Program Description October 2012

A PC Program

COMFEN 4.1

for Calculating the Energy Demand and Comfort Impacts of Windows in Commercial Buildings

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This work was supported by the Assistant Secretary for Energy Efficiency and Renewable Energy, Office of Building Technology, State and Community Programs, Office of Building Systems of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

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COMFEN 4.1: Program Description

A PC Program for Calculating the Heating and Cooling Energy Use of Windows in Commercial Buildings

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1. INTRODUCTION

Overview

Today's energy-efficient windows can dramatically lower the heating and cooling costs associated with windows while increasing occupant comfort and minimizing window surface condensation problems. However, consumers are often confused about how to pick the most efficient window design for a commercial building. Product information typically offers window properties: U-factors or R-values, Solar Heat Gain Coefficients or Shading Coefficients, and air leakage rates. However, the relative importance of these properties depends on site- and building-specific conditions. Furthermore, these properties are based on static evaluation conditions that are very different from the real situation a window will be used in.

A computer tool such as COMFEN can help architects and builders pick the most energy-efficient and cost-effective window for a given application. It calculates heating and cooling energy use and associated costs as well as peak heating and cooling demand for specific window products. Users define a specific "scenario" by specifying the building type, geographic location, orientation, and window configuration. Users also specify size, shading, and thermal properties of the window they wish to investigate.

Update information, future releases, and program information about COMFEN and other software tools (such as WINDOW, THERM, and Optics) from the Windows and Daylighting Group at LBNL can be found on the World Wide Web at URL: http://windows.lbl.gov, in the Software section. To obtain COMFEN, WINDOW, or THERM, check the web site for the current downloadable version.

2. QUICK START

2.1. Getting started

- Install the COMFEN program (see Chapter 3, "Installation").
- When the program is installed, **double click** on the COMFEN4 icon.

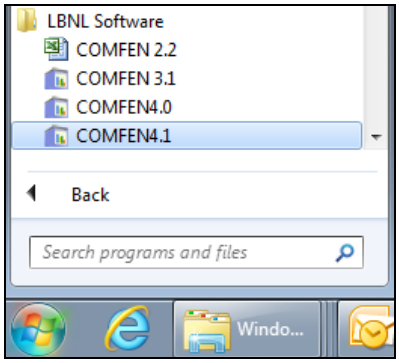


Figure 2-1. Click on the COMFEN icon in the Programs/LBNL Software list.

- The Startup Menu screen that appears allows you to either start a new project or open existing projects. There are a few example projects in COMFEN, which are listed under Recent Projects. Projects are collections of "scenarios" or façade designs, that can be compared.

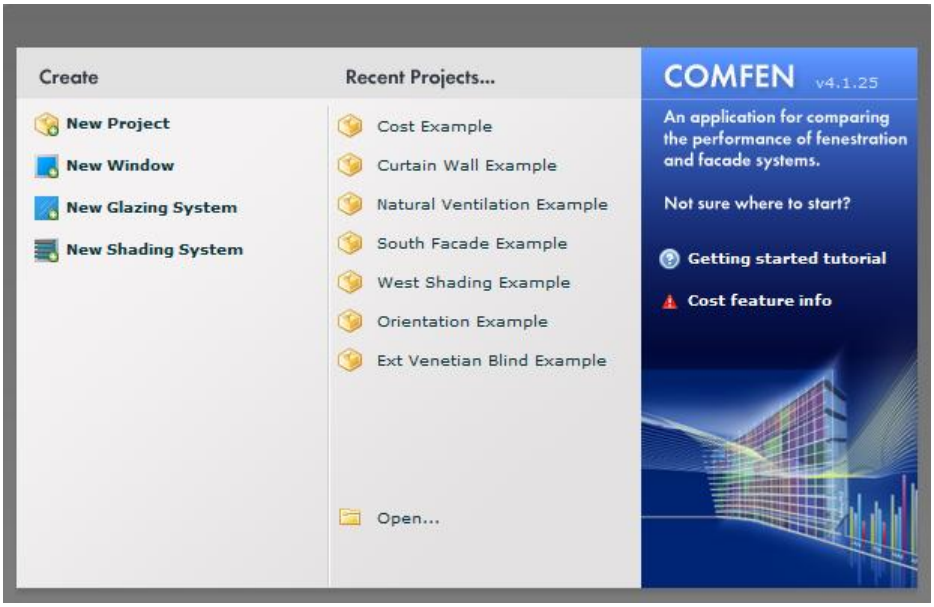


Figure 2-2. The Startup Menu screen allows you to create a new project or open already defined projects.

2.2. Quick Tour of COMFEN

To take a tour of the program, we will start by opening an existing project, **West Shading Example.**

2.2.1. Main Screen

Below is the main screen when you first open the program. Following discussions will explain in more detail each section on this screen. The program opens with the Overview / Summary results tab being displayed.

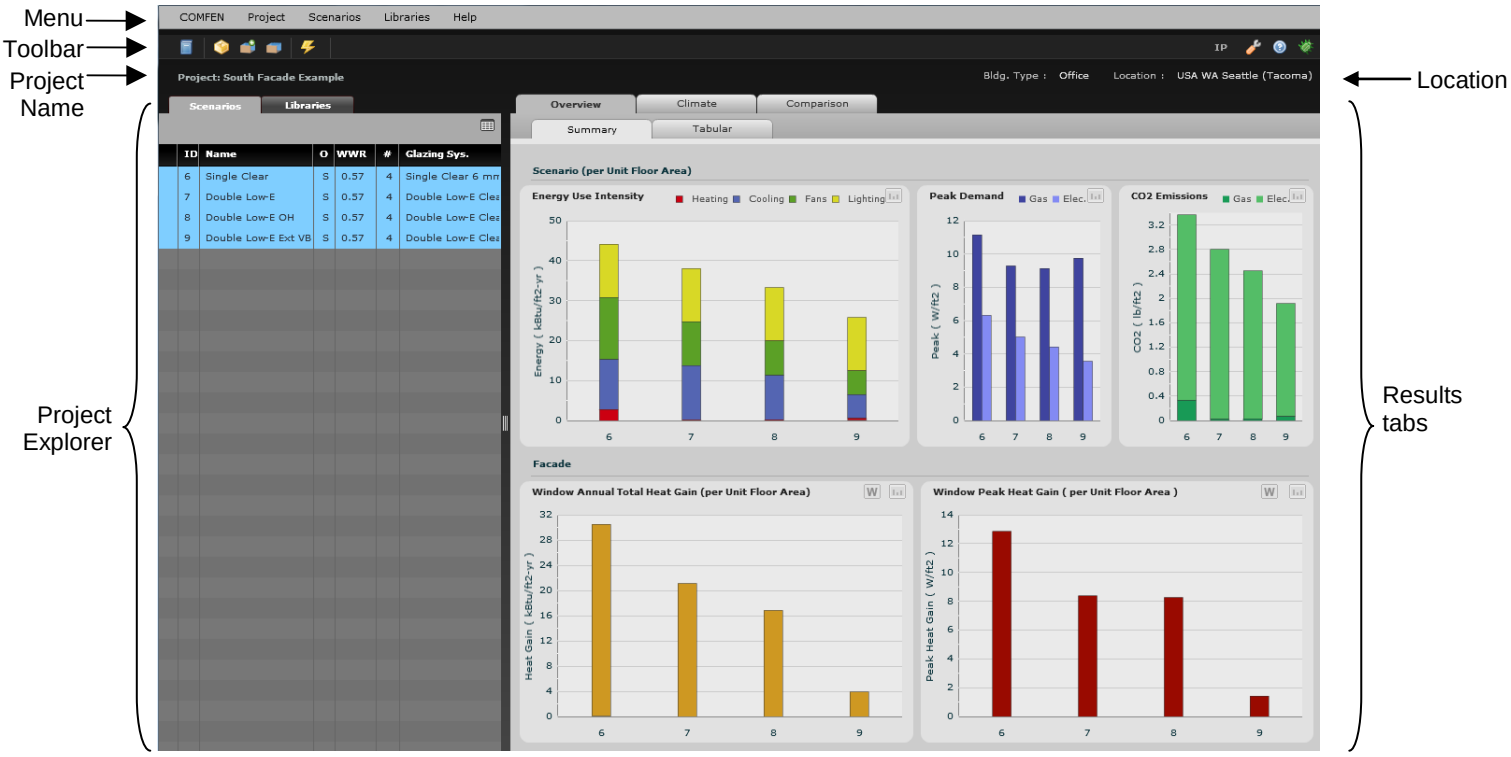


Figure 2-3. The Overview / Summary View.

Project Explorer

The Project Explorer is the primary navigation tool in the Project. In the Project Explorer, there are two tabs, Scenarios and Libraries.

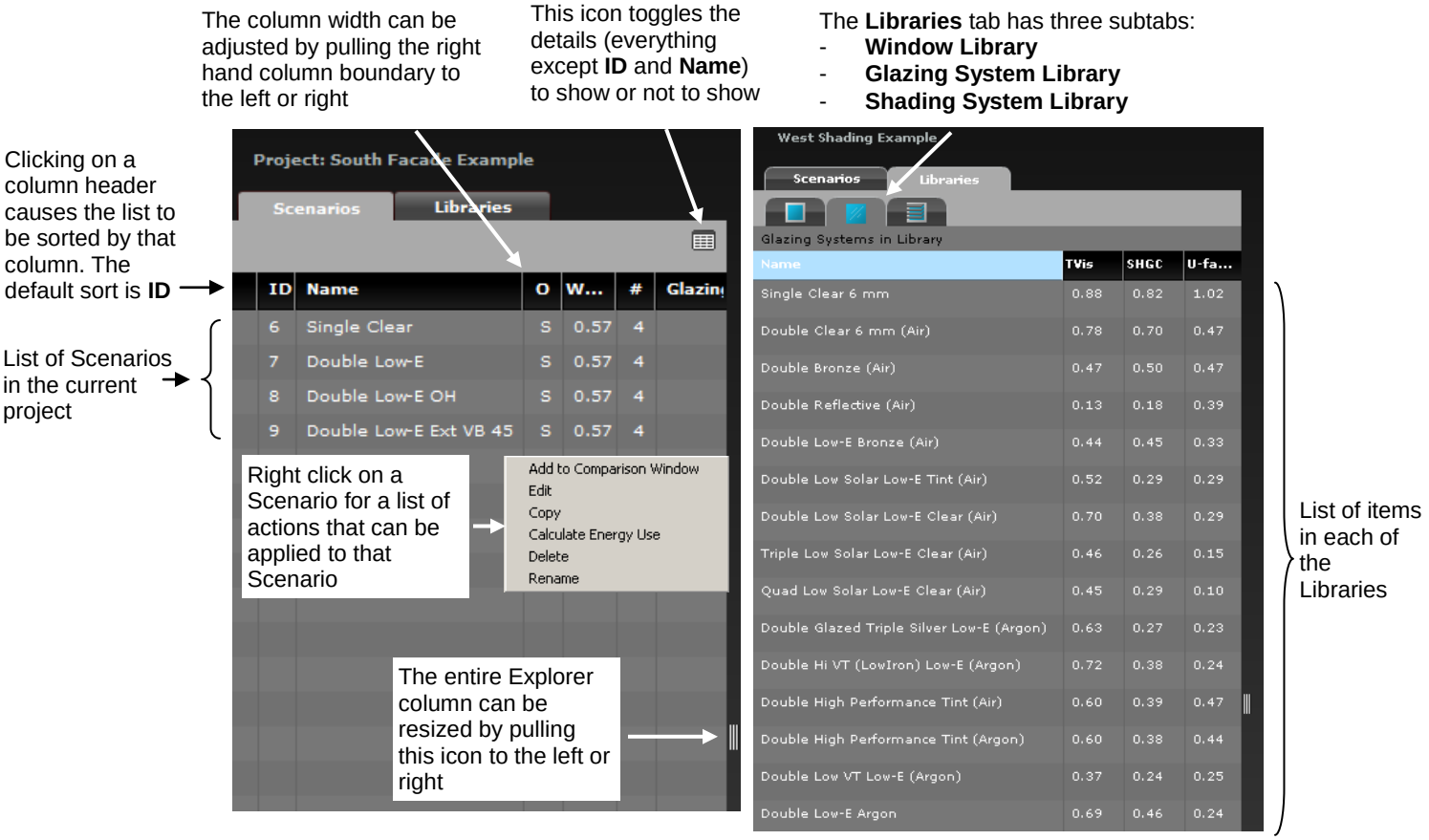


Figure 2-4. The Project Explorer.

Scenarios The Scenarios tab shows a list of all the Scenarios in the current Project

Libraries The Libraries tab has three subtabs:

- **Window Library Tab:** this shows the records in the Window Library. There is one default window. You can highlight a window and drag it onto the façade in the Edit Scenario View.
- **Glazing System Tab:** this shows the records in the Glazing System Library. You can highlight a glazing system and drag it onto a window in the Edit Scenario View.
- **Shading System Library Tab:** this shows the records in the Shading System Library. You can highlight a shading system and drag it onto a window in the Edit Scenario View.

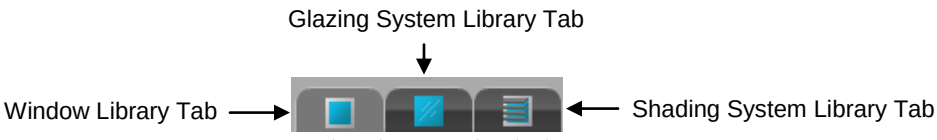


Figure 2-5. The Libraries Tab subtabs.

Scenario Visualization

Under the Comparison Tab, you can show up to four of the scenarios by dragging them from the Project Explorer Scneario tab to the upper right part of the screen. Highlight the desired Scenarios in the Scenarios tab and drag your mouse to the right.

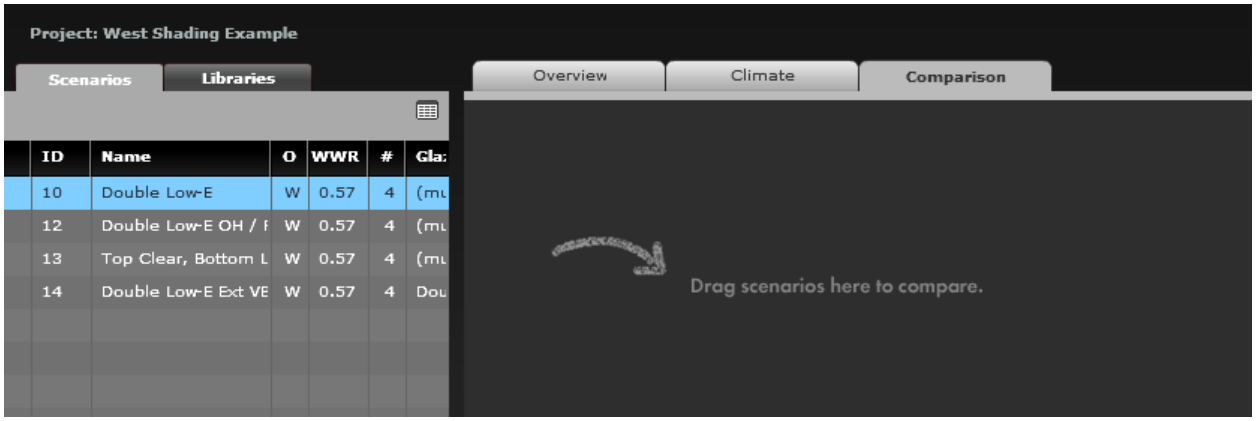


Figure 2-6. Highlight up to four scenarios and drag them to the right under the Comparison tab.

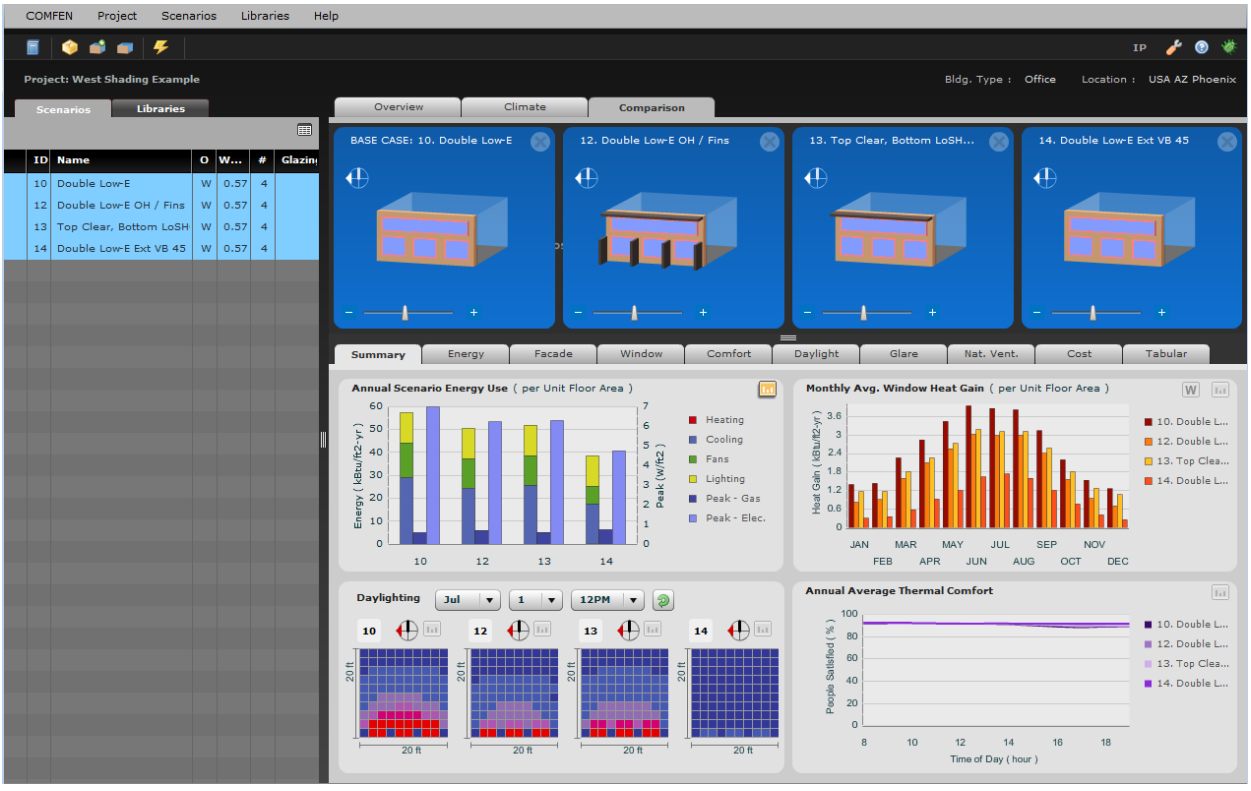
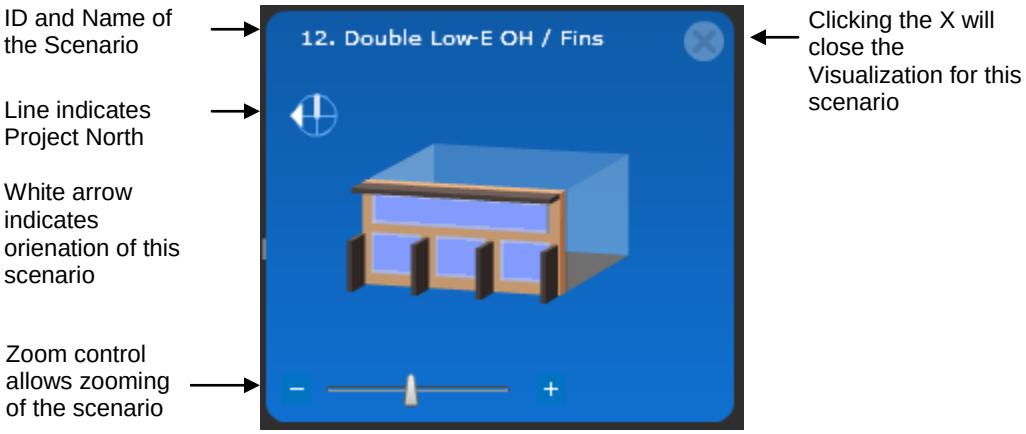


Figure 2-7. The scenarios will be displayed in "3D" and results, if they exist, will be shown below each.

The Scenario Visualization section of the main screen shows the geometry of any Scenarios in the Project Explorer that you have dragged into the Visualization section of the screen. They do not have to be simulated to be in the Visualization section, but results will only show in the Results section if they are simulated.

Figure 2-8. The elements of the Scenario Visualization.



2.2.2. Menu

Figure 2-9. The COMFEN menu options.

The COMFEN menu options are:

COMFEN The menu options are:

- **About COMFEN:** This option shows the program version
- **Preferences:** Controls various settings in the program
- **Hide COMFEN**
- **Quit**

Project The File menu is used to control projects and general program options

- **New Project:** Starts a new project, opening up the Project Properties dialog box
- **Open Project:** Opens a list of projects that are in the current database
- **Close Project:** Closes the current project
- **Project Properties:** Opens the Project Properties dialog box, which contains the Project Name, Building Type, Project North and Location
- **Delete Projects:** Allows you to delete projects from the database
- **Import Project Definition from CSV file:** Allows you to import projects from a CSV text file. All projects must be closed for this option to be active
- **Export current project results to CSV:** Exports the Annual Energy Use results for all the scenarios in the currently open project to a CSV file, which can then be opened in a spreadsheet program.

Scenarios The Scenarios menu is used to control the Scenarios within Projects.

- **Create Scenario:** Creates a new scenario within the currently opened project
- **Copy Scenario:** Makes a copy of the highlighted scenario
- **Import Scenario from Project:** Shows all the scenarios in all the projects in the current database, and allows import of those scenarios into the current project
- **Delete Scenario:** Deletes the highlighted scenario
- **Rename scenario:** Renames the highlighted scenario
- **Add Window to Scenario:** When in Scenario Edit mode, opens the New Window dialog box to define a new window on the scenario facade
- **Add Exterior Shade to Scenario:** When in Scenario Edit mode, opens the New Wall Shade dialog box to define a new fin or overhang.
- **Export compared scenarios images to PNG:** Exports one image per compared scenario as a PNG file to the location specified.
- **Calculate All:** Calculates the results for all the scenarios in the currently open project
- **Calculate Selected:** calculates the results for the highlighted scenarios

Libraries The Libraries menu is used to access all the Libraries

Help The Help menu is used to view the program version number as well as the program Help file.

2.2.3. Toolbar

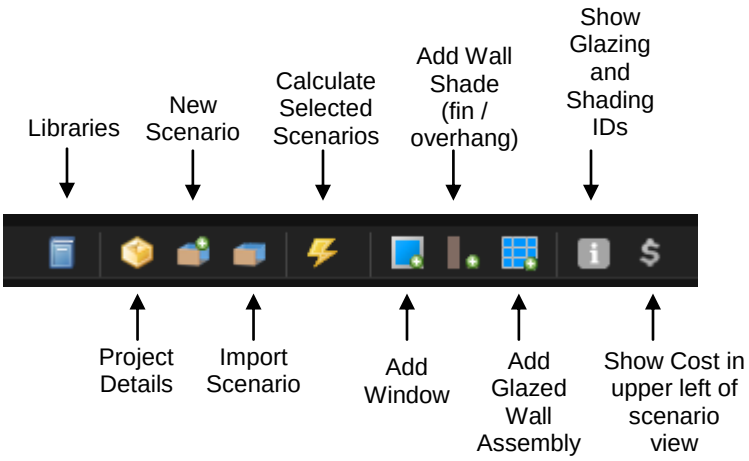


Figure 2-10. The COMFEN Toolbar.

Toolbar Icon	Description	Menu / Choice
	Library	Libraries / View All Windows
	Project Details	File / Project Properties
	Add New Scenario to Project	Scenarios / Create Scenario
	Import Scenario into Project	Scenarios / Import Scenario
	Calculate energy use for selected scenarios	Scenarios / Calculate Selected
	Add a window to the current scenario	Scenarios / Add Window to Scenario
	Add a wall shade (fin or overhang) to the current scenario	Scenarios / Add Exterior Shade to Scenario
	Add a Glazed Wall Assembly to the current scenario	
	Show Glazing System and Shading System IDs on the Scenario graphic	
	Show Scenario cost in the upper left of the Scenario Visualization	

2.3. Open an Existing Project

When you first open a Project that is already in the database, the Project Explorer is shown on the left side of the screen and the Overview Tab is shown on the right side of the screen. If the scenarios have not been calculated, there will be yellow triangles to the left of the scenarios and there will not be graphs in the Summary tab.

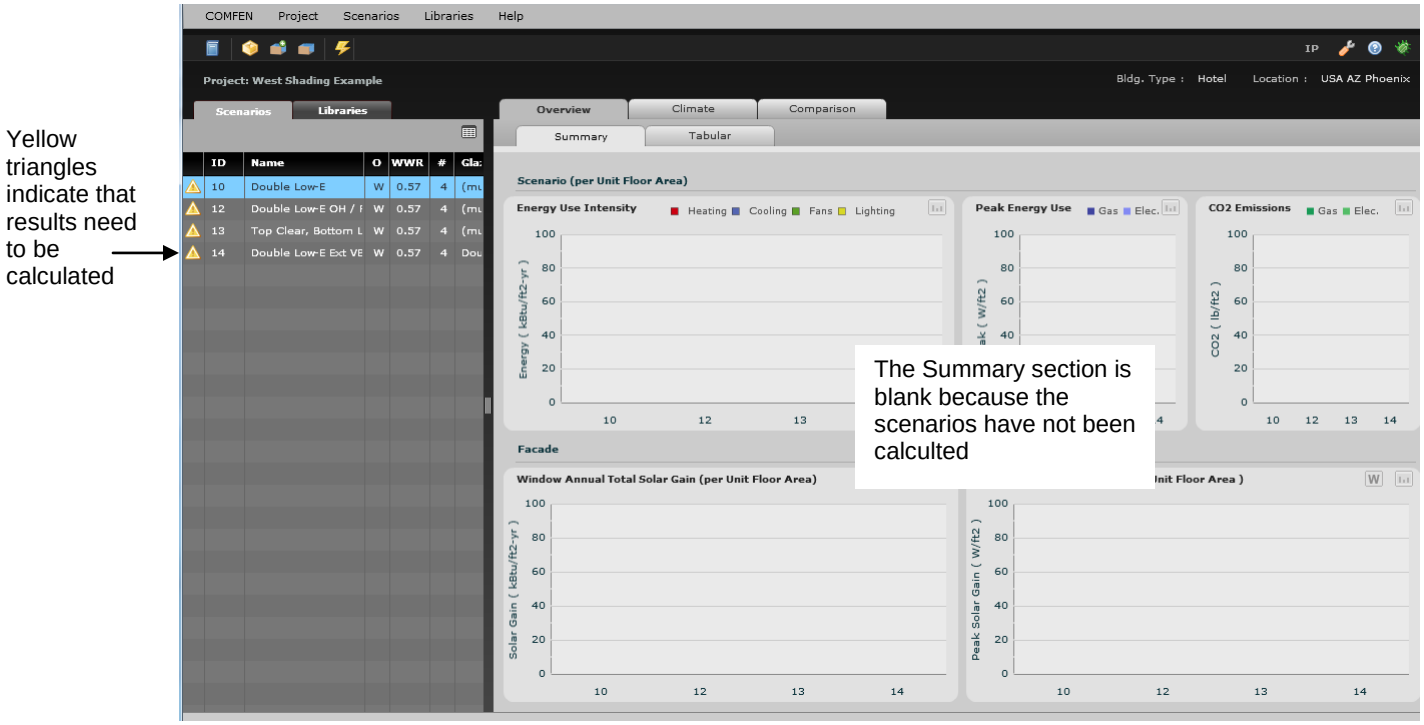


Figure 2-11. The Overview screen, which appears when you open an existing project.

You can calculate the results at this point, and they will appear in the Summary tab. To calculate the results, highlight as many scenarios as you want to calculate, and click on the Lightning Bolt toolbar, or right click and choose the Calculate Enery Use option.

Going to the Comparison tab will allow you to see the Scenario Visualization view, but it will be blank until you highlight the scenario from the Scenario List on the left, and drag it them to the right.

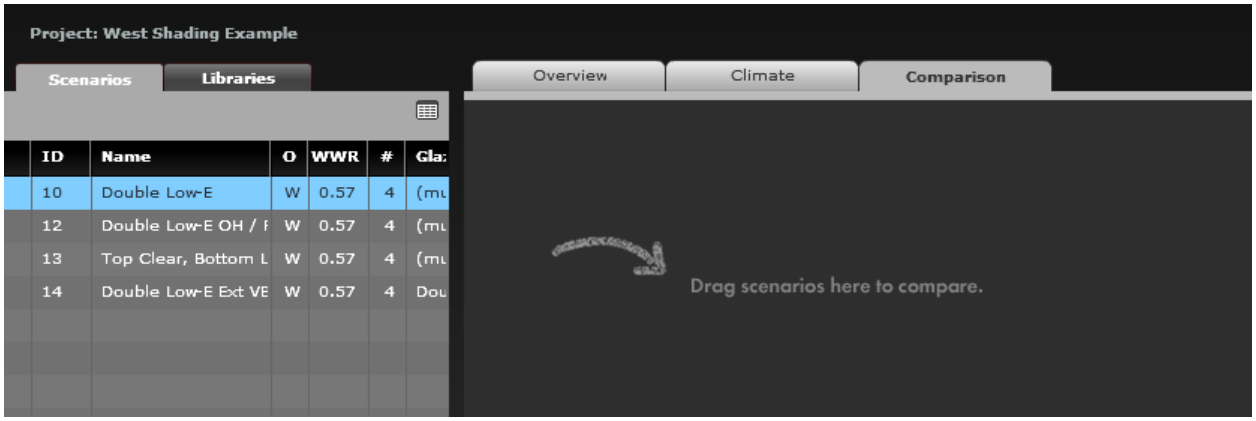


Figure 2-12. Drag scenarios to the right in the Comparison tab.

Then you will be able to see the "3D" versions of the scenarios, but there will still not be results until the scenarios are calculated.

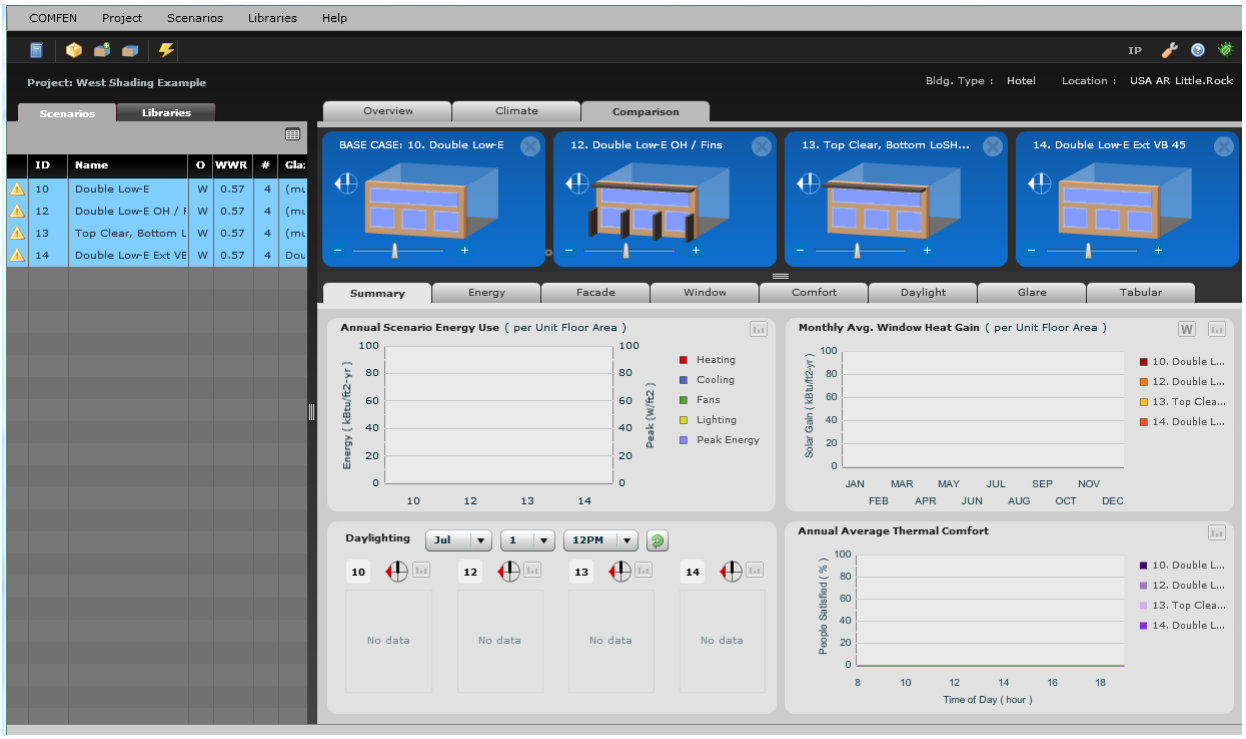


Figure 2-13. The 3D visualizations are shown in the Comparison tab.

If the scenarios have a triangle icon to the left, this means that they do not have current results (and therefore the Results Section will be blank) and must be simulated.

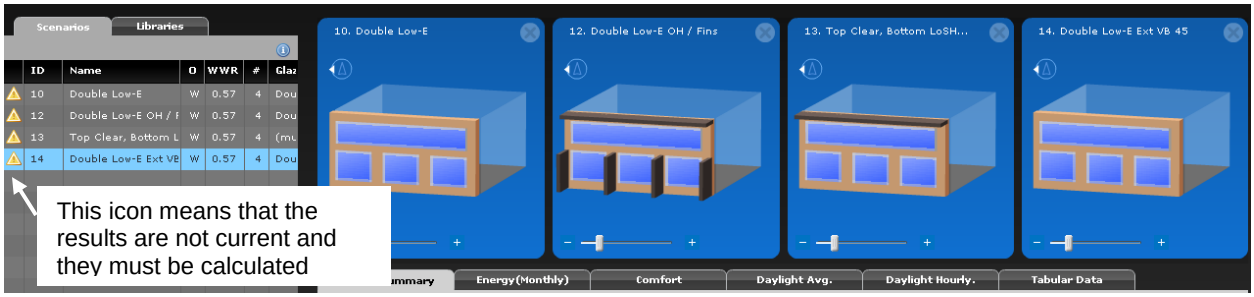


Figure 2-14. The yellow triangle icon to the left of the scenario means it needs to be calculated

To calculate the results, select as many scenarios as desired, then click the lightning bolt tool bar button, and the program will start to run the Energy Plus simulation program for each scenario.

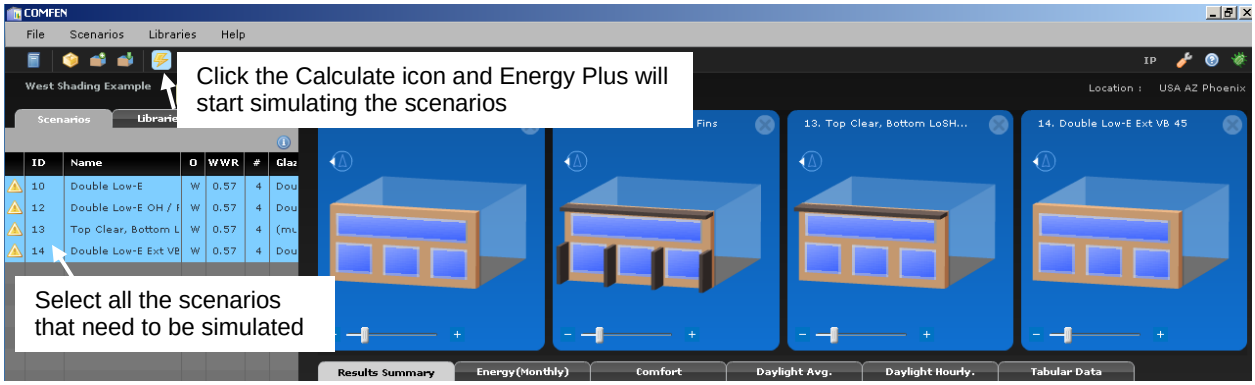


Figure 2-15. Highlight the scenarios to be calculated and press the Lightning Bolt toolbar button.

As the calculations are proceeding, a status box will appear.

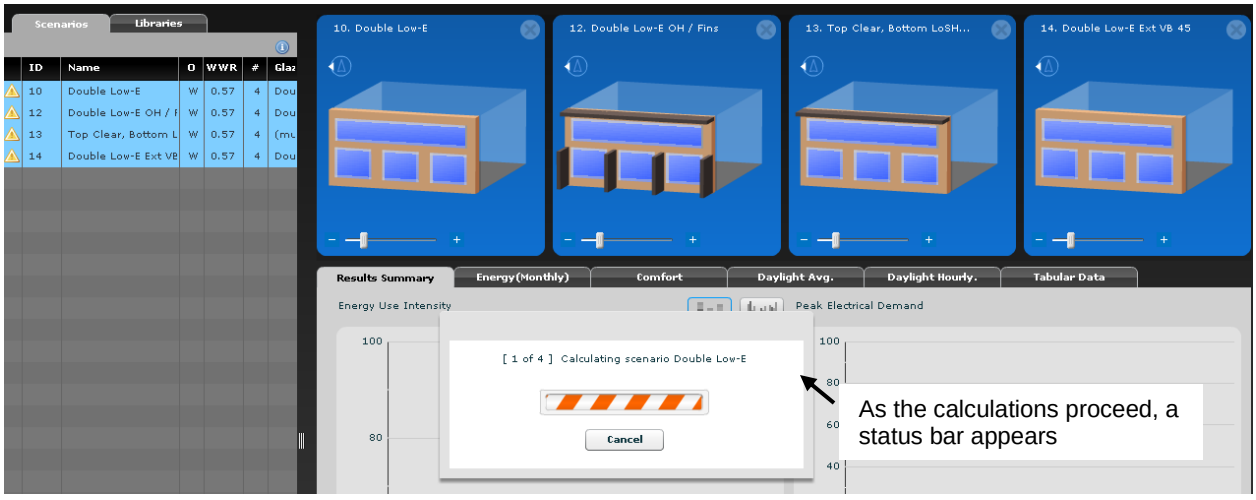


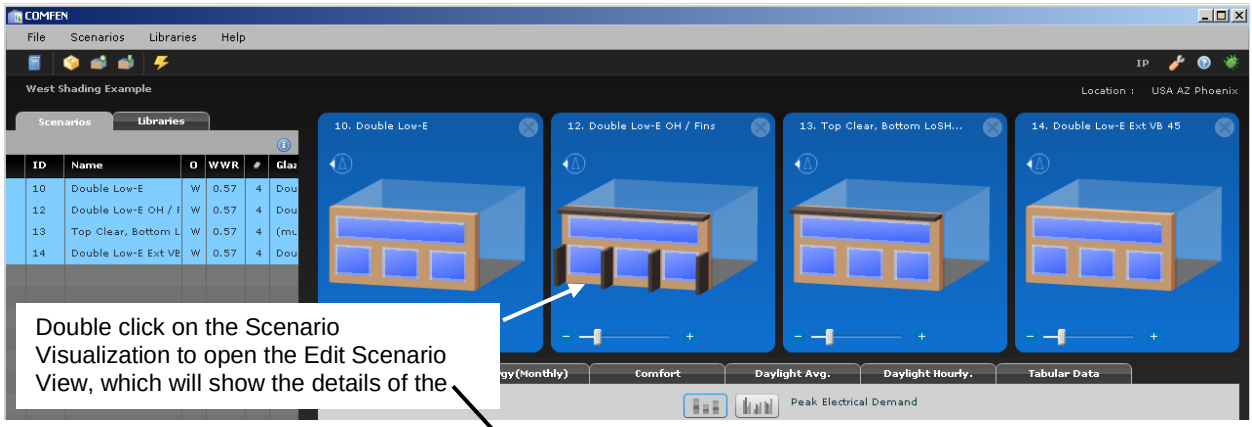
Figure 2-16. A status bar will appear as the scenarios are calculated.

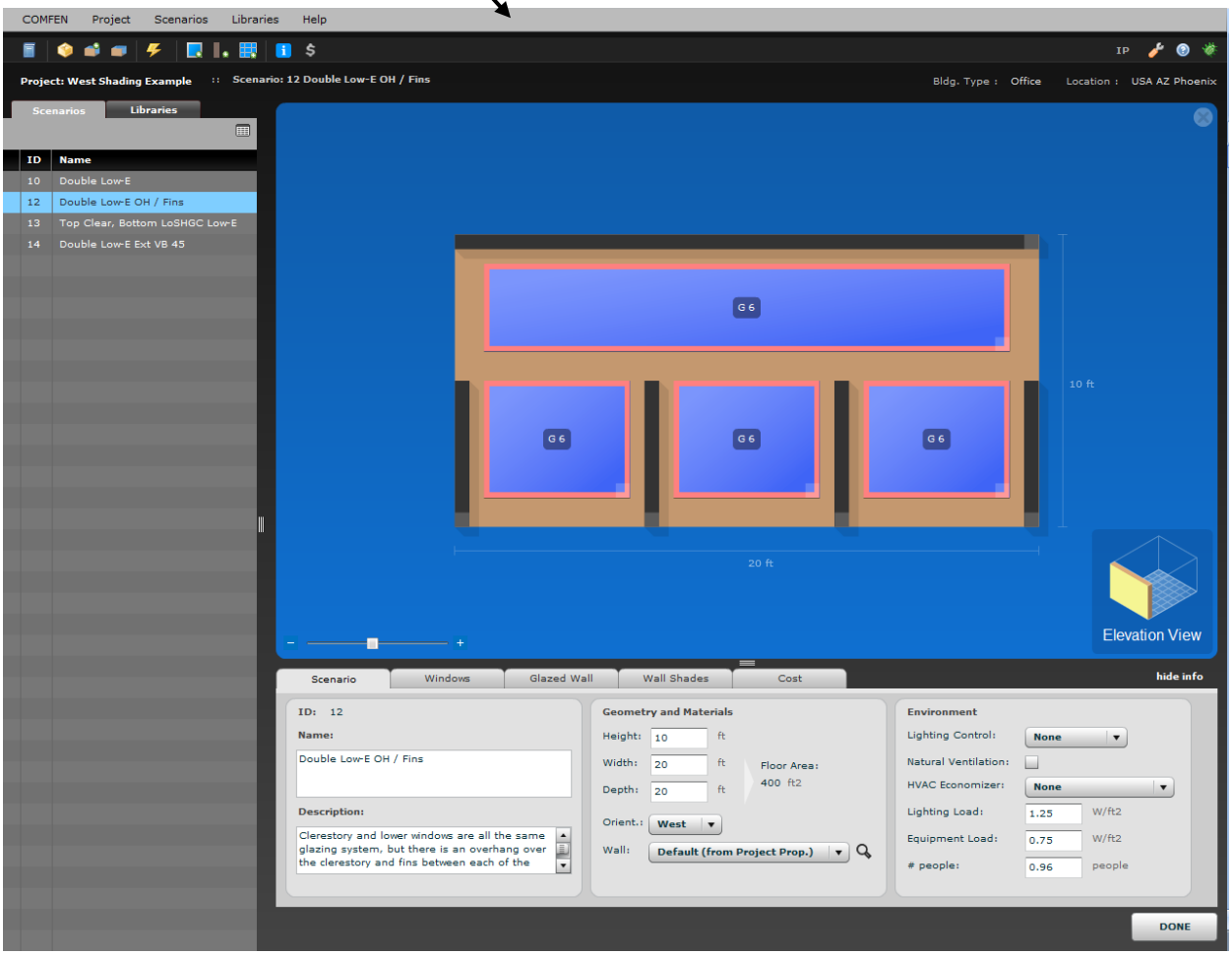
When the calculations are finished, the results will appear in the Results Section

Figure 2-17. When the results have been calculated, the results will display under the Comparison tab.

2.3.1. Viewing the Scenario Details

In order to view the details of a scenario, you need to open the Edit Scenario Viewby double clicking on the graphic of the scenario.





Edit Scenario View

The Edit Scenario View allows you to enter information about the geometry of the space to be modeled, the lighting controls, the lighting and equipment loads, and the number of people in the space.

Scenario Tab

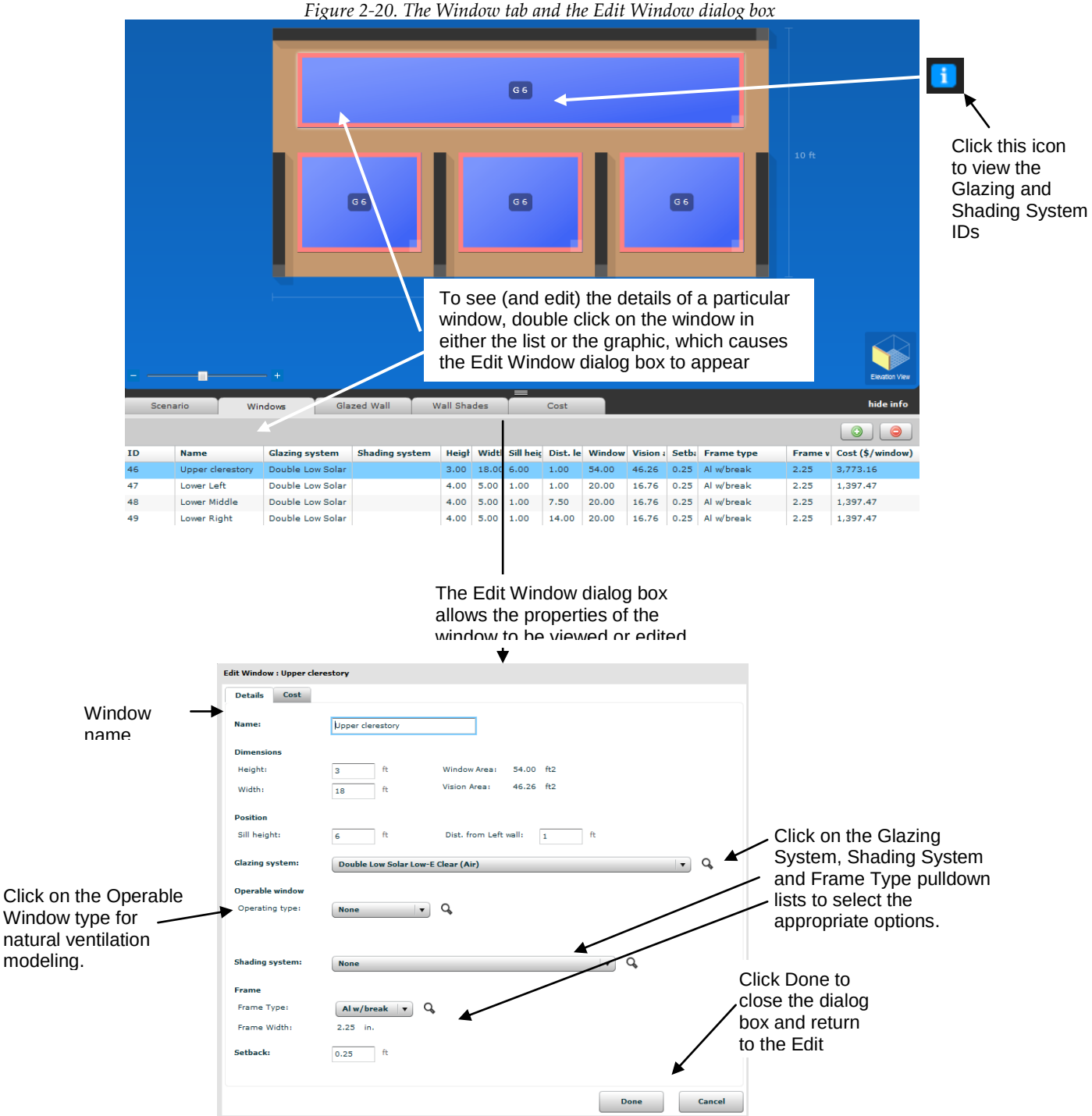
The scenario tab contains the title of the scenario, as well as information about the geometry and loads of the scenario.

Figure 2-19. The Scenario tab on the Edit Scenario View.

Windows Tab

The **Windows Tab** shows a list of all the windows on the façade. Double click on any window in either the list or the graphic and the **Edit Window dialog box** appears, which allows you to view and edit the window information.

Figure 2-20. The Window tab and the Edit Window dialog box



Edit Window dialog box

The Edit Window dialog box allows you to view and edit all the information pertaining to the window.

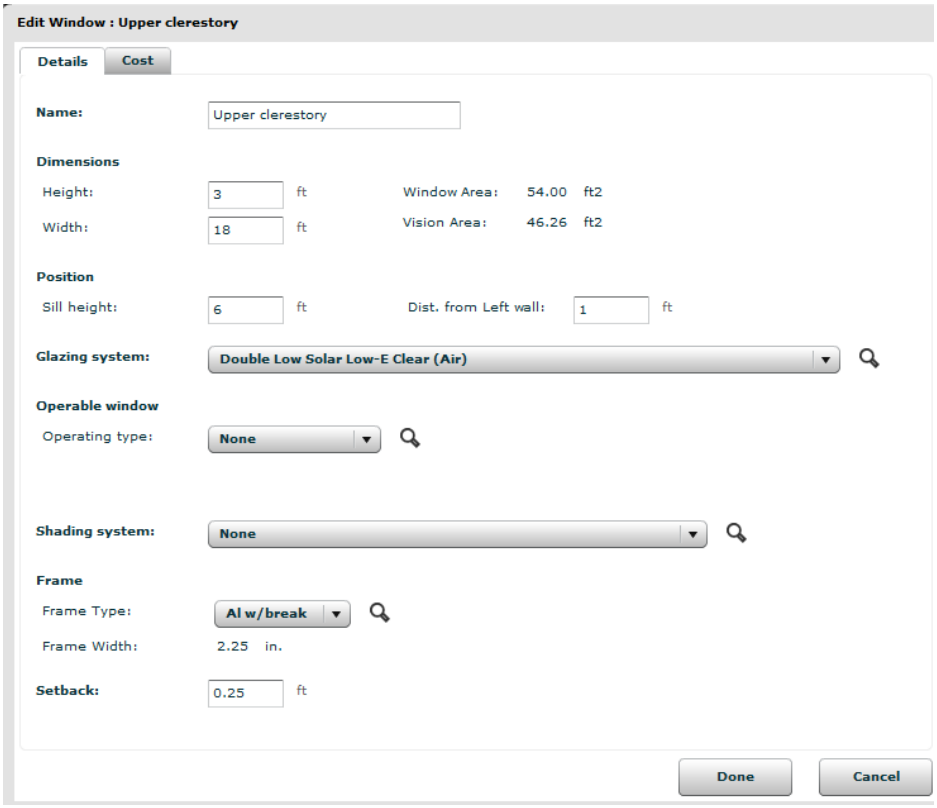
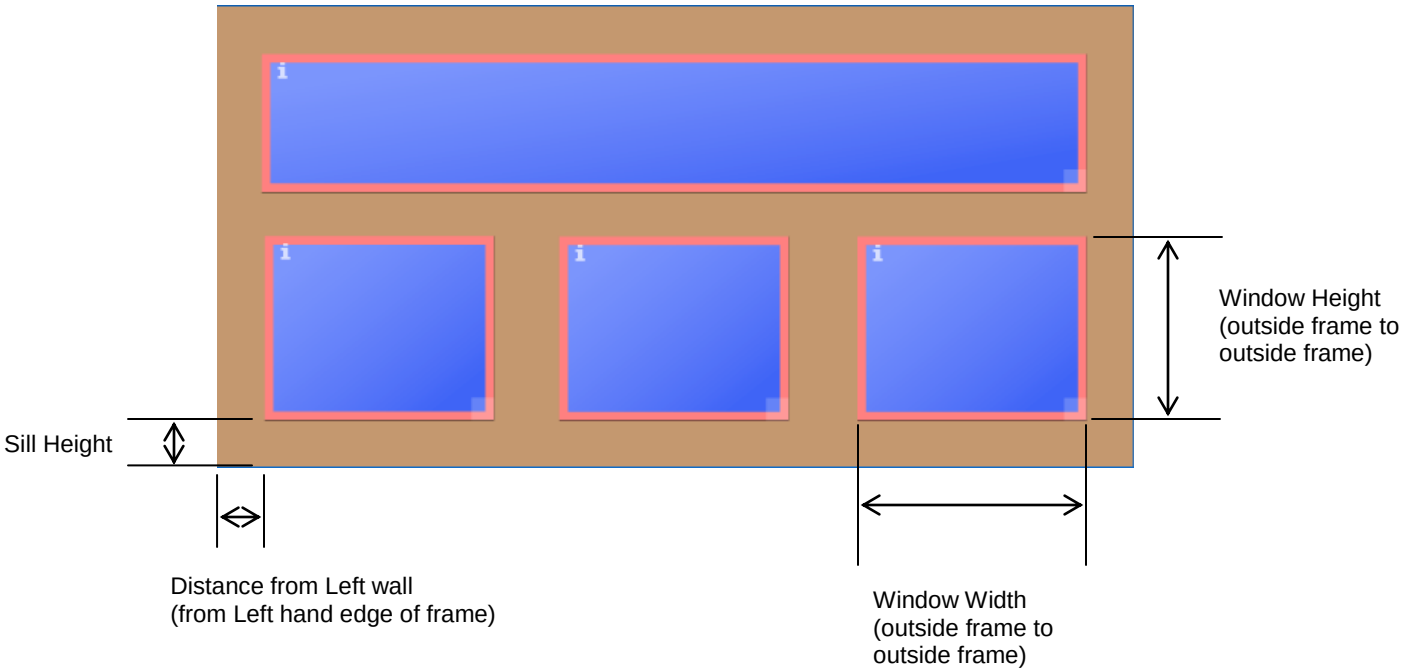


Figure 2-21. The Basic Info tab on the Edit Window dialog box.



