight Area

Area of the skylight (in square feet).

7.7.1.4 Skylight Status

Select New, Existing, or Altered.

7.7.1.5 Multiplier

The number of identical skylights.

7.7.1.6 NFRC U-factor

U-factor from National Fenestration Rating Council for the skylight (www.nfrc.org), or default from Section 110.6, Table 110.6-A.

7.7.1.7 Solar Heat Gain Coefficient

Solar Heat Gain Coefficient (SHGC) from National Fenestration Rating Council for the skylight (www.nfrc.org), or default from Section 110.6, Table 110.6-B.

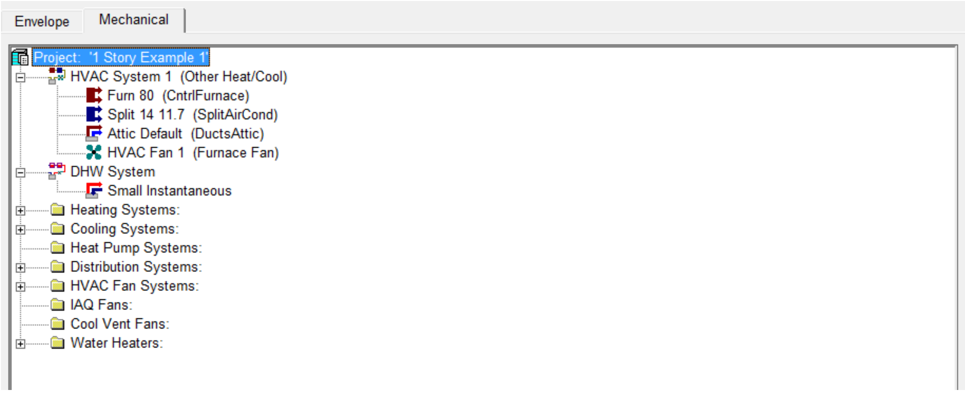
7.7.1.8 Source of U-factor/SHGC

The three valid sources are NFRC, default, or Alternate Default Fenestration Procedure (ADFP). See Section 7.7.1.13.

Chapter 8. Mechanical Systems

The heating, cooling, duct/distribution system and space conditioning fans are defined at the zone level (see Section 5.1.1.10). The indoor air quality ventilation and cooling ventilation are defined at the project level (see Sections 4.9 and 4.10). The details of these systems are contained under the mechanical tab (see Figure 8-1). The information in this chapter is from the point of view of the mechanical tab.

Figure 8-1: Mechanical Tab



Libraries of equipment can be added to an input file for any of the systems and fan types. In the figure below, the file has four furnaces with different efficiencies. A piece of equipment is only used when it is defined as part of the HVAC system data (see Figure 8-2).

NOTE: Ductless mini-split, multi-split, Variable Refrigerant Flow (VRF) and ground source heat pumps—Until an exceptional method is approved, these systems are modeled as equivalent to a standard design system with no penalty and no credit.

8.1 HVAC System Data

The details of the HVAC system are shown in Figure 8-2.

8.1.1.1 System Name

User-defined name.

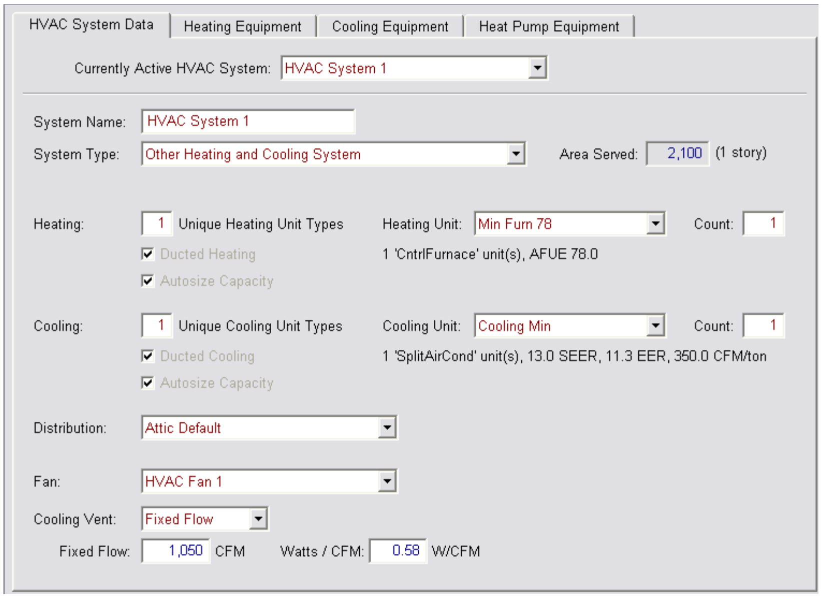
8.1.1.2 System Type

Select the correct system type as:

- Heat pump heating and cooling system,
- Variable outdoor air ventilation central heat/cool system for central fan integrated night ventilation cooling - *variable* speed (for example, NightBreeze™), or

- Other heating and cooling system for typical HVAC systems, and when modeling central fan integrated night ventilation cooling - *fixed* speed (for example, SmartVent™), which is activated by selecting CFI on the Cool Vent Tab (if more information is needed, see Section 4.10).

Figure 8-2: HVAC System Data



8.1.1.3 Unique Heating Unit Types

Indicate the number of unique system types. Not the same as “count” which is the number of identical systems. When modeling multiple efficiencies in a single zone, the worst case efficiency is assumed in the compliance analysis.

8.1.1.4 Heating Unit

Name of the heating system, details of which are specified as shown in Section 8.2.

8.1.1.5 Count

Number of specified heating units to be installed. This value is also noted by the HERS provider when a project is uploaded.

8.1.1.6 Unique Cooling Unit Types

Indicate the number of unique system types. Not the same as “count” which is the number of systems. When modeling multiple efficiencies in a single zone, the worst case efficiency is assumed in the compliance analysis.

8.1.1.7 Cooling Unit

Name of the cooling system, details of which are specified as shown in Section 8.3 (heat pump cooling is included with heating in Section 8.2.2).

8.1.1.8 Count

Number of specified cooling units to be installed. This value is also noted by the HERS provider when a project is uploaded.

8.1.1.9 Distribution

Name of the duct or distribution system, details of which are specified as shown in Section 8.4. In some cases “none” can be modeled. For example, where a default system with ducts is assumed (e.g., no cooling, ductless heat pump), the software can simulate this with a user input of “none.”

8.1.1.10 Fan

Name of the HVAC fan system, details of which are specified in Section 8.5. If a system type does not have a fan (e.g., combined hydronic, wall furnace), or if there is no cooling system, a value of “none” may be modeled. If using central fan integrated night ventilation cooling, this is the furnace fan that operates in ventilation mode.

8.1.1.11 Cooling Vent

When displayed for a central fan integrated night ventilation cooling system, select Fixed Flow.

8.1.1.12 Fixed Flow

When displayed, specify the fixed flow CFM for the system (or let the program set the default value).

8.1.1.13 Watts/CFM

When displayed, specify the Watts/CFM for the proposed central fan integrated night ventilation cooling system. The default value is 0.58 Watts/CFM.

8.1.1.14 Attic (relief zone)

When displayed, specify the attic zone in which the CFI fan is located.

8.1.2 Multiple HVAC Systems

When multiple systems of the same type serve different areas of a building, it is the user’s option to separately zone the systems. If modeled as one system, the compliance program will use the lowest efficiency.

When multiple systems of different equipment or fuel types serve the building, each type must be modeled as a separate zone to accommodate the different equipment types.

When multiple systems serve the same floor area, only one system can be modeled. The system modeled depends on the size and types of systems. If the capacity of the secondary system does not exceed 2 kW or 7,000 Btu/hr and is controlled by a time-limiting device of 30 minutes or less, the system is considered supplemental and may be ignored (*Residential Compliance Manual*, Section 8.7.3, and Section 150.1(c)6). If the system does not meet these criteria, the system that is modeled is the one that consumes the most TDV energy. For spaces with electric resistance heat in addition to another heating system, the electric resistance heat is the system that must be modeled.

8.1.3 Zonal Control

With zonal control, the sleeping and living areas are modeled separately for space conditioning. To model zonal control credit, the first step is to specify that the building will have zonal control on the ***Building*** tab (Figure 8-3). Once this is specified, the zone type can be set to Living or Sleeping (see Figure 8-4) which changes the setback thermostat settings for the heating system. Zonal control credit is not a HERS verified credit. Zonal control credit is not available if space heating is provided by a heat pump or combined hydronic system.

For information on zonal cooling, multi-speed compressors, when it is acceptable to model a lower target CFM/ton, and the presence of a bypass duct, see Zonal Cooling, Section 8.3.3.

Figure 8-3: Zonal Control from Section 4.7.1.10

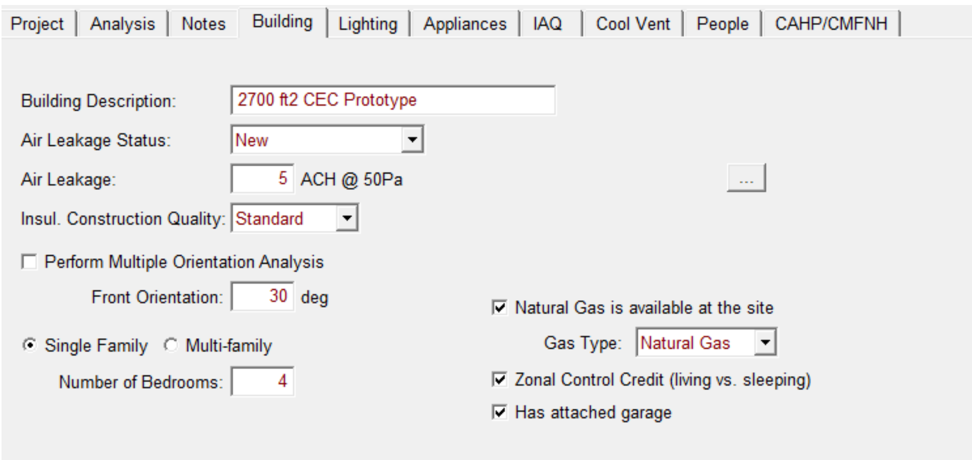
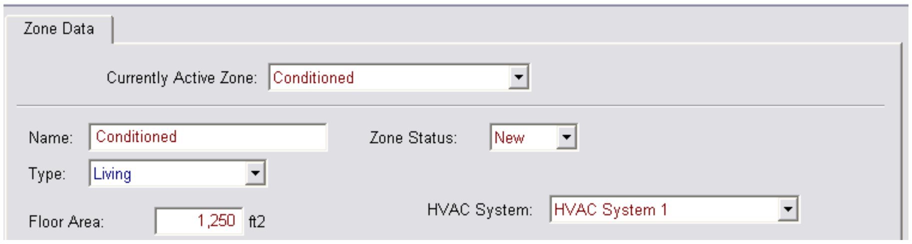


Figure 8-4: Type from Section 5.1.1



Zonal control credit is a special feature. Some of the requirements for this compliance option include:

- Each habitable room must have a source of space conditioning,
- The sleeping and living zones must be separately controlled,
- A non-closeable opening between the zones cannot exceed 40 ft^2,
- Each zone must have a temperature sensor and a setback thermostat, and
- The return air for the zone must be located within the zone.

A full list of eligibility criteria for this measure is found in the *Residential Compliance Manual*, Section 4.5.2.

8.2 Heating Systems

The heating system is the equipment that supplies heat to an HVAC System. Heating systems are categorized according to the types show in Table 8-1.

8.2.1 Heating System Data (other than heat pump)

See Figure 8-5 for the heating system data input screen, which varies slightly by equipment type.

8.2.1.1 Name

User-defined name for the heating system.

8.2.1.2 Type

Heating system type (see Table 8-1).

8.2.1.3 Efficiency

Enter an appropriate efficiency for the equipment type (e.g., 80.6 AFUE). The software will include the minimum efficiency for typical system types. Efficiency information for a specific model number of heating and cooling equipment is found by performing an "advanced search" in the Energy Commission's appliance directories or from the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) Certified Products Directory https://www.ahridirectory.org/ahridirectory/pages/home.aspx.

Figure 8-5: Heating System Data

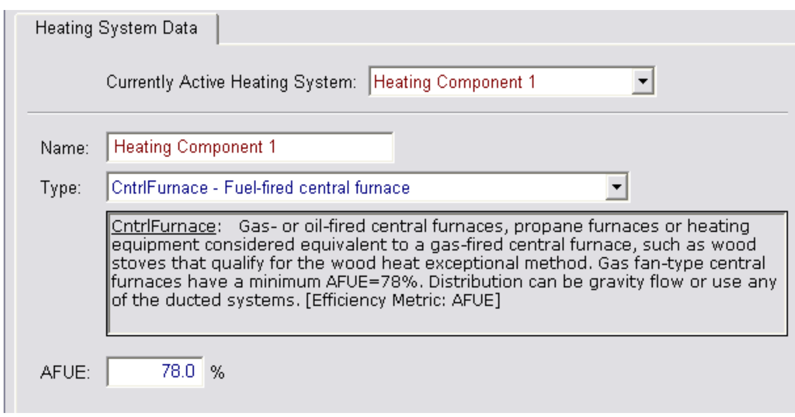


Table 8-1: Heating Equipment

Descriptor	Heating Equipment Reference
Central Furnace	Gas- or oil-fired central furnaces, propane furnaces or heating equipment considered equivalent to a gas-fired central furnace, such as wood stoves that qualify for the wood heat exceptional method. Gas fan-type central furnaces have a minimum AFUE=78%. Distribution can be gravity flow or use any of the ducted systems. [Efficiency Metric: AFUE]
Wall Furnace Fan	Wall furnace, fan type. Minimum AFUE=75%. Distribution is ductless. [Efficiency Metric: AFUE]
Boiler	Gas or oil boiler. Distribution systems can be Radiant, Baseboard or any of the ducted systems. Boiler may be specified for dedicated hydronic systems. Systems in which the boiler provides space heating and fires an indirect gas water heater (IndGas) may be listed as Boiler/CombHydro Boiler and shall be listed under “Equipment Type” in the HVAC Systems listing. [Efficiency metric: AFUE] – for Hydronic using a boiler, model Combined Hydronic and see Sections 8.2.6 and 9.8).
Wood Heat	Wood Heat: Wood-fired stove. In areas with no natural gas available, a wood heating system with any back-up heating system is allowed to be installed if exceptional method criteria described in the Residential Compliance Manual are met. [Efficiency Metric: N/A]
Electric	All electric heating systems other than space conditioning heat pumps. Included are electric resistance heaters, electric boilers and storage water heat pumps (air-water)_ (StoHP). Distribution system can be Radiant, Baseboard or any of the ducted systems. [Efficiency Metric: HSPF]
Combined Hydronic	Water heating system can be storage gas (StoGas, LgStoGas), storage electric (StoElec) or heat pump water heaters (StoHP). Distribution systems can be Radiant, Baseboard, or any of the ducted systems and can be used with any of the terminal units (FanCoil, RadiantFlr, Baseboard, and FanConv).
Wall Furnace Gravity	Wall furnace, gravity flow. Minimum AFUE=65%. Distribution is ductless. [Efficiency Metric: AFUE]
Floor Furnace	Floor furnace. Minimum AFUE=57%. Distribution is ductless. [Efficiency Metric: AFUE]
Room Heater	Room heater. Minimum AFUE=61%. Distribution is ductless. [Efficiency Metric: AFUE]

8.2.2 Central Air Conditioning Heat Pumps (Air Source)

See Figure 8-6 for heat pump system data input screen, which varies slightly by equipment type.

8.2.2.1 Name

User-defined name for the system.

8.2.2.2 Type

Heat pump system type (see Table 8-2).

Table 8-2: Heat Pump Equipment

Descriptor	Heating Pump Equipment Reference
Split Heat Pump	Central split system heat pump heating systems. Distribution system shall be one of the ducted systems. [Efficiency Metric: HSPF]
SDHV Split Heat Pump	Small Duct, High Velocity, Central split system that produces at least 1.2 inches of external static pressure when operated at the certified air volume rate of 220–350 CFM per rated ton of cooling and uses high velocity room outlets generally greater than 1,000 fpm that have less than 6.0 square inches of free area. [Efficiency Metric: HSPF]
Ductless Mini-Split Heat Pump	A heat pump system that has single outdoor section and one or more ductless indoor sections. The indoor section(s) cycle on and off in unison in response to a single indoor thermostat. [Efficiency Metric: HSPF]
Ductless Multi-Split Heat Pump	A heat pump system that has a single outdoor section and two or more ductless indoor sections. The indoor sections operate independently and can be used to condition multiple zones in response to multiple indoor thermostats. [Efficiency Metric: HSPF]
Ductless VRF Heat Pump	A variable refrigerant flow (VRF) heat pump system that has one or more A variable refrigerant flow (VRF) heat pump system that has one or more outdoor sections and two or more ductless indoor sections. The indoor sections operate independently and can be used to condition multiple zones in response to multiple indoor thermostats. [Efficiency Metric: HSPF]
Package Heat Pump	Central packaged heat pump systems. Central packaged heat pumps are heat pumps in which the blower, coils and compressor are contained in a single package, powered by single phase electric current, air cooled, rated below 65,000 Btuh. Distribution system shall be one of the ducted systems. [Efficiency Metric: HSPF]
Large Package Heat Pump	[Not enabled] Large packaged units rated at or above 65,000 Btu/hr (heating mode). Distribution system shall be one of the ducted systems. These include water source and ground source heat pumps. [Efficiency Metric: COP]
Room Heat Pump	Non-central room air conditioning systems. These include small ductless split system heat pump units and packaged terminal (commonly called “through-the-wall”) units. Distribution system shall be ductless. [Efficiency Metric: HSPF]
Air to Water Heat Pump	An indoor conditioning coil, a compressor, and a refrigerant-to-water heat exchanger that provides heating and cooling functions. Also able to heat domestic hot water. [Efficiency Metric: COP]
Ground Source Heat Pump	An indoor conditioning coil with air moving means, a compressor, and a refrigerant-to-ground heat exchanger that provides heating, cooling, or heating and cooling functions. Also able to heat domestic hot water. [Efficiency Metric: COP]

8.2.2.3 Heating Performance HSPF

Enter the heating seasonal performance Factor (HSPF). Efficiency information for a specific model number is found by performing an “advanced search” in the Energy Commission’s appliance directories (https://cacertappliances.energy.ca.gov/Pages/Search/AdvancedSearch.aspx) or from the AHRI Certified Products Directory.

For systems rated with a COP only, which require an HSPF, convert the COP using Equation 8-1.

