

A PC Program

COMFEN 4.0

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

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DRAFT

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COMFEN 4.0: 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.

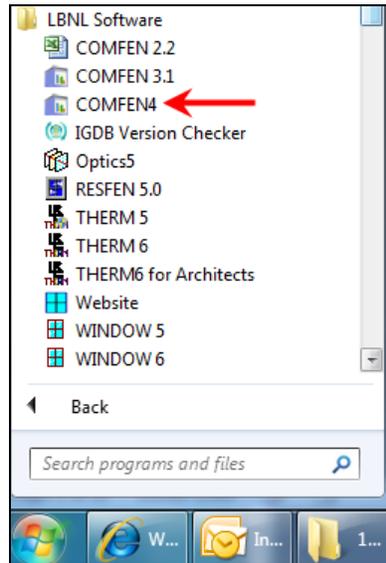


Figure 2-1. Click on the COMFEN icon in the Programs/LBNL Software list.

- 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.

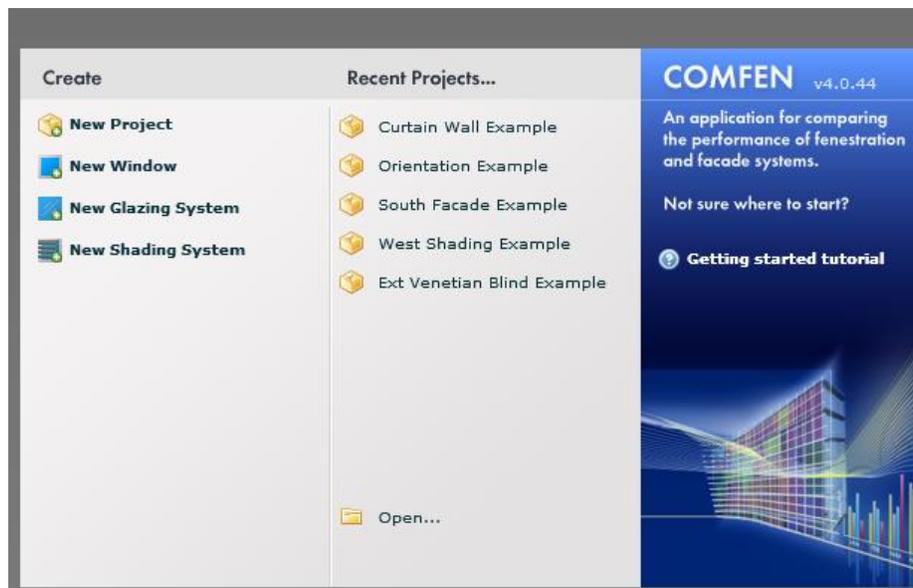


Figure 2-2. The Startup Menu screen allows you to create a new project or open already defined projects.

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.

The column width can be adjusted by pulling the right hand column boundary to the left or right

This icon toggles the details (everything except ID and Name) to show or not to show

The **Libraries** tab has three subtabs:
 - **Window Library**
 - **Glazing System Library**
 - **Shading System Library**

Clicking on a column header causes the list to be sorted by that column. The default sort is ID

List of Scenarios in the current project

Right click on a Scenario for a list of actions that can be applied to that Scenario

Add to Comparison Window
 Edit
 Copy
 Calculate Energy Use
 Delete
 Rename

The entire Explorer column can be resized by pulling this icon to the left or right

List of items in each of the Libraries

ID	Name	O	WWR	#	Glazing Sys.
10	Double Low-E	W	0.57	4	Double Low-E Argon
12	Double Low-E OH / Fins	W	0.57	4	Double Low-E Argon
13	Top Clear, Bottom LoSHG	W	0.57	4	(multiple)
14	Double Low-E Ext VB 45	W	0.57	4	Double Low-E Argon

Name	TVis	SHGC	U-fa...
Single Clear 6 mm	0.88	0.82	1.02
Double Clear 6 mm (Air)	0.78	0.70	0.47
Double Bronze (Air)	0.47	0.50	0.47
Double Reflective (Air)	0.13	0.18	0.39
Double Low-E Bronze (Air)	0.44	0.45	0.33
Double Low Solar Low-E Tint (Air)	0.52	0.29	0.29
Double Low Solar Low-E Clear (Air)	0.70	0.38	0.29
Triple Low Solar Low-E Clear (Air)	0.46	0.26	0.15
Quad Low Solar Low-E Clear (Air)	0.45	0.29	0.10
Double Glazed Triple Silver Low-E (Argon)	0.63	0.27	0.23
Double Hi VT (LowIron) Low-E (Argon)	0.72	0.38	0.24
Double High Performance Tint (Air)	0.60	0.39	0.47
Double High Performance Tint (Argon)	0.60	0.38	0.44
Double Low VT Low-E (Argon)	0.37	0.24	0.25
Double Low-E Argon	0.69	0.46	0.24

Figure 2-4. The Project Explorer.

Scenarios
 Libraries

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

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 Scenario tab to the upper right part of the screen. Highlight the desired Scenarios in the Scenarios tab and drag your mouse to the right.

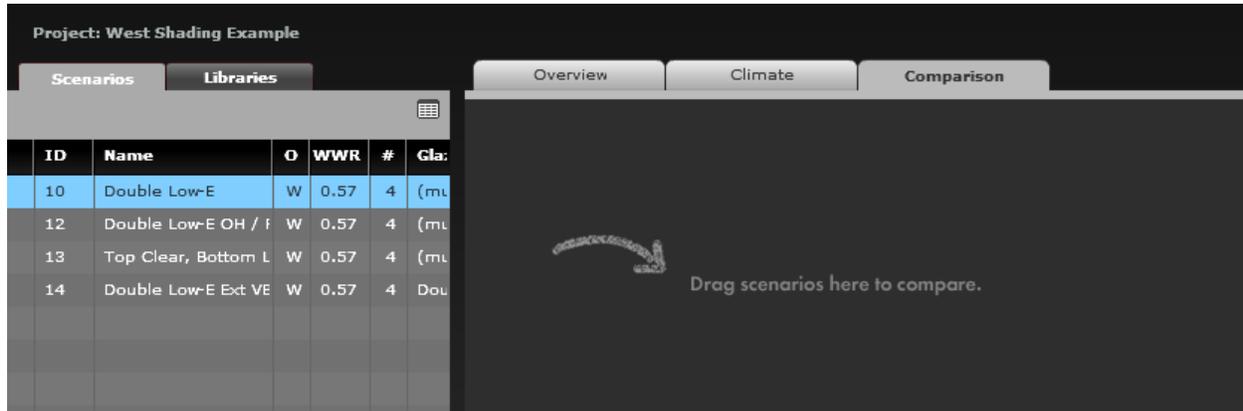


Figure 2-6. Highlight up to four scenarios and drag them to the right under the Comparison tab.

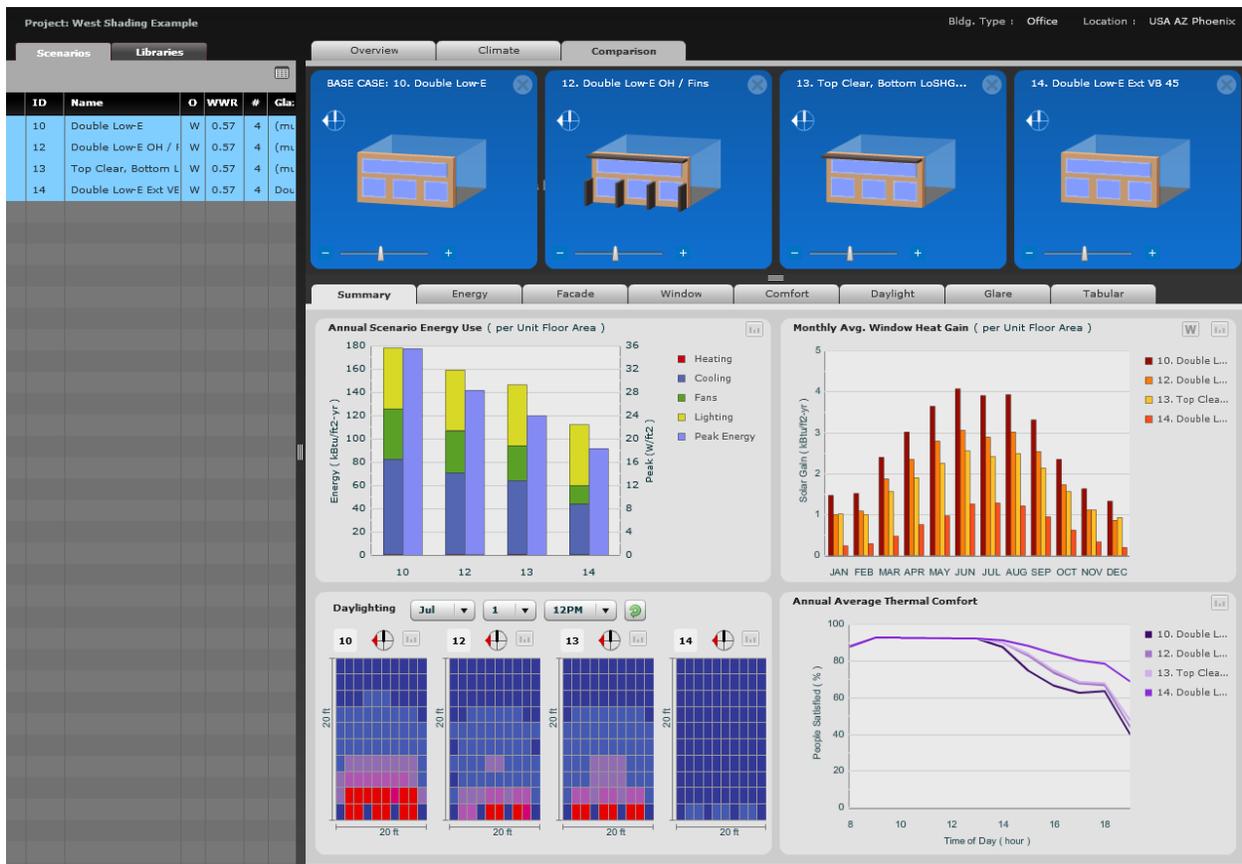


Figure 2-7. The scenarios will be displayed in "3D" and results, if they exist, will be shown below each.

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.

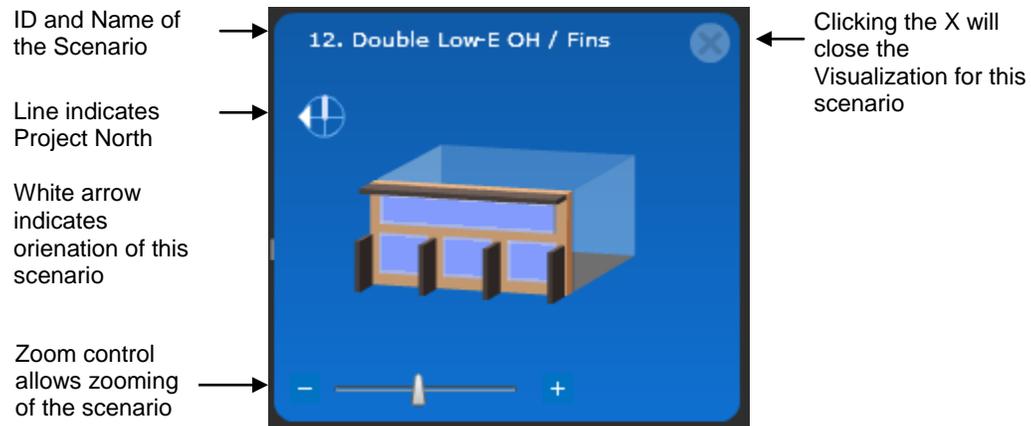


Figure 2-8. The elements of the Scenario Visualization.

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
- Hid 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

Scenarios

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

- Create Scenario: Creates a new scenario within the currently opened project
- Duplicate 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
- Export scenario output data 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.
- Export compared scenarios images to PNG
- 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

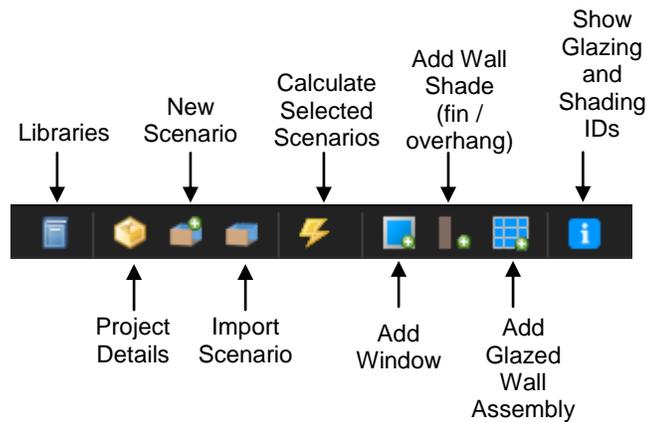


Figure 2-10. The COMFEN Toolbar.

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	

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.

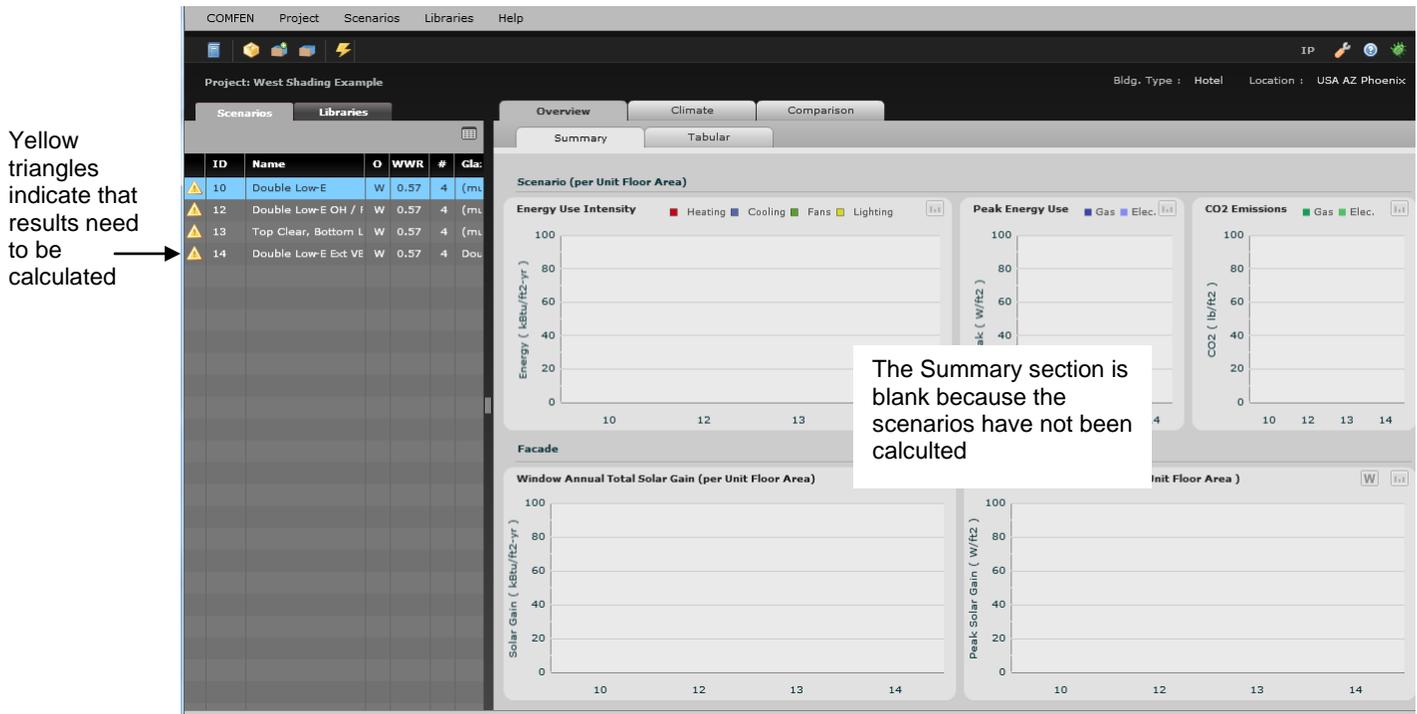


Figure 2-11. The Overview screen, which appears when you open an existing project.

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 Energy 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.

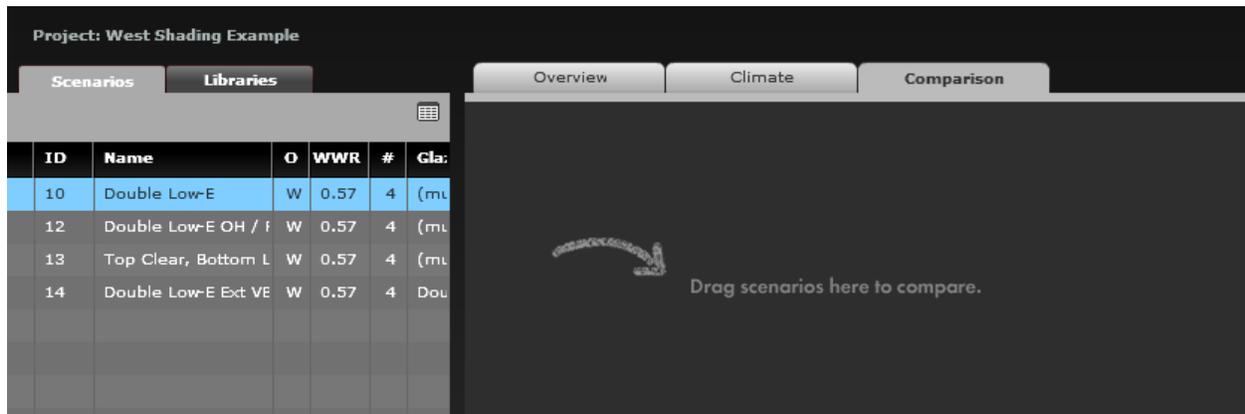


Figure 2-12. Drag scenarios to the right in the Comparison tab.

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.

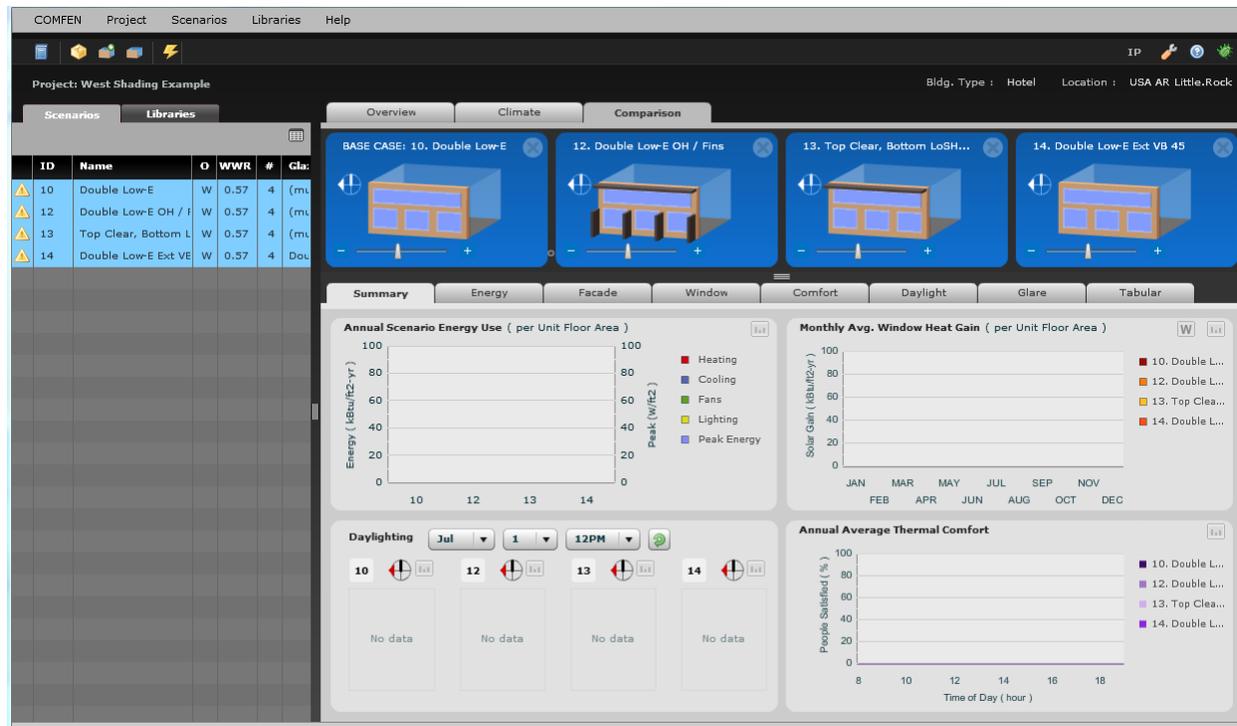


Figure 2-13. The 3D visualizations are shown in the Comparison tab.

2. QUICK START

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 toolbar button, and the program will start to run the Energy Plus simulation program for each scenario.

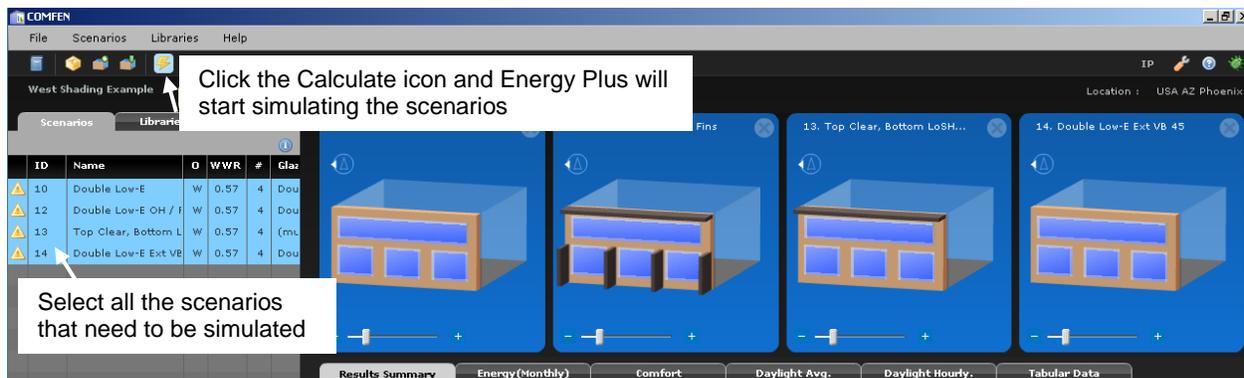


Figure 2-15. Highlight the scenarios to be calculated and press the Lightning Bolt toolbar button.