Wall ShadesTab

The **Wall Shades Tab** shows a list of all the overhangs and fins on the façade. Double click on any overhang or fin in either the list or the graphic and the **Edit Wall Shade dialog box** will appear, which allows you to view and edit the window information.

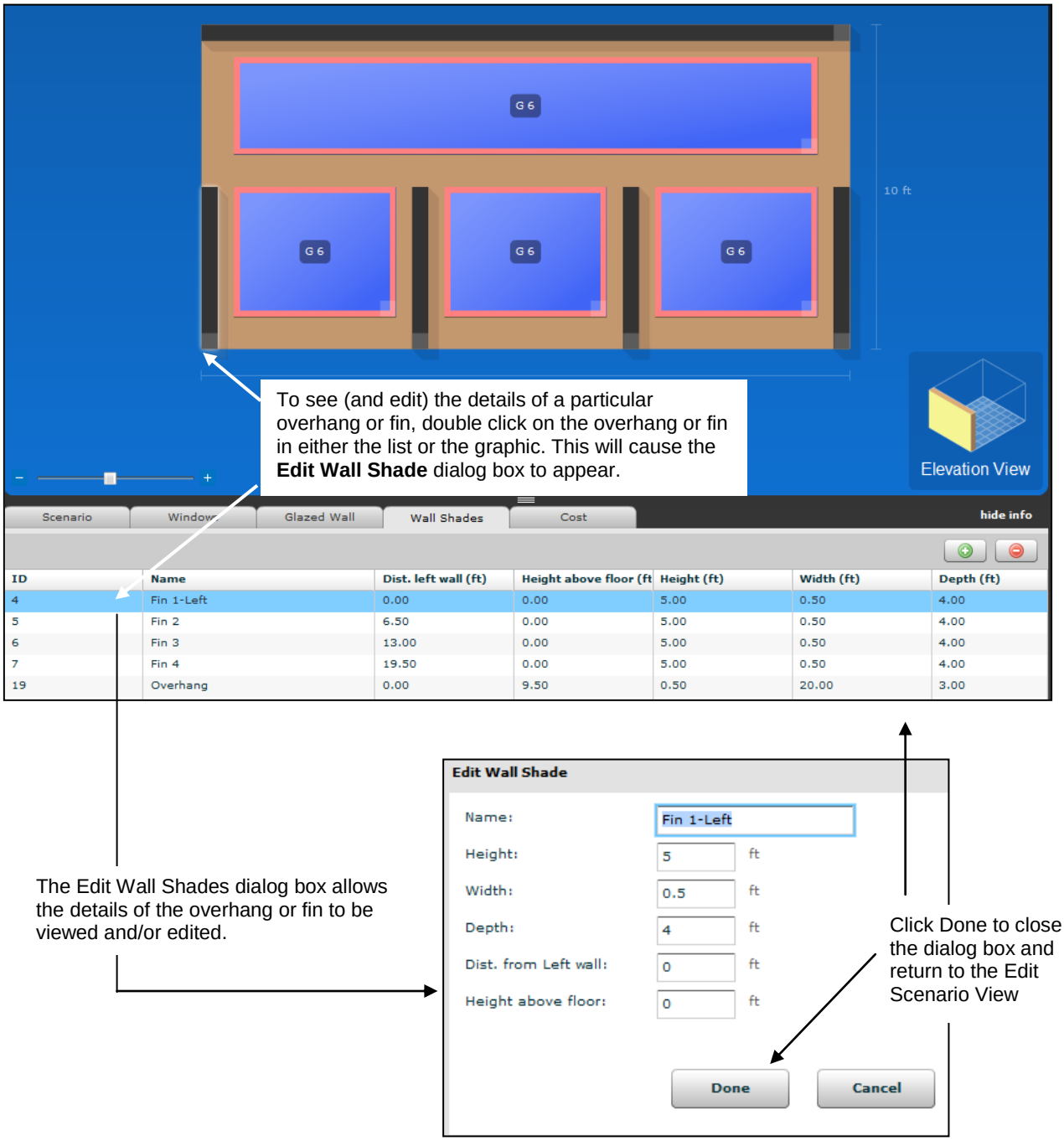


Figure 2-22. The Wall Shades tab and Edit Wall Shade dialog box.

2.4. Creating a New Project

When first starting the program, click on the **New Project** choice under **Create** to start a new project. If you are already in the program, use the Project > New Project menu option to create a new project.

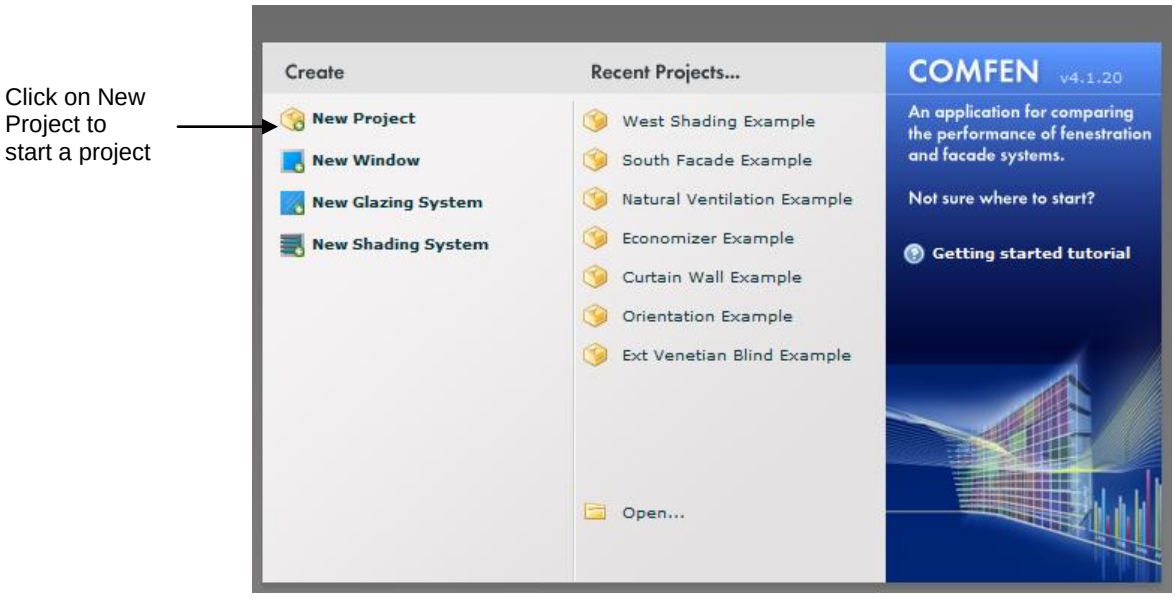


Figure 2-23. Click on New Project to start a project.

The Create COMFEN Project will appear. There are several tabs with different information to be filled out about the project.

General

The General tab is used to give the project a name (required), a description (optional), and specify a building type (required).

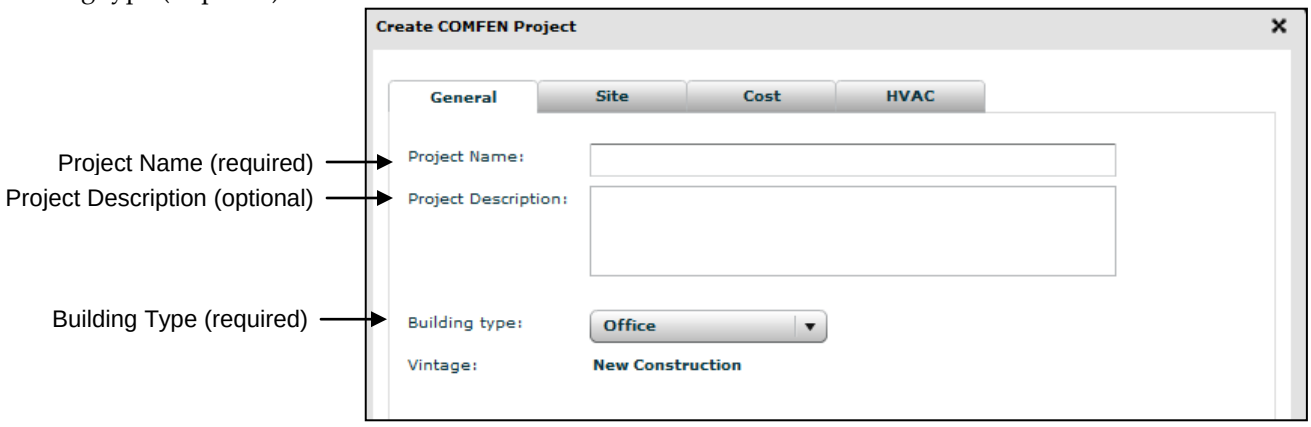


Figure 2-24. The Project Properties "General" tab

Site

The Site tab is used to define the properties of the site, such as location and project orientation

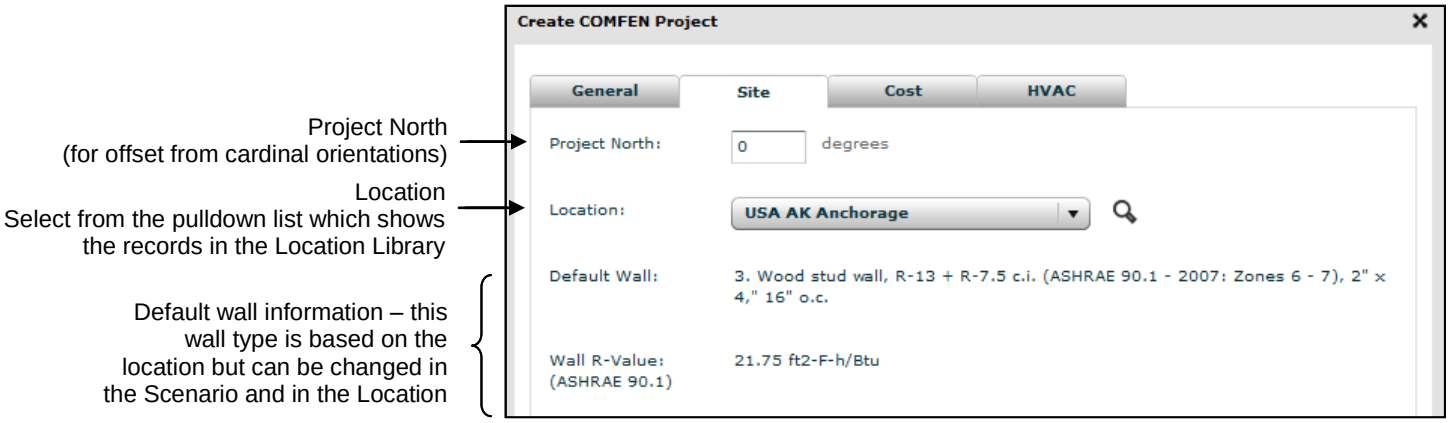


Figure 2-25. The Project Properties "Site" tab

Cost

The Cost tab is used to set overrides to the default costs in the program for lighting, HVAC, and utility rates.

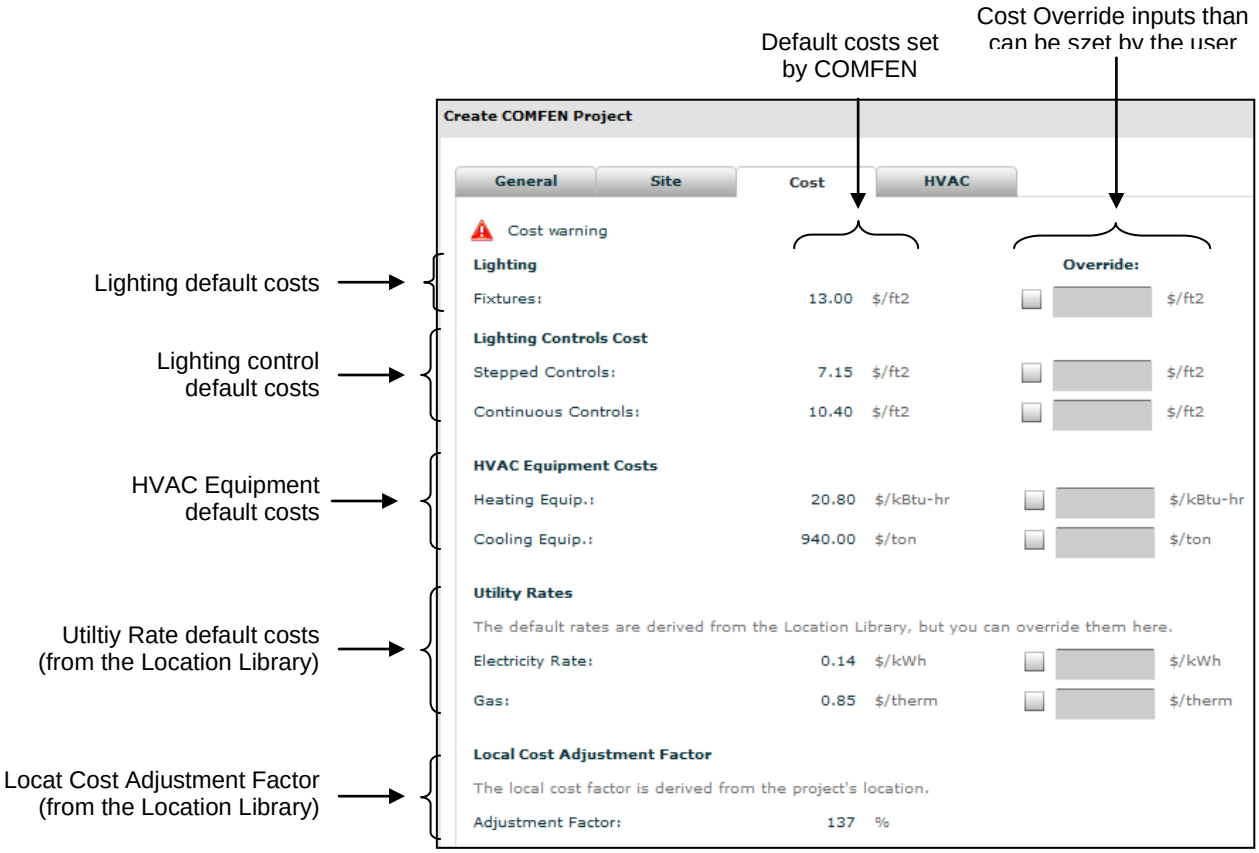


Figure 2-26. The Project Properties "Cost" tab

HVAC

The HVAC tab is used to set some default properties for how the HVAC system is operated

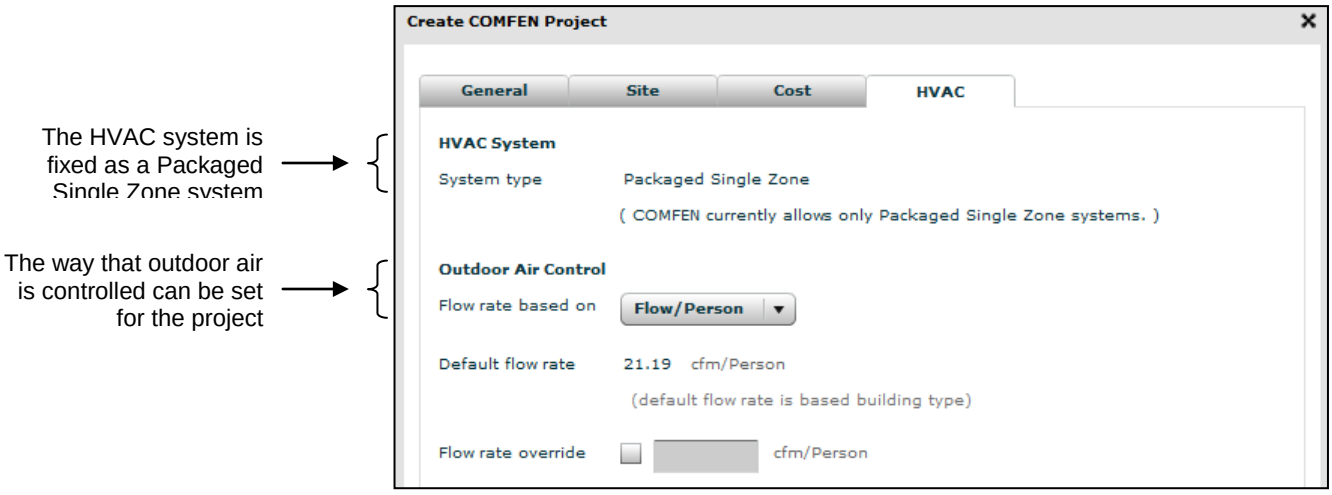


Figure 2-27. The Project Properties "HVAC" tab

2.4.1. Defining Scenarios

When you are starting a new Project, there are no scenarios defined. To define a new scenario, go to the Scenarios menu and select Create Scenario

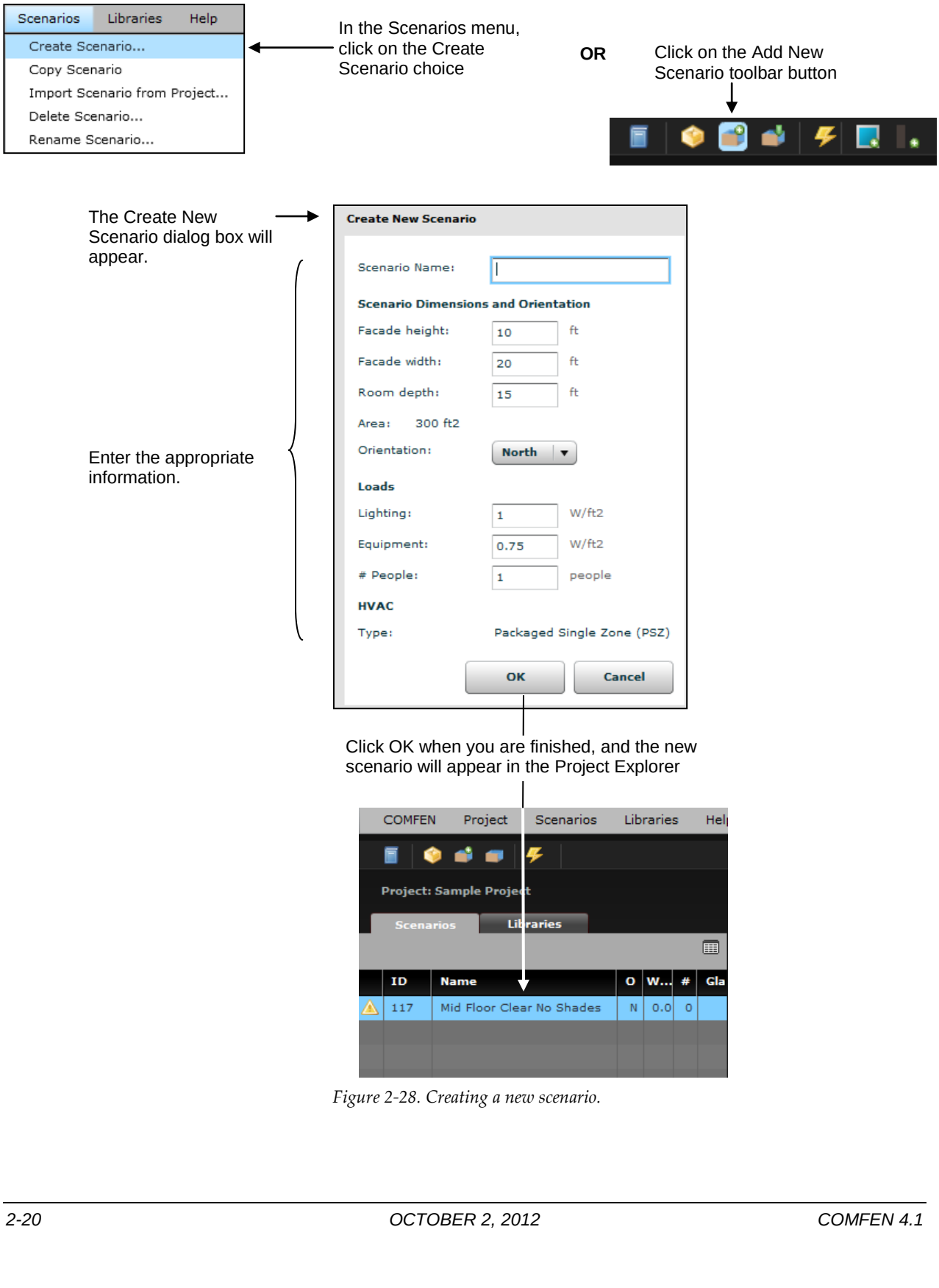


Figure 2-28. Creating a new scenario.

2.4.2. Edit Scenario

To edit the scenario (so that you can add windows, shades, etc), do the following:

- Double click on the scenario name in the Project Explorer to open the Edit Scenario View

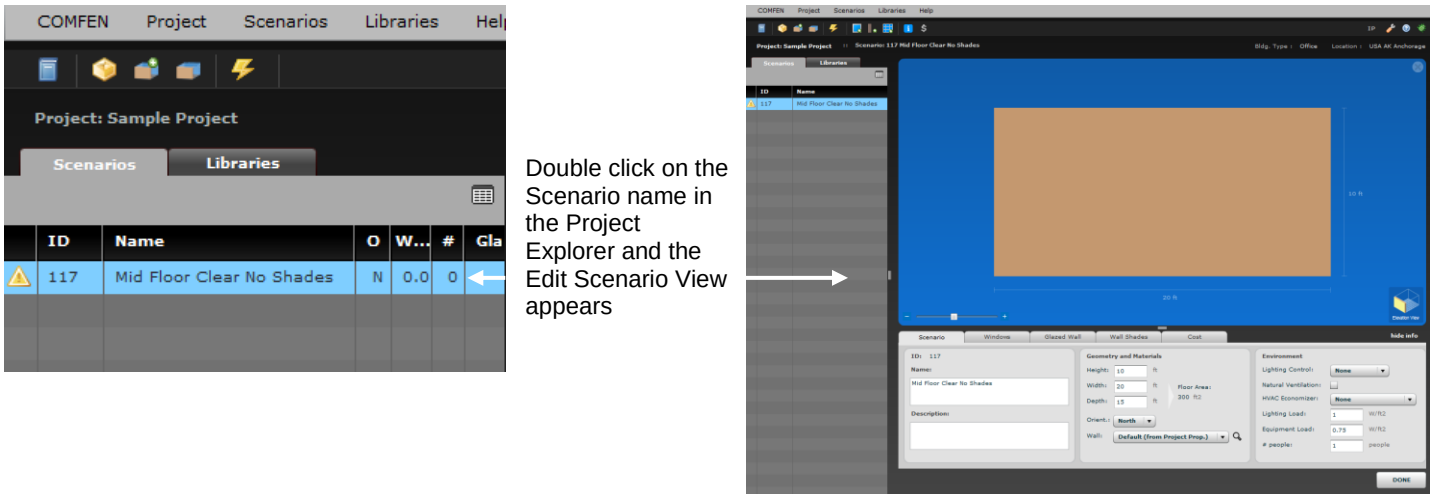
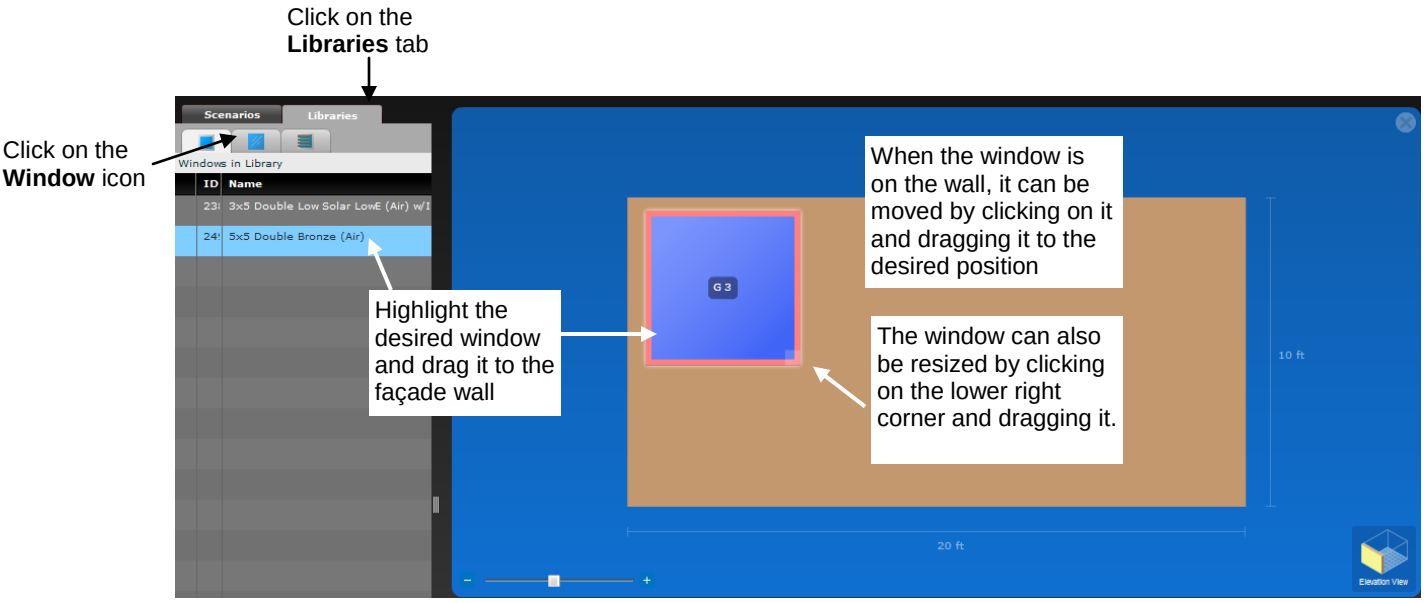


Figure 2-29. Open the Edit Scenario View from the Project Explorer

2.4.3. Add Windows

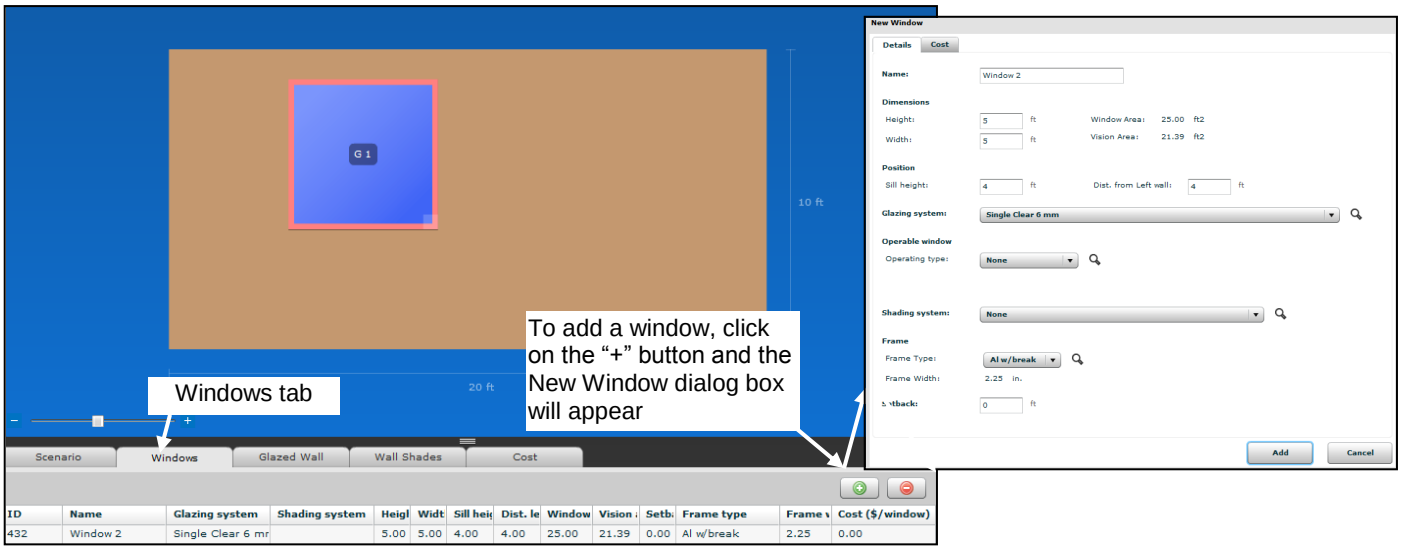
There are several ways to add a window to a scenario:

- From the Project Explorer, select the Libraries tab, Window Library icon, and drag a window to the facade



OR

- From the Edit Scenario Windows tab, click on the  button and the enter the appropriate information in the New Window dialog box. From this dialog box you can also define the Glazing System, Shading System and Frame Type from the appropriate tabs.



OR

- From the Scenarios menu, click on the "Add Window to Scenario" menu choice, which will display the New Window dialog box. From this dialog box you can also define the Glazing System, Shading System and Frame Type from the appropriate tabs.

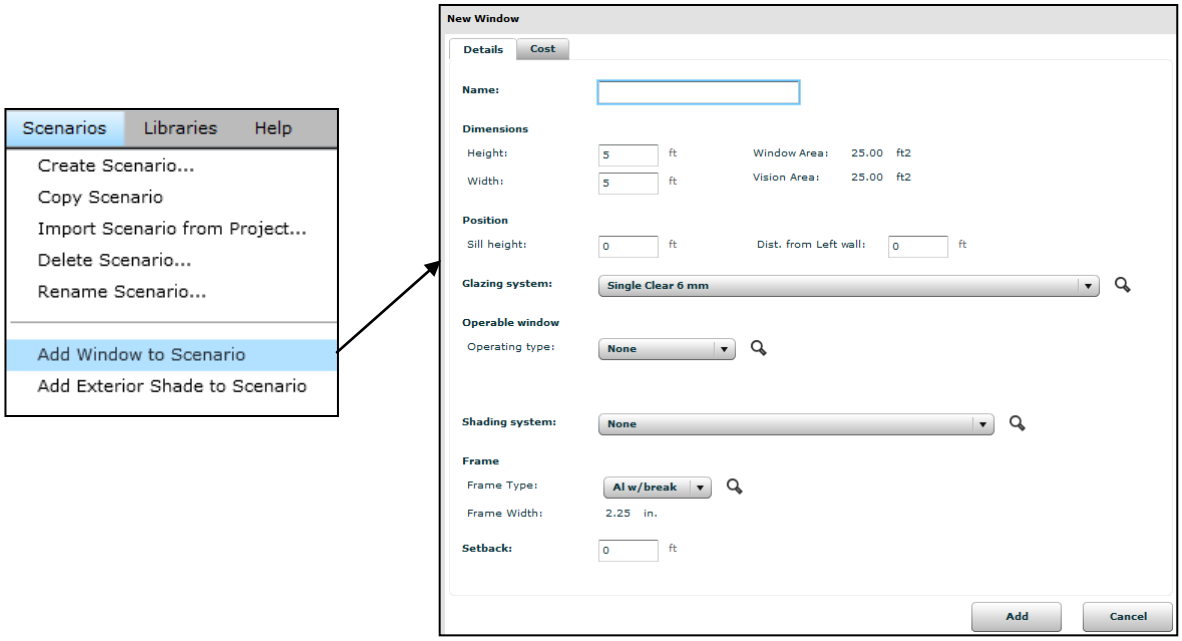
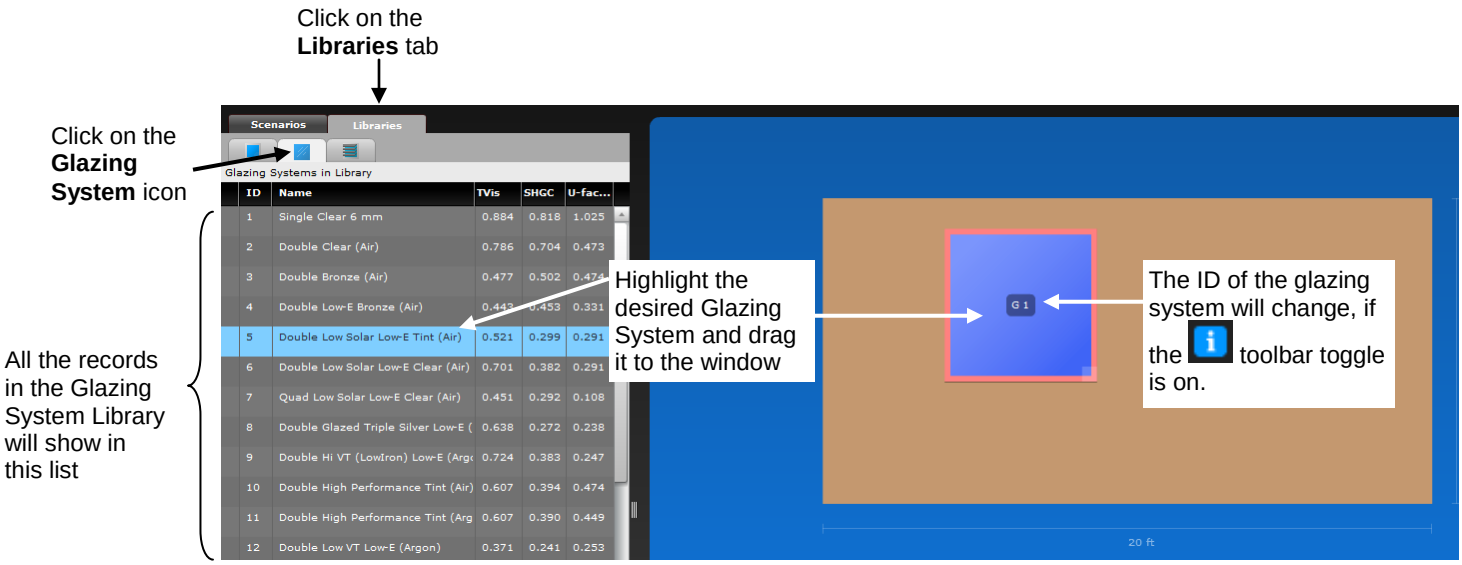


Figure 2-30. Add Windows to a Scenario.

Defining the Glazing System for the Window

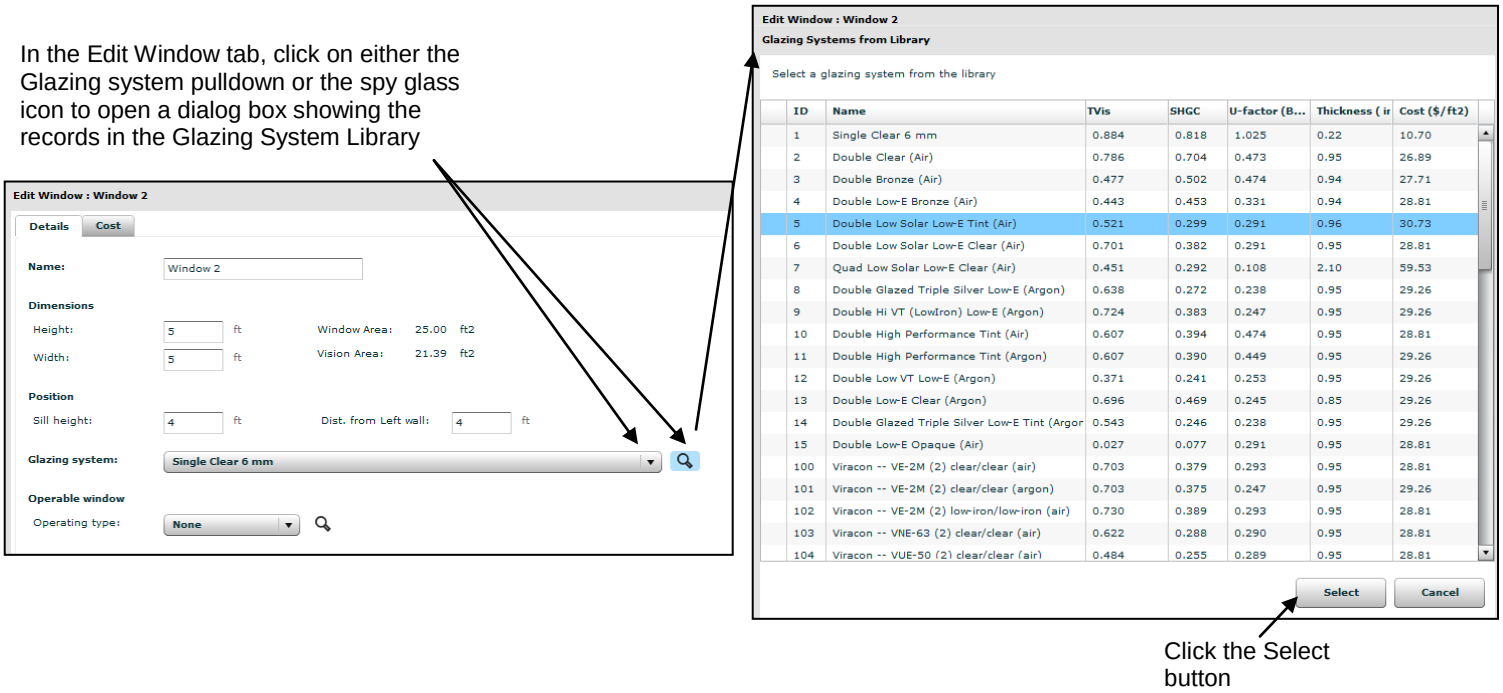
There are several ways to define or change a glazing system for a window:



- From the Project Explorer, select the **Libraries** tab, **Glazing System Library** icon, highlight the desired glazing system, and drag it to the window.

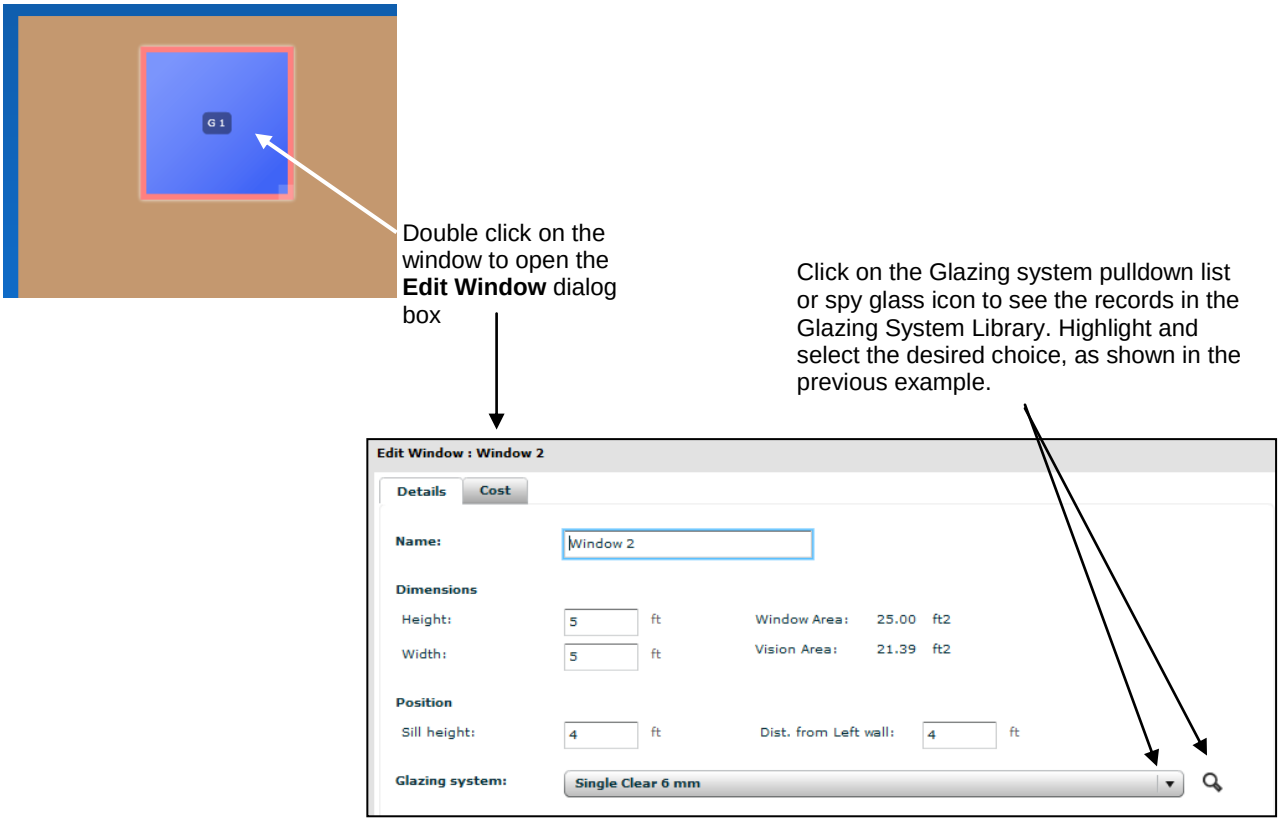
OR

- When defining the window, in the **New Window** dialog box, click on the Glazing System pulldown list or the spy glass next to it and the records in the **Glazing System Library** will be displayed. Highlight the desired glazing system and click the **Select** button.



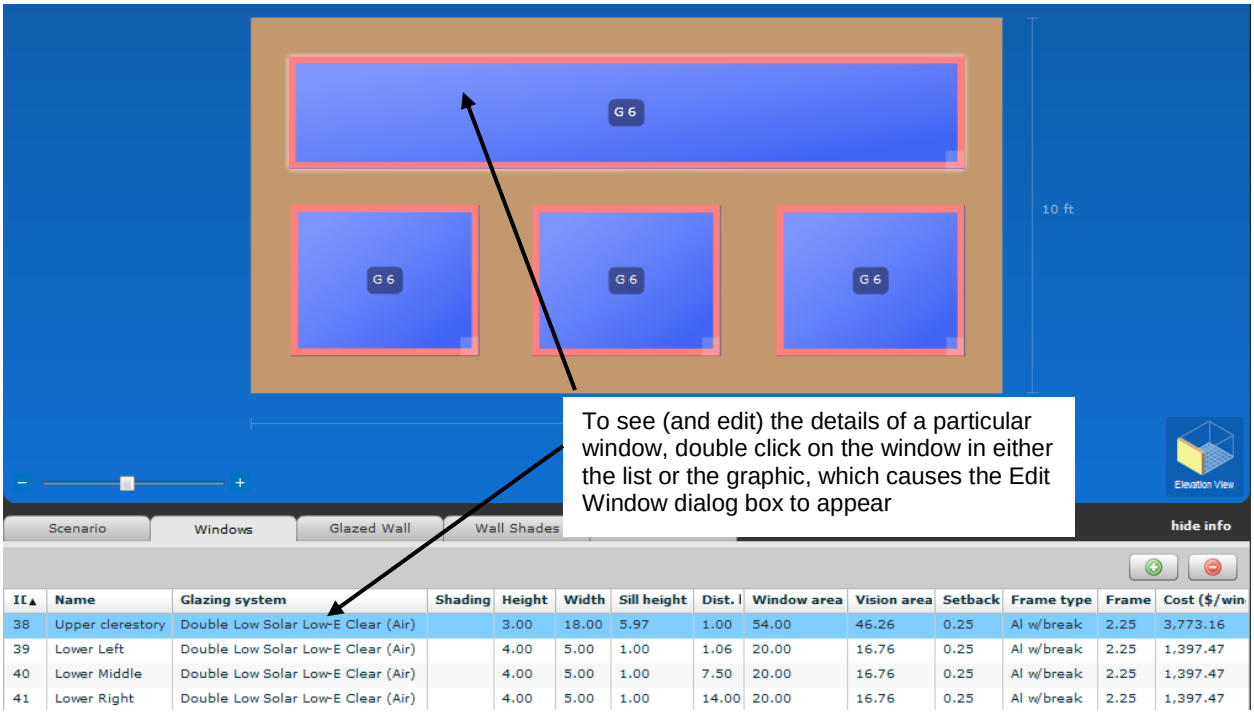
OR

- Double click on the window to open the Edit Window dialog box. Click on the Glazing System tab to define or change the glazing system for the window. Highlight the desired glazing system and click the Done button.



Windows Tab on Edit Scenario View

The **Windows Tab** shows a list of all the windows on the façade. Double click on any window in either the list or the graphic and the **Edit Window dialog box** appears, which allows you to view and edit the window information.



ID	Name	Glazing system	Shading	Height	Width	Sill height	Dist.	Window area	Vision area	Setback	Frame type	Frame	Cost ($/win
38	Upper clerestory	Double Low Solar Low-E Clear (Air)		3.00	18.00	5.97	1.00	54.00	46.26	0.25	Al w/break	2.25	3,773.16
39	Lower Left	Double Low Solar Low-E Clear (Air)		4.00	5.00	1.00	1.06	20.00	16.76	0.25	Al w/break	2.25	1,397.47
40	Lower Middle	Double Low Solar Low-E Clear (Air)		4.00	5.00	1.00	7.50	20.00	16.76	0.25	Al w/break	2.25	1,397.47
41	Lower Right	Double Low Solar Low-E Clear (Air)		4.00	5.00	1.00	14.00	20.00	16.76	0.25	Al w/break	2.25	1,397.47

The Edit Window dialog box allows the properties of the window to be viewed or edited.

The Glazing System, Shading System and Frame can be edited, as well as the Operating type of the window

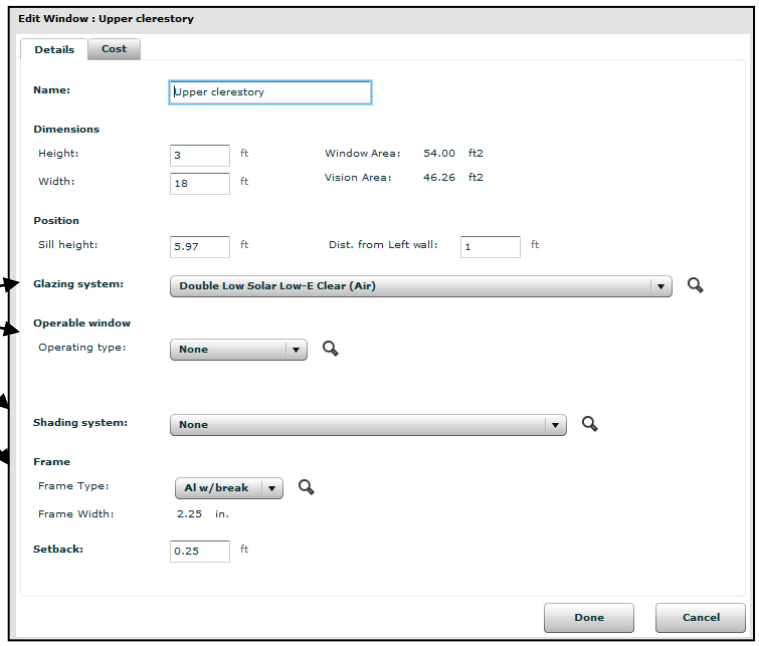


Figure 2-31. The Windows tab and the Edit Window dialog box

Edit Window dialog box

The Edit Window dialog box allows you to view and edit all the information pertaining to the window. There are several tabs in this dialog box:

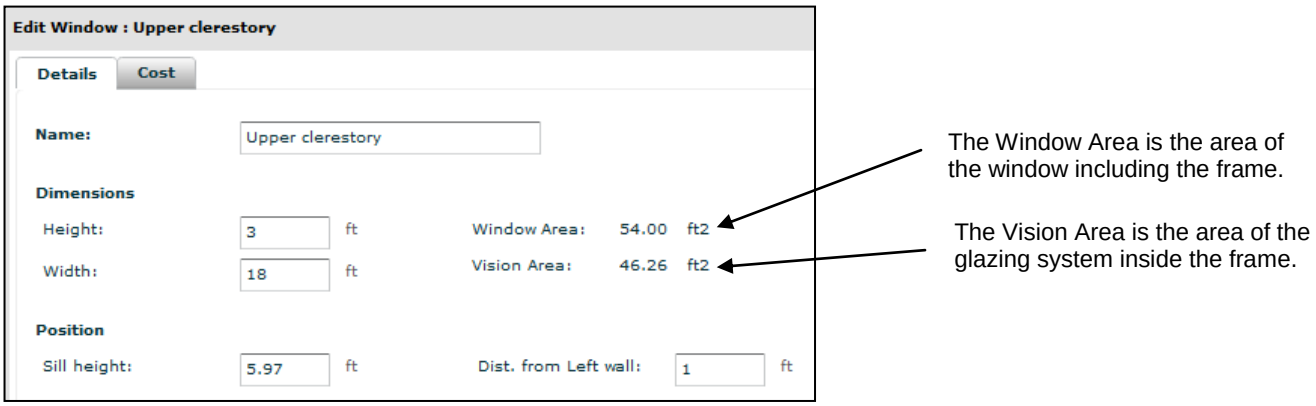


Figure 2-32. The Dimensions and Position on the Edit Window dialog box.

The Frame Width is the frame dimension when looking at the frame in elevation.

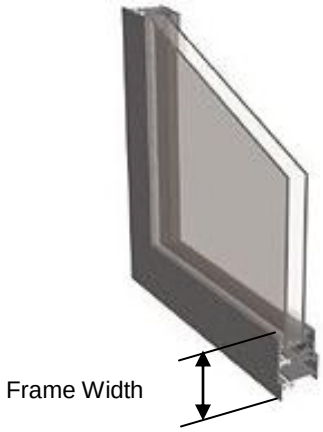


Figure 2-33. The Frame Width.

The Setback is the distance from the outside surface of the wall that the window is inset into the wall.

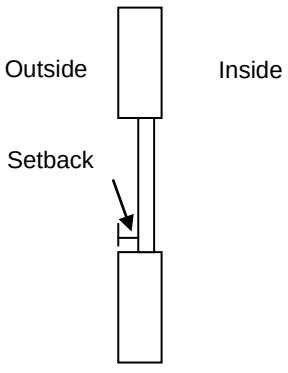


Figure 2-34. The Setback.