Equation 8-1: HSPF = (3.2 x COP) – 2.4

8.2.2.4 Capacity @ 47 Degrees F

Required value from AHRI). Capacity is used to determine the energy use of the backup electric resistance heat. In a multi-family building you will indicate the capacity for the defined system and specify the number of units of that given capacity assigned to the zone (see Section 8.1.1.5).

8.2.2.5 Capacity @ 17 Degrees F

Required value from AHRI.

8.2.2.6 Cooling Performance - SEER

Cooling equipment Seasonal Energy Efficiency Ratio (SEER). For equipment tested only with an EER, enter the EER as the SEER. When a value higher than 14 SEER for "Compliance 2017" is modeled, it triggers a HERS Verification of High SEER. Efficiency information can be obtained from an advanced search of the Energy Commission's appliance directories (https://cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx) or from the AHRI Certified Products Directory.

8.2.2.7 EER

Cooling equipment Energy Efficiency Ratio (EER). CBECC-Res has default values for the EER based on the SEER value modeled. Two conditions will result in a HERS verified EER. (a) An EER higher than the default of 11.7 for "Compliance 2017", and (b) checking the box "☑ Use this EER in compliance analysis." Because the EER depends on the specific combination of coil and condenser model numbers, other than default EER ratings can be obtained from AHRI.

8.2.2.8 CFM per Ton

The mandatory requirement for cooling airflow is 350 CFM/ton for ducted cooling systems (also assumed for dwellings with no cooling), or 150 CFM/ton for Zonal Single Speed systems. Users may model a higher airflow. All cooling systems require HERS verified system airflow using diagnostic testing procedures from *Reference Appendices*, Residential Appendix RA3.

8.2.2.9 AC Charge

Verified refrigerant charge. Select Not Verified, Verified, or Charge Indicator Display (CID). There is no mandatory requirement for verified refrigerant charge, however, the standard design in climate zones 2 and 8-15 includes proper refrigerant charge for most equipment types (see standards Section 150.1(c)8.).

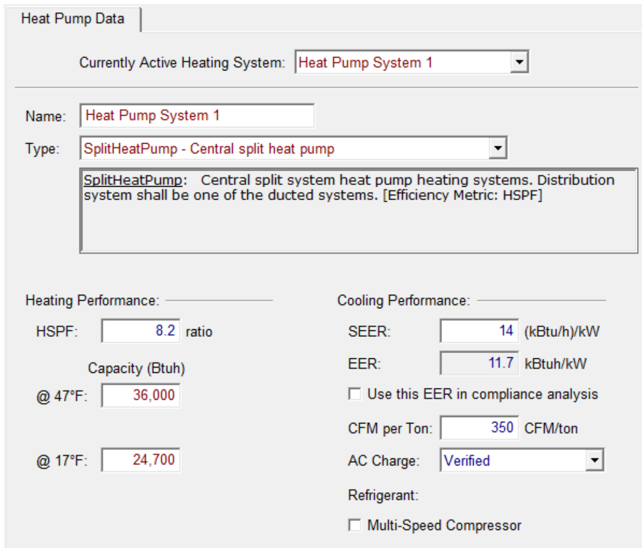
8.2.2.10 Refrigerant Type

Default R410A assumed for all refrigerant containing equipment.

8.2.2.11 Multi-Speed Compressor

Use this field to indicate if the cooling system is a zonally controlled multi-speed compressor. An exception for single speed compressors would leave this box unchecked and specify 150 CFM/ton (see Section 8.3.1.5).

Figure 8-6: Heat Pump Data



8.2.3 Air to Water Source Heat Pump

See Figure 8-7 for air to water source heat pump input screens.

An example file included with the program (1StoryExample3HVAC.ribd16) contains an air to water source heat pump system. If the system provides water heating, see Section 9.10.

8.2.3.1 Name

User-defined name for the system.

8.2.3.2 Type

Heat pump system type (see Table 8-2).

8.2.3.3 Heating Performance

Enter the Coefficient of Performance (COP). Efficiency information for a specific model number is found by performing an "advanced search" in the Energy Commission's appliance directories (https://cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx) or from the AHRI Certified Products Directory.

8.2.3.4 Capacity @ 47 Degrees F

Required value from AHRI. Capacity is used to determine the energy use of the backup electric resistance heat. In a multi-family building you will indicate the capacity for the defined system and specify the number of units of that given capacity assigned to the zone (see Section 8.1.1.5).

8.2.3.5 Capacity @ 17 Degrees F

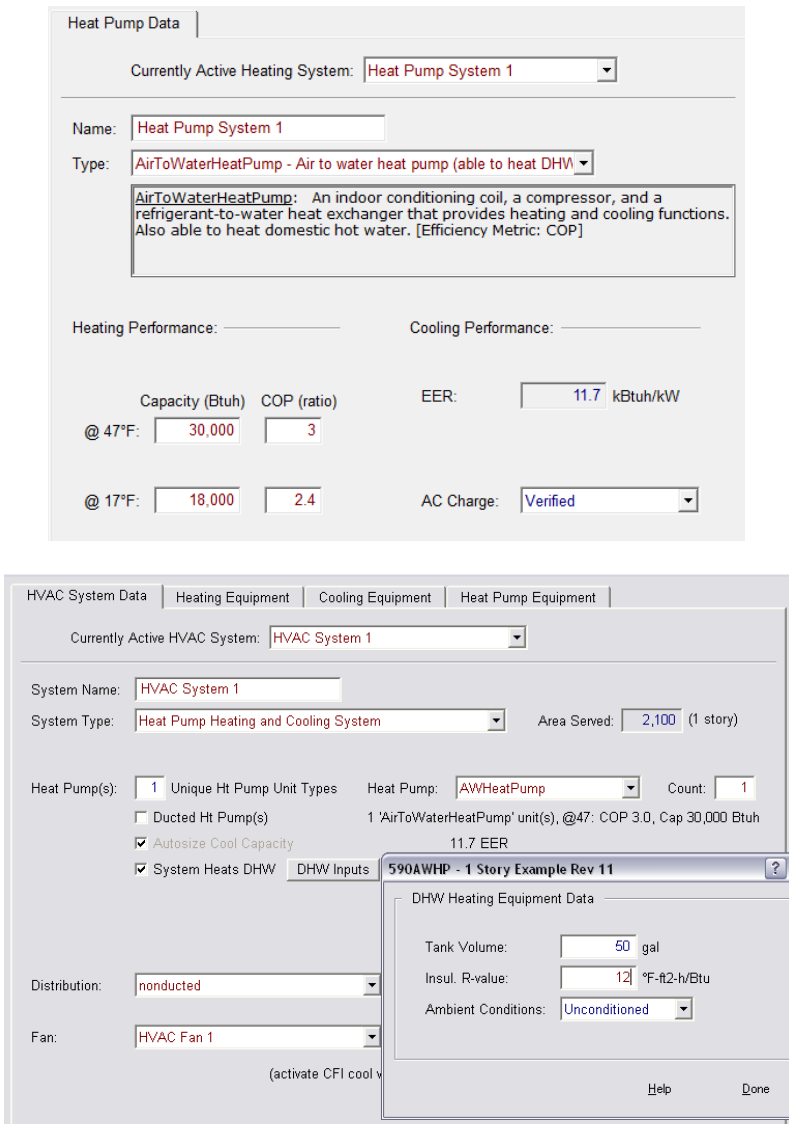
Required value from AHRI.

8.2.3.6 EER

Cooling equipment Energy Efficiency Ratio (EER).

There are two additional options on the HVAC System Data screen (one level higher on the input screen). If the system is ducted, check the Ducted Ht Pump(s) box before specifying a distribution system. If the system also provides water heating check the box “System Heats DHW” (see Figure 8-7) and enter the tank volume, insulation R-value and ambient conditions.

Figure 8-7: Air to Water Source Heat Pump



8.2.4 Ground Source Heat Pump

Because there is no current method for simulating the performance of these systems, they are modeled as equivalent to a standard design ducted system (split system heat pump). The characteristics modeled are reported on the CF1R.

An example file included with the program (1StoryExample3HVAC.ribd16) contains a ground source heat pump system. If the system provides water heating, see Section 9.10.

8.2.4.1 Name

User-defined name for the system.

8.2.4.2 Type

Heat pump system type is Ground Source Heat Pump (as shown in Table 8-2).

8.2.4.3 Heating Performance

Enter the Coefficient of Performance (COP). Efficiency information for a specific model number is found by performing an "advanced search" in the Energy Commission's appliance directories (https://cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx) or from the AHRI Certified Products Directory.

8.2.4.4 Capacity

Capacity of the proposed heat pump model.

8.2.4.5 EER

Cooling equipment Energy Efficiency Ratio (EER).

There are two additional options on the HVAC System Data screen (one level higher on the input screen). If the system is ducted, check the Ducted Ht Pump(s) box before specifying a distribution system. If the system also provides water heating check the box "System Heats DHW" and enter the tank volume, insulation R-value and ambient conditions.

8.2.5 Ductless Mini-Split, Multi-Split, and VRF Heat Pump

See Figure 8-8 for ductless mini-split heat pump input screens. An example file (1StoryExample3HVAC.ribd16) is included in the projects folder. Distribution system and fan can be set to "none" on the HVAC System Data screen (see Figure 8-2).

8.2.5.1 Name

User-defined name for the system.

8.2.5.2 Type

Heat pump system type (from Table 8-2) is a ductless mini-split, multi-split or VRF heat pump.

8.2.5.3 Heating Performance

Enter the Heating Seasonal Performance Factor (HSPF) for a specific model number from the AHRI Certified Products Directory.

8.2.5.4 Capacity @ 47 Degrees F

Required value from AHRI. Capacity is used to determine the energy use of the backup electric resistance heat. In a multi-family building you will indicate the capacity for the defined system and specify the number of units of that given capacity assigned to the zone (see Section 8.1.1.5).

8.2.5.5 Capacity @ 17 Degrees F

Required value from AHRI.

8.2.5.6 SEER

Cooling equipment Seasonal Energy Efficiency Ratio (EER).

8.2.5.7 EER

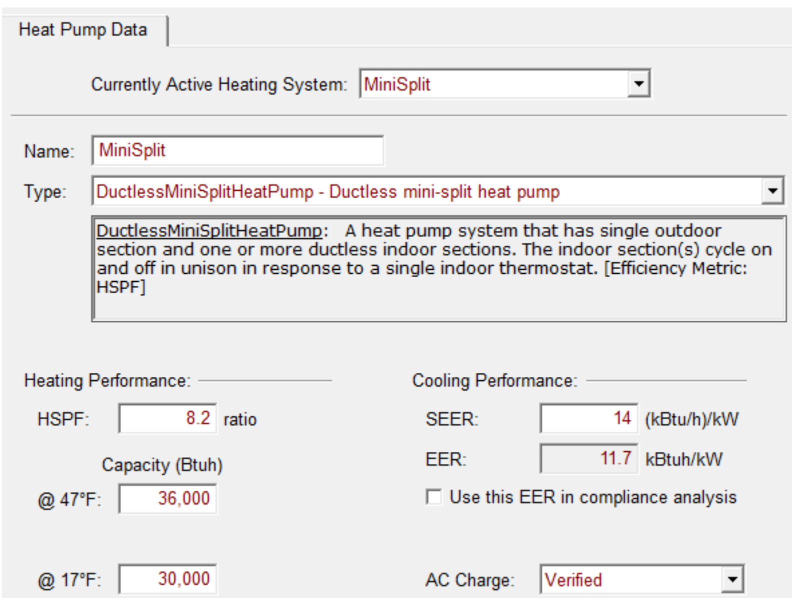
Cooling equipment Energy Efficiency Ratio (EER).

8.2.5.8 AC Charge

Verified refrigerant charge. Select Not Verified, Verified, or Charge Indicator Display (CID). There is no mandatory requirement for verified refrigerant charge, however, the standard design in climate zones 2 and 8-15 includes proper refrigerant charge for most equipment types (see standards Section 150.1(c)8.).

Required inputs for a mini-split, multi-split or VRF are the HSPF, capacity at 47°F and 17°F, the SEER, EER and a selection for AC charge. All three of these system types are modeled as equivalent to a standard design ducted HVAC system.

Figure 8-8: Ductless Mini-Split Heat Pump Data



8.2.6 Room Air Conditioning Heat Pumps

See Figure 8-9 for room heat pump system data input screen.

8.2.6.1 Name

User-defined name for the system.

8.2.6.2 Type

Select RoomHeatPump as the system type (see Table 8-2).

8.2.6.3 Heating Performance HSPF

Convert the COP to an HSPF using Equation 8-1. Find the COP using the model number and performing an "advanced search" in the Energy Commission's appliance directories (https://cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx) or from the AHRI Certified Products Directory.

Equation 8-2: HSPF = (3.2 x COP) – 2.4

8.2.6.4 Capacity @ 47 Degrees F

Required value.

8.2.6.5 Capacity @ 17 Degrees F

Required value.

8.2.6.6 Cooling Performance - SEER

Because this equipment uses an EER as its required efficiency, enter the same efficiency value for both EER and SEER. The SEER is not used to calculate compliance results.

8.2.6.7 EER

Check the box "☑ Use this EER in compliance analysis" and enter the EER for the proposed equipment. The default value is 10 EER.

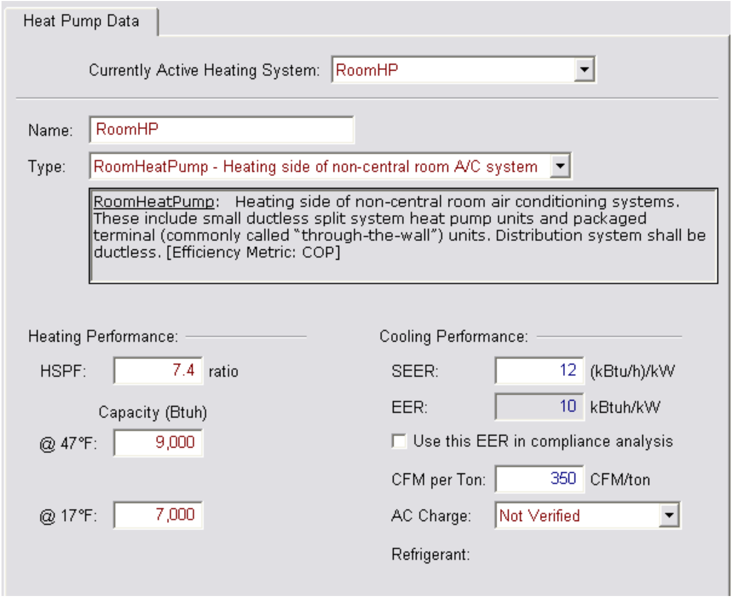
8.2.6.8 CFM per Ton

The mandatory requirement for cooling airflow applies to ducted systems only.

8.2.6.9 AC Charge

Select Not Verified for this equipment type.

Figure 8-9: Room Heat Pump



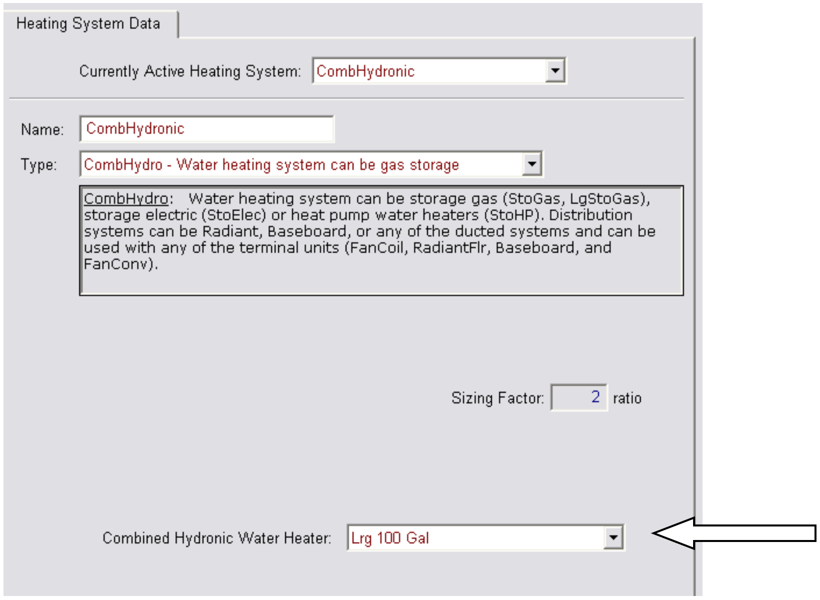
8.2.7 Combined Hydronic

A combined hydronic system uses the same device to provide both space heating and water heating.

Define the system type from the drop down menu as 'CombHydro'. In the field labeled Combined Hydronic Water Heater, specify the device that is providing the source for the space and/or water heating (currently limited to large gas water heater or gas boiler). Figure 8-10 shows a large storage 100 gallon water heater.

An example file included with the program (2Story Example3CombHydNoCool.ribd16) is a combined hydronic system using a water heating boiler.

Figure 8-10: Combined Hydronic Heating Data



NOTE: For the water heating system, define a system using the same water heating device (such as the large water heater shown in the figure above).

8.2.8 Hydronic Distribution Systems and Terminals

The only combined hydronic systems currently implemented are those that have 10 feet or less of piping in unconditioned space.

When hydronic systems have more than 10 feet of piping (plan view) located in unconditioned space, additional information about the distribution system is needed.

Other information reported includes:

- *Piping Run Length (ft).* The length (plan view) of distribution pipe located in unconditioned space, in feet, between the primary heating/cooling source and the point of distribution.
- *Nominal Pipe Size (in.).* The nominal (as opposed to true) pipe diameter in inches.
- *Insulation Thickness (in.).* The thickness of the insulation in inches. Enter "none" if the pipe is uninsulated.
- *Insulation R-value (hr-ft^2- °F/Btu).* The installed R-value of the pipe insulation. Minimum pipe insulation for hydronic systems is as specified in Section 150.1(j).

8.2.9 Wood Heat

When all of the qualifications for the wood heat exceptional method are met (see *Residential Compliance Manual*, Section 4.7.7), the heating system (which includes any back-up heating system) receives neither a penalty nor a credit. A hypothetical heating system that meets Package A is simulated by the program.

8.2.10 Non-central Heating

Specify the appropriate system type as electric, floor furnace, room heater, fan type wall furnace, or gravity flow wall furnace. .”

CBECC-Res uses the lowest efficiency for the product type, as is displayed on the screen. The minimum AFUE for gas heating appliances is:

System Type	Minimum AFUE %
Wall furnace, fan type	75
Wall furnace, gravity flow	65
Floor furnace	57
Room heater	61

Assuming there is no cooling system, or the cooling is also ductless, model the distribution system and fan as “none. See Section 8.3.2 for the proper way to model no cooling.