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

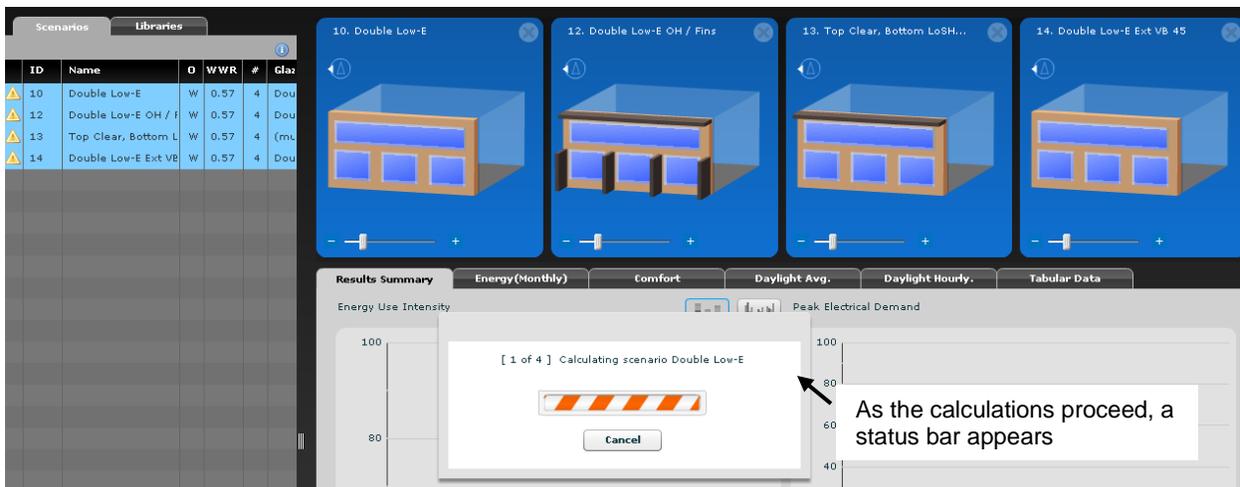


Figure 2-16. A status bar will appear as the scenarios are calculated.

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 View by double clicking on the graphic of the scenario.

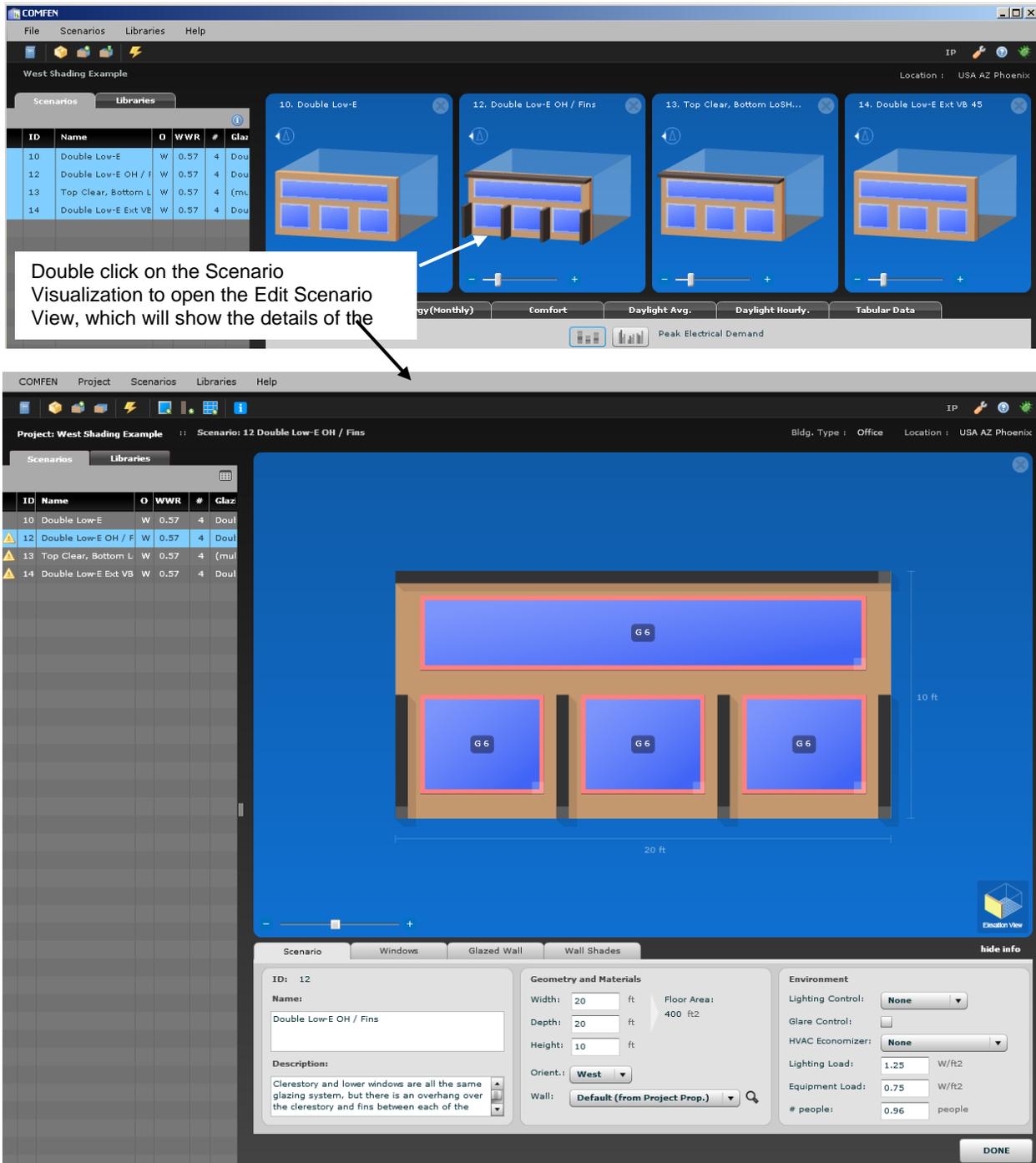


Figure 2-18. The Scenario tab on the Edit Scenario View.

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.

The screenshot displays the Edit Scenario View interface. At the top, a 3D model of a window wall is shown with four windows labeled 'G 6'. A vertical dimension line on the right indicates a height of 10 ft, and a horizontal dimension line below the windows indicates a width of 20 ft. Below the model, there are four tabs: Scenario, Windows, Glazed Wall, and Wall Shades. The Scenario tab is active, showing a control panel with the following sections:

- Scenario:** ID: 12, Name: Double Low-E OH / Fins, Description: Clerestory and lower windows are all the same glazing system, but there is an overhang over the clerestory and fins between each of the...
- Geometry and Materials:** Width: 20 ft, Depth: 20 ft, Height: 10 ft, Orient.: West, Wall: Default (from Project Prop.), Floor Area: 400 ft².
- Environment:** Lighting Control: None, Glare Control: , HVAC Economizer: None, Lighting Load: 1.25 W/ft², Equipment Load: 0.75 W/ft², # people: 0.96 people.

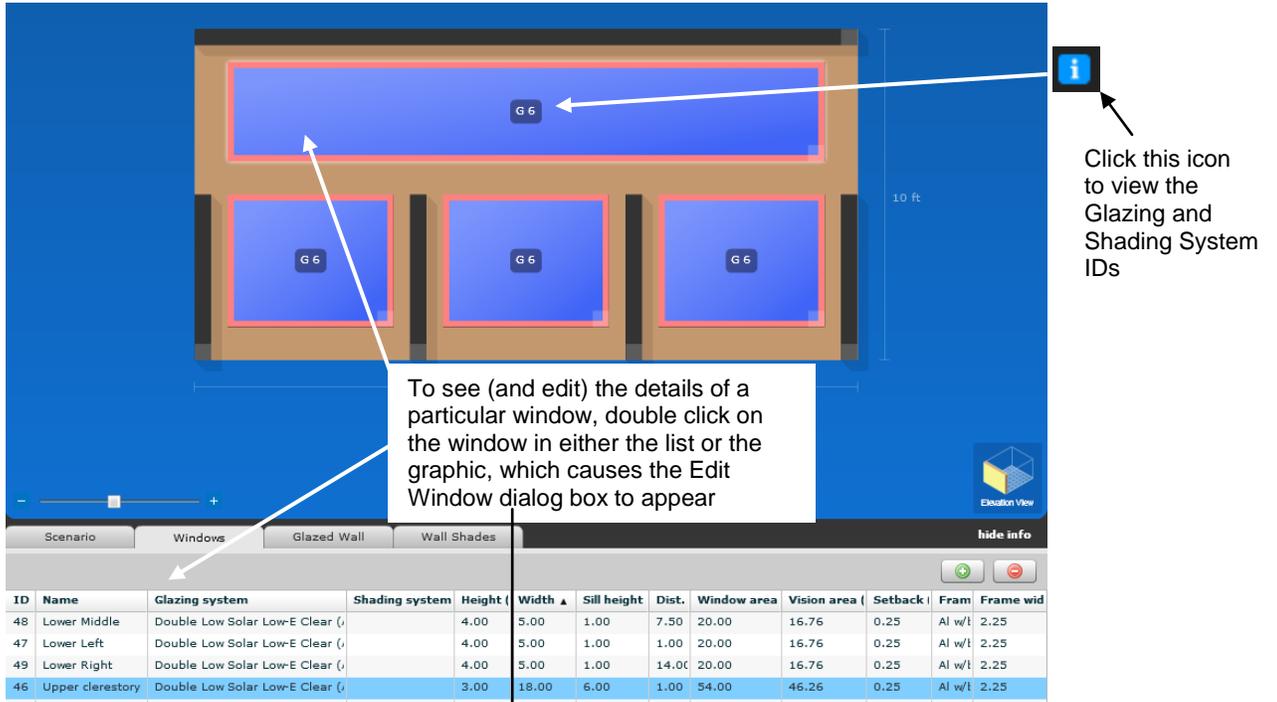
Annotations with arrows point to various parts of the interface:

- Three callout boxes point to the Windows, Glazed Wall, and Wall Shades tabs, explaining their functions.
- An arrow points to the 'DONE' button, with the instruction: 'Click Done to close this view and return to the Scenario Visualization view'.
- Two arrows point to the Geometry and Environment sections, with descriptive text:
 - 'The Geometry section contains the dimensions of the scenario, as well as the orientation of the front of the facade'
 - 'The Environment section contains information about lighting and glare controls, as well as loads for lighting, equipment and people'

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.



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

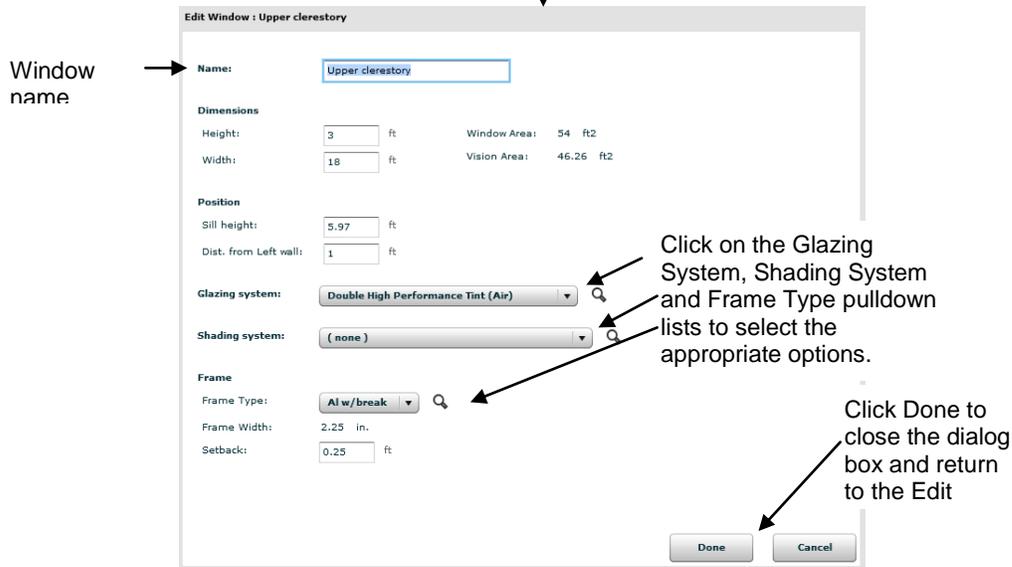


Figure 2-20. The Window tab and the Edit Window dialog box

Edit Window dialog box

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

Edit Window : Upper clerestory

Name:

Dimensions

Height: ft Window Area: 54 ft²

Width: ft Vision Area: 46.26 ft²

Position

Sill height: ft

Dist. from Left wall: ft

Glazing system: 🔍

Shading system: 🔍

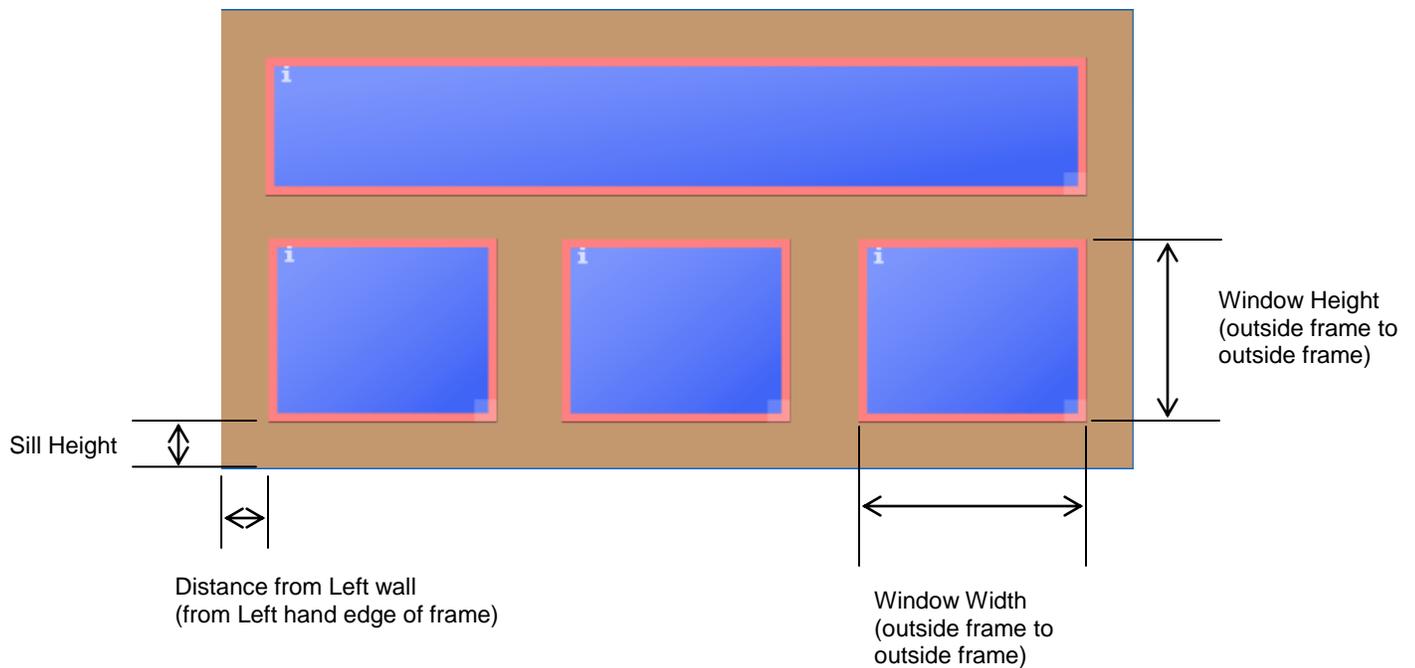
Frame

Frame Type: 🔍

Frame Width: 2.25 in.

Setback: ft

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.

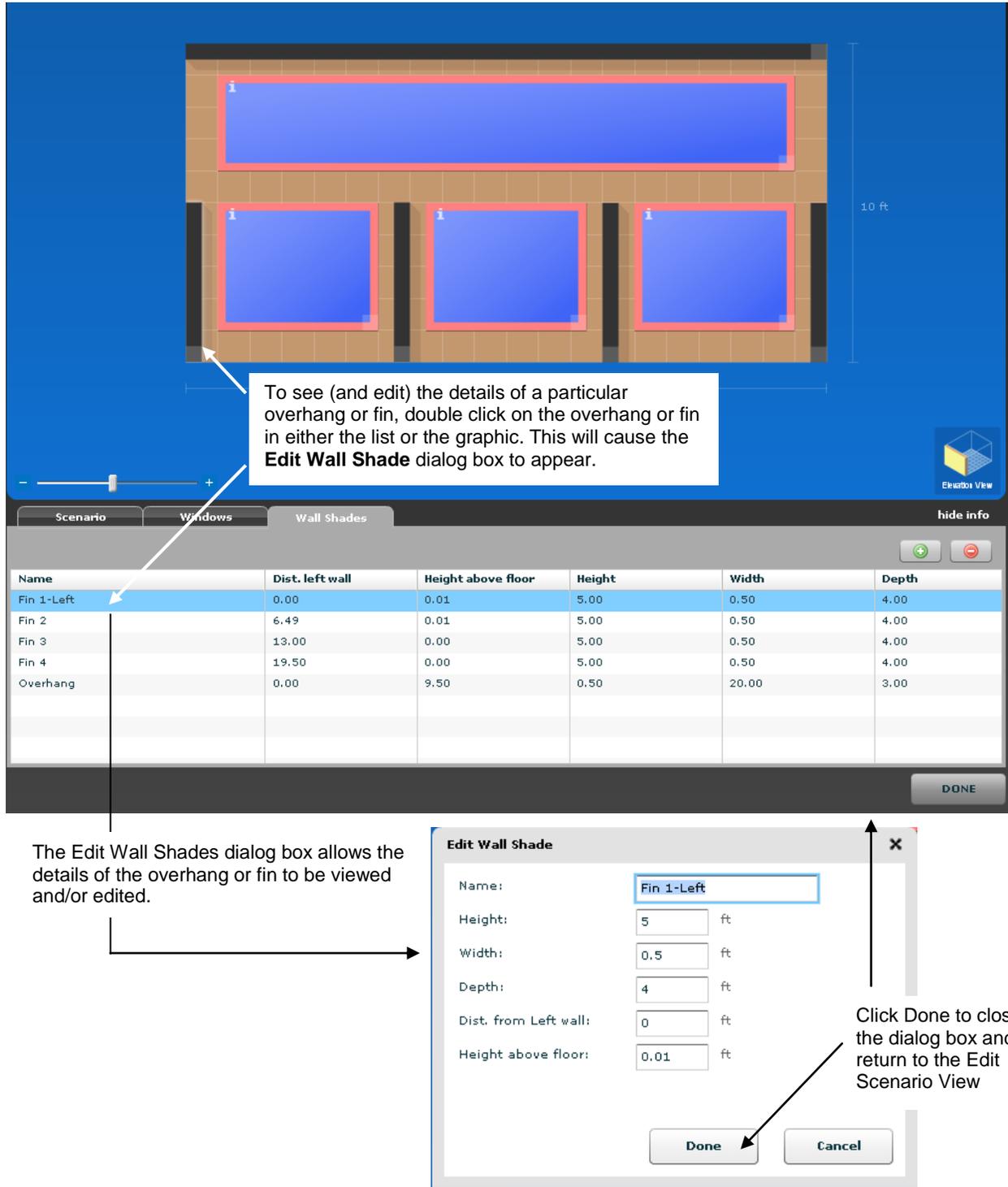


Figure 2-22. The Wall Shades tab and Edit Wall Shade dialog box.

2.4. Creating a New Project

Click on the **New Project** choice under **Create**

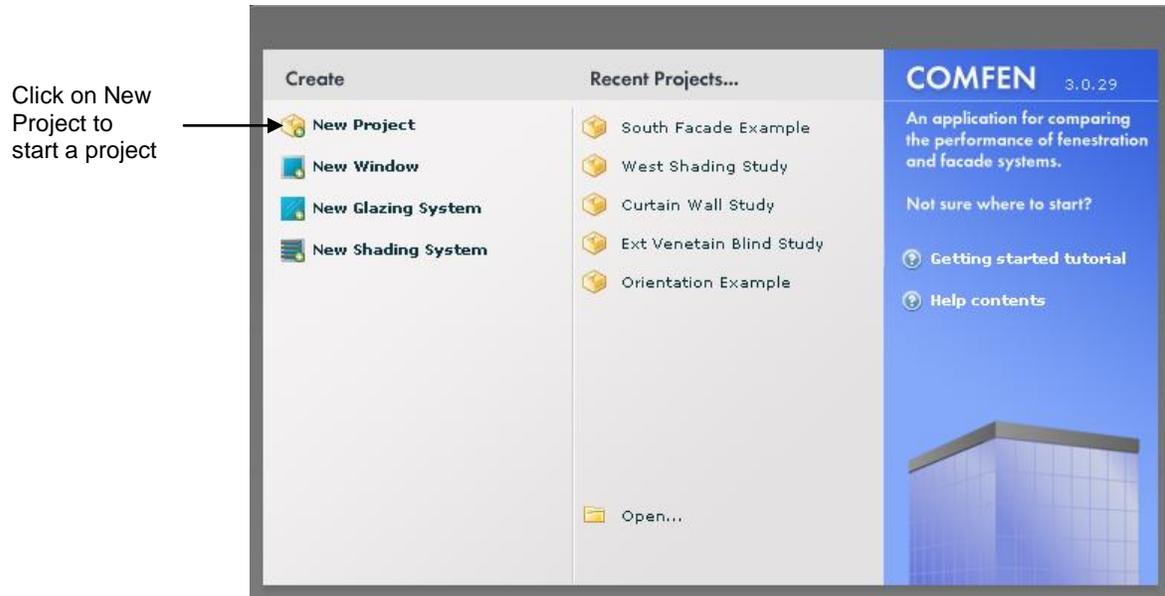


Figure 2-23. Click on *New Project* to start a project.