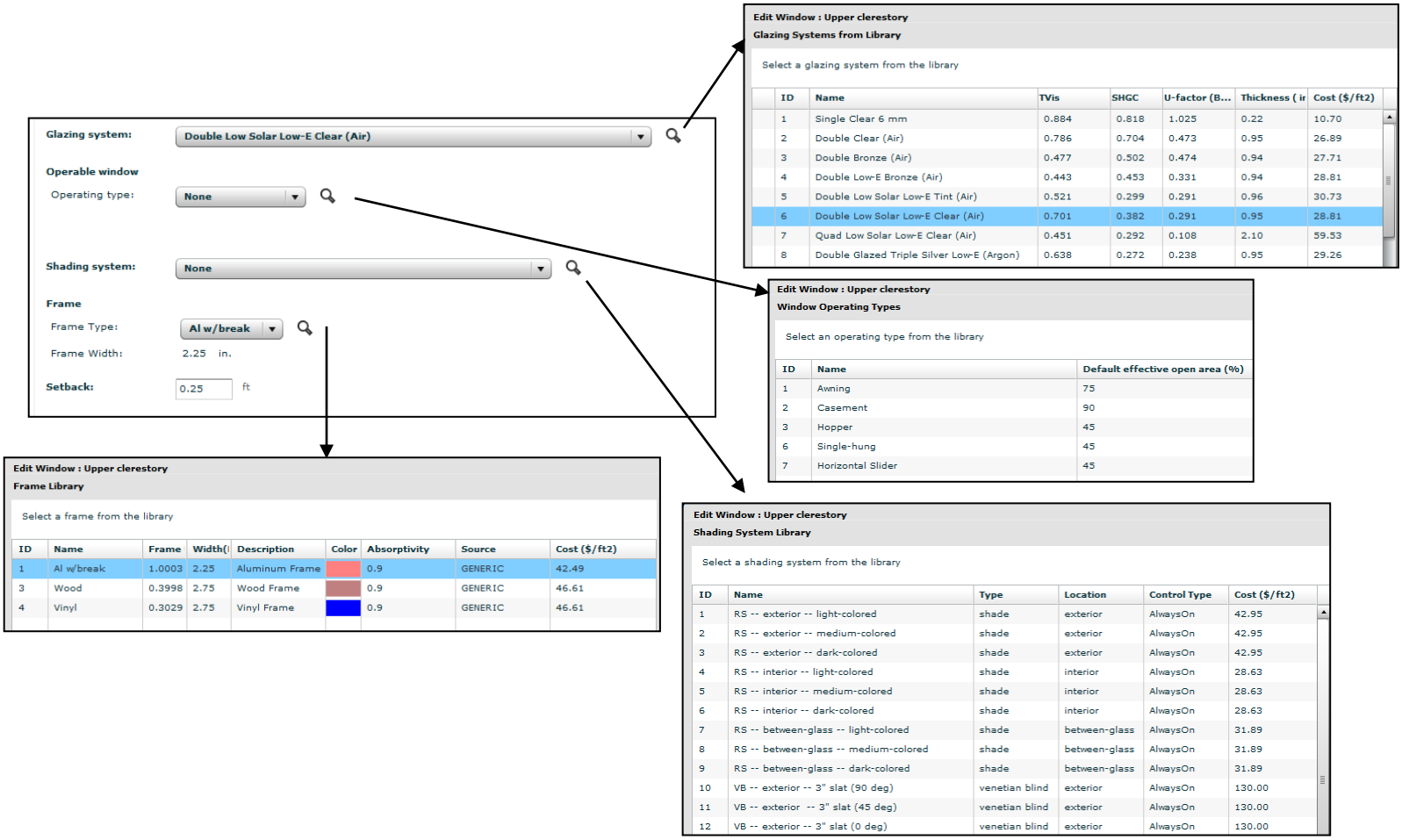


Figure 2-35. The Edit Window dialog box defining glazing system, operating type, shading system and frame type.

2.4.4. Add Wall Shades (Overhangs and Fins)

To add overhangs and fins to the scenario, go to the Wall Shades tab in the Scenario Edit view, and click on the **+** button. A dialog box will appear which allows you to define overhangs and fins.

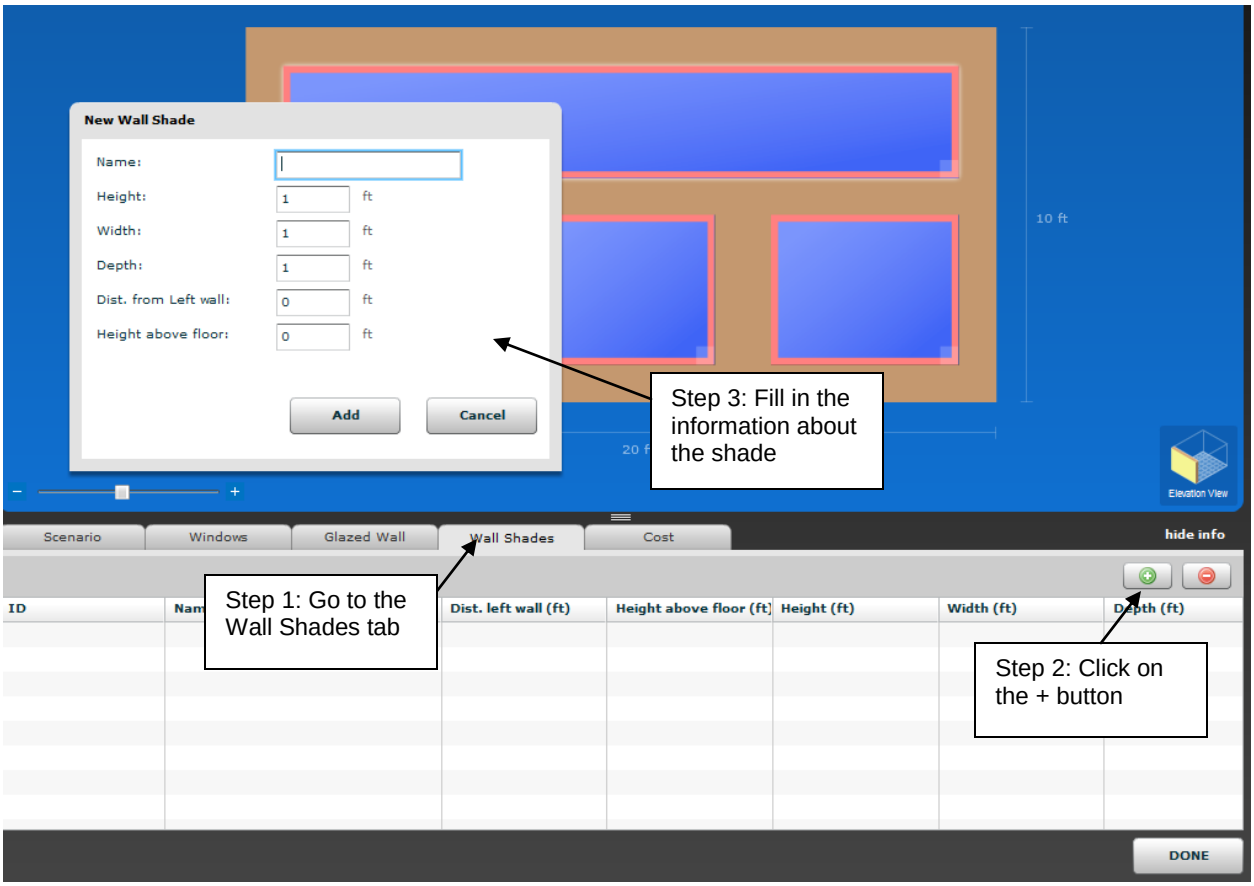
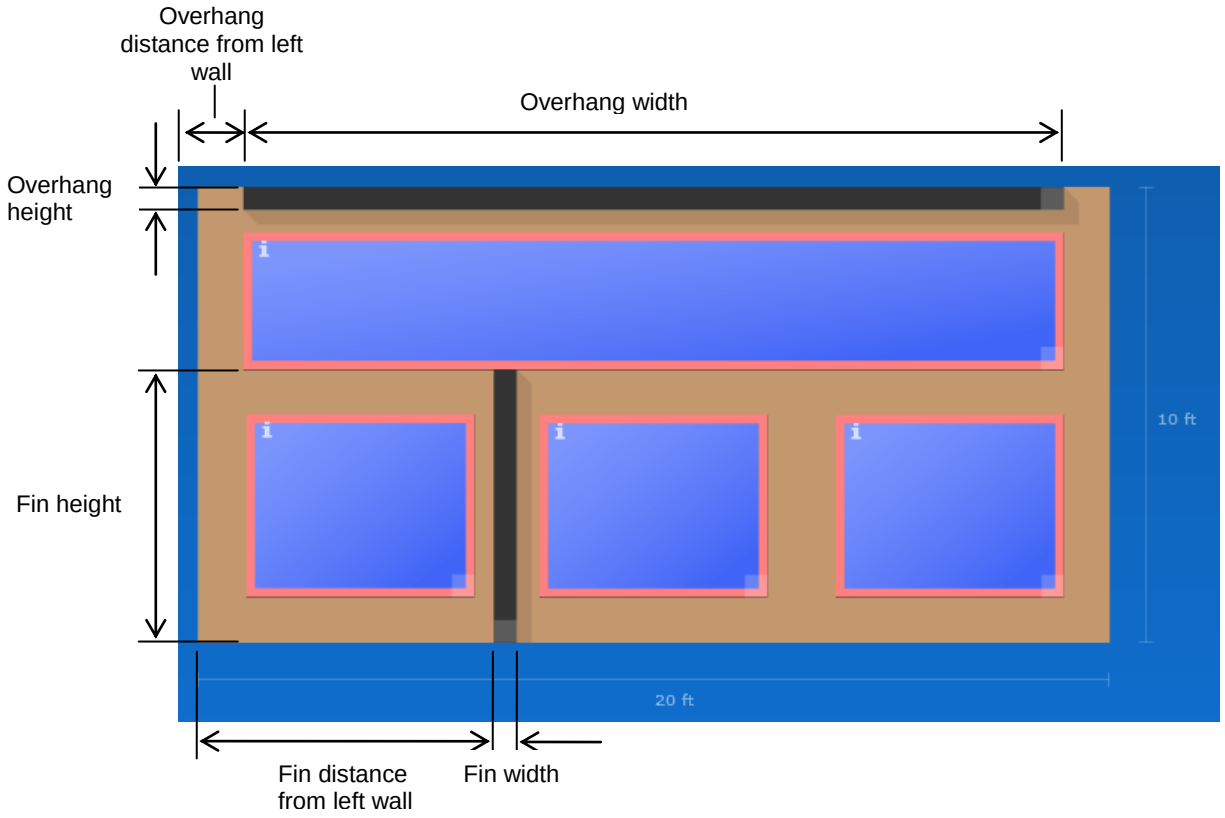
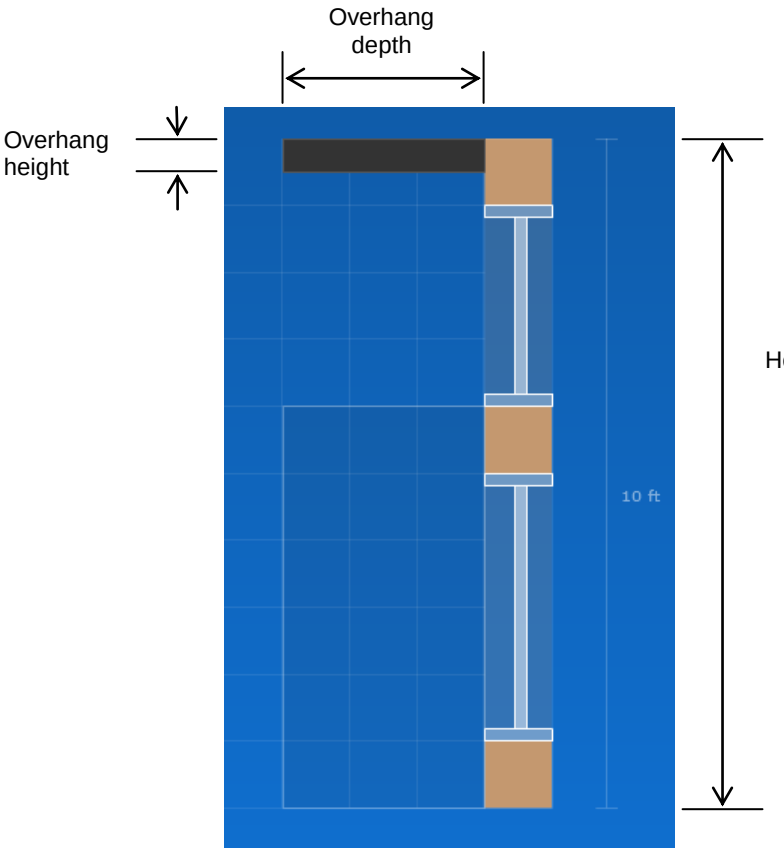
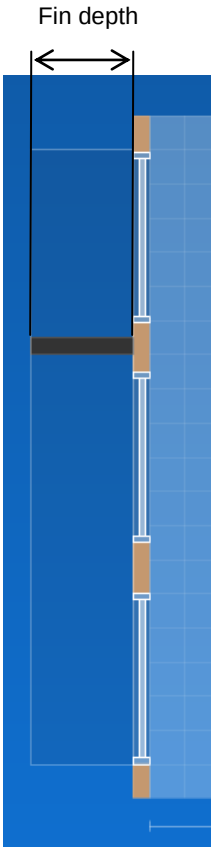


Figure 2-36. Defining an overhang or fin.





Section View



Plan View

3. INSTALLATION

3.1. Hardware Requirements

First, make sure your computer system meets these specifications:

- At least 16 MB of random access memory (RAM), configured as extended memory. 32 MB of RAM is preferred for optimum operation.
- Microsoft Windows XP™, Windows Vista™ or Windows 7™.
- Hard disk drive with at least 100 megabytes of available disk space.
- Monitor and mouse.

3.2. Setup

The installation program can be downloaded from the LBNL website at
http://windows.lbl.gov/software/comfen

Once you have downloaded the installation program, follow these steps to install the program:

1. Using Windows Explore, browse to where the installation file was downloaded and double click on it.

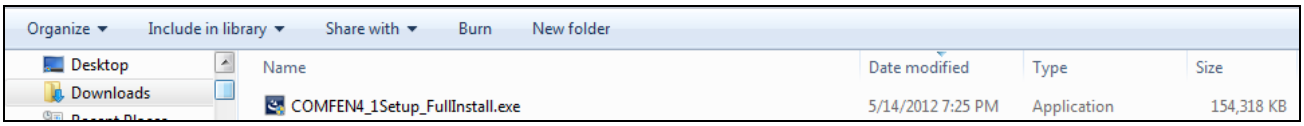


Figure 3-1. Double click on the downloaded installation file.

2. A Welcome window will display. Click the **Next** button to proceed with the installation, or **Cancel** to stop.

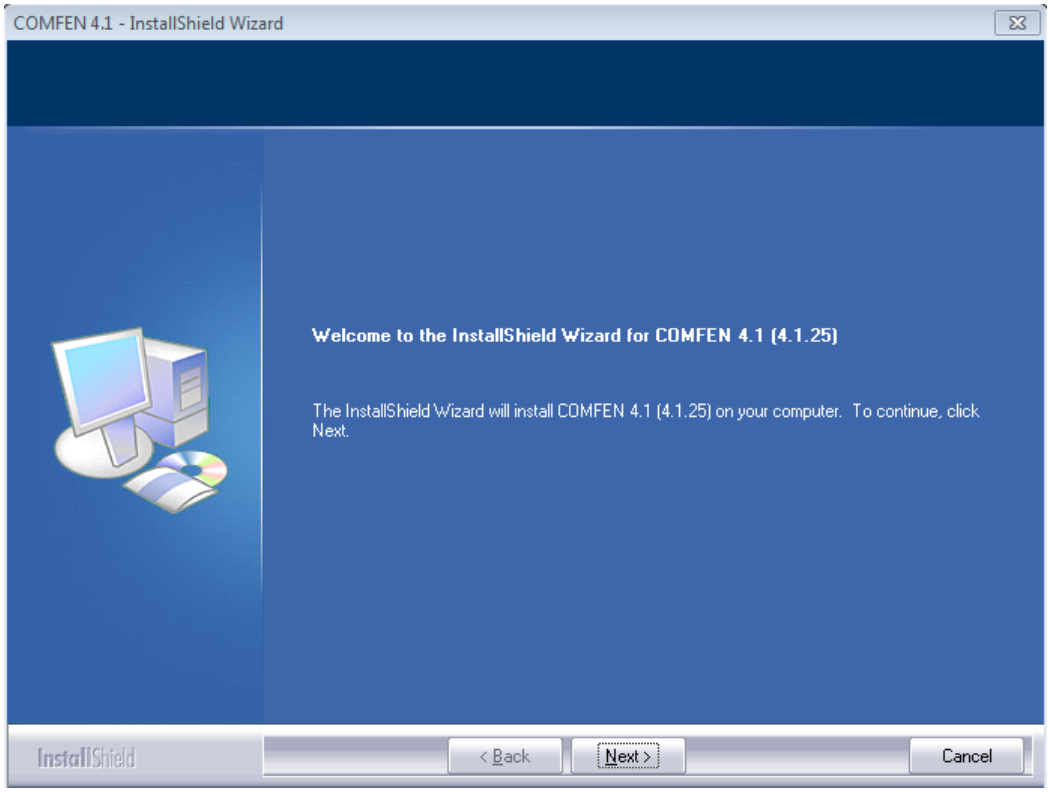


Figure 3-2. The initial COMFEN Welcom window.

3. The **Software License Agreement** window will display next. Read through the license and make sure you agree to all the terms before proceeding. To proceed with the installation, click on the **Yes** button, or click on **No** to stop.

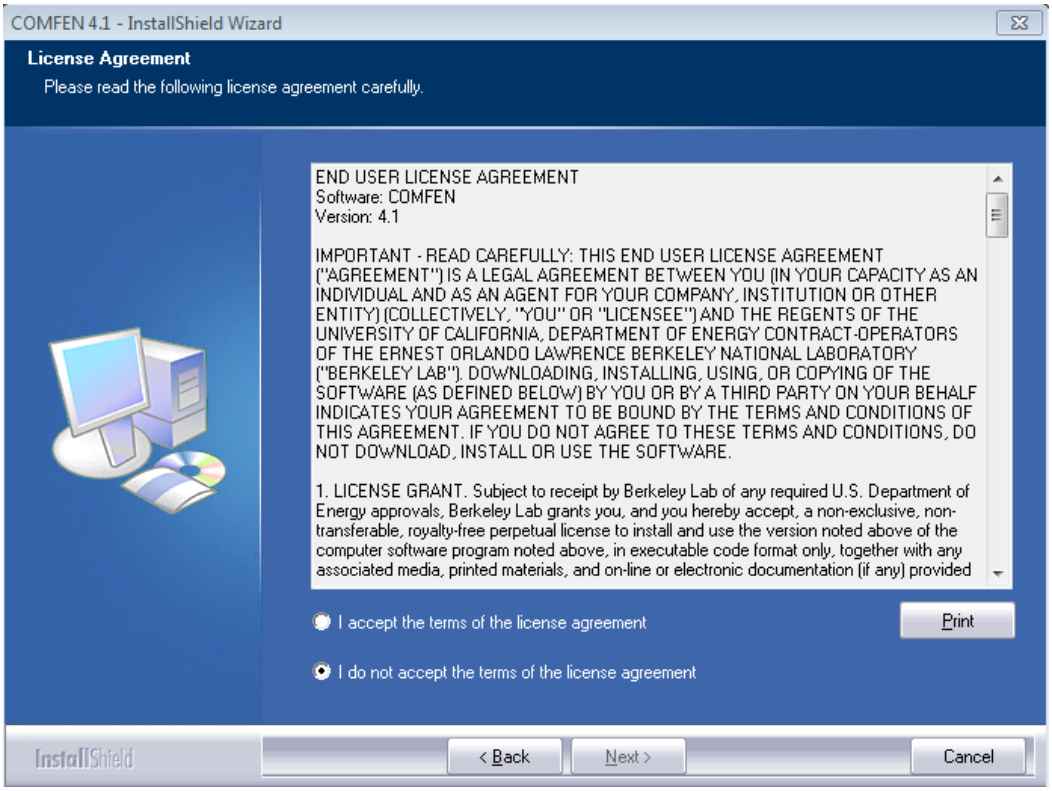


Figure 3-3. The COMFEN License Agreement window.

4. The **Ready to Install the Program** window will display next. Press the **Install** button to begin the installation.

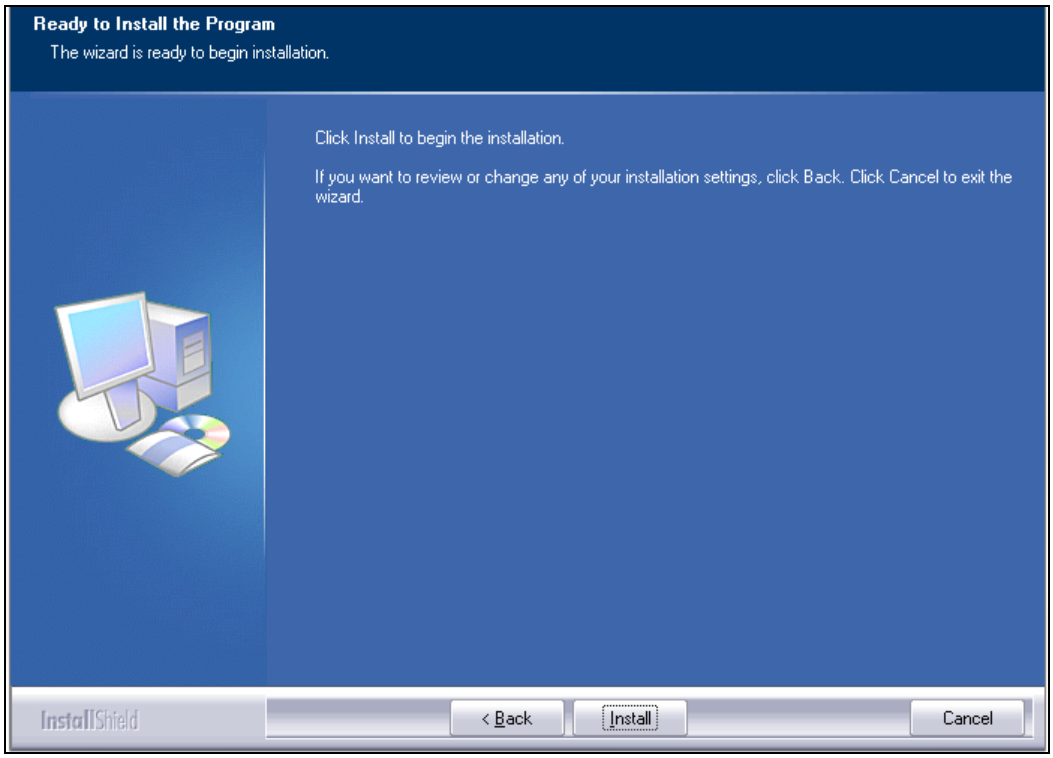


Figure 3-4. ***Ready to Install the Program*** *screen.*

5. The next screen to display is the **Setup Status** screen, which shows the files being installes.

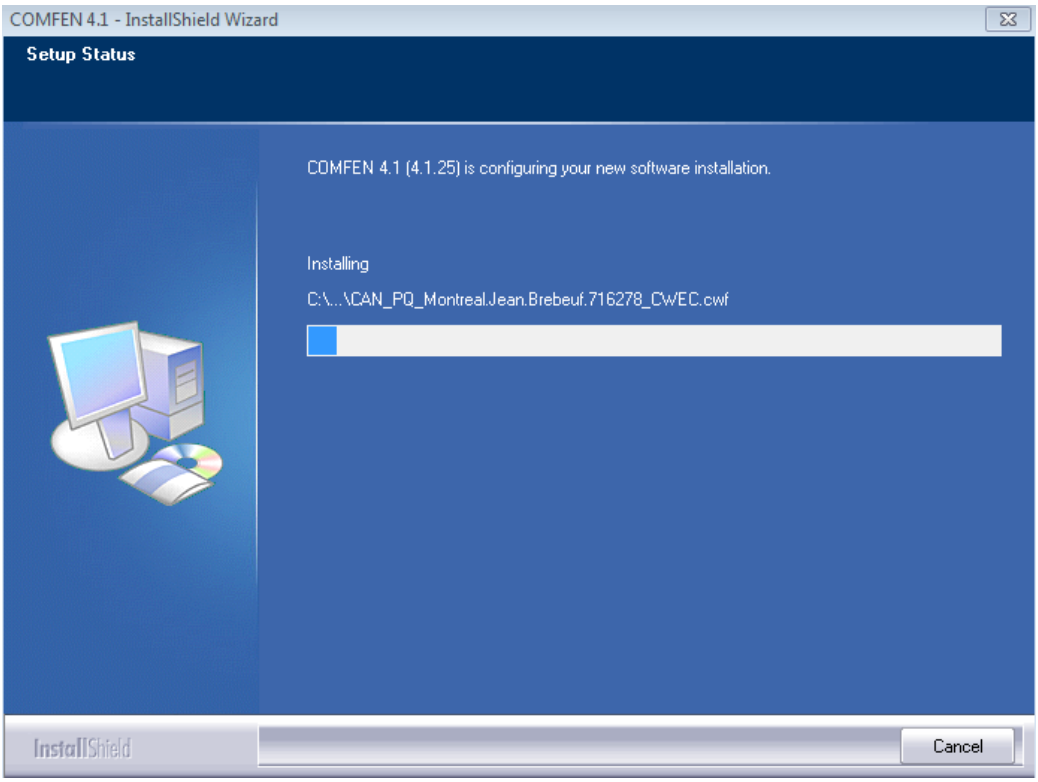


*Figure 3-5. The **Setup Status** screen shows the files being installed.*

6. When the installation is complete, the **InstallShield Wizard Complete** screen will be displayed. Press **Finish** to finalize the installation. Sometimes this screen will appear, but you can't click the **Finish** button. In this case, click on another area of the screen, then click back to this screen and you should be able to click on the **Finish** button.

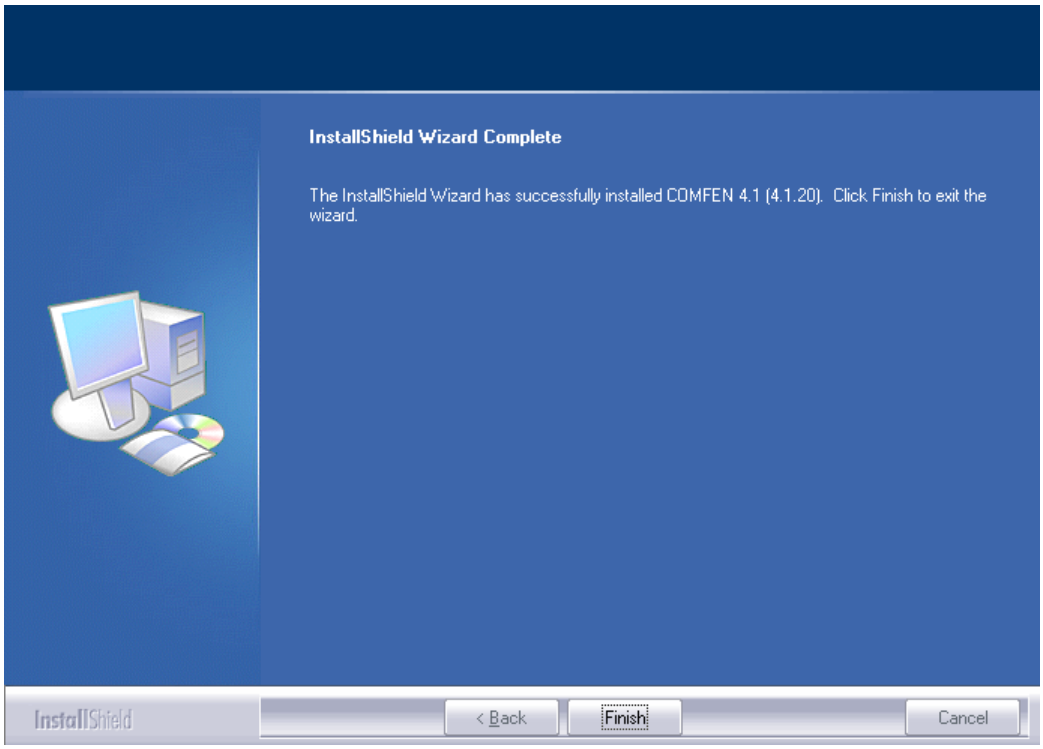


*Figure 3-6. The **InstallShield Wizard Complete** screen will display when the installation is finished. Press the **Finish** button to finalize the installation.*

7. Setup will automatically put a COMFEN Icon in the **Programs** menu under the **LBNL Software** group.

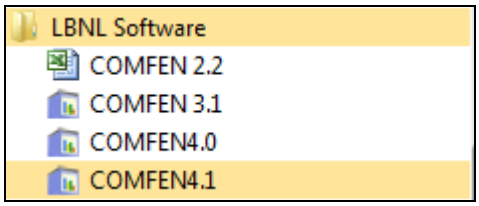


Figure 3-7. Program icon to run COMFEN.

3.3. Running COMFEN

To run COMFEN, go to the **Programs** menu, single click on the **LBNL Software** group, and single click on the **COMFEN** icon. Additionally, there may be a shortcut icon in the main list of programs, depending on the operating system: In either case, click on the shortcut, and the program will start.

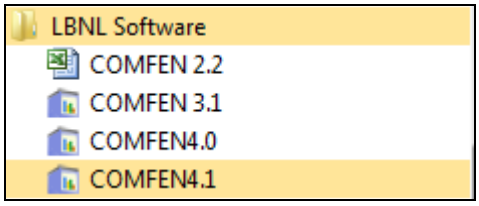


Figure 3-8. Click on the COMFEN 3.1 shortcut icon to start the program.

COMFEN will open to the following view and you can begin using the program by selecting either a recent Project to open or creating a New Project.

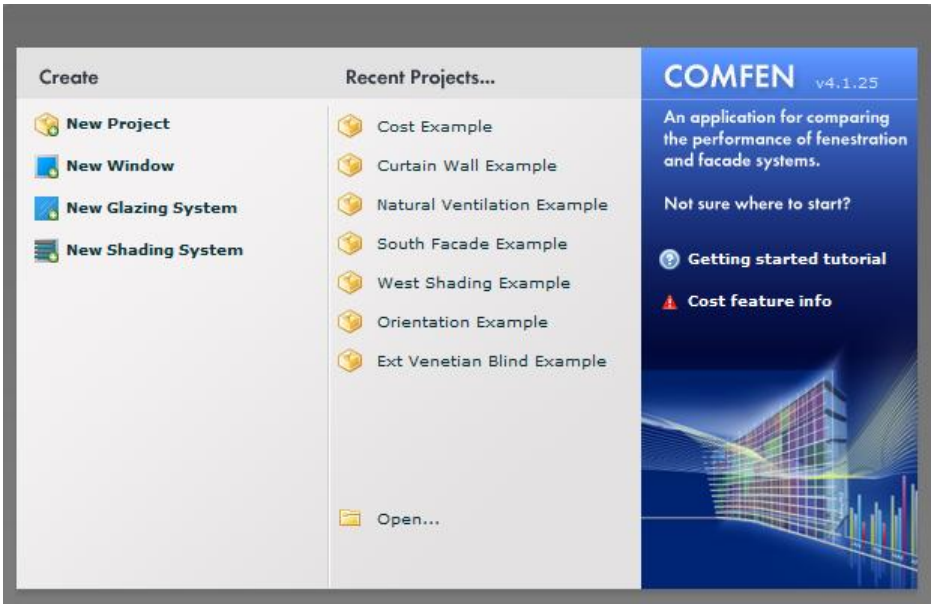


Figure 3-9. The first screen when COMFEN starts

3.4. Uninstalling COMFEN

If you need to uninstall COMFEN, follow the steps below.

1. Go to the Control Panel and go to the Programs or Add/Remove Programs (depending on the operating system) choice. Highlight the previous version of COMFEN and select uninstall or remove (depending on the operating system).

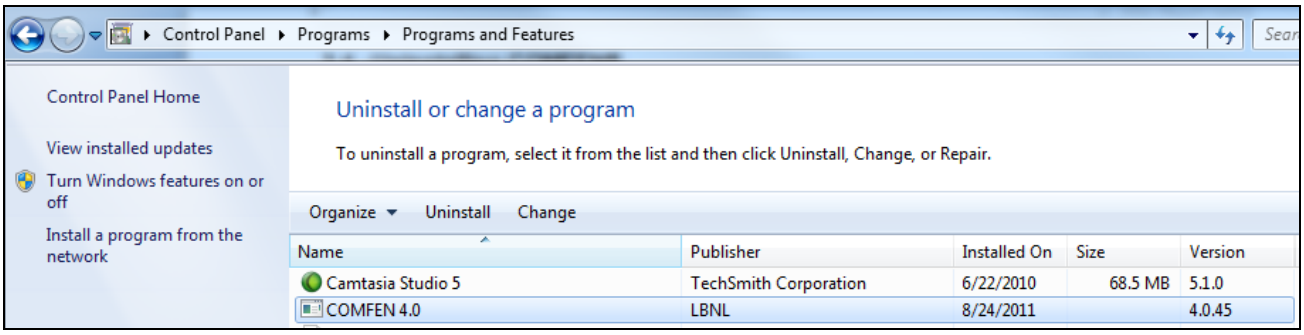


Figure 3-10. Go to Control Panel and click on Programs or Add/Remove Programs.

2. The program will ask if you want to completely remove the application. Click **OK** to uninstall the program, or **Cancel** to cancel the uninstall process.

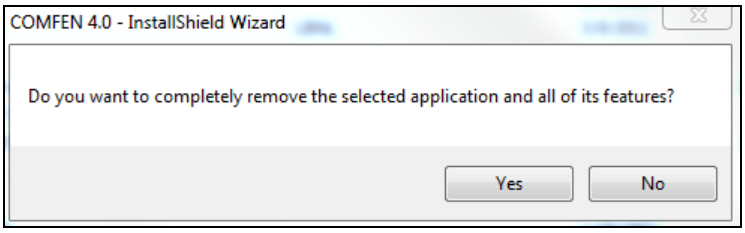


Figure 3-11. Click OK to continue with the uninstall process.

3. While the program is being uninstalled, the **Setup Status** screen will appear.

4. When the uninstall process is complete, the **Maintenance Complete** screen appears. Click **Finish** to complete the uninstall.

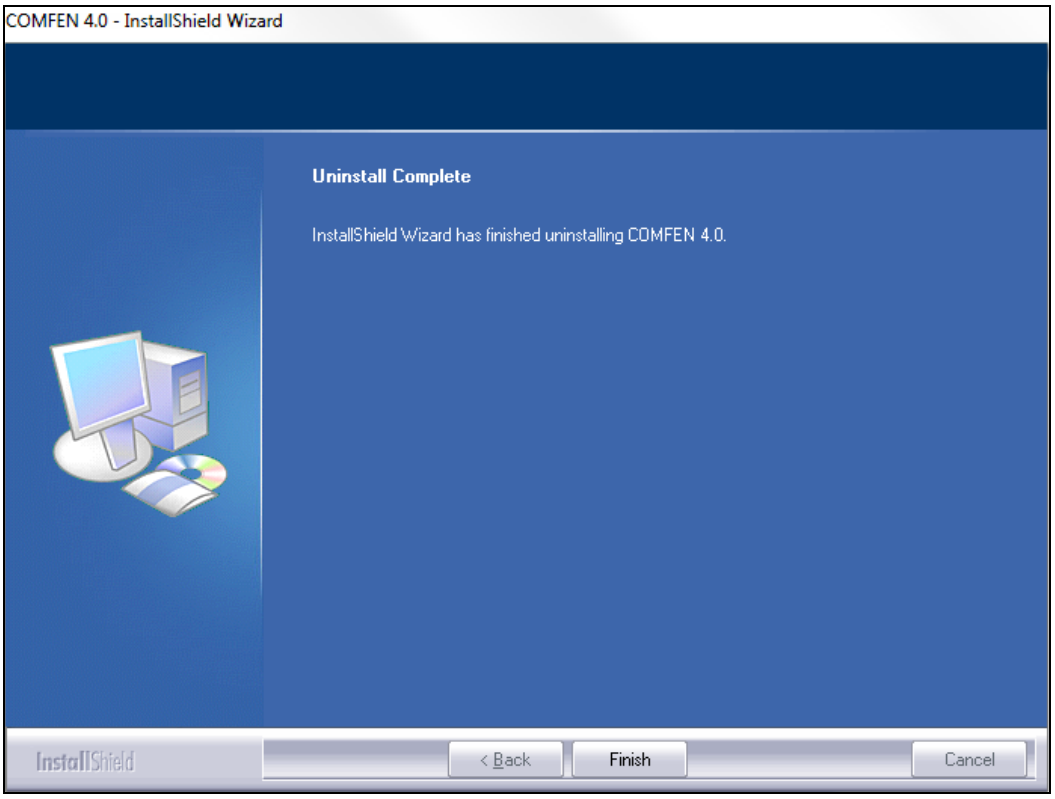


*Figure 3-12. Click **Finish** to complete the uninstall process.*

3.5. Troubleshooting

When you first run the program after installing it, the results may show as zeros after the first calculation. If you have this problem, close the program, run it again, and the problem should go away.

Please send E-mail to COMFENhelp@lbl.gov if you have any trouble running the program.

4. PROGRAM DESCRIPTION

4.1. Program overview

COMFEN, short for commercial fenestration, is a simple single-zone facade analysis tool based on EnergyPlus, a powerful building simulation engine. COMFEN can be used to evaluate a range of facade configurations in order to understand the impact of different design variables on facade performance. After defining a building type, location and zone properties (dimensions and loads from equipment and people and fenestration layout), several additional scenarios can be quickly created and compared side-by-side. Orientation, window-to-wall ratio (WWR), glazing type and/or shading can easily be varied in order to assess their impact on energy use, peak loads, daylighting and thermal and visual comfort.

COMFEN includes a number of libraries with predefined facade components, including glazing, shading, material, wall and spandrel libraries. In addition to fixed exterior fins and overhangs, automated interior or exterior venetian blinds and roller shades can be evaluated using one of a number of predefined shading control options. . The shading system library, developed based on performance data for commercially-available products, incorporates venetian blinds, roller shades, metal mesh screens and glazing-integrated venetian blinds.

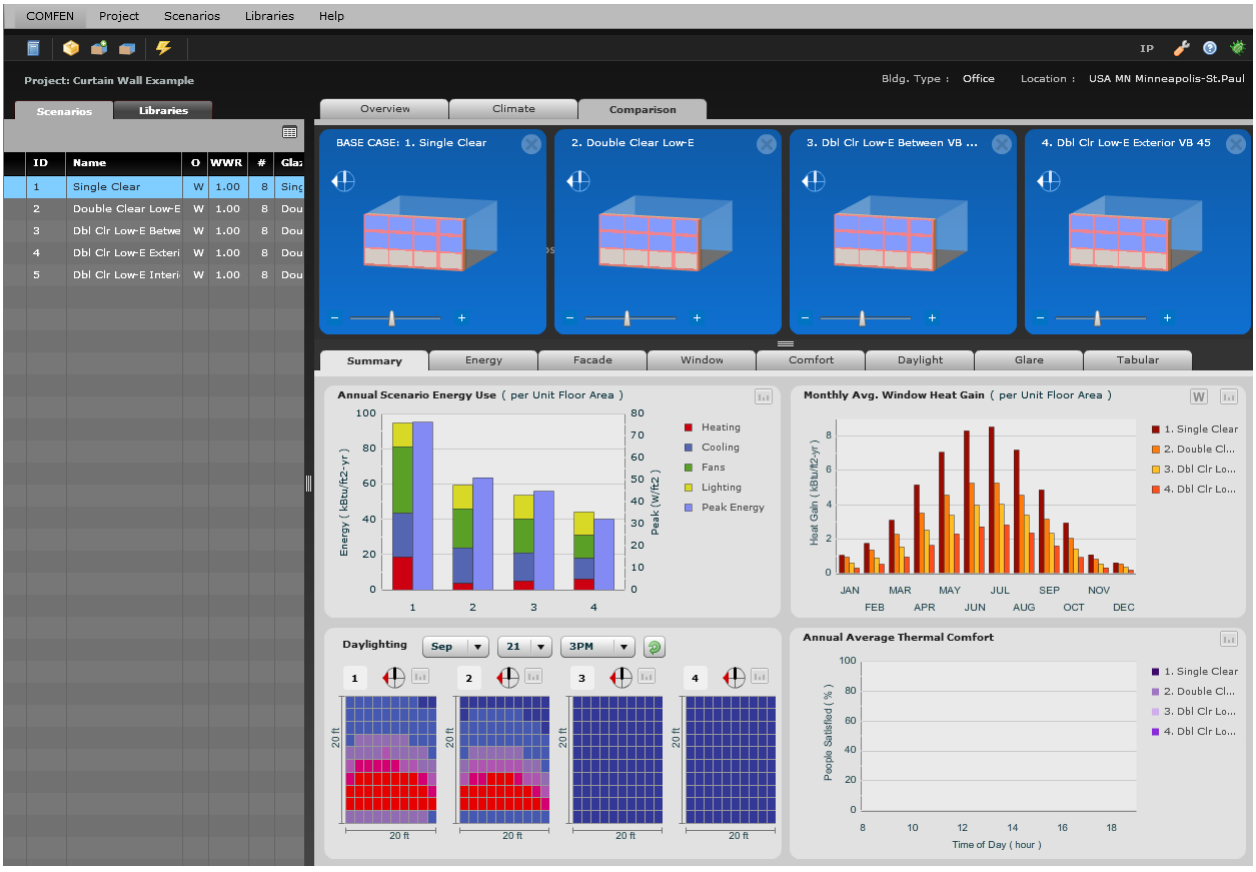


Figure 4-1. The COMFEN Project Comparison Summary screen

The primary steps to completing a COMFEN calculation are:

- **Defining the "scenarios"** (alternative facade configurations for comparison)
- **Calculating the scenarios.** This is done by highlighting one or more of the scenarios in the list on the left of the screen and clicking the lightning bolt icon  . Alternatively, scenarios can be calculated by clicking the right mouse button and choosing **Calculate performance**. The program will calculate the heating, cooling, lighting, and fan energy use for each scenario, peak energy consumption, CO2 emissions, annual daylight levels, and visual and thermal comfort.
- **Comparing scenarios of interest.** Upon the completion of the calculations, the user can compare select scenarios side-by-side by navigating to the **Comparison** tab and then dragging select scenarios from the scenario list on the left of the screen to the blank area under the **Comparison** tab.

  This chapter describes the program in detail.

4.1.1. COMFEN database

COMFEN projects are saved in a single database. The default database that comes with the program is comfen.sqlite and the location of this file can be determined by accessing COMFFEN > Preferences > database tab. The same database is automatically opened each time the user starts up COMFEN unless they change the path of the database in this dialog box.

When COMFEN starts, the program prompts the user to select an existing project, or create a new project, window, glazing, or shading system. Double-clicking on one of the existing projects opens the project screen.

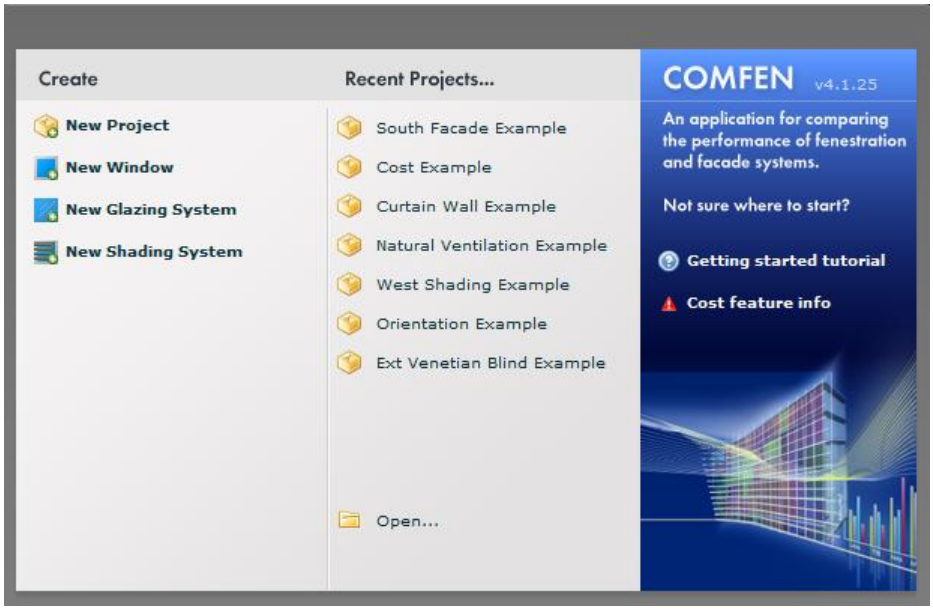


Figure 4-2. Opening Screen

4.1.2. Menu

The COMFEN menu options are:

COMFEN The **COMFEN** menu can be used to view the program version number and modify general program options.

Project The **Project** menu is used to control projects

Scenarios The **Scenarios** menu is used to control Scenarios within projects.

Libraries The **Libraries** menu is used to access all of the libraries

Help The **Help** menu provides links to the COMFEN website, websites discussing various aspects of facade design, and an online glossary

COMFEN

About COMFEN Lists program version number and program contributors

Preferences Opens the Application Settings dialog box, which has five tabs:

- **Basic Settings:** The verbose logging allows for detailed logging of what happens in the program to the program log file (application-log.txt), i.e. in addition to warning and error messages, all debug messages are logged as well. The log file is mainly used for troubleshooting software problems.

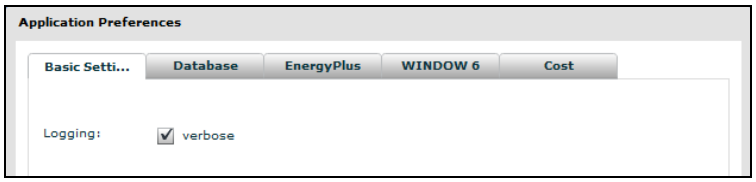


Figure 4-3. Preferences > Basic Settings

- **Database:** This sets the database that COMFEN opens when the program is started. The default database that comes with the program is comfen.sqlite. However, by copying and renaming the default database the user can easily create multiple databases as needed. The user can locate a database by clicking the browse button and navigating to the file. Compact database option allows user to defragment the database and reduce its file size. A backup copy of the database is created before compacting.

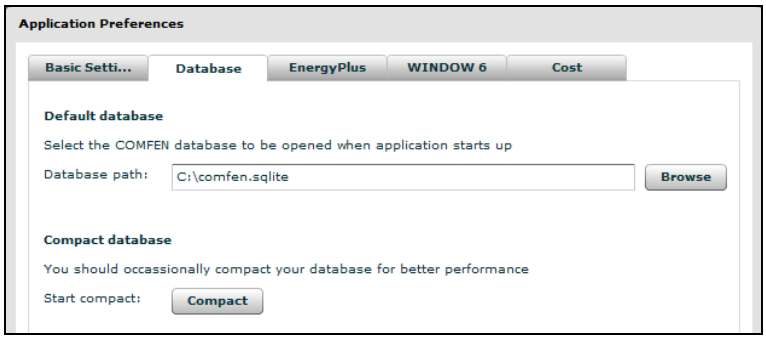


Figure 4-4. Preferences > Database

- **EnergyPlus:** This tab controls some basic settings for the Energy Plus simulation program, the underlying calculation engine for COMFEN:
  - The *Site-to-source multiplier* determines whether energy use results are displayed in terms of site or source energy. Site energy is energy used by the building on site (as measured at the meter), while source energy is a measure that accounts for energy consumed on site as well as the energy consumed during the storage, transport and delivery of the fuel to the building. Source energy is a better indicator of building environmental performance impact. By default, the multiplier is set to 1; electricity use results are displayed in terms of site energy.
  - If the *Calculate illuminance* box is checked, COMFEN calculates hourly horizontal illuminances throughout the space for a specific date and time. The results are displayed under the Comparison > Overview results tab in the form of color illuminance maps.
  - When "Show EnergyPlus error log" or "Show in.imf file" are selected, these two files open automatically if EnergyPlus crashes.

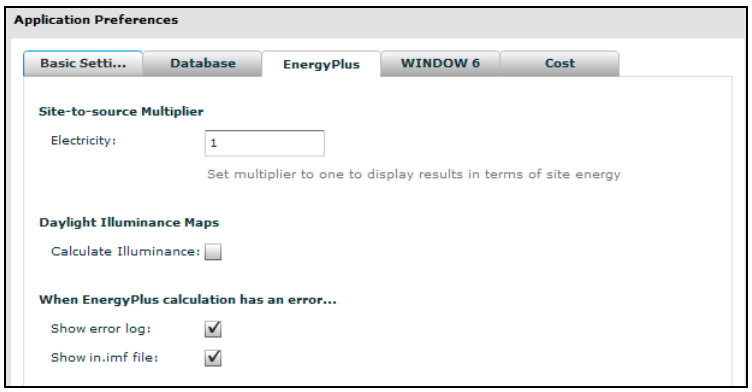


Figure 4-5. Preferences > EnergyPlus

- **WINDOW 6:** This tab specifies the WINDOW 6 database from which additional glazing systems will be imported into COMFEN.

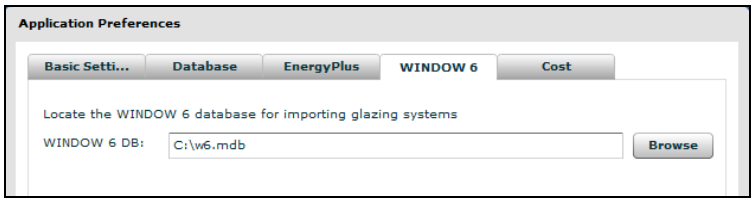


Figure 4-6. Preferences > WINDOW6

- **Cost:** The cost tab provides user with the option to override the baseline glass cost. For a definition of baseline glass cost, see the cost section.

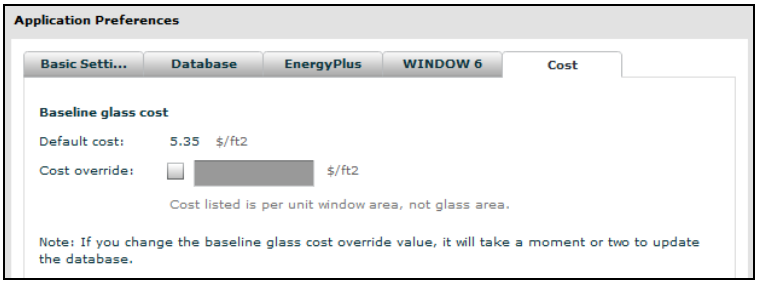


Figure 4-7. Preferences > Cost

Hide COMFEN Minimizes the COMFEN window

Quit Closes COMFEN

Project

New project Opens the **Create COMFEN project** dialog box where new project properties can be entered (project name, description, building type, project North, location, etc.). See the next section for more detailed information on creating projects.

Open project Opens the **Open COMFEN Project** dialog box, which shows all of the projects currently defined in the currently open database. Projects can be opened by double-clicking or highlighting a project and then selecting **Open**.

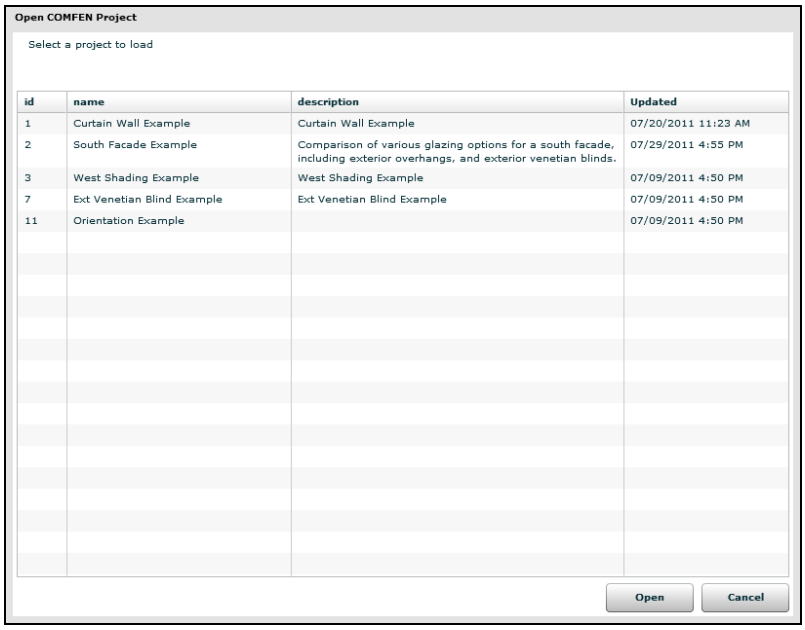


Figure 4-8. Project > Open Project

Close project Closes the currently open project, and returns to the startup menu screen.