8.3 Cooling Systems

The cooling system is the equipment that supplies cooled air to an HVAC System (see Figure 8-11). Cooling systems are categorized according to the types shown in Table 8-3. See **Table 8-4** for which measures (some of which are mandatory) require HERS verification.

8.3.1 Cooling System Data

8.3.1.1 Name

User-defined name for the cooling system.

8.3.1.2 Type

Cooling system type (see Table 8-3).

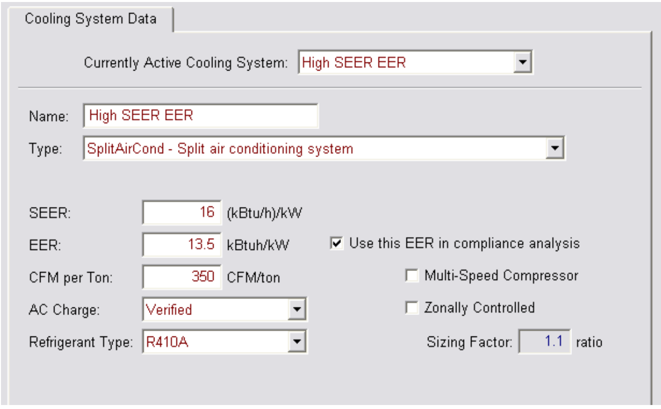
Table 8-3: Cooling Equipment

Descriptor	Cooling Equipment Reference
No Cooling	No cooling equipment. Distribution is ducted (either the same system as heating or default ducts in attic). (See also section 8.3.2). [Efficiency metric: SEER]
Split Air Conditioner	Split air conditioning systems. Distribution is ducted. [Efficiency metric: SEER and EER]
Package Air Conditioner	Central packaged air conditioning systems less than 65,000 Btu/hr cooling capacity. Distribution is ducted. [Efficiency metric: SEER and EER]
Large Package Air Conditioner	[Not enabled] Systems rated at or above 65,000 Btu/hr (cooling capacity). Distribution is ducted. [Efficiency metric: EER]
SDHV Split Air Conditioner	Small duct, high velocity, split A/C system [Efficiency metric: EER]
Ductless Mini-Split Air Conditioner	Ductless mini-split A/C [Efficiency metric: SEER]
Ductless Multi-Split Air Conditioner	Ductless multi-split A/C [Efficiency metric: SEER]
Ductless VRF Air Conditioner	Ductless Variable Refrigerant Charge A/C [Efficiency metric: SEER]
Room Air Conditioner	A factory encased air conditioner that is designed as a unit for mounting in a window, through a wall, or as a console. Distribution is non-ducted. [Efficiency metric: EER]
Evaporative Direct	[Not enabled] Direct evaporative cooling systems. Assume minimum efficiency air conditioner. The default distribution system is ducts in attic. [Efficiency metric: SEER]
Evaporative Indirect/Direct	[Not enabled] Indirect-direct evaporative cooling systems. Assume energy efficiency ratio of 13 EER. Requires air flow and media saturation effectiveness from the Energy Commission appliance directory. Distribution is ducted or non-ducted. [Efficiency metric: SEER]
Evaporative Indirect	[Not enabled] Indirect cooling systems. The default distribution system is duct in attic; evaporative cooler duct insulation requirements are the same as those for air conditioner ducts. Assume energy efficiency ratio of 13 EER. Requires air flow and media saturation effectiveness from the Energy Commission directory. [Efficiency metric: SEER]
EvapCondenser	Evaporatively-cooled condenser. The default distribution system is duct in attic; evaporatively cooled condenser duct insulation requirements are the same as those for air conditioner ducts. Requires refrigerant charge testing, EER verification, and compliance with RA4.3.2. [Efficiency metric: EERa and EERb]

Table 8-4: Air Conditioning Measures Requiring HERS Verification

Measure	Description
Refrigerant Charge	Air-cooled air conditioners and air-source heat pumps must be diagnostically tested to verify that the system has the correct refrigerant charge.
Charge Indicator Display	A Charge Indicator Display (CID), alternative to refrigerant charge testing.
System Airflow	Ducted systems require a verified system airflow greater than or equal to 350 CFM/ton (mandatory requirement) or another specified value.
Air-handling Unit Fan Efficacy	To verify that fan efficacy is less than or equal to 0.58 Watts/CFM (a mandatory requirement) or other specified criterion.
EER	Credit for higher than minimum EER by installation of specific air conditioner or heat pump models.
SEER	Credit for higher than minimum SEER.

Figure 8-11: Cooling System Data



8.3.1.3 SEER

Cooling equipment Seasonal Energy Efficiency Ratio (SEER). For equipment tested only with an EER, enter the EER as the SEER. When a value higher than 14 SEER for "Compliance 2017" is modeled, it triggers a HERS Verification of High SEER. Efficiency information can be obtained from the Energy Commission's appliance directories (http://www.appliances.energy.ca.gov/AdvancedSearch.aspx) or from AHRI Certified Products Directory.

8.3.1.4 EER

Cooling equipment Energy Efficiency Ratio (EER). CBECC-Res has default values for the EER based on the SEER value modeled. Two conditions will result in a HERS verified EER. (a) An EER higher than the default of 11.7 for "Compliance 2017", and (b) checking the box "☑ Use this EER in compliance analysis." Because the EER depends on the specific combination of coil and condenser model numbers, other than default EER ratings can be obtained from AHRI.

8.3.1.5 CFM per Ton

The mandatory minimum requirement for cooling airflow is 350 CFM/ton for ducted cooling systems (also assumed for dwellings with no cooling). The only exception is single speed zonally controlled systems, which may model a value as low as 150 CFM/ton. Users may model a higher airflow. All systems other than no cooling require HERS verified system airflow using diagnostic testing procedures from *Reference Appendices*, Residential Appendix RA3.

8.3.1.6 AC Charge

Verified refrigerant charge. Select not verified, verified, or Charge Indicator Display (CID). There is no mandatory requirement for verified refrigerant charge, however, the standard design in climate zones 2 and 8-15 includes proper refrigerant charge in the standard design for most equipment types (see standards Section 150.1(c)8.).

8.3.1.7 Refrigerant Type

Default R410A assumed for all refrigerant containing equipment.

8.3.1.8 Multi-Speed Compressor

Use this field to indicate if the system is a multi-speed compressor. Zonally controlled multi-speed compressors must meet 350 CFM/ton. The exception for zonally controlled single speed compressors would leave this box unchecked and specify a value as low as 150 CFM/ton (see Section 8.3.1.5).

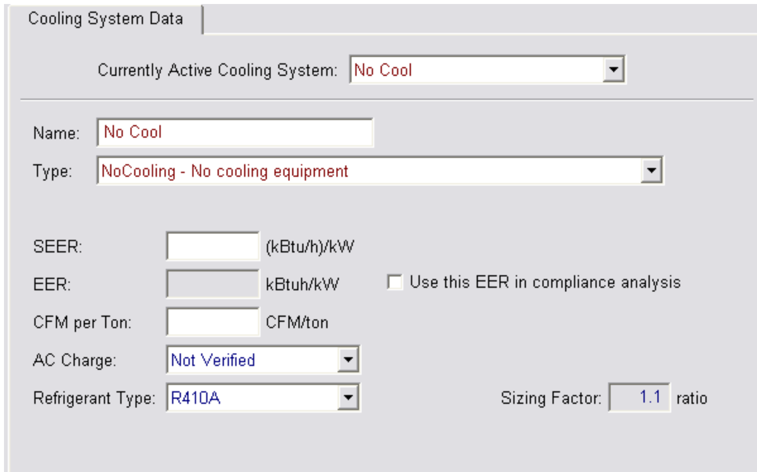
8.3.1.9 Zonally Controlled

Checkbox to indicate zonally controlled cooling equipment. A HERS rater will verify the modeling assumptions associated with a bypass duct, CFM/ton, and single- or multi-speed compressor.

8.3.2 No Cooling

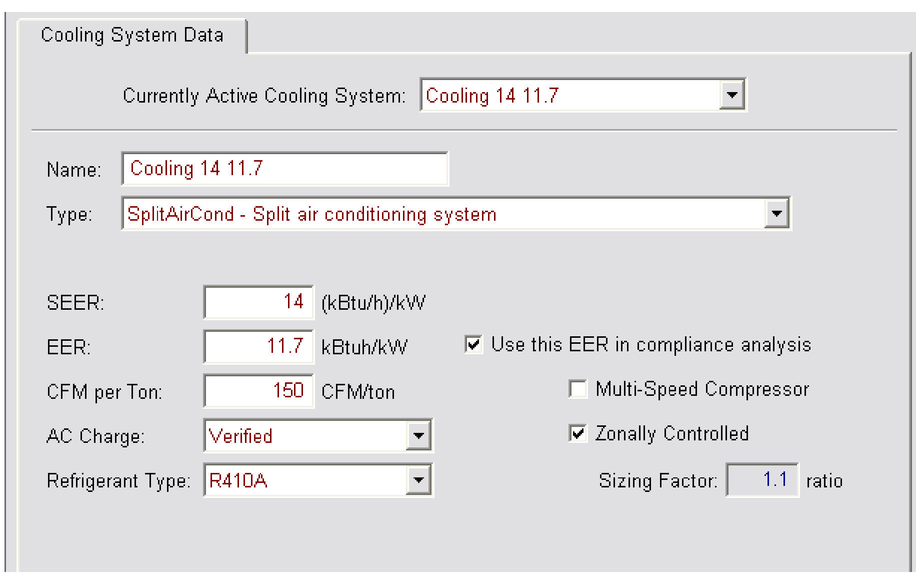
When no cooling system is installed in a dwelling, create a cooling system using the system type NoCooling (see Figure 8-12). The distribution system is the same as the heating system (if any). If the heating system has no ducts, set the distribution to none. The fan system can also be set to none.

Figure 8-12: No Cooling System



8.3.3 Zonal Cooling

CBECC can model zonally controlled cooling equipment (different than the compliance option that involves living and sleeping zones). Some of the choices with this modeling option include the ability to specify if the equipment is a single-speed or multi-speed compressor. A single-speed compressor with a bypass duct has an exception that allows modeling a cooling airflow as low as 150 CFM/ton (an energy penalty). It is important to know the details of the system because in some cases it may not be possible to meet 350 CFM/ton when in zonal mode. See Sections 8.3.1.5, 8.3.1.8 and 8.3.1.9. Specify a bypass duct as shown in Section 8.4.1.6. See also *Reference Appendices*, Residential Appendix RA3.1.4.6.



8.3.4 Evaporatively Cooled Condenser

This type of air conditioning is suited for hot dry climates. The efficiencies are reported as multiple EER values at different conditions. More information can be obtained from the 2016 Residential Manual, Section 4.7.9 and a full list of compliance requirements is included in the 2016 Residential Appendices, Residential Appendix RA4.3.2. This system type requires HERS verification of EER, refrigerant charge, and duct leakage testing.

An example file (1StoryExample3EvapCond.ribd16) is included in the projects folder.

8.3.4.1 EERa

EER at 95°F dry bulb and 75°F wet bulb, obtained from AHRI Certified Products Directory.

8.3.4.2 EERb

EER at 82°F dry bulb and 65°F wet bulb. This value must be tested and published by the manufacturer according to AHRI guidelines.

8.3.5 Non-Central Air Conditioners

8.3.5.1 Name

User-defined name for the cooling system.

8.3.5.2 Type

Cooling system type is selected from Table 8-3.

8.3.5.3 SEER and/or EER

Enter the SEER and/or EER for the proposed equipment. See the *2015 Appliance Efficiency Standards* (Table B-3) for the minimum efficiency of room air conditioners. To enter a different value for EER, check the box "☑ Use this EER in compliance analysis."

8.3.5.4 CFM per Ton

For most non-central system types, there is no airflow testing required. The CF1R will correctly identify if airflow testing is required.

8.3.5.5 AC Charge

Select Verified, Not Verified or fault indicator display. NOTE: because anything other than "not verified" is a HERS verified measure, be sure to take the time to see if verifying the AC charge provides any benefit.

8.3.6 Evaporative Cooling

[NOT YET IMPLEMENTED] Specify one of three types of evaporative cooling: (1) direct evaporative cooler, the most commonly available system type, (2) indirect, or (3) indirect-direct. Product specifications and other modeling details are found in the Energy Commission's appliance directory for evaporative cooling, including the evaporative cooling system type and efficiency. The default system type is evaporative direct, which is assigned an efficiency of 13 SEER (or the minimum appliance standard for split system cooling). For indirect or indirect-direct, select the appropriate type, based on the Energy Commission appliance directory as well as the air flow and media saturation effectiveness or cooling effectiveness from the Energy Commission appliance directory, and specify 13 EER (if required input 13 SEER as well).

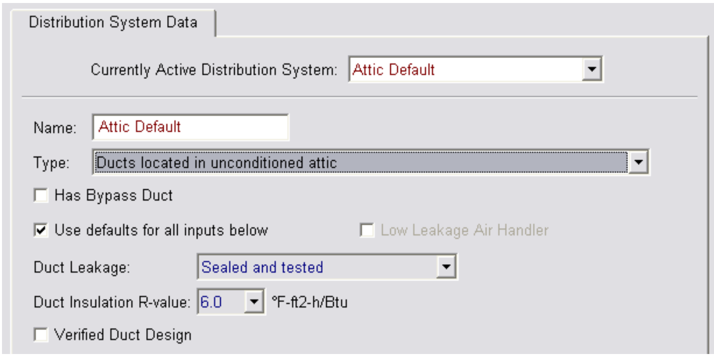
Direct evaporative coolers are assumed equivalent to a minimum split system air conditioner. The evaporative cooling modeling methodology addresses two performance issues: (1) rising indoor relative humidity during periods with extended cooler operation, and (2) evaporative cooler capacity limitations. Since modeling of indoor air moisture levels is beyond the capability of simulation models, a simplified algorithm is used to prohibit evaporative cooler operation during load hours when operation is expected to contribute to uncomfortable indoor conditions. The algorithm disallows cooler operation when outdoor wet bulb temperatures are 70°F, or above. As for the capacity limitations, since evaporative coolers are 100 percent outdoor air systems, their capacity is limited by the outdoor wet bulb temperature. Each hour with calculated cooling load, the algorithm will verify that the cooling capacity is greater than the calculated house cooling load.

8.4 Distribution System Data

Model the distribution system (ducts) associated with the HVAC system within a given zone. When modeled as one system, assume the worst case conditions.

When modeling a multi-story building, the computer model already assumes that some ductwork is between floors and inside the conditioned space.

Figure 8-13: Distribution System Data



8.4.1.1 Name

User-defined name.

8.4.1.2 Type

Indicate the type of duct system, location, or no ducts (see Table 8-5).

Table **8-6** summarizes the duct conditions that require HERS verification, including sealed and tested ducts, which are a mandatory requirement.

Proposed HVAC systems with ducts in the crawl space or a basement must have supply registers within two feet of the floor and show the appropriate locations for the ducts. Ducts in a crawl space or basement can be verified by the local enforcement agency (no HERS verification or duct design).

Table 8-5: Distribution Type

Descriptor	**Distribution Type and Location**
Ducts located in attic (Ventilated and Unventilated)	Ducts located overhead in the attic space, whether the attic is ventilated or unventilated (and default condition for no cooling).
Ducts located in a crawl space	Ducts located in crawl space.
Ducts located in a garage	Ducts located in garage space.
Ducts located within the conditioned space (except < 12 lineal feet)	Less than 12 linear feet of duct is outside of the conditioned space.
Ducts located entirely in conditioned space	HVAC equipment and all ducts (supply and return), furnace cabinet and plenums, located within the conditioned space. Location of ducts in conditioned space eliminates conduction losses but does not change losses due to leakage. Leakage from either ducts that are not tested for leakage or from sealed ducts is modeled as leakage to outside the conditioned space.
Distribution system without ducts	Air distribution systems without ducts such as window air conditioners, wall furnaces, floor furnaces, radiant electric panels or combined hydronic heating equipment.
None	Same as above. Specified at the HVAC System Data screen.
Ducts located in outdoor locations	Ducts located in exposed locations outdoors.
Verified low-leakage ducts entirely in conditioned space	Verified Low Leakage Ducts in Conditioned Space - defined as duct systems for which air leakage to outside conditions is equal to or less than 25 CFM when measured in accordance with *Reference Appendices*, Residential Appendix RA3.1.
Ducts located in multiple places	Allows a different location for supply and return ducts.

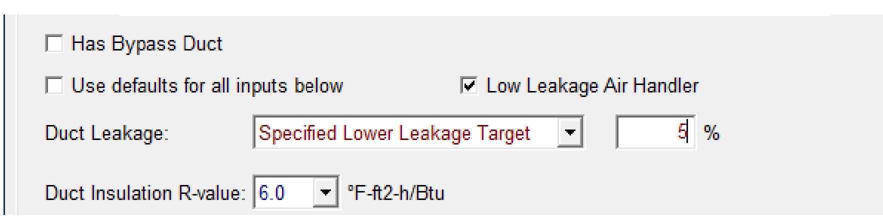
Table 8-6: Summary of Verified Air Distribution Systems

Measure	**Description**
Duct Sealing	Mandatory measures require that space conditioning ducts be sealed. Field verification and diagnostic testing is required.
Supply Duct Location, Reduced Surface Area and R-value	Compliance credit for improved supply duct location, reduced surface area and R-value. Field verification that duct system was installed according to the duct design, including location, size and length of ducts, duct insulation R-value and installation of buried ducts. For buried ducts, this measure also requires improved construction quality or QII and duct sealing.
Low Leakage Ducts in Conditioned Space	When space conditioning ducts are located entirely in directly conditioned space, this is verified by diagnostic testing. Compliance credit can be taken for verified duct systems with low air leakage to the outside. Field Verification for ducts in conditioned space and duct sealing are required (*Reference Appendices*, Residential Appendix RA3.1.4.3.8).
Low Leakage Air-handling Units	Compliance credit can be taken for installation of a factory sealed air handling unit tested by the manufacturer and certified to the Commission to have met the requirements for a Low Leakage Air-Handling Unit achieved. Field verification of the air handler's model number is required. Duct sealing is required.
Return Duct Design	Verification to confirm that the return duct design conforms to the criteria given in Table 150.0-C or Table 150.0-D. as an alternative to meeting 0.58 W/CFM fan efficacy of Section 150.0(m)12.
Bypass Duct Condition	Verification to determine if system is zonally controlled, and confirm that bypass ducts condition modeled matches installation.