The Create COMFEN Project will appear. On the left are different categories of information to be defined. Highlight each category to define those properties

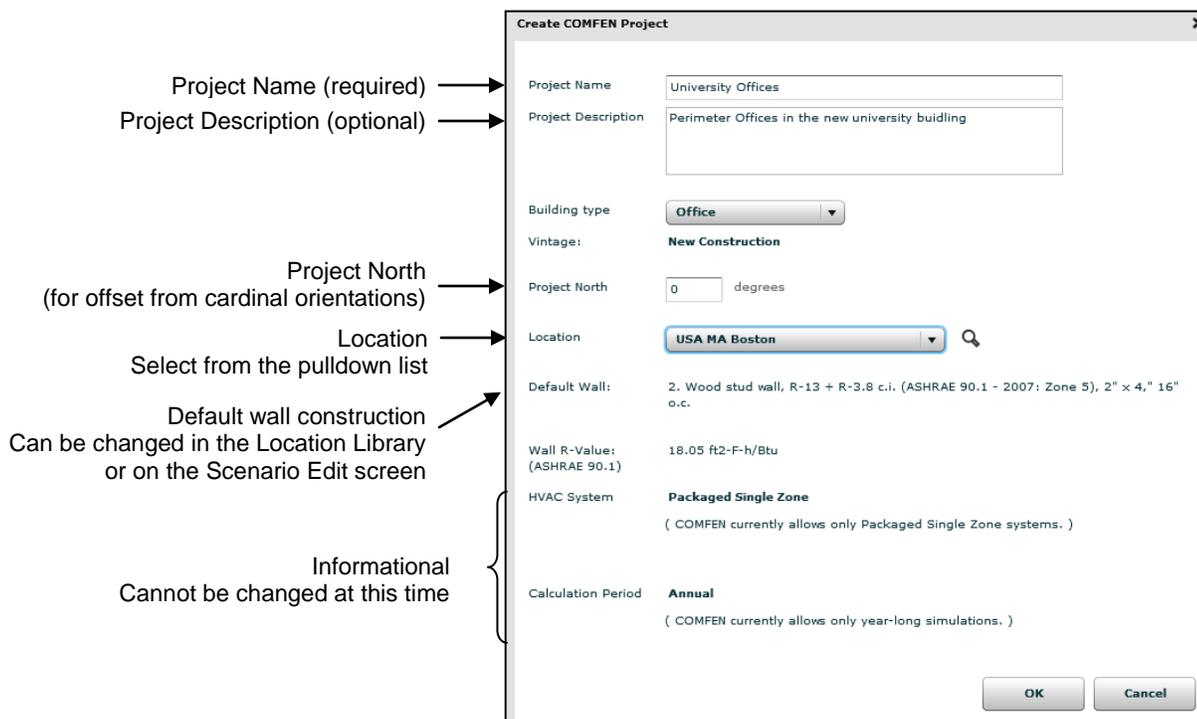


Figure 2-24. Fill in the Create COMFEN Project dialog box with the appropriate information.

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

In the Scenarios menu, click on the Create Scenario choice

OR Click on the Add New Scenario toolbar button

The Create New Scenario dialog box will appear.

Enter the appropriate information.

Click OK when you are finished, and the new scenario will appear in the Project Explorer

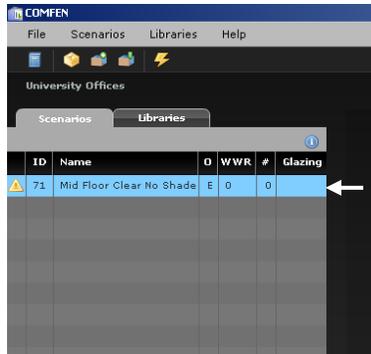
ID	Name	O	WWR	#	Glazing
71	Mid Floor Clear No Shade	E	0	0	

Figure 2-25. Creating a new scenario.

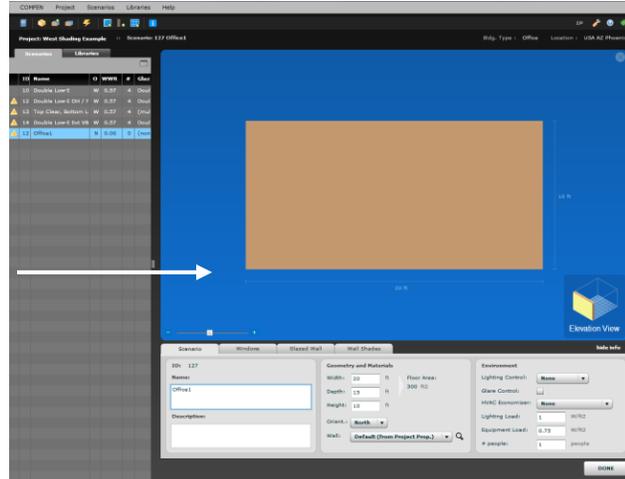
2.4.2. Edit Scenario

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

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

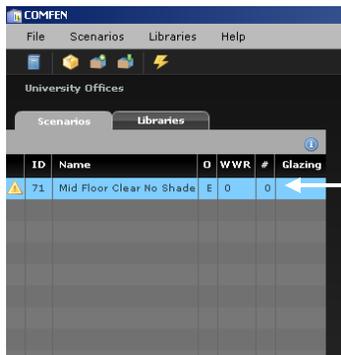


Double click on the Scenario name in the Project Explorer and the Edit Scenario View appears

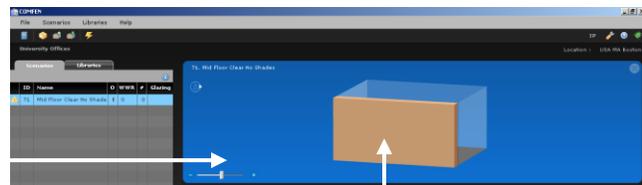


OR

- Highlight the scenario (single click) and drag it to the right with your mouse. This will cause a graphic image of it to appear on the right in the Scenario Visualization section. Then double click on the graphic to open the Edit Scenario View.



Highlight the Scenario name, then drag it to the right, so that the graphic Scenario Visualization appears



Then double click on the graphic Scenario Visualization, and the Edit Scenario View appears

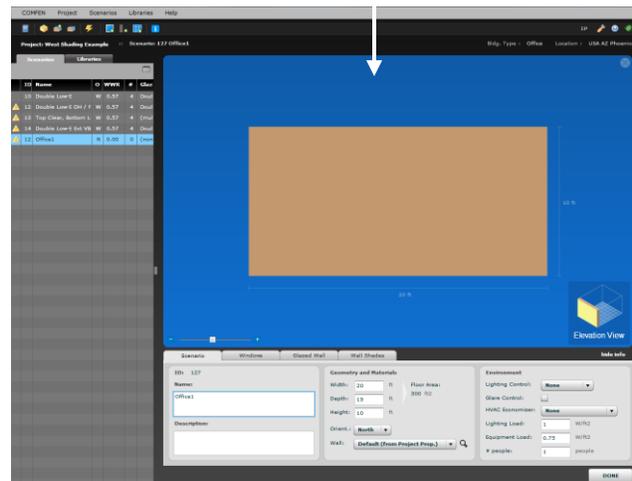
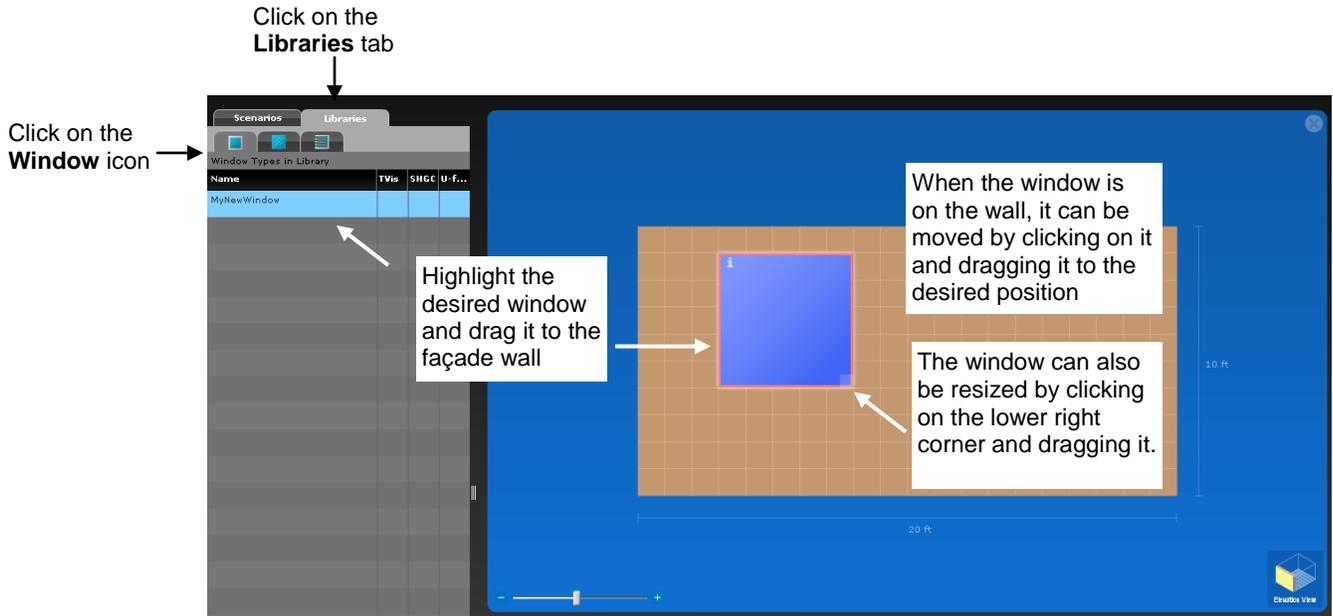


Figure 2-26. The two ways to open the Edit Scenario View from the Project Explorer

2.4.3. Add Windows

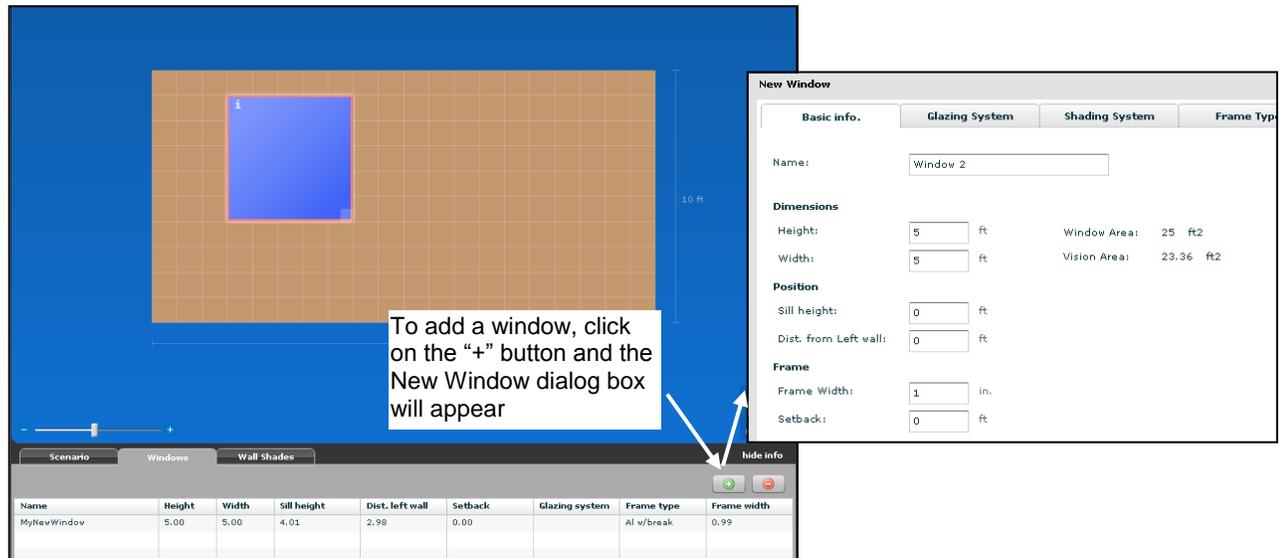
There are several ways to add a window to a scenario:

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



OR

- From the Edit Scenario Window tab, click on the  button and then 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.

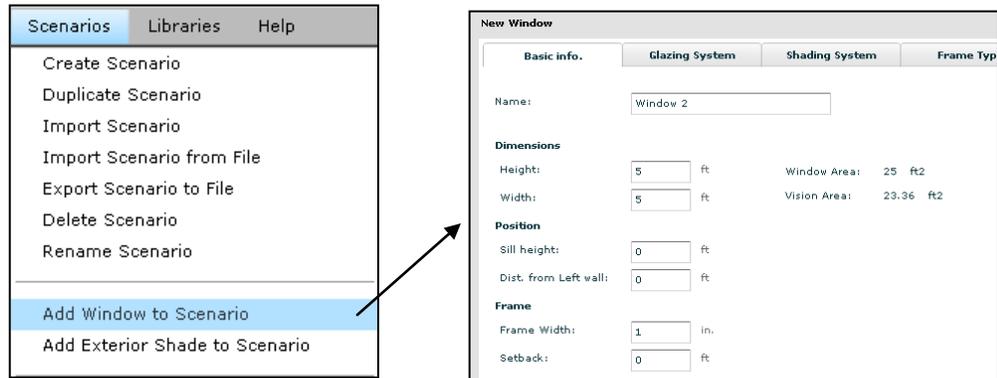
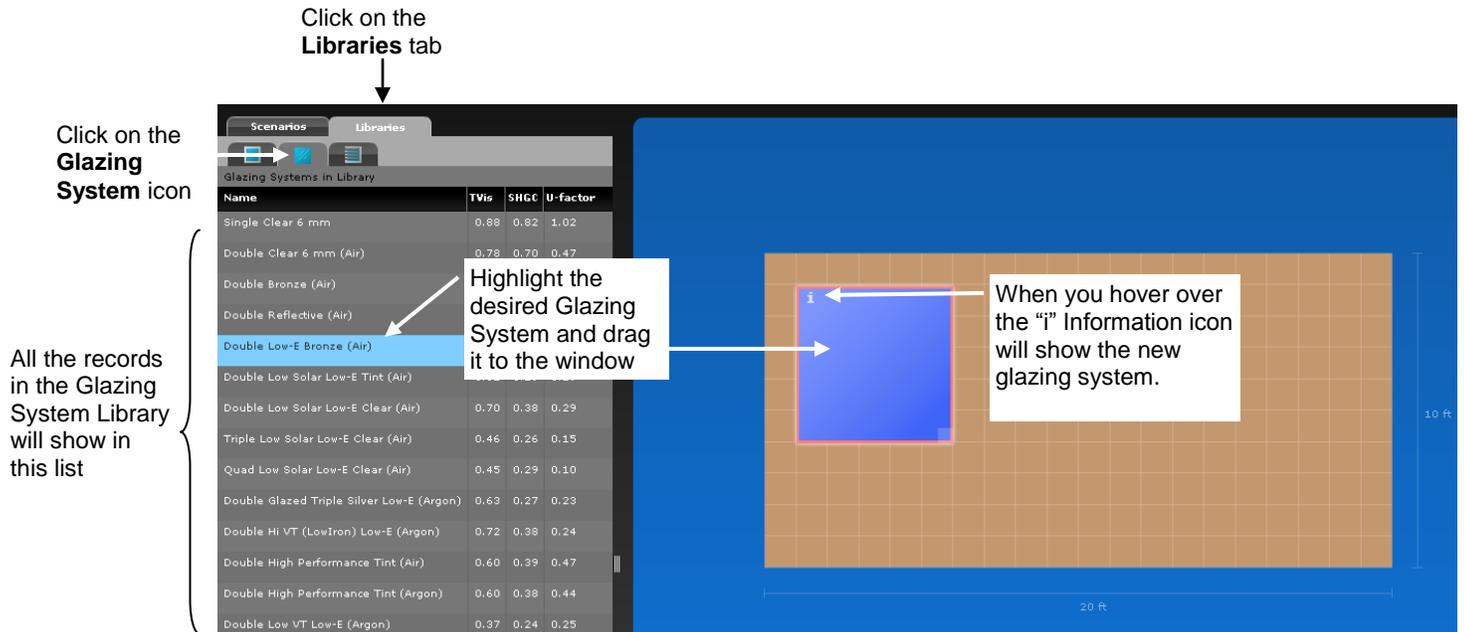


Figure 2-27. View a Façade that is already defined in the Façade Library.

Defining the Glazing System for the Window

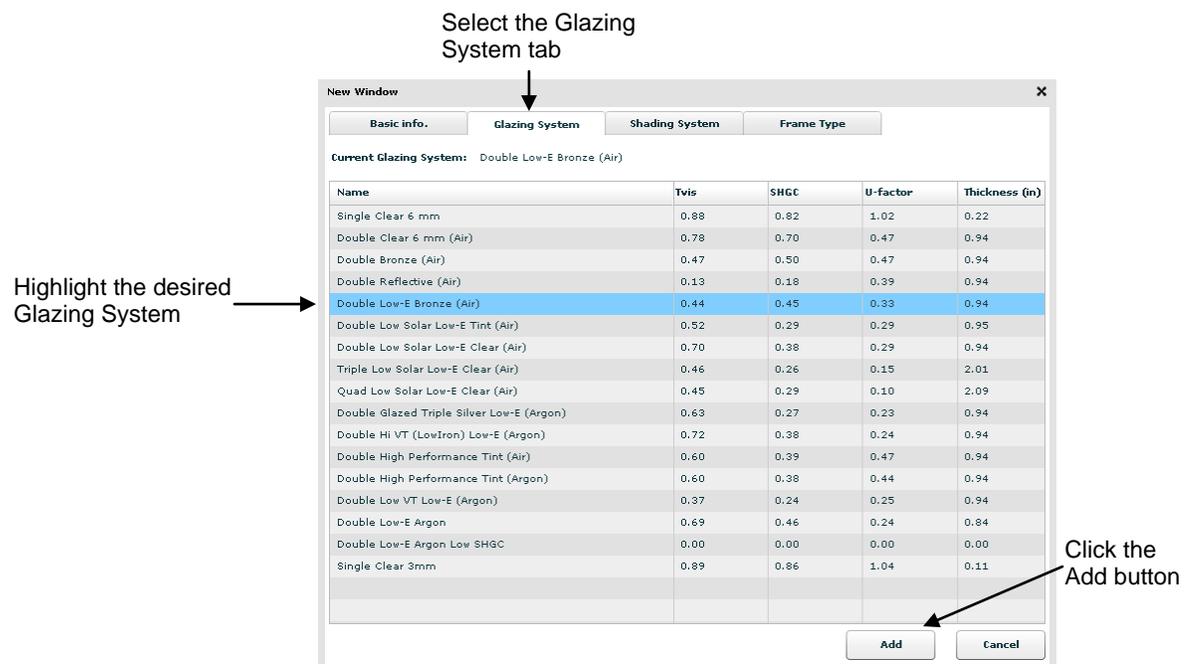
There are several ways to define or change a glazing system for a window:



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

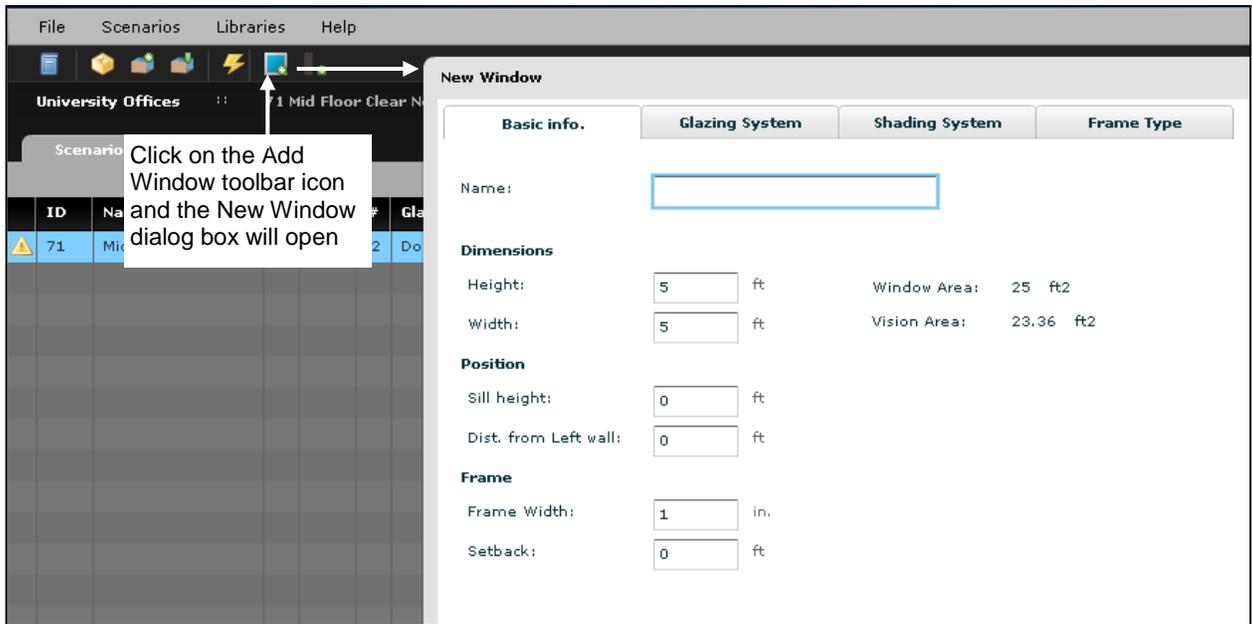
OR

- When defining the window, in the **New Window** dialog box, click on the **Glazing System** tab and the records in the **Glazing System Library** will be displayed in a list. Highlight the desired glazing system and click the **Add** button.



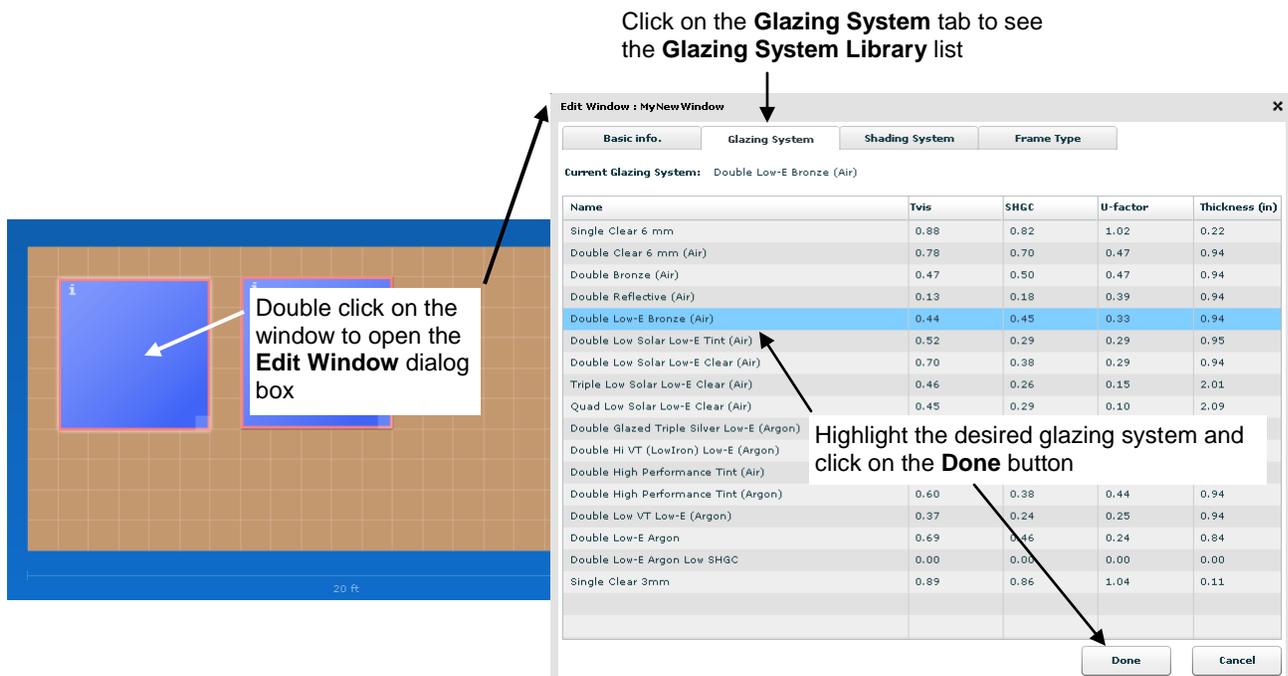
OR

- Click on the Add Window to Scenario toolbar button  and the New Window dialog box will open.



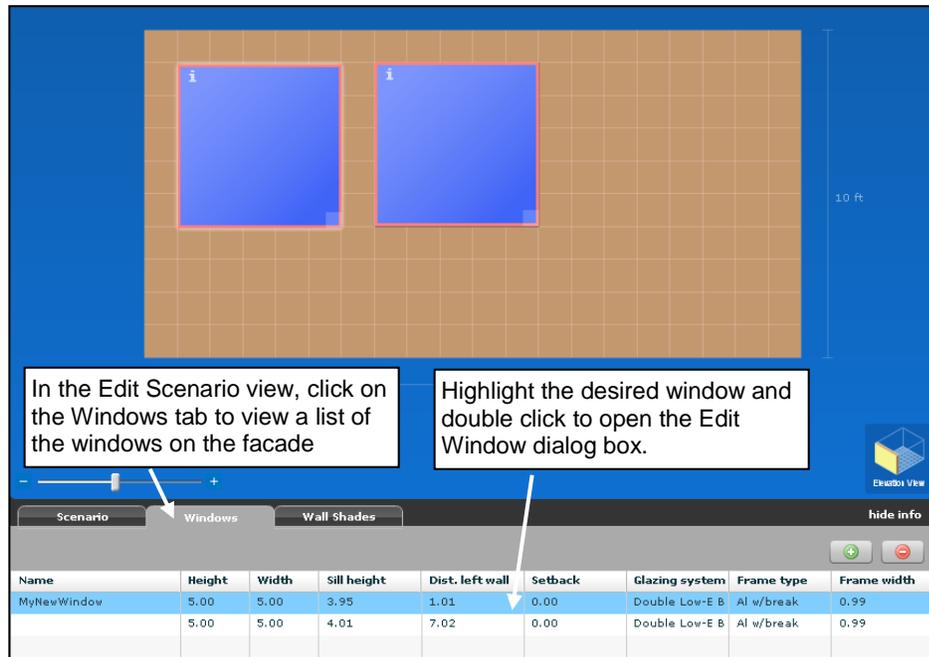
OR

- 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.



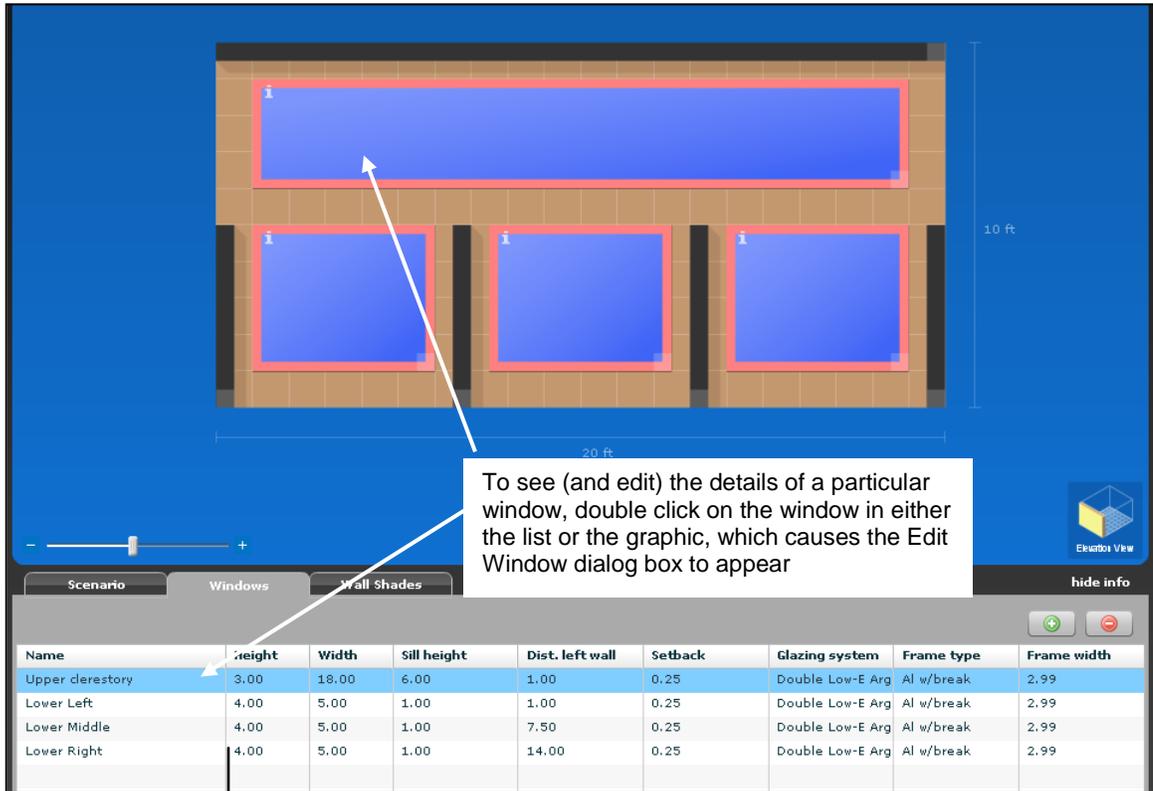
OR

- In the **Edit Scenario View**, click on the **Window** tab, double click on the desired window and the **Edit Window** dialog box will appear.



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.



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

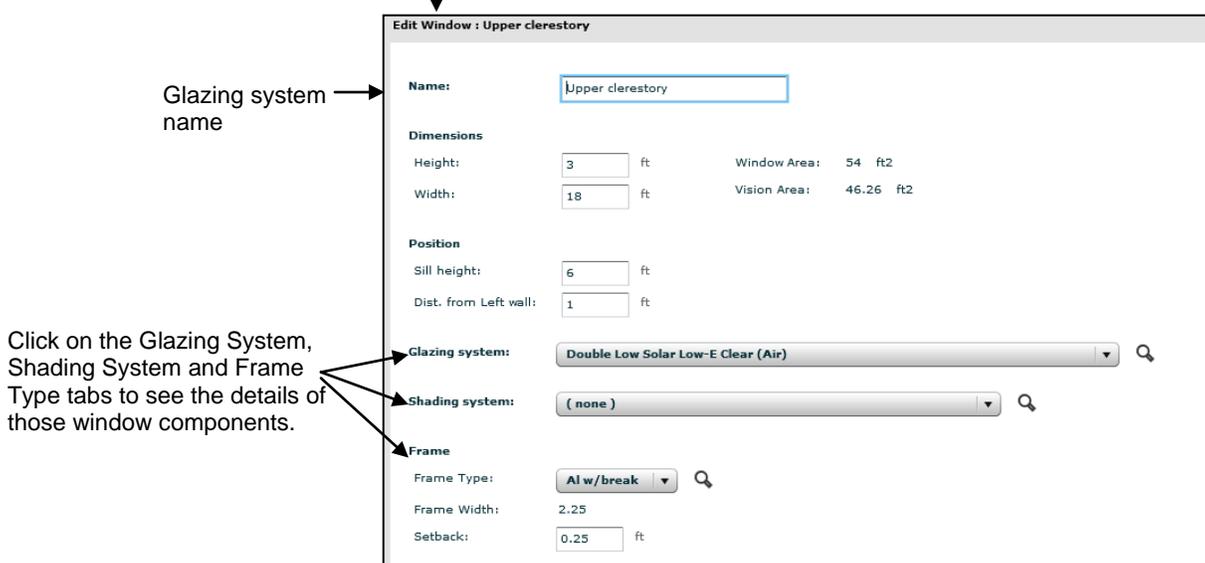
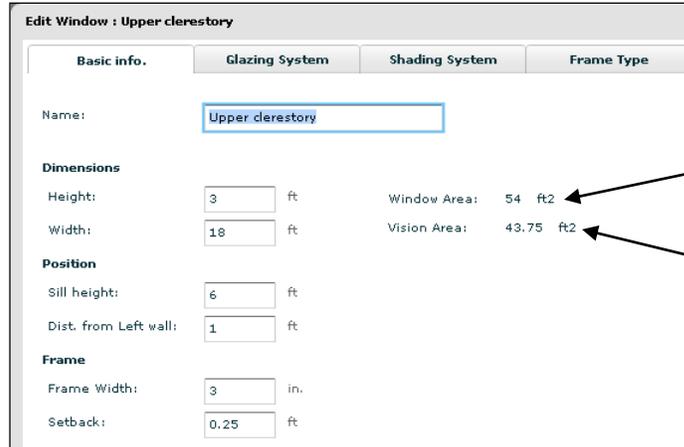


Figure 2-28. The Window tab and the Edit Window dialog box

Edit Window dialog box

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

Basic info The window dimensions and position in the wall



The Window Area is the area of the window including the frame.

The Vision Area is the area of the glazing system inside the frame.

Figure 2-29. The Basic Info tab on the Edit Window dialog box.

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

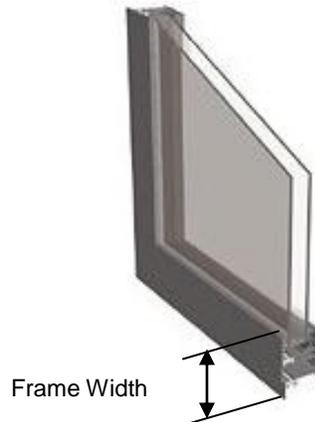


Figure 2-30. The Frame Width.

The Frame Setback is the distance from the outside wall that the window is inset into the frame.

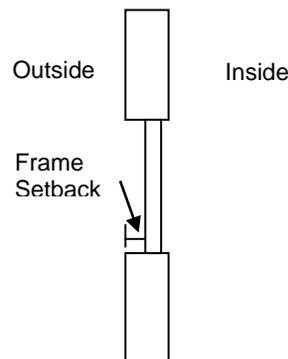


Figure 2-31. The Frame Setback.

Glazing System The glazing system that is selected for the window

The highlighted glazing system is the one selected for this window

Edit Window : Upper clerestory [X]

Basic info. | **Glazing System** | Shading System | Frame Type

Current Glazing System: Double Low-E Argon

Name	Tvis	SHGC	U-factor	Thickness (in)
Single Clear 6 mm	0.88	0.82	1.02	0.22
Double Clear 6 mm (Air)	0.78	0.70	0.47	0.94
Double Bronze (Air)	0.47	0.50	0.47	0.94
Double Reflective (Air)	0.13	0.18	0.39	0.94
Double Low-E Bronze (Air)	0.44	0.45	0.33	0.94
Double Low Solar Low-E Tint (Air)	0.52	0.29	0.29	0.95
Double Low Solar Low-E Clear (Air)	0.70	0.38	0.29	0.94
Triple Low Solar Low-E Clear (Air)	0.46	0.26	0.15	2.01
Quad Low Solar Low-E Clear (Air)	0.45	0.29	0.10	2.09
Double Glazed Triple Silver Low-E (Argon)	0.63	0.27	0.23	0.94
Double Hi VT (LowIron) Low-E (Argon)	0.72	0.38	0.24	0.94
Double High Performance Tint (Air)	0.60	0.39	0.47	0.94
Double High Performance Tint (Argon)	0.60	0.38	0.44	0.94
Double Low VT Low-E (Argon)	0.37	0.24	0.25	0.94
Double Low-E Argon	0.69	0.46	0.24	0.84
Double Low-E Argon Low SHGC	0.00	0.00	0.00	0.00
Single Clear 3mm	0.89	0.86	1.04	0.11
MyNewGlazingSystem	0.00	0.00	0.00	0.00

Done Cancel

Figure 2-32. The Glazing System tab on the Edit Window dialog box.

Shading System The shading system (such as venetian blind, shade, exterior screen) for the window

In this example, there is not a shading system selected, so no shading system in the list is highlighted

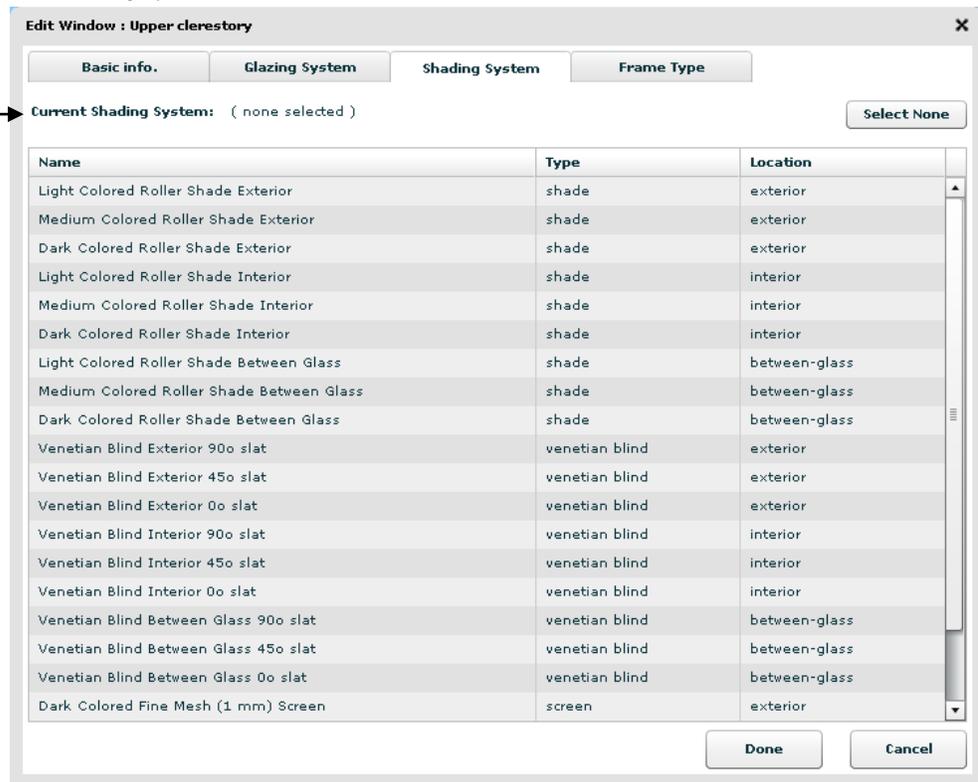


Figure 2-33. The Shading System tab on the Edit Window dialog box.

Frame Type The frame type for the window.

The highlighted frame is the one selected for this window

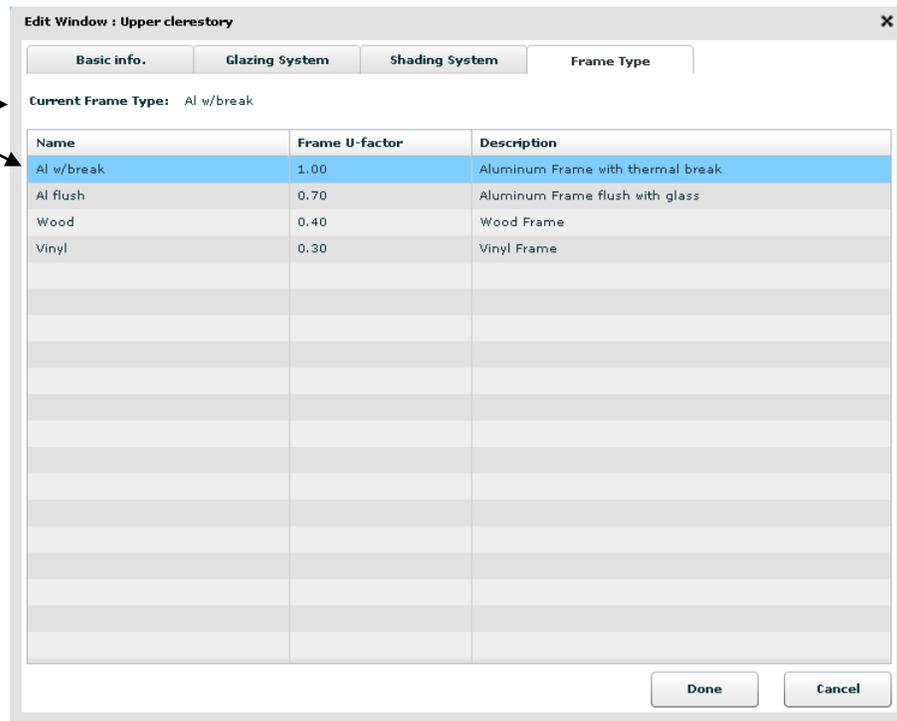


Figure 2-34. The Frame Type tab on the Edit Window dialog box.

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.

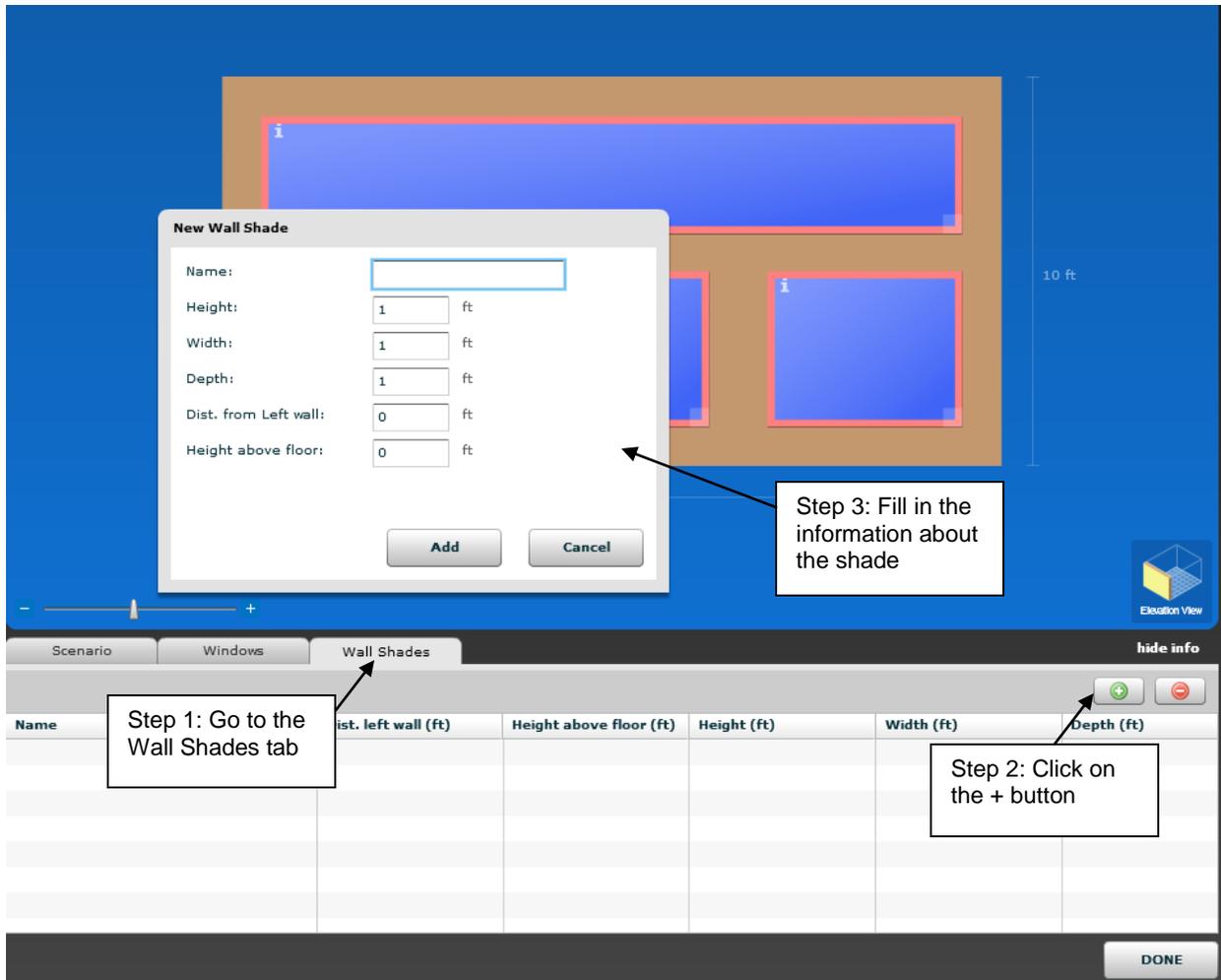
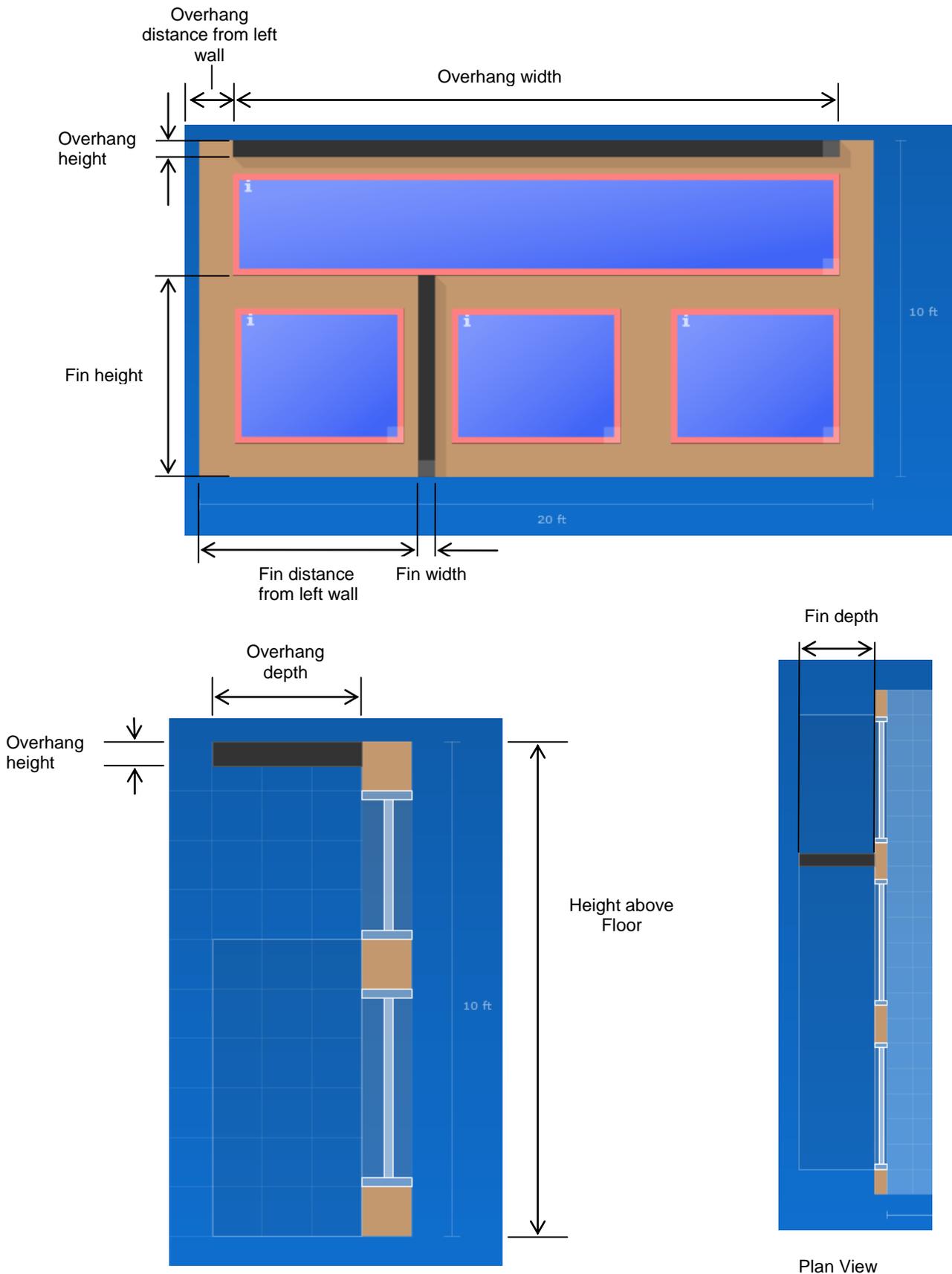


Figure 2-35. Defining an overhang or fin.



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.

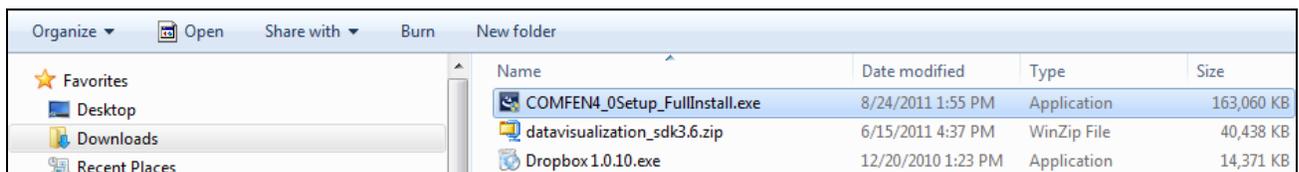


Figure 3-1. Double click on the downloaded installation file.

3. INSTALLATION

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

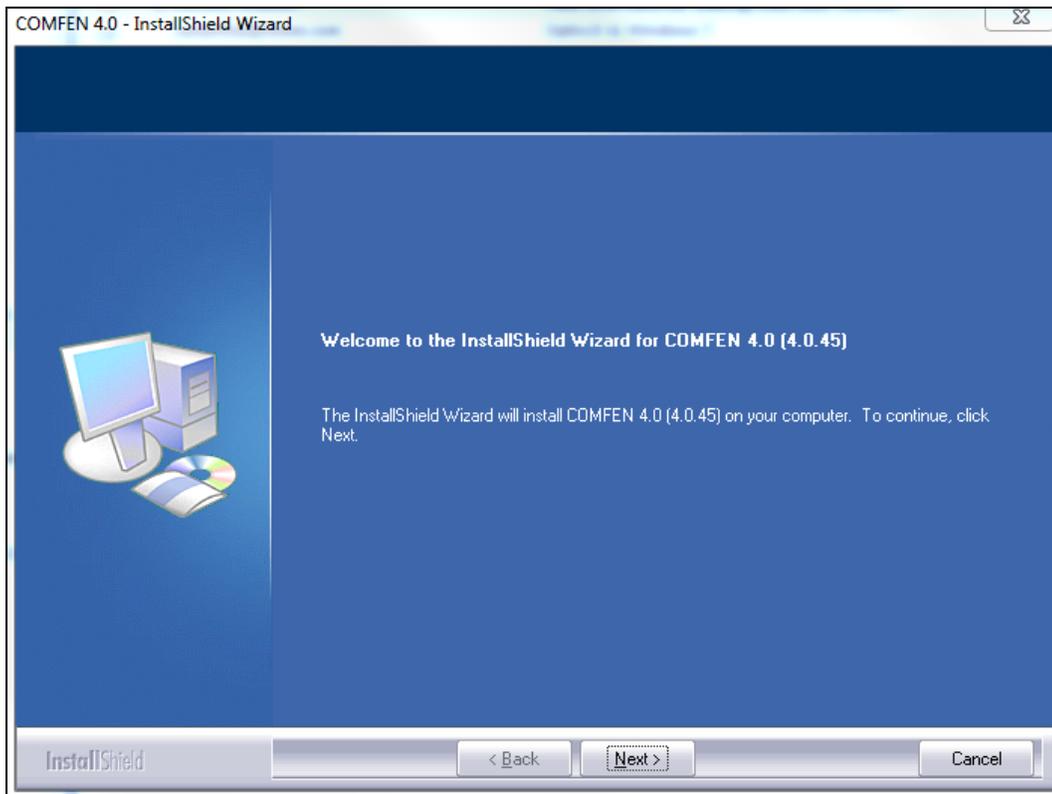


Figure 3-2. The initial COMFEN Welcome window.

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.

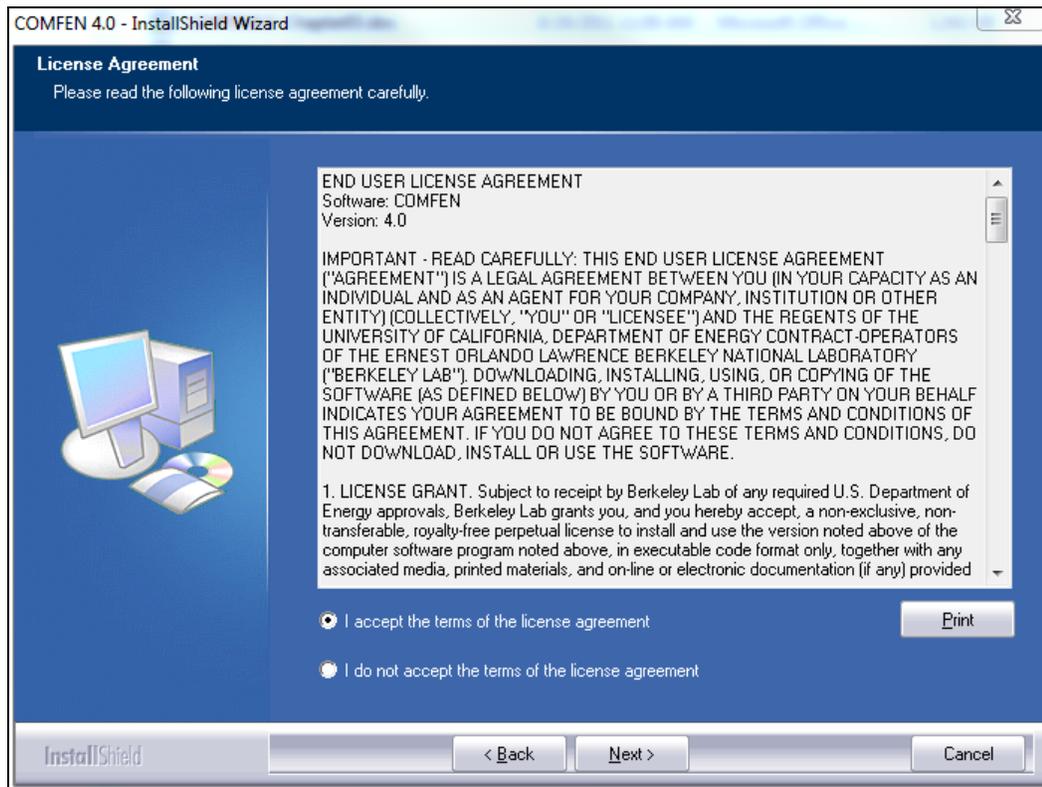


Figure 3-3. The COMFEN License Agreement window.

3. INSTALLATION

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

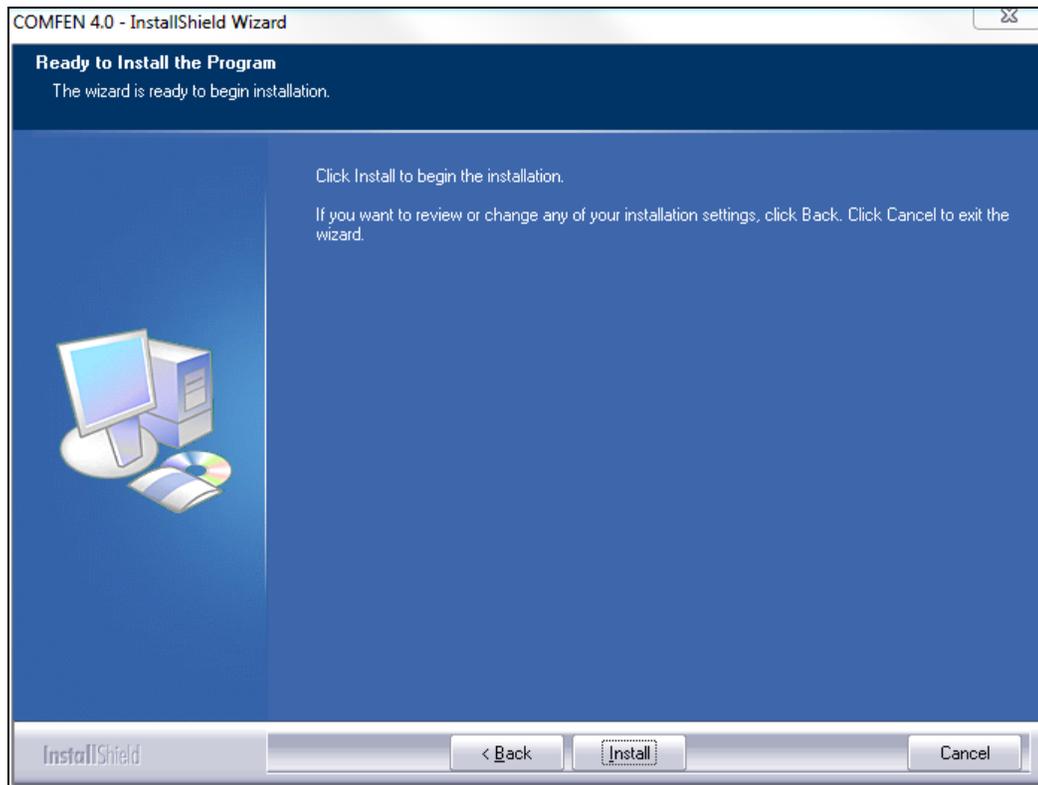


Figure 3-4. Ready to Install the Program screen.

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

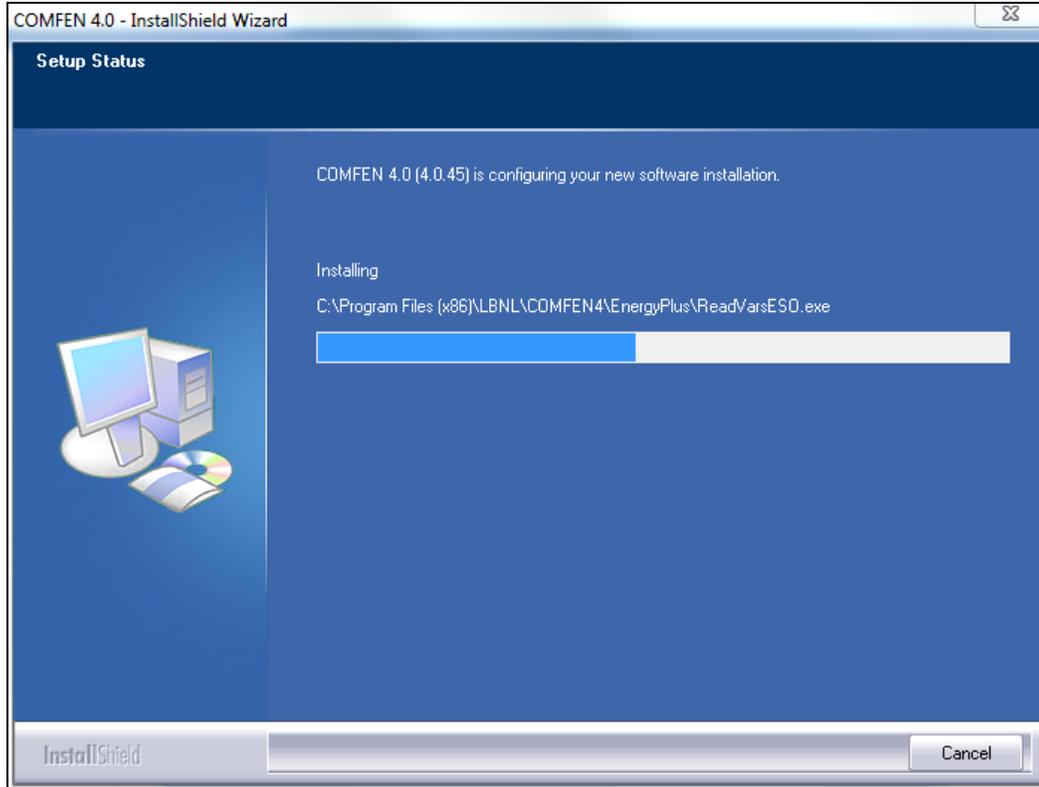


Figure 3-5. The **Setup Status** screen shows the files being installed.

- 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.

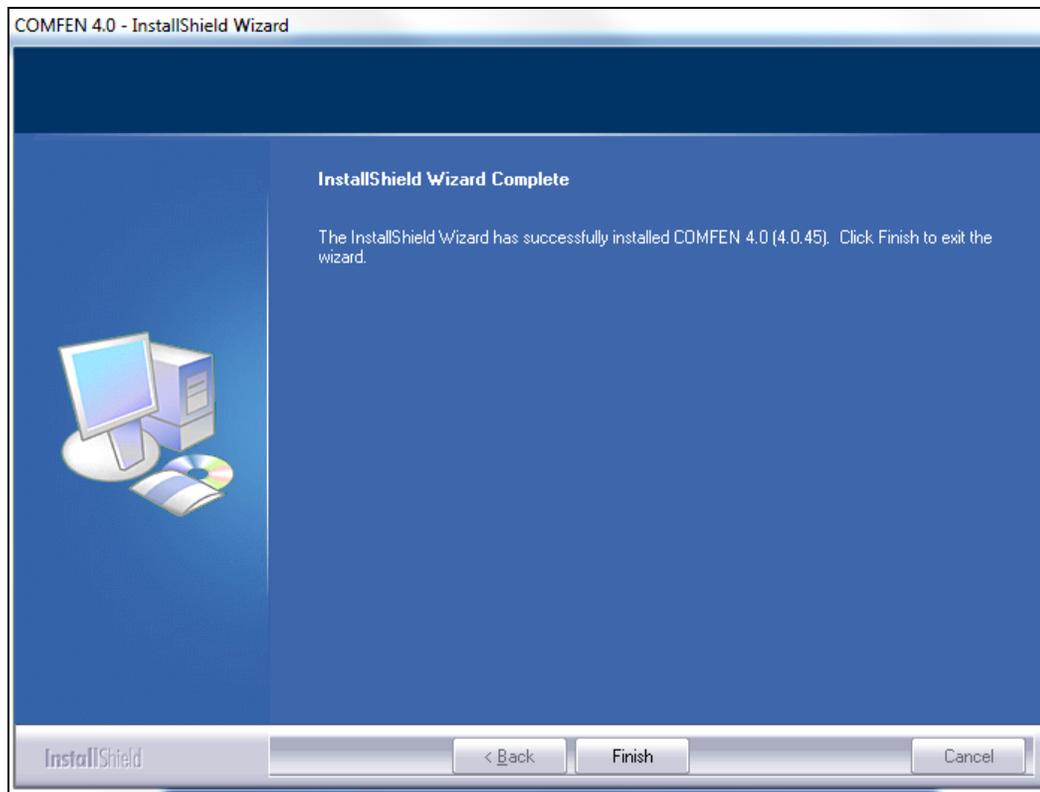


Figure 3-6. The *InstallShield Wizard Complete* screen will display when the installation is finished. Press the **Finish** button to finalize the installation.

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

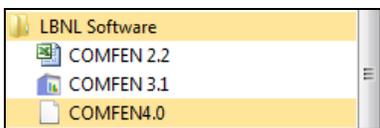


Figure 3-7. Program icon to run COMFEN.

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.

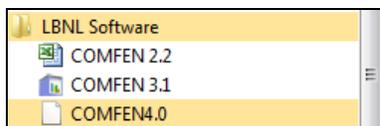


Figure 3-8. Click on the COMFEN 3.1 shortcut icon to start the program.

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).

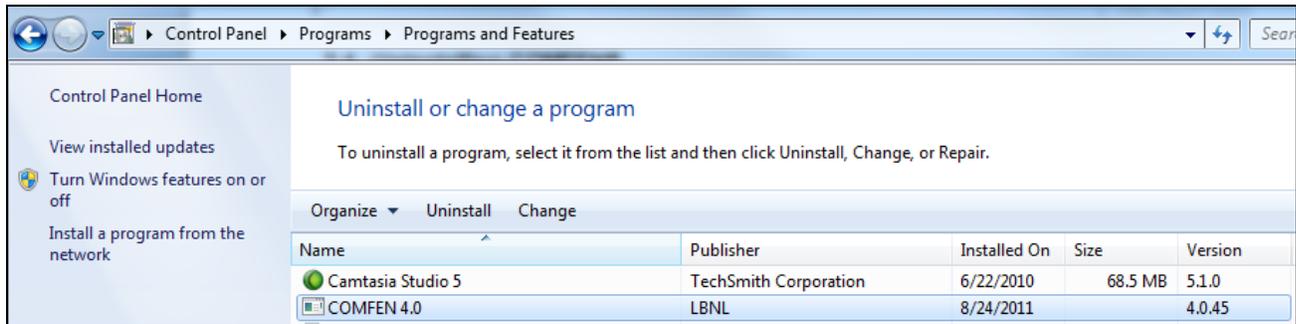


Figure 3-10. Go to Control Panel and click on Programs or Add/Remove Programs.

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.

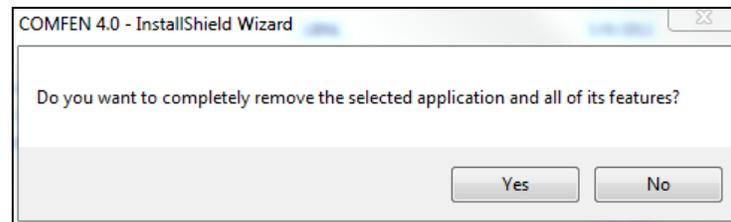
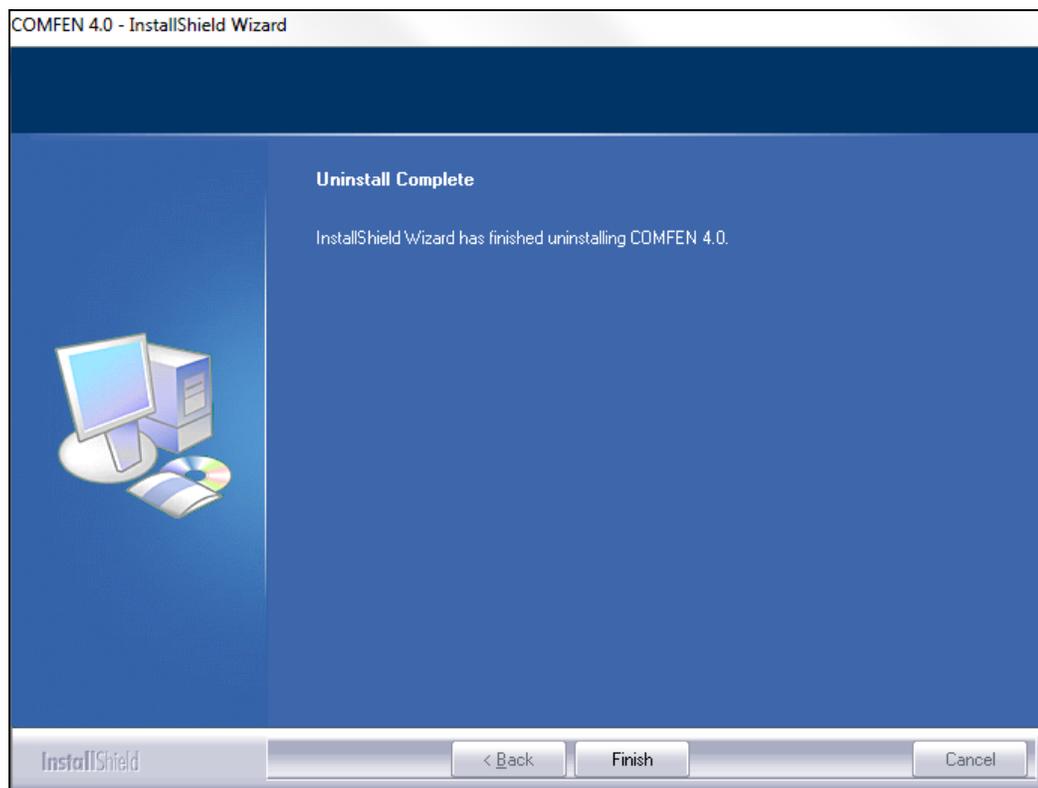


Figure 3-11. Click OK to continue with the uninstall process.

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. 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.

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.

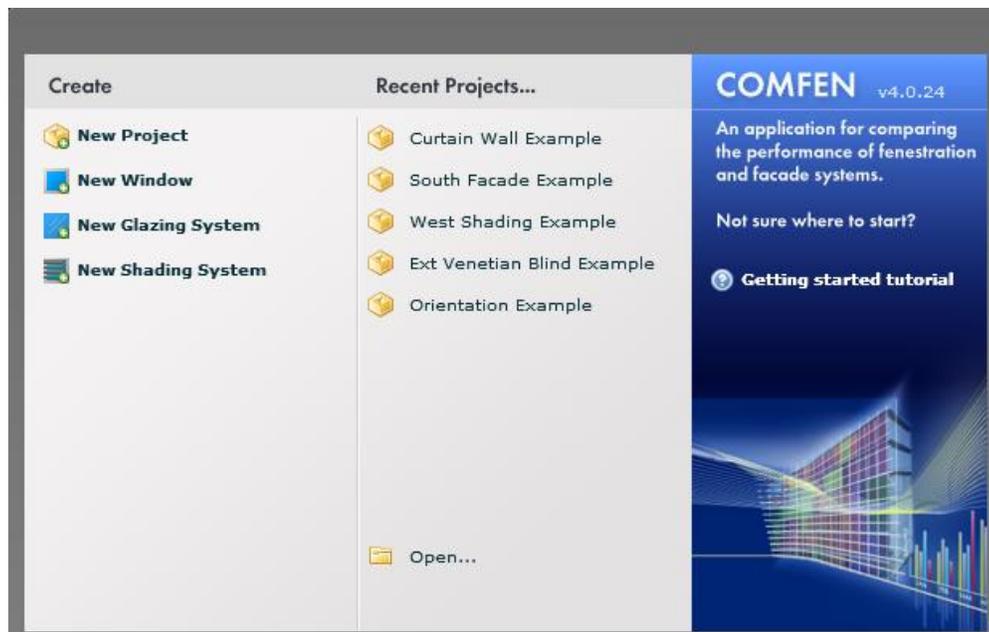


Figure 4-1. Opening Screen

4. PROGRAM DESCRIPTION

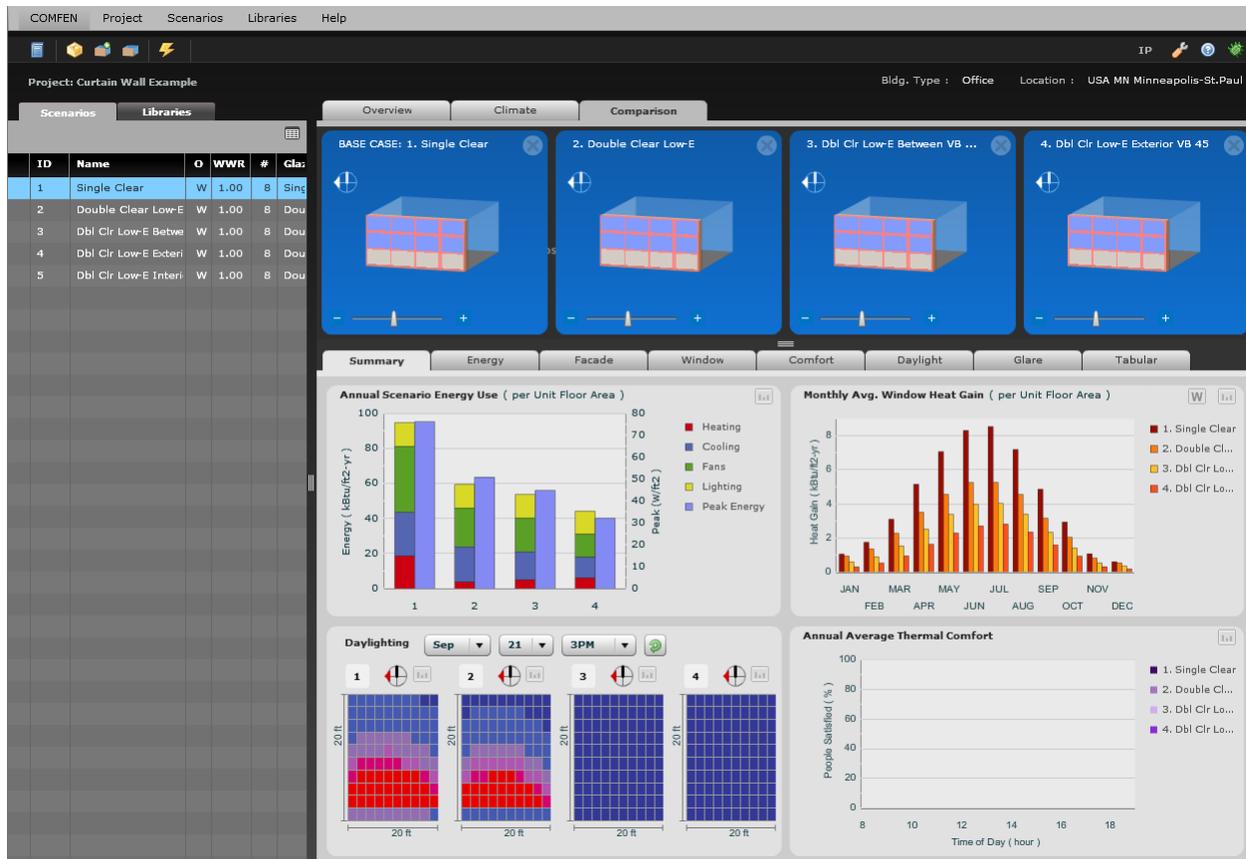


Figure 4-2. The COMFEN Project Comparison Summary screen

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.

4.2. Menu

The COMFEN menu options are:

<i>COMFEN</i>	The COMFEN menu can be used to view the program version number and modify general program options.
<i>Project</i>	The Project menu is used to control projects
<i>Scenarios</i>	The Scenarios menu is used to control Scenarios within projects.
<i>Libraries</i>	The Libraries menu is used to access all of the libraries
<i>Help</i>	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 four tabs:
 - **Basic Settings:** Allows the user to turn on or off verbose logging.



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. Once a new database is created, the user can locate the new database by clicking the browse button and navigating to the correct file.

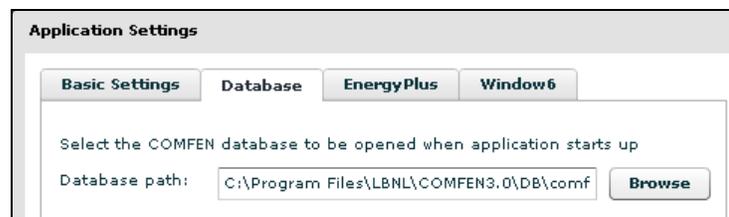


Figure 4-4. Preferences / Database

- **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 the *When calculating peak electricity usage...* checkbox is checked, electrical energy used by equipment is included in the peak electricity use results for the zone. Regardless of whether this checkbox is selected, COMFEN uses the equipment load inputs to account for the heat generated by the equipment and its impact on heating and cooling loads. By default, electricity used by equipment is not included in the results.
- When “Show EnergyPlus error log” or “Show in.imf file” are selected, these two files open automatically if EnergyPlus crashes.

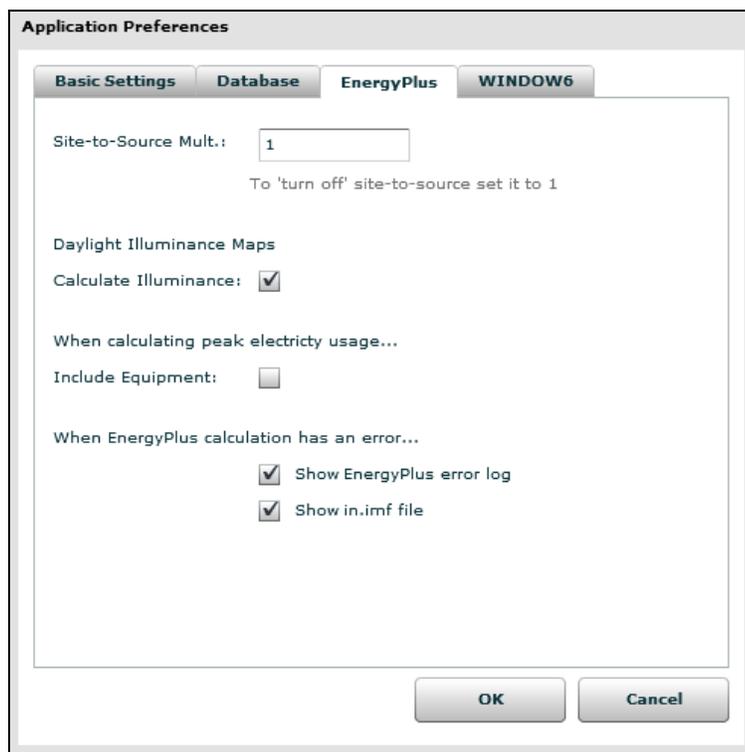


Figure 4-5. Preferences / EnergyPlus

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



Figure 4-6. Preferences / WINDOW6

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**.

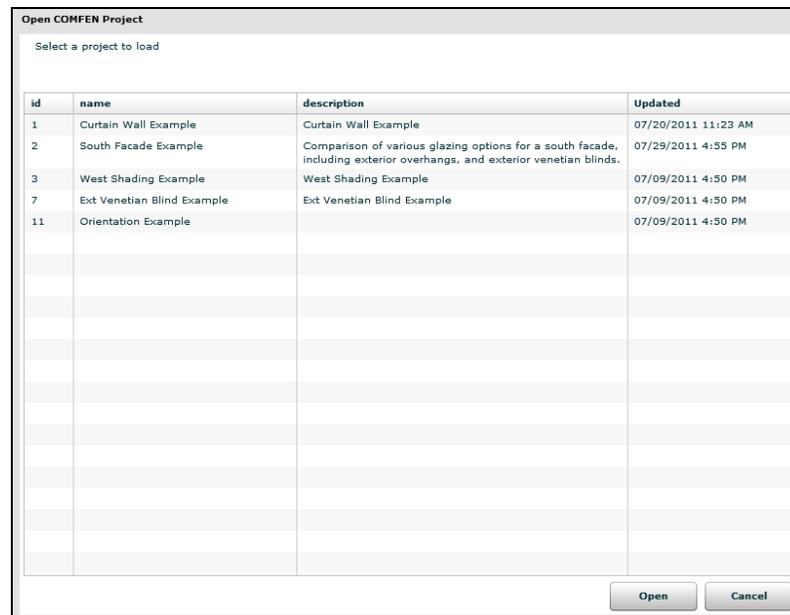


Figure 4-7. Project / Open Project

Close project

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

Project

Properties

Opens the **Edit COMFEN project** 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.

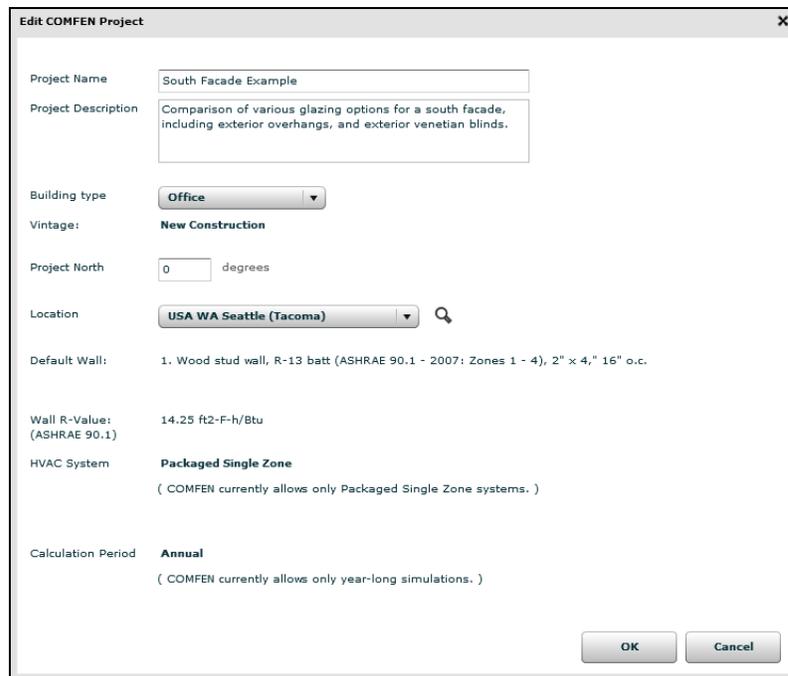


Figure 4-8. Project / Project Properties

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.

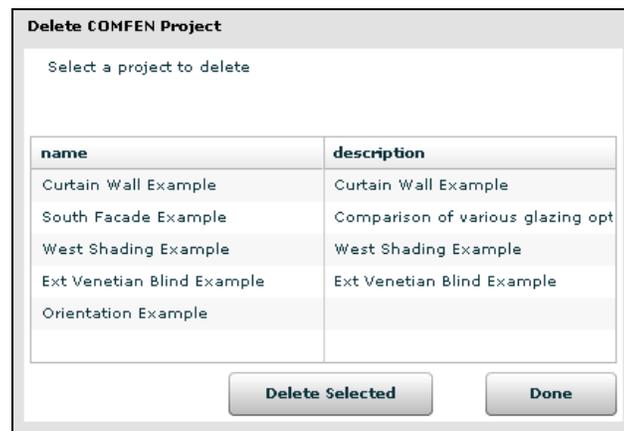


Figure 4-9. Project / Delete Projects

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

<i>Create Scenario</i>	Opens the Create New Scenario dialog box.
<i>Copy Scenario</i>	Creates a copy of highlighted scenario.
<i>Import Scenario from Project</i>	Allows the user to import a select scenario from another project.
<i>Delete Scenario</i>	Deletes highlighted scenario.
<i>Rename Scenario</i>	Renames highlighted scenario.
<i>Add Window to Scenario</i>	Adds a window to scenario. Unless scenario is active, this option is grayed out.
<i>Add Exterior Shade to Scenario</i>	Adds fixed exterior projection (overhangs, fins, etc.) to scenario. Unless scenario is active, this option is grayed out.
<i>Export scenario output data to CSV</i>	Exports basic scenario information (orientation, glazing name, lighting control type, glazing type, etc.) and annual performance data (energy use by end use, peak energy use by end use, CO2 emissions, etc.) for all scenarios in open project.
<i>Export compared scenarios images to PNG</i>	Exports thumbnail images of select scenarios in *.png format.
<i>Calculate All</i>	Calculates performance of all scenarios in project
<i>Calculate Selected</i>	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. See section on glass library for more information on the IGDB database.

4.3. Project

To create a new project, select New Project from the Project menu. The Create COMFEN Project dialog box includes the following inputs:

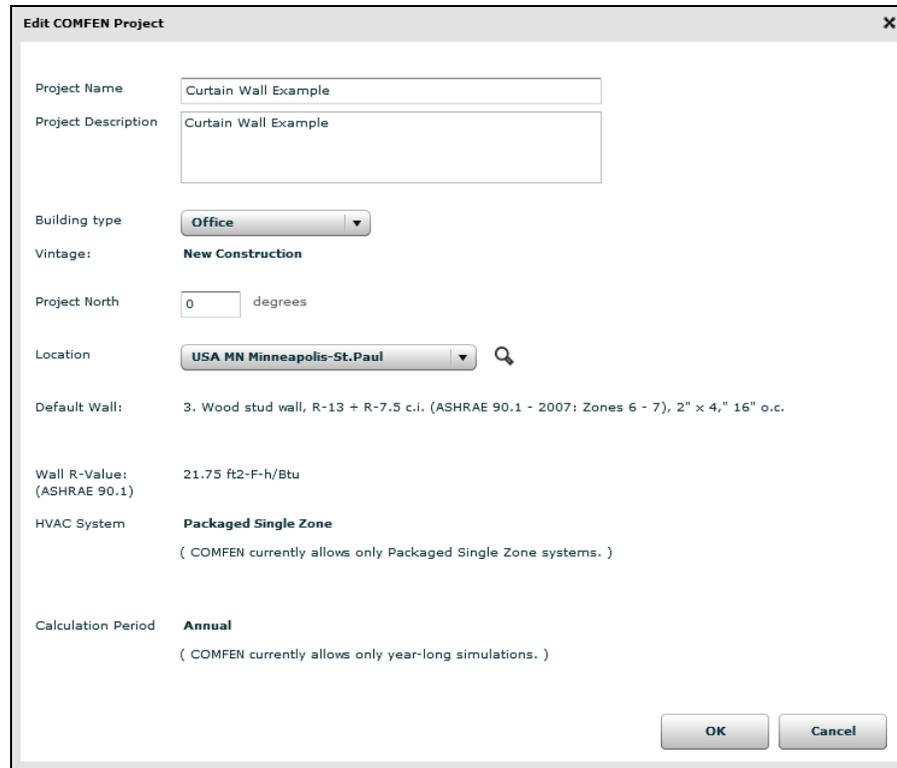


Figure 4-10. Project Properties from New Project menu

- **Project Name:** Field used to provide a unique name for the project.
- **Building Type:** 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.

- **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.

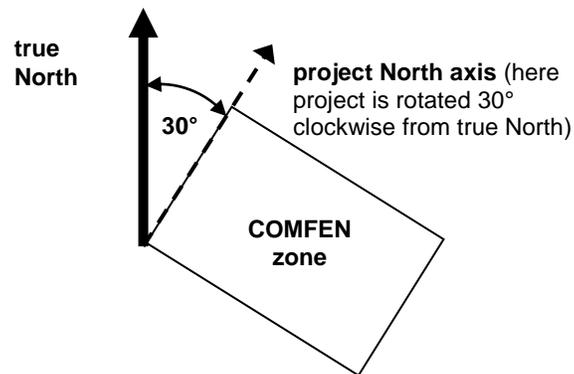


Figure 4-11. Illustration of project North axis.

- **Location:** 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.
- **HVAC system:** The default HVAC system is presently a packaged single zone system for all building types.
- **Calculation period:** By default, the simulation runs for the entire year, January 1 through December 31.

4.4. 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 4.7.2. for a more detailed description of these 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. See 4.7.2. for a more detailed description of these options.

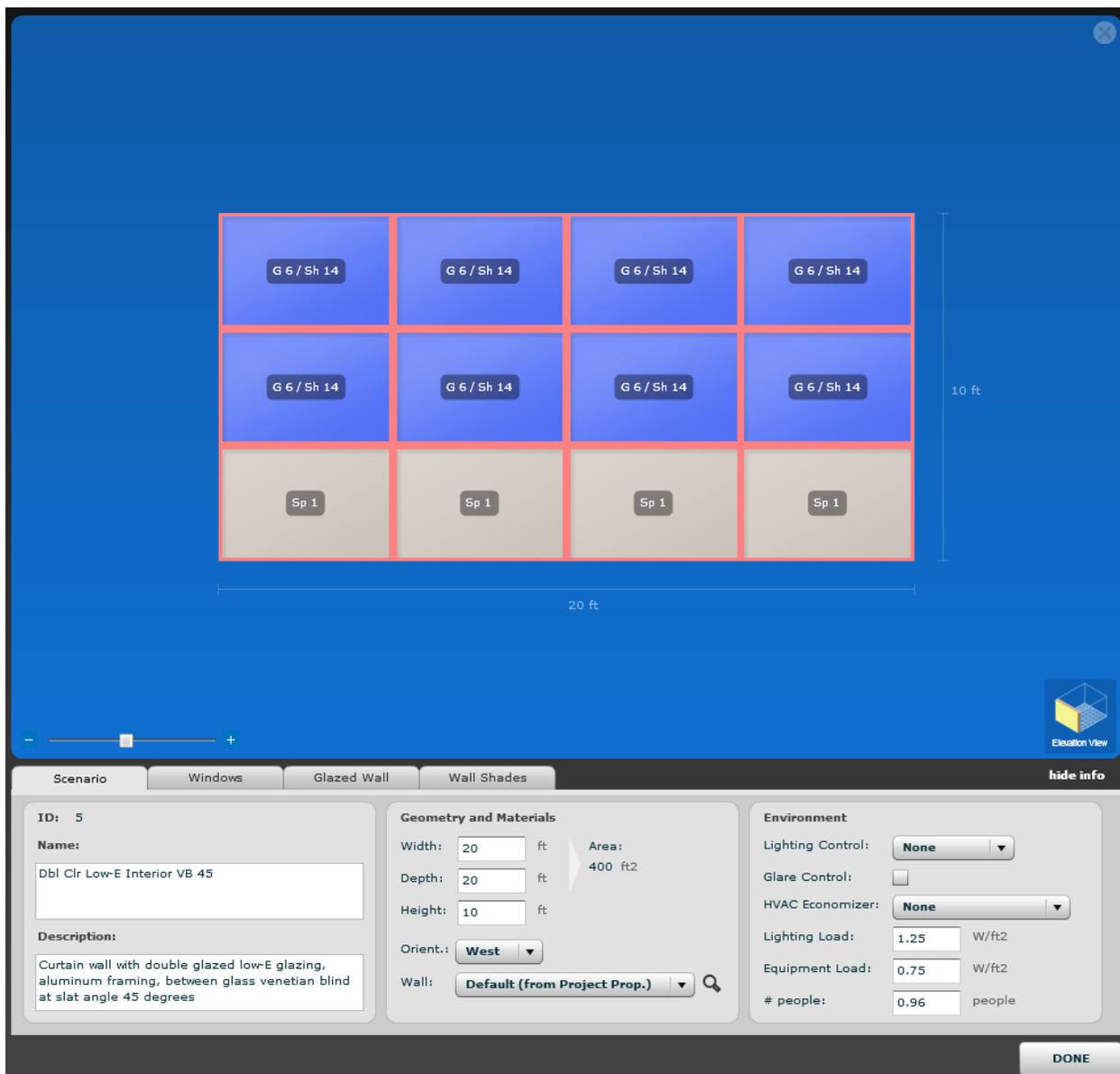


Figure 4-13. Scenario tab.

4.5. Facade components and libraries

This chapter discusses construction components and COMFEN libraries in more 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 glass products from a range of manufacturers. New entries can be created in all libraries except for the glass and gas libraries.

4.5.1. Glazed wall assembly

In addition to the option of creating individual 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 4-14. Toolbar with Glazed Wall Assembly icon

This will pull up the glazed wall assembly dialog box:

New Glazed Wall Assembly

10 ft.
30 ft.

Default Frame: Al w/break Q

Generate Horizontal Frame Elements

Assembly Height: ft

Count: ▲ ▼

Offset from bottom: ft

Name	Width(in) *	Spacing(ft)	Distance(ft)

Assembly height: 10 ft
Facade height: 10 ft

Generate Vertical Frame Elements

Assembly Width: ft

Count: ▲ ▼

Offset from left: ft

Frame Name	Width(in) *	Spacing(ft)	Distance(ft)

Assembly width: 30 ft
Facade width: 30 ft

Assembly Glazing System

Default glazing system: Single Clear 6 mm Q

Default shading system: (none) Q

You can change the glazing or shading system of individual lites after the assembly is created.

Done
Cancel

Figure 4-15 New glazed wall assembly dialog

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 4-16. 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.

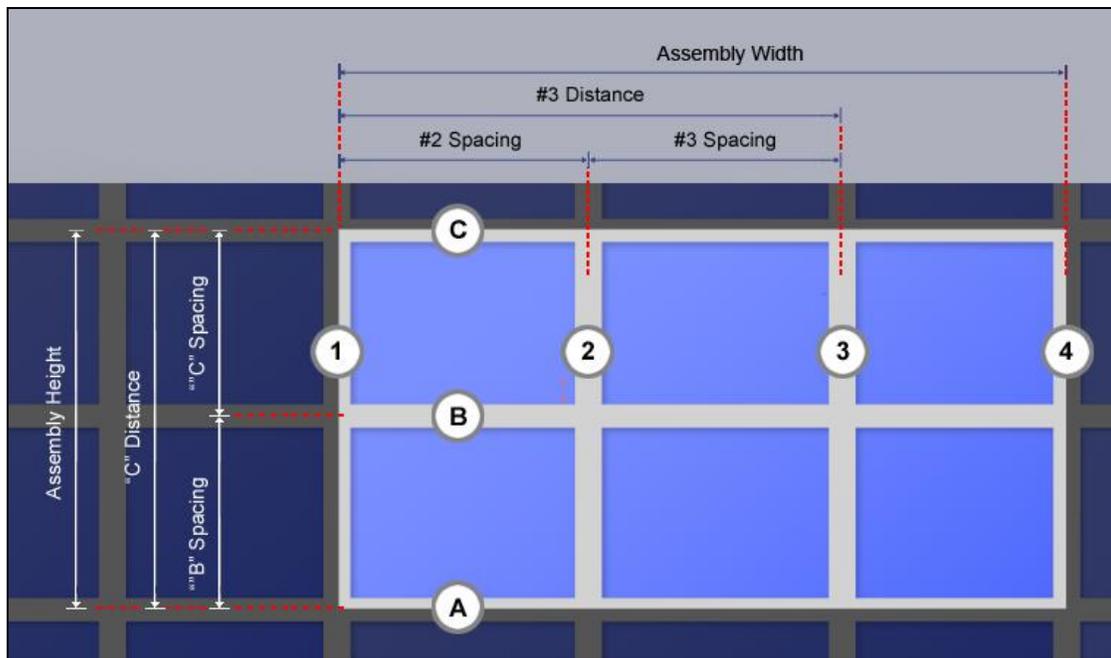


Figure 4-17 Framing member spacing and distance

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:

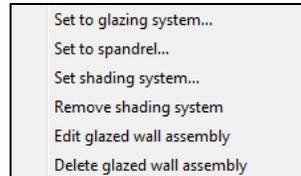


Figure 4-18 Glazed wall assembly menu

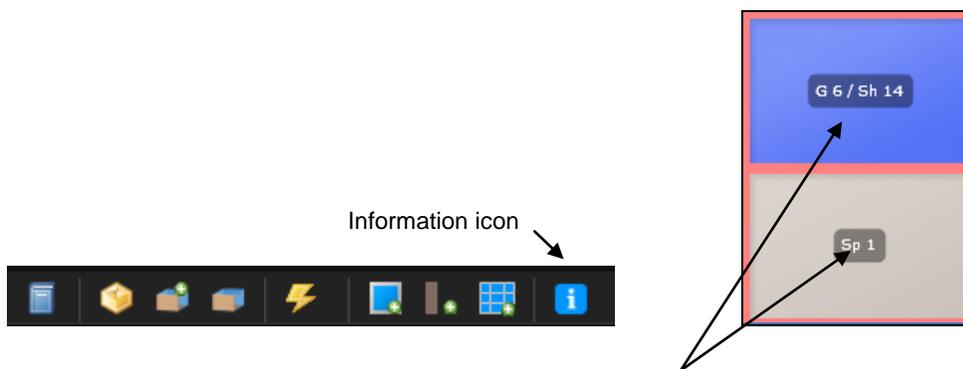
From this menu, the user can opt to edit a glazing system, assign or delete a shading system or specify a spandrel. "Edit glazed wall assembly" will bring up the **New glazed wall assembly** dialog box.

NOTE: Any changes (e.g. glazing, shading or 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 highlighted. At this point, if you right-click, the menu with the options listed above will appear.



Figure 4-19 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 4-20 Glazed wall tab

4.5.1. Glass layers

The glass library contains entries from the International Glazing Database (IGDB) – a database containing measured performance data for commercially-available products that is submitted by manufacturers to LBNL, where they undergo technical and a peer review. 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 update file from the COMFEN online Knowledge Base.

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

<i>NFRC ID</i>	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.
<i>Name</i>	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.
<i>Thickness</i>	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
<i>Source</i>	Lists the IGDB version.
<i>Emis1</i>	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.
<i>Emis2</i>	Emissivity of the back surface of the glass layer. See comment for front emissivity above.

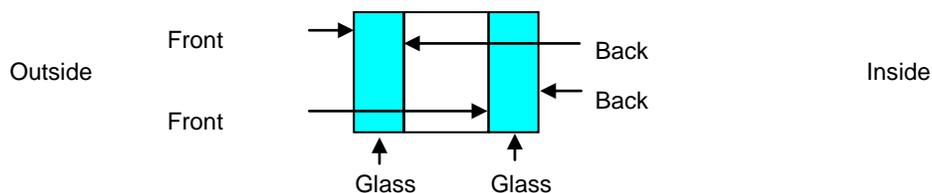


Figure 4-21. Definition of front and back glass layer surfaces

4.5.2. 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.

id	Name	# gases	Comment
1	Air	0	
2	Argon	0	
3	Krypton	0	
4	Xenon	0	
6	Air (5%) / Argon (95%) Mix	2	
7	Air (12%) / Argon (22%) / Krypton (66%) Mix	3	
8	Air (5%) / Krypton (95%) Mix	2	
9	Air (10%) / Argon (90%) Mix	2	

Figure 4-22. COMFEN gas library

4.5.3. Glazing systems

Glazing system library

The glazing system library is accessed by selecting “View all glazing systems” from the Libraries menu. There are approximately 50 predefined glazing systems in the Glazing System Library, which includes both several generic glazing systems (ID# 1-15) 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 6 glazing system library.

Windows		Glazing Systems	Shading Systems	Frames	Glass	Gas
ID	Name	TVis	SHGC	U-factor (Btu/h-ft ² -F)	Thickness (in)	
1	Single Clear 6 mm	0.88	0.81	1.02	0.23	
2	Double Clear (Air)	0.78	0.70	0.47	0.97	
3	Double Bronze (Air)	0.47	0.50	0.47	0.97	
4	Double Low-E Bronze (Air)	0.44	0.45	0.33	0.97	
5	Double Low Solar Low-E Tint (Air)	0.51	0.29	0.29	0.97	
6	Double Low Solar Low-E Clear (Air)	0.70	0.38	0.29	0.97	
7	Quad Low Solar Low-E Clear (Air)	0.45	0.29	0.10	2.09	
8	Double Glazed Triple Silver Low-E (Argon)	0.63	0.26	0.23	0.97	
9	Double Hi VT (LowIron) Low-E (Argon)	0.72	0.38	0.24	0.97	
10	Double High Performance Tint (Air)	0.59	0.39	0.47	0.97	
11	Double High Performance Tint (Argon)	0.59	0.38	0.44	0.97	
12	Double Low VT Low-E (Argon)	0.37	0.24	0.25	0.97	
13	Double Low-E Clear (Argon)	0.69	0.47	0.24	0.85	
14	Double Double Glazed Triple Silver Low-E Tint (Argon)	0.53	0.24	0.23	0.97	
15	Double Low-E Opaque (Air)	0.02	0.07	0.29	0.97	

Figure 4-23. Glazing system library

4. PROGRAM DESCRIPTION

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 already in this 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 following 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.

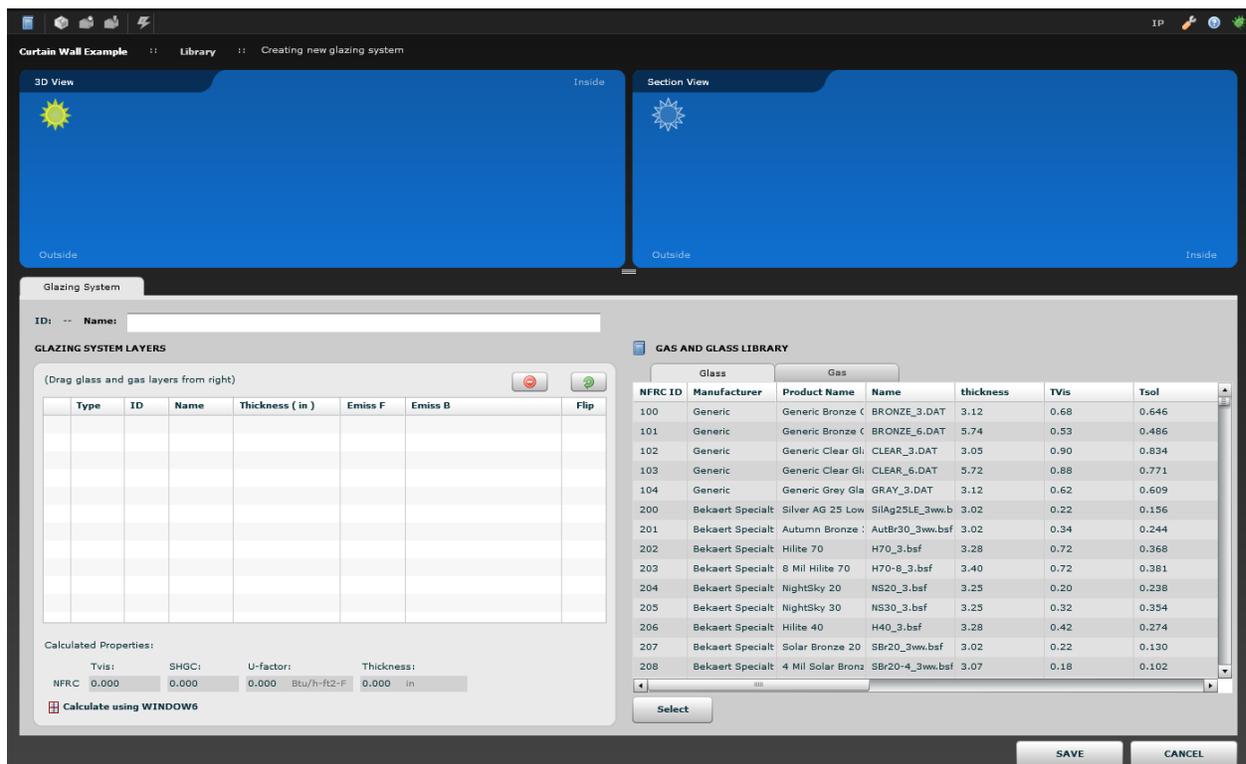


Figure 4-24. Glazing system creation screen

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	

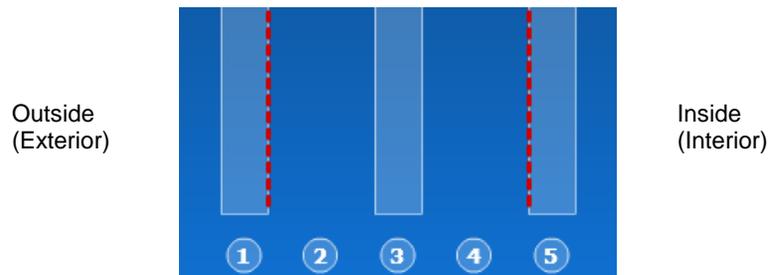


Figure 4-25. Glass and gas layers are numbered from outside to inside

The **Calculate using WINDOW 6** button calculates the thermal and optical properties for the glazing system (T_{vis} , 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.

Calculated Properties:				
	T_{vis} :	SHGC:	U-factor:	Thickness:
NFRC	0.617	0.467	0.150 Btu/h-ft ² -F	1.709 in
Calculate using WINDOW 6				

Figure 4-26. The Results section of the Glazing System Library

- T_{vis} 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)

4. PROGRAM DESCRIPTION

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 4-27. 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.

Import Glazing System from WINDOW6

ID	Glazing System	# Layers	Thickness (in)	SHGC	TVis	U-factor (Btu/h-ft2-
1	1 Single clear 6 mm	1	0.236	0.815	0.881	1.023
2	2 Double clear (air)	2	0.972	0.702	0.781	0.473
3	3 Double bronze (air)	2	0.972	0.504	0.473	0.473
4	4 Double low-e bronze (air)	2	0.972	0.454	0.440	0.330
5	5 Double low solar low-e tint (air)	2	0.972	0.298	0.512	0.290
6	6 Double low solar low-e clear (air)	2	0.972	0.386	0.701	0.290
7	7 Quad low solar low-e clear (air)	4	2.091	0.298	0.457	0.108
8	8 Double glazed triple silver low-e	2	0.972	0.270	0.636	0.238
9	9 Double high VT (low-iron) low-e	2	0.972	0.386	0.727	0.246
10	10 Double high performance tint (	2	0.972	0.392	0.596	0.473
11	11 Double high performance tint (	2	0.972	0.388	0.596	0.448
12	12 Double low VT low-e (argon)	2	0.972	0.242	0.372	0.253
13	13 Double low-e clear (argon)	2	0.854	0.473	0.698	0.245
14	14 Double glazed triple silver low-	2	0.972	0.243	0.536	0.238
15	Double Low-E Opaque (air)	2	0.972	0.079	0.027	0.290
100	100 Viracon -- VE-2M (2) clear/cle	2	0.972	0.381	0.702	0.292
101	101 Viracon -- VE-2M (2) clear/cle	2	0.972	0.377	0.702	0.246
102	102 Viracon -- VE-2M (2) low-iron/	2	0.972	0.393	0.732	0.292
103	103 Viracon -- VNE-63 (2) clear/cle	2	0.972	0.288	0.620	0.289

X = glazing system must be calculated in WINDOW6 before importing.

Figure 4-28. 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.

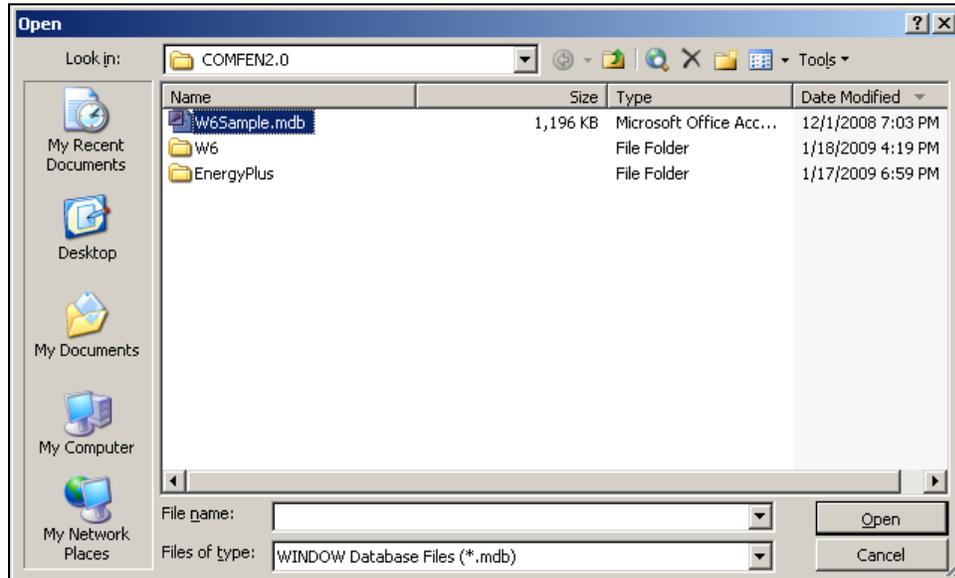


Figure 4-29. Select a WINDOW 6 database from which to import glazing systems

4.5.4. 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.

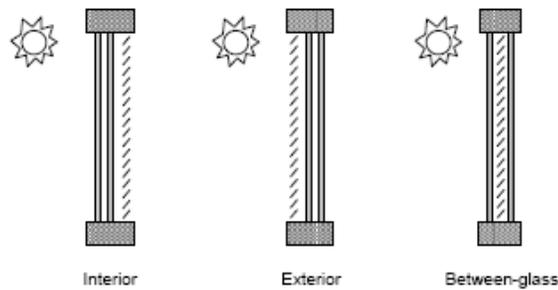


Figure 4-30. Venetian blinds can be defined in three different locations relative to the glazing system.

Shading System

NAME AND PROPERTIES

Name: Venetian Blind Interior 45o slat
 Type: venetian blind
 Location: Interior

Shading Control

Type: Always on

Slat angle: Fixed Slat angle

DETAILS

Orientation: Horizontal

Slat Geometry

Width: 0.45 in
 Spacing: 0.3 in
 Thickness: 0.04 in

Slat Tilt

Tilt: 45 degrees
 Min Tilt: 0 degrees
 Max Tilt: 180 degrees

Slat Conductivity

Conductivity: 92 Btu/h-ft-F

Slat Optical Properties

	Solar		Visible	
	Beam	Diffuse	Beam	Diffuse
Transmittance	0	0	0	0
Reflectance, front	0.7	0.7	0.7	0.7
Reflectance, back	0.7	0.7	0.7	0.7

Slat IR Thermal Hemispheric Properties

IR Trans.: 0
 IR Emiss., Front: 0.9

Figure 4-31. 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

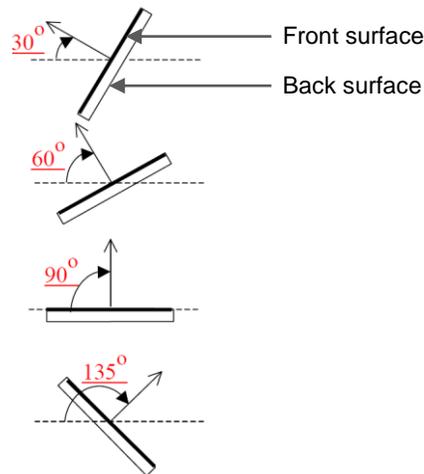


Figure 4-32. Slat angle definition

(Source: EnergyPlus Input Output Reference)

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

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

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

Slat IR thermal hemispheric properties

<i>Transmittance</i>	Slat transmittance for infrared radiation
<i>Emissivity, Front</i>	Emissivity of the front surface of the slat. Default value: 0.9
<i>Emissivity, Back</i>	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 which 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 ($^{\circ}C$). 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 ($^{\circ}C$). 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/ m²) 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/ m²) 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/ m²). 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/m²). 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
AlwaysOn	N/A	N/A	N/A	N/A
AlwaysOff	N/A	N/A	N/A	N/A
OnIfScheduleAllows	N/A	N/A	N/A	N/A
OnIfHighSolarOnWindow	0 0	W/m ² (SI) Btu/h-ft ² (IP)	N/A	N/A
OnIfHighHorizontalSolar	0 0	W/m ² (SI) Btu/h-ft ² (IP)	N/A	N/A
OnIfHighOutdoorAirTemperature	0 0	°C (SI) °F (IP)	N/A	N/A
OnIfHighZoneAirTemperature	0 0	°C (SI) °F (IP)	N/A	N/A
OnIfHighZoneCooling	0 0	Watts (SI) BTU/hr (IP)	N/A	N/A
OnIfHighGlare*	N/A	N/A	N/A	N/A
OnNightIfLowOutdoorTempAndOffDay	0 0	°C (SI) °F (IP)	N/A	N/A
OnNightIfLowInsideTempAndOffDay	0 0	°C (SI) °F (IP)	N/A	N/A
OnNightIfHeatingAndOffDay	0 0	Watts (SI) BTU/hr (IP)	N/A	N/A
OnNightIfLowOutdoorTempAndOnDayIfCooling	0 0	°C (SI) °F (IP)	N/A	N/A
OnNightIfHeatingAndOnDayIfCooling	0 0	Watts (SI) BTU/hr (IP)	N/A	N/A
OffNightAndOnDayIfCoolingAndHighSolarOnWindow	0 0	W/m ² (SI) Btu/h-ft ² (IP)	N/A	N/A
OnNightAndOnDayIfCoolingAndHighSolarOnWindow	0 0	W/m ² (SI) Btu/h-ft ² (IP)	N/A	N/A
OnIfHighOutdoorAirTempAndHighSolarOnWindow	0 0	°C (SI) °F (IP)	0 0	W/m ² (SI) Btu/h-ft ² (IP)
OnIfHighOutdoorAirTempAndHighHorizontalSolar	0 0	°C (SI) °F (IP)	0 0	W/m ² (SI) Btu/h-ft ² (IP)
OnIfHighZoneAirTempAndHighSolarOnWindow	0 0	°C (SI) °F (IP)	0 0	W/m ² (SI) Btu/h-ft ² (IP)
OnIfHighZoneAirTempAndHighHorizontalSolar	0 0	°C (SI) °F (IP)	0 0	W/m ² (SI) Btu/h-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. PROGRAM DESCRIPTION

4.5.5. 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 (20E	Brick (face), applied,	3.00	3.0304	0.33	130.0000	0.2200	Default	DOE 2.2 sr	
5	Masonry	Brick, 130 lbs/ft3 (20E	Brick (face), 4" (130	4.00	2.2728	0.44	130.0000	0.2200	Default	DOE 2.2 sr	
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 sr	
15	Masonry	Concrete, lightweight,	Concrete, precast, 2"	2.00	0.4506	2.22	30.0000	0.2000	Default	DOE 2.2 sr	
16	Masonry	Concrete, lightweight,	Concrete, cast-in-pla	8.00	0.1126	8.88	30.0000	0.2000	Default	DOE 2.2 sr	
17	Masonry	Concrete, lightweight,	Concrete, cast-in-pla	1.00	0.9012	1.11	30.0000	0.2000	Default	DOE 2.2 sr	
18	Masonry	Concrete block, heavy	CMU, 4" (hollow)	4.00	1.4082	0.71	101.0000	0.2000	Default	DOE 2.2 sr	
19	Masonry	Concrete block, heavy	CMU, 4" (concrete-fill	4.00	2.2725	0.44	140.0000	0.2000	Default	DOE 2.2 sr	
20	Masonry	Concrete block, heavy	CMU, 4" (perlite-fill)	4.00	0.9003	1.11	103.0000	0.2000	Default	DOE 2.2 sr	
21	Masonry	Concrete block, heavy	CMU, 8" (hollow)	8.00	0.9090	1.10	69.0000	0.2000	Default	DOE 2.2 sr	
22	Masonry	Concrete block, heavy	CMU, 8" (concrete-fill	8.00	1.1363	0.88	140.0000	0.2000	Default	DOE 2.2 sr	
23	Masonry	Concrete block, heavy	CMU, 8" (perlite-fill)	8.00	0.3408	2.93	70.0000	0.2000	Default	DOE 2.2 sr	
24	Masonry	Concrete block, lightw	CMU, 4" (hollow)	4.00	0.6666	1.50	65.0000	0.2000	Default	DOE 2.2 sr	
25	Boards and f	Gypsum/plaster board	Gypsum board, 1/2"	0.50	2.2000	0.45	40.0000	0.2700	Default	ASHRAE 20	
26	Boards and f	Gypsum/plaster board	Gypsum board, 5/8"	0.62	1.7600	0.57	40.0000	0.2700	Default	ASHRAE 20	
27	Boards and f	Gypsum/plaster board	Gypsum board, 3/4"	0.75	1.4667	0.68	40.0000	0.2700	Default	ASHRAE 20	
28	Boards and f	Gypsum/plaster	Gypsum, lightweight	1.00	1.5960	0.63	45.0000	0.2000	Default	DOE 2.2 sr	
29	Boards and f	Gypsum/plaster	Gypsum, sand agg.,	1.00	5.6000	0.18	105.0000	0.2000	Default	ASHRAE 20	
30	Boards and f	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 4-33. 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 thermophysical 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

Edit Material

ID: 1

Name: Brick, fired clay, 4" (120 lbs/ft3)

Group: Masonry

Subgroup: Brick, 120 lbs/ft3 (1920 kg/m3)

Source: ASHRAE 2009

Type: Default (with thermal capacity)

Roughness: Rough

Conductance: 1.55 Btu/hr-ft2-F Density: 120 lb/ft3

Resistance: 0.6452 hr-ft2-F/Btu Specific Heat: 0.19 Btu/lb-F

Emissivity, Front: 0.9 Emissivity, Back: 0.9

Thickness: 4 in

Optical properties

Solar Transmittance: 0 Visible Transmittance: 0

Solar Reflectance, Front: 0.8 Visible Reflectance, Front: 0.8

Solar Reflectance, Back: 0.8 Visible Reflectance, Back: 0.8

IR Transmittance: 0

Comment:

SAVE CANCEL

Figure 4-34. 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

4.5.6. 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.

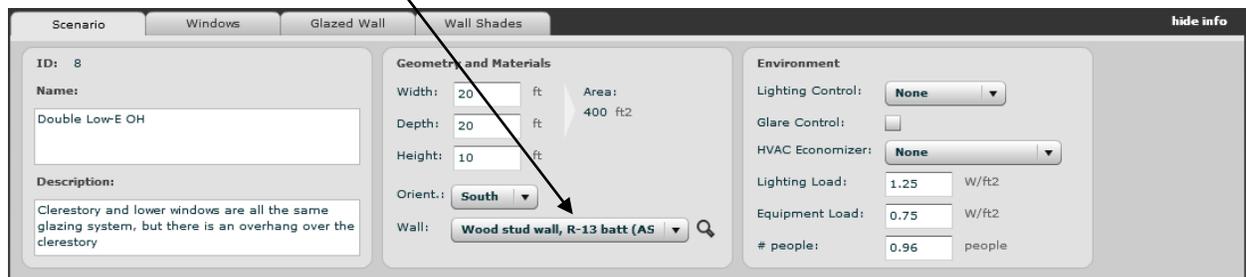


Figure 4-35. Scenario Wall Construction Reference

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.

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 4-36. 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.

<i>ID</i>	Unique material ID#
<i>Material</i>	Material name
<i>Framing</i>	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.
<i>Thickness</i>	Thickness of the material layer
<i>R-value frame</i>	R-value of the layer designated as "framing"
<i>R-value cavity</i>	R-value of the layer designated as "cavity"

Wall assembly characteristics

% framing Width of framing/framing spacing * 100%. **Range: 1 to 99%**

4. PROGRAM DESCRIPTION

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

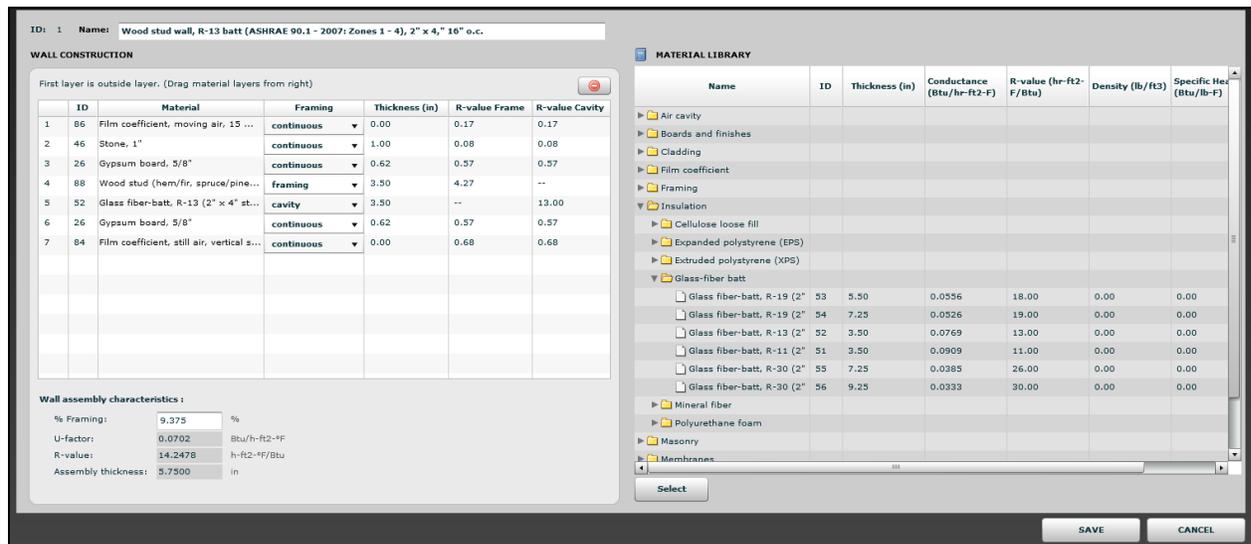


Figure 4-37. Wall Construction Detail View

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 inbetween two other construction materials (i.e. material types "regular" and/or "lightweight"). Air spaces cannot be adjacent to one another.

ID: 1 Name: Wood stud wall, R-13 batt (ASHRAE 90.1 - 2007: Zones 1 - 4), 2" x 4," 16" o.c.

WALL CONSTRUCTION

First layer is outside layer. (Drag material layers from right)

ID	Material	Framing	Thickness (in)	R-value Frame
1	Film coefficient, moving air, 15 ...	continuous	0.00	0.17
2	Stone, 1"	continuous	1.00	0.08
3	Gypsum board, 5/8"	continuous	0.62	0.57
4	Wood stud (hem/fir, spruce/pine...	framing	3.50	4.27
5	Glass fiber-batt, R-13 (2" x 4" st...	cavity	3.50	--
6	Gypsum board, 5/8"	continuous	0.62	0.57
7	Film coefficient, still air, vertical s...	continuous	0.00	0.68

Current Wall Example | Library | Editing Wood stud wall, R-13 batt (ASHRAE 90.1 - 2007: Zones 1 - 4), 2" x 4," 16" o.c.

Wall Schematic

(visualization for wall not yet available)

ID: 1 Name: Wood stud wall, R-13 batt (ASHRAE 90.1 - 2007: Zones 1 - 4), 2" x 4," 16" o.c.

WALL CONSTRUCTION

First layer is outside layer. (Drag material layers from right)

ID	Material	Framing	Thickness (in)	R-value Frame	R-value Cavity
1	Film coefficient, moving air, 15 ...	continuous	0.00	0.17	0.17
2	Stone, 1"	continuous	1.00	0.08	0.08
3	Gypsum board, 5/8"	continuous	0.62	0.57	0.57
4	Wood stud (hem/fir, spruce/pine...	framing	3.50	4.27	--
5	Glass fiber-batt, R-13 (2" x 4" st...	cavity	3.50	--	13.00
6	Gypsum board, 5/8"	continuous	0.62	0.57	0.57
7	Film coefficient, still air, vertical s...	continuous	0.00	0.68	0.68

Wall assembly characteristics:

% Framing: 9.375 %
 U-factor: 0.0702 Btu/h-ft²-F
 R-value: 14.2478 h-ft²-F/Btu
 Assembly thickness: 5.7500 in

MATERIAL LIBRARY

Name	ID	Thickness (in)	Conductance (Btu/hr-ft ² -F)	R-value (hr-ft ² -F/Btu)	Density (lb/ft ³)	Specific Heat (Btu/lb-F)
Air cavity						
Boards and finishes						
Cladding						
Film coefficient						
Framing						
Insulation						
Cellulose loose fill						
Expanded polystyrene (EPS)						
Extruded polystyrene (XPS)						
Glass-fiber batt						
Glass fiber-batt, R-19 (2"	53	5.50	0.0556	18.00	0.00	0.00
Glass fiber-batt, R-19 (2"	54	7.25	0.0526	19.00	0.00	0.00
Glass fiber-batt, R-13 (2"	52	3.50	0.0769	13.00	0.00	0.00
Glass fiber-batt, R-11 (2"	51	3.50	0.0909	11.00	0.00	0.00
Glass fiber-batt, R-30 (2"	55	7.25	0.0385	26.00	0.00	0.00
Glass fiber-batt, R-30 (2"	56	9.25	0.0333	30.00	0.00	0.00
Mineral fiber						
Polysurethane foam						
Masonry						
Membranes						

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Figure 4-38. 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 level of the scenario or at the level of the project. To change the wall for the scenario, open the scenario 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 wall of choice and click select to assign wall to scenario.

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

4.5.7. 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 4-39. 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.

Curtain Wall Example :: Library	
ID	Name
1	Single-glazed spandrel, R-13 insulation
2	Double-glazed spandrel, R-13 insulation
3	Double-glazed low-e spandrel, R-13 insulation

Figure 4-40. 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.

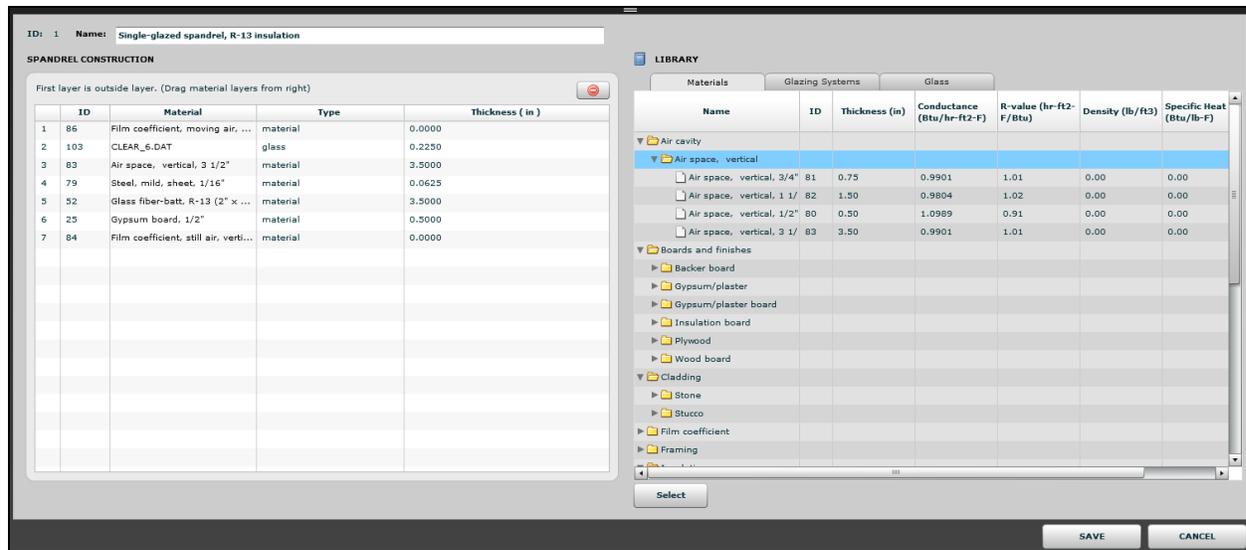


Figure 4-41. Spandrel Library Detailed View

4.5.8. Locations

Curtain Wall Example :: Library										
	Windows	Glazing Sys.	Shading Sys.	Frames	Glass	Gas	Walls	Spandrels	Materials	Locations
id	Country	State/Province	City	Weather File			CO2 Electricity (lb/kV)	CO2 Gas (lb/kBtu)		
1	United States of America	Alaska	Anchorage	USA_AK_Anchorage.Intl.AP.702730_TMY3			1.3800	0.1200		
2	United States of America	Alaska	Fairbanks	USA_AK_Fairbanks.Intl.AP.702610_TMY3			1.3800	0.1200		
3	United States of America	Alabama	Birmingham	USA_AL_Birmingham.Muni.AP.722280_TMY3			1.3100	0.1200		
4	United States of America	Arkansas	Little.Rock	USA_AR_Little.Rock.AFB.723405_TMY3			1.2900	0.1200		
5	United States of America	Arizona	Phoenix	USA_AZ_Phoenix-Sky.Harbor.Intl.AP.722760_TMY3			1.0500	0.1200		
6	United States of America	California	Arcata	USA_CA_Arcata.AP.725945_TMY3			0.6100	0.1200		
7	United States of America	California	Arcata.(CTZ.01)	CZ01RV2			0.6100	0.1200		
8	United States of America	California	Bakersfield	USA_CA_Bakersfield-Meadows.Field.723840_TMY3			0.6100	0.1200		
9	United States of America	California	Barstow-Daggett	USA_CA_Barstow.Daggett.AP.723815_TMY3			0.6100	0.1200		
11	United States of America	California	El.Centro.(CTZ.15)	CZ15RV2			0.6100	0.1200		
12	United States of America	California	El.Toro.(CTZ.08)	CZ08RV2			0.6100	0.1200		
13	United States of America	California	Fresno	USA_CA_Fresno.Air.Terminal.723890_TMY3			0.6100	0.1200		
14	United States of America	California	Long.Beach	USA_CA_Long.Beach-Daugherty.Field.722900_TMY3			0.6100	0.1200		
15	United States of America	California	Long.Beach (CTZ.06)	CZ06RV2			0.6100	0.1200		
16	United States of America	California	Los.Angeles	USA_CA_Los.Angeles.Intl.AP.722950_TMY3			0.6100	0.1200		
18	United States of America	California	Oakland (CTZ.03)	CZ03RV2			0.6100	0.1200		
19	United States of America	California	Pasadena (CTZ.09)	CZ09RV2			0.6100	0.1200		
20	United States of America	California	Red.Bluff (CTZ.11)	CZ11RV2			0.6100	0.1200		

Figure 4-42. Location Library List View

Edit Location ✕

Energy Plus Weather File (*.epw)

Weather File:

An Energy Plus Design Day (*.ddy) file must exist in the same folder.
 Energy Plus files can be downloaded from the following website:
http://apps1.eere.energy.gov/buildings/energyplus/cfm/weather_data.cfm

Location Information

ID:

Country:

City:

State/Province:

Envelope Insulation

Standard:

Zone:

ASHRAE Wall:

Default Wall:

Wall R Value: ft2-F-h/Btu

CO2 Factor

Electricity: lb/kWh

Gas: lb/kBtu

Figure 4-43. Location Library Detailed View

4.6. Results

4.6.1. Detailed reports

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

- scen_ID.idf
- scen_ID_binned_eplus_output_data.csv
- scen_ID_eplusmap.csv
- scen_ID_eplusout.csv
- scen_ID_eplusTbl_Table.csv

The last two files contain additional results, including peak load and shade operation.

An additional file, *scen_ID_user_report.csv*, will be generated if the user edits the *user_report_variables.xml* file in the LBNL\COMFEN4\settings folder and specifies 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.

4.7. Calculation assumptions

General simulation parameters such as schedule, building type, etc. are written to the in.idf file located in the COMFEN Energy Plus Input folder.

4.7.1. 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

4. PROGRAM DESCRIPTION

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,

4. PROGRAM DESCRIPTION

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,

4. PROGRAM DESCRIPTION

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

4.7.2. Lighting control

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

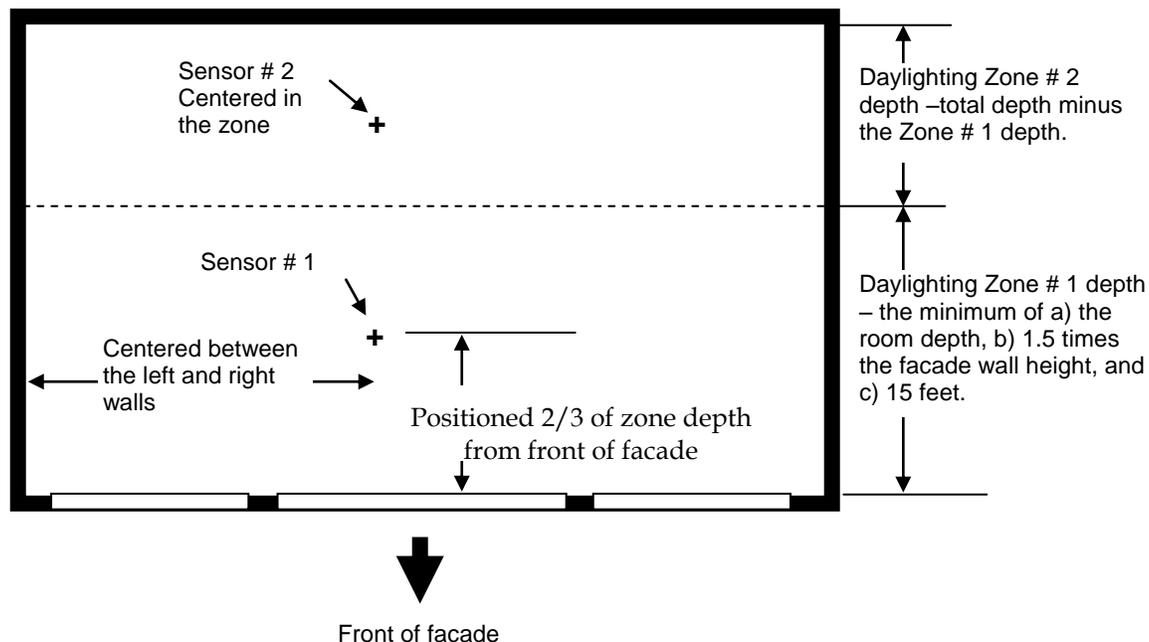


Figure 4-44. Plan view of daylighting control sensors.

- **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

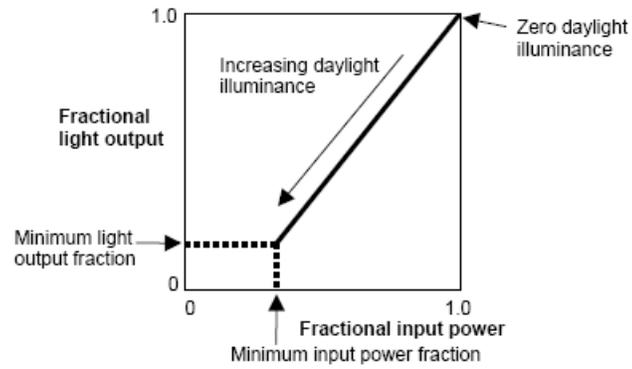


Figure 4-45. Continuous light dimming based on daylight levels.
(from the EnergyPlus Input/Output documentation)

- **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)

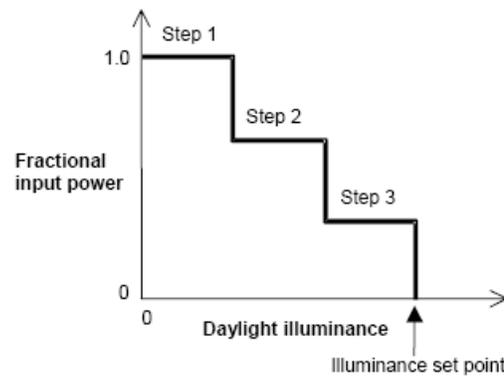


Figure 4-46. Stepped lighting controls based on daylight levels.
(from the EnergyPlus Input/Output documentation)