Project Properties Opens the **Project Properties** dialog box, which shows the details of the currently open project. The project properties can be changed here as needed and are discussed in more detail in the next section.

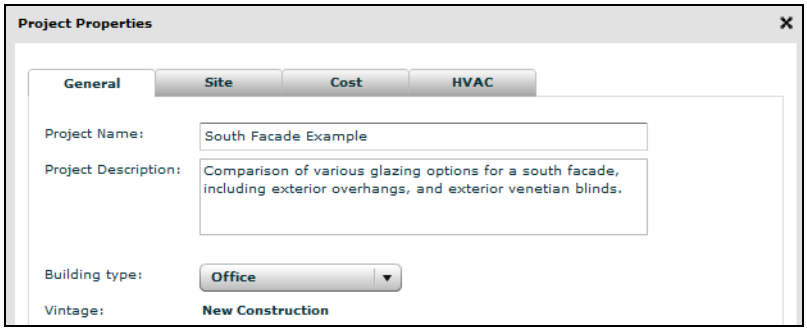


Figure 4-9. Project > Project Properties

Delete projects Opens the **Delete COMFEN project** dialog box, which shows the list of projects in the currently open database. Highlight a project, and click the **Delete Selected** to delete the entire project from the database.

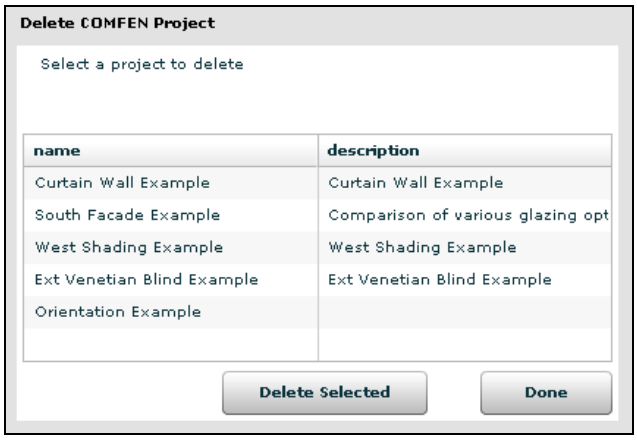


Figure 4-10. Project / Delete Projects

Import project definition from CSV file — Allows the user to import project and scenario information using previously created tabulated inputs in csv format. This option is especially useful for projects with multiple scenarios. All projects must be closed in order to import a csv file (the option is grayed out if a project is open).

Export project results to CSV — Option that allows the export of COMFEN project results (annual and peak energy by end use, average illuminance levels, visual and thermal comfort, etc.) and basic scenario properties (orientation, WWR, glazing, shading system, lighting control setting, etc.) to a CSV file.

Scenarios

Create Scenario — Opens the **Create New Scenario** dialog box.

Copy Scenario — Creates a copy of highlighted scenario.

Import Scenario from Project — Allows the user to import a select scenario from another project.

Delete Scenario — Deletes highlighted scenario.

Rename Scenario — Renames highlighted scenario.

Add Window to Scenario — Adds a window to scenario. Unless scenario is active, this option is grayed out.

Add Exterior Shade to Scenario — Adds fixed exterior projection (overhangs, fins, etc.) to scenario. Unless scenario is active, this option is grayed out.

Export compared scenarios images to PNG — Exports thumbnail images of select scenarios in *.png format.

Calculate All — Calculates performance of all scenarios in project

Calculate Selected — Calculates performance of highlighted scenarios. To select multiple scenarios in explorer hold shift or ctrl key down while making selections with the left mouse button.

Libraries

The library menu allows the user to access all system and component libraries:

- Windows
- Glazing systems
- Shading systems
- Frames
- Glass
- Gas
- Walls
- Spandrels
- Materials
- Locations

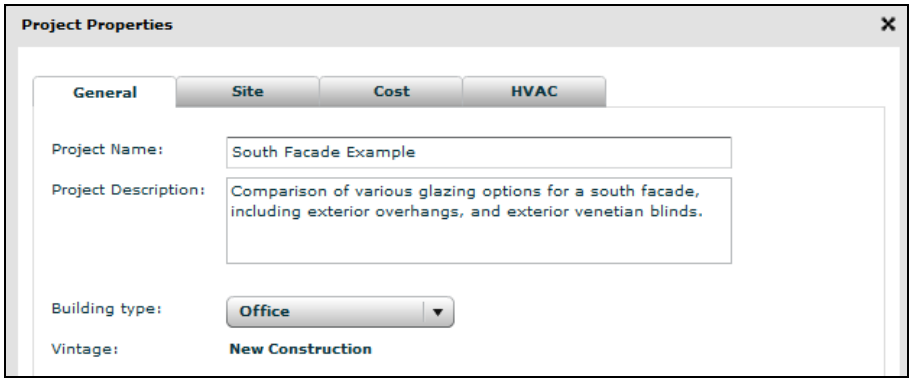
Import glazing system From WINDOW 6 Allows the user to import a glazing system from a WINDOW 6 database.

Import IGDB data… Allows the user to update the glass library using a COMFEN *.sqlite database file that can be downloaded from the COMFEN website. See section on glass library for more information on the IGDB database.

4.1.3. Project

To create a new project, select New Project from the Project menu. The Create COMFEN Project dialog box contains the same inputs as the Project Properties dialog box and includes the following tabs:

General Lists project name, project description, building type and vintage.



- **Project Name**: Field used to provide a unique name for the project.
- **Project description**: Field for user comments about project.
- **Building type:** Building type determines several default values, including occupancy schedules, heating and cooling setpoints, and default outdoor air flow rate. The following building/space type options are available:
  - Office (office space)
  - Mid-rise residential (apartment)
  - Hotel (guest room)
  - Retail (point of sale)
  - School (classroom)

  A more detailed description of the different building types and schedule assumptions is provided in the *Calculation assumptions* section.

Site Lists project North, location, default wall and Wall R-value.

Project North: Defines the overall project orientation, measured clockwise from true North. A project with a Project North of 0° faces true North. The value specified for Project North is added to the scenario orientation definition (North, South, East or West) to calculate the "resolved" orientation. For example, a scenario facing South with a

Project North of 45° will in effect face southwest (45° degrees west of South) and its "resolved" orientation will be 45° + 180° = 225.° Default: 0 (project faces true north); Legal values: 0-359; Units: degrees.

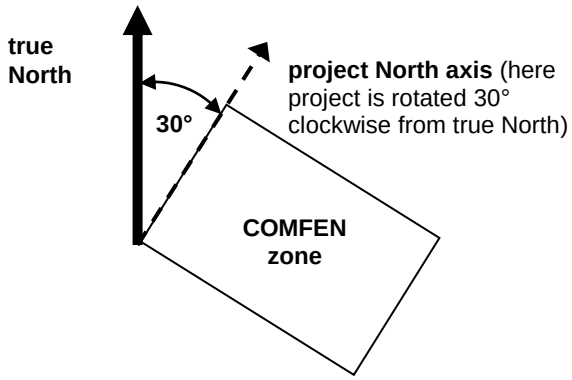
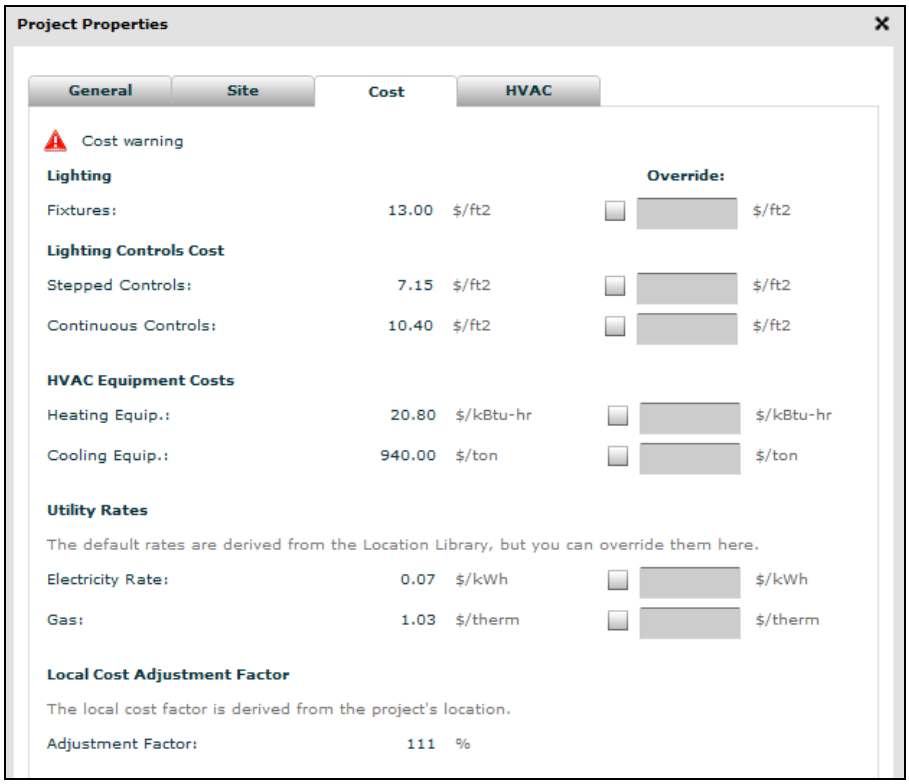


Figure 4-11. Illustration of project North axis

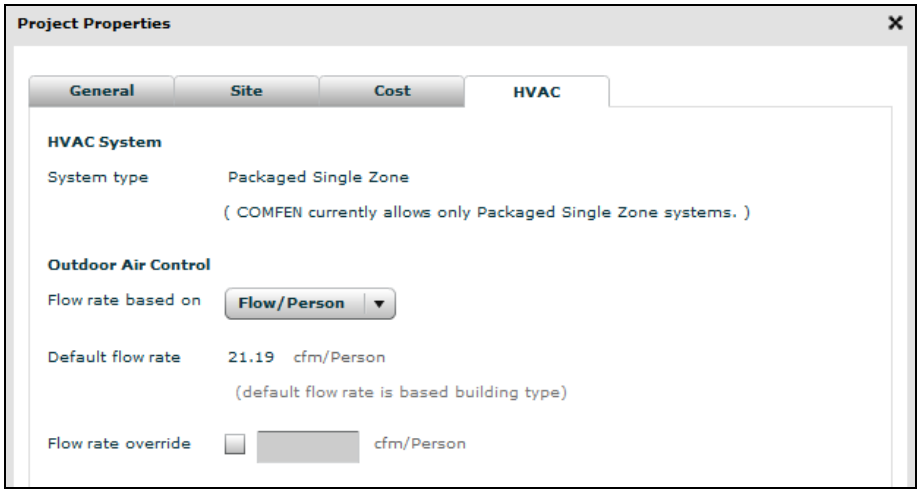
- **Location**: Field used to provide a unique name for the project. This drop-down will determine the weather data that will be used for the simulation.
- **Default Wall**: This is the default exterior wall construction assigned to the project based on the project's location. When the user specifies the project location, an ASHRAE-90.1-compliant wall is automatically assigned as the default wall for the project. See components and libraries section for information on creating and assigning custom walls.
- **Wall R-value**: This is the R-value corresponding for the default exterior wall.

Cost

The cost tab provides user with the option to override several default first cost values (e.g. lighting fixtures and controls, HVAC, etc.), utility rates for electricity and gas, and location adjustment factor. See cost section for a more detailed explanation of cost data.



HVAC Lists general information on HVAC system and outdoor flow rate.



- **HVAC system:** The default HVAC system is presently a packaged single zone system for all building types.
- **Outdoor air control:** This section lists the default outdoor air flow rate used for ventilation. The user can override the air flow control type (flow/person or flow/area) and flow rate.

4.1.4. Scenario

To create a new scenario, select Create Scenario from the Scenarios menu. This opens the Create New Scenario dialog box, shown in the image below, where new scenario information can be entered, including space dimensions, orientation and load information. The scenario orientation can be specified at one of the four cardinal directions (North, South, East, West). If the facade is not facing these cardinal orientations, this can be accounted for by entering a value in the Project North box in the Project Properties dialog box.

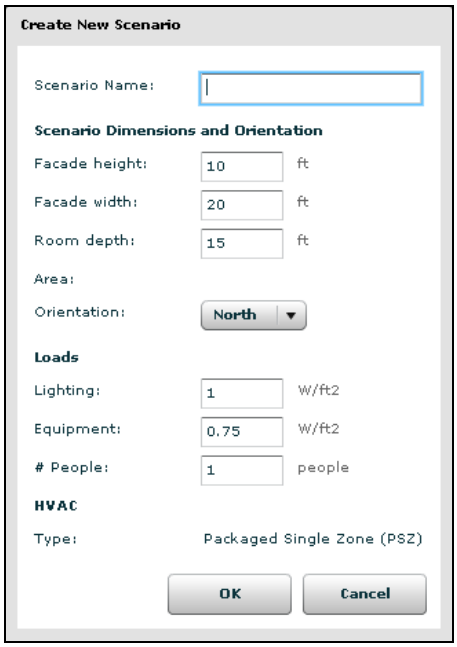


Figure 4-12. Create New Scenario

After creating the enclosure for the scenario and inputting load information through the Create New Scenario dialog box, scenario inputs can be further edited in the scenario edit screen shown on the next page. The edit screen can be accessed by 1) double-clicking on the scenario under the scenario tab on the left side of the screen or 2) double-clicking on the image of the scenario in the Comparison tab.

The scenario edit screen consists of the following tabs:

- **Scenario tab**: tab where general scenario parameters, including geometry, orientation, loads and lighting controls are defined. The lighting control pulldown contains three choices for lighting and daylighting controls: none, continuous and stepped. See the calculation assumptions section for a more detailed description of lighting control options.

  Windows: Tab where window configuration is defined. Windows are added by clicking on the green "+" icon in the upper-right hand corner of the tab, which brings up the New Dialog box. The new window inputs include window dimensions and position, glazing system, shading system (all systems except for fixed exterior projections) and frame type. Double-clicking on any entry in the table list view will bring up the edit window dialog box. Windows are deleted by highlighting the window and clicking the red "-" icon .

***NOTE**: The glare control checkbox will turn on the glare control option, meaning that a shading system will be activated (deployed) when the glare index setpoint is reached. The glare index setpoint is 22 and this value cannot be changed by the user. Additional shading control options can be specified under the shading system properties.*

- **Wall Shades**: Tab where fixed exterior projections such as horizontal overhangs and vertical fins are defined. Similar to window definition, wall shades are added by clicking on the green "+" icon  in the upper-right hand corner of the tab, which brings up the new wall shade definitions screen. Wall shades are deleted by highlighting the shade and clicking the red "-" icon  .

Scenario tab: tab where general scenario parameters, including geometry, orientation, loads and lighting controls are defined. The lighting control pulldown contains three choices for lighting and daylighting controls: none, continuous and stepped.

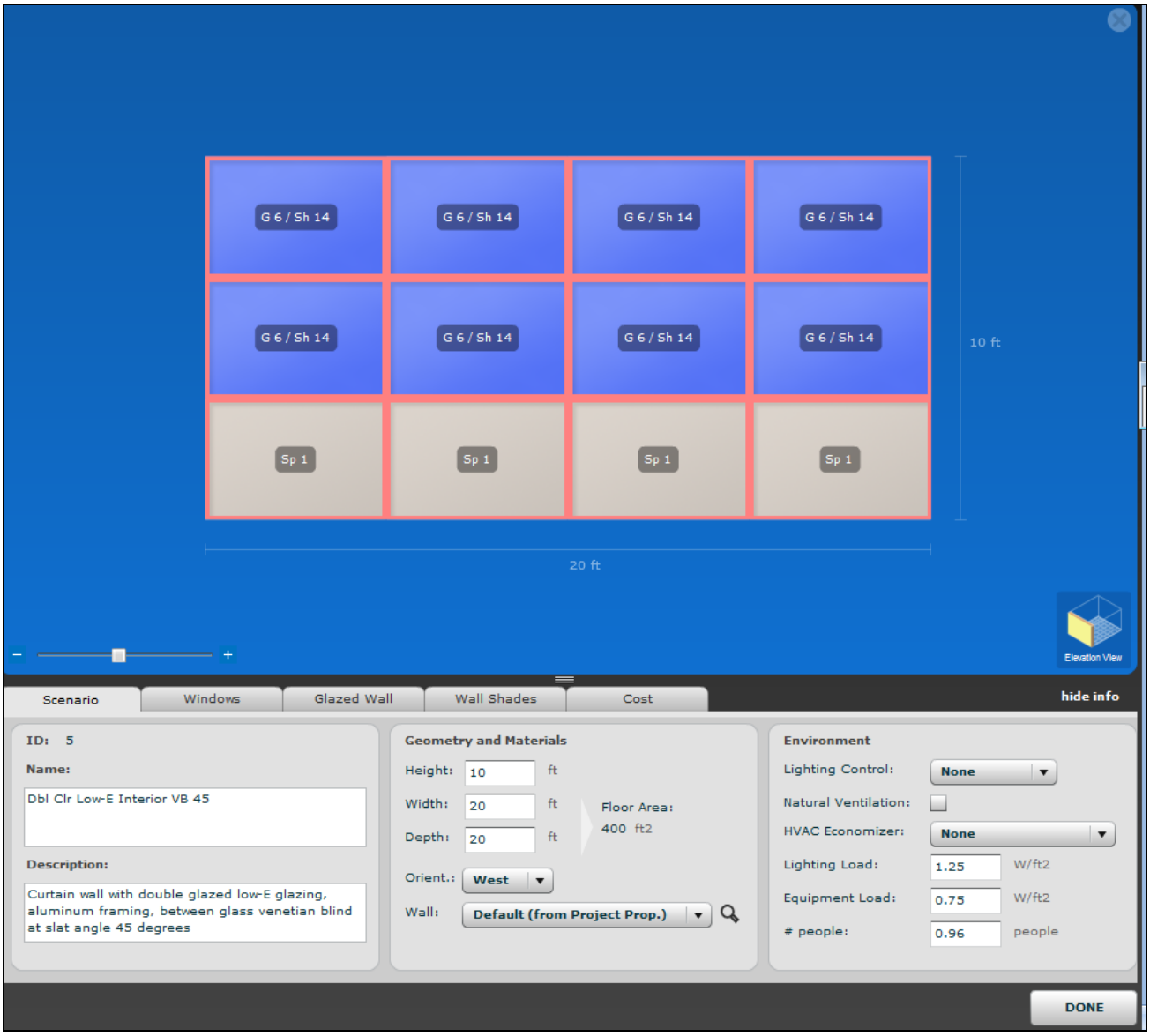


Figure 4-13. Scenario tab

4.2. Facade components and libraries

This section discusses construction components and COMFEN libraries in detail. The libraries contain a range of predefined facade components such as windows, glazing systems, shading systems and frames as well as locations. They also include a comprehensive list of glazing products from a range of commercial glazing manufacturers. New entries can be created in all libraries except for the glass and gas libraries.

The COMFEN facade components and libraries discussed in this section include the following

Glass Layers

Gas Layers

Glazing Systems

Frames

Windows

Shading Systems

Glazed Wall Assembly

Materials

Walls

Spandrels

Locations

4.2.1. Glass layers

The glass library contains entries from the International Glazing Database (IGDB) – a database containing measured performance data for commercially-available glass products. This performance data is submitted by manufacturers to LBNL, where it undergoes a technical and peer review prior to its incorporation in the IGDB. While the latest version of the IGDB database is automatically installed with COMFEN, it is updated bimonthly by LBNL in an effort to ensure that it contains all of the latest commercially-available products. COMFEN users are encouraged to periodically update their libraries by downloading a COMFEN *.sqlite IGDB update file from the COMFEN online Knowledge Base.

Below is a description of select fields in the glass library:

NFRC ID The ID field in the glazing system edit view refers to the glass or gas layers, and displays the NFRC identification number from the IGDB used in WINDOW 6 software. This field cannot be edited by the user.

Name The IGDB filename for the glass layer or the name of the gas layer. These names come from the respective glass and gas selection lists, and cannot be edited by the user.

Thickness The thickness of the glass or gas layer. The glass layer thickness values cannot be edited, but the gap (gas) layer thicknesses can be edited by the user. **Units:** mm

Source Lists the IGDB version.

Emis1 Emissivity of the front surface of the glass layer. This value is 0.84 for uncoated glass. The emissivity values for front and back can be used to determine if a layer should be "flipped" so that the coating is on the correct surface. This field cannot be edited by the user.

Emis2 Emissivity of the back surface of the glass layer. See comment for front emissivity above.

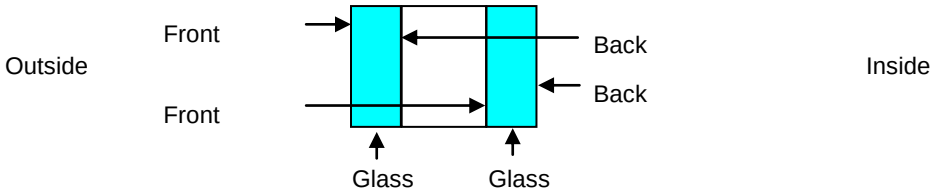


Figure 4-14. Definition of front and back glass layer surfaces

4.2.2. Gas layers

The entries in the COMFEN gas library come from a database that is installed with COMFEN, which contains the standard gases defined in the LBNL WINDOW software programs. The figure below shows the current gases available for glazing systems in COMFEN. The gas layers are used in the creation of COMFEN glazing systems.

Windows | Glazing Sys. | Shading Sys. | Frames | Glass | Gas

id	Name	Cost ($/ft2)
1	Air	0.00
2	Argon	1.00
3	Krypton	5.50
4	Xenon	21.83
6	Air (5%) / Argon (95%) Mix	0.95
7	Air (12%) / Argon (22%) / Krypton (66%) Mix	3.77
8	Air (5%) / Krypton (95%) Mix	5.22
9	Air (10%) / Argon (90%) Mix	0.90

Figure 4-15. COMFEN gas library

4.2.3. Glazing systems

Glazing system library

There are approximately 50 predefined glazing systems in the Glazing System Library, which includes both several generic glazing systems as well as a limited selection of commercially available insulated glazing products (ID# 100 and beyond). A glazing system can consist of a single glass layer (e.g. similar to the first entry in the image below), or of two or more glass layers separated by a gas layer. Any glazing systems defined in the glazing system library can be assigned to a window, whether it is a window in the window library or a window in the scenario edit screen. New glazing systems can be added to this library as needed, by either creating the assembly directly in COMFEN or importing a glazing system from the WINDOW glazing system library.

Windows | Glazing Sys. | Shading Sys. | Frames | Glass | Gas | Walls | Spandrels

ID	Name	TVis	SHGC	U-factor (Btu/h-ft2-F)	Thickness (in)	Cost ($/ft2)
1	Single Clear 6 mm	0.884	0.818	1.025	0.22	10.70
2	Double Clear (Air)	0.786	0.704	0.473	0.95	26.89
3	Double Bronze (Air)	0.477	0.502	0.474	0.94	27.71
4	Double Low-E Bronze (Air)	0.443	0.453	0.331	0.94	28.81
5	Double Low Solar Low-E Tint (Air)	0.521	0.299	0.291	0.96	30.73
6	Double Low Solar Low-E Clear (Air)	0.701	0.382	0.291	0.95	28.81
7	Quad Low Solar Low-E Clear (Air)	0.451	0.292	0.108	2.10	59.53
8	Double Glazed Triple Silver Low-E (Argon)	0.638	0.272	0.238	0.95	29.26
9	Double Hi VT (LowIron) Low-E (Argon)	0.724	0.383	0.247	0.95	29.26
10	Double High Performance Tint (Air)	0.607	0.394	0.474	0.95	28.81
11	Double High Performance Tint (Argon)	0.607	0.390	0.449	0.95	29.26
12	Double Low VT Low-E (Argon)	0.371	0.241	0.253	0.95	29.26
13	Double Low-E Clear (Argon)	0.696	0.469	0.245	0.85	29.26
14	Double Glazed Triple Silver Low-E Tint (Argon)	0.543	0.246	0.238	0.95	29.26
15	Double Low-E Opaque (Air)	0.027	0.077	0.291	0.95	28.81
100	Viracon -- VE-2M (2) clear/clear (air)	0.703	0.379	0.293	0.95	28.81
101	Viracon -- VE-2M (2) clear/clear (argon)	0.703	0.375	0.247	0.95	29.26

Figure 4-16. Glazing system library list view

The ID of the glazing system is automatically generated in sequence by COMFEN. When glazing systems are imported into COMFEN, the ID from WINDOW will not be kept, but a new ID will be assigned based on the records existing in the COMFEN glazing system library.

The user can specify a unique glazing system name under the name field. Existing entries based on commercially available products follow the a specific naming format:

- Uncoated double glazing:

  <Manufacturer> -- <substrate #1> <substrate #2> <gap fill>

- Double insulated glazing with a low-e or solar control coating:

  <Manufacturer> -- <coating name> <coating surface no.> <substrate #1> <substrate #2> <gap fill>

- Triple insulated glazing with a low-e or solar control coating:

  <Manufacturer> -- <coating name> <coating surface no.> <substrate #1> <substrate #2> <substrate #3> <gap fill>

Creating a new glazing system

To create a new glazing system, select the new button in the lower right-hand corner of the glazing system library. Under the Create New Glazing System screen (see image below), drag glass and gas layers from the right-hand list view to create desired assembly.

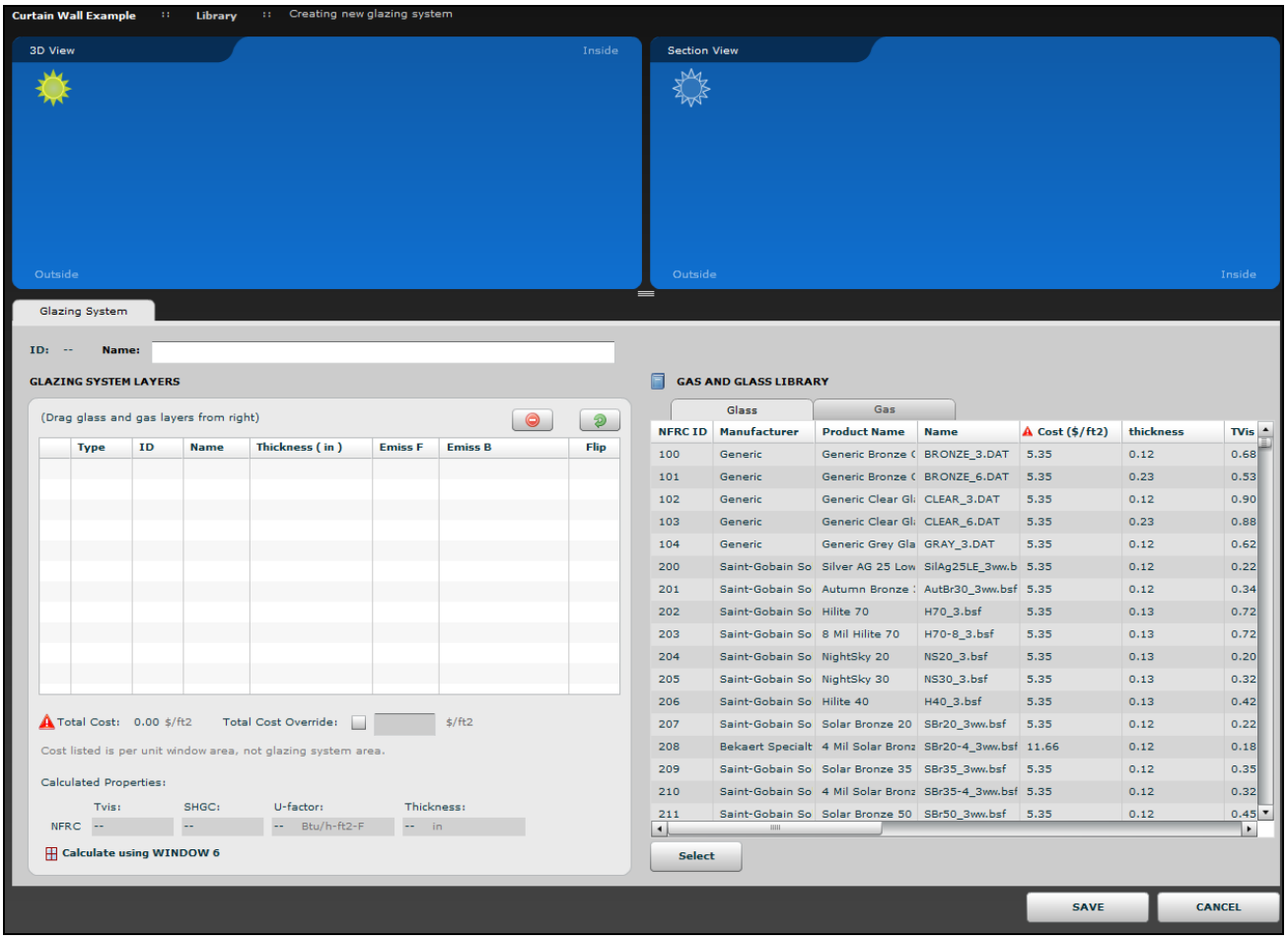


Figure 4-17. Create new glazing system screen

Layer no. field

The layer no. field (far left column in the image below) identifies the layer sequence number in the glazing system. The first layer is the layer on the outside (exterior) of the glazing system, the last layer is the layer on the inside (interior) of the glazing system. Gas spaces are also counted as layers. The outside and inside layers have to be a glass layers, and each glass layer has to be separated by a gas fill.

	Type	ID	Name	Thickness (in)	Emiss F	Emiss B	Flip
1	Glass	923	TiPS_6.AFG	0.22	0.84	0.06	✓
2	Gas	9	Air (10%) / Argon (90%) Mix	0.50			
3	Glass	890	CLR_6.AFG	0.22	0.84	0.84	
4	Gas	9	Air (10%) / Argon (90%) Mix	0.50			
5	Glass	910	CMFTE2_6.AFG	0.22	0.20	0.84	

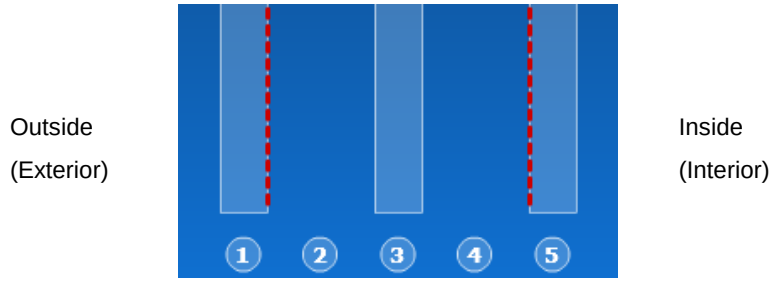


Figure 4-18. Glass and gas layers are numbered from outside to inside

The **Calculate using WINDOW 6** button calculates the thermal and optical properties for the glazing system (Tvis, SHGC, U-factor and thickness) using WINDOW 6 calculation algorithms. If the glazing system is imported from WINDOW 6, these values will usually already be calculated and will appear in this section.

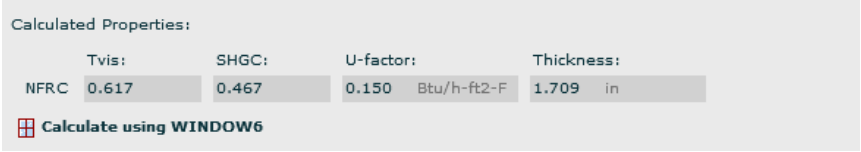


Figure 4-19. The Results section of the Glazing System Library

Tvis	Visible transmission of the complete glazing system
SHGC	Solar Heat Gain Coefficient for the whole glazing system
U-factor	U-factor for the complete glazing system, in Btu/h-ft-F (IP units) or W-m2-K (SI units)
Thickness	Thickness of the complete glazing system in in. (IP units) or mm (SI units)

Importing a glazing system from WINDOW 6

To import a glazing system from WINDOW 6, navigate to the main glazing system library tab (Libraries > glazing systems) and click on the Import from WINDOW6 button at the bottom of the screen.

Figure 4-20. Import from WINDOW6 Glazing System Option

Or go to Libraries > Import glazing system from WINDOW 6.

This will bring up a list of glazing systems in the WINDOW 6 database. Navigate to the desired system and click Import.

NOTE: COMFEN cannot import WINDOW 6 glazing systems that have shading systems associated with them.

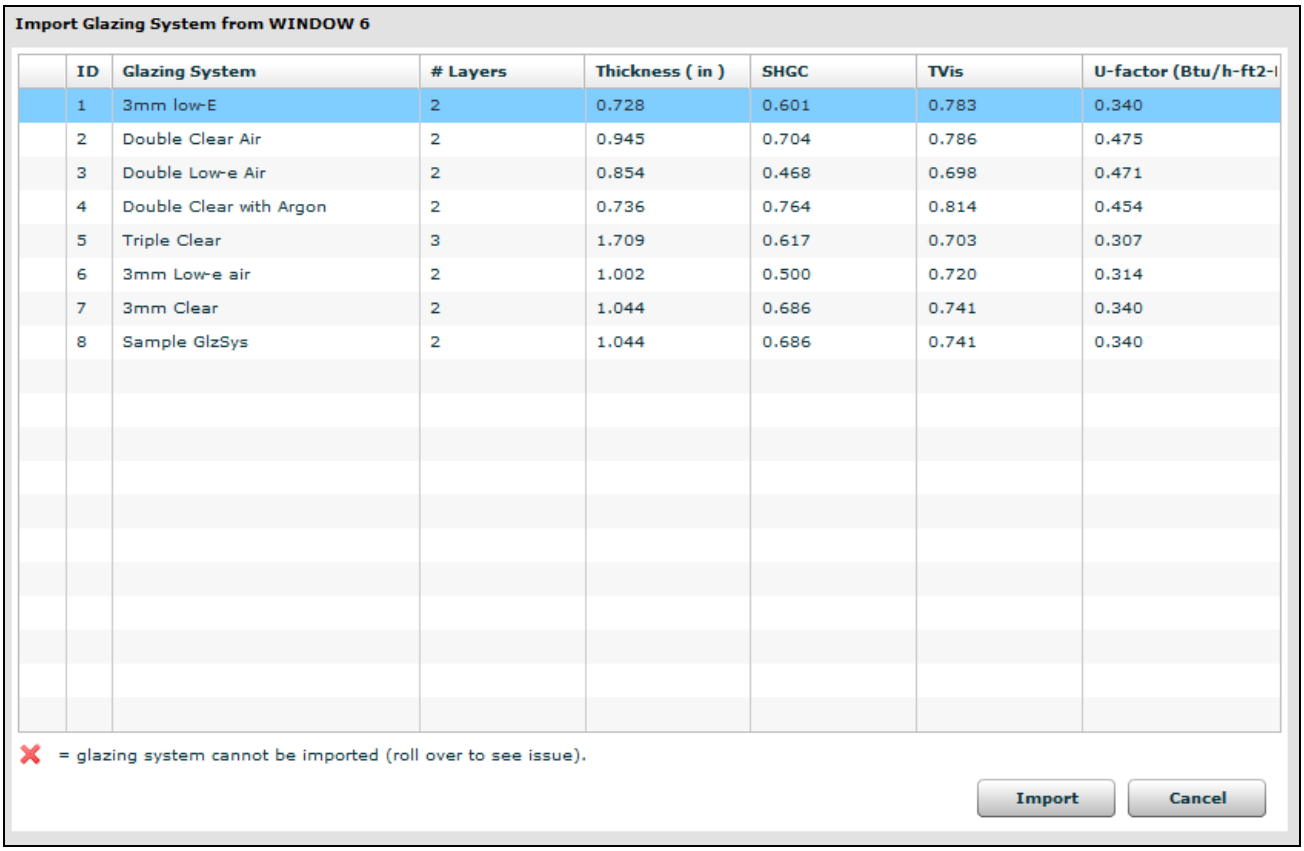


Figure 4-21. WINDOW 6 glazing system import screen

NOTE: *The WINDOW 6 library from which glazing systems will be imported is specified through Preferences under the COMFEN menu. If you want to change the database, click on the Browse button and navigate to the desired WINDOW 6 database.*

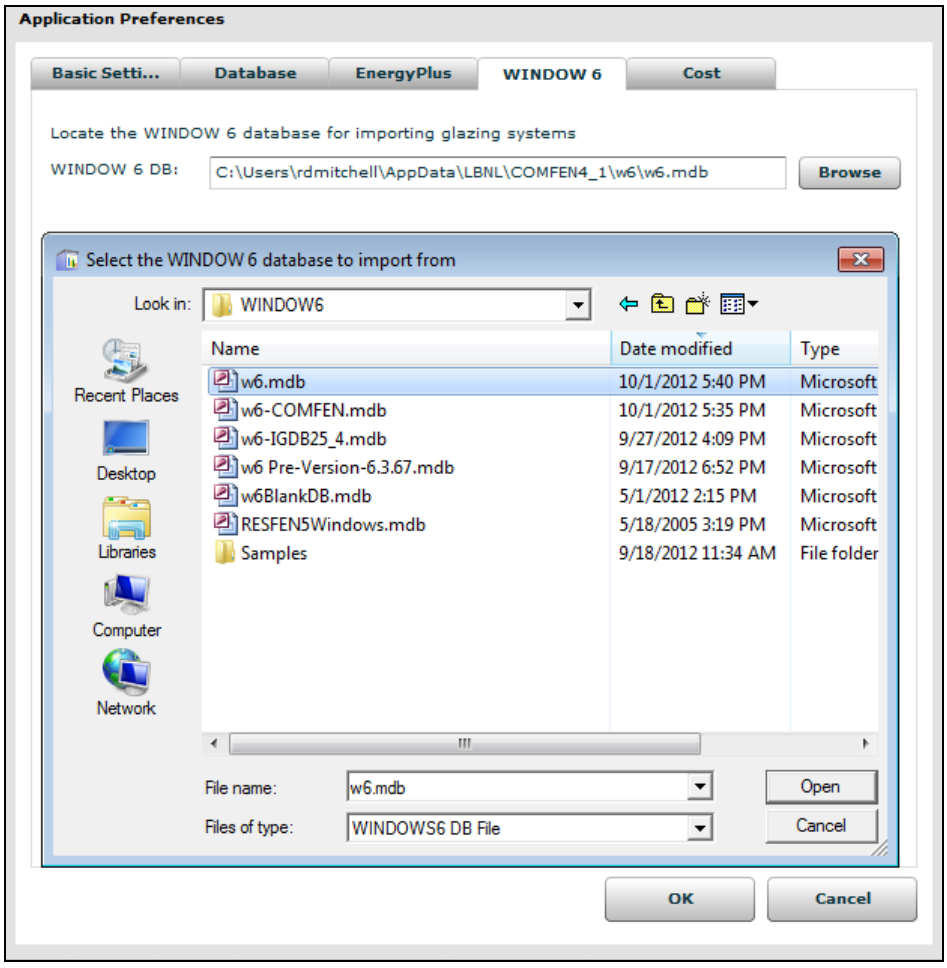


Figure 4-22. Select a WINDOW 6 database from which to import glazing systems

4.2.4. Frames

The frame library consists of a predefined set of frames. The thermal properties of these frames are characteristic of commercially-available systems. Due to limitations in the Energy Plus simulation engine, highly conductive frames such as aluminum frames without a thermal break cannot be modeled. The U-factor cannot exceed 1.1 Btu/h-ft2-F (6.2 W/m2-K). In order to account for the effect of framing with a U-factor exceeding this limit, the user could increase the area of the modeled framing.

Windows | Glazing Sys. | Shading Sys. | Frames | Glass | Gas | Walls | Spandrels | Materials | Locations

ID	Name	Frame U-factor (Btu/h-ft2-F)	Width (PFD) (in.)	Description	Type	Cost ($/ft2)	Color	Absorptivity	Source
1	Al w/break	1.00	2.25	Aluminum Frame with	Metal with thermal break	42.49		0.9	GENERIC
3	Wood	0.40	2.75	Wood Frame	Reinforced vinyl/wood	46.61		0.9	GENERIC
4	Vinyl	0.30	2.75	Vinyl Frame	Reinforced vinyl/wood	46.61		0.9	GENERIC

Figure 4-23. Frame library list view

The frame edit dialog box consists of the following inputs:

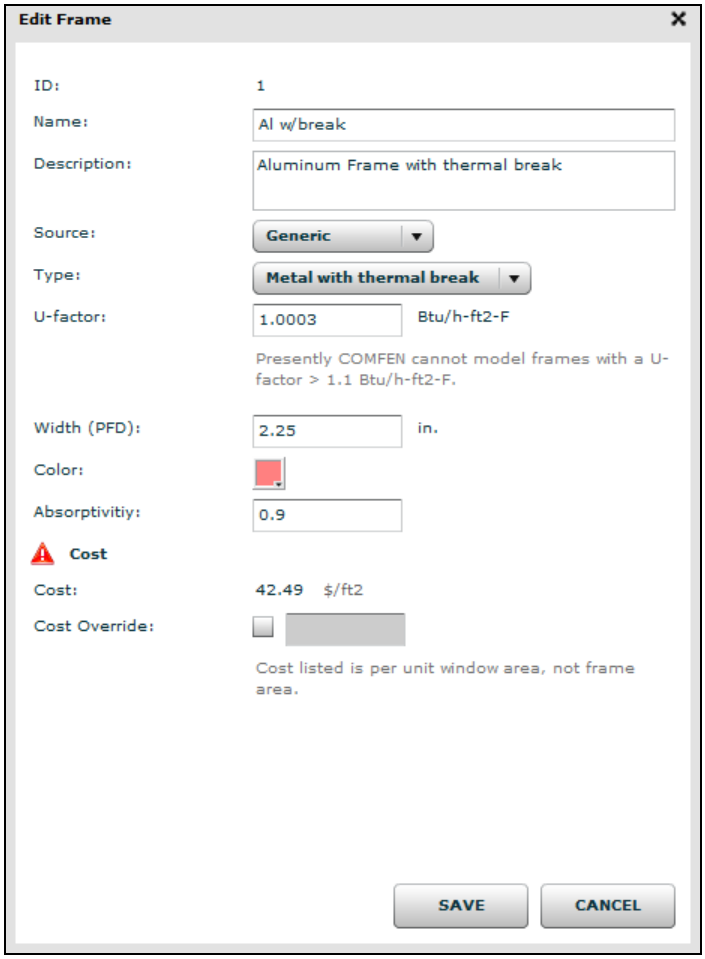


Figure 4-24 Edit frame dialog box

4.2.5. Windows

The window library stores predefined windows which can later be easily added to a scenario. A COMFEN window consists of a glazing system, frame and shading system. A window from the library is added to a scenario by dragging the window from the Libraries tab in the scenario explorer on the left side of the screen (see image below).

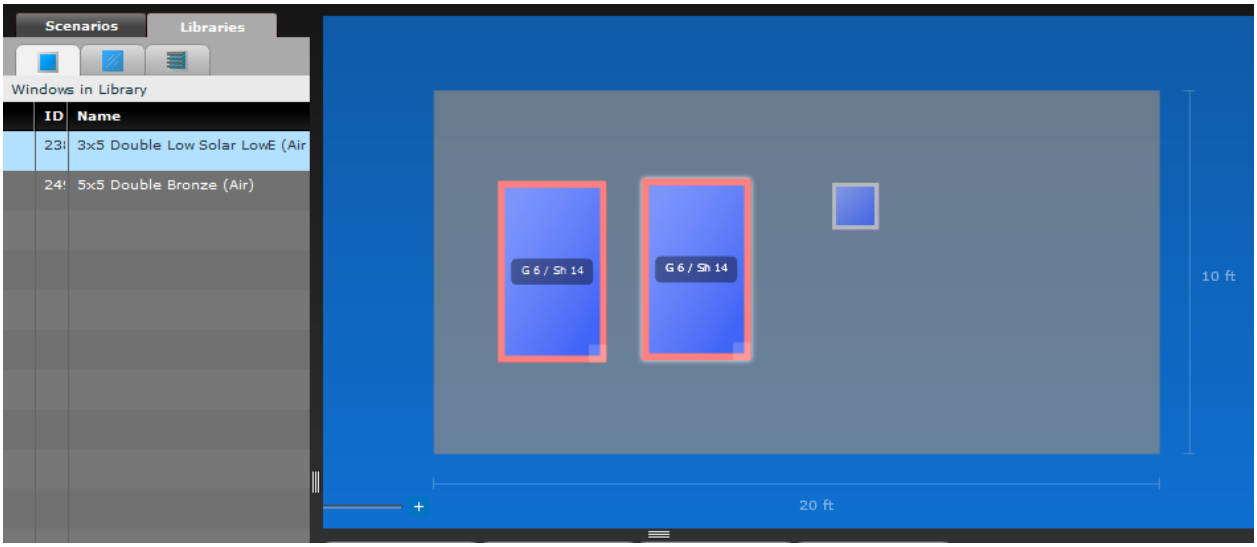


Figure 4-25 Edit frame dialog box

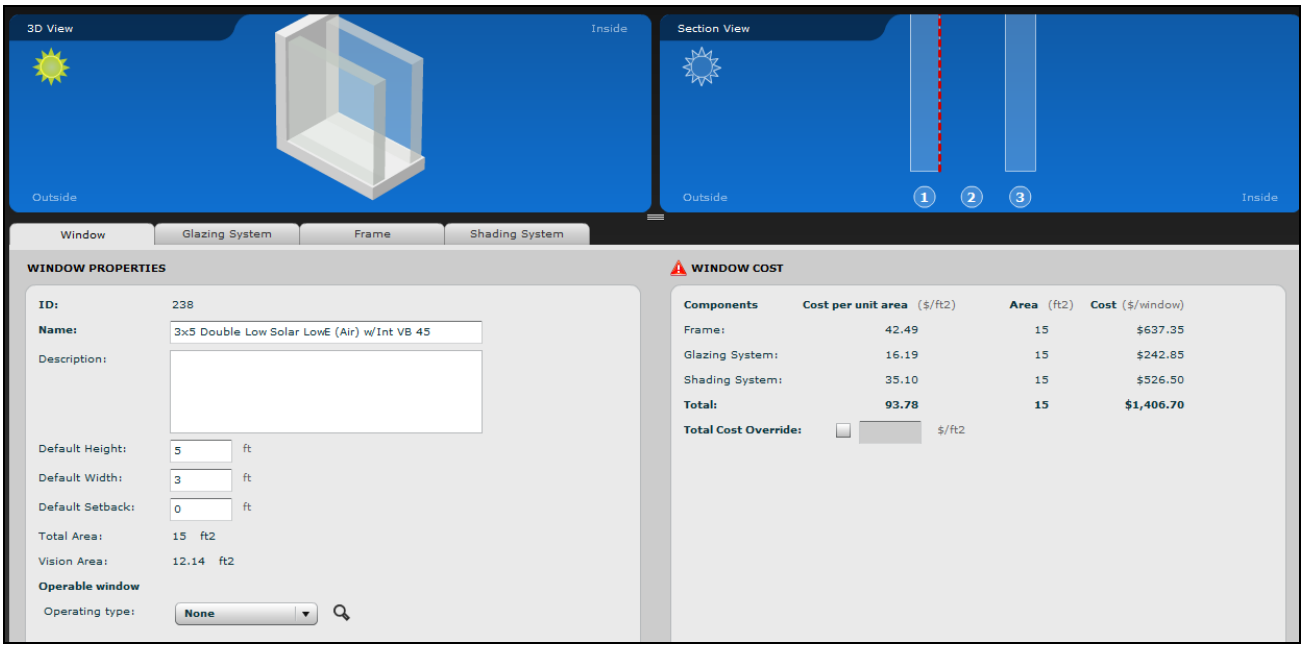


Figure 4-26 Window edit screen

4.2.6. Shading systems

The shading system library is used to model venetian blinds, shades (cloth blinds, roller shades, drapes, etc.) and fixed exterior screen shading systems. The types of shading systems that can currently be modeled in COMFEN are based on the modeling capabilities of the EnergyPlus simulation engine used by COMFEN. Venetian blinds and roller shades can be controlled automatically using one of the control options in COMFEN. The list of systems and available modeling options are summarized in more detail in the sections below.

Venetian blinds

COMFEN allows modeling of interior, exterior and in-between-glass venetian blinds, which can be defined under the shading system properties screen (see image below). All of these systems can be modeled as fixed or automated using one of COMFEN's predefined shading control algorithms. To access the shading system properties screen, double-click on any shading system under the shading system library tab, or select "New" to create a new system.

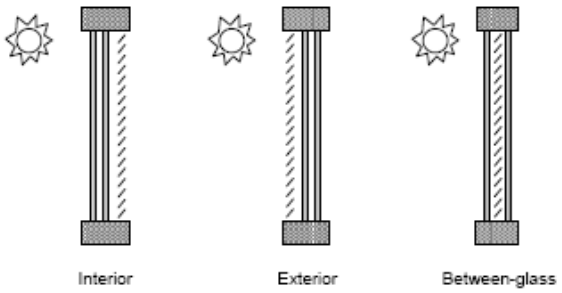


Figure 4-27. Venetian blinds can be defined in three different locations relative to the glazing system

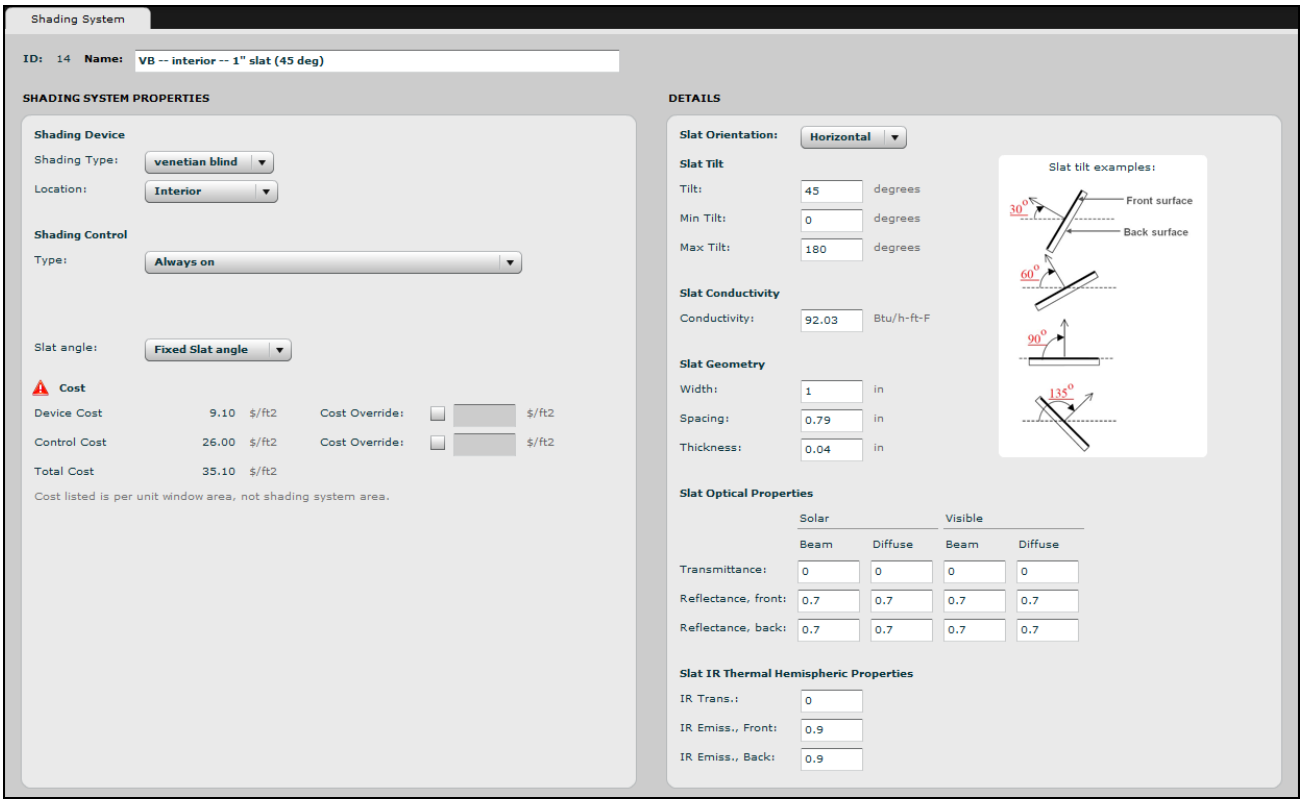


Figure 4-28. Shading system properties screen

Slat Orientation Orientation of the venetian blind, either:

- Horizontal - slat is parallel to window sill
- Vertical - slat is perpendicular to window sill

Slat geometry

Slat width The width of the slat. **Units:** inches (IP), mm (SI)

Slat Spacing The spacing between slats. **Units:** inches (IP), mm (SI)

Slat Tilt The rotation of the slat, measured clockwise from the glazing outward normal to the slat outward normal. **Units:** degrees

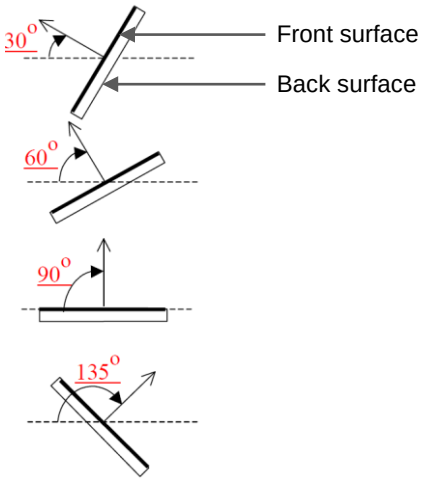


Figure 4-29. Slat angle definition
(Source: EnergyPlus Input Output Reference)

Slat Thickness	The thickness of the slat. **Units:** inches (IP), mm (SI)
Slat Conductivity	The conductivity of the slat material. **Units:** Btu/h-ft-°F (IP), W/m-K (SI)
Min Slat Tilt	The minimum slat tilt, used for the "Block Beam Solar" control. **Units:** degrees
Max Slat Tilt	The maximum slat tilt, used for the "Block Beam Solar" control. **Units:** degrees.