8.4.1.3 Use all distribution system defaults

By checking this option, the detailed information about the supply and return ducts is completed based on other building inputs, including climate zone. NOTE: If you change the climate zone to one with a different Package A duct insulation value, the program will change to match Package A, which may not match the plans.

Figure 8-14: Duct Leakage



8.4.1.4 Duct Leakage

Select sealed and tested. To specify a target leakage number, select Low Leakage Air Handler (see Figure 8-14). HERS verification is required for this mandatory measure.

8.4.1.5 Duct Insulation R-value

Specify the R-value of HVAC system ducts. The mandatory minimum R-value allowed is 6. Valid options are 0, 2.1, 4.2, 6.0 and 8.0. For new construction, the default value is based on the climate zone and attic option B, which is R-6 in climate zones 3, and 5-7 and R-8 for all other climate zones.

8.4.1.6 Has Bypass Duct

If the system is zonally controlled, indicate if the system has a bypass duct. This is a HERS verified feature (*Reference Appendices*, Residential Appendix RA3.1.4.6).

8.4.1.7 Supply Ducts

If Section 0 is unchecked so that credit may be obtained for a verified duct design/reduced surface area (see *Reference Appendices*, Residential Appendix RA3.1), enter the supply duct details for area, diameter and location. The supply duct begins at the exit from the furnace or air handler cabinet.

The supply duct surface area for crawl space and basement applies only to buildings or zones with all supply ducts installed in the crawl space or basement. If the supply duct is installed in locations other than crawl space or basement, the default supply duct location is "Other." Do not include the surface area of supply ducts completely inside conditioned space, or ducts in floor cavities or vertical chases when surrounded by conditioned space with draft stops.

The surface area of each supply duct system segment is calculated based on its inside dimensions and length. The total supply surface area in each unconditioned location (attic, attic with radiant barrier, crawl space, basement, other) is the sum of the area of all duct segments in that location.

8.4.1.8 Verified Duct Design

When this option is selected, additional fields become available for inputs related to the distribution system, including supply and return duct details, and buried ducts.

8.4.1.9 Supply Duct Attic

Enter the location of the supply duct. If verified duct design is selected, also enter the area and R-value of supply ducts.

8.4.1.10 Return Duct Attic

Enter the location of the return duct. If verified duct design is selected, also enter the area and R-value of return ducts.

The calculations assume that the return duct is located entirely in the attic, unless (a) the return duct is located entirely in the basement, in which case the calculation shall assume basement conditions for the return duct efficiency calculation, or (b) the return duct is located entirely in conditioned space and the system meets the requirements for *Verified Low Leakage Ducts in Conditioned Space*, in which case the return duct is assumed to be in conditioned space.

8.4.2 Low Leakage Air Handlers

Credit can be taken for installation of a factory sealed air handling unit tested by the manufacturer and certified to the Energy Commission to meet the requirements for a Low Leakage Air-Handler. Field verification of the air handler's model number is required.

A Low Leakage Air Handler is reported on the compliance report and field verified in accordance with the procedures specified in *Reference Appendices*.

8.4.3 Verified Low Leakage Ducts in Conditioned Space

For ducted systems the user may specify that all ducts are entirely in conditioned space and the duct system is assumed to have no leakage and no conduction losses.

Systems that have all ducts entirely in conditioned space are reported on the compliance documents and this is verified by measurements showing duct leakage to outside conditions is equal to or less than 25 CFM when measured in accordance with *Reference Appendices*, Residential Appendix RA3.

8.4.4 Buried Ducts

Ducts partly or completely buried under blown attic insulation also meeting the requirements for verified quality insulation installation, verified duct design and duct leakage testing may take credit for increased effective duct insulation using the HERS verified credit for buried ducts. The program inputs require the user to calculate a weighted average duct R-value and input that value in the program.

The duct design shall identify the segments of the duct that meet the requirements for buried ducts on the ceiling ("buried ducts") and ducts that are enclosed in a lowered ceiling and completely covered by ceiling insulation ("deeply buried ducts"). Buried ducts shall have a minimum of R-4.2 duct insulation prior to being buried. The ceiling must be level with at least 6 inches of space between the outer jacket of the installed duct and the roof sheathing above. Additional details regarding the duct design and the inspection process can be found in *Reference Appendices*, Residential Appendix RA3.1.4, *Residential Compliance Manual* Section 4.4.3, and form CF2R-MCH-29-H.

8.4.4.1 Buried Ducts

Select verified duct design (see Figure 8-15). Enter the calculated effective R-value of return and supply duct lengths that are partly or completely buried in blown attic insulation of at least R-30, using values from Table 8-7.

8.4.4.2 Deeply Buried Ducts

Select verified duct design (see Figure 8-15). Enter the calculated effective R-value of return and supply duct lengths that are enclosed in a lowered ceiling and covered by at least 3.5 inches of insulation above the top of the duct insulation jacket. Ducts meeting the criteria for deeply buried ducts have an effective value of R-25 for fiberglass ceiling insulation or R-31 for cellulose ceiling insulation.

Figure 8-15: Buried Ducts

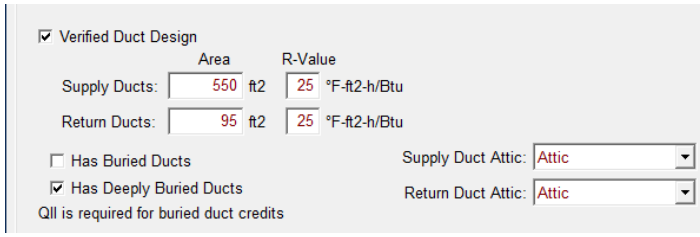


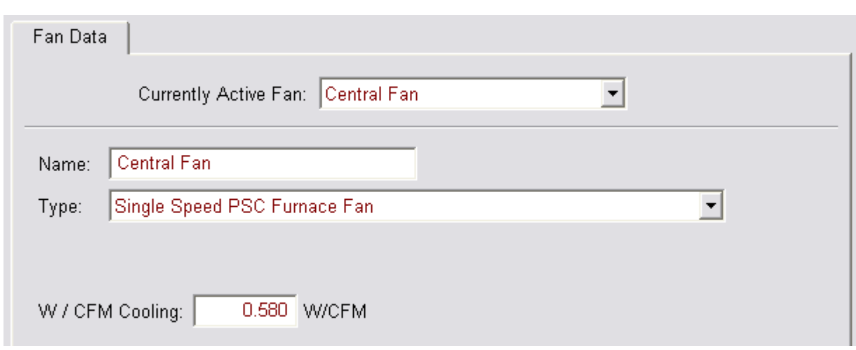
Table 8-7: Buried Duct Effective R-values

	Nominal Round Duct Diameter							
Attic Insulation	4''	5''	6''	7''	8''	10''	12''	14''	16''
	Effective Duct Insulation R-value for Blown Fiberglass Insulation								
R-30	R-13	R-13	R-13	R-9	R-9	R-4.2	R-4.2	R-4.2	R-4.2
R-38	R-25	R-25	R-25	R-13	R-13	R-9	R-9	R-4.2	R-4.2
R-40	R-25	R-25	R-25	R-25	R-13	R-13	R-9	R-9	R-4.2
R-43	R-25	R-25	R-25	R-25	R-25	R-13	R-9	R-9	R-4.2
R-49	R-25	R-25	R-25	R-25	R-25	R-25	R-13	R-13	R-9
R-60	R-25	R-25	R-25	R-25	R-25	R-25	R-25	R-25	R-13
	Effective Duct Insulation R-value for Blown Cellulose Insulation								
R-30	R-9	R-4.2	R-4.2	R-4.2	R-4.2	R-4.2	R-4.2	R-4.2	R-4.2
R-38	R-15	R-15	R-9	R-9	R-4.2	R-4.2	R-4.2	R-4.2	R-4.2
R-40	R-15	R-15	R-15	R-9	R-9	R-4.2	R-4.2	R-4.2	R-4.2
R-43	R-15	R-15	R-15	R-15	R-9	R-4.2	R-4.2	R-4.2	R-4.2
R-49	R-31	R-31	R-15	R-15	R-15	R-9	R-9	R-4.2	R-4.2
R-60	R-31	R-31	R-31	R-31	R-31	R-15	R-15	R-9	R-9

8.5 HVAC Fan System

The HVAC fan system moves air for the air conditioning and heating systems.

Figure 8-16: HVAC Fan



8.5.1.1 Name

User-defined name.

8.5.1.2 Type

Default single speed furnace fan.

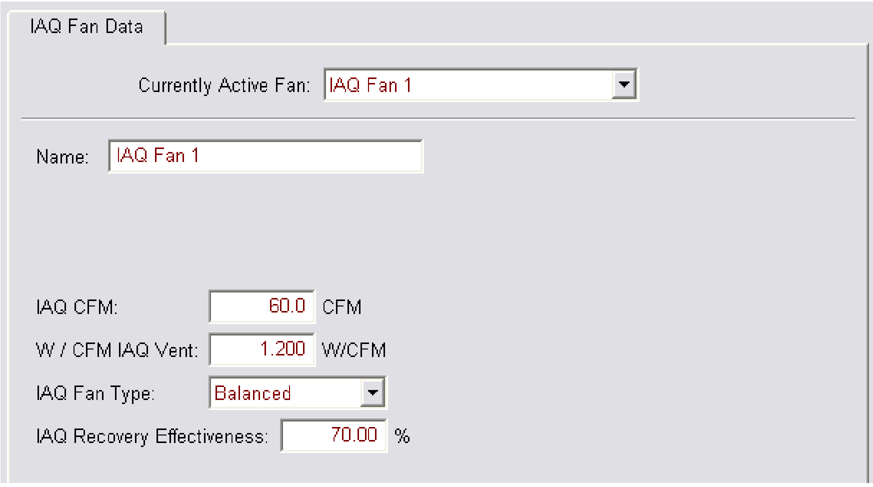
8.5.1.3 Watts/CFM Cooling

The mandatory requirement in Section 150.0(m)13 is for an air-handling unit fan efficacy less than or equal to 0.58 Watts/CFM as verified by a HERS rater. The alternative to HERS verification of 0.58 Watts/CFM is HERS verification of a return duct design that conforms to the specification given in Table 150.0-C or D. However, if a value less than 0.58 Watts/CFM is modeled for compliance credit, the fan efficacy value must be verified and the alternative is not allowed.

If no cooling system is installed, this value is assumed to be 0.58 W/CFM.

8.6 Indoor Air Quality (IAQ) Fan Data

Figure 8-17: IAQ Fan Data



Mechanical ventilation is required to meet minimum indoor air quality (IAQ) requirements of ASHRAE Standard 62.2 (see *Residential Compliance Manual*, Section 4.6, and CF2R-MCH-27) for single- or multi-family dwelling units. The IAQ system requires HERS verification meeting *Reference Appendices*, Residential Appendix RA3.3.

The simplest IAQ fan system is an exhaust fan, such as a bathroom fan that meets the criteria in ASHRAE Standard 62.2 for air delivery and low noise, and that operates continuously. More advanced IAQ fan systems have a supply or both supply and exhaust fans. In most cases, the energy impact of this mandatory requirement is neutral. The only system for which credit can accrue is a central fan integrated system with HERS verified W/CFM of less than 0.58.

8.6.1.1 Name

User-defined name (must be the same name as specified in Section 4.9).

8.6.1.2 IAQ CFM

Enter the size of fan being installed to meet the minimum CFM required to meet the mandatory ventilation requirements (found under Building in Section 4.5).

8.6.1.3 W/CFM IAQ Vent

The default value is 0.25 W/CFM. The standard design is set to the same value as proposed up to 1.2 W/CFM).

8.6.1.4 IAQ Fan Type

Select exhaust, supply, or balanced (both exhaust and supply).

8.6.1.5 IAQ Recovery Effectiveness

When the fan type is balanced, enter the IAQ Recovery Effectiveness.

8.7 Cooling Ventilation

Although not a mandatory requirement, a whole house fan (one type of cooling ventilation) is included in the standard design building in climate zones 8-14. CBECC-Res can model system types shown in

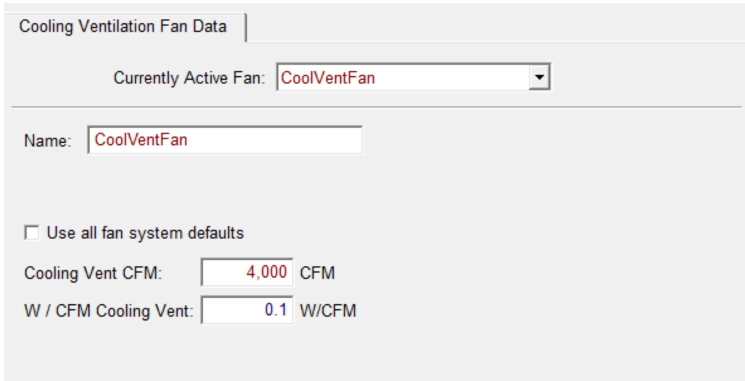
Table 4-1. Inputs associated with each type are shown below.

Ventilation cooling systems bring in outside air to cool the house when this can reduce cooling loads and save cooling energy. Whole house fans involve window operation and attic venting. Central fan integrated (CFI) systems use the HVAC duct system to distribute ventilation air. Any ventilation cooling system that exhausts air through the attic requires a minimum of 1 ft^2 of free attic ventilation area per 750 CFM of rated capacity for relief (based on Section 150.1(c)12 of the standards). The amount of attic venting is not a user input.

8.7.1 Whole House Fan

If a "default prescriptive whole house fan" was specified (see Section 4.10), there is no need to provide details about the fan in this section. If multiple fans are being modeled, or to specify a different fan size, the data shown in Figure 8-18 is needed.

Figure 8-18: Cooling Ventilation



8.7.1.1 Name

User defined name. Unless none or the default fan is specified, this name must match the input in Section 4.10.

8.7.1.2 Use all fan system defaults

Sets the default minimum to 1.5 CFM/ft^2.

8.7.1.3 CFM (Cooling Vent, Fixed or Maximum Flow)

Select either system default (for whole house fans) or enter the actual CFM of the proposed fan.

8.7.1.4 W/CFM Cooling Vent

Enter the Watts/CFM of the proposed system.

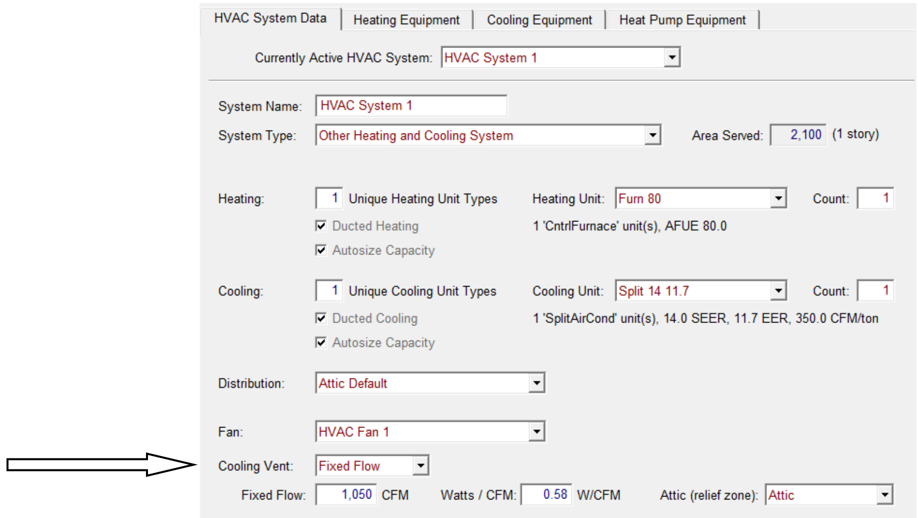
8.7.1.5 Attic (relief zone)

Specify the name of the attic zone in which the fan venting is located.

8.7.2 CFI Fixed Flow

For central fan integrated (CFI) night ventilation, fixed flow (e.g., SmartVent™), select CFI (central fan integrated) Cool Vent on the Cool Vent tab (see Section 4.10). This will reveal additional fields on the HVAC System data screen (see Figure 8-19). The inputs are described above in Sections 8.1.1.11 through 8.1.1.14.

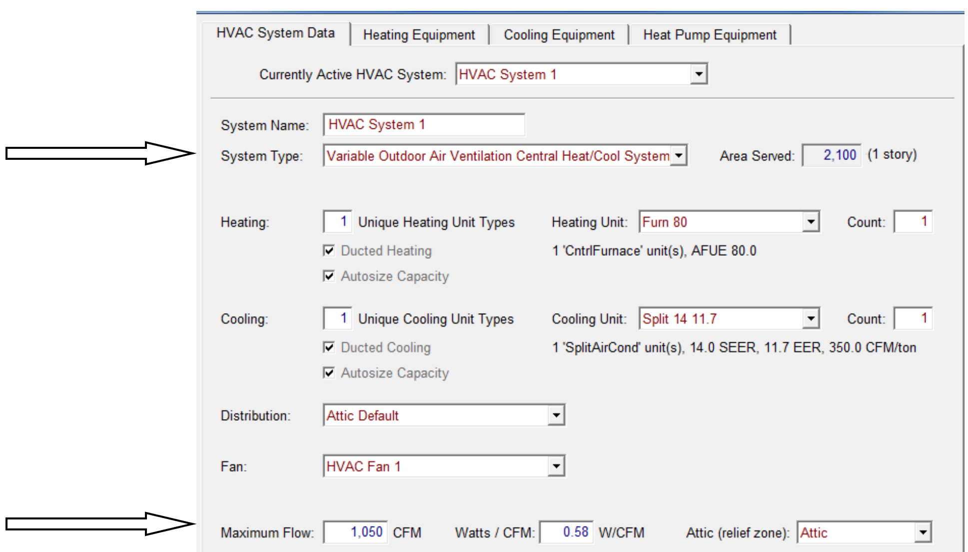
Figure 8-19: CFI Fixed Flow



8.7.3 CFI Variable Speed

For central fan integrated (CFI) night ventilation, variable speed (e.g., Night Breeze™), select CFI (central fan integrated) Cool Vent on the Cool Vent tab (see Section 4.10). Define the HVAC System Type (Section 8.1.1.2) as a variable outdoor air ventilation system. This will reveal additional fields for defining the cooling ventilation system (see Figure 8-20). The inputs are described above in Sections 8.1.1.11 through 8.1.1.14.

Figure 8-20: CFI Variable Flow



Chapter 9. Domestic Hot Water (DHW)

The water heating system is defined at the zone level (see Section 5.1.1.11), or as part of the dwelling unit details of a multi-family building, while the details of the systems are contained under the mechanical tab.

How the water heating system is modeled will depend on the distribution system details as well as the type(s) of water heater. Often multiple water heaters share the same distribution system. When there is more than one water heater of the same type, enter the appropriate count. If there are different water heater types in the system, this is modeled as shown in Figure 9-1. Lastly, if there are multiple distribution systems, at the zone level define a second domestic hot water system.

The standard design for single-family construction, and for multi-family dwellings served by a non-central water heating system, is a tankless gas water heater. For details on the standard design for central water heating, see the *ACM Reference Manual*, Section 2.9.2.

9.1 Efficiency Information

Water heaters are required to be certified to the Energy Commission and the applicable efficiency values needed for modeling are found in the on-line certified appliance directory (https://cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx). From this site, an ***advanced search*** yields the most useful information, which can be exported to a spreadsheet format for sorting and searching. For heat pump water heaters, see also Section 9.8.

Alternatively, some data may be found in the Air-Conditioning, Heating and Refrigeration Institute (https://www.ahridirectory.org/ahridirectory/pages/home.aspx). The AHRI directory does not contain the standby loss for large water heaters, which is a required input.

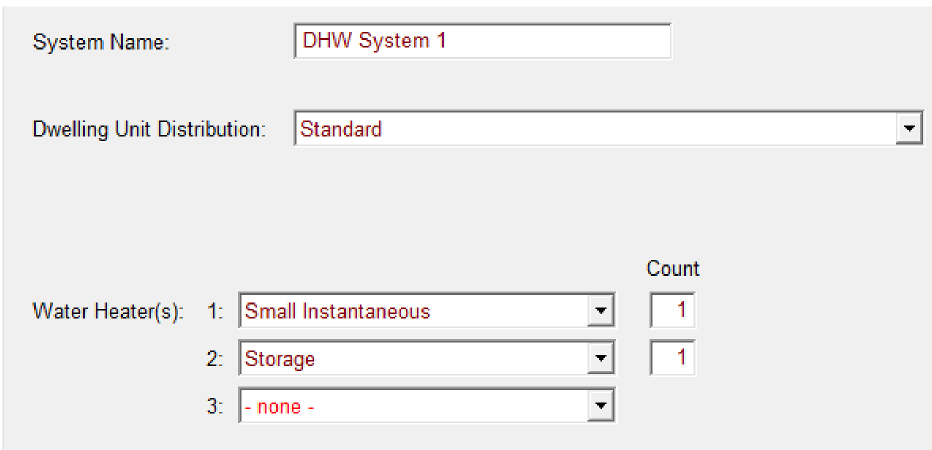
9.2 Water Heater and Tank Types

Water heater types are based on the *Appliance Efficiency Regulations* definitions:

- Boiler is a hot water supply boiler (not a space heating boiler intended for space heating).
- Indirect is a water heater consisting of a storage tank with no heating elements or combustion devices, connected via piping and recirculating pump to a heat source consisting of a boiler.
- Heat pump water heater uses the vapor compression cycle to transfer heat from a low-temperature source to a higher temperature sink for the purpose of heating water.
- Large storage has an input greater than 75,000 Btu/hr gas or propane, greater than 105,000 Btu/hr oil-fired, or greater than 12 kW electric. Rated with thermal efficiency and standby loss.

- Large tankless has an input of greater than 200,000 Btu per hour gas/propane, greater than 210,000 Btu per hour oil-fired, or greater than 12 kW electric. Tankless water heater is a water heater with an input rating of at least 4,000 Btu per hour per gallon of stored water.
- Mini-tank is an electric water heater used with tankless water heaters to regulate temperature fluctuations (see Figure 9-5).
- Small storage has an input of less than or equal to 75,000 Btu gas/propane, less than or equal to 105,000 Btu/hr oil, less than or equal to 12 kW electric, or less than or equal to 24 amps heat pump.
- Small tankless has an input of less than or equal to 200,000 Btu per gas/propane, 210,000 Btu per hour or less oil-fired, or 12 kW or less electric. A tankless water heater is a water heater with an input rating of at least 4,000 Btu per hour per gallon of stored water.

Figure 9-1: Water Heating Data



9.3 Distribution Types

9.3.1 Single Family Distribution Type

Distribution types (Figure 9-2) range from standard (distribution system multiplier 1.0) to recirculating with no control (distribution system multiplier 9.0). Some distribution systems provide more credit if the system will be verified by a HERS rater. See Table 9-1 for a comparison of the multiplier (the lower the number the more efficient the system). More information about distribution types is in *Residential Compliance Manual* and *Reference Appendices.*

For recirculation systems, the recirculation pump can be located external to or integral to the water heater. Pick the appropriate recirculation distribution system based on the control strategy. Systems that do not meet the criteria for Demand Control Push Button, or Demand Control Occupancy/ Motion must be modeled using the Non-Demand Control option.

Figure 9-2: Single Family Distribution Systems

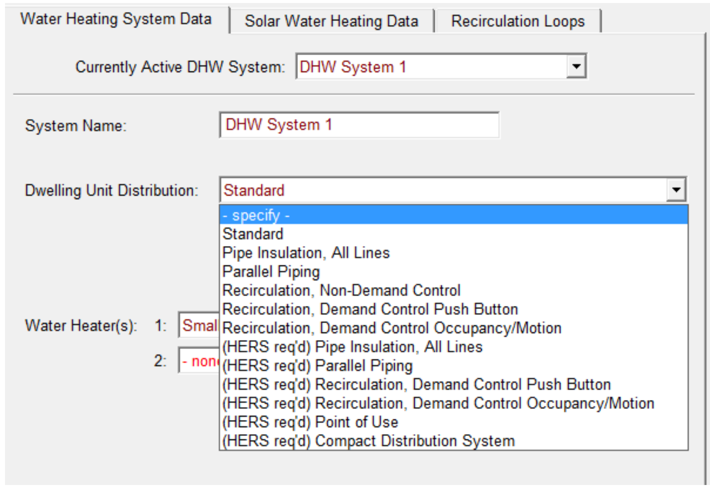


Table 9-1: Water Heater Distribution System Multipliers

Distribution System	Distribution System Multiplier
NO HERS INSPECTION REQUIRED	
Standard	1.00
Pipe Insulation, All Lines	0.90
Central Parallel Piping	1.05
Point of Use	0.30
Recirculation, Demand Control Push Button	1.60
Recirculation, Demand Control Occupancy/Motion	2.40
Recirculation, Non-demand Control (continuous pumping)	9.00
OPTIONAL CASES: HERS INSPECTION REQUIRED	
Pipe Insulation, All Lines	0.80
Central Parallel Piping	0.95
Recirculation, Demand Control Push Button	1.45
Recirculation, Demand Control Occupancy/Motion	2.20
Compact Distribution System	0.70

9.3.2 Multi-Family Distribution Type

When central water heating is used in a multi-family building, the options for the distribution system within the dwelling unit are limited to:

- Standard
- Pipe Insulation, All Lines
- Pipe Insulation, All Lines (HERS verification)

The distribution types available for the central system are:

- No loops or central system pump
- Recirculating with no control (continuous pumping)
- Recirculating with demand control (standard design for new construction)
- Recirculating with temperature modulation
- Recirculating with temperature modulation and monitoring

More information about distribution types is in *Residential Compliance Manual*, Section 5.3 and *Reference Appendices*, Residential Appendix RA3.6 and RA4.4.

9.4 Water Heating System Data

The water heating system is identified on the conditioned zone data tab for single family (see Section 5.1.1) and the dwelling unit type tab for multi-family dwellings (see Section 5.6). The system is limited to one per dwelling unit (multiple water heaters can be accommodated).

9.4.1.1 System Name

User defined name. This is the same name that was provided under the zone data tab (see Section 5.1.1.11).

9.4.1.2 Dwelling Unit Distribution (type)

Specify one distribution system from the drop-down menu (see Section 9.3 and Table 9-1). For installation and compliance requirements see *Residential Compliance Manual* Chapter 5 and *Reference Appendices*, Residential Appendix RA3.6 and 4.4.

In a multi-family building with central water heating, the distribution type within the dwelling unit is limited to one of three types: standard, pipe insulation, or pipe insulation with HERS verification.

9.4.1.3 Central System Distribution (for Multi-Family)

Drop-down menu with options for the level of control on the recirculating system serving the dwelling unit, based on the building and water heater type being specified (see Sections 9.3.2). An input for the recirculation loops is also required (see Figure 9-3).

9.4.1.4 Recirculation Pump Power (bhp)

Multi-family recirculation pump power (brakehorse power). Typical value is less than 1.00.

9.4.1.5 Efficiency (fraction)

Multi-family recirculation motor efficiency (fraction). Typical value is less than 1.00. See Table 9-2 for default efficiencies.

9.4.1.6 Water Heater(s)

The name of the water heater (which holds more information about the water heater, see Section 5.1.1.11).

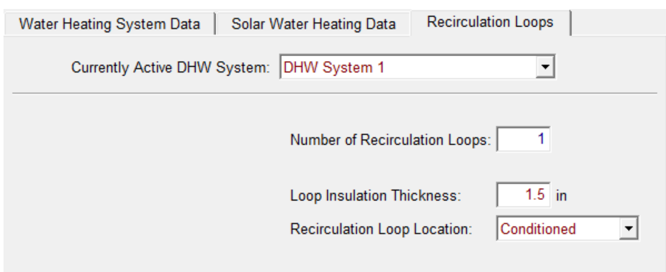
9.4.1.7 Count

The number of water heaters named in the adjacent field. Include different water heater types or different water heater efficiencies on a different row.

Table 9-2: Default Recirculating Pump Motor Efficiency

Nameplate or Brake Horsepower	Standard Fan Motor Efficiency
0.050 (1/20)	0.40
0.083 (1/12)	0.49
0.125 (1/8)	0.55
0.167 (1/6)	0.60
0.250 (1/4)	0.64
0.333 (1/3)	0.66
0.500 (1/2)	0.70
0.750 (3/4)	0.72
Source: Reference Appendices, Nonresidential Appendix NA3	

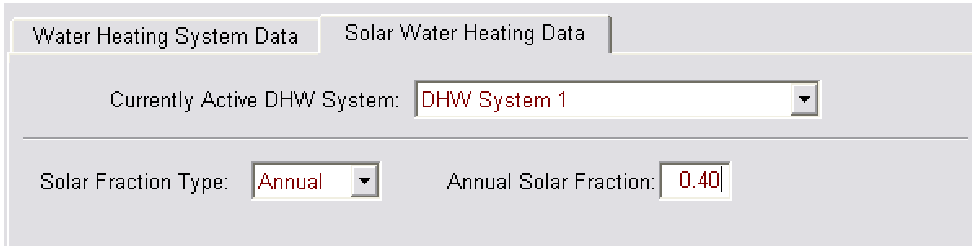
Figure 9-3: Recirculation Loops



9.5 Solar Water Heating Data

When a water heating system has a solar system to meet the water heating load, a Solar Fraction (SF) is determined using an F-chart program, or OG-100 / OG-300 calculation method (see www.gosolarcalifornia.org). The calculation methods require varying levels of detail about the solar system and the site of the installation.

Figure 9-4: Solar Water Heating Data, Annual



9.5.1.1 Solar Fraction Type

Select annual.

9.5.1.2 Solar Fraction

Enter the calculated annual solar fraction (see Figure 9-4). A typical value is 0.40 or less. The program limits this input to less than 1.

9.6 Recirculation Loops for a Central DHW System

9.6.1.1 Number of Recirculation Loops

Enter the number of recirculation loops.

9.6.1.2 Loop Insulation Thickness

Enter the thickness in inches of the insulation.

9.6.1.3 Recirculation Loop Location

Options include conditioned, semi-conditioned, unconditioned and underground.

9.7 Water Heater Data (Gas and Electric Resistance)

The details of the water heater specified in water heating system data are illustrated in Figure 9-5 and Figure 9-6. The fields will vary based on the tank type selected.

Figure 9-5: Small Instantaneous Water Heater Data

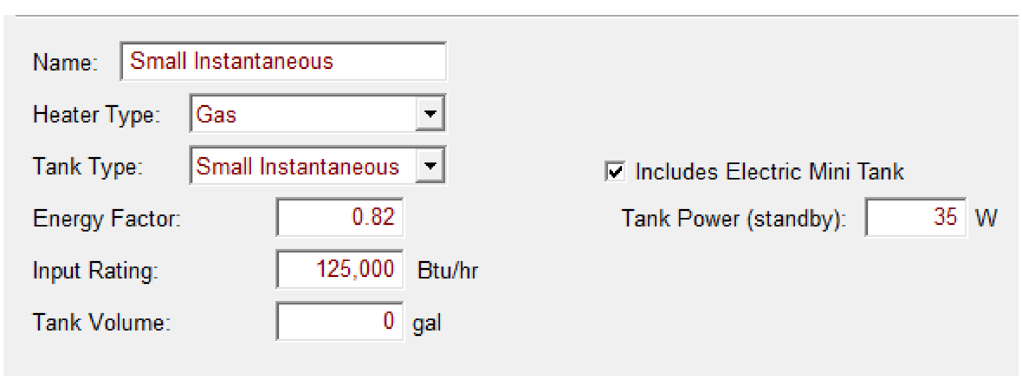
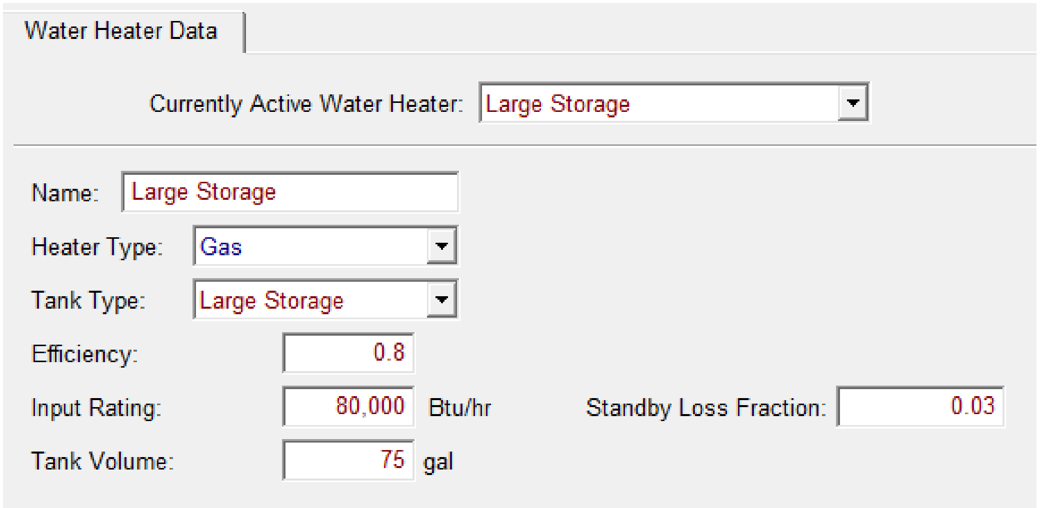


Figure 9-6: Large Storage Water Heater Data



9.7.1.1 Name

User-defined name that is specified in the water heating system data for the field water heater (see Section 9.4.1.6).

9.7.1.2 Heater Type

Choose gas (natural gas, propane, or oil) or electric resistance water heater (see Section 9.8 for heat pump).

9.7.1.3 Tank Type

Choose boiler, indirect, large instantaneous, large storage, small instantaneous, small storage.

NOTE: Most gas instantaneous water heaters are small, based on the rated input (see Section 9.2).

9.7.1.4 Includes Electric Mini Tank

For instantaneous water heaters, check if the system includes a mini tank which helps regulate temperature fluctuations.

9.7.1.5 Tank Power (standby)

Enter the watts of the mini-tank from the appliance directory (see Section 9.1).

9.7.1.6 Energy Factor or Efficiency

Value entered as a decimal, such as 0.60 or 0.80. Certified efficiency from one of the sources listed in Section 9.1. Based on the tank type, the efficiency is energy factor for small storage, small instantaneous, and small heat pump water heaters. For large storage, large instantaneous, large heat pump, or boilers the efficiency is thermal efficiency, recovery efficiency, or AFUE. Indirect water heater efficiency is based on the type of device being used to heat the water.

9.7.1.7 Standby Loss Fraction

Required input for large storage water heaters. Find the standby loss by conducting an advanced search in the Energy Commission's appliance efficiency database of water heating equipment (see Section 9.1). The input into the software depends on what is available for the specified equipment based on the search as follows:

For large storage water heaters where the standby loss is reported in percent per hour, the standby loss fraction is calculated by dividing the percent by 100. For example, a standby loss of 3% is entered as 0.03.

For large storage water heaters where the standby loss is reported in Btu/hr, the standby loss fraction is calculated as:

Standby Loss Fraction = (standby loss Btu/hr) / (8.25 x volume x 70)

For gas and oil large storage water heaters that do not have a reported standby loss, the standby loss fraction is calculated as:

Standby Loss Fraction = (rated input / 800) + (110 x (volume)^0.5) / (8.25 x Volume x 70)

For electric large storage water heaters that do not have a reported standby loss, the standby loss fraction is calculated as:

Standby Loss Fraction = (0.3 + (27/volume)) / 100

9.7.1.8 Pilot Energy

Required input for boiler, large instantaneous and indirect water heaters. Find the pilot energy by conducting an advanced search in the Energy Commission's appliance efficiency database of water heating equipment (see Section 9.1) or in manufacturer's literature. The input into the software depends on what is available:

If pilot energy is in Btu/hr, model that value.

If pilot energy is in percent, convert as:

Pilot energy = ((pilot energy percent) / 100) x (8.25 x Volume x 70) Btu/hr

If no pilot energy information is found, calculate the value using the applicable equation as described in Table 9-3 (based on Table F-2 of the 2015 *Appliance Efficiency Standards)*.