NOTE: *COMFEN will not run if slats overlap, so when slat spacing is less than the slat width, make sure that the minimum and maximum slat angles account for the fact that slat angle will be greater than 0 (or smaller than 180) when blinds are completely closed.*

NOTE: *Inbetween venetian blinds can only be simulated in double and triple glazing systems.*

Slat Optical Properties

Transmittance, Beam Solar	Slat transmittance for direct beam solar radiation.
Transmittance, Diffuse Solar	Slat transmittance for diffuse solar radiation.
Transmittance, Beam Visible	Slat transmittance for direct beam visible radiation.
Transmittance, Diffuse Visible	Slat transmittance for diffuse visible radiation.
Reflectance, front Beam Solar	Reflectance on the front surface of the slat for direct beam solar radiation.
Reflectance, front	

Diffuse Solar Reflectance, front	Reflectance on the front surface of the slat for diffuse solar radiation.
Beam Visible Reflectance, front	Reflectance on the front surface of the slat for direct beam visible radiation.
Diffuse Visible Reflectance, back	Reflectance on the front surface of the slat for diffuse visible radiation.
Beam Solar Reflectance, back	Reflectance on the back surface of the slat for direct beam solar radiation.
Diffuse Solar Reflectance, back	Reflectance on the back surface of the slat for diffuse solar radiation.
Beam Visible Reflectance, back	Reflectance on the back surface of the slat for direct beam visible radiation.
Diffuse Visible	Reflectance on the back surface of the slat for diffuse visible radiation.

Slat IR thermal hemispheric properties

Transmittance	Slat transmittance for infrared radiation
Emissivity, Front	Emissivity of the front surface of the slat. **Default value:** 0.9
Emissivity, Back	Emissivity of the back surface of the slat. **Default value:** 0.9

Shading control

The following control options are presently available in COMFEN. Some of the options are limited to specific shading systems. The default shading system setpoints are listed in Table 4-3.

NOTE: Timestep is equal to 15 minutes.

- **Always on:** Shading is always lowered/deployed
- **Always off:** Shading is always raised/retracted
- **On If Schedule Allows:** This control cannot be used in COMFEN because it does not allow scheduling of controls
- **On If High Solar On Window:** Shading is lowered/deployed if beam solar radiation plus diffuse solar radiation incident on the window exceeds the setpoint (W/m^2). The setpoint value is specified in the control setpoint 1 field.
- **On If High Horizontal Solar:** Shading is lowered/deployed if total (beam plus diffuse) horizontal solar irradiance exceeds setpoint (W/ m^2). The setpoint value is specified in the control setpoint 1 field.
- **On If High Outdoor Air Temp:** Shading is lowered/deployed if outside air temperature exceeds setpoint (˚C). The setpoint value is specified in the Control setpoint 1 field.

- **On If High Zone Air Temp:** Shading is lowered/deployed if the room air temperature in the previous timestep exceeds setpoint (˚C). The setpoint value is specified in the control setpoint 1 field.
- **On If High Zone Cooling:** Shading is lowered/deployed if the room cooling rate in the previous timestep exceeds setpoint (W). The setpoint value is specified in the control setpoint 1 field.
- **On If High Glare:** Shading is lowered/deployed if the daylight glare index (DGI) at the room's first daylighting reference point (sensor #1) exceeds the maximum glare index (22). The calculation is performed assuming that the occupant is positioned at the first daylighting reference point is at desk level - 2'-6" (0.76 m) above floor level.

  The glare view azimuth (i.e. rotation of the sensor) determines the rotation of the occupant from the facade. By default, the azimuth (measured clockwise from an axis normal to the facade) is set to 90˚, i.e. the sensor is rotated 90˚ clockwise from the facade so that it faces one of the zone side walls. For a south-facing zone and a glare view azimuth angle of 90˚ the occupant faces west, while for a west-facing scenario and a glare view azimuth angle of 90˚ the occupant faces north, and so on. The glare view azimuth is equal to 90˚ regardless of orientation.

  Presently the user cannot change the occupant's position or glare view azimuth angle through the COMFEN interface. They can, however, change the glare view azimuth angle by accessing the comfen_settings.xml file in the settings folder. ***NOTE:*** *COMFEN* ***must be closed*** *when editing the glare view azimuth angle in the comfen_settings.xml file in order for the change to take effect.*
- **On Night If Low Outdoor Temp / Off Day:** Shading is lowered/deployed at night if the outside air temperature is less than the setpoint (˚C). Shading is raised/retracted throughout the day. The setpoint value is specified in the control setpoint 1 field.
- **On Night If Low Inside Temp / Off Day:** Shading is lowered/deployed at night if the room air temperature in the previous timestep is less than the setpoint (˚C). Shading is raised/retracted throughout the day. The setpoint value is specified in the control setpoint 1 field.
- **On Night If Heating / Off Day:** Shading is lowered/deployed at night if the zone heating rate in the previous timestep exceeds the setpoint (W). Shading is raised/retracted throughout the day. The setpoint value is specified in the control setpoint 1 field.
- **On Night If Low Outside Temp / On Day If Cooling:** Shading is lowered/deployed at night if the outside air temperature is less than setpoint (˚C). During the day, shading is raised/retracted if the zone cooling rate in the previous timestep is non-zero. The setpoint value is specified in the control setpoint 1 field.
- **On Night If Heating / On Day If Cooling:** Shading is lowered/deployed at night if the zone heating rate in the previous timestep exceeds setpoint (W). During the day, shading is raised/retracted if the zone cooling rate in the previous timestep is non-zero. The Setpoint value is specified in the control setpoint 1 field.
- **Off Night / On Day If Cooling And High Solar On Window:** Shading is raised/retracted at night. Shading is lowered/deployed during the day if the solar radiation incident on the window exceeds setpoint (W/ m^2) and if the zone cooling rate in the previous timestep is non-zero. The setpoint value is specified in the control setpoint 1 field.
- **On Night / On Day If Cooling And High Solar On Window:** Shading is lowered/deployed throughout the night. During the day, shading is lowered/deployed if the solar radiation incident on the window exceeds setpoint (W/ m^2) and if the zone cooling rate in the previous timestep is non-zero. The setpoint value is specified in the control setpoint 1 field.
- **On If High Outside Air Temp And High Solar On Window:** Shading is lowered/deployed if the outside air temperature exceeds Setpoint 1 (˚C) and if the solar radiation incident on the

window exceeds setpoint 2 (W/ m^2). The setpoint values are specified in the control setpoint 1 and Control setpoint 2 fields.

- **On If High Outside Air Temp And High Horizontal Solar:** Shading is lowered/deployed if the outside air temperature exceeds the setpoint (˚C) and if the horizontal solar radiation on the window exceeds setpoint 2 (W/m^2). The setpoint values are specified in the control setpoint 1 and control setpoint 2 fields.

Control Setpoint 1 — For controls that require one setpoint, enter it here. See the control list above.

Control Setpoint 2 — For controls that require two setpoints, enter the second one here. See the control list above.

Slat Angle for Control for Venetian Blinds — The following slat control options are available for venetian blinds:

- **Fixed slat angle:** Slat angle is fixed at the angle defined under the slat tilt input field.
- **Block beam solar:** Slat angle is adjusted at every simulation timestep (15 minutes) in order to block direct solar radiation from coming into the room. The minimum slat tilt (min. tilt) and maximum slat tilt (max. tilt) entries under the "Details" section of the shading properties dialog box define the range of slat rotation.

The list of available shading control types in COMFEN is based on the modeling features of Energy Plus. The Energy Plus Input/Output Reference documentation (found on their website at http://apps1.eere.energy.gov/buildings/energyplus/energyplus_documentation.cfm) contains detailed information about each control.

Table 4-1. Shading System Controls Strategies

Shading Control	Setpoint 1 default value	Setpoint 1 Units	Setpoint 1 default value	Setpoint 2 Units
Always On	N/A	N/A	N/A	N/A
On If High Solar On Window	- -	W/m^2 (SI) $Btu/h\text{-}ft^2$ (IP)	N/A	N/A
On If High Horizontal Solar	- -	W/m^2 (SI) $Btu/h\text{-}ft^2$ (IP)	N/A	N/A
On If High Outdoor Air Temperature	- -	˚C (SI) ˚F (IP)	N/A	N/A
On If High Zone Air Temperature	- -	˚C (SI) ˚F (IP)	N/A	N/A
On If High Zone Cooling	- -	Watts (SI) BTU/hr (IP)	N/A	N/A
On If High Glare*	N/A	N/A	N/A	N/A
On Night If Low Outdoor Temp And Off Day	- -	˚C (SI) ˚F (IP)	N/A	N/A
On Night If Low Inside Temp And Off Day	- -	˚C (SI) ˚F (IP)	N/A	N/A
On Night If Heating And Off Day	- -	Watts (SI) BTU/hr (IP)	N/A	N/A
On Night If Low Outdoor Temp And On Day If Cooling	- -	˚C (SI) ˚F (IP)	N/A	N/A
On Night If Heating And On Day If Cooling	- -	Watts (SI) BTU/hr (IP)	N/A	N/A
Off Night And On Day If Cooling And High Solar On Window	- -	W/m^2 (SI) $Btu/h\text{-}ft^2$ (IP)	N/A	N/A
On Night And On Day If Cooling And High Solar On Window	- -	W/m^2 (SI) $Btu/h\text{-}ft^2$ (IP)	N/A	N/A
On If High Zone Air Temp And High Solar On Window	- -	˚C (SI) ˚F (IP)	0 0	W/m^2 (SI) $Btu/h\text{-}ft^2$ (IP)
On If High Zone Air Temp And High Horizontal Solar	- -	˚C (SI) ˚F (IP)	0 0	W/m^2 (SI) $Btu/h\text{-}ft^2$ (IP)
On If High Outdoor Air Temp And High Solar On Window	- -	˚C (SI) ˚F (IP)	0 0	W/m^2 (SI) $Btu/h\text{-}ft^2$ (IP)
On If High Outdoor Air Temp And High Horizontal Solar	- -	˚C (SI) ˚F (IP)	0 0	W/m^2 (SI) $Btu/h\text{-}ft^2$ (IP)

***** When this option is selected, no setpoint input is required; shading is automatically retracted when the Daylight Glare Index exceeds 22.

4.2.7. Glazed wall assembly

In addition to the option of creating individuals windows, i.e. punched windows within a scenario, the user can create a series of windows that fill up a part of or the whole facade by using the glazed wall assembly option. This feature is particularly useful for modeling storefronts and curtain wall assemblies as it makes it possible to create these quickly and easily.

Creating a glazed wall assembly

To create a glazed wall assembly, open the **New glazed wall assembly** dialog box by clicking on the "add glazed wall assembly icon" in the toolbar:

Figure 4-30. Toolbar with Glazed Wall Assembly icon

This will pull up the glazed wall assembly dialog box:

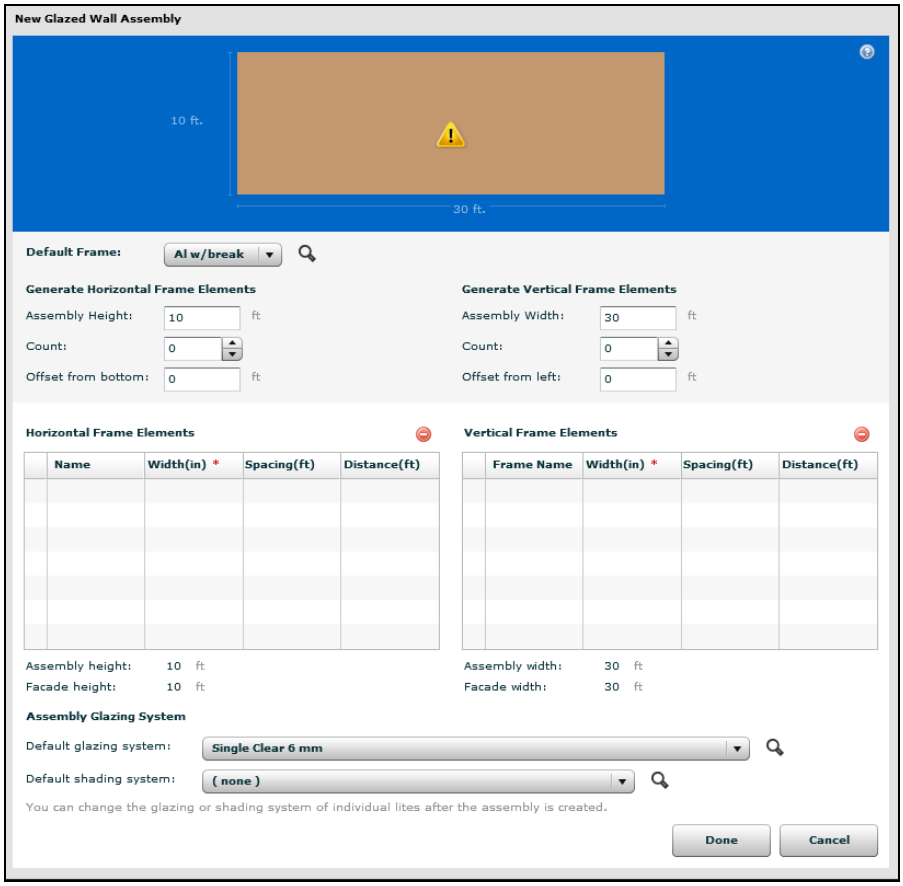


Figure 4-31 New glazed wall assembly dialog box

***NOTE:** Only one glazing assembly can be created within a scenario and a scenario with a glazed wall assembly cannot have a punched window, or vice versa.*

The inputs for this dialog box are explained below:

- **Default frame:** This is the frame that will be used for the glazed wall assembly. Only one type of frame can be specified.
- **Assembly Height:** Height of the glazed wall assembly, measured from the bottom edge of the first framing member to the top edge of the last member.
- **Assembly Width:** Width of the glazed wall assembly, measured from the outside of the first framing member to the outside of the last member.
- **Count:** Number of horizontal or vertical framing elements. Minimum number of horizontal or vertical framing elements is 2.
- **Offset from bottom:** Position of the bottom edge of glazed wall assembly relative to the bottom edge of the scenario.
- **Offset from left:** Position of the left edge of glazed wall assembly relative to the left edge of the scenario.

The table below the inputs lists each framing element (horizontal elements on the left and vertical on the right), along with its width, spacing and distance:

Width: Width of framing element, equal to the width of the framing defined under the default frame input above.

NOTE: *Since it is assumed that the glazed wall assembly represents a "slice" through a glazed wall, perimeter framing elements are automatically modeled at 1/2 of the width of the framing member selected as the default frame.*

Spacing - framing spacing, measured from center line to center line of framing member. The spacing of the first framing member is always 0.

Distance - distance of framing from edge of scenario elevation (either left or bottom edge) and the center line of framing member.

After defining the type and position of the framing, the user specifies the default glazing and shading for the assembly (individual glazing units can be later edited interactively in the scenario elevation view).

Figure 4-32. Select the Glazed Wall Assembly Default Shading System and Glazing System

When the glazed wall assembly framing and glazing is defined, click **Done** to save changes and exit.

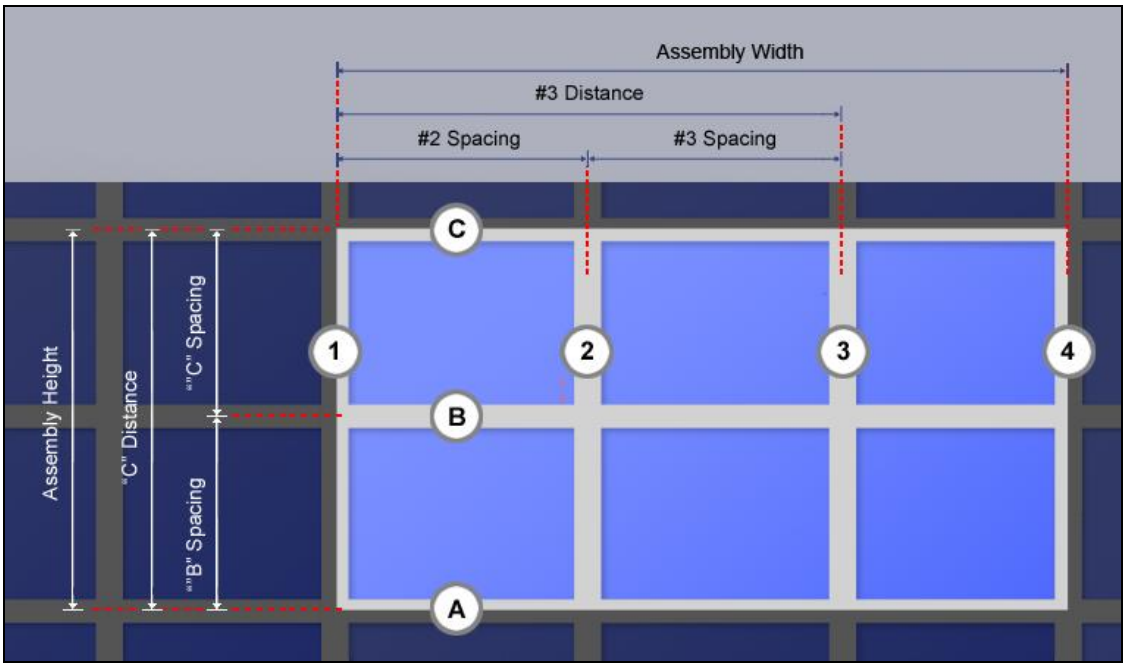


Figure 4-33 Framing member spacing and distance

Editing a glazed wall assembly

Individual lites can be edited in the interactive scenario view if needed by left-clicking on a lite to highlight the lite and then right-clicking within the highlighted area to bring up the edit glazed wall assembly menu:

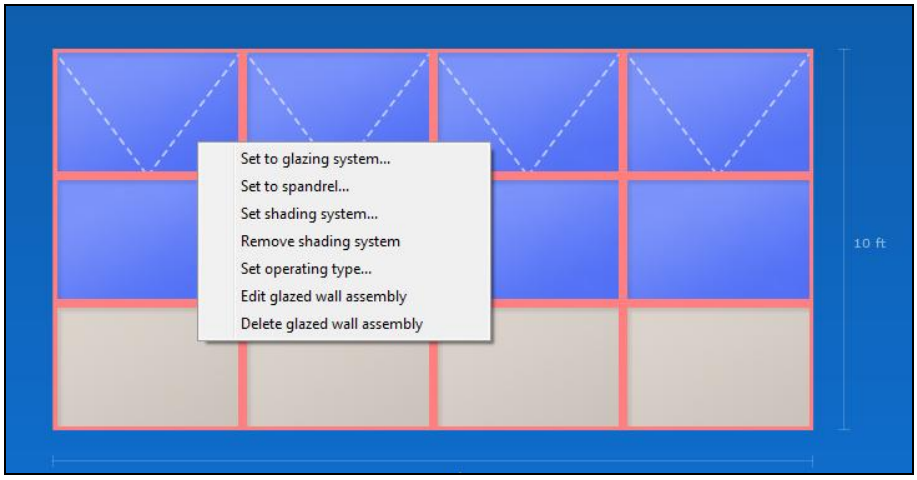


Figure 4-34. Glazed wall assembly menu

From this menu, the user can opt to edit a glazing system, assign or delete a shading system, specify an operable window or a spandrel. "Edit glazed wall assembly" will bring up the **New glazed wall assembly** dialog box.

> ***NOTE:*** *Any changes (e.g. glazing, shading an spandrel definitions) made in the interactive scenario view will be overwritten if changes are made under the* ***New glazed wall assembly*** *dialog box.*

To select multiple lites, hold the shift key while drawing a window starting with the window's upper left corner. Any lites that overlap with the drawn window will be highlithed. At this point, if you right-click, the menu with the options listed above will appear.

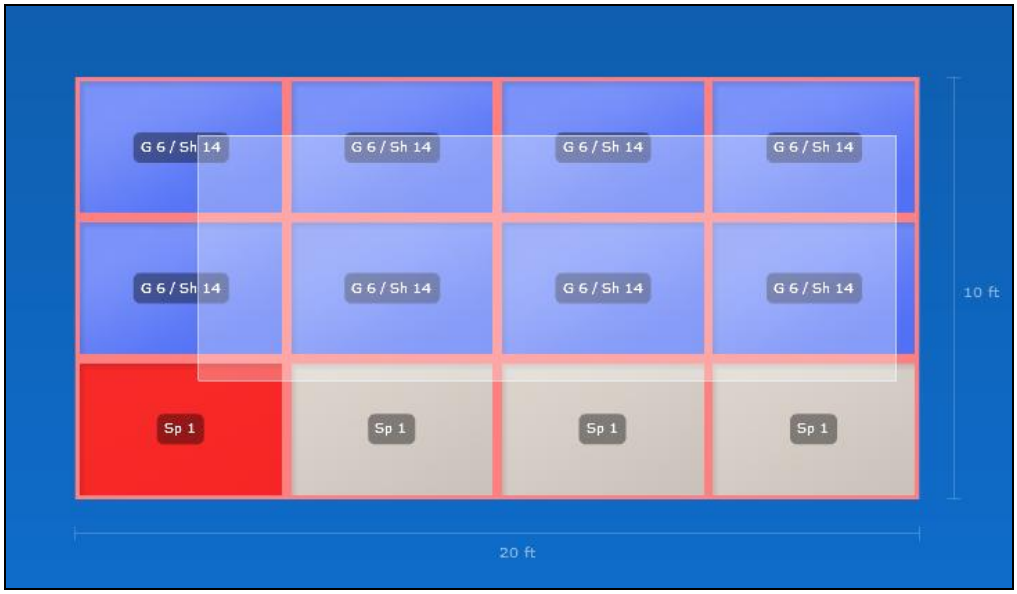
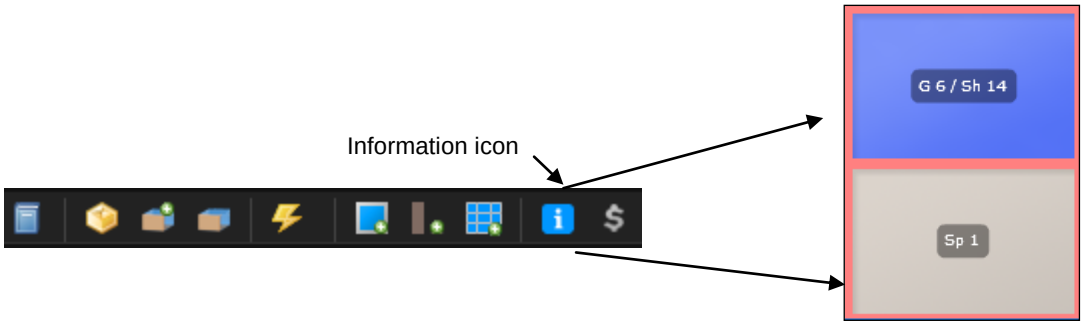


Figure 4-35 Multiple glazing unit selection



TIP: *To display the glazing, shading system and spandrel info markers, click on the information icon in the toolbar.*

General glazed wall assembly properties are summarized under the glazed wall tab. This is also where the user can select edit button to return to the glazed wall assembly dialog box.

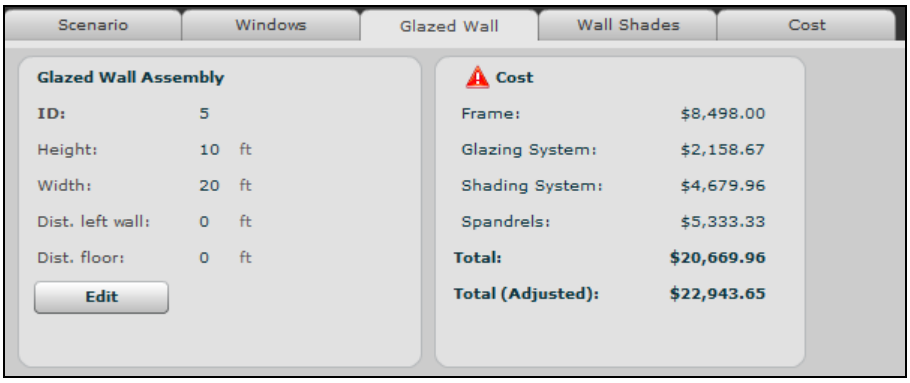
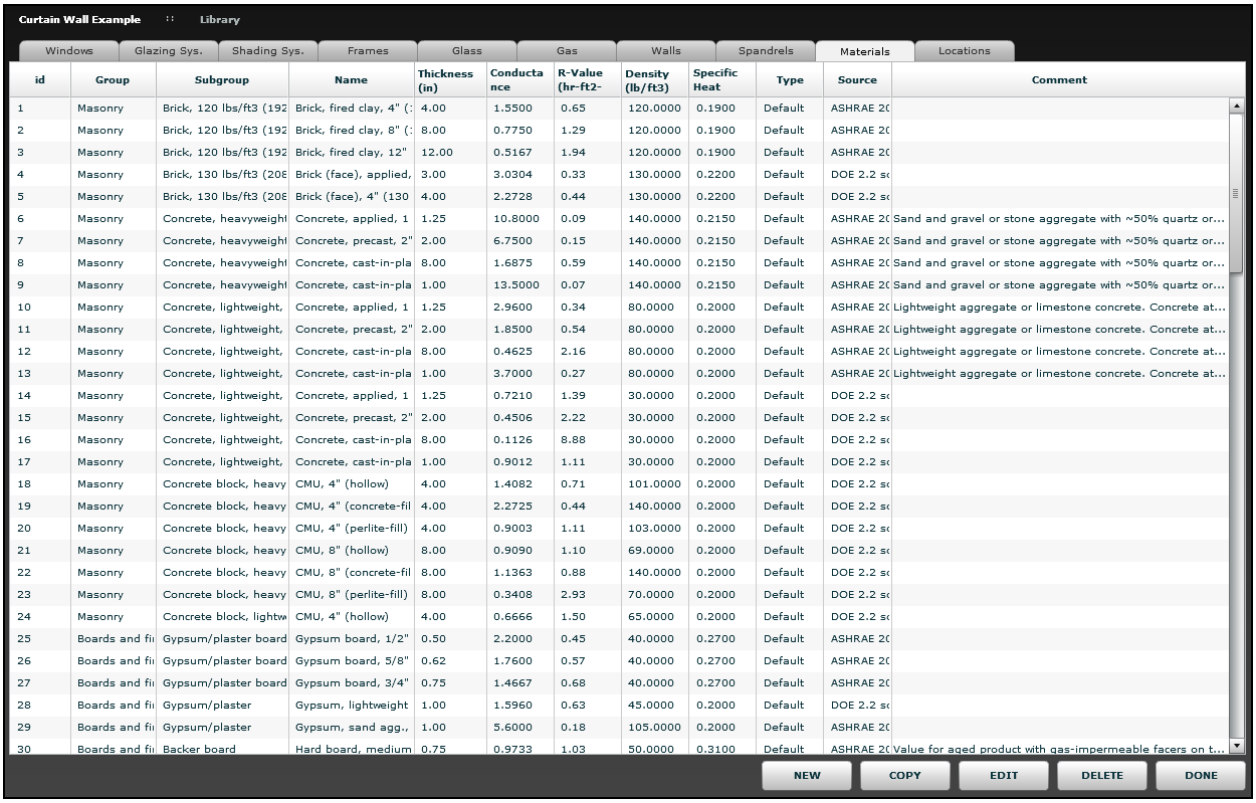


Figure 4-36 Glazed wall tab

4.2.8. Materials

The material library contains a range of predefined construction materials used for wall and spandrel assemblies. New materials can be easily added to the library. A number of properties need to be defined for a typical material in order to ensure that heat transfer through the material is modeled correctly by the program – see image of material properties dialog box.



id	Group	Subgroup	Name	Thickness (in)	Conductance	R-Value (hr-ft2-	Density (lb/ft3)	Specific Heat	Type	Source	Comment
1	Masonry	Brick, 120 lbs/ft3 (192	Brick, fired clay, 4" (:	4.00	1.5500	0.65	120.0000	0.1900	Default	ASHRAE 20	
2	Masonry	Brick, 120 lbs/ft3 (192	Brick, fired clay, 8" (:	8.00	0.7750	1.29	120.0000	0.1900	Default	ASHRAE 20	
3	Masonry	Brick, 120 lbs/ft3 (192	Brick, fired clay, 12"	12.00	0.5167	1.94	120.0000	0.1900	Default	ASHRAE 20	
4	Masonry	Brick, 130 lbs/ft3 (208	Brick (face), applied,	3.00	3.0304	0.33	130.0000	0.2200	Default	DOE 2.2 sc	
5	Masonry	Brick, 130 lbs/ft3 (208	Brick (face), 4" (130	4.00	2.2728	0.44	130.0000	0.2200	Default	DOE 2.2 sc	
6	Masonry	Concrete, heavyweight	Concrete, applied, 1	1.25	10.8000	0.09	140.0000	0.2150	Default	ASHRAE 20	Sand and gravel or stone aggregate with ~50% quartz or...
7	Masonry	Concrete, heavyweight	Concrete, precast, 2"	2.00	6.7500	0.15	140.0000	0.2150	Default	ASHRAE 20	Sand and gravel or stone aggregate with ~50% quartz or...
8	Masonry	Concrete, heavyweight	Concrete, cast-in-pla	8.00	1.6875	0.59	140.0000	0.2150	Default	ASHRAE 20	Sand and gravel or stone aggregate with ~50% quartz or...
9	Masonry	Concrete, heavyweight	Concrete, cast-in-pla	1.00	13.5000	0.07	140.0000	0.2150	Default	ASHRAE 20	Sand and gravel or stone aggregate with ~50% quartz or...
10	Masonry	Concrete, lightweight,	Concrete, applied, 1	1.25	2.9600	0.34	80.0000	0.2000	Default	ASHRAE 20	Lightweight aggregate or limestone concrete. Concrete at...
11	Masonry	Concrete, lightweight,	Concrete, precast, 2"	2.00	1.8500	0.54	80.0000	0.2000	Default	ASHRAE 20	Lightweight aggregate or limestone concrete. Concrete at...
12	Masonry	Concrete, lightweight,	Concrete, cast-in-pla	8.00	0.4625	2.16	80.0000	0.2000	Default	ASHRAE 20	Lightweight aggregate or limestone concrete. Concrete at...
13	Masonry	Concrete, lightweight,	Concrete, cast-in-pla	1.00	3.7000	0.27	80.0000	0.2000	Default	ASHRAE 20	Lightweight aggregate or limestone concrete. Concrete at...
14	Masonry	Concrete, lightweight,	Concrete, applied, 1	1.25	0.7210	1.39	30.0000	0.2000	Default	DOE 2.2 sc	
15	Masonry	Concrete, lightweight,	Concrete, precast, 2"	2.00	0.4506	2.22	30.0000	0.2000	Default	DOE 2.2 sc	
16	Masonry	Concrete, lightweight,	Concrete, cast-in-pla	8.00	0.1126	8.88	30.0000	0.2000	Default	DOE 2.2 sc	
17	Masonry	Concrete, lightweight,	Concrete, cast-in-pla	1.00	0.9012	1.11	30.0000	0.2000	Default	DOE 2.2 sc	
18	Masonry	Concrete block, heavy	CMU, 4" (hollow)	4.00	1.4082	0.71	101.0000	0.2000	Default	DOE 2.2 sc	
19	Masonry	Concrete block, heavy	CMU, 4" (concrete-fil	4.00	2.2725	0.44	140.0000	0.2000	Default	DOE 2.2 sc	
20	Masonry	Concrete block, heavy	CMU, 4" (perlite-fill)	4.00	0.9003	1.11	103.0000	0.2000	Default	DOE 2.2 sc	
21	Masonry	Concrete block, heavy	CMU, 8" (hollow)	8.00	0.9090	1.10	69.0000	0.2000	Default	DOE 2.2 sc	
22	Masonry	Concrete block, heavy	CMU, 8" (concrete-fil	8.00	1.1363	0.88	140.0000	0.2000	Default	DOE 2.2 sc	
23	Masonry	Concrete block, heavy	CMU, 8" (perlite-fill)	8.00	0.3408	2.93	70.0000	0.2000	Default	DOE 2.2 sc	
24	Masonry	Concrete block, lightw	CMU, 4" (hollow)	4.00	0.6666	1.50	65.0000	0.2000	Default	DOE 2.2 sc	
25	Boards and fi	Gypsum/plaster board	Gypsum board, 1/2"	0.50	2.2000	0.45	40.0000	0.2700	Default	ASHRAE 20	
26	Boards and fi	Gypsum/plaster board	Gypsum board, 5/8"	0.62	1.7600	0.57	40.0000	0.2700	Default	ASHRAE 20	
27	Boards and fi	Gypsum/plaster board	Gypsum board, 3/4"	0.75	1.4667	0.68	40.0000	0.2700	Default	ASHRAE 20	
28	Boards and fi	Gypsum/plaster	Gypsum, lightweight	1.00	1.5960	0.63	45.0000	0.2000	Default	DOE 2.2 sc	
29	Boards and fi	Gypsum/plaster	Gypsum, sand agg.,	1.00	5.6000	0.18	105.0000	0.2000	Default	ASHRAE 20	
30	Boards and fi	Backer board	Hard board, medium	0.75	0.9733	1.03	50.0000	0.3100	Default	ASHRAE 20	Value for aged product with gas-impermeable facers on t...

Figure 4-37. Material library list view

Material properties dialog box input fields:

ID A unique material ID automatically generated when a material is created

Name A unique material name assigned by user

Group Primary material library subdivisions (e.g. masonry, boards and finishes, insulation, cladding, membranes, etc.)

Subgroup Group subdivision

Source Source from which material properties were obtained, e.g. ASHRAE Handbook of Fundamentals

Type This field is used to characterize the material's thermophyscial properties, primarily its thermal storage capacity. The field also determines the required inputs for the material properties dialog box. COMFEN recognizes three different types of materials:

1. **Default (with thermal capacity):** A material with thermal storage capacity; this is the default material type for materials. This option should typically be selected as it will ensure that EnergyPlus will account for the thermal mass of the material and thus evaluate the effect of transient conduction. This material type requires that a range of thermophysical properties be specified.

   Required inputs: Conductance, density, specific heat, emissivity, (front), emissivity (back), thickness, and optical properties: solar transmittance and reflectance (front and back), visible transmittance and reflectance (front and back), and IR transmittance.

2. **Lightweight (no thermal capacity):** Similar to a "Default (no thermal capacity)" material, however the material's thermal storage capacity is not taken into account. Option should only be used for materials with minimal thermal storage capacity (e.g. insulation).

   Required inputs: Same as default material type, except density and specific heat are not required. Also, thermal resistance (R-value) is required in place of conductance.

3. **Air gap:** This option is used to define an air gap between layers in a construction. Similar to a lightweight material, the thermal capacity of an air gap layer is negligible. However since the layer is not exposed to any external environment, surface properties such as absorptance and reflectance are not a required input.

   Required inputs: Thermal resistance (R-value) and thickness

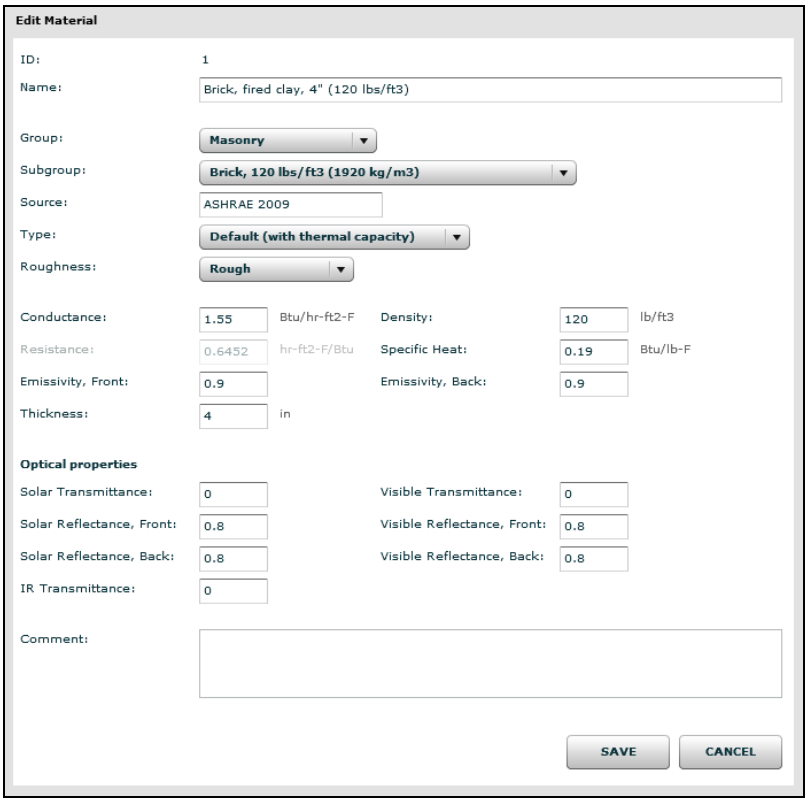


Figure 4-38. Material properties dialog box

Energy Plus Documentation: Note that the corresponding Energy Plus material descriptors for the COMFEN material types listed are "Material," "Material:NoMass" and "Material:AirGap." For a more detailed description of the Energy Plus material types please refer to the "Group – Surface Construction Elements" chapter in the *Energy Plus Input Output Reference*.

Roughness

Field used to define material roughness, a property which influences convection coefficients used in the calculation of surface heat transfer. Inputs range from very rough to very smooth. Only default and lightweight materials require a roughness input. The following table lists roughness categories and provides examples of specific construction materials.

Table 4-2. Example of different roughness materials

Roughness index	**Example material**
Very rough	Stucco
Rough	Brick, rough plaster, rough stone, unfinished terra cotta tile
Medium rough	Concrete

Medium smooth	Clear pine, wood siding
Smooth	Smooth plaster, smooth stone
Very smooth	Glass, painted pine, polished metal

Energy Plus Documentation: For a more detailed description of roughness and the calculation methodology for exterior convection coefficients please refer to the "Group – Simulation Parameters: SurfaceConvectionAlgorithm: Outside" and "Group - Surface Construction Elements: Material" chapters in the *Energy Plus Input Output Reference* and the "Outside Surface Heat Balance – Outdoor/Exterior Convection" chapter in the *Energy Plus Engineering Reference.*

Comment Field for optional comments

4.2.9. Walls

The scenario wall construction can be changed under the scenario tab, where any wall from the wall library can be selected from a drop-down menu. All of the walls listed under this drop-down can be edited and deleted under the wall library.

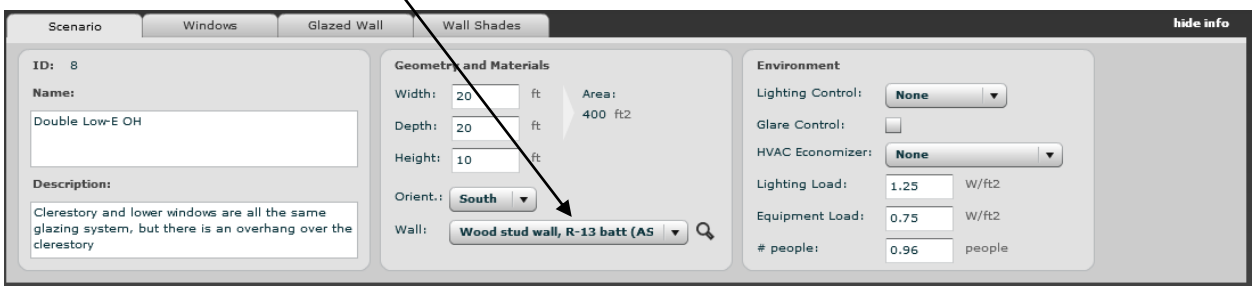
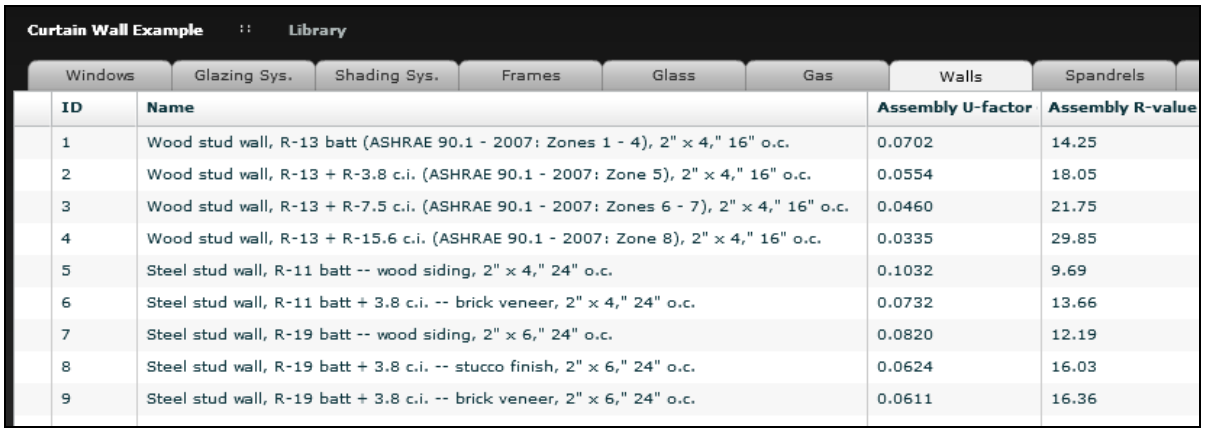


Figure 4-39. Scenario Wall Construction Reference

Wall library

To access the wall library, go to the menu - Libraries > Walls. The first few walls in the library represent wood stud walls that comply with the requirements of ASHRAE Standard 90.1; these walls meet ASHRAE minimum wall R-value requirements for specific climate zones. The effect of thermal bridging at the wood studs within the cavity is already accounted for, i.e. frame spacing and width, requirements for cavity insulation and continuous insulation (c.i.) outboard of the cavity match ASHRAE prescriptive method requirements. When a user creates a new project, an ASHRAE-compliant wall is automatically assigned to the project as the default wall based on the project's location and climate zone.



Curtain Wall Example :: Library

Windows | Glazing Sys. | Shading Sys. | Frames | Glass | Gas | Walls | Spandrels

ID	Name	Assembly U-factor	Assembly R-value
1	Wood stud wall, R-13 batt (ASHRAE 90.1 - 2007: Zones 1 - 4), 2" x 4," 16" o.c.	0.0702	14.25
2	Wood stud wall, R-13 + R-3.8 c.i. (ASHRAE 90.1 - 2007: Zone 5), 2" x 4," 16" o.c.	0.0554	18.05
3	Wood stud wall, R-13 + R-7.5 c.i. (ASHRAE 90.1 - 2007: Zones 6 - 7), 2" x 4," 16" o.c.	0.0460	21.75
4	Wood stud wall, R-13 + R-15.6 c.i. (ASHRAE 90.1 - 2007: Zone 8), 2" x 4," 16" o.c.	0.0335	29.85
5	Steel stud wall, R-11 batt -- wood siding, 2" x 4," 24" o.c.	0.1032	9.69
6	Steel stud wall, R-11 batt + 3.8 c.i. -- brick veneer, 2" x 4," 24" o.c.	0.0732	13.66
7	Steel stud wall, R-19 batt -- wood siding, 2" x 6," 24" o.c.	0.0820	12.19
8	Steel stud wall, R-19 batt + 3.8 c.i. -- stucco finish, 2" x 6," 24" o.c.	0.0624	16.03
9	Steel stud wall, R-19 batt + 3.8 c.i. -- brick veneer, 2" x 6," 24" o.c.	0.0611	16.36

Figure 4-40. Wall Construction Library List View

Creating a new wall

To add a new wall to the COMFEN library, go to Libraries > Walls to pull up the wall library, and then click "New." This pulls up the wall create/edit screen. The table on the left side of the screen shows the wall assembly. Wall layers are added by dragging entries from the material library on the right side of the screen. Layers in the wall construction table can be reordered by dragging the entries. The table columns are described below.

	The first column represents the layer number. Layers are counted from the outermost (outside) layer to the innermost (inside) layer.
ID	Unique material ID#
Material	Material name
Framing	Indicates whether the layer is continuous or discontinuous. For the latter option, the layer is designated as either framing or cavity. This option is intended for modeling layers with thermal bridging such as wood stud walls with insulated cavities (COMFEN cannot presently model steel stud cavities). The user specifies % framing area below the table. COMFEN calculates the effective wall R-value using the isothermal planes method which accounts for the effect of thermal bridging through wood studs.
Thickness	Thickness of the material layer
R-value frame	R-value of the layer designated as "framing"
R-value cavity	R-value of the layer designated as "cavity"

Wall assembly characteristics

% framing	Width of framing/framing spacing * 100%. **Range:** 1 to 99%
U-factor	Effective U-factor for whole wall (accounts for effect of framing and outside and inside film coefficients).
R-value	Effective R-value for whole wall (accounts for effect of framing and outside and inside film coefficients)

Assembly thickness Effective wall thickness

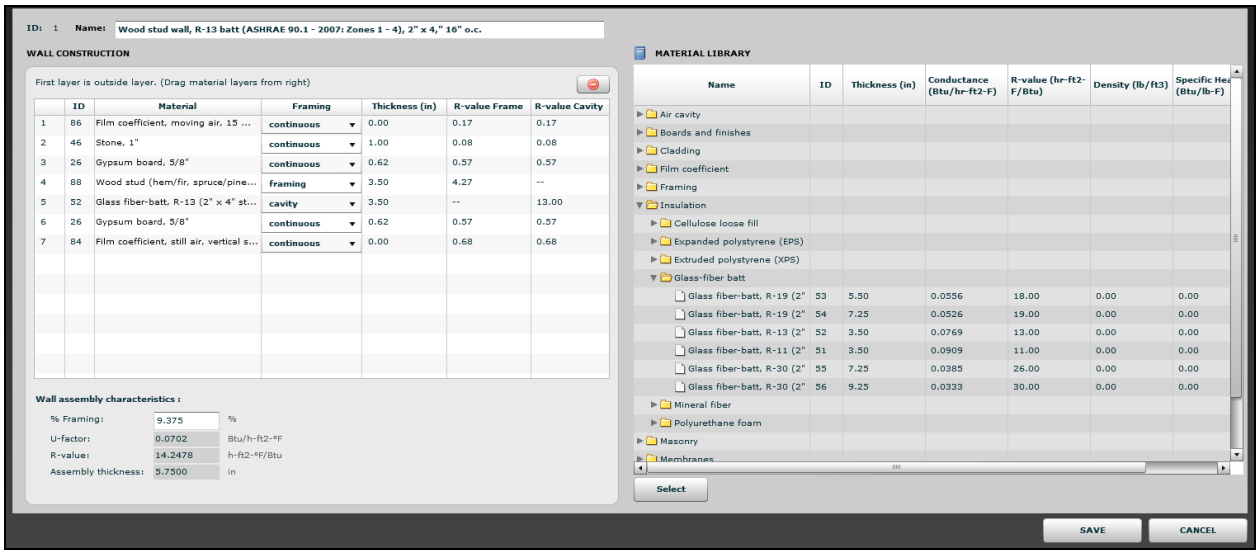
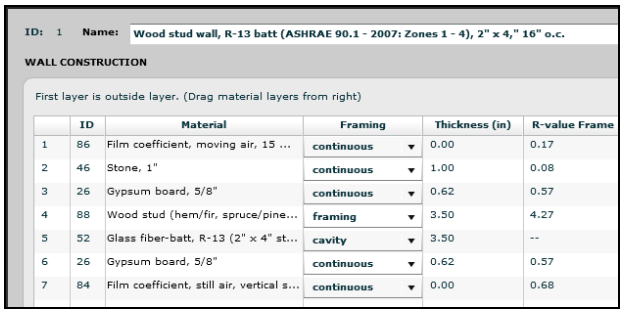


Figure 4-41. Wall Construction Detail View

NOTE: *While COMFEN can accurately model thermal bridging through wood stud cavities, it cannot presently calculate the resistance of a wall with highly conductive materials, such as metal studs. However sample steel stud walls have been provided in the wall library.*

NOTE: *When creating a wall, the following conditions must be met:*

1. *The outermost and innermost layers of the construction must be air films (materials from the "film coefficient" group).*
2. *A wall with a "composite" layer - a combination of two discontinuous materials such as wood studs (framing) with insulation in the cavity must have a continuous "enclosing" layer on either side of the composite: a "regular" or "lightweight" material type. The cavity and framing must be modeled as adjacent layers.*
3. *If you define a material as a "cavity" in the wall construction table on the left-hand screen of the wall edit screen, you also have to define a "framing" material, and vice versa.*
4. *Framing materials must come from the framing group in the material library and cavity materials must come from the air cavity or insulation group.*
5. *Air spaces must be in between two other construction materials (i.e. material types "regular" and/or "lightweight"). Air spaces cannot be adjacent to one another.*



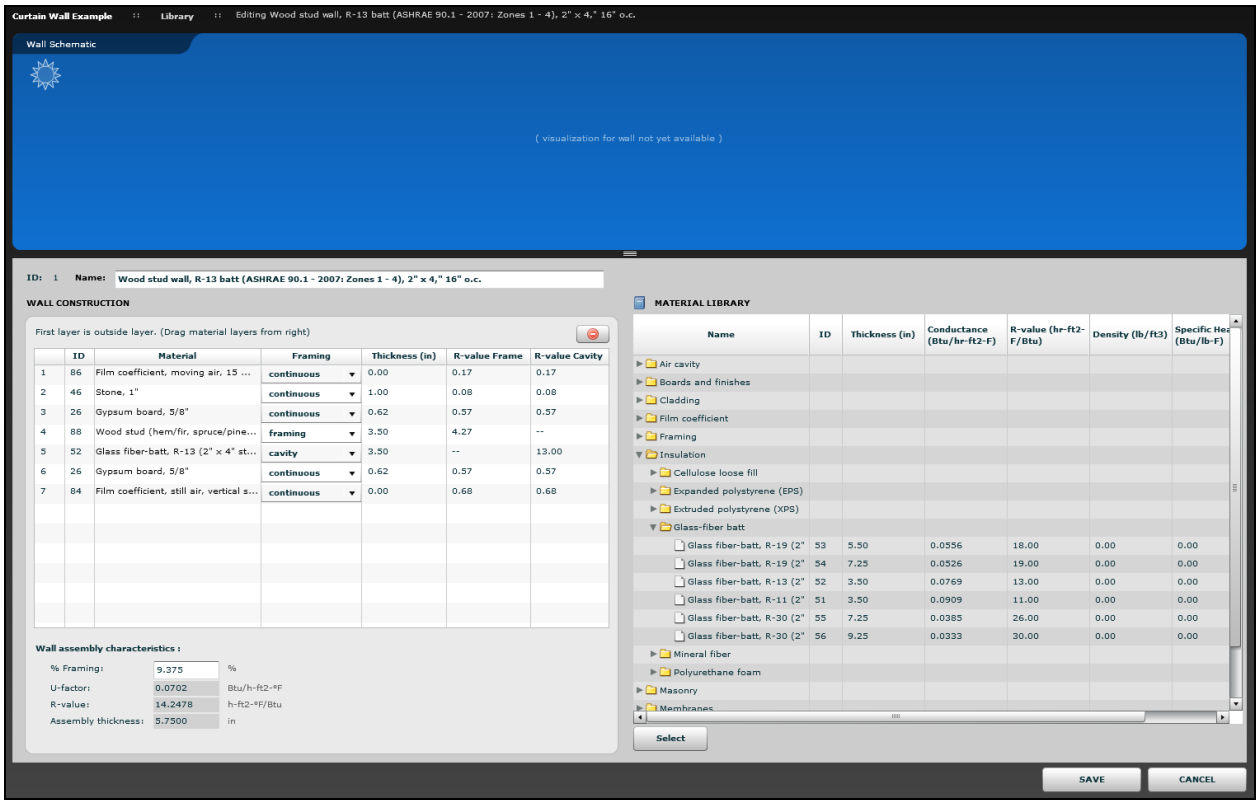


Figure 4-42. Creating a New Wall Construction

Changing the default project wall

The user can change the default project wall defined based on the project location (see Project > Project properties dialog box) at the scenario or project level. To change the wall for the scenario, double-click on the scenario in the explorer and go to the scenario tab. Under the Geometry and materials section, click on the search icon to bring up a list of walls in the library. Highlight a wall of choice and click ***Select*** to assign wall to scenario.