Table 9-3: Pilot Energy Calculation

Appliance	Input to Volume Ratio	Size (Volume)	Maximum Standby Loss [1,2]
Gas storage water heater	< 4,000 Btu/hr/gal	Any	$Q/800 + 110(V_r)^{1/2}$Btu/hr
Gas instantaneous water heaters	≥ 4,000 Btu/hr/gal	< 10 gal	--
		≥ 10 gal	$Q/800 + 110(V_r)^{1/2}$Btu/hr
Gas hot water supply boilers	≥ 4,000 Btu/hr/gal	< 10 gal	--
		≥ 10 gal	$Q/800 + 110(V_r)^{1/2}$Btu/hr
Oil storage water heaters	< 4,000 Btu/hr/gal	< 10 gal	--
		≥ 10 gal	$Q/800 + 110(V_r)^{1/2}$Btu/hr
Oil instantaneous water heaters	≥ 4,000 Btu/hr/gal	< 10 gal	--
		≥ 10 gal	$Q/800 + 110(V_r)^{1/2}$Btu/hr
Oil hot water supply boilers	≥ 4,000 Btu/hr/gal	< 10 gal	--
		≥ 10 gal	$Q/800 + 110(V_r)^{1/2}$Btu/hr
Electric storage water heaters	< 4,000 Btu/hr/gal	Any	$0.3 + 27/V_m$%/hr

[1] V_r is rated volume in gallons, V_m is measured volume in gallons, and Q is the nameplate input rate in Btu/hr.

[2] Water heaters and boilers > 140 gallons of storage capacity are not required to meet the standby loss requirement if the tank surface is thermally insulated to R-12.5, if a standing pilot light is not installed, and for gas- or oil-fired storage water heaters, there is a flue damper or fan-assisted combustion.

For electric powered water heaters, where Table F-2 reports the maximum standby loss as a percent, convert to Btu/hr using the following calculation:

Pilot energy = ((0.3 + (27/Volume)) / 100) x (8.25 x Volume x 70) Btu/hr

9.7.1.9 Tank Volume

The volume (in gallons) from one of the listed sources in Section 9.1.

9.7.1.10 Input Rating

The input rating (consistent with the tank type) from one of the listed sources in Section 9.1.

9.7.1.11 Tank Insulation R-values

For boilers, or indirect water heaters, enter exterior and interior tank insulation R-values.

9.7.1.12 Ambient Conditions

For an indirect water heater, specify whether it is installed in unconditioned or conditioned space.

9.7.1.13 Recovery Efficiency

If the equipment is part of a hydronic system, enter the recovery efficiency, thermal efficiency or AFUE for appropriate water heating type. The value comes from one of the listed sources in Section 9.1 and is entered as a percent (e.g., 78, 80).

9.7.1.14 Tank Outside or in Exterior Closet / Location

For electric resistance water heaters, indicate if the tank is outside, or its location in the building.

9.8 Heat Pump Water Heater Data

CBECC-Res includes a new heat pump water heater model. The specifications needed for the input file will vary based on the ratings. A heat pump rated by the Northwest Energy Efficiency Alliance (NEEA) will identify a name that encompasses several make and model numbers (see Figure 9-7 and the latest Frequently Asked Questions posted at the CBECC website). If the heat pump water heater is not rated by NEEA, model the Energy Factor and volume (Figure 9-8) (see Section 9.1).

NOTE: Building inspectors will be advised to check equipment against the list in Table 9-4.

Figure 9-7: NEEA Rated Heat Pump Water Heater

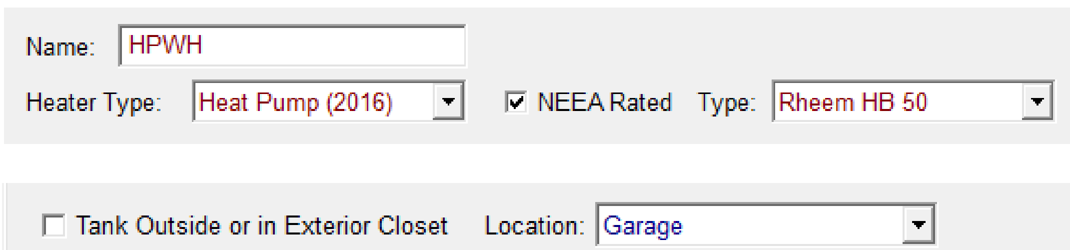
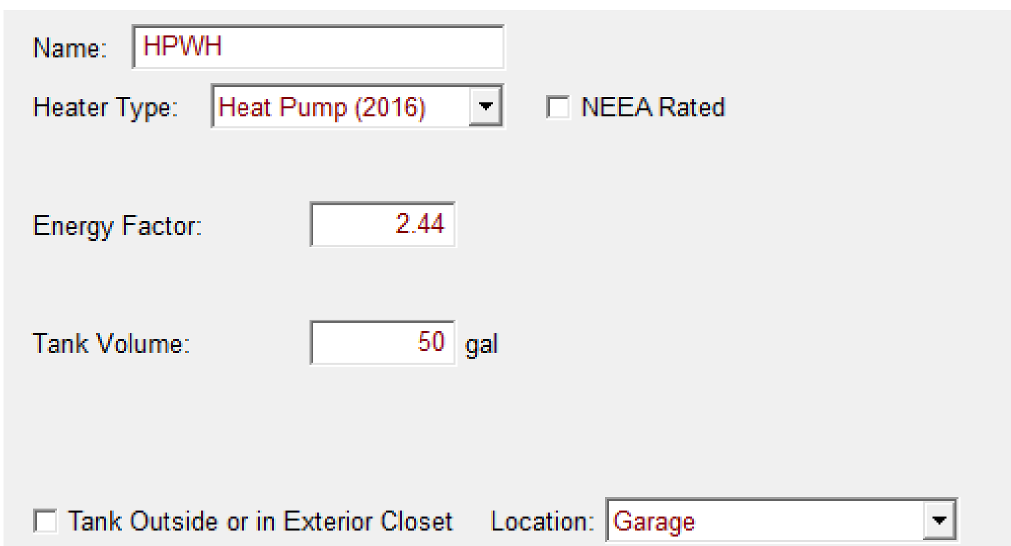


Figure 9-8: Heat Pump Water Heater



9.8.1.1 Name

User-defined name for the water heater (see Section 9.4.1.6).

9.8.1.2 Heater Type

Choose heat pump. For electric resistance or gas see Section 9.7.

9.8.1.3 NEEA Rated

If the heat pump water heater is rated by the Northwest Energy Efficiency Alliance (NEEA) check this box, and identify a name.

9.8.1.4 Type

Select from the list of water heaters (see the latest Frequently Asked Questions for NEEA qualified products). The list, which includes manufacturer, model number, first hour rating, and energy factor, is updated as NEEA updates the list).

9.8.1.1 Energy Factor

Unless NEEA rated, enter the certified Energy Factor (EF), such as 2.33, from one of the sources listed in Section 9.1. Heat pump water heaters typically have an EF of 2 or higher. Energy Factor limited from 2 to 3.5.

9.8.1.2 Volume

The volume (in gallons) from one of the listed sources in Section 9.1.

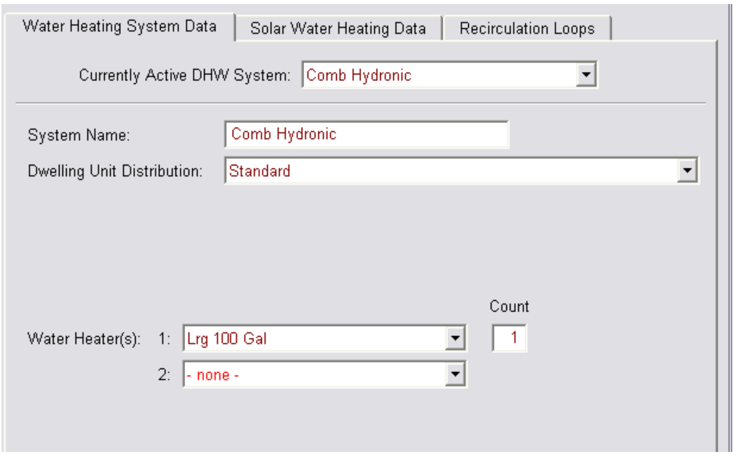
9.8.1.3 Tank Outside or in Exterior Closet / Location

Indicate if the tank is located outside, or specify the location in the building (only for heat pump and electric resistance water heaters).

9.9 Combined Hydronic

A combined hydronic system uses a device such as a boiler, large storage or tankless water heater to provide both space heating and water heating. For the space heating system inputs, see Section 8.2.6. See Figure 9-8 for the proper way to model the water heating portion of a combined hydronic system.

Figure 9-9: Combined Hydronic



To receive the full credit for a combined hydronic system, rather than leaving the water heating field as "none", list the same device providing the space heating as the water heating system (for example, large storage 100 gallon water heater).

9.10 Ground Source Heat Pump and Air to Water Heat Pump

The water heating portion of a ground source heat pump or air to water heat pump is modeled by first defining the HVAC system, as described in Section 8.2.3 and checking the box "System Heats DHW" or domestic hot water.

The inputs for the water heating equipment data are:

9.10.1.1 Tank Volume

Enter the tank volume (in gallons).

9.10.1.2 Insulation R-value

R-value of external tank insulation.

9.10.1.3 Ambient Conditions

Specify whether installed in unconditioned or conditioned space.

NOTE: The final step is to connect the HVAC system to the DHW system. In this example, an HVAC system named Ground Source HP was specified and can be selected to serve as the water heating system for the zone. Once this connection is made, the mechanical tab will look like Figure 9-11.

Figure 9-10: Water Heater from an HVAC System

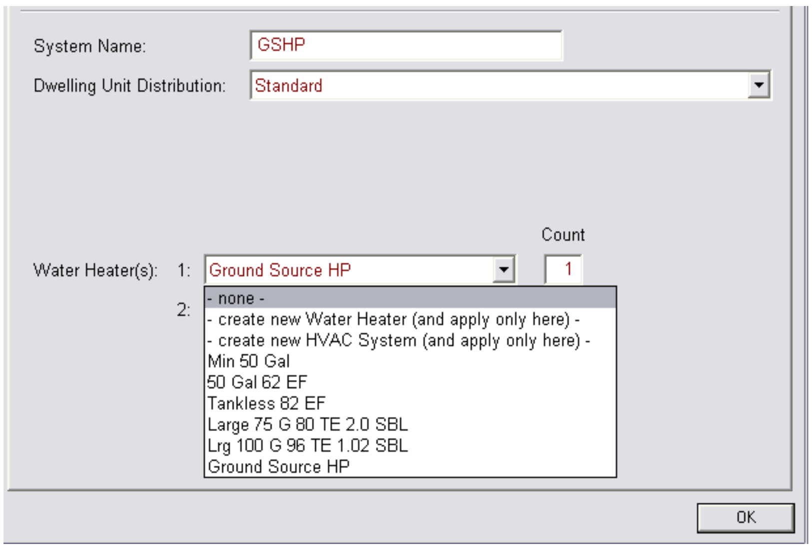
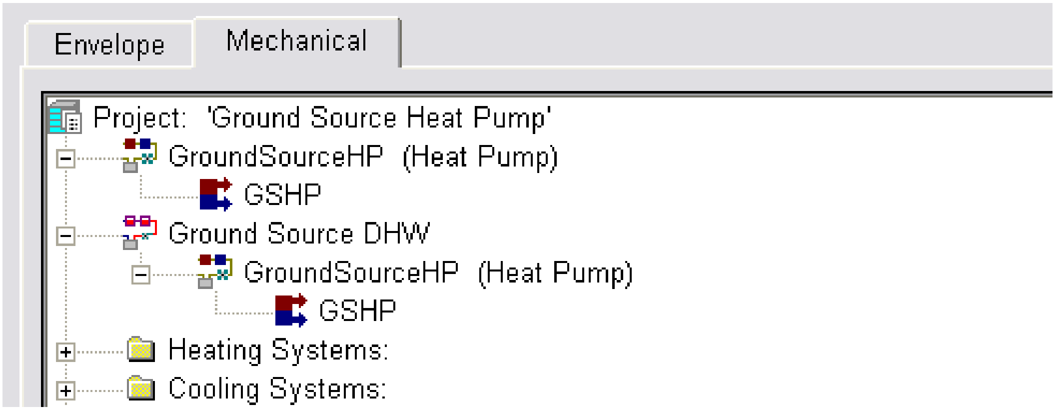


Figure 9-11: Water Heating Correctly Connected to HVAC



Chapter 10. Additions and Alterations

10.1 Overview

- Addition alone is the most difficult compliance approach
- The status of a feature has a big effect on your compliance
- Removed/deleted surfaces are not modeled
- Existing characteristics are not specified unless using verified existing conditions (see Section 10.6.1)
- Use one of the example files - AAExample . . . or EAAExample . . .

Additions and alterations requirements are from Section 150.2 of the standards. Because of the many variables of a given project, it can be complex. It is highly recommended that before beginning a project, you read this chapter and Section 150.2(a)1. to determine if modeling the building is the best option.

Prescriptive compliance allows more glazing area and has exceptions based on the size of a project that can often make it a better fit, particularly if you are considering addition alone compliance, which is the most restrictive, or a very small addition. The only exceptions for addition alone in performance compliance are: (1) cool roof requirements for an addition that is 300 ft^2 or less, (2) whole house fan for an addition that is 1,000 ft^2 or less, and (3) indoor air quality for an addition that is 1,000 ft^2 or less. Forms for the prescriptive approach can be found at the Energy Commission's website for alterations and additions non-HERS verified forms.

CBECC-Res can model addition alone or alteration alone. Performance compliance for an alteration alone can only be used if two or more components are altered. These components include the building's ceiling, wall or floor insulation, fenestration, space conditioning (HVAC) equipment, duct system, water heating system, or roofing products.

10.2 Changes in the 2016 Standards

For an addition alone, standards Section 150.1, Table 150.1-A (Package A) contains the features that are modeled to determine a project's energy budget (see Section 1.3 for a partial list of changes).

For existing plus addition plus alteration compliance, the standard design is based on Package A as follows:

10.2.1 Attics/roofs

For additions of 700 ft^2 or less, the attic standard design assumes only the mandatory insulation requirement of R-22. Radiant barrier requirements for this size addition are based on Package A, attic option C. For additions greater than 700 ft^2, the standard design is based on Package A, attic option B (see Section 1.3.1 for more details).

10.2.2 Walls

The 2016 standard design wall in all additions is the same as new construction requirements in Package A. NOTE: While there is a prescriptive exception that allows the wall where an addition is connected to an existing building to be built without continuous insulation if the existing building has no such insulation, there is no such provision in CBECC-Res.

10.3 Project Scope

On the analysis tab, select the run scope. For an addition alone do not select addition and/or alteration, which requires an existing zone. Select newly constructed and check addition alone (see Figure 10-1). Enter the areas of the existing building and the addition.

Figure 10-1: Addition Alone Run Scope

An alteration alone or an existing plus addition will set the project scope on the analysis tab to addition and/or alteration. If there is no addition, the user must also select the check box on the analysis tab confirming that there are multiple categories of alterations (as required by Section 150.2(b)2).

Figure 10-2: Alteration with No Addition

10.4 Existing Building

If the existing building will be modeled as part of an existing plus addition/alteration analysis, model the entire existing building. The user has the option of specifying the status of a component as existing, altered, or new. Deleted or removed surfaces are not modeled. Section 10.4 below contains guidance for determining if a feature is altered or new.

The zone status is always existing, even if features of the zone are altered.

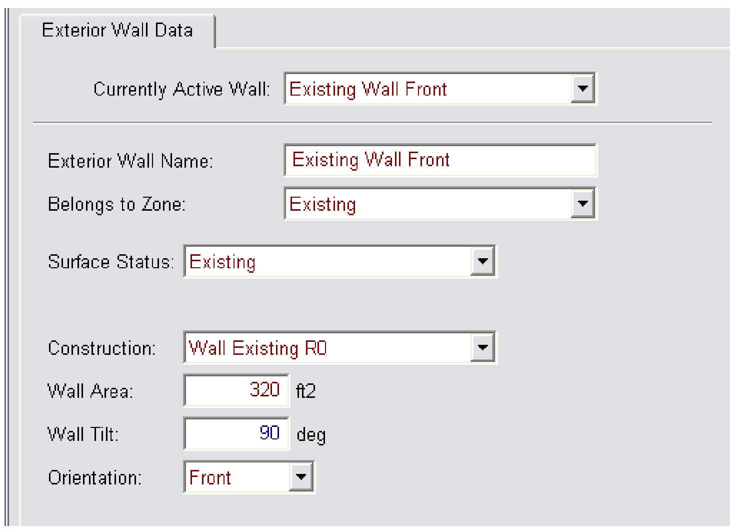
Model an interior wall connecting the existing building to the addition. If an addition (not an entire dwelling unit) is detached, model a hypothetical interior wall connecting the two buildings.

Specify the characteristics of all existing, altered or new components (for example, a new window in an existing wall) associated with the existing part of the building.

If an existing garage is being converted to conditioned space, do not model the unconditioned garage. The garage is the addition because it is becoming conditioned space.

If existing features are unknown, a table of default assumptions (vintage table values) is included in Appendix B of the 2016 Residential Manual. Features that are being altered will follow the guidelines found in Section 10.4. Although credit is reduced without verification of existing conditions, a pre-construction inspection is not required (see Section 10.5.1). For details on how to model altered components, see Section 10.7.

Figure 10-3: Existing Surface



10.5 Status Fields

The status field identifies a feature as ***Existing***, ***New***, or ***Altered*** and affects the standard design. For the HVAC and DHW equipment, the status needs to be set at the zone level.

NOTE: If you find that the status of an HVAC or water heating system is incorrect on the CF1R, it is best to access the building zone, set the status, and redefine the system from the zone screen.

10.5.1 Zone Status

Status for the zone is either ***existing*** or ***new***. Only characteristics of the zone are altered, not the zone itself. A space that was previously not supplied with space conditioning equipment is new even if it currently exists (for example, a garage that will become living space). All envelope components of a new zone are set as new.

10.5.2 Surface Status

Surfaces (windows, walls, floors, ceilings) in an existing zone are either (a) ***existing*** (if not being altered), (b) ***altered*** (with or without verified existing conditions), or (c) ***new*** if the surface did not previously exist.

Surfaces in the new zone are always ***new*** (if the surface previously existed, it is still considered new if it is in the new zone).

NOTE: If creating a new project rather than using an existing or example file, pay close attention to the status as the default status is always new. This can negatively impact your compliance results. Check the CF1R for accuracy with regard to the status.

10.5.3 Space Conditioning Status

In an existing zone, the space conditioning status should not be new. It is either existing or altered.

Existing is the correct status for space conditioning equipment in the existing or new zone if it will not be changed.

Altered is the correct status for space conditioning equipment that is replaced or changed. If the same equipment will condition the existing and new zones, the HVAC system status is set to altered in the existing and new zones.