The default wall assigned to projects can also be changed under the location tab. To do this, go to the location library (Libraries > Locations) and double-click on the location (you may want to make a copy of the original location beforehand and edit the copy rather than the original location entry to conserve the defaults). Once open, select wall of choice under the default wall drop-down and save the revised location. Any project created with this location will now have the new default wall automatically assigned to it.

4.2.10. Spandrels

Spandrels can only be assigned to scenarios with a glazed wall assembly. To assign a spandrel to a glazed wall assembly, highlight one or more glazing units in the scenario view. Right-click within the highlighted area to bring up the glazed wall assembly menu and select "Set to spandrel." This will bring up a list of spandrels in the library. Select the spandrel of choice and click "Select." To edit the spandrel, select "Set to spandrel" in the glazed wall assembly menu to once again bring up the list of options.

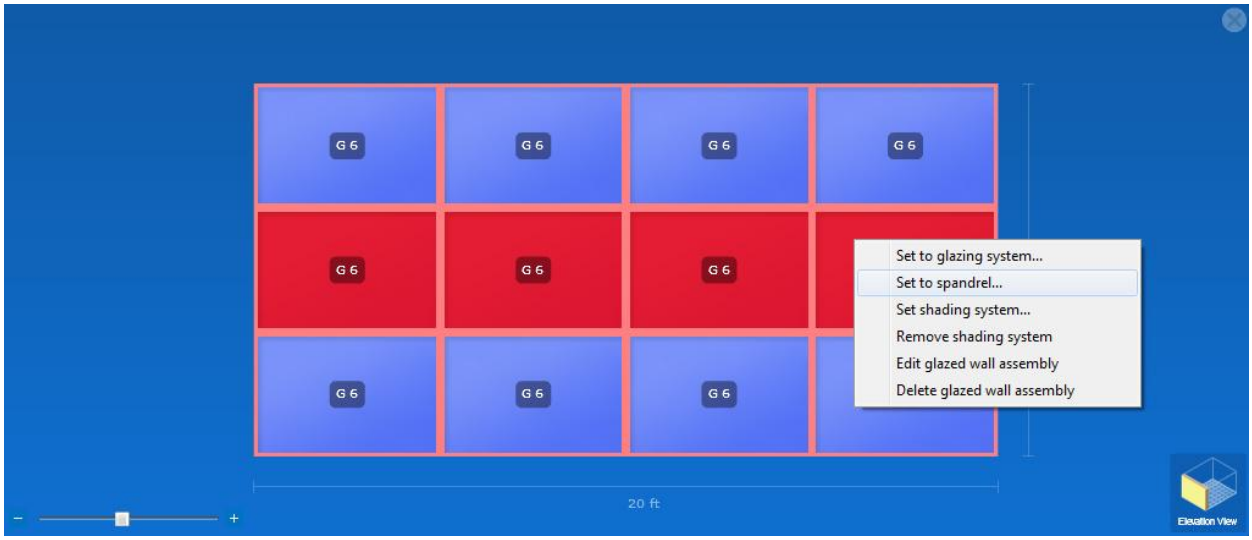
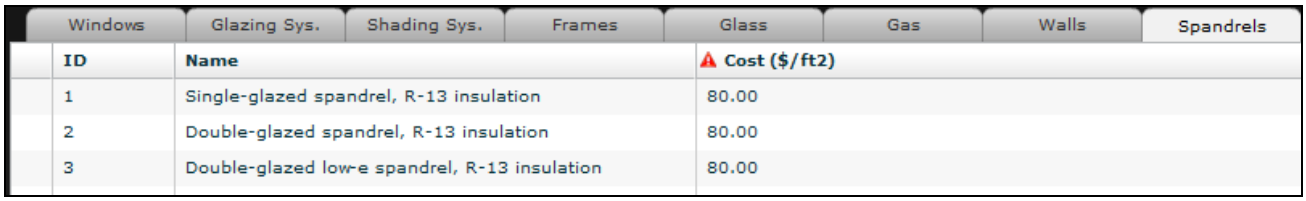


Figure 4-43. Defining Spandrels

Spandrel library

To access the spandrel library, go to the menu - Libraries > Spandrels. The existing entries represent examples of typical spandrel construction. The user can add new spandrel constructions to the library as needed.



ID	Name	Cost ($/ft2)
1	Single-glazed spandrel, R-13 insulation	80.00
2	Double-glazed spandrel, R-13 insulation	80.00
3	Double-glazed low-e spandrel, R-13 insulation	80.00

Figure 4-44. Material properties dialog box

Creating a new spandrel

To add a new spandrel to the COMFEN library, go to Libraries > Spandrels to pull up the spandrel library, and then click "New." This pulls up the spandrel create/edit screen. Here, you can drag materials from the right-side of the screen to create a custom spandrel.

NOTE: When creating a spandrel, the following conditions must be met:

1. *The outermost and innermost layers of the construction must be air films (materials from the "film coefficient" group).*
2. *Air spaces must be inbetween two other construction materials (i.e. material types "regular" and/or "lightweight"). There cannot be adjacent air spaces within the construction.*
3. *Only glazing systems with up to three glass layers can be specified in a spandrel.*
4. *Multiple glazing systems within a spandrel are not allowed; only one glazing system or glass layer can be used.*

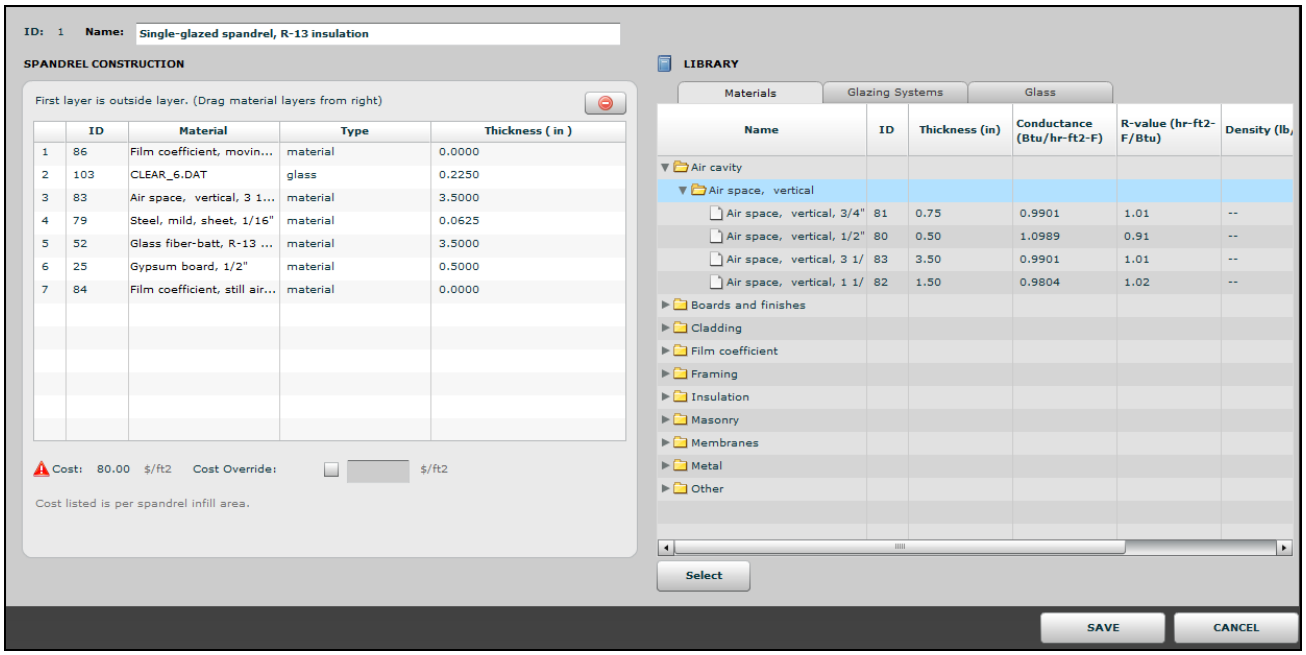


Figure 4-45. Spandrel Library Detailed View

4.2.11. Locations

The COMFEN location library contains weather data for a range of cities in the United States, Australia, Canada, India and Russia. Many of the locations also include additional data such as CO_2 emissions factors, utility cost data, and default walls for each location.

Windows | Glazing Sys. | Shading Sys. | Frames | Glass | Gas | Walls | Spandrels | Materials | Locations

id ▲	Country	State/Province	City	Weather File	CO2 Electricity (lb/kWh)	CO2 Gas (lb/kBtu)	Elec. Rate ($/kWh)	Cost ($/therm)	Cost Adjustment Factor
24	United States of America	California	San Diego	USA_CA_San.Diego	0.6100	0.1200	0.13	0.76	1.13
26	United States of America	California	San Francisco	USA_CA_San.Franci	0.6100	0.1200	0.13	0.76	1.25
28	United States of America	Colorado	Denver (Stapleton)	USA_CO_Denver.In	1.9300	0.1200	0.08	0.74	1.01
29	United States of America	District of Columbi	Washington (Dulles)	USA_VA_Sterling-W	1.1600	0.1200	0.13	1.27	1.04
30	United States of America	Delaware	Wilmington	USA_DE_Wilmingto	1.8300	0.1200	0.12	1.55	1.05
31	United States of America	Florida	Miami	USA_FL_Miami.Intl.	1.3900	0.1200	0.11	1.03	0.96
32	United States of America	Florida	Orlando	USA_FL_Orlando.Ex	1.3900	0.1200	0.11	1.03	0.95
33	United States of America	Florida	Tampa	USA_FL_Tampa.Int	1.3900	0.1200	0.11	1.03	0.93
34	United States of America	Georgia	Atlanta	USA_GA_Atlanta-Ha	1.3700	0.1200	0.09	1.06	0.95
35	United States of America	Hawaii	Honolulu	USA_HI_Honolulu.I	1.6600	0.1200	0.22	3.58	1.35
36	United States of America	Iowa	Des Moines	USA_IA_Des.Moine	1.8800	0.1200	0.08	0.77	1.01
37	United States of America	Idaho	Boise	USA_ID_Boise.Air.T	0.0300	0.1200	0.06	0.81	0.99
38	United States of America	Illinois	Chicago (Ohare)	USA_IL_Chicago-O	1.1600	0.1200	0.09	0.86	1.15
39	United States of America	Indiana	Fort Wayne	USA_IN_Fort.Wayne	2.0800	0.1200	0.08	0.73	1
40	United States of America	Kansas	Wichita	USA_KS_Wichita-Mi	1.6800	0.1200	0.08	0.96	0.93
41	United States of America	Kentucky	Lexington	USA_KY_Lexington-	2.0100	0.1200	0.08	0.83	0.93
42	United States of America	Kentucky	Louisville	USA_KY_Louisville-	2.0100	0.1200	0.08	0.83	0.96
43	United States of America	Louisiana	New Orleans	USA_LA_New.Orlear	1.1800	0.1200	0.08	0.97	0.95
44	United States of America	Massachusetts	Boston	USA_MA_Boston-Lo	1.2800	0.1200	0.15	1.25	1.18
45	United States of America	Maryland	Baltimore	USA_MD_Baltimore	1.3700	0.1200	0.12	0.97	0.98
46	United States of America	Michigan	Detroit	USA_MI_Detroit.Me	1.5800	0.1200	0.09	0.88	1.11

Figure 4-46. Location library list view

Location Library List Detailed View – General Tab

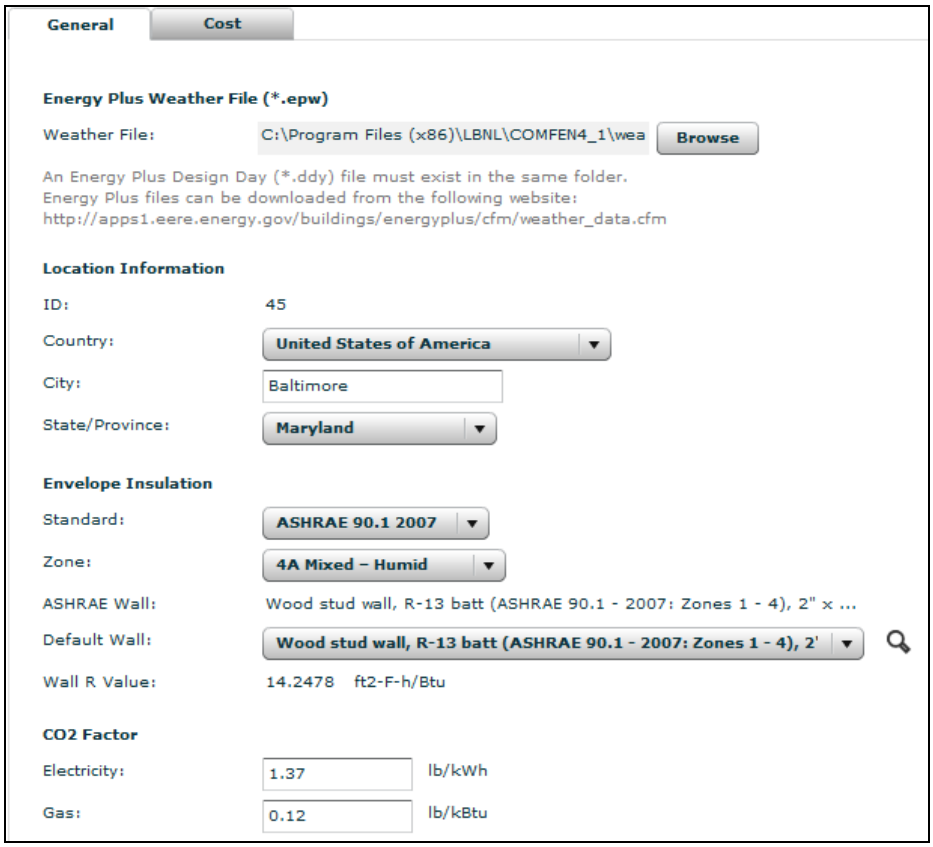


Figure 4-47. Edit location Detailed view, General tab

Location Library List Detailed View – Cost Tab

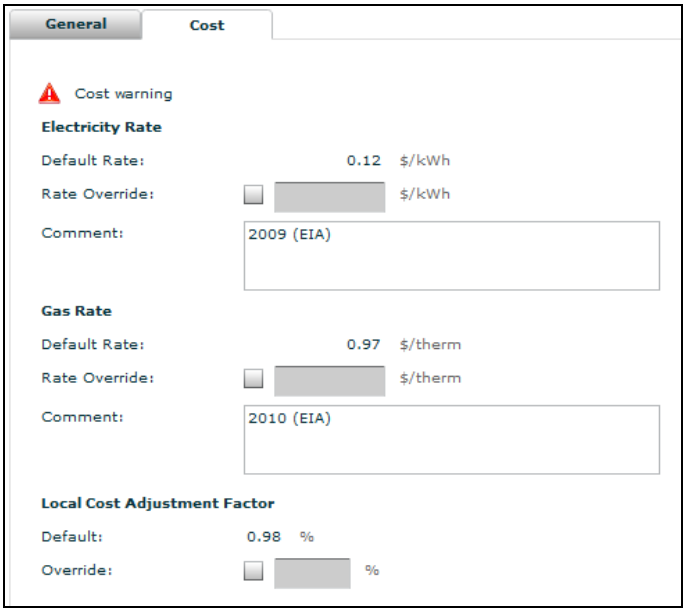


Figure 4-48. Edit location Detailed view, General tab

Creating a new location

General tab

Energy Plus Weather File

Weather File — Each location in the library references a weather file in Energy Plus (*.epw). New locations can be assigned to the library by selecting the ***New*** button at the bottom of the library list view screen.

Weather data for additional locations can be downloaded from the Energy Plus weather data website:
http://apps1.eere.energy.gov/buildings/energyplus/cfm/weather_data.cfm

The Energy Plus website contains three types of files for each location: the *.epw, *.stat, and *.ddy. The user should download the zip file, which contains all three files.

When creating a new location, the user must specify the *.epw weather file location by clicking ***Browse*** under the General tab. An associated *.ddy must be located in the same folder as the *.epw file. Once the weather file has been loaded, the user must complete all of the missing fields. The require information for the Zone field can be found in the *.stat file by searching for the term "climate type" and looking up the ASHRAE 90.1 climate zone designation.

Location Information

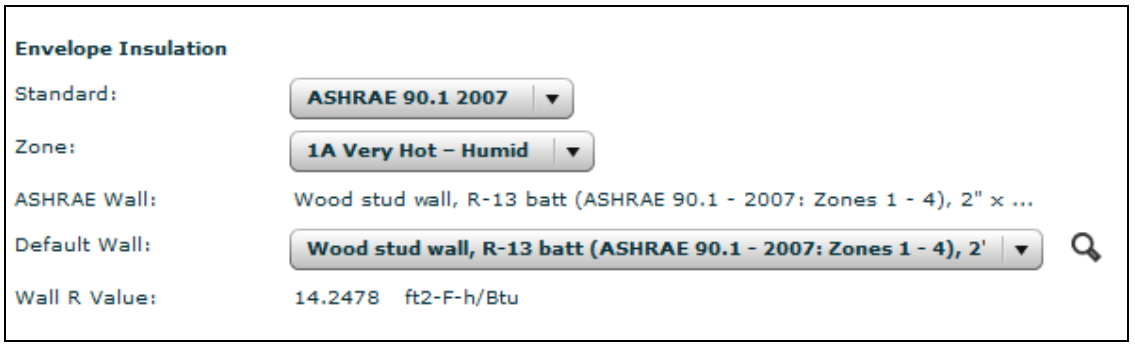
ID — Automatically assigned by the program when making a new location. Not editable.

Country — Select from the choice of countries in the pulldown list when creating a new location

City — Type the name of the city for the new location

State/Province — A pulldown list of states / provinces will be shown for the United States and Canada. Otherwise, type the state / province in the input field.

Envelope insulation



Standard — Building energy standard used to determine envelope insulation requirements for the location. Based on the required insulation levels (R-value) set by the standard, a default wall construction (listed under ASHRAE wall) is assigned to the location.

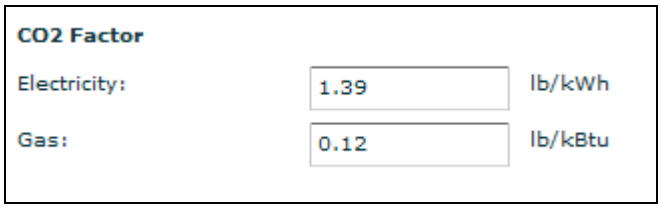
Zone — Location's ASHRAE climate zone. The climate zone information is listed in the location's *.stat file (summary weather data file), which can be downloaded from the Energy Plus website.

ASHRAE wall — A wall meeting the insulation (R-value) requirements of the standard listed in the *Standard* field.

Default wall — Default wall that is assigned to projects in the location. The user can use the construction listed under *ASHRAE wall* if they want to ensure that the construction meets the requirements of the standard listed under the *Standard* field, or they can assign a custom wall construction by selecting a wall from the drop-down list. The walls listed here correspond to walls defined in the wall library.

Wall R-value — Effective wall R-value for the wall specified under the *Default wall* field.

CO2 factor

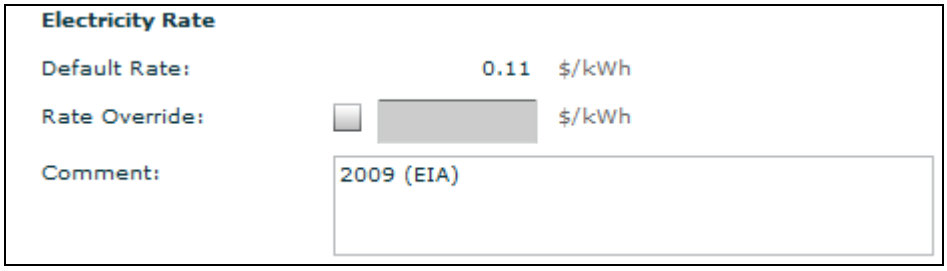


Electricity — Average carbon emissions per unit of electricity generated by utility and nonutility electric generators. **Default:** data for the 1998-2000 time period (EIA, 2002). Since these factors can vary considerably by year for some U.S. states, it is recommended that the user input updated values if available.

Gas — Average carbon emissions per unit of natural gas. **Default:** 0.12

Cost tab

Electricity rate

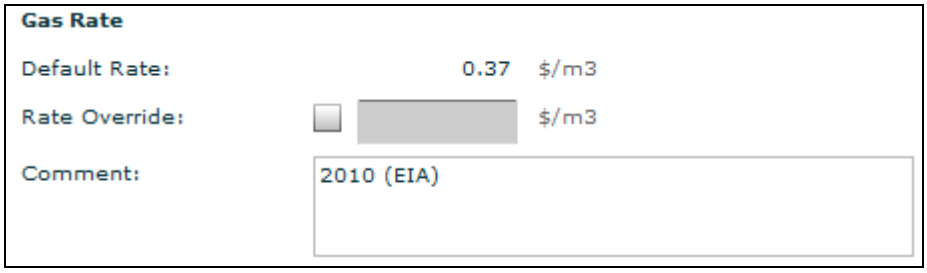


Default rate The average price of electricity used by end-user in the commercial sector (EIA, 2011b). **Units:** $/Kwh (IP & SI).

Rate Override Check the box if you want to use different data than the default. This will cause the input box to the right of the checkbox to become active and a new rate can be input. **Units:** $/Kwh (IP & SI).

Comment Optional comment.

Gas rate

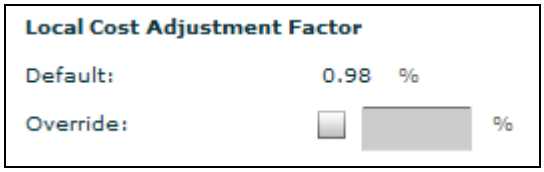


Default rate The average price of natural gas used by end-user in the commercial sector (EIA, 2011a). The price is inclusive of all tax, delivery, commodity, demand and other charges. Here, the commercial sector is defined as the sector encompassing nonmanufacturing establishments engaged in the sale of goods or services and local, State and Federal agencies engaged in nonmanufacturing activities. **Units:** $/therm (IP); $/m3 (SI).

Rate Override Check the box if you want to use different data than the default. This will cause the input box to the right of the checkbox to become active and a new rate can be input.

Comment Optional comment.

Local Cost Adjustment Factor



Default The labor and materials cost adjustment factor that is multiplied by the base cost the final total scenario cost. Based on data from RS Means (2011). **Units:** %

Override Check the box if you want to use different data than the default. This will cause the input box to the right of the checkbox to become active and a new value can be input. **Units:** %.

References

1. Energy Information Administration [EIA] (2002). [Table 1. 1998-2000 Average State-level Carbon Dioxide Emissions Coefficients for Electric Power]. *Updated State-level Greenhouse Gas Emission Coefficients for Electricity Generation, 1998-2000*. Retrieved from: http://www.eia.gov/FTPROOT/environment/e-supdoc-u.pdf
2. Energy Information Administration [EIA] (2011a). [Commercial natural gas prices]. *U.S. and state natural gas prices for wellhead, imports, exports, citygate, and end-use sectors*. Retrieved from http://205.254.135.24/dnav/ng/ng_pri_sum_a_EPG0_FWA_DMcf_a.htm
3. Energy Information Administration [EIA] (2011b). [Table 5B. Commercial Average Monthly Bill by Census Division, and State, 2009]. *Electric Sales, Revenue, and Average Price 2009*. Retrieved from http://205.254.135.24/cneaf/electricity/esr/table5_b.html

4.3. HVAC

The default HVAC system is presently a packaged single zone system for all building types. Cooling and heating setpoints and schedules vary by building type (see appendix). The economizer option provides a means to reduce the need for cooling by introducing outdoor air when the conditions are favorable.

4.3.1. Ventilation

The default outdoor air flow rate is listed under the Project Properties > HVAC tab. The default flow rate type is set to flow/person and the volume of supplied air varies by building type. The user can override the air flow control type (flow/person or flow/area) and flow rate.

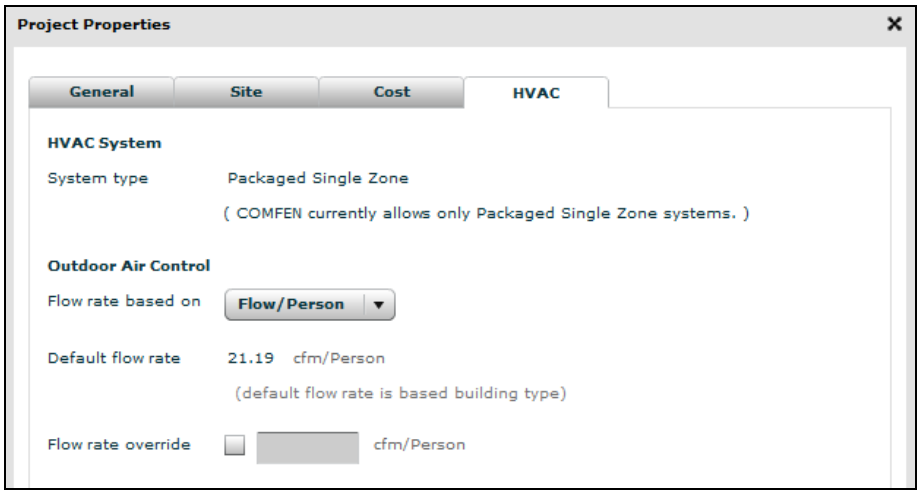


Figure 4-49. Project Properties > HVAC tab

4.3.2. Economizer

The economizer option in COMFEN is accessed from the scenario tab in the main screen (see figure below). The user can choose from three economizer control options:

1. Temperature – economizer is enabled when the cooling setpoint is not met and the drybulb temperature of outdoor air is lower than the dry-bulb temperature of return air.
2. Enthalpy - economizer is enabled when the cooling setpoint is not met and the enthalpy of outdoor air is lower than the enthalpy of return air.
3. Temperature and enthalpy – economizer is enabled when the cooling setpoint is not met and both the drybulb temperature and enthalpy of outdoor air are lower than the dry-bulb temperature and enthalpy, respectively, of return air.

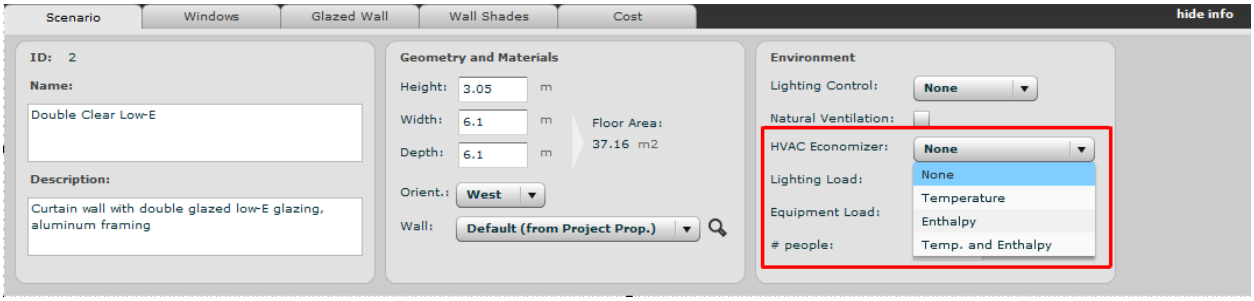


Figure 4-50. HVAC economizer

4.4. Lighting, Equipment and Occupancy Loads

Default occupancy, lighting and equipment loads are set to the following when you create a new scenario:

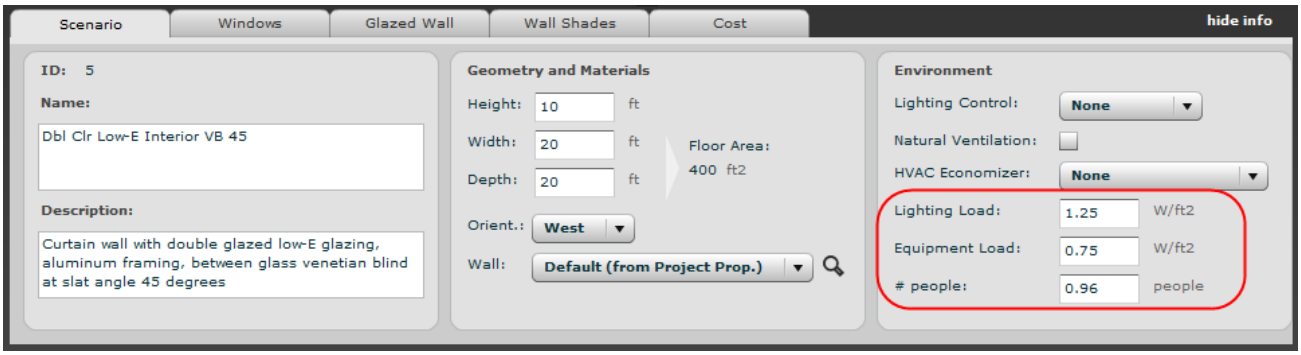


Figure 4-51. Lighting, equipment and occupancy loads

Lighting load: 1 W/ft2
Equipment load: 0.75 W/ft2
Occupancy: 1 person per zone

NOTE: *The loads listed above are the maximum loads, i.e. loads in a fully-occupied office. Actual loads at any given time will vary based on occupancy, lighting and equipment schedules (see appendix).*

NOTE: *Since the current default loads presently do not vary by building type, it is recommended that the user review and adjust loads and occupancy based on building type.*

4.5. Daylighting and glare analysis

A daylight analysis for scenarios can be performed under the Comparison tab. Here users can evaluate up to four scenarios side-by-side by calculating illuminance levels, luminances and occupant visual discomfort due to the glare. COMFEN uses two underlying simulation engines for daylight calculations – Energy Plus and Radiance, a state-of-the-art daylight simulation software. Some of the daylight simulations are calculated for the whole year while others are calculated for a user-defined date and time, i.e. point-in-time simulations. Radiance, a photometrically-accurate raytracing program, has been extensively tested and validated against physical measurements. The following sections discuss the types of analyses available and how to define different types of daylight simulations in more detail.

4.5.1. Point-in-time daylight simulations

Point-in-time simulations refer to simulations conducted for a user-defined date and time. In contrast to annual daylight simulations, for which solar radiation data is obtained from the location's weather file, point-in-time simulations require that the user specify the sky condition (e.g. clear, overcast or intermediate) for the calculation. In addition, some daylight calculations such as the glare analysis or the 3D contour map may require the user to specify the occupant's position and angle of view. The next few pages discuss the Radiance-based daylight simulations, which include the illuminance contour maps found under the daylight tab and the glare analysis.

Illuminance contour maps

The illuminance contour maps generated in COMFEN under the Plan Contour and 3D Contour tabs show lines of equal illuminance for a plan view of the space and a user-defined perspective view. In order to generate either plan or perspective view contours for a set of scenarios, the user needs to define several simulation parameters in the Radiance toolbar.

The Radiance toolbar options are defined below. Parameters on the right of the Radiance toolbar are used to adjust how results are displayed (e.g. legend maximum and divisions) but they do not affect the results, i.e. they will not change the calculated illuminance values.

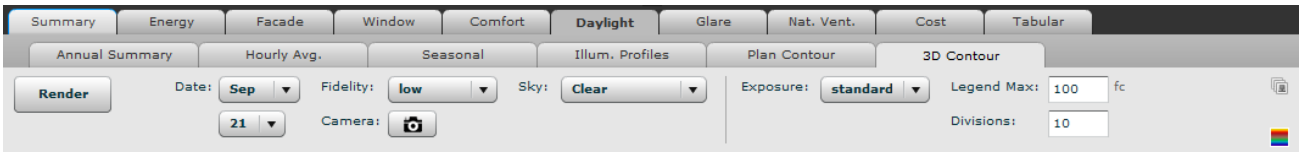


Figure 4-52. Radiance toolbar

Render	Starts the simulation and updates image display
Date	Month and day for simulation
Fidelity	Precision of the simulation
Camera	View angle for the perspective view (option is only displayed under the 3D contour tab)
Sky	Sky condition for the simulation (clear, overcast or intermediate)
Exposure	Displayed image brightness

Legend Max	Maximum illuminance value displayed [***Units:*** fc (IP), lux (SI)]
Divisions	Number of legend divisions
	Export all renderings icon for exporting all renderings as individual *.png image files
	Icon for displaying color legend for illuminance contour lines [***Units:*** fc (IP), lux (SI)]

NOTE: *COMFEN automatically generates a rendering for 9 am, noon, and 3 pm for the specified date, however the user can override the default by selecting different times from the drop-down lists on the left of the display.*

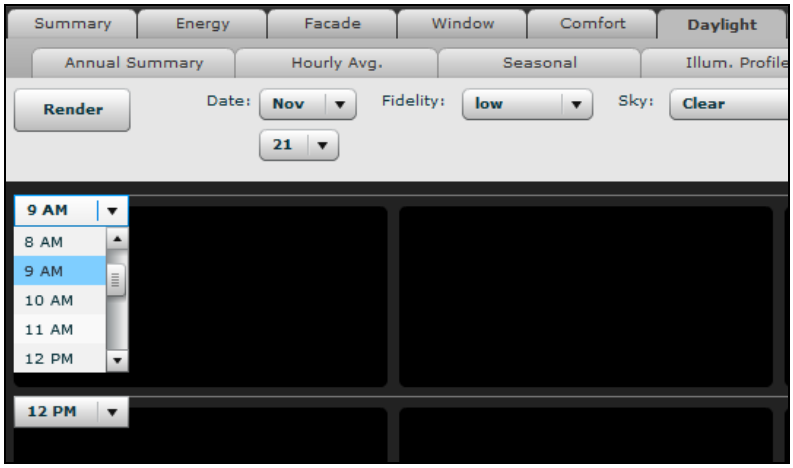


Figure 4-53. Specifying the time for the daylight simulation

When the user clicks on the camera view icon, the "Position RADIANCE camera" dialog box appears. Here the user can define the x and y position of the camera (in ft or m) as well as the direction of the view. The position of the camera (i.e. how far it is from the window and side walls) is measured relative to the origin in the upper-left corner. The view direction is defined from the camera position.

NOTE: By default, the angle of view represents a 180° cone of vision (fish-eye view), so there is no input for view angle or zoom.

After defining simulation parameters, the user selects Render to run the simulations. Three renderings corresponding to three different times (default times are set to 9 am, noon, and 3 pm) will be generated for each scenario. Depending on the fidelity selected, the simulation may take some time. Upon making any changes to the scenario or to the simulation parameters in the Radiance toolbar, the user needs to click the Render button to recalculate and/or update the images.

NOTE: *If parameters on the left side of the Radiance toolbar are edited, the calculation is invalidated and results need to be recalculated. However, changing the options on the right side of the toolbar will only change how the image is displayed, so images only need to be updated (by clicking the Rerender button). The updating process may take a little bit of time, but it will be much shorter than a full Radiance calculation.*

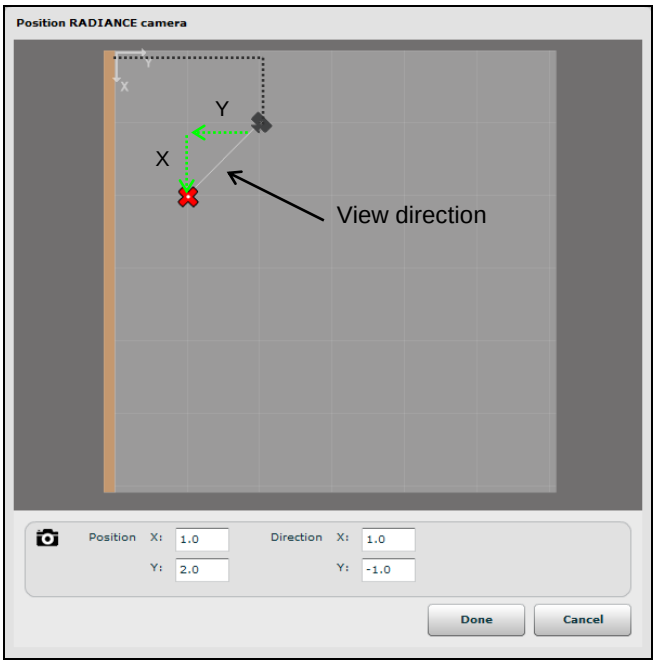


Figure 4-54. Radiance camera dialog box for defining camera position and angle

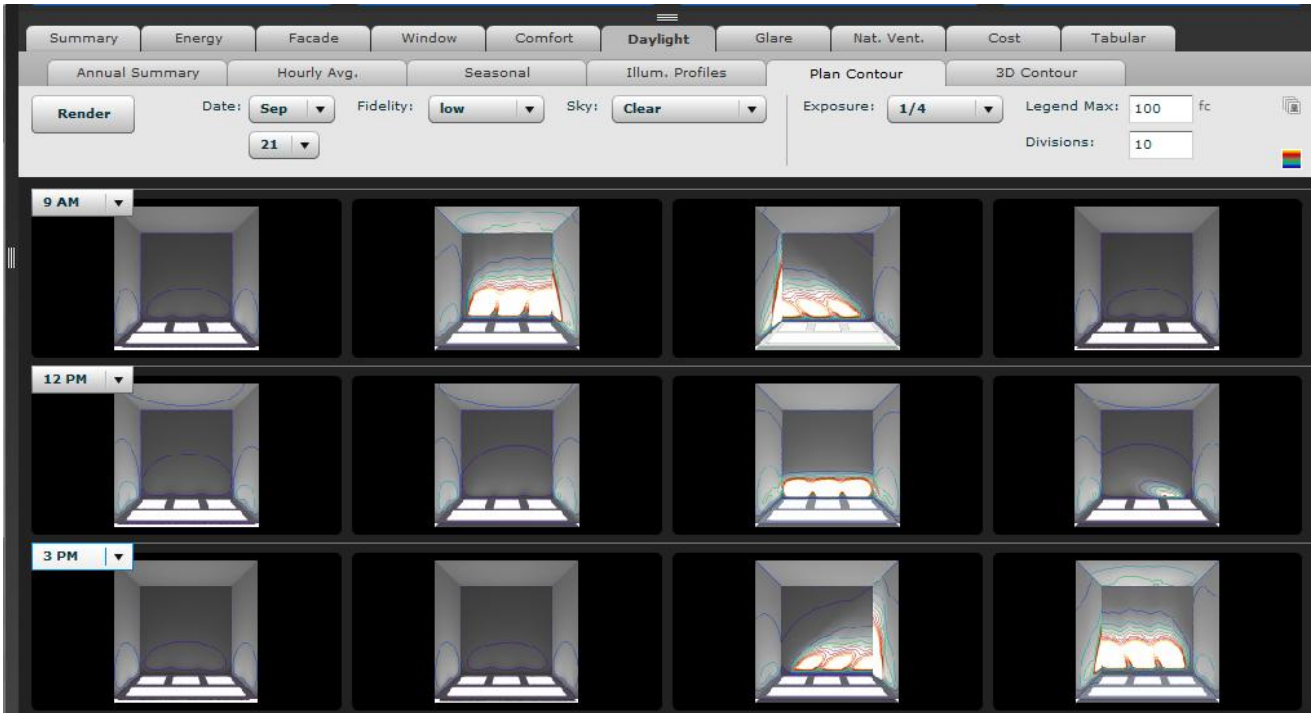


Figure 4-55. Plan view illuminace contour lines

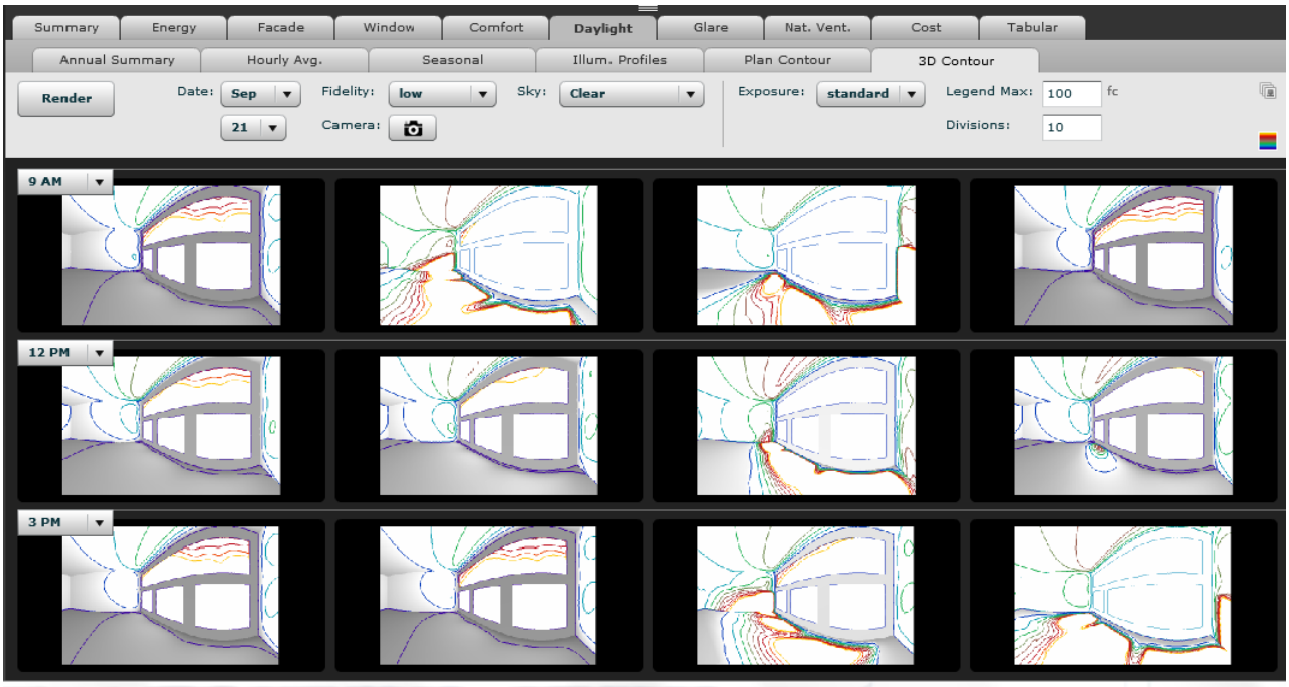


Figure 4-56. Perspective view illuminace contour lines

Glare analysis

Glare analyses can be conducted under the Clear Sky and Overcast Sky tabs under Comparison > Daylight > Glare. Here, the user can create photo-realistic images of the space, apply falsecolor filters to show luminance ranges within the rendered view, and calculate the Daylight Glare Index (DGI). The DGI is described in more detail further in the section.

The Radiance toolbar under these tabs is quite similar to the toolbar under illuminance contour tabs. While most of the toolbar options have already been discussed above, the following options differ:

Falsecolor 	Checkbox used to apply a color mask to the rendered image to show luminances
Legend Max	Maximum luminance value displayed in color mask [Units: cd/m² (IP and SI)]
	Icon for displaying the DGI scale dialog box
	Color legend icon used for identifying color mask luminances values [Units: cd/m² (IP and SI)]

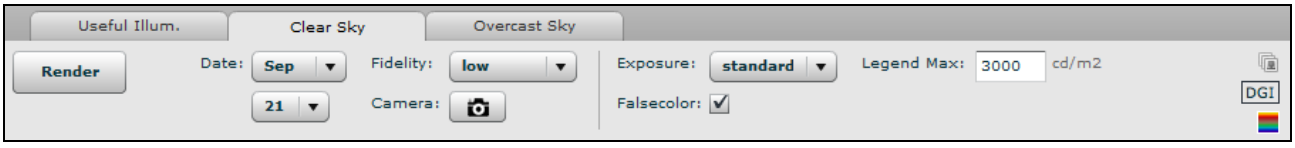


Figure 4-57. Radiance toolbar

DGI is a measure of glare calculated based on the glare source (e.g. window) luminance, glare source size, surround background luminance, and the location of the glare source relative to the occupant's field of view. The fisheye camera view (180° cone of vision) defined in COMFEN approximates the human field of view (90° to either side, 60° up, and 70° down from the line of sight). The DGI value is displayed in the upper left corner of each rendering. The displayed values correspond to a subjective user assessment of glare displayed in the DGI scale dialog box:

DGI	Subjective Glare Assessment
16	Just perceptible
20	Just acceptable
22	Borderline between comfort and discomfort
24	Just uncomfortable
28	Just intolerable

Figure 4-58. DGI scale dialog box

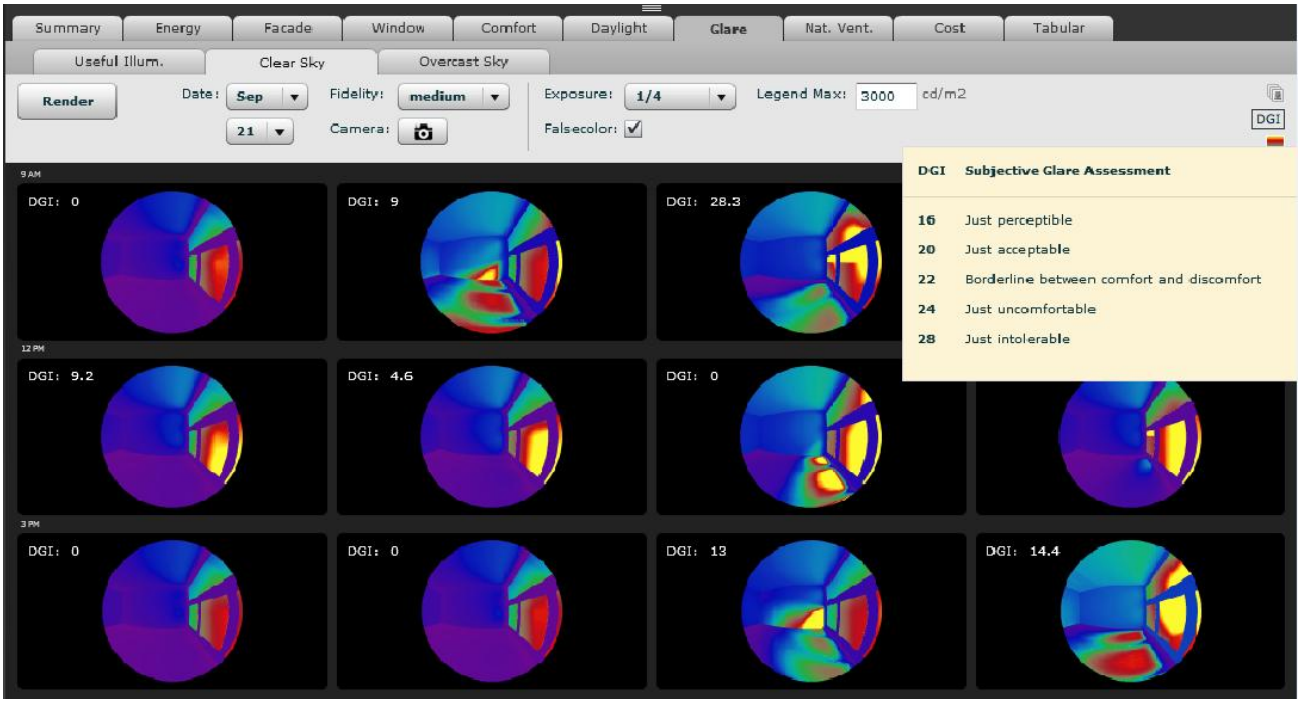


Figure 4-59. Radiance toolbar

4.5.2. Annual daylight simulations

Annual illuminance values in COMFEN are calculated by Energy Plus based on the annual solar radiation data contained in the weather file used for the energy use calculations. These annual daylight simulations are automatically calculated by COMFEN when the user calculates the energy performance of scenarios. Results of these calculations are displayed in several tabs under the Comparison > Daylight tab (e.g. Annual Summary, Hourly Average, Seasonal Average and Illuminance Profiles).

Calculations are performed for two predefined sensor points. The position of these sensor points is automatically assigned by COMFEN; the user presently has no control over these points:

- **Sensor # 1:** Daylight sensor #1 is positioned 2/3 of the primary daylight zone depth from facade wall (centered in the width of the facade zone) and positioned at desk height: 2'-6" (0.76 m) above the floor. Sensor #1 controls a fraction of the facade zone lights equal to the primary daylight zone depth divided by the facade zone depth.
- **Sensor # 2:** Any remaining depth in the facade zone is considered a secondary daylight zone. Sensor #2 is positioned halfway between the primary daylight zone depth and the "back wall." Similar to sensor #1, the sensor is centered in the width of the facade zone and positioned at desk height: 2'-6" (0.762 m) above the floor. Sensor #2, if used, controls the remaining fraction of lights.
- **Zone Depth:** A primary daylight zone depth is calculated as the minimum of a) the room depth, b) 1.5 times the facade wall height, and c) 15 feet.

4.5.3. Daylight illuminance maps

The user can choose to generate an additional set of illuminance results in the form of daylight illuminance maps. These maps are generated by Energy Plus and displayed under the Comparison > Summary tab. The maps display worksurface illuminances, calculated at 2'-6" (0.762 m) above the floor, for the entire space in the form of a 10 x 10 grid. The grid is scaled to fit the space, so the dimensions of each grid square (or rectangle) will vary depending on the dimensions of the scenario.

Illuminance values are displayed for the date and time specified in the drop-down menu above the map. After selecting a date, the user needs to click on the refresh button (green arrow to the right of the date) to regenerate results for the new date. When hovering the mouse over a particular point in the grid, the illuminance value for that point is displayed.