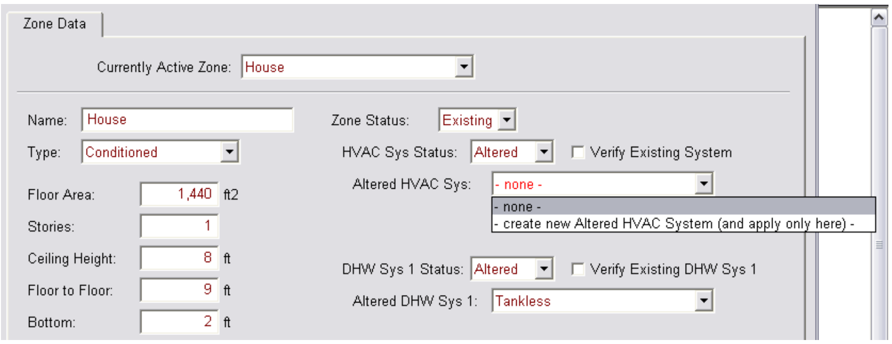
New is different than altered and applies only to new zones with equipment that serves only the new zone. New means equipment that space conditioning equipment did not previously exist.

NOTES:

(1) Because the status of an HVAC system cannot be changed once it is created, begin at the Zone Data tab (see Figure 10-4), select the appropriate status, and if necessary define the system.

(2) Check the status of the ducts to be sure it is set correctly.

Figure 10-4: EAA HVAC System Status



10.5.4 Duct Status

The status of the distribution system can be defined as a distinct entry from the rest of the HVAC system. Be sure to check the status after defining the HVAC system because the default status is new, which triggers HERS verified duct leakage testing. The duct status is set to:

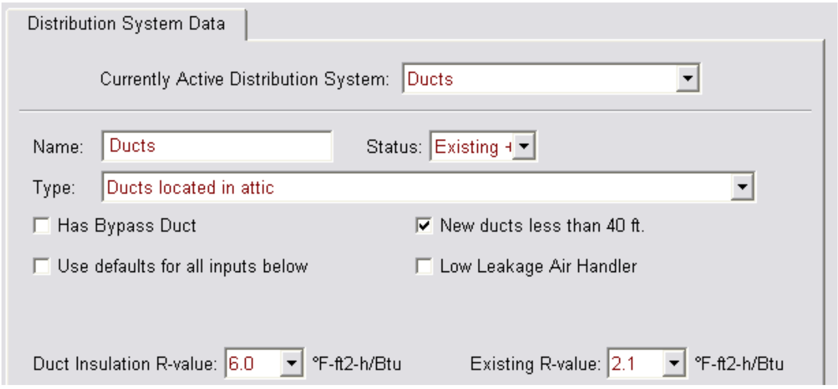
Existing when the existing ducts are remaining in the existing zone only (such as a separately defined HVAC system is being added for an addition).

Existing + new when the same space conditioning equipment is conditioning both the existing and new zones, the existing ducts will remain, and new ducts are added for the addition. An exception to duct leakage testing (Exception 2 to Section 150.2(b)1E) applies if less than 40 feet of duct in unconditioned space is added. Check the box if that condition applies (see Figure 10-5).

Altered when all the existing ductwork is being replaced and new ducts are being added for the addition.

New (or ***altered***) when an existing non-ducted system is being replaced with a ducted system.

Figure 10-5: Less than 40 feet of new duct



10.5.5 Water Heating Status

Water heating is assigned to the dwelling unit, not to specific floor area. In the existing zone, the water heating status is either ***existing*** or ***altered,*** and is **never *new***.

Existing status is used if no water heating changes are being made (it is also acceptable to model none for the Existing DHW System name).

Altered status is modeled if the water heater is being replaced.

New status is only used in the new zone if an additional water heating system is being added to supplement the existing water heater.

NOTE: Because the status of a DHW system cannot be changed once it is created, begin at the Zone Data tab (see Figure 10-4), select the appropriate status, and define the system.

10.6 Standard Design (Energy Budget)

The standard design (energy budget) can vary significantly depending on the compliance type selected. The budget will depend on if: (1) the project is an addition alone, (2) the project includes the existing building and the size of the addition, (3) any existing conditions will be verified by a HERS rater, and (3) individual altered components meet or exceed a minimum efficiency threshold (see Section 10.6.2 or Table 150.2-C).

NOTE: Verifying existing conditions is optional (see Section 10.6.1). You will not be able to obtain a registered CF1R until the inspection by the HERS rater is complete.

10.6.1 Third Party Verification

While not required, the amount of credit for proposed alterations depends on whether the existing conditions are verified by a HERS rater. It is feasible to comply without this added step.

As an example, if windows that are single-pane, metal frame, with clear glass are altered with dual-pane, wood frame, Low-E windows, the standard design without HERS rater verification is windows having a 0.40 U-factor and 0.35 SHGC (or 0.50 in zones with no SHGC requirement). The amount of credit for this alteration depends on how much lower than 0.40 is the U-factor of the proposed windows, or how much lower than 0.35 is the SHGC. If verified by a HERS rater, the standard design is set using the actual efficiency of the existing windows, which is 1.28 U-factor and 0.80 SHGC.

10.6.2 Efficiency Threshold

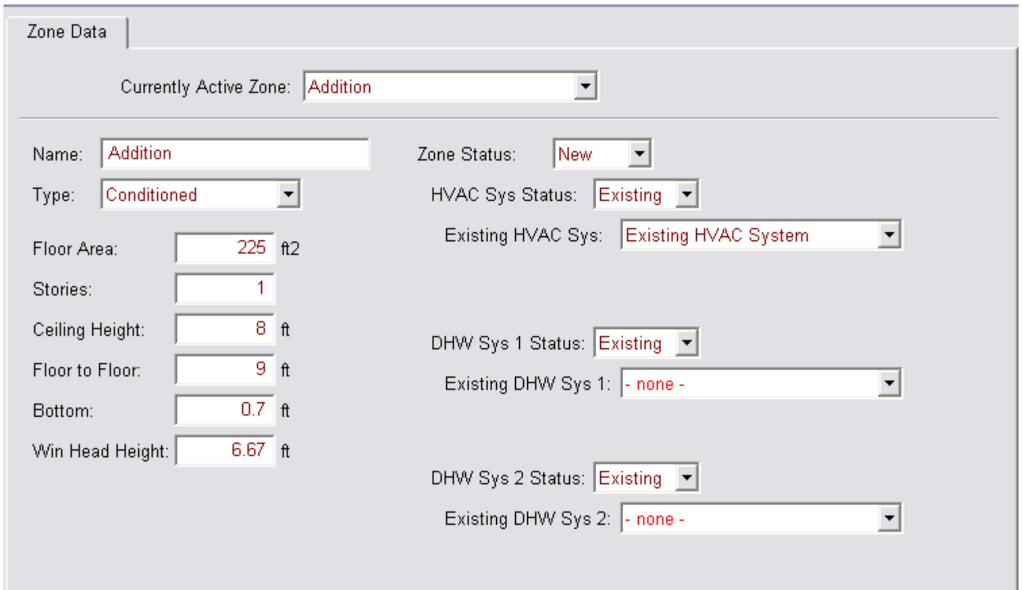
Another factor in determining the amount of credit or even a penalty that is achieved by an alteration is the proposed efficiency of the alteration. If an altered component does not meet the mandatory or prescriptive requirement set out in Section 150.2, the standard design will be based on the higher level. For example, if a ceiling has a verified insulation level of R-11, but the proposed alteration is to achieve R-19, the standard design is based on the standards' requirement of R-30, and the proposed ceiling alteration will receive an energy penalty.

10.7 Addition

The addition is modeled as a separate zone, identified by a zone status of new. If modeling the addition only (no existing zone) see also Section 10.8 for the correct run scope. Set the surface status to "new" for all envelope components in the addition including existing components in a previously unconditioned space. The exception is an existing HVAC system being extended for the addition (see Section 10.7.2 for an explanation of how to model various scenarios). It is not necessary to define a DHW system in either the existing or new zone, unless one is being altered or added.

Define the connection to the existing dwelling, if any, with an interior surface. If this is a wall, select the field "☑ is a party surface."

Figure 10-6: Addition HVAC and DHW



10.8 Alteration

Altered components are modeled with the new characteristics. You will only specify the existing characteristics if the existing conditions are verified by a HERS rater (see Figure 10-7 and Figure 10-8). The "verified" check box opens additional fields to define the existing conditions.

Since only one surface status can be selected, model components that are being altered separately from those that will not be altered.

If a surface did not previously exist, it is modeled with a status of "new."

NOTE: Deleted or removed surfaces are not modeled.

Figure 10-7: Altered with Verified Existing Conditions

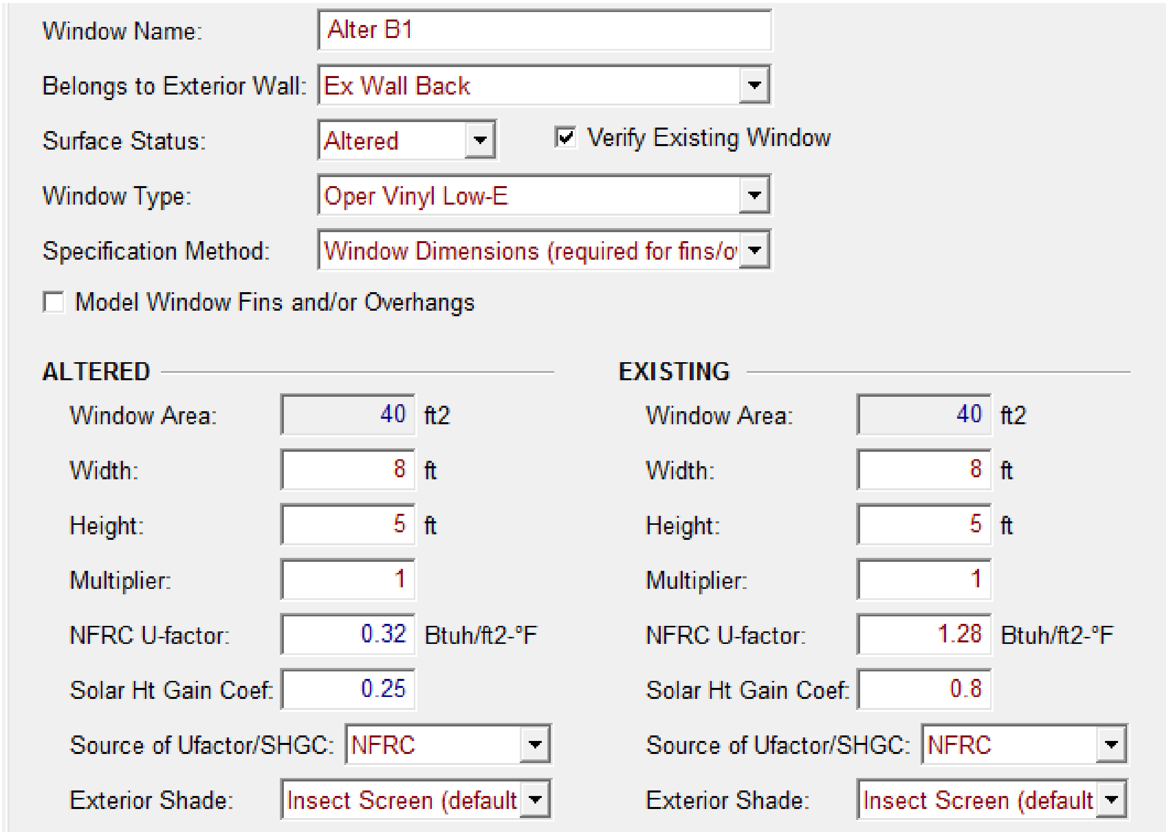
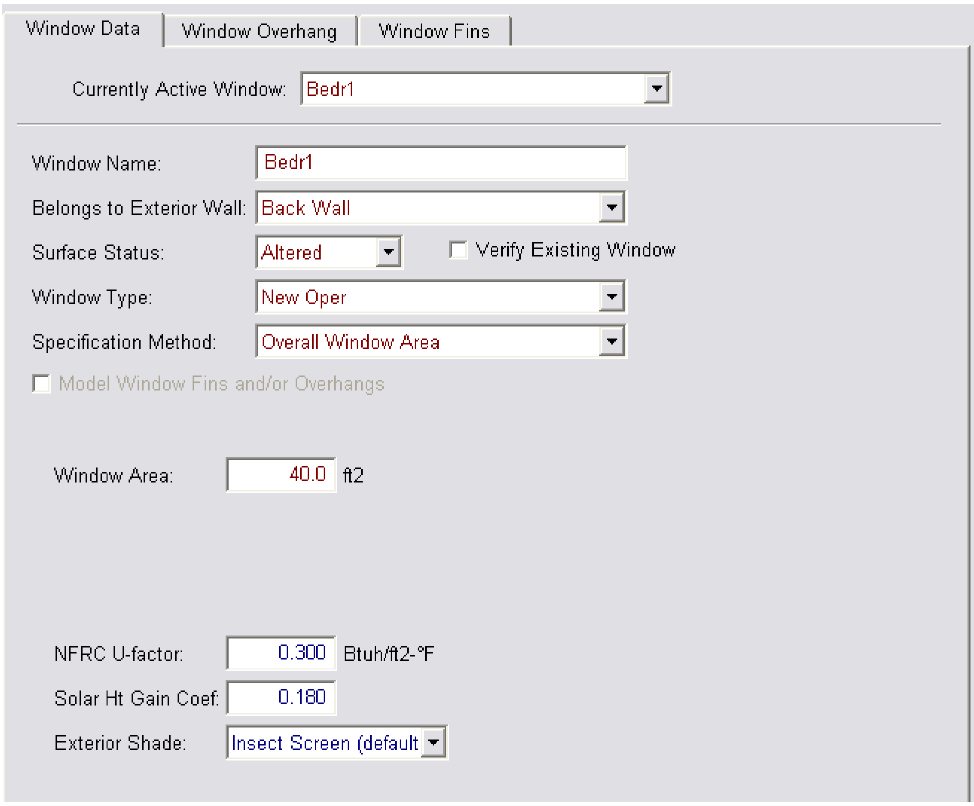


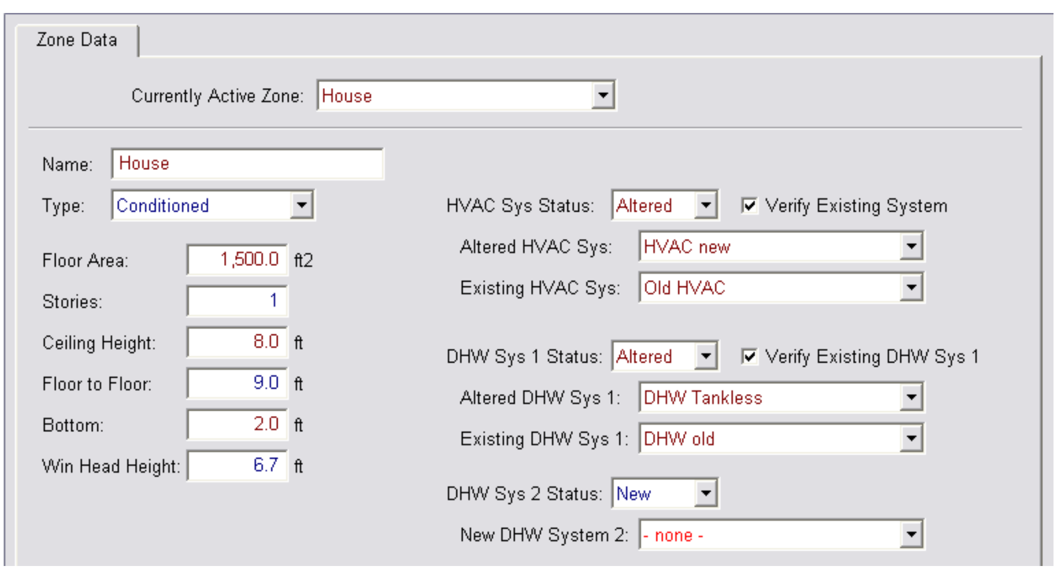
Figure 10-8: Altered Without Verified Existing Conditions



10.8.1 Radiant Barrier

It is now possible to model an addition with a radiant barrier or cool roof, even if the existing building does not have that feature. When creating the ceiling below attic for the addition, create a second attic zone with the appropriate features.

Figure 10-9: Altered HVAC and DHW



10.8.2 HVAC

First determine (1) if an existing system will be extended to serve an addition, (2) if a replacement (altered) system (including ducts) will be installed for the whole house, or (3) if a supplemental system will be added for the addition only. Existing equipment does not need to meet current standards (Exception 4 to Section 150.2(a)).

10.8.2.1 Existing equipment to serve addition.

For the existing and new zones, set the system status to "existing" and model the actual values for the existing system (Figure 10-10). The distribution system data will have both existing and new sections of the system defined (Figure 10-11).

10.8.2.2 Replacement system for whole house.

For the existing and new zones, set the system status to "altered" and model the proposed conditions for the equipment (if selecting ***Verify Existing System***, also specify the existing conditions that were verified by the HERS rater). Model the appropriate conditions for the ducts, which may be altered if the existing ducts are being altered (this includes new ducts in the addition, as altered ducts will require duct leakage testing), new (if ducts did not previously exist) or existing + new if only the ducts in the addition are new.