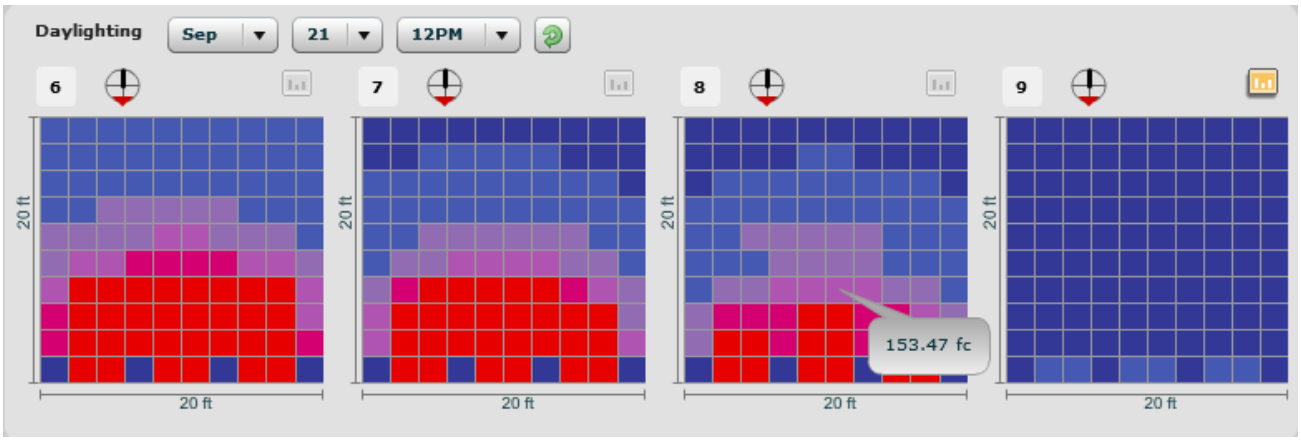


Figure 4-60. Daylight illuminance maps

Since the daylight illuminance map calculation can considerably increase the length of the simulation (Energy Plus calculates values for each hour of the year), the illuminance maps are disabled by default to conserve simulation time. The illuminance map option can be enabled by accessing the Energy Plus tab under COMFEN > Preferences and selecting the "Calculate Illuminance" checkbox.

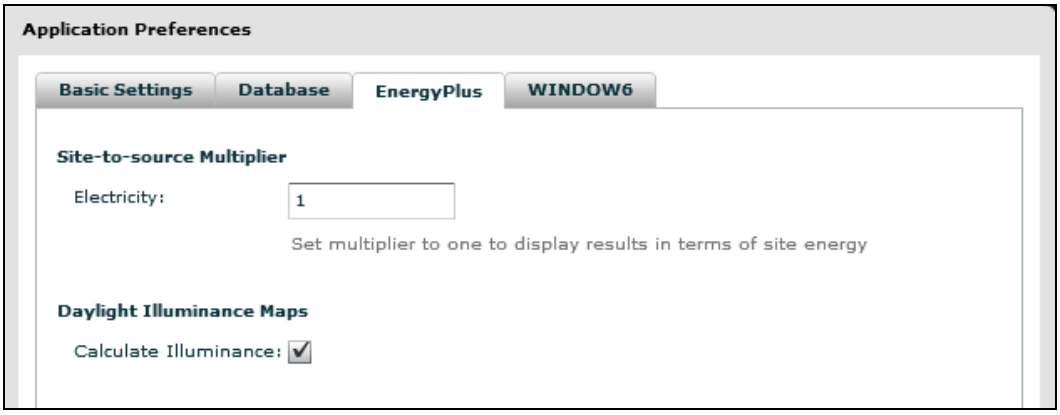


Figure 4-61. Enabling the daylight illuminance map calculation

4.6. Natural ventilation

COMFEN allows the user to model the effect of natural ventilation in single-sided zones, i.e. zones with window openings on one elevation. When the natural ventilation option is selected, COMFEN will automatically model the scenario without mechanical cooling. It is thus not possible to model mixed-mode scenarios, i.e. scenarios where natural ventilation is used in combination with mechanical cooling. Before using the natural ventilation feature, it is recommended that the user first read this entire section and thoroughly familiarize themselves with the assumptions as well as the limitations of the natural ventilation module.

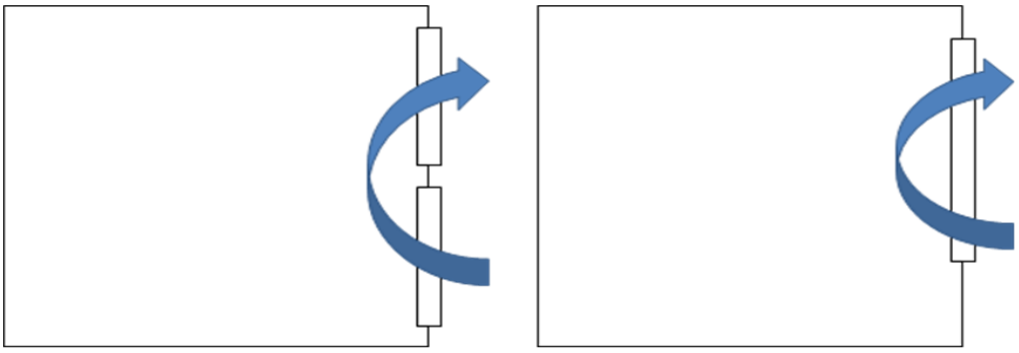


Figure 4-62. Sections showing two possible single-sided ventilation scenarios in COMFEN

4.6.1. Assumptions

There are several assumptions related to the geometry of the building, site, HVAC, and window implicit in the COMFEN natural ventilation model:

1. Window operation is entirely automated and optimized in terms of energy performance. It does not reflect how occupants actually operate windows in buildings. The operation sequence of the windows is described in more detail below.
2. Cooling is disabled for the whole year when natural ventilation is enabled.
3. The default effective open areas for predefined operable window types do not take into consideration the effect of insect screens on air flow.
4. The target space temperature for assessing thermal comfort is assumed to be the same as for a mechanically-cooled building, i.e. the upper threshold is equal to the cooling setpoint.
5. Wind speeds are calculated assuming that the space is located on the 4th floor of the building – 32. 8 ft (10 m) above ground level, half-way between the scenario floor and ceiling.
6. The wind pressure coefficients used in the model were sourced from Chapter 16 of the 2004 ASHRAE Handbook of Fundamentals.
7. The zone is located on the 4th floor of a low-rise building (building height is less than three times its width), 10 m (32.8 ft) above ground level.
8. The building is assumed roughly square in plan and is located in a suburban area.

4.6.2. Window operation

The operation of windows is controlled by the Energy Management System (EMS). Once open, window opening size is incrementally adjusted at defined timesteps in order to optimize energy performance while meeting basic occupant comfort requirements. The window control model implemented in COMFEN is a highly optimized model that is representative of an automated control system.

The following points describe the window control sequence in more detail:

1. There is no schedule for window operation; windows can open at any hour if the criteria for opening windows are met.
2. Windows open whenever the indoor temperature exceeds 73.4 F (23 °C) Windows open whenever the indoor temperature exceeds 73.4 F (23 °C) provided that the outdoor air is cooler than the indoor air. Windows close when indoor temperature falls below 73.4 F (23 °C).
3. Once open, the window opening size may be adjusted to reduce thermal discomfort due to cool incoming air based on the temperature difference between inside and outside:

   < 41 F (5°C) windows are open at 100%

   41 – 59 F (5 - 15°C) window opening size modulates between 100 and 30%

   > 59 F (> 15°C) windows are open at 30%

   This is illustrated in the figure below. The venting open factor represents the unobstructed portion of the open window area.

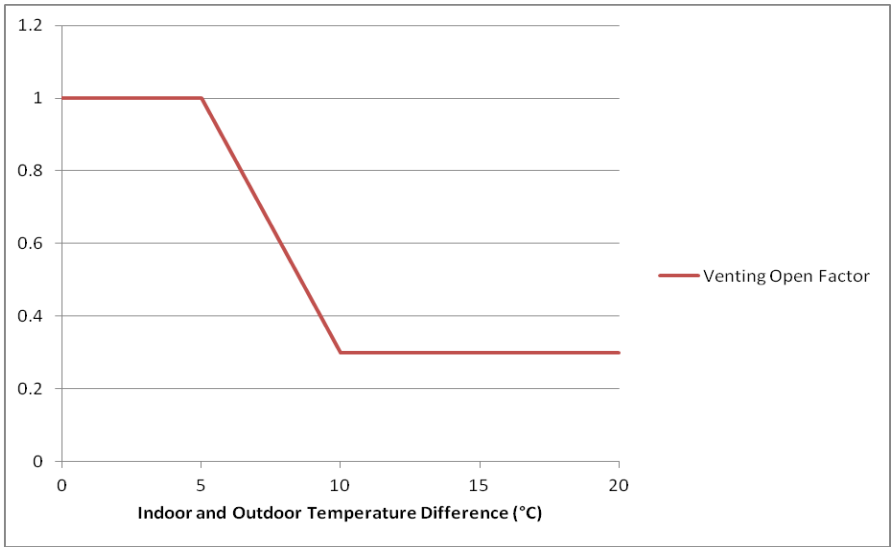


Figure 4-63. Relationship between indoor outdoor temperature difference and window venting open factor

4. In order to prevent occupant discomfort due to drafts, window opening size is modulated to ensure that air speed at the window is below 1 m/s (3.3 ft/s). Air speed at the window is approximated by dividing the volume flow rate of air through each window by the window opening area. If the resulting speed does not exceed 0.7 m/s (2.3 ft/s), windows remain fully open. If the speed is greater than 5 m/s (16.4 ft/s), windows close. At all other speeds the windows modulate between 100% and 70% open.
5. It is assumed that ventilation through the windows is sufficient to meet space requirements for fresh air, so when windows are open, fans and economizer are off unless additional air for cooling is required. If windows are closed, fans and economizer operate as they would in a non-naturally-ventilated scenario.
6. If windows are open yet additional outside air is required to cool the space (i.e. indoor temperature exceeds target for two consecutive timespteps), the fan turn ons, but only if the windows are open at 100% (i.e. the difference between inddor and outdoor temperature is < 5°C).
7. Heating is allowed to run concurrently with natural ventilation, i.e. while the windows are open.

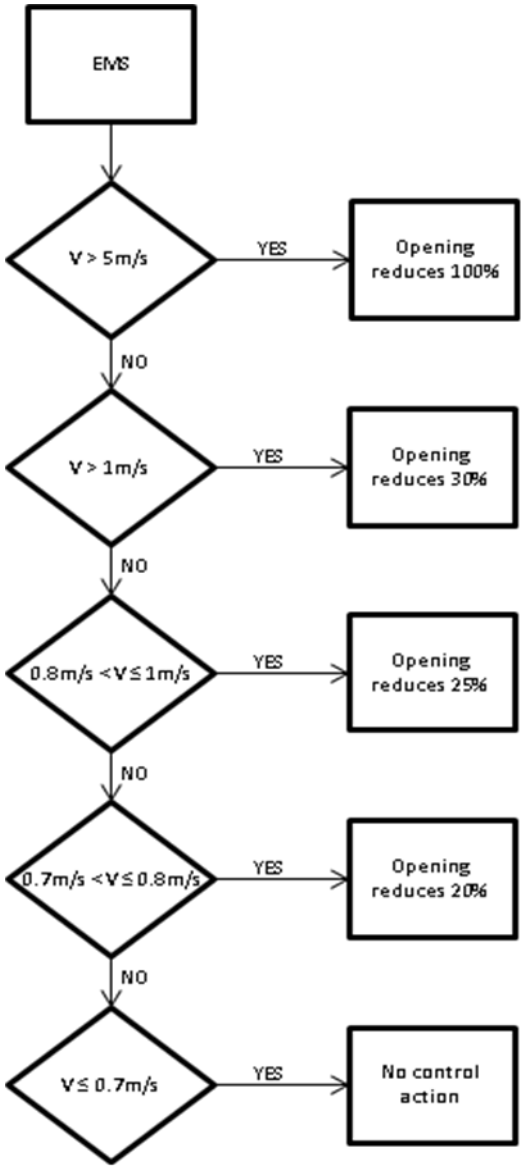


Figure 4-64. Schematic of control sequence for window modulation based on indoor airspeed

4.6.3. Limitations

The COMFEN natural ventilation model has several limitations:

1. Mechanical cooling cannot be modeled in conjunction with natural ventilation.
2. The natural ventilation model does not account for the impact of exterior projections (overhangs and fins, open operable sashes of windows, etc.) on air flow. While the user is allowed to model shading systems and exterior projections (such as overhangs and fins) in conjunction with natural ventilation, they should be aware that COMFEN does not model their impact, so air flow may thus be overestimated. This also applies to the open operable sash of hinged windows (casement, awning, and hopper, etc.) In order to ensure that air flow is not overestimated in scenarios with shading or exterior projections, the user may want to consider applying a factor to the window effective open area. Similarly, since the impact of insect screens is presently not factored in the effective open area of the different operating types, the user may want to again apply a factor to the EOA value to account for the insect screen.
3. Thermal and optical performance of partially- or fully-open windows is not fully accounted for in the energy model, i.e. the model does not adjust operable window solar and visible light transmittance at times when the window is open. As a result, the visible light transmittance and solar radiation transmitted by the window may be somewhat under- or overestimated at times.

4.6.4. Creating a scenario with natural ventilation

In order to simulate a scenario with natural ventilation, the user has to first define which windows are operable and then check the natural ventilation checkbox under the scenario tab under the scenario edit screen.

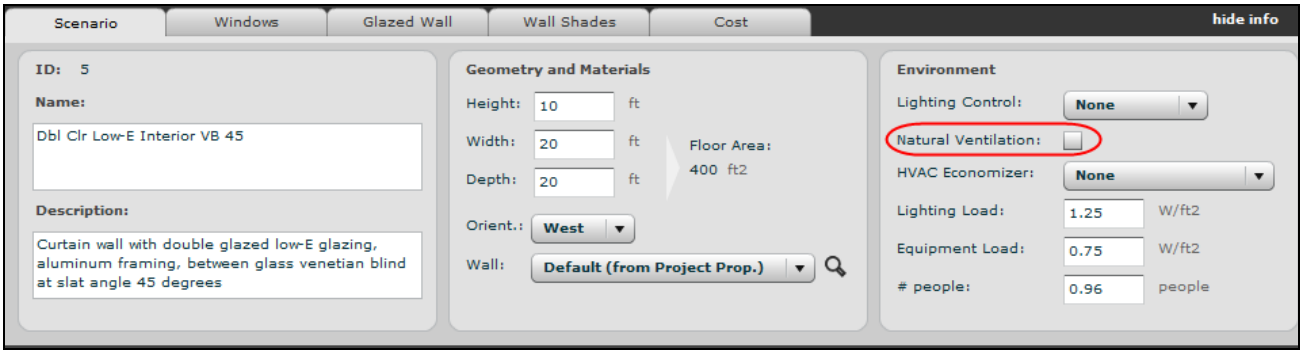


Figure 4-65. Natural ventilation checkbox in the Scenario Edit view

Adding an operable window to a scenario

Operable windows can be defined in two ways:

1. By adding a predefined operable window from the window library to the scenario.
2. By editing a specific scenario window under the scenario edit window.

To define an operable window in the window library, the user creates a window just as they would a fixed window and then specify an operable window type under the "operating type" pull-down under the window tab. Options include hinged windows (casement, awning and hopper windows) and two sliding windows (horizontal slider and single-hung). The operating types are differentiated by effective open area and by the position of the effective opening with respect to the window (discussed in more detail below). Depending on the option selected, a different value is displayed in the effective open area dialog box below the "operating type" pull-down.

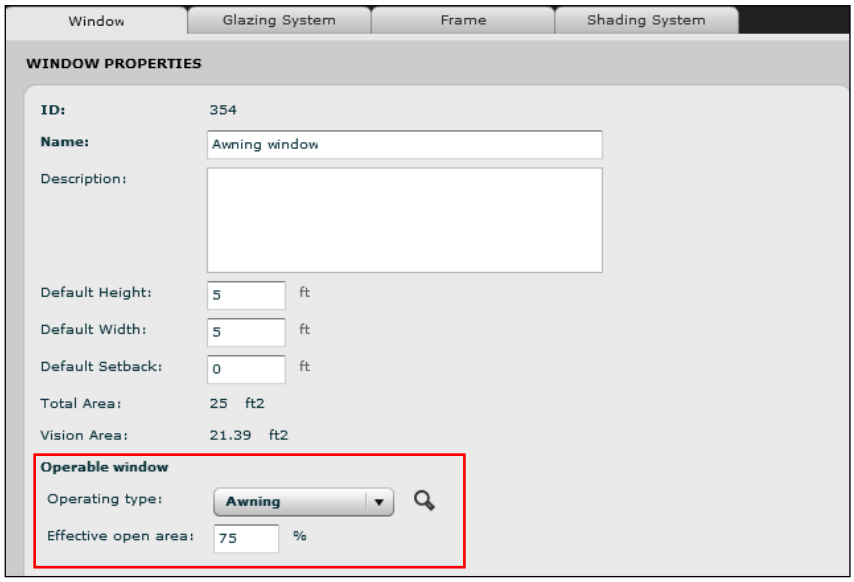


Figure 4-66. Creating of an operable window in the window library

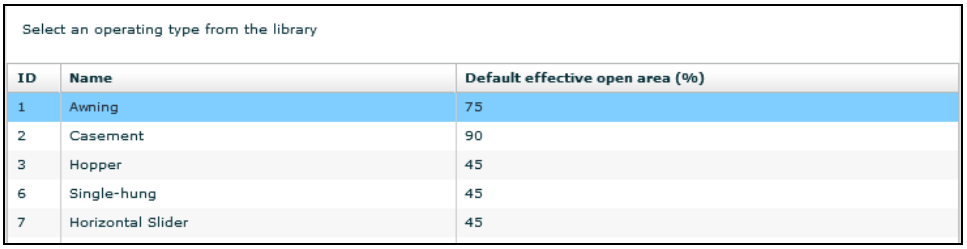


Figure 4-67. Window Operating types

Operating type can also be specified after the user creates a window in a scenario. For scenarios with punched windows, operating type is specified under the window edit dialog box where the user can select an option from the "operating type" pull-down. To define the operating type for scenarios with glazed wall assemblies, left-click to highlight a lite and then right-click and select "set operating type" to pull up a dialog box with the list of operating types. See section 4.2. *Facade components and libraries* for more information on creating operable windows for punched windows and glazed wall assemblies.

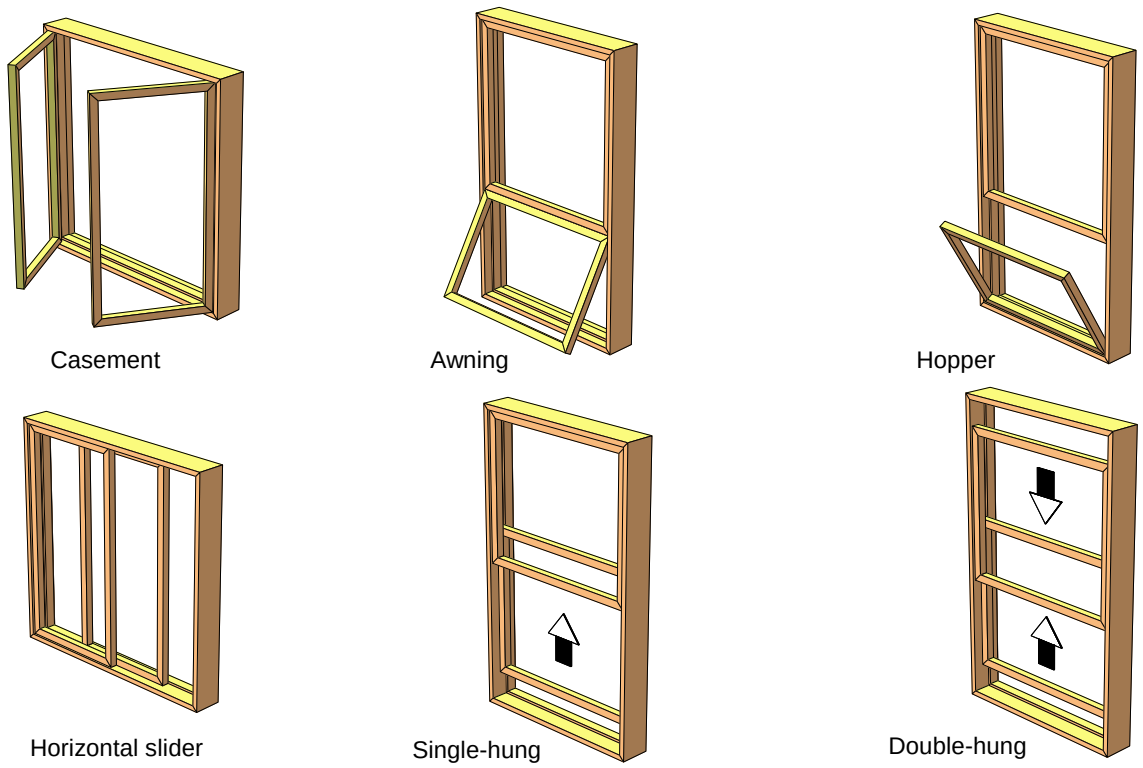


Figure 4-68. Window Operating types

Window effective open area

The effective open area (EOA) describes the portion of the opening area that is open (i.e. not obstructed by glazing and operable sashes of windows) and is calculated as follows:

EOA = width $_{eff}$ x height $_{eff}$ / window area [%]

where

window area = window height x window width and includes glazing and frame area

width $_{eff}$ is the effective opening width (see diagram below)

height $_{eff}$ is the effective opening height (see diagram below)

The diagram below illustrates that the vertical projection of the operable sash unto the window delineates the edge of the open area.

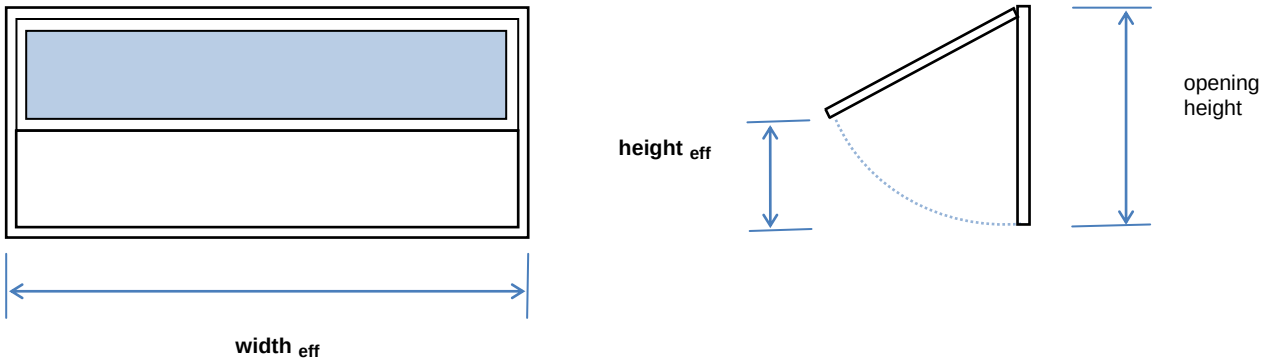


Figure 4-69. Effective opening width and height

The position of the opening is determined based on the position of the window and it is assumed that the lower left-hand corner of the opening coincides with the lower left-hand corner of the window when looking at the scenario in elevation view for all operating window types except hoppers, where the upper left-hand corner of the opening coincides with the upper left-hand corner of the window.

NOTE: *The width of the window frame is not considered when calculating the position of the opening – the corner of the opening always coincides with the outer corner of the frame regardless of the width of the frame.*

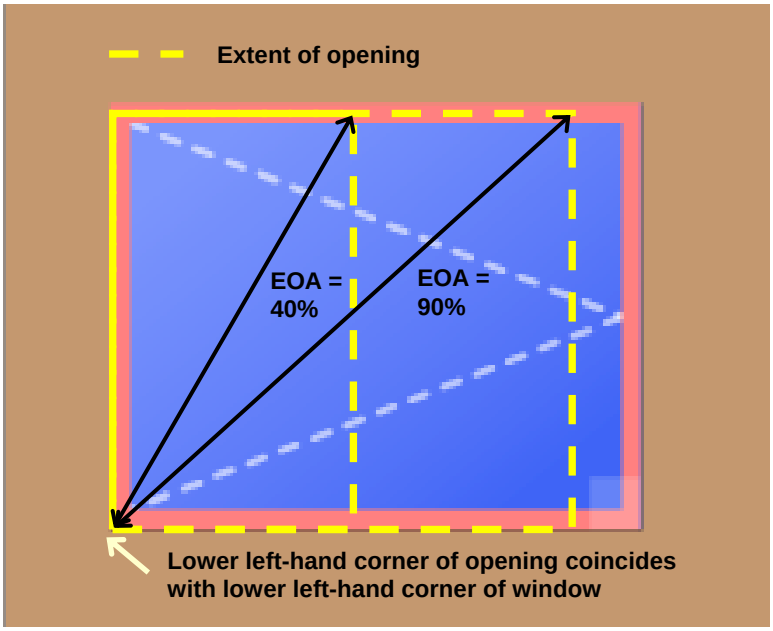


Figure 4-70. Position of effective opening relative to window area (casement window)

The width and height of the opening are determined in accordance with the operating window type, where one of the dimensions is held fixed. For example, for a casement window, changing the EOA affects the width of the window while the height of the opening is held fixed (equal to the height of the window). The diagram below illustrates how the value of EOA and the position of the opening varies with the different operating window types. The EOA values listed are the default values used in COMFEN however the user can override these by inputting a custom EOA value under the window edit screen.

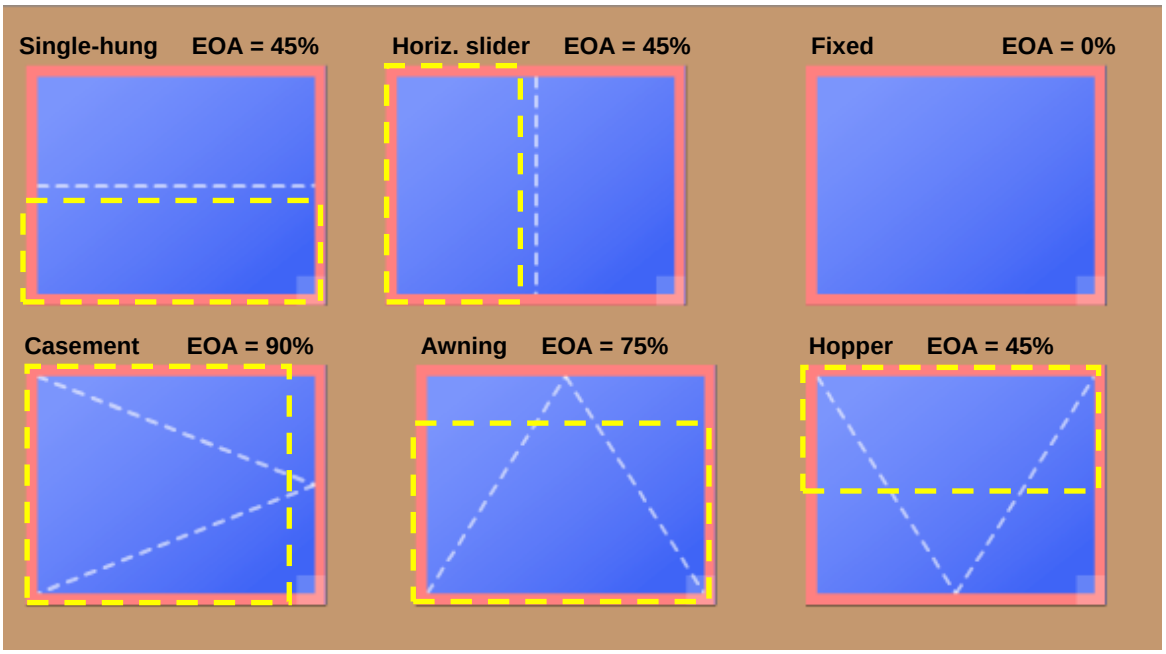


Figure 4-71. Default effective open areas for different window types

4.6.5. References

1. ASHRAE (2004). *2004 ASHRAE Handbook – Fundamentals*, Chapter 16, Air Flow Around Buildings, Atlanta: American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc.
2. Chandra, S., Fairey, P., & Houston, M. (1986). *Cooling with ventilation*. A Product of the Solar Technical Information Program, Published by the Solar Energy Research Institute. Publication number FSEC-CR-1658-86. Cape Canaveral, Florida: Florida Solar Energy Center. Retrieved from http://www.fsec.ucf.edu/en/publications/pdf/FSEC-CR-1658-86.pdf
3. Chandra, S. (1983). *A Design Procedure to Size Window for Naturally Ventilated Rooms*. Cape Canaveral, Florida: Florida Solar Energy Center.
4. *Selecting Windows for Energy Efficiency* (1997). DOE/GO-DE-AC03-76SF00098. U.S. Department of Energy. Retrieved from: http://windows.lbl.gov/pub/selectingwindows/window.pdf

4.7. Cost calculation

A simple cost model is incorporated into COMFEN to help the user compare the economic feasibility of different scenarios. Basic cost data obtained from R.S. Means and ASHRAE documentation is provided for the following components:

- Glass layers
- Gases
- Frames
- Glazing systems
- Shading systems
- Window systems
- HVAC system
- Lighting and lighting controls

Assumptions for specific systems and components are discussed below.

4.7.1. Overview

1. All costs listed throughout the COMFEN interface include a material and labor cost, i.e. the cost of all components and systems is the *installed* cost and includes a 30% markup to account for contractor and subcontractor costs. This applies to both total costs listed in the scenario cost tab as well as component costs listed in the libraries.
2. After total project cost has been calculated, it is multiplied by a location-specific adjustment factor to account for variation in construction costs. The resulting value is called the "Adjusted cost." Since this adjustment is location-specific, none of the component costs in the libraries are adjusted. This adjustment is made under the scenario's cost tab.
3. Costs for glass, gas, frame, glazing, and shading are listed **per unit window area**, i.e. area of the window rough opening. Lighting and HVAC costs are listed **per unit floor area**.
4. Costs for opaque wall construction and exterior projections (overhangs and fins) are not available.

The user can override the cost of most components by inputting their own value. Since the current cost data is only approximate, it is recommended that the user input their own data whenever possible. The cost toggle icon in the menu bar –  , determines if the total scenario cost is displayed in the upper left corner of the scenario view.

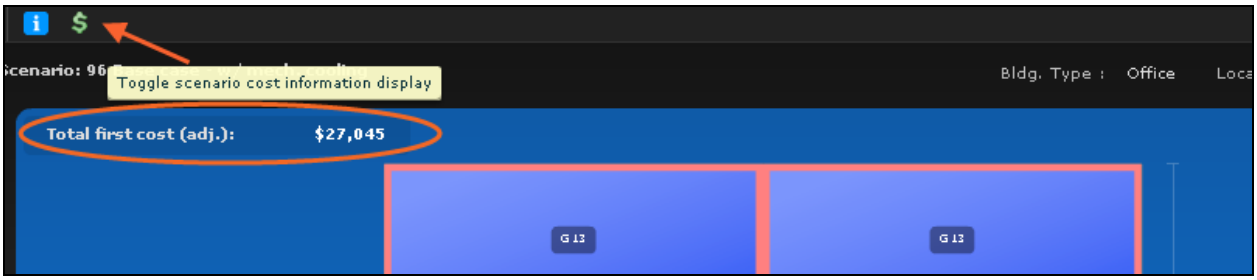


Figure 4-72. Cost toggle icon

4.7.2. Component cost assumptions

Glass layer cost

NOTE: *COMFEN glass layer costs assume 6 mm glass and do not account for varying thicknesses of glass.*

Present glass layer unit costs, C_{glass} ($/ft² window), are approximate and provided in terms of a baseline glass (6 mm clear uncoated glass) cost – 10.70 $/ft² (115.17 $/m²). An incremental cost is added to the baseline glass cost for to account for additional cost premiums (based on the data provided in the table below):

$$C_{glass} = C_{glass\ base} + C_{glass\ inc} = 10.70\ \$/ft^2 + C_{glass\ inc} \qquad [\$/ft^2\ \text{window area}]$$

Table 4-3. Glass layer incremental costs

Baseline glass (6mm clear uncoated glass) cost is 5.35 $/ft2 (57.59 $/m2). To calculate total glass cost, add incremental cost to baseline glass cost.

	Glass characteristic	Notes	Incremental cost ($/ft2 of window)	Incremental cost ($/m2 of window)
1	Clear		+$0.00	+$0.00
2	Tinted	Green, bronze, gray	+$0.82	+$8.83
3	High-performance tint	Green, blue	+$1.92	+$20.67
4	Reflective	Pyrolitic or sputter coating on clear glass	+$4.11	+$44.24
5	Reflective on Tint	Pyrolitic or sputter coating, all tints	+$6.31	+$67.92
6	Low-E	Pyrolitic or sputter coating on clear glass	+$1.10	+$11.84
7	Tint + low-e	All tints, all low-e types	+$2.74	+$29.49
8	Sunbelt low-e	Sunbelt Low-e	+$1.92	+$20.67
9	Suspended film	Mylar film with low-e coating	+$10.97	+$118.08
10	Double suspended film	Double film and special edge treatment	+$21.95	+$236.57

The default glass cost can be modified by checking the override box in the Edit glass dialog box and inputting a custom value in the field. The "Type" drop-down determines the incremental cost (or premium) added to the base glass cost based on the values listed in the table.

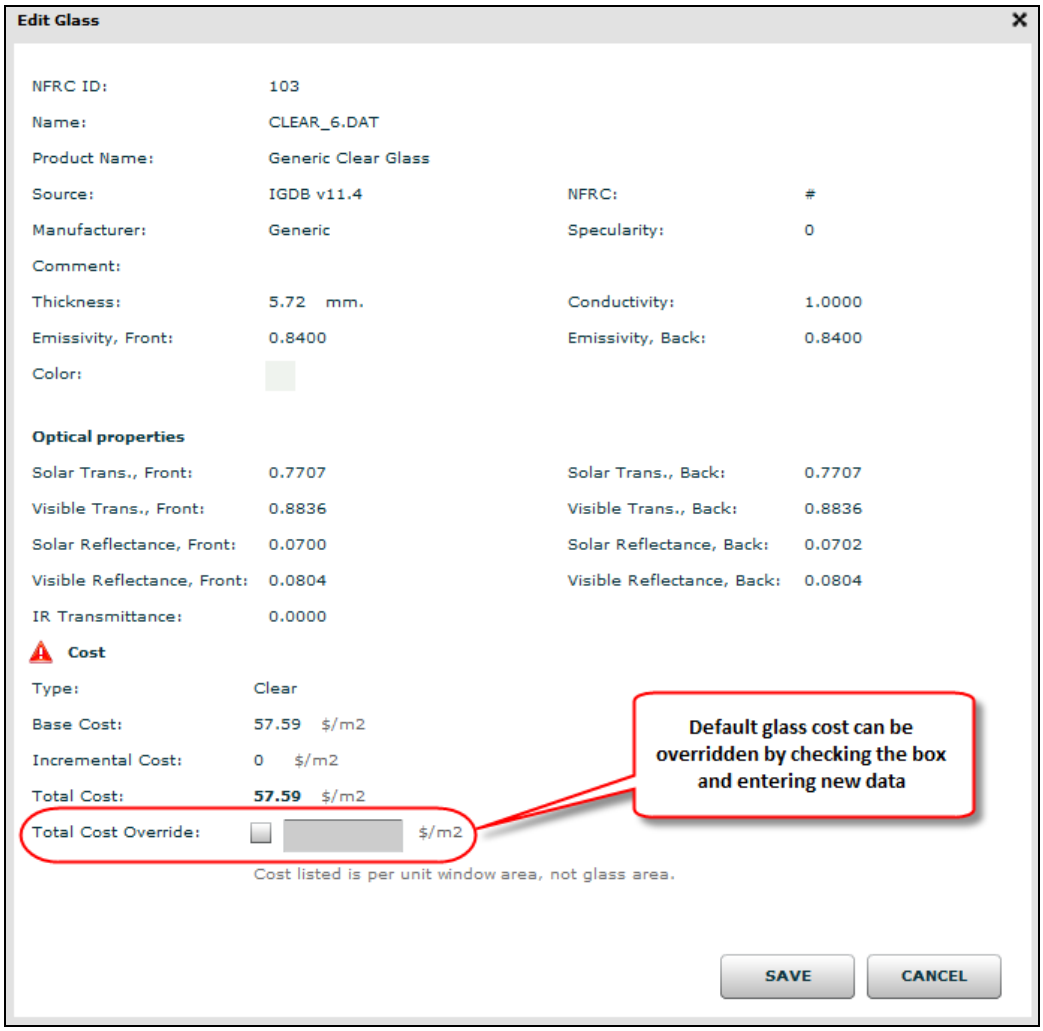


Figure 4-73. Edit glass dialog box, whre the default glass cost can be overridden

Gas layer cost

Gas costs are listed per unit window area. The gas costs assume 2′-6″ by 4′-0″ glazing and the gap thicknesses listed in the table below.

NOTE: *Cost per unit area values are fixed, i.e. they* ***are not adjusted*** *depending on gap thickness.*

Table 4-4. Gas layer widths

ID	Gas	Gap width (in.)	Gap width (mm)	$/ft^2	$/m^2
1	Air	1/2"	12.70	$0.00	$0.00
2	Argon	1/2"	12.70	$1.00	$10.78
3	Krypton	5/16"	7.94	$5.50	$59.17
4	Xenon	1/4"	6.35	$21.83	$234.92
6	Air (5%) / Argon (95%) Mix	1/2"	12.70	$0.95	$10.24
7	Air (12%) / Argon (22%) / Krypton (66%) Mix	5/16"	7.94	$3.77	$40.53
8	Air (5%) / Krypton (95%) Mix	5/16"	7.94	$5.22	$56.21
9	Air (10%) / Argon (90%) Mix	1/2"	12.70	$0.90	$9.70

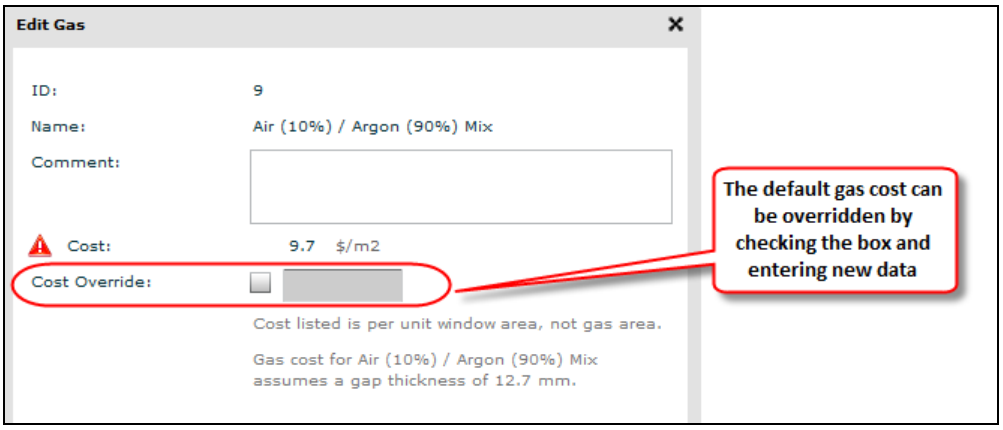


Figure 4-74. Edit gas dialog box, where the default gas cost can be overridden.

Glazing system cost

Glazing system unit cost (in $/ft² window area) is calculated based on glass layer, gas layer and fabrication cost:

$$C_{glz\ sys} = (C_{glass\ 1} + \ldots + C_{glass\ n}) + (C_{gas\ 1} + \ldots + C_{gas\ n}) + \text{fabrication cost} \qquad [\$/ft^2 \text{ window area}]$$

Where

$C_{glass\ 1} + \ldots + C_{glass\ n}$ is the combined cost of individual glass layers [$/ft² window area]

$C_{gas\ 1} + \ldots + C_{gas\ n}$ is the combined cost of individual gas layers [$/ft² window area]

Fabrication cost is the additional cost (per unit area of window area) associated with the making of an insulated glazing system; it includes the cost of an aluminum spacer and fabrication:

Single glazing = $0/ft²

Double glazing = $5.49/ft²

More than two glass layers = $2.74/ ft² for each additional glazing layer

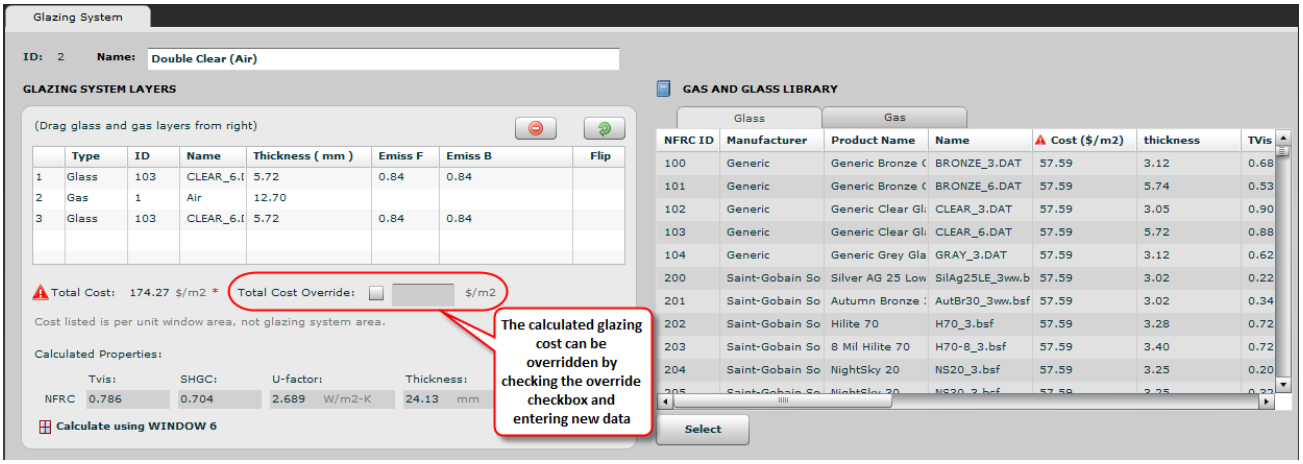


Figure 4-75. Glazing system edit screen, where the calculated cost can be overridden.

Frame cost

Similar to other window component cost data, frame cost, C_{frame}, is listed per unit window area, i.e. area of the window rough opening. User should note that frame costs are approximate – costs do not change if area of framing is increased since the framing cost is per unit window area, not frame area.

Windows | Glazing Sys. | Shading Sys. | Frames | Glass | Gas | Walls | Spandrels | Materials | Locations

ID	Name	Frame U-factor (Btu/h-ft2-	Width (PFD) (in.)	Description	Type	Cost ($/ft2)	Color	Absorptivity	Source
1	Al w/break	1.00	2.25	Aluminum Frame	Metal with thermal break	42.49		0.9	GENERIC
3	Wood	0.40	2.75	Wood Frame	Reinforced vinyl/wood	46.61		0.9	GENERIC
4	Vinyl	0.30	2.75	Vinyl Frame	Reinforced vinyl/wood	46.61		0.9	GENERIC

Figure 4-76. Frame Library List View

The user can override the cost of framing by checking the cost override checkbox under the *Edit frame* dialog box and inputting a custom value.

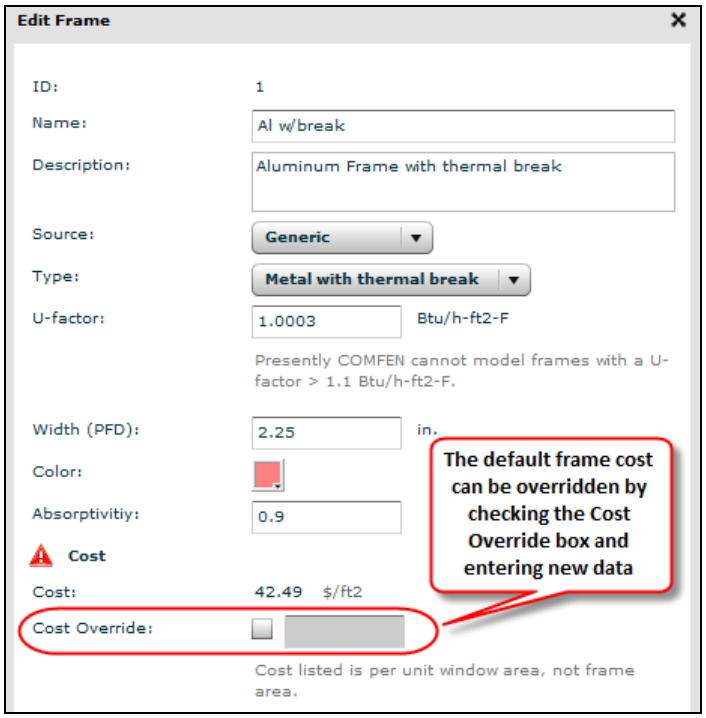


Figure 4-77. Frame Library Detailed View, where the default cost can be overridden.

Spandrel cost

Glazed wall assembly spandrel costs are approximated due to lack of adequate cost data. One of two fixed numbers – $80/ft² and $50/ft² is assumed for spandrels with and without glazing, respectively. These costs assume a "standard" spandrel construction: exterior cladding, air space, metal backpan, 4" of insulation and interior finish. The cost for the spandrel is not adjusted if any of these layers change.

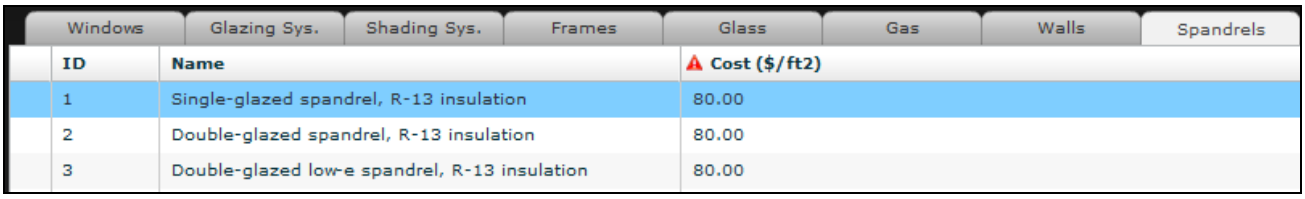


Figure 4-78. Spandrel Library List View

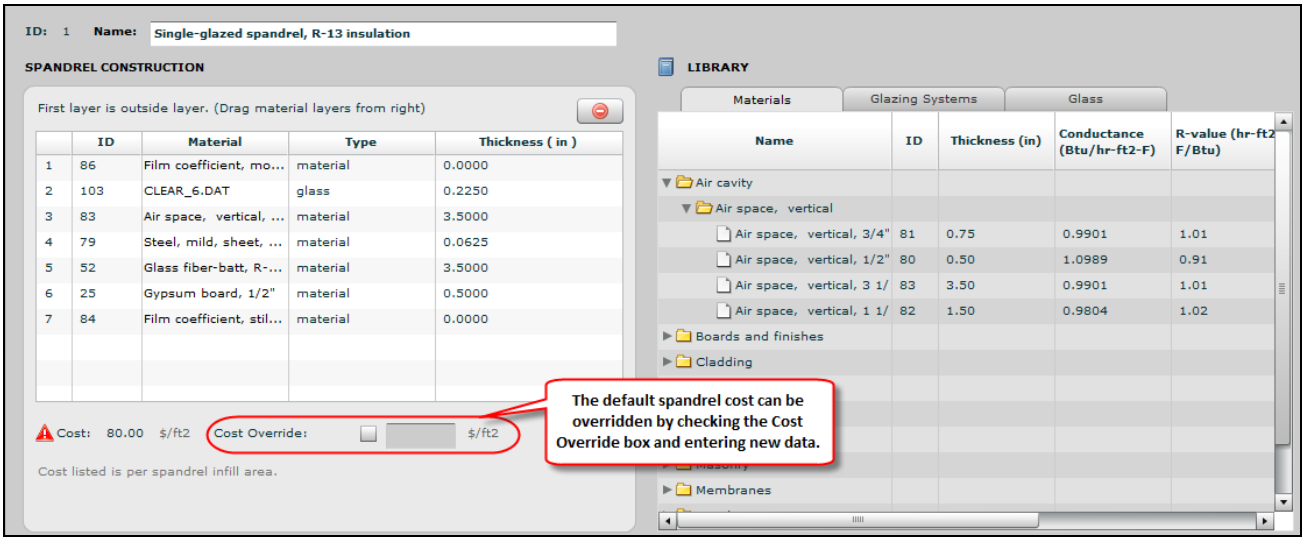


Figure 4-79. Spandrel Library Detailed View where the default cost can be overridden

Shading system cost

Shading system cost, $C_{shad\ sys}$ ($/ft² window area) is calculated based on shading system type (venetian blind, roller shade and screen), shading position (interior, exterior, inbetween glazing) and presence of automated shading systems controls. The cost of the shading system is calculated as follows:

$$C_{shad\ sys} = C_{shad\ device} + C_{control} \qquad [\$/ft^2\ window\ area]$$

Where

$C_{shad\ device}$ shading device cost [$/ft² window area]

$C_{control}$ shading system control cost [$/ft² window area]

Venetian blind device costs presently do not vary by slat depth – it is assumed that interior blinds have a 1″-deep slat while exterior blinds have a 3″-deep slat. Exterior metal screen cost represents the cost of a mid-range metal architectural screen.

The user can override the shading device and/or control cost under the shading system edit screen.

Windows | Glazing Sys. | Shading Sys. | Frames | Glass | Gas | Walls | Spandrels | Materials

ID	Name	Type	Location	Control Type	Cost ($/ft2)
1	RS -- exterior -- light-colored	shade	exterior	Always on	42.95
2	RS -- exterior -- medium-color	shade	exterior	Always on	42.95
3	RS -- exterior -- dark-colored	shade	exterior	Always on	42.95
4	RS -- interior -- light-colored	shade	interior	Always on	28.63
5	RS -- interior -- medium-colore	shade	interior	Always on	28.63
6	RS -- interior -- dark-colored	shade	interior	Always on	28.63
7	RS -- between-glass -- light-col	shade	between-glass	Always on	31.89
8	RS -- between-glass -- mediun	shade	between-glass	Always on	31.89
9	RS -- between-glass -- dark-co	shade	between-glass	Always on	31.89
10	VB -- exterior -- 3" slat (90 deg	venetian blind	exterior	Always on	130.00
11	VB -- exterior -- 3" slat (45 de	venetian blind	exterior	Always on	130.00
12	VB -- exterior -- 3" slat (0 deg)	venetian blind	exterior	Always on	130.00
13	VB -- interior -- 1" slat (90 deg	venetian blind	interior	Always on	35.10
14	VB -- interior -- 1" slat (45 deg	venetian blind	interior	Always on	35.10
15	VB -- interior -- 1" slat (0 deg)	venetian blind	interior	Always on	35.10
16	VB -- between-glass -- 0.45" sl	venetian blind	between-glass	Always on	40.14
17	VB -- between-glass -- 0.45" sl	venetian blind	between-glass	Always on	40.14
18	VB -- between-glass -- 0.45" sl	venetian blind	between-glass	Always on	40.14
19	Screen -- exterior -- dark-color	screen	exterior	Always on	97.50
20	Screen -- exterior -- dark-color	screen	exterior	Always on	97.50
21	Screen -- exterior -- dark-color	screen	exterior	Always on	97.50

Figure 4-80. Shading System Library List View

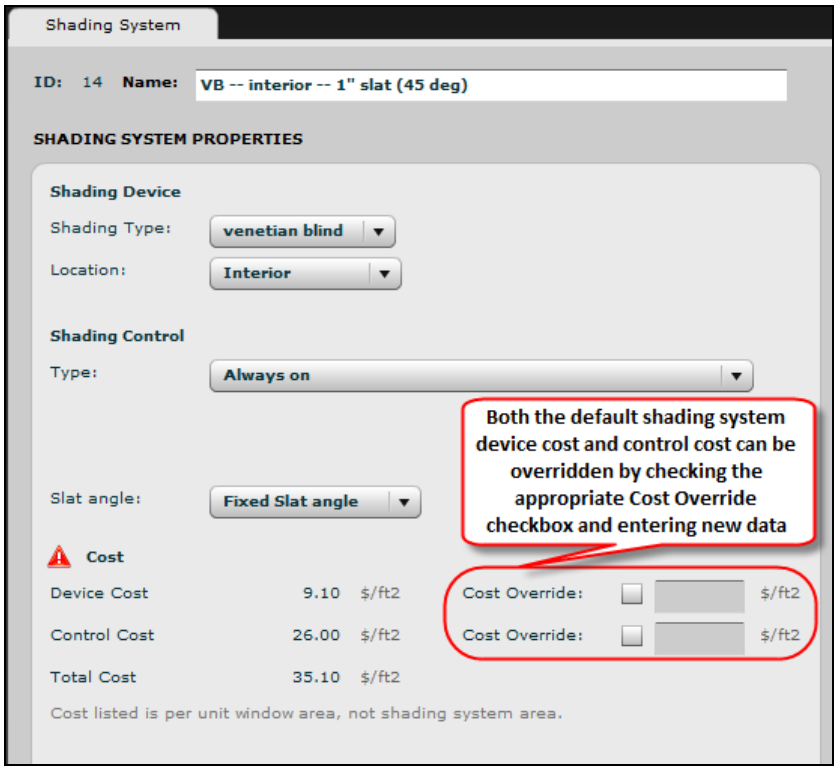


Figure 4-81. Shading System Detailed View where the default costs can be overridden.

Window cost

Window cost is the sum of the frame, glazing and shading system costs. The cost of the window is calculated as follows:

$C_{win} = A_{win} \times (C_{frame} + C_{shad\ sys} + C_{glz})$ [$/window]

Where

A_{win} Area of rough opening (includes frame area) [ft²]

C_{frame} Unit frame cost [$/ft² window area]

$C_{shad\ sys}$ Unit shading system cost [$/ft² window area]

C_{glz} Unit glazing system cost [$/ft² window area]

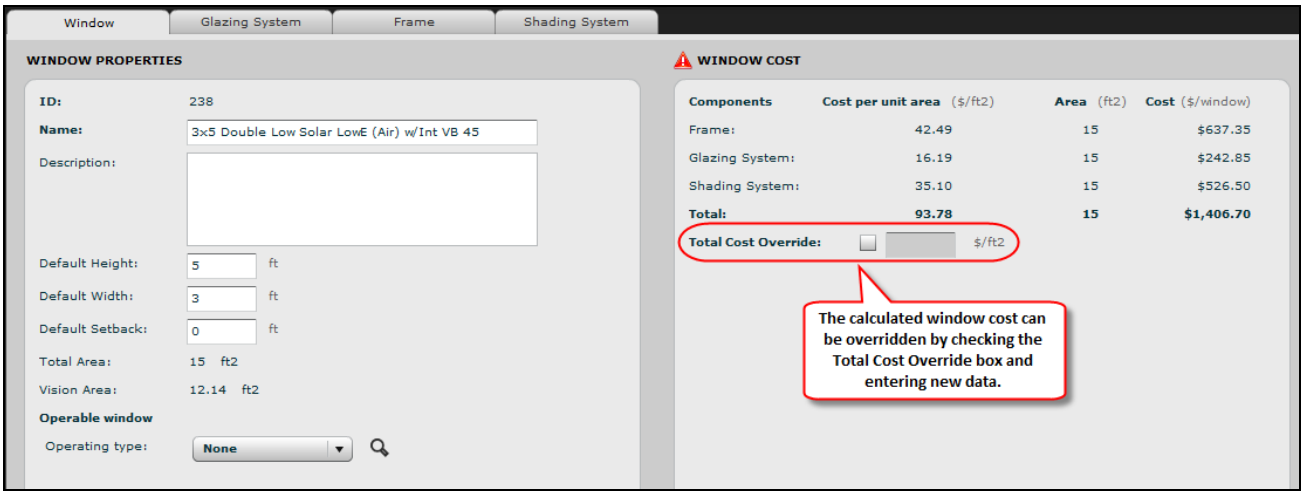


Figure 4-82. Window Detailed View, which can be used to override the calculated cost value.

HVAC cost

HVAC system costs are determined based on heating and cooling equipment size. Thus, in order to obtain HVAC system costs, the user must first calculate the scenario so that the program can determine the equipment sizing. Equipment costs are then calculated by multiplying the following default unit costs by the equipment size:

- Heating equipment: 20.80 $/kBtu-hr (70.97 $/kW)
- Cooling equipment: 939.73 $/ton (267.27 $/kW)

Similar to other default cost values in COMFEN, the default HVAC equipment costs can be overriden by the user under the cost tab in the Project Properties dialog box.

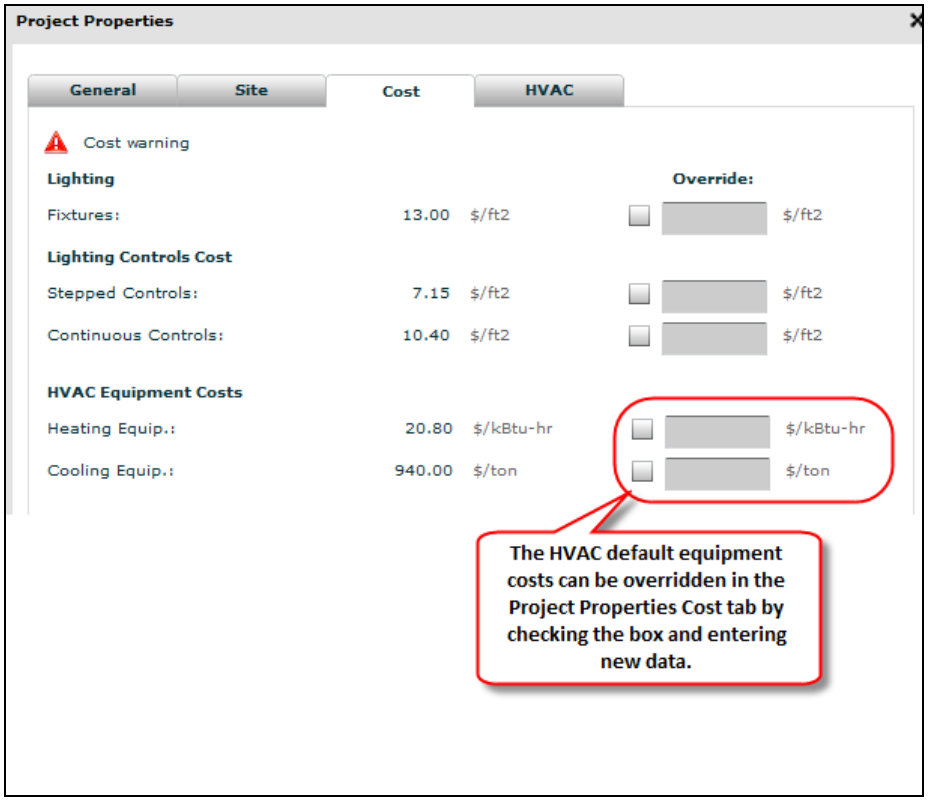


Figure 4-83. The default HVAC equipment costs can be overridden in the Project Properties Cost tab.

Lighting cost

Cost data for the lighting system is calculated as follows:

lighting power density, cost per lighting load specified by the user under the scenario tab:

$$C_{light\ sys} = A_{zone} \times (C_{fixture} + C_{control}) \qquad [\$]$$

Where

$C_{fixture}$	Fixture cost per unit floor area [W/ft²]
$C_{control}$	Control cost per unit floor area [W/ft²]
A_{zone}	Scenario floor area [ft²]

Lighting fixture and control costs can be overriden under the cost tab in the Project Properties dialog box.

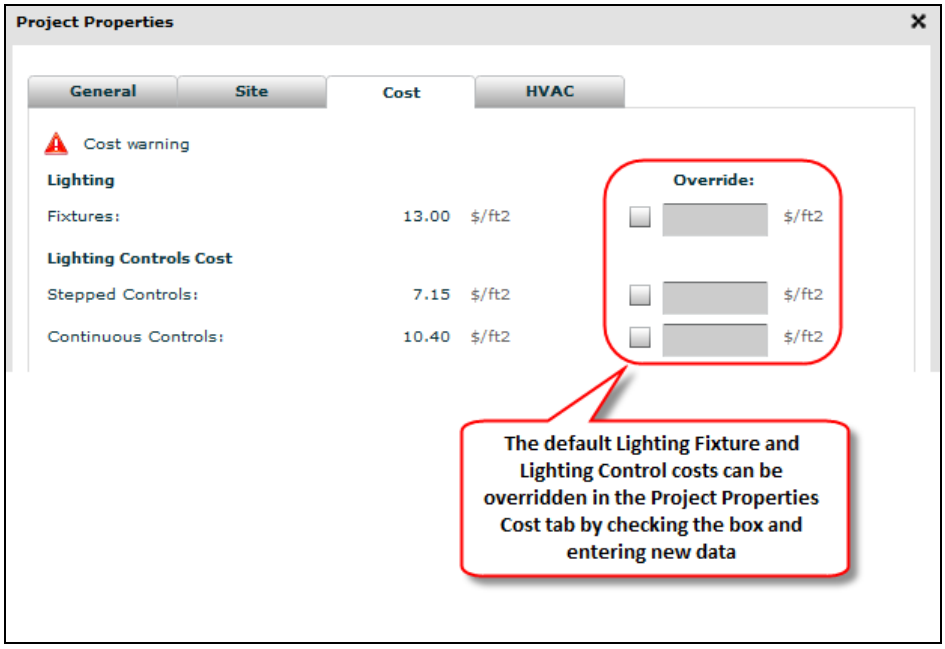


Figure 4-84. The default Lighting Fixture and Lighting Control costs can be overridden in the Project Properties Cost tab.

4.7.3. Cost Results

Under the Comparison > Cost tab there are three results tabs:

- First Cost
- Energy Cost
- Simple Payback

The default COMFEN database (comfen.sqlite) has a Cost Example Project, where three scenarios are defined:

- # 118 -- Single Clear (SHGC = 0.818, Tvis = 0.884)
- # 119 -- Double Clear Low E (Low SHGC - 0.288, High Tvis - 0.622)
- # 120 -- Double Clear Low E with continuous lighting controls

First Cost

The first cost is the initial cost of construction. In the case of COMFEN it is the installed cost of the HVAC equipment, the lighting fixtures and controls, windows and shading (exterior projections and opaque wall construction are not included in these costs at present), adjusted by location to account for the cost of construction. In order to account for variation in construction costs in different locations, the first cost includes an adjustment factor for the project location. The adjustment factors are defined in the Location Library.

The project first cost is calculated as follows:

$$FC_{Adj} = \text{Adj factor} \times (FC_{Light} + FC_{Win} + FC_{HVAC})$$

Where

Adj factor – location-specific construction cost adjustment factor

FC_{Light} - first cost of lighting fixtures and lighting controls ($)

FC_{Win} - first cost of windows and shading (excluding exterior projections) ($)

FC_{HVAC} - first cost of heating, cooling and ventilation equipment ($)

The figure below shows the Comparison > Cost > First Cost results for the Cost Example project.

The first cost of Scenario ID # 119 includes substituting high performance glazing for the single clear in the Base Case. The first cost of Scenario ID # 120 includes the cost of both the high performance glazing and continuous dimming lighting controls (based on daylighting levels in the space). The cost of the lighting controls is set to the default value of $10/sf, which is a cost potentially appropriate for a retrofit situation where rewiring is needed.

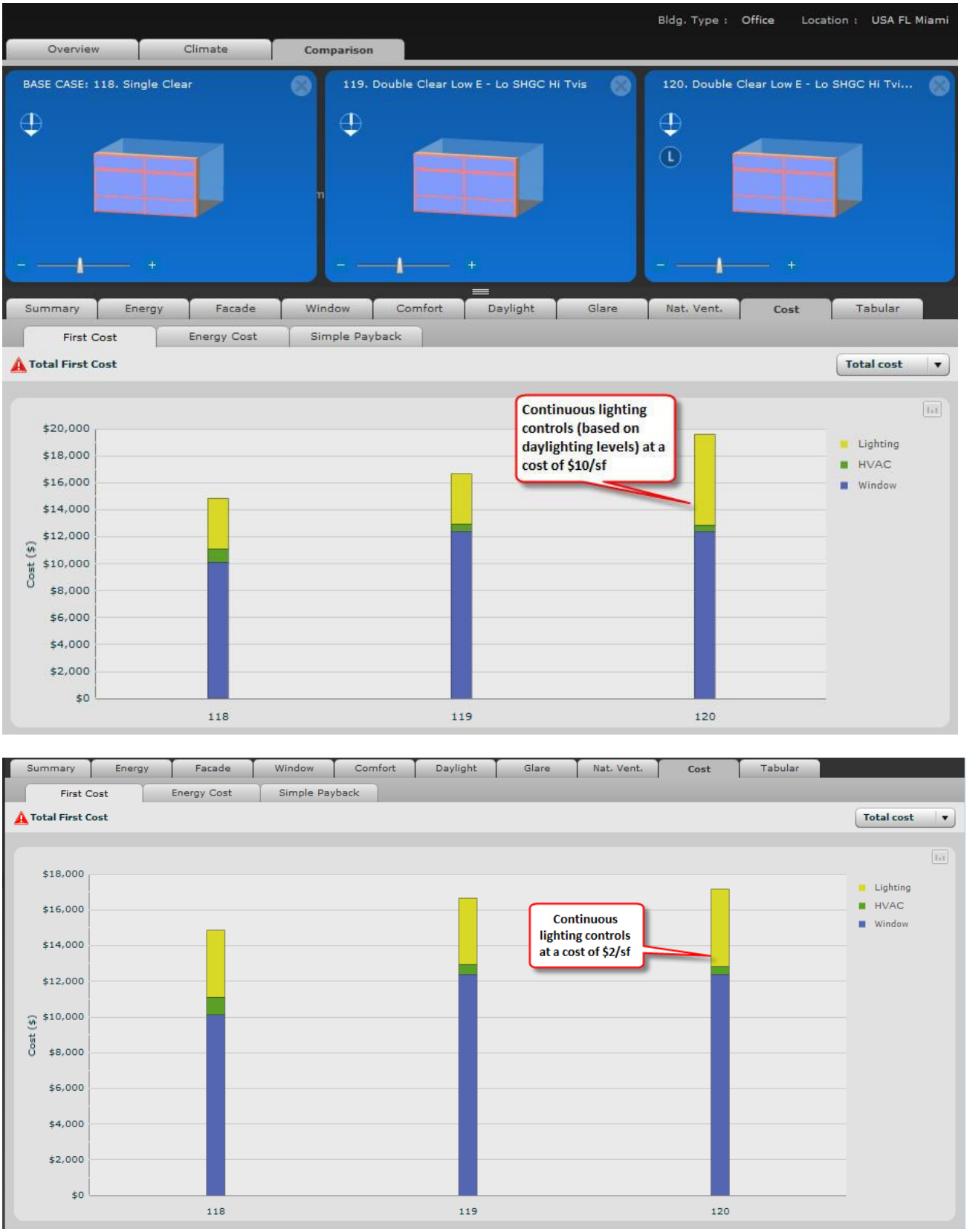


Figure 4-85. Two different first costs for the scenario with lighting controls – the top is based on $10/sf (potential cost for retrofit rewiring) and the bottom is based on $2/sf (potential cost for new construction).

Energy cost

Annual energy cost in COMFEN is the sum of the annual cost of gas and electricity consumed by the scenario. Due to differences in the cost of natural resources, the electric and gas rates vary by location. These utility rates are stored in the location library.

The project energy cost is calculated as follows:

$$EC = r_{elec} \times E_{elec} + r_{gas} \times E_{gas}$$

Where

EC – annual energy cost ($)

r_{elec} – electricity rate ($/kWh)

r_{gas} – gas rate ($/m^3 or $$/therm)

E_{elec} – annual electricity consumption (MJ or kBtu)

Egas – annual gas consumption (MJ or kBtu)

The figures below show the Energy Cost for the three scenarios in the Cost Example project. Note that the energy cost for the third scenario reflects reductions in cooling and fan energy due to the reduced lighting energy use because of the lighting controls.

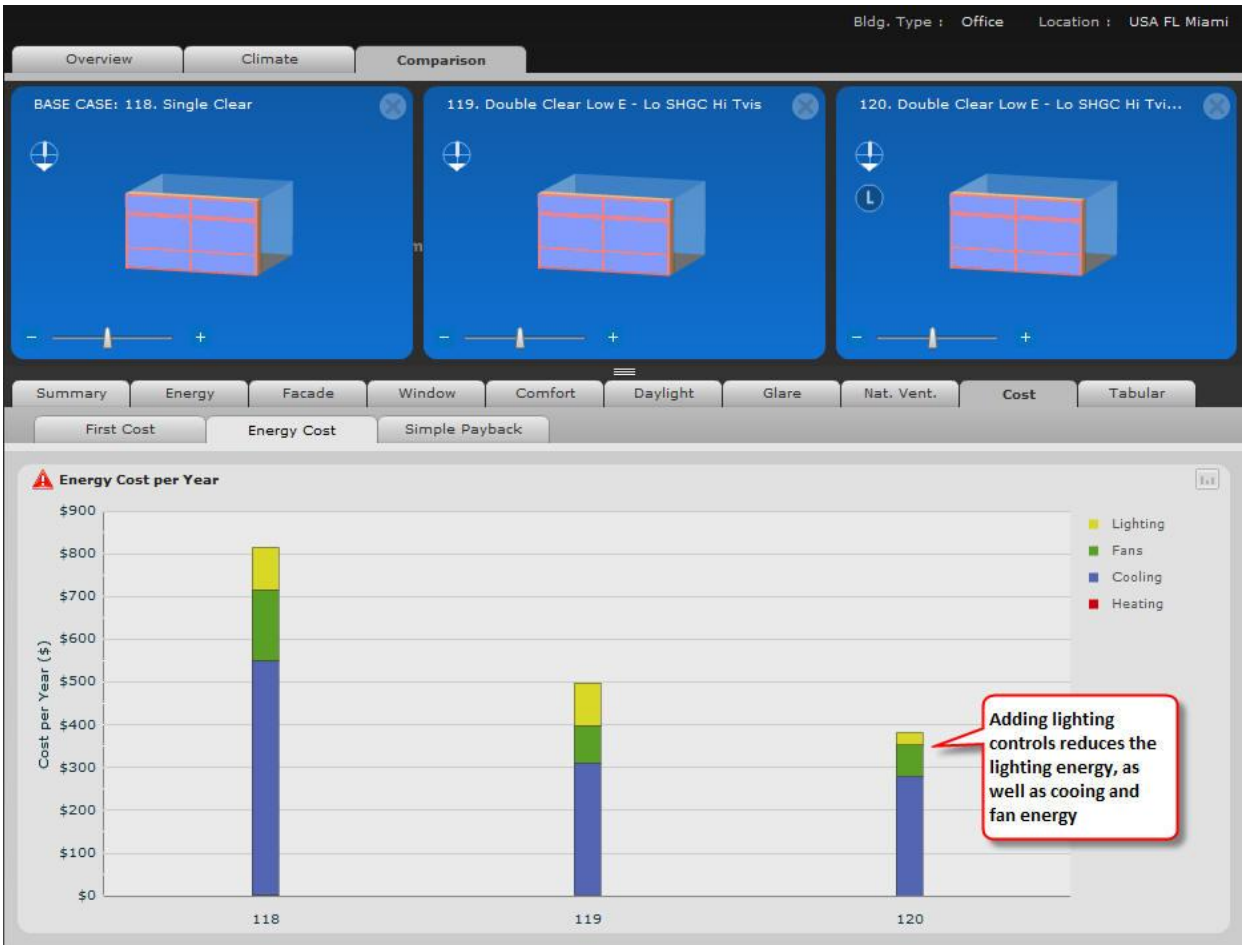


Figure 4-86. The Energy Cost tab for the three scenarios.

Simple Payback

Energy-efficiency strategies in buildings are often evaluated in terms of their economic feasibility. One such measure is the simple payback – the amount of time (usually in years) required to recover the initial project cost in an opportunity. For example, simple payback can be used to calculate the time it will take for cost savings accrued during the building operation phase to offset the increased capital cost associated with a specific design strategy or set of design strategies, such as better-performing windows or lighting controls. While increased investment in advanced facade design strategies may yield savings in other ways, including higher worker productivity and improved building market value, the payback calculation in COMFEN only takes into consideration the annual energy savings of the scenario.

The payback is calculated as follows:

$$\text{Payback (years)} = (FC_{\text{Case 1}} - FC_{\text{BC}}) / (EC_{\text{Case 1}} - EC_{\text{BC}})$$

Where

$FC_{\text{Case 1}}$ – first cost of scenario

FC_{BC} – first cost of base case (reference) scenario

$EC_{\text{Case 1}}$ – energy cost of scenario

EC_{BC} – energy cost of base case (reference) scenario

The figure below shows two different payback results, the top being for the case where the lighting control costs were set to $10/sf (the program default) for a retrofit situation and the second for the case where the lighting control costs were overridden and set to $2/sf for a new construction situation.

The lighting control costs can be overridden in the Project Properties > Cost tab > Lighting Controls Cost section.

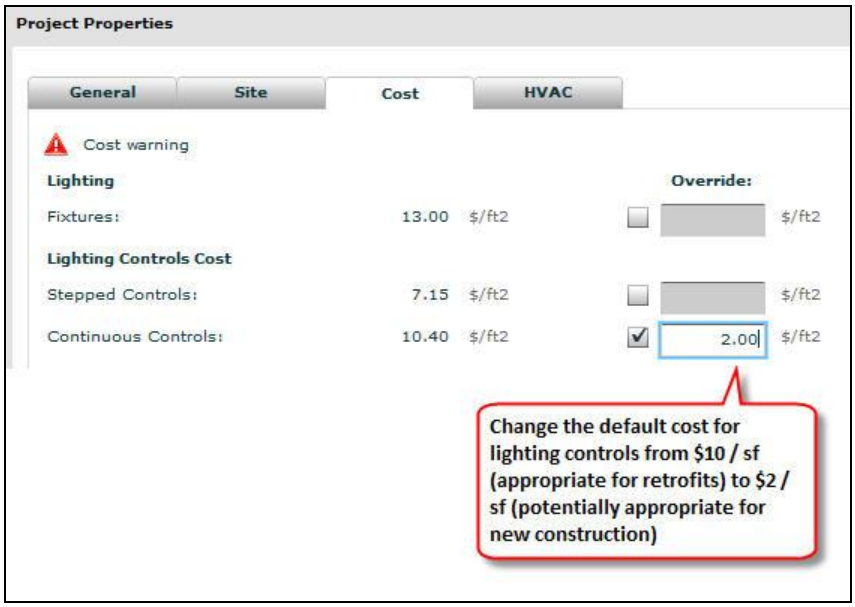


Figure 4-87. The default lighting controls cost can be overridden in the Project Properties > Cost tab > Lighting Controls Cost section.

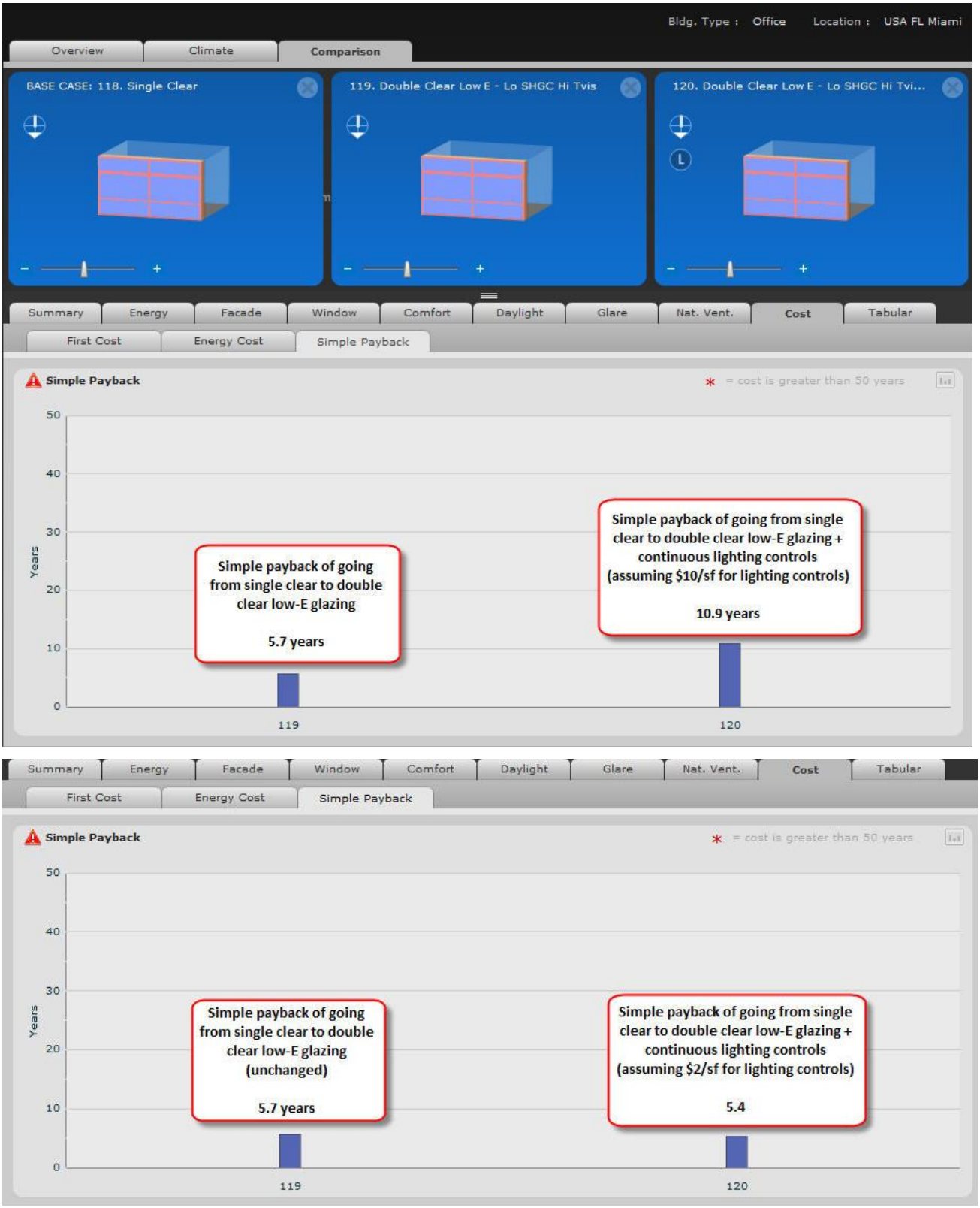


Figure 4-88. Two different Simple Payback resutls for the scenario with lighting controls – the top is based on $10/sf (potential cost for retrofit rewiring) and the bottom is based on $2/sf (potential cost for new construction).

4.8. Results

4.8.1. Detailed reports

In addition to the many graphic results that can be obtained from COMFEN, the detailed report files generated by the Energy Plus simulation engine are also stored, and can be used to delve even deeper into the scenario results and create custom graphs and data sets.

The COMFEN results folder (LBNL\COMFEN4\Results) contains the following Energy Plus files:

- scen_ID.idf – Energy Plus input file
- scen_ID_binned_eplus_output_data.csv
- scen_ID_eplusmap.csv
- scen_ID_eplusout.csv – hourly Energy Plus simulation output
- scen_ID_eplusTbl_Table.csv – Energy Plus output results summary

The *scen_ID_ eplusout.csv* and *scen_ID_ eplusTbl_Table.csv* files provide a wealth of additional information about scenario results which may be of interest to the more advanced COMFEN user who would like to analyze the result in greater detail.

Additional results can be generated by editing the *user_report_variables.xml* file in the LBNL\COMFEN4\settings folder. The results will be compiled in a file called *scen_ID_user_report.csv*. See below.

scen_ID_eplusTbl_Table.csv

The *scen_ID_ eplusTbl_Table.csv* file includes a number of summary reports, some of which have been listed below:

- HVACSizingSummary – Heating and cooling equipment size (user design load column)

Additional reports: editing the *user_report_variables.xml* file

An additional file, *scen_ID_user_report.csv*, can be generated by editing the *user_report_variables.xml* file in the LBNL\COMFEN4\settings folder and specifying additional variables for which they would like detailed results to be generated. By default, none of these variables are selected so no reports are generated. The user can specify reports they want generated by enclosing variables of interest with the following markers:

<!-- denotes beginning of section

--> denotes end of section

In the following example, which shows only a few of the variables in the .xml file, hourly "Direct Solar"and "Solar Azimuth Angle" reports will be generated.

<variable keyValue="*" nameInReport="Diffuse Solar" nameInRVI="Diffuse Solar" />

<!-- <variable keyValue="*" nameInReport="Direct Solar" nameInRVI="Direct Solar" />

<variable keyValue="*" nameInReport="Solar Azimuth Angle" nameInRVI="Solar Azimuth Angle" />

<variable keyValue="*" nameInReport="Solar Altitude Angle" nameInRVI="Solar Altitude Angle" /> **-->**

<variable keyValue="*" nameInReport="Solar Hour Angle" nameInRVI="Solar Hour Angle" />

NOTE: It is a good idea to create a copy of this file prior to editing in order to keep the original with complete list of variables. A more advanced text editor (e.g. TextPad) is recommended for editing the file because lack of paragraph formatting in Notepad makes it difficult to view the list of report variables.

4.9. Appendix

General simulation parameters such as schedule, building type, etc. are written to the in.idf file located in the COMFEN Energy Plus Input folder. It is recommended that the user interested in understanding the calculation assumptions review this file and reference the Energy Plus Input/Output Reference documentation (available for download from the Energy Plus website) for an explanation of each parameter.

4.9.1. Occupancy, lighting and equipment loads

Information on occupancy, lighting and equipment loads can be found in the in.idf file, a section of which is included below. The Number of People, LightingLevel, EquipmentLevel inputs correspond to values defined by the user. Occupancy, lighting and equipment load schedules vary by building type.

```
People,
    COMFENZone People 1,     !- Name
    COMFENZone,              ! Zone Name
    OCC-SCHED,                 ! People Schedule Name
    People,                  ! Number of people calculation method
    0.96,                !- Number of People
    ,                        !- People per Zone Floor Area {person/m2}
    ,                        !- Zone Floor Area per Person {m2/person}
    0.3,                     !- Fraction Radiant
    ,                        !- Sensible Heat Fraction
    ACTIVITY-SCHED,          !- Activity Level Schedule Name
    ,                        !- Carbon Dioxide Generation Rate {m3/s-W}
    ,                        !- Enable ASHRAE 55 Comfort Warnings
    zoneaveraged,            !- Mean Radiant Temperature Calculation Type
    ,                        !- Surface Name/Angle Factor List Name
    WORK_EFF-SCHED,            !- Work Efficiency Schedule Name
    CLOTHING-SCHED,            !- Clothing Insulation Schedule Name
    AIR_VELO-SCHED,            !- Air Velocity Schedule Name
    Fanger;                  !- Thermal Comfort Model 1 Type

Lights,
    COMFENZone Lights,       !- Name
    COMFENZone,              !- Zone Name
    LIGHT-SCHED,               !- Schedule Name
    LightingLevel,           !- Design Level Calculation Method
     500.820068359,           !- Lighting Level {W}
    ,                        !- Watts per Zone Floor Area {W/m2}
    ,                        !- Watts per Person {W/person}
    0.,                      !- Return Air Fraction
    0.7,                    !- Fraction Radiant
    0.2,                     !- Fraction Visible
    1.,                      !- Fraction Replaceable
    GeneralLights;           !- End-Use Subcategory

  ElectricEquipment,
    COMFENZone ElecEq,       !- Name
    COMFENZone,              !- Zone Name
    EQUIP-SCHED,               !- Schedule Name
    EquipmentLevel,          !- Design Level Calculation Method
     300.492034912,  ! Design Level {W}
    ,                        !- Watts per Zone Floor Area {W/m2}
    ,                        !- Watts per Person {W/person}
    0.,                      !- Fraction Latent
    0.5,                     !- Fraction Radiant
    0.,                      !- Fraction Lost
    0;                       !- End-Use Subcategory
```

4.9.2. Schedules and setpoints

The following building types can be presently modeled in COMFEN.

- Office (office space)
- Mid-rise residential
- Hotel (guest room)
- Retail (point of sale)
- School (classroom)

This section includes heating and cooling setpoints and schedules (occupancy, lighting, electrical equipment and infiltration) by building/space type.

Office (office space)

Cooling and heating setpoints, °C

```
CLG-SCHED
Temperature,
  Through: 12/31,
  For: Weekdays SummerDesignDay
  Until: 06:00,
  26.7,
  Until: 22:00,
  24.0,
  Until: 24:00,
  26.7,
  For: Saturday,
  Until: 06:00,
  26.7,
  Until: 18:00,
  24.0,
  Until: 24:00,
  26.7,
  For: AllOtherDays,
  Until: 24:00,
  26.7

HTG-SCHED,
  Temperature,
  Through: 12/31,
  For: Weekdays,
  Until: 06:00,
  15.6,
  Until: 22:00,
  21.0,
  Until: 24:00,
  15.6,
  For: Saturday,
  Until: 06:00,
  15.6,
  Until: 18:00,
  21.0,
  Until: 24:00,
  15.6,
  For: WinterDesignDay,
  Until: 24:00,
  21.0,
  For: AllOtherDays,
  Until: 24:00,
  15.6
```

Infiltration

Time	Infiltr. (week day)	Infiltr. (Sat.)	Infiltr. (all other days)
24:00 – 6:00	1	1	1
6:00 – 18:00	0.25	0.25	1
18:00 – 22:00	0.25	1	1
22:00 – 24:00	1	1	1

Occupancy, Lighting and Equipment

Time	Occ. (week day)	Occ. (Sat.)	Occ. (all other days)	Light. (week day)	Light. (Sat.)	Light. (all other days)	Equip. (week day)	Equip. (Sat.)	Equip. (all other days)
24:00 – 5:00	0	0	0	0.05	0.05	0.05	0.4	0.3	0.3
5:00 – 6:00	0	0	0	0.1	0.05	0.05	0.4	0.3	0.3
6:00 – 7:00	0.1	0.1	0	0.1	0.01	0.05	0.4	0.4	0.3
7:00 – 8:00	0.2	0.1	0	0.3	0.01	0.05	0.4	0.4	0.3
8:00 – 12:00	0.95	0.5	0	0.9	0.5	0.05	0.9	0.5	0.3
12:00 – 13:00	0.5	0.5	0	0.9	0.5	0.05	0.8	0.5	0.3
13:00 – 14:00	0.95	0.5	0	0.9	0.5	0.05	0.9	0.5	0.3
14:00 – 17:00	0.95	0.1	0	0.9	0.15	0.05	0.9	0.35	0.3
17:00 – 18:00	0.7	0	0	0.7	0.05	0.05	0.8	0.3	0.3
18:00 – 20:00	0.4	0	0	0.5	0.05	0.05	0.6	0.3	0.3
20:00 – 22:00	0.1	0	0	0.3	0.05	0.05	0.5	0.3	0.3
22:00 – 24:00	0.05	0	0	0.1	0.05	0.05	0.4	0.3	0.3

Time	Summer design day				Winter design day			
	Occ.	Light.	Equip.	Infiltr.	Occ.	Light.	Equip.	Infiltr.
24:00 – 6:00	0	1	1	1	0	0	0	1
6:00 – 18:00	1	1	1	0.25	0	0	0	0.25
18:00 – 22:00	1	1	1	0.25	0	0	0	1
22:00 – 24:00	0.05	1	1	1	0	0	0	1

Mid-rise residential (apartment)

Cooling and heating setpoints, °C

```
CLG-SCHED
 Temperature,
  THROUGH: 12/31,
  FOR:AllDays,
  UNTIL: 24:00
  23.9

HTG-SCHED,
  Temperature,
  THROUGH: 12/31,
  FOR:AllDays,
  UNTIL: 24:00,
  21.1
```

Infiltration

All times 1.0

Occupancy, Lighting and Equipment

All days

Time	Occ.	Light.	Equip.
24:00 – 1:00	1.00	0.07	0.45
1:00 – 2:00	1.00	0.07	0.41
2:00 – 3:00	1.00	0.07	0.39
3:00 – 4:00	1.00	0.07	0.39
4:00 – 5:00	1.00	0.19	0.38
5:00 – 6:00	1.00	0.39	0.43
6:00 – 7:00	1.00	0.44	0.54
7:00 – 8:00	0.85	0.39	0.65
8:00 – 9:00	0.39	0.17	0.66
9:00 – 10:00	0.25	0.12	0.67
10:00 – 11:00	0.25	0.12	0.69
11:00 – 12:00	0.25	0.12	0.70

Time	Occ.	Light.	Equip.
12:00 – 13:00	0.25	0.12	0.69
13:00 – 14:00	0.25	0.12	0.66
14:00 – 15:00	0.25	0.12	0.65
15:00 – 16:00	0.25	0.21	0.68
16:00 – 17:00	0.30	0.44	0.80
17:00 – 18:00	0.52	0.62	1.00
18:00 – 19:00	0.87	0.83	1.00
19:00 – 20:00	0.87	0.99	0.93
20:00 – 21:00	0.87	1.00	0.89
21:00 – 22:00	1.00	0.69	0.85
22:00 – 23:00	1.00	0.38	0.71
23:00 – 24:00	1.00	0.16	0.58

Hotel (guest room)

Cooling and heating setpoints, °C

```
CLG-SCHED,
  Temperature,
  Through: 12/31,
  For: AllDays,
  Until: 24:00,
  24

HTG-SCHED,
  Temperature,
  Through: 12/31,
  For: AllDays,
  Until: 24:00,
  21
```

Infiltration

All times 0.25

Occupancy, Lighting and Equipment

Time	Occ. (weekday)	Occ. (all other days)	Light. (weekday)	Light. (all other days)	Equip. (weekday)	Equip. (all other days)
24:00 – 1:00	0.65	0.65	0.22	0.26	0.2	0.3
1:00 – 2:00	0.65	0.65	0.17	0.26	0.2	0.3
2:00 – 5:00	0.65	0.65	0.11	0.11	0.2	0.3
5:00 – 6:00	0.65	0.65	0.22	0.11	0.2	0.3
6:00 – 7:00	0.5	0.5	0.44	0.41	0.62	0.3
7:00 – 8:00	0.28	0.34	0.56	0.41	0.9	0.62
8:00 – 9:00	0.28	0.34	0.44	0.56	0.43	0.9
9:00 – 10:00	0.13	0.2	0.44	0.56	0.43	0.62
10:00 – 11:00	0.13	0.2	0.28	0.41	0.26	0.29
11:00 – 12:00	0.13	0.2	0.28	0.33	0.26	0.29
12:00 – 13:00	0.13	0.2	0.28	0.33	0.26	0.29
14:00 – 15:00	0.13	0.2	0.28	0.33	0.26	0.29
15:00 – 16:00	0.2	0.2	0.28	0.33	0.26	0.29
16:00 – 17:00	0.35	0.2	0.28	0.33	0.26	0.29
17:00 – 18:00	0.35	0.34	0.28	0.33	0.51	0.43
18:00 – 19:00	0.35	0.35	0.67	0.85	0.51	0.51
19:00 – 20:00	0.5	0.65	0.89	1	0.49	0.49
20:00 – 21:00	0.5	0.65	1	1	0.66	0.66
21:00 – 22:00	0.65	0.5	0.89	1	0.7	0.7
22:00 – 23:00	0.65	0.5	0.67	0.85	0.35	0.35
23:00 – 24:00	0.65	0.5	0.33	0.41	0.2	0.2

Time	Summer design day			Winter design day		
	Occ.	Light.	Equip.	Occ.	Light.	Equip.
All day	1	1	1	0	0	0

Retail (point-of-sale)

Cooling and heating setpoints, °C

CLG-SCHED,
Temperature,
Through: 12/31,
For: Weekdays SummerDesig
Until: 06:00,
30.0,
Until: 21:00,
24.0,
Until: 24:00,
30.0,
For: Saturday,
Until: 06:00,
30.0,
Until: 22:00,
24.0,
Until: 24:00,
30.0,
For WinterDesignDay,
Until: 24:00,
30.0,
For: Sunday Holidays AllO
Until: 8:00,
30.0,
Until: 19:00,
24.0,
Until: 24:00,
30.0

HTG-SCHED,
Temperature,
Through: 12/31,
For: Weekdays,

Until: 06:00,

15.6,

Until: 21:00,

21.0,

Until: 24:00,

15.6,

For SummerDesignDay,

Until: 24:00,

15.6,

For WinterDesignDay,

Until: 24:00,

21.0,

For: Saturday,

Until: 06:00,

15.6,

Until: 22:00,

21.0,

Until: 24:00,

15.6,

For: Sunday Holidays All

Until: 8:00,

15.6,

Until: 19:00,

21.,

Until: 24:00,

15.6

Infiltration

Time	**Infiltr.** (week day)	**Infiltr.** (Sat.)	**Infiltr.** (all other days)
24:00 – 6:00	1	1	1
6:00 – 8:00	0.5	0.5	1
8:00 – 17:00	0.5	0.5	0.5
17:00 – 21:00	0.5	0.5	1
21:00 – 22:00	1	0.5	1
22:00 – 24:00	1	1	1

Time	**Occ.** (weekday)	**Occ.** (Sat.)	**Occ.** (all other days)	**Light.** (weekday)	**Light.** (Sat.)	**Light.** (all other days)	**Equip.** (weekday)	**Equip.** (Sat.)	**Equip.** (all other days)
24:00 – 6:00	0	0	0	0.05	0.05	0.05	0.2	0.15	0.15
6:00 – 7:00	0	0	0	0.05	0.05	0.05	0.2	0.15	0.15
7:00 – 8:00	0.1	0.1	0	0.2	0.1	0.05	0.4	0.3	0.15
8:00 – 9:00	0.2	0.2	0	0.5	0.3	0.1	0.7	0.5	0.3
9:00 – 10:00	0.5	0.5	0.1	0.9	0.6	0.1	0.9	0.8	0.3
10:00 – 11:00	0.5	0.6	0.2	0.9	0.9	0.4	0.9	0.9	0.6
11:00 – 12:00	0.7	0.8	0.2	0.9	0.9	0.4	0.9	0.9	0.6
12:00 – 17:00	0.7	0.8	0.4	0.9	0.9	0.6	0.9	0.9	0.8
17:00 – 18:00	0.5	0.6	0.2	0.9	0.9	0.4	0.9	0.9	0.6
18:00 – 19:00	0.5	0.2	0.1	0.6	0.5	0.2	0.8	0.7	0.4
19:00 – 20:00	0.3	0.2	0	0.6	0.3	0.05	0.8	0.5	0.15
20:00 – 21:00	0.3	0.2	0	0.5	0.3	0.05	0.7	0.5	0.15
21:00 – 22:00	0	0.1	0	0.2	0.1	0.05	0.4	0.3	0.15
22:00 – 24:00	0	0	0	0.05	0.05	0.05	0.2	0.15	0.15

Time	Summer design day				Winter design day			
	Occ.	Light.	Equip.	Infiltr.	Occ.	Light.	Equip.	Infiltr.
24:00 – 6:00	1	1	1	1	1	0	0	1
6:00 – 21:00	1	1	1	0.5	1	0	0	1
21:00 – 24:00	1	1	1	1	1	0	0	1

School (classroom)

Cooling and heating setpoints, °C

```
CLG-SCHED,
  Temperature,
  Through: 6/30,
  For: SummerDesignDay,
  Until: 24:00, 24,
  For: WeekEnds Holidays WinterDesignDay,
  Until: 24:00, 27,
  For: AllOtherDays,
  Until: 06:00, 27,
  Until: 21:00, 24,
  Until: 24:00, 27,
  Through: 9/1,
  For: SummerDesignDay,
  Until: 24:00, 24,
  For: WeekEnds Holidays WinterDesignDay,
  Until: 24:00, 27,
  For: AllOtherDays,
  Until: 07:00, 27,
  Until: 18:00, 24,
  Until: 24:00, 27,
  Through: 12/31,
  For: SummerDesignDay,
  Until: 24:00, 24,
  For: WeekEnds Holidays WinterDesignDay,
  Until: 24:00, 27,
  For: AllOtherDays,
  Until: 06:00, 27,
  Until: 21:00, 24,
  Until: 24:00, 27;

HTG-SCHED,
  Temperature,
  Through: 6/30,
  For: WinterDesignDay,
  Until: 24:00, 21,
  For: WeekEnds Holidays SummerDesignDay,
  Until: 24:00, 16,
  For: AllOtherDays,
  Until: 06:00, 16,
  Until: 21:00, 21,
  Until: 24:00, 16,
  Through: 9/1,
  For: WinterDesignDay,
  Until: 24:00, 21,
  For: WeekEnds Holidays SummerDesignDay,
  Until: 24:00, 16,
  For: AllOtherDays,
  Until: 07:00, 16,
  Until: 18:00, 21,
  Until: 24:00, 16,
  Through: 12/31,
```

```
For: WinterDesignDay,
Until: 24:00, 21,
For: WeekEnds Holidays SummerDesignDay,
Until: 24:00, 16,
For: AllOtherDays,
Until: 06:00, 16,
Until: 21:00, 21,
Until: 24:00, 16;
```

Infiltration, all days:

All days, 24:00-7:00 1
All days, 7:00-21:00 0.5
All days, 21:00-24:00 1

Occupancy, Lighting and Equipment

Weekdays

Time	**Occ.** 9/2-6/30	**Occ.** 7/1 - 9/1	**Light.** 9/2-6/30	**Light.** 7/1 - 9/1	**Equip.** 9/2-6/30	**Equip.** 7/1 - 9/1
24:00 – 7:00	0	0	0.1773	0.1773	0.35	0.25
7:00 – 8:00	0	0	0.9	0.1773	0.35	0.25
8:00 – 9:00	0.7	0.15	0.9	0.5	0.95	0.5
9:00 – 10:00	0.7	0.15	0.9	0.5	0.95	0.5
10:00 – 11:00	0.7	0.15	0.9	0.5	0.95	0.5
11:00 – 12:00	0.7	0.15	0.9	0.5	0.95	0.5
12:00 – 16:00	0.7	0.15	0.9	0.5	0.95	0.5
16:00 – 17:00	0.15	0.15	0.9	0.5	0.95	0.5
17:00 – 20:00	0.15	0.15	0.9	0.5	0.35	0.25
20:00 – 21:00	0.15	0.15	0.9	0.1773	0.35	0.25
21:00 – 24:00	0	0	0.1773	0.1773	0.35	0.25

Weekends and holidays

Time	**Occ.**	**Light.**	**Equip.** 9/2-6/30	**Equip.** 7/1 - 9/1
All day	0	0.1773	0.35	0.25

4.9.3. Lighting control

The lighting control logic is embedded in the program as illustrated in the diagram below:

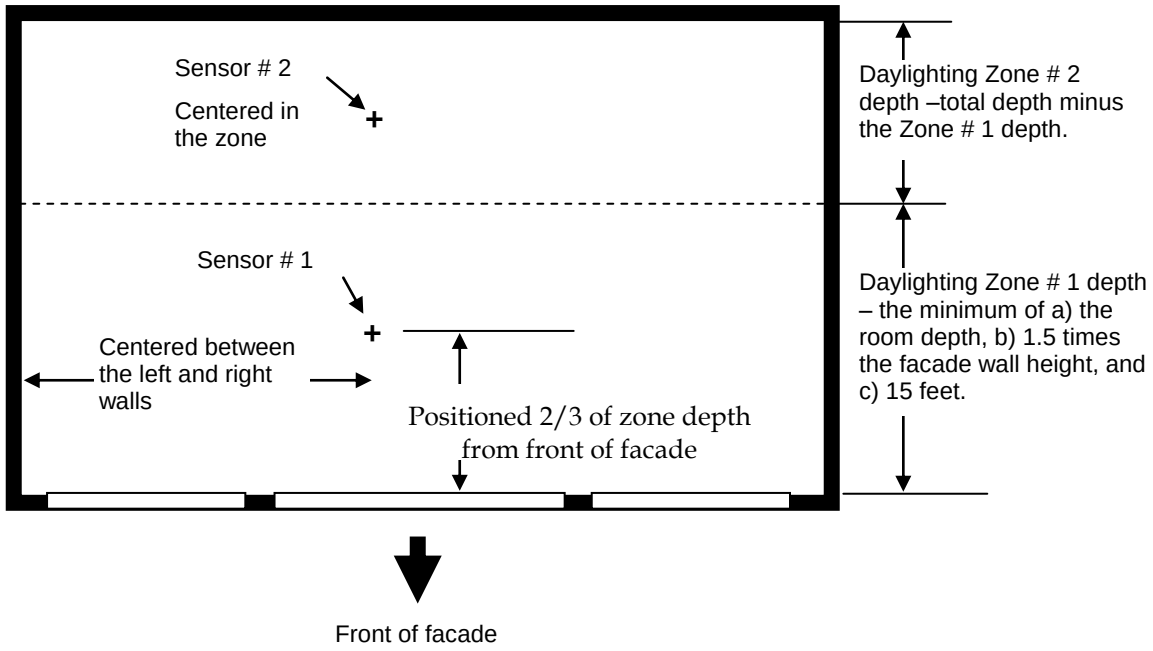


Figure 4-89. Plan view of daylighting control sensors.

- **Daylight Illuminance:** The daylight illuminance setpoint is currently set at 50 footcandles.
- **Zone Depth:** A primary daylight zone depth is calculated as the minimum of a) the room depth, b) 1.5 times the facade wall height, and c) 15 feet.
- **Sensor # 1:** Daylight sensor #1 is positioned 2/3 of the primary daylight zone depth from facade wall (centered in the width of the facade zone) and positioned at desk height: 2'-6" (0.76 m) above the floor. Sensor #1 controls a fraction of the facade zone lights equal to the primary daylight zone depth divided by the facade zone depth.
- **Sensor # 2:** Any remaining depth in the facade zone is considered a secondary daylight zone. Sensor #2 is positioned halfway between the primary daylight zone depth and the "back wall." Similar to sensor #1, the sensor is centered in the width of the facade zone and positioned at desk height: 2'-6" (0.76 m) above the floor. Sensor #2, if used, controls the remaining fraction of lights.

The Lighting Control pulldown under the scenario edit screen contains three choices for lighting controls:

- **None:** No lighting controls based on daylight levels.
- **Continuous:** Continuous lighting controls based on daylight levels.

Min Power Fraction = 0.1

Min Light Fraction = 0.05

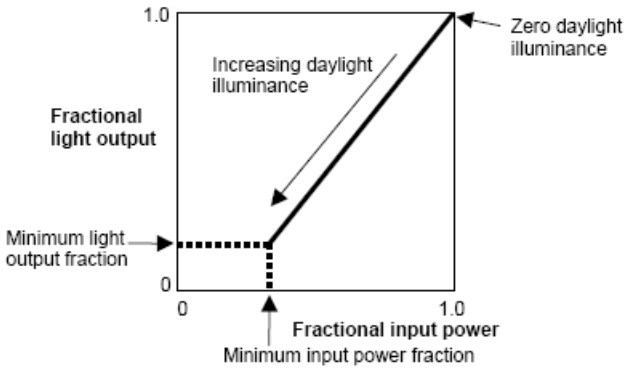


Figure 4-90. Continuous light dimming based on daylight levels. (from the EnergyPlus Input/Output documentation)

- **Stepped:** Stepped lighting controls based on daylight levels. Min Power Fraction = 0, Min Light Fraction = 0, Number of Steps = 3, Probability of Reset = 1.0 (perfect occupants)

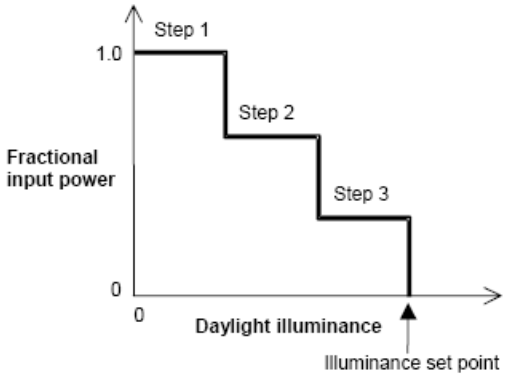


Figure 4-91. Stepped lighting controls based on daylight levels. (from the EnergyPlus Input/Output documentation)

4.9.4. Shading control

- **Glare view azimuth angle: T**he glare calculation is performed assuming that the occupant faces the facade (glare view azimuth angle = 0) and is positioned at the first daylighting reference point (sensor #1). Presently the user cannot change the occupant's position or glare view azimuth angle through the COMFEN interface. They can, however, change the glare view azimuth angle by accessing the comfen_setting.xml file in the settings folder.

- **Maximum Glare Index:** The Maximum Glare Index is set to 22. However, since there are not currently any dynamically controlled shading devices, no aspect of the facade changes above this glare index value.