Figure 10-10: Existing System

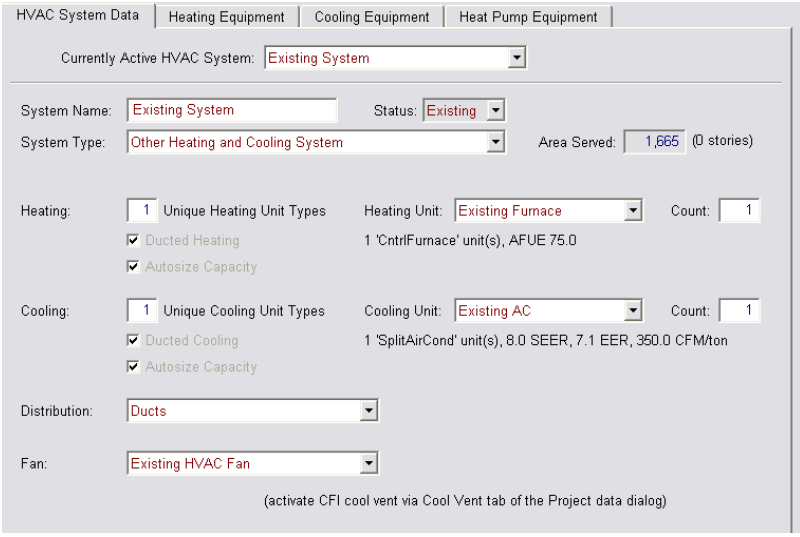
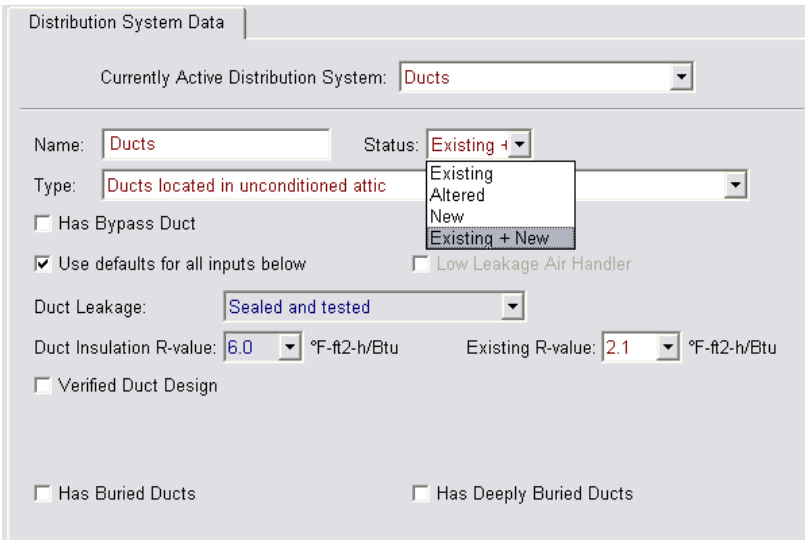


Figure 10-11: Duct System



10.8.2.3 Adding a system for the addition.

For the addition zone, define a separate system with the system status "new" with the proposed conditions of the new/supplemental system and duct conditions.

10.8.3 Water heating

If altering a water heater, define the altered specifications. If existing conditions were verified, check the box and include the specifications of the existing equipment. If the distribution system is being altered and the existing conditions are verified set the dwelling unit distribution type to an appropriate value (see Section 9.3).

If adding a water heater, define both the existing water heater in the existing zone, and the added water heater in the addition zone.

10.8.4 Mechanical Ventilation

Alterations and additions of 1,000 square feet or less are not required to meet the mechanical ventilation requirements of Section 150.0(o).

10.8.5 Cooling Ventilation/Whole House Fan

It is not feasible to model ventilation cooling that serves only the addition.

Alterations and additions of 1,000 square feet or less are not required to meet the requirements of 150.1(c)12, which is part of the standard design in climate zones 8-14.

10.8.6 QII in an Existing Plus Addition Analysis

As noted in the Residential Manual, improved insulation quality (modeled under the Analysis tab) is not allowed for an existing plus addition analysis.

10.9 Addition Alone

To model an addition alone, (1) set the run scope to Newly Constructed, (2) check the box for Addition Alone, and (3) set the fraction of the dwelling unit that the addition represents (for example, a 500 ft^2 addition to a 1500 ft^2 house = 500/(1500+500) = 0.25).

With CBECC-Res version 4, it is possible to model existing HVAC equipment as serving an addition without triggering any HERS requirements. Follow the guidelines provided in Section 10.4.3 for setting the status flag. Follow the guidelines in Section 10.4.4 for the duct conditions.

All interior surfaces beginning with version 4 have an option that allows checking "is a party surface" meaning the zone on the other side of the surface is not being modeled.

10.9.1 QII in an Addition Alone Analysis

As noted in the Residential Manual, improved insulation quality (modeled under the Analysis tab) is allowed for addition alone compliance only, and is not permitted with existing plus addition compliance. The entire addition envelope must comply with the requirements found in *Reference Appendices*, Residential Appendix RA3.5 for the ceiling/attic, knee walls, exterior walls and exterior floors.

INDEX

Appendix A – CF1R

GENERAL INFORMATION					
01	Project Name	1 Story Example with Crawl Space, Rev 3			
02	Calculation Description	2100 ft2 CEC Prototype with tile roof			
03	Project Location	1516 Ninth St			
04	City	Sacramento, CA	05	Standards Version	Compliance 2017
06	Zip Code	95814	07	Compliance Manager Version	BEMCmpMgr 2016.2.0 (592)
08	Climate Zone	CZ12	09	Software Version	CBECC-Res 2016.2.0 (857)
10	Building Type	Single Family	11	Front Orientation (deg/Cardinal)	0
12	Project Scope	Newly Constructed	13	Number of Dwelling Units	1
14	Total Cond. Floor Area (ft^2)	2100	15	Number of Zones	1
16	Slab Area (ft^2)	0	17	Number of Stories	1
18	Addition Cond. Floor Area	N/A	19	Natural Gas Available	Yes
20	Addition Slab Area (ft^2)	N/A	21	Glazing Percentage (%)	20.0%

COMPLIANCE RESULTS	
01	**Building Complies with Computer Performance**
02	**This building incorporates features that require field testing and/or verification by a certified HERS rater under the supervision of a CEC-approved HERS provider.**
03	**This building incorporates one or more Special Features shown below**

ENERGY USE SUMMARY				
04	05	06	07	08
Energy Use (kTDV/ft^2-yr)	Standard Design	Proposed Design	Compliance Margin	Percent Improvement
Space Heating	18.33	19.98	-1.65	-9.0%
Space Cooling	21.82	13.74	8.08	37.0%
IAQ Ventilation	1.17	1.17	0.00	0.0%
Water Heating	9.82	9.82	0.00	0.0%
Photovoltaic Offset	----	0.00	0.00	----
Compliance Energy Total	**51.14**	**44.71**	**6.43**	**12.6%**

REQUIRED SPECIAL FEATURES

The following are features that must be installed as condition for meeting the modeled energy performance for this computer analysis.

- **Cool roof**
- **Insulation below roof deck**
- **Window overhangs and/or fins**
- **Whole house fan**

HERS FEATURE SUMMARY

The following is a summary of the features that must be field-verified by a certified HERS Rater as a condition for meeting the modeled energy performance for this computer analysis. Additional detail is provided in the building components tables below.

Building-level Verifications:
- **IAQ mechanical ventilation**

Cooling System Verifications:
- **Minimum Airflow**
- **Refrigerant charge or fault indicator display**
- **Fan Efficacy Watts/CFM**

HVAC Distribution System Verifications:
- **Duct Sealing**

Domestic Hot Water System Verifications:
- **-- None --**

BUILDING - FEATURES INFORMATION

01	02	03	04	05	06	07
Project Name	**Conditioned Floor Area (ft2)**	**Number of Dwelling Units**	**Number of Bedrooms**	**Number of Zones**	**Number of Ventilation Cooling Systems**	**Number of Water Heating Systems**
1 Story Example with Crawl Space, Rev 3	2100	1	3	1	1	1

ZONE INFORMATION

01	02	03	04	05	06	07
Zone Name	**Zone Type**	**HVAC System Name**	**Zone Floor Area (ft^2)**	**Avg. Ceiling Height**	**Water Heating System 1**	**Water Heating System 2**
Conditioned	Conditioned	HVAC System 1	2100	9	DHW System	

OPAQUE SURFACES

01	02	03	04	05	06	07	08
Name	**Zone**	**Construction**	**Azimuth**	**Orientation**	**Gross Area (ft^2)**	**Window & Door Area (ft^2)**	**Tilt (deg)**
Front	Conditioned	R19 R5 Stucco Wall	0	Front	270	120	90
Left	Conditioned	R19 R5 Stucco Wall	90	Left	324	56.04	90
Back	Conditioned	R19 R5 Stucco Wall	180	Back	450	207.32	90
Right	Conditioned	R19 R5 Stucco Wall	270	Right	414	56.04	90
GarToHouse Front	Conditioned>>Garage	Gar House R15			180	20	
GarToHouse Left	Conditioned>>Garage	Gar House R15			90	0	
Ceiling (below attic) 1	Conditioned	R38 Ceiling below attic			2100		
Crawlspace Flr	Conditioned	R19 2x6 FlrOvrCrawl			2100		
Gwall Front	Garage	Garage Ext Wall	0	Front	180	108	90
Gwall Left	Garage	Garage Ext Wall	90	Left	198	0	90
Gwall Right	Garage	Garage Ext Wall	270	Right	108	0	90
Gar Ceiling	Garage	R0 ClgBlwAttic Cons			440		

ATTIC

01	02	03	04	05	06	07	08
Name	**Construction**	**Type**	**Roof Rise**	**Roof Reflectance**	**Roof Emittance**	**Radiant Barrier**	**Cool Roof**
Attic	Tile High Performance	Ventilated	5	0.2	0.85	No	Yes
Gar Attic	Tile Roof	Ventilated	5	0.2	0.85	No	No

WINDOWS

01	02	03	04	05	06	07	08	09	10
Name	**Type**	**Surface (Orientation-Azimuth)**	**Width (ft)**	**Height (ft)**	**Multiplier**	**Area (ft^2)**	**U-factor**	**SHGC**	**Exterior Shading**
F1	Window	Front (Front-0)	10.0	5.0	1	50.0	0.32	0.25	Insect Screen (default)
F2	Window	Front (Front-0)	10.0	5.0	1	50.0	0.32	0.25	Insect Screen (default)
L1	Window	Left (Left-90)	6.0	4.7	2	56.0	0.32	0.25	Insect Screen (default)
B1 SGD	Window	Back (Back-180)	8.0	7.7	1	61.4	0.32	0.25	Insect Screen (default)
B2	Window	Back (Back-180)	6.0	4.7	3	84.6	0.32	0.25	Insect Screen (default)
B3 SGD	Window	Back (Back-180)	8.0	7.7	1	61.4	0.32	0.25	Insect Screen (default)
R1	Window	Right (Right-270)	6.0	4.7	2	56.0	0.32	0.25	Insect Screen (default)

DOORS			
01	02	03	04
Name	Side of Building	Area (ft^2)	U-factor
Front Dr	Front	20.0	0.50
GarToHouse Dr	GarToHouse Front	20.0	0.50
GDoor	Gwall Front	108.0	1.00

OVERHANGS AND FINS													
01	02	03	04	05	06	07	08	09	10	11	12	13	14
	Overhang					Left Fin				Right Fin			
Window	Depth	Dist Up	Left Extent	Right Extent	Flap Ht.	Depth	Top Up	DistL	Bot Up	Depth	Top Up	Dist R	Bot Up
F1	1	1.33	3	28	0.4	0	0	0	0	0	0	0	0
F2	1	1.33	28	3	0.4	0	0	0	0	0	0	0	0
L1	1	1.33	6	8	0.4	0	0	0	0	0	0	0	0
B1 SGD	6	1.33	4	40	0.4	0	0	0	0	0	0	0	0
B2	6	1.33	23	23	0.4	0	0	0	0	0	0	0	0
B3 SGD	6	1.33	40	4	0.4	0	0	0	0	0	0	0	0
R1	1	1.33	8	8	0.4	0	0	0	0	0	0	0	0

OPAQUE SURFACE CONSTRUCTIONS

01	02	03	04	05	06	07
Construction Name	**Surface Type**	**Construction Type**	**Framing**	**Total Cavity R-value**	**Winter Design U-value**	**Assembly Layers**
Garage Ext Wall	Exterior Walls	Wood Framed Wall	2x4 @ 16 in. O.C.	none	0.361	• *Inside Finish: Gypsum Board* • *Cavity / Frame: no insul. / 2x4* • *Exterior Finish: 3 Coat Stucco*
R0 ClgBlwAttic Cons	Ceilings (below attic)	Wood Framed Ceiling	2x4 Bottom Chord of Truss @ 24 in. O.C.	none	0.481	• *Inside Finish: Gypsum Board* • *Cavity / Frame: no insul. / 2x4 Btm Chrd*
Gar House R15	Interior Walls	Wood Framed Wall	2x4 @ 16 in. O.C.	R 15	0.086	• *Inside Finish: Gypsum Board* • *Cavity / Frame: R-15 / 2x4* • *Other Side Finish: Gypsum Board*
Tile High Performance	Attic Roofs	Wood Framed Ceiling	2x4 @ 24 in. O.C.	R 13	0.072	• *Under Roof Joists: R-0.0 insul.* • *Cavity / Frame: R-13.0 / 2x4* • *Roof Deck: Wood Siding/sheathing/decking* • *Tile Gap: present* • *Roofing: 10 PSF (RoofTile)*
Tile Roof	Attic Roofs	Wood Framed Ceiling	2x4 @ 24 in. O.C.	none	0.400	• *Cavity / Frame: no insul. / 2x4* • *Roof Deck: Wood Siding/sheathing/decking* • *Tile Gap: present* • *Roofing: 10 PSF (RoofTile)*
R38 Ceiling below attic	Ceilings (below attic)	Wood Framed Ceiling	2x4 Bottom Chord of Truss @ 24 in. O.C.	R 38	0.025	• *Inside Finish: Gypsum Board* • *Cavity / Frame: R-9.1 / 2x4 Btm Chrd* • *Over Ceiling Joists: R-28.9 insul.*
R19 R5 Stucco Wall	Exterior Walls	Wood Framed Wall	2x6 @ 16 in. O.C.	R 19	0.051	• *Inside Finish: Gypsum Board* • *Cavity / Frame: R-19 / 2x6* • *Sheathing / Insulation: R1 Sheathing* • *Exterior Finish: R4 Synthetic Stucco*
R19 2x6 FlrOvrCrawl	Floors Over Crawlspace	Wood Framed Floor	2x6 @ 16 in. O.C.	R 19	0.049	• *Floor Surface: Carpeted* • *Floor Deck: Wood Siding/sheathing/decking* • *Cavity / Frame: R-19 / 2x6*

BUILDING ENVELOPE - HERS VERIFICATION

01	02	03	04
Quality Insulation Installation (QII)	**Quality Installation of Spray Foam Insulation**	**Building Envelope Air Leakage**	**CFM50**
Not Required	Not Required	Not Required	---

WATER HEATING SYSTEMS

01	02	03	04	05	06
Name	**System Type**	**Distribution Type**	**Water Heater**	**Number of Heaters**	**Solar Fraction (%)**
DHW System - 1/1	DHW	Standard	Small Instantaneous	1	- none -

WATER HEATERS									
01	02	03	04	05	06	07	08	09	10
Name	**Heater Element Type**	**Tank Type**	**Tank Volume (gal)**	**Energy Factor/Efficiency**	**Input Rating/Pilot**	**Tank Insulation R-value (Int/Ext)**	**Standby Loss (Fraction)**	**Heat Pump Type**	**Tank Location or Ambient Condition**
Small Instantaneous	Gas	Small Instantaneous	NA	0.82 EF	125,000 Btu/hr	0	0	NA	NA

SPACE CONDITIONING SYSTEMS					
01	**02**	**03**	**04**	**05**	**06**
SC Sys Name	**System Type**	**Heating Unit Name**	**Cooling Unit Name**	**Fan Name**	**Distribution Name**
HVAC System 1	Other Heating and Cooling System	Furn 78	Cooling Min	HVAC Fan System 1	Attic Default

HVAC - HEATING UNIT TYPES			
01	**02**	**03**	**04**
Name	**System Type**	**Number of Units**	**Efficiency**
Furn 78	CntrlFurnace	1	78 AFUE

HVAC - COOLING UNIT TYPES							
01	**02**	**03**	**04**	**05**	**06**	**07**	**08**
			Efficiency				
Name	**System Type**	**Number of Units**	**EER**	**SEER**	**Zonally Controlled**	**Compressor Type**	**HERS Verification**
Cooling Min	SplitAirCond	1	11.7	14	Not Zonal	Single Speed	Cooling Min-hers-cool

HVAC COOLING - HERS VERIFICATION					
01	**02**	**03**	**04**	**05**	**06**
Name	**Verified Airflow**	**Airflow Target**	**Verified EER**	**Verified SEER**	**Verified Refrigerant Charge**
Cooling Min-hers-cool	Required	350	Not Required	Not Required	Required

HVAC - DISTRIBUTION SYSTEMS						
01	**02**	**03**	**04**	**05**	**06**	**07**
Name	**Type**	**Duct Leakage**	**Insulation R-value**	**Duct Location**	**Bypass Duct**	**HERS Verification**
Attic Default	DuctsAttic	Sealed and tested	8	Attic	None	Attic Default-hers-dist

HVAC DISTRIBUTION - HERS VERIFICATION

01	02	03	04	05	06	07	08
Name	**Duct Leakage Verification**	**Duct Leakage Target (%)**	**Verified Duct Location**	**Verified Duct Design**	**Buried Ducts**	**Deeply Buried Ducts**	**Low-leakage Air Handler**
Attic Default-hers-dist	Required	5.0	Not Required	Not Required	Not Required	Not Required	---

HVAC - FAN SYSTEMS

01	02	03	04
Name	Type	Fan Power (Watts/CFM)	HERS Verification
HVAC Fan System 1	Single Speed PSC Furnace Fan	0.58	HVAC Fan System 1-hers-fan

HVAC FAN SYSTEMS - HERS VERIFICATION

01	02	03
Name	Verified Fan Watt Draw	Required Fan Efficiency (Watts/CFM)
HVAC Fan System 1-hers-fan	Required	0.58

IAQ (Indoor Air Quality) FANS

01	02	03	04	05	06
Dwelling Unit	**IAQ CFM**	**IAQ Watts/CFM**	**IAQ Fan Type**	**IAQ Recovery Effectiveness(%)**	**HERS Verification**
SFam IAQVentRpt	51	0.25	Default	0	Required

COOLING VENTILATION

01	02	03	04	05
Name	**Cooling Vent CFM**	**Cooling Vent Watts/CFM**	**Total Watts**	**Number of Fans**
Whole House Fan	3150	0.1	315	1

DOCUMENTATION AUTHOR'S DECLARATION STATEMENT	
1. I certify that this Certificate of Compliance documentation is accurate and complete.	
Documentation Author Name:	Documentation Author Signature:
Company:	Signature Date:
Address:	CEA/HERS Certification Identification (If applicable):
City/State/Zip:	Phone:

RESPONSIBLE PERSON'S DECLARATION STATEMENT	
I certify the following under penalty of perjury, under the laws of the State of California: 1. I am eligible under Division 3 of the Business and Professions Code to accept responsibility for the building design identified on this Certificate of Compliance. 2. I certify that the energy features and performance specifications identified on this Certificate of Compliance conform to the requirements of Title 24, Part 1 and Part 6 of the California Code of Regulations. 3. The building design features or system design features identified on this Certificate of Compliance are consistent with the information provided on other applicable compliance documents, worksheets, calculations, plans and specifications submitted to the enforcement agency for approval with this building permit application.	
Responsible Designer Name:	Responsible Designer Signature:
Company:	Date Signed:
Address:	License:
City/State/Zip:	Phone: