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Program Description August 1999

A PC Program

RESFEN 3.1

for Calculating the Heating and Cooling Energy Use of Windows in Residential Buildings

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

DISCLAIMER

LBNL-40682 Rev.
BS-371

RESFEN 3.1: Program Description

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

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1. INTRODUCTION

1.1. 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 for a residence. 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 RESFEN can help consumers and builders pick the most energy-efficient and cost-effective window for a given application, whether it is a new home, an addition, or a window replacement. 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 house type (single-story or two-story), geographic location, orientation, electricity and gas cost, and building configuration details (such as wall, floor, and HVAC system type). Users also specify size, shading, and thermal properties of the window they wish to investigate. The thermal properties that RESFEN requires are: U-factor, Solar Heat Gain Coefficient, and air leakage rate. RESFEN calculates the energy and cost implications of the window compared to an insulated wall. The relative energy and cost impacts of two different windows can be compared.

RESFEN 3.0 was a major improvement over previous versions because it performs hourly calculations using a version of the DOE 2.1E (LBL 1980, Winkelmann et al. 1993) energy analysis simulation program. RESFEN 3.1 incorporates additional improvements including input assumptions for the base case buildings taken from the National Fenestration Rating Council (NFRC) Annual Energy Subcommittee's efforts.

Table 6-2 lists the input assumptions used in RESFEN 3.1, along with those from the previous version. These assumptions are reviewed continually and may be refined in future versions to more accurately reflect typical building configurations and operation.

Update information, future releases, and program information about RESFEN 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 RESFEN, WINDOW, or THERM, check the web site first to see if it is downloadable; if not, fax your shipping address and phone number to "RESFEN 3.1 Software Request" at (510) 486-4089.

1.2. Changes from RESFEN 3.0

The significant changes that differentiate RESFEN 3.1 from RESFEN 3.0 are listed below. Some of these changes affect program results. Engineering judgement suggests that the results obtained from RESFEN 3.1 are more accurate than the results from version 3.0. As a result, it is strongly recommended that all users switch to version 3.1.

- **Whole House Results:** RESFEN 3.0 evaluated the energy impact of windows compared to a windowless insulated wall. In RESFEN 3.1, analysis results for the whole house (energy consumption from all the envelope components of the building, including windows on all orientations, walls, roofs, and foundations) are also presented. Whole house results are calculated during a DOE2 simulation that is automatically generated by RESFEN when you press either of the calculation buttons. Results for only windows, by orientation, are still included and are useful for looking at specific cases where different windows may perform more efficiently depending on the direction they are facing. See Section 4.7, "Results" for more information on this feature.

- **NFRC Input Assumptions:** For each set of RESFEN 3.1 results, many input assumptions are made including insulation levels in the building envelope and HVAC equipment efficiencies. The assumptions in RESFEN 3.1 are the same as those used in the National Fenestration Rating Council (NFRC) Annual Energy Rating Subcommittee efforts. These assumptions are documented in Table 6.2.
- **Building Floor Area:** It is now possible to input the floor area of the building being modeled, up to 4,000 square feet. Many assumptions, such as wall area, internal gain, infiltration rates, and internal mass, depend on the floor area, and the program automatically changes these values when the floor area changes.
- **Location-based Defaults:** The following values are defaulted based on location: foundation type, electricity cost, and gas cost. The foundation types that appear in the Foundation List depend on location, reflecting that common building practice is different based on geographical areas.
- **Skylights:** A column has been added in the Window Data section for skylights. These are modeled as vertical glazing in the roof of the building, with solar heat gain reduced by 50% to account for skylight-well effects. This correction factor is a placeholder; research is ongoing to improve the skylight well solar gain correction.
- **Toolbar:** A toolbar has been added below the menu for the most commonly used functions, including **Print** and **Calc**. See *Section 4* for a more complete description.
- **File Format:** The format and name of the RESFEN input files has changed from RESFEN 3.0. The extension for RESFEN 3.1 is "RSF" rather than "BSE". RESFEN 3.1 can read BSE files but RESFEN 3.0 cannot read the RESFEN 3.1 RSF files. If you open a RESFEN 3.0 BSE file check the input values very carefully because some of the information may not translate correctly, in particular the Solar Gain Reduction choices, the electricity and gas costs, the house type, and foundation type.

2. QUICK START

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

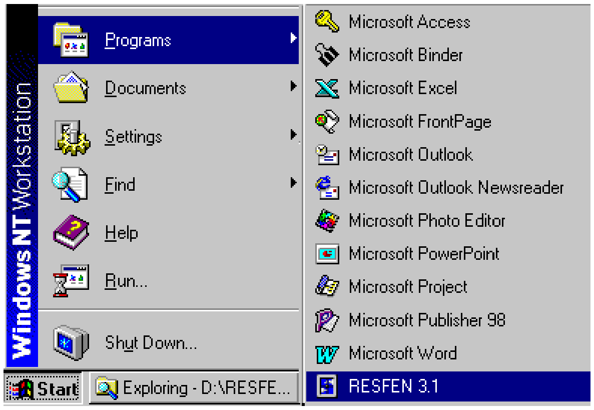
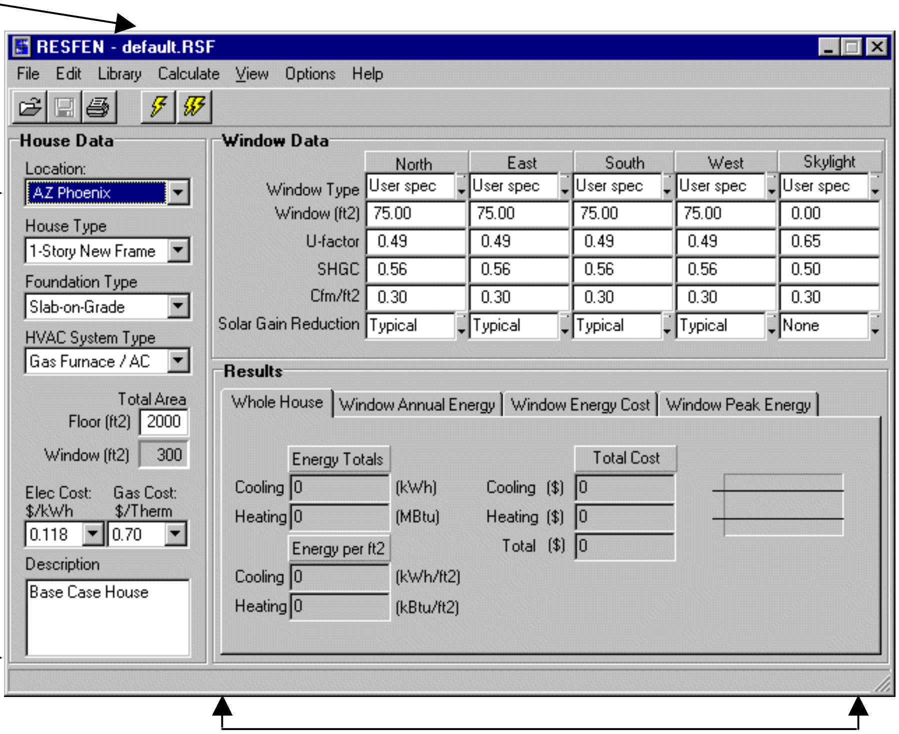


Figure 2-1. Click on the RESFEN icon in the Programs list.

- The program will start with the input values contained in an input file called "default.rsf".
- Change any input values that are not correct for the case you wish to model. For example, you can change the location to another city, change the HVAC system type, or input another window type. When you change an input value, the **Calculate** button becomes active and the values in the **Results** tabs are set to zero.

When RESFEN starts, it opens the input file **default.rsf**.
After you have changed the values, use the **File/Save As** menu to save your input to another file name.



House Data

Location: AZ Phoenix

House Type: 1-Story New Frame

Foundation Type: Slab-on-Grade

HVAC System Type: Gas Furnace / AC

Total Area

Floor (ft2) 2000

Window (ft2) 300

Elec Cost: $/kWh 0.118

Gas Cost: $/Therm 0.70

Description: Base Case House

Window Data

	North	East	South	West	Skylight
Window Type	User spec	User spec	User spec	User spec	User spec
Window (ft2)	75.00	75.00	75.00	75.00	0.00
U-factor	0.49	0.49	0.49	0.49	0.65
SHGC	0.56	0.56	0.56	0.56	0.50
Cfm/ft2	0.30	0.30	0.30	0.30	0.30
Solar Gain Reduction	Typical	Typical	Typical	Typical	None

Results

Energy Totals

Cooling 0 (kWh)

Heating 0 (MBtu)

Energy per ft2

Cooling 0 (kWh/ft2)

Heating 0 (kBtu/ft2)

Total Cost

Cooling ($) 0

Heating ($) 0

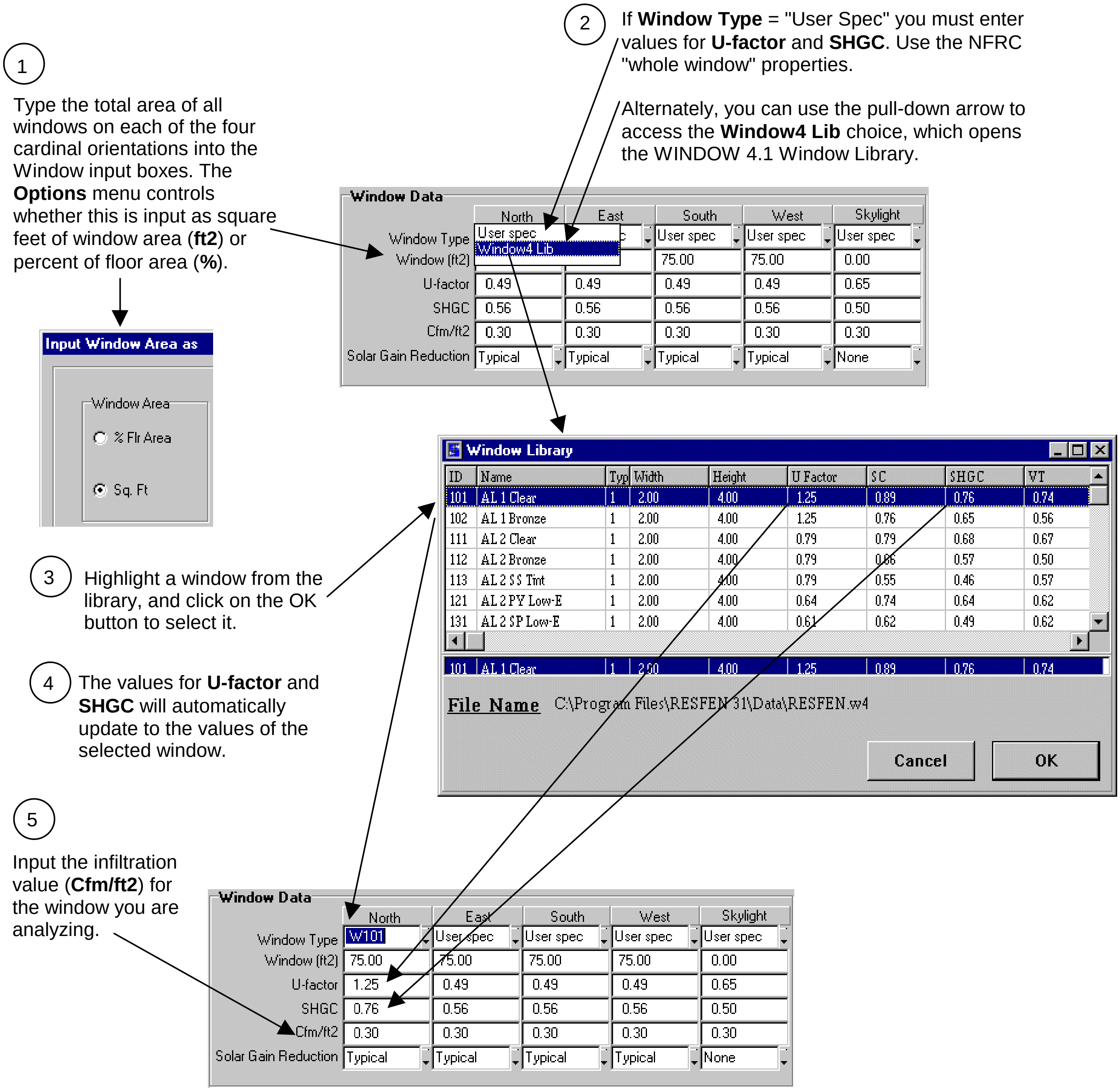
Total ($) 0

Change the values in any of these input boxes to model your specific situation.

When you change input values, the results boxes will be reset to "0, until you recalculate the results.

Figure 2-2. Change input values as needed for your building.

- You can change the **Window Data** section either by entering all the values for each orientation by hand or by picking windows from a library of predetermined generic window products. Since this library was created with the WINDOW 4.1 software, it is called the WINDOW 4.1 library. This library contains values for typical casement windows, but these values can be used for sliders and fixed windows because their properties are essentially the same. See Section 6.5, "Making Custom WINDOW 4.1 Libraries" for detailed information about making your own libraries.



① Type the total area of all windows on each of the four cardinal orientations into the Window input boxes. The **Options** menu controls whether this is input as square feet of window area (**ft2**) or percent of floor area (**%**).

② If **Window Type** = "User Spec" you must enter values for **U-factor** and **SHGC**. Use the NFRC "whole window" properties.

Alternately, you can use the pull-down arrow to access the **Window4 Lib** choice, which opens the WINDOW 4.1 Window Library.

③ Highlight a window from the library, and click on the OK button to select it.

④ The values for **U-factor** and **SHGC** will automatically update to the values of the selected window.

⑤ Input the infiltration value (**Cfm/ft2**) for the window you are analyzing.

Input Window Area as

Window Area

○ % Flr Area

● Sq. Ft

Window Data

	North	East	South	West	Skylight
Window Type	User spec Window4 Lib	c	User spec	User spec	User spec
Window (ft2)			75.00	75.00	0.00
U-factor	0.49	0.49	0.49	0.49	0.65
SHGC	0.56	0.56	0.56	0.56	0.50
Cfm/ft2	0.30	0.30	0.30	0.30	0.30
Solar Gain Reduction	Typical	Typical	Typical	Typical	None

Window Library

ID	Name	Typ	Width	Height	U Factor	SC	SHGC	VT
101	AL 1 Clear	1	2.00	4.00	1.25	0.89	0.76	0.74
102	AL 1 Bronze	1	2.00	4.00	1.25	0.76	0.65	0.56
111	AL 2 Clear	1	2.00	4.00	0.79	0.79	0.68	0.67
112	AL 2 Bronze	1	2.00	4.00	0.79	0.66	0.57	0.50
113	AL 2 SS Tint	1	2.00	4.00	0.79	0.55	0.46	0.57
121	AL 2 PY Low-E	1	2.00	4.00	0.64	0.74	0.64	0.62
131	AL 2 SP Low-E	1	2.00	4.00	0.61	0.62	0.49	0.62
101	AL 1 Clear	1	2.00	4.00	1.25	0.89	0.76	0.74

File Name C:\Program Files\RESFEN 31\Data\RESFEN.w4

Window Data

	North	East	South	West	Skylight
Window Type	W101	User spec	User spec	User spec	User spec
Window (ft2)	75.00	75.00	75.00	75.00	0.00
U-factor	1.25	0.49	0.49	0.49	0.65
SHGC	0.76	0.56	0.56	0.56	0.50
Cfm/ft2	0.30	0.30	0.30	0.30	0.30
Solar Gain Reduction	Typical	Typical	Typical	Typical	None

Figure 2-3. Use the WINDOW 4.1 library to select windows for your building.

- Press the **Calculate** button -- the single lightning bolt calculates only **Whole House** results, and the double lightning bolt calculates both **Whole House** and **Window Orientation** results.

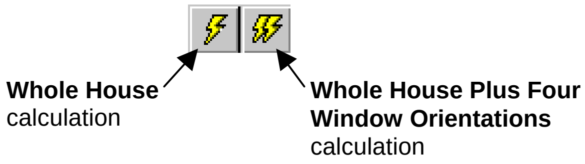
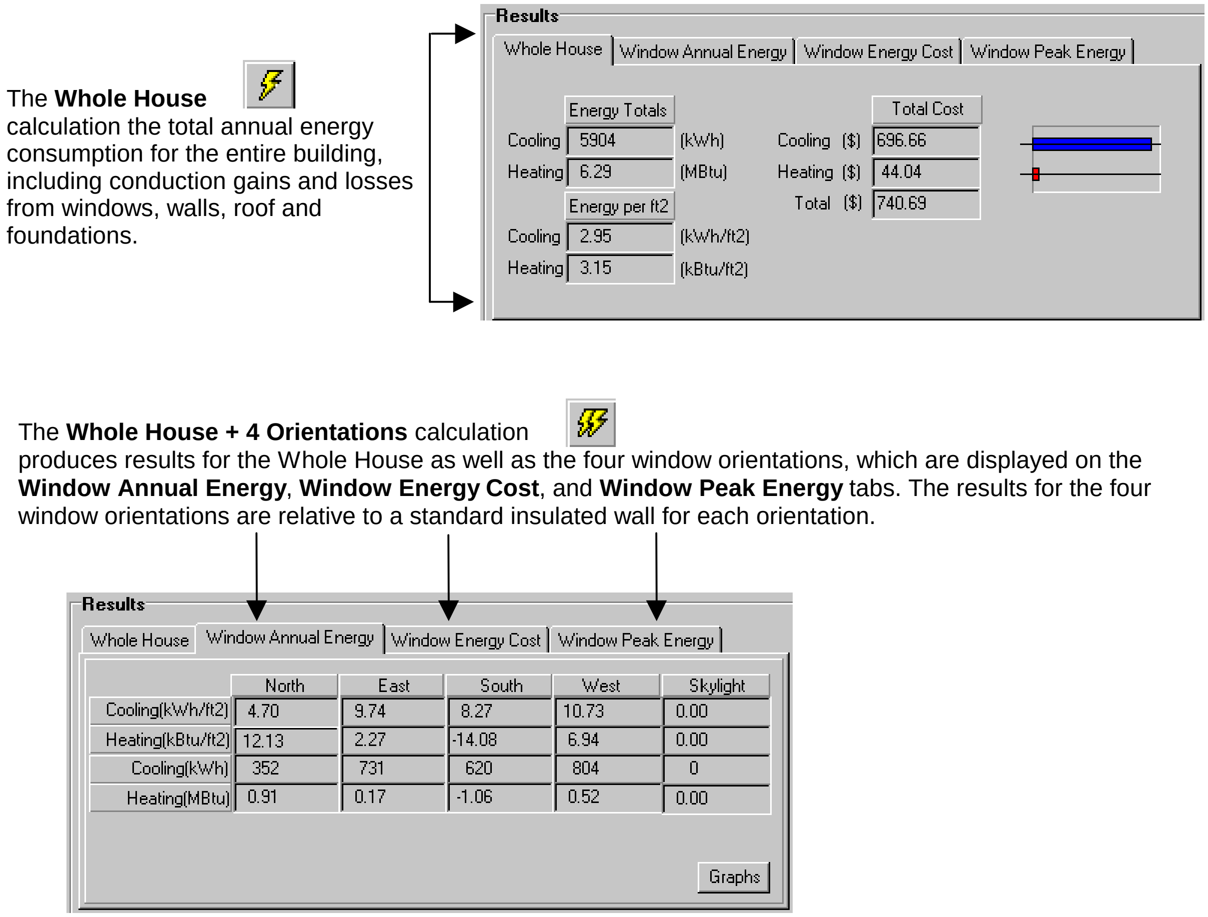


Figure 2-4. There are two calculation options, accessed with the lightning bolt toolbar buttons.

- An hourly simulation using DOE2 will be performed, which may take a few seconds for **the Whole House** only calculation, or up to a few minutes for the **Whole House + 4 Orientations** calculation, depending on the speed of your computer. When the calculation is finished, the values in the **Results** tabs will be updated.



The **Whole House** calculation the total annual energy consumption for the entire building, including conduction gains and losses from windows, walls, roof and foundations.

Energy Totals
Cooling 5904 (kWh)
Heating 6.29 (MBtu)

Energy per ft2
Cooling 2.95 (kWh/ft2)
Heating 3.15 (kBtu/ft2)

Total Cost
Cooling ($) 696.66
Heating ($) 44.04
Total ($) 740.69

The **Whole House + 4 Orientations** calculation produces results for the Whole House as well as the four window orientations, which are displayed on the **Window Annual Energy**, **Window Energy Cost**, and **Window Peak Energy** tabs. The results for the four window orientations are relative to a standard insulated wall for each orientation.

	North	East	South	West	Skylight
Cooling(kWh/ft2)	4.70	9.74	8.27	10.73	0.00
Heating(kBtu/ft2)	12.13	2.27	-14.08	6.94	0.00
Cooling(kWh)	352	731	620	804	0
Heating(MBtu)	0.91	0.17	-1.06	0.52	0.00

Figure 2-5. The two calculation options are used to calculate different types of results.

3. INSTALLATION

3.1. Hardware Requirements

First, make sure your computer system meets these specifications:

- 100% IBM-compatible pentium or higher with a math co-processor. A 400 MHz pentium computer will take about 9 seconds to perform a whole house simulation, and 16 seconds to perform a whole house + four orientations simulation.
- At least 16 MB of random access memory (RAM), configured as extended memory. 32 MB of RAM is preferred for optimum operation.
- Microsoft Windows 95™, Windows 98™ or Windows NT™.
- Hard disk drive with at least 10 megabytes of available disk space.
- Monitor and mouse.
- Optional: Printer supported by Microsoft Windows 95™, Windows 98™, or Windows NT™ (serial, parallel, or shared over a network).

3.2. Setup

The installation program is provided on CD. Diskettes are available upon request by emailing RESFENHelp@lbl.gov or by faxing Software Request at (510) 486-4089.

1. Insert the installation CD into the CD-ROM drive on your computer.
2. In Microsoft Windows 95™, Windows 98™, or Windows NT™, if your computer doesn't automatically recognize the CD and start the installation process, click the **Start** toolbar button and select **Run**:

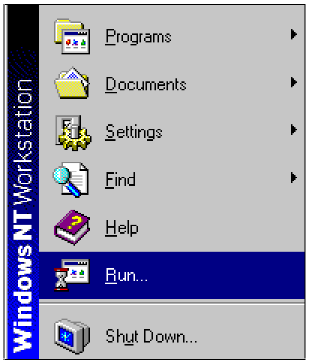


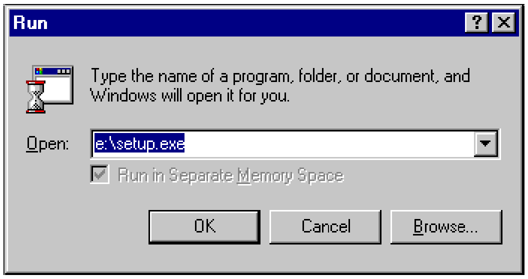
*Figure 3-1. Pick **Run** from the Start toolbar.*

In the **Run** window, type

<CDROM drive>:setup.exe

where <CDROM> is the drive letter of the CD-ROM drive on your machine, such as "**D:**" or "**E:**"

Press the **OK** button in the **Run** dialog box.



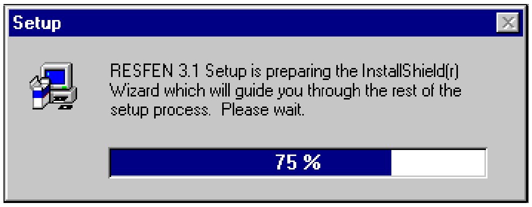
Type the name of a program, folder, or document, and Windows will open it for you.

Open: e:\setup.exe

☑ Run in Separate Memory Space

*Figure 3-2. Type <drive letter>:setup and press **OK**.*

3. The initial RESFEN **Setup** window will appear..

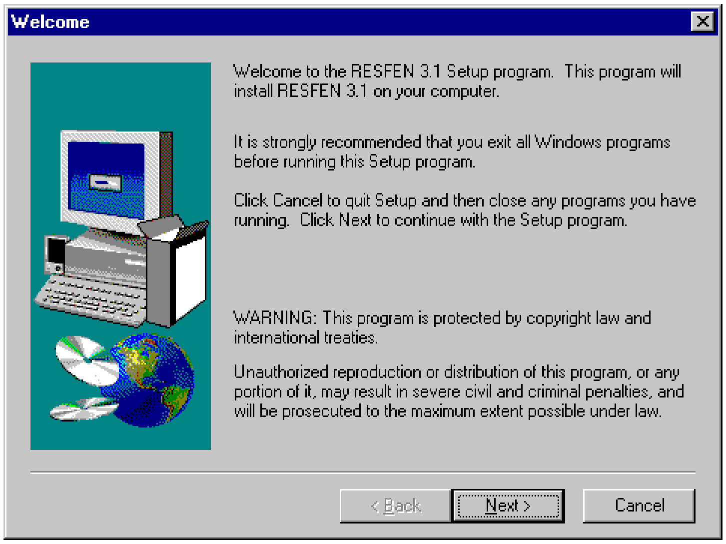


RESFEN 3.1 Setup is preparing the InstallShield(r) Wizard which will guide you through the rest of the setup process. Please wait.

75 %

Figure 3-3. The initial RESFEN Setup window.

4. When the initial **Setup** window has finished, a Welcome window will display. Click the **Next** button to proceed with the installation, or **Cancel** to stop.



Welcome to the RESFEN 3.1 Setup program. This program will install RESFEN 3.1 on your computer.

It is strongly recommended that you exit all Windows programs before running this Setup program.

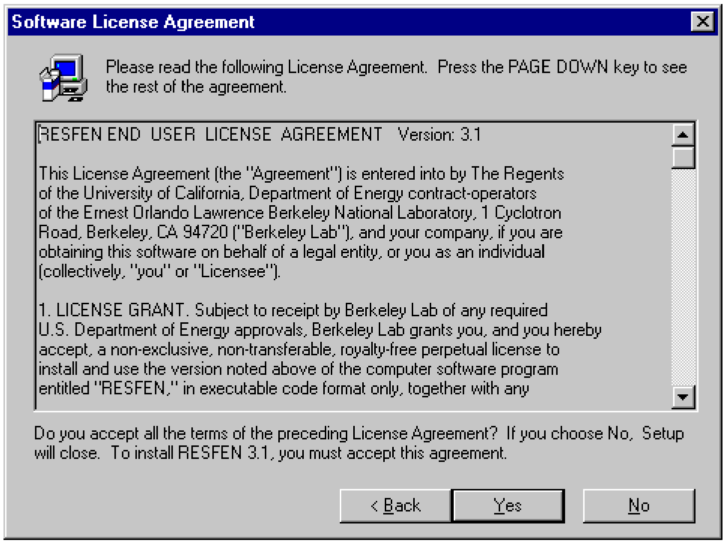
Click Cancel to quit Setup and then close any programs you have running. Click Next to continue with the Setup program.

WARNING: This program is protected by copyright law and international treaties.

Unauthorized reproduction or distribution of this program, or any portion of it, may result in severe civil and criminal penalties, and will be prosecuted to the maximum extent possible under law.

Figure 3-4. The initial RESFEN Setup window.

5. 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.



Please read the following License Agreement. Press the PAGE DOWN key to see the rest of the agreement.

RESFEN END USER LICENSE AGREEMENT Version: 3.1

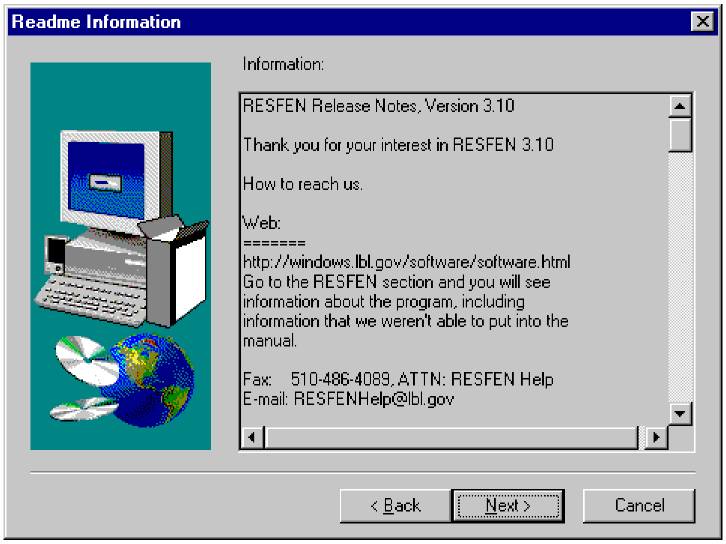
This License Agreement (the "Agreement") is entered into by The Regents of the University of California, Department of Energy contract-operators of the Ernest Orlando Lawrence Berkeley National Laboratory, 1 Cyclotron Road, Berkeley, CA 94720 ("Berkeley Lab"), and your company, if you are obtaining this software on behalf of a legal entity, or you as an individual (collectively, "you" or "Licensee").

1. LICENSE GRANT. Subject to receipt by Berkeley Lab of any required U.S. Department of Energy approvals, Berkeley Lab grants you, and you hereby accept, a non-exclusive, non-transferable, royalty-free perpetual license to install and use the version noted above of the computer software program entitled "RESFEN," in executable code format only, together with any

Do you accept all the terms of the preceding License Agreement? If you choose No, Setup will close. To install RESFEN 3.1, you must accept this agreement.

Figure 3-5. The initial RESFEN Setup window.

6. The **Readme Information** window will display next. This window contains general information about how to get more information about the program, as well as general information about how to start the program and anything that has changed in the program that is not included in manual.



Information:

RESFEN Release Notes, Version 3.10

Thank you for your interest in RESFEN 3.10

How to reach us.

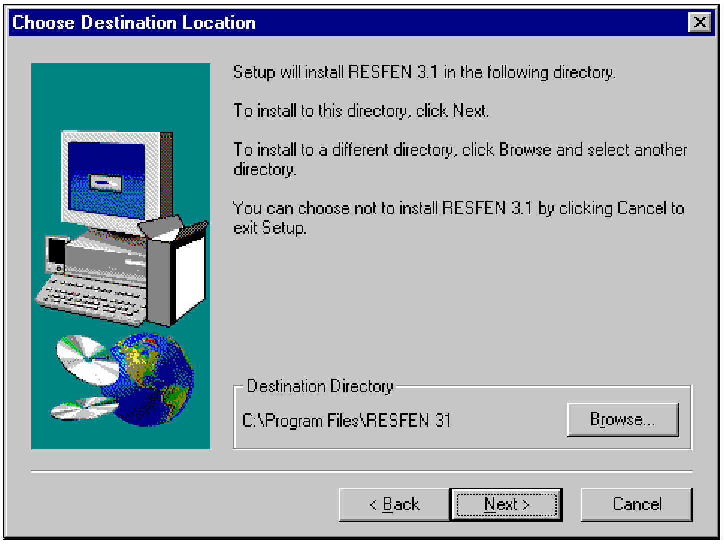
Web:
=======
http://windows.lbl.gov/software/software.html
Go to the RESFEN section and you will see information about the program, including information that we weren't able to put into the manual.

Fax: 510-486-4089, ATTN: RESFEN Help
E-mail: RESFENHelp@lbl.gov

Figure 3-6. The initial RESFEN Setup window.

7. The **Choose Destination Location** window will display next. The default directory where the program will be installed is C:\Program File\RESFEN. However, if you want to install the program in another directory on your computer, you can use the **Browse** button to specify the location.

   Press the **Next** button when you are satisfied with the Destination Directory.



Choose Destination Location

Setup will install RESFEN 3.1 in the following directory.

To install to this directory, click Next.

To install to a different directory, click Browse and select another directory.

You can choose not to install RESFEN 3.1 by clicking Cancel to exit Setup.

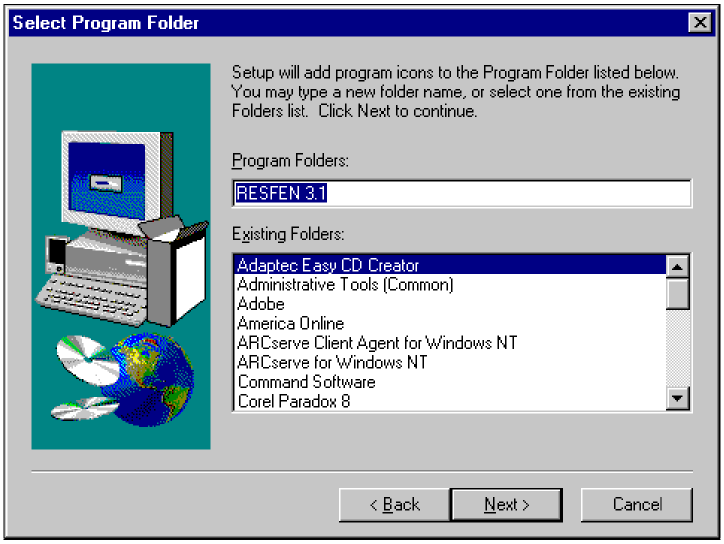
Destination Directory

C:\Program Files\RESFEN 31

*Figure 3-7. **Choose Destination Location** screen. A different location can be selected using the **Browse** button. Press **Next** when you are satisfied with the Destination Directory.*

8. The next screen to display is the **Select Program Folder**, which specifies a default folder for the program icons and allows you to define an alternate folder name.

   Press the **Next** button when you are satisfied with the **Program Folder** name.



Select Program Folder

Setup will add program icons to the Program Folder listed below. You may type a new folder name, or select one from the existing Folders list. Click Next to continue.

Program Folders:

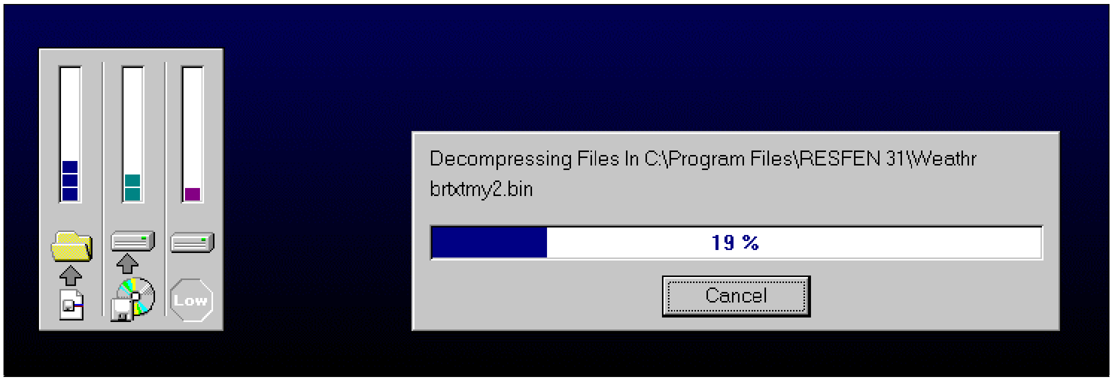
RESFEN 3.1

Existing Folders:

- Adaptec Easy CD Creator
- Administrative Tools (Common)
- Adobe
- America Online
- ARCserve Client Agent for Windows NT
- ARCserve for Windows NT
- Command Software
- Corel Paradox 8

*Figure 3-8. Use the default folder name "RESFEN" or specify a new folder name. Then press **Next** to go to the next screen.*

9. Setup will automatically install RESFEN into the specified destination directory on your computer.



Decompressing Files In C:\Program Files\RESFEN 31\Weathr
brtxtmy2.bin

19 %

Figure 3-9. Setup will decompress and copy the program files into the specified destination directory.

10. Setup will automatically put a RESFEN Icon in the **Programs** menu accessed from the **Start** button.

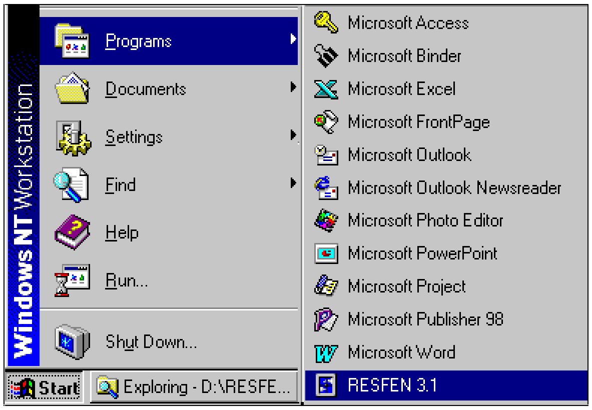


Figure 3-10. Program icon to run RESFEN.

3.3. Running RESFEN 3.1

To run RESFEN 3.1, click on the Windows95™, Windows98™ or WindowsNT™ **Start** button, go to the **Programs** menu, and single click on the **RESFEN 3.1** icon:

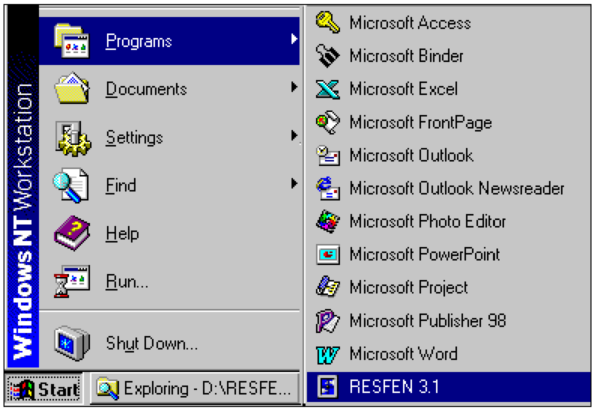
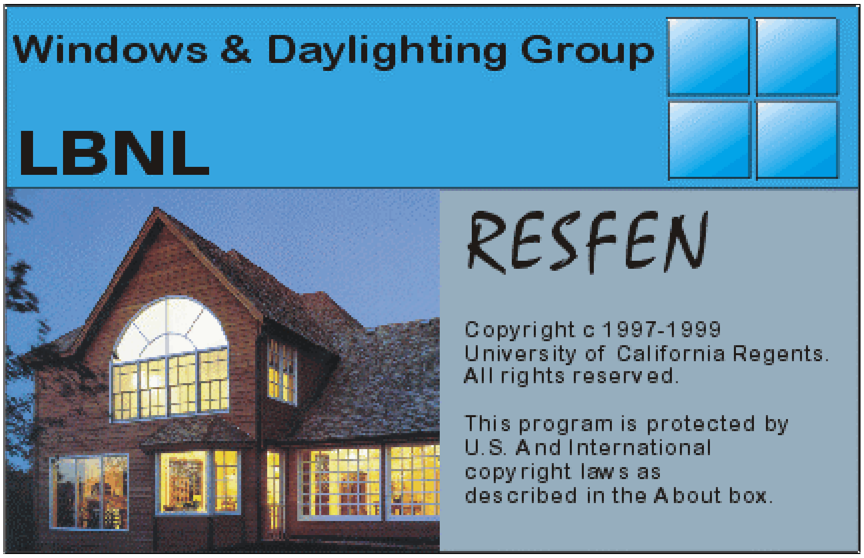


Figure 3-11. Click on Start / Programs / RESFEN 3.1

A "splash" screen, shown in Figure 3-10, is briefly displayed when you start the program.

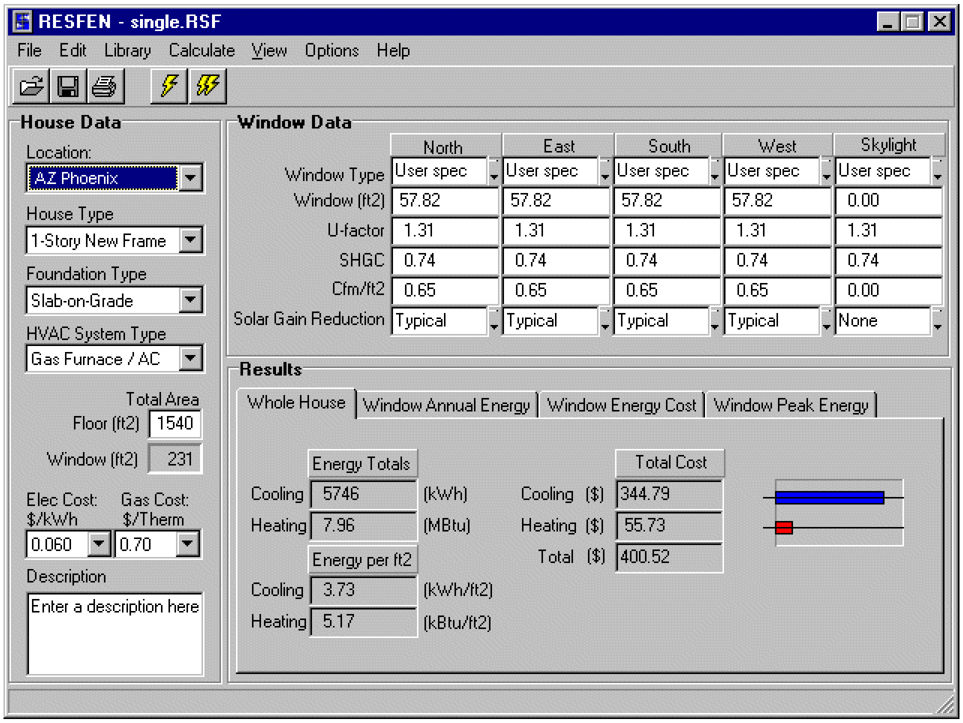


Copyright c 1997-1999
University of California Regents.
All rights reserved.

This program is protected by
U.S. And International
copyright laws as
described in the About box.

Figure 3-12. RESFEN Splash Screen

The main program screen appears and starts with an input file called "default.rsf", as shown in Figure 3-13.



House Data

Location: AZ Phoenix
House Type: 1-Story New Frame
Foundation Type: Slab-on-Grade
HVAC System Type: Gas Furnace / AC
Total Area
Floor (ft2): 1540
Window (ft2): 231
Elec Cost: $/kWh: 0.060
Gas Cost: $/Therm: 0.70
Description: Enter a description here

Window Data

	North	East	South	West	Skylight
Window Type	User spec	User spec	User spec	User spec	User spec
Window (ft2)	57.82	57.82	57.82	57.82	0.00
U-factor	1.31	1.31	1.31	1.31	1.31
SHGC	0.74	0.74	0.74	0.74	0.74
Cfm/ft2	0.65	0.65	0.65	0.65	0.00
Solar Gain Reduction	Typical	Typical	Typical	Typical	None

Results

	Energy Totals	
Cooling	5746	(kWh)
Heating	7.96	(MBtu)
	Energy per ft2	
Cooling	3.73	(kWh/ft2)
Heating	5.17	(kBtu/ft2)

		Total Cost
Cooling	($)	344.79
Heating	($)	55.73
Total	($)	400.52

Figure 3-13. Main RESFEN screen.

3.4. 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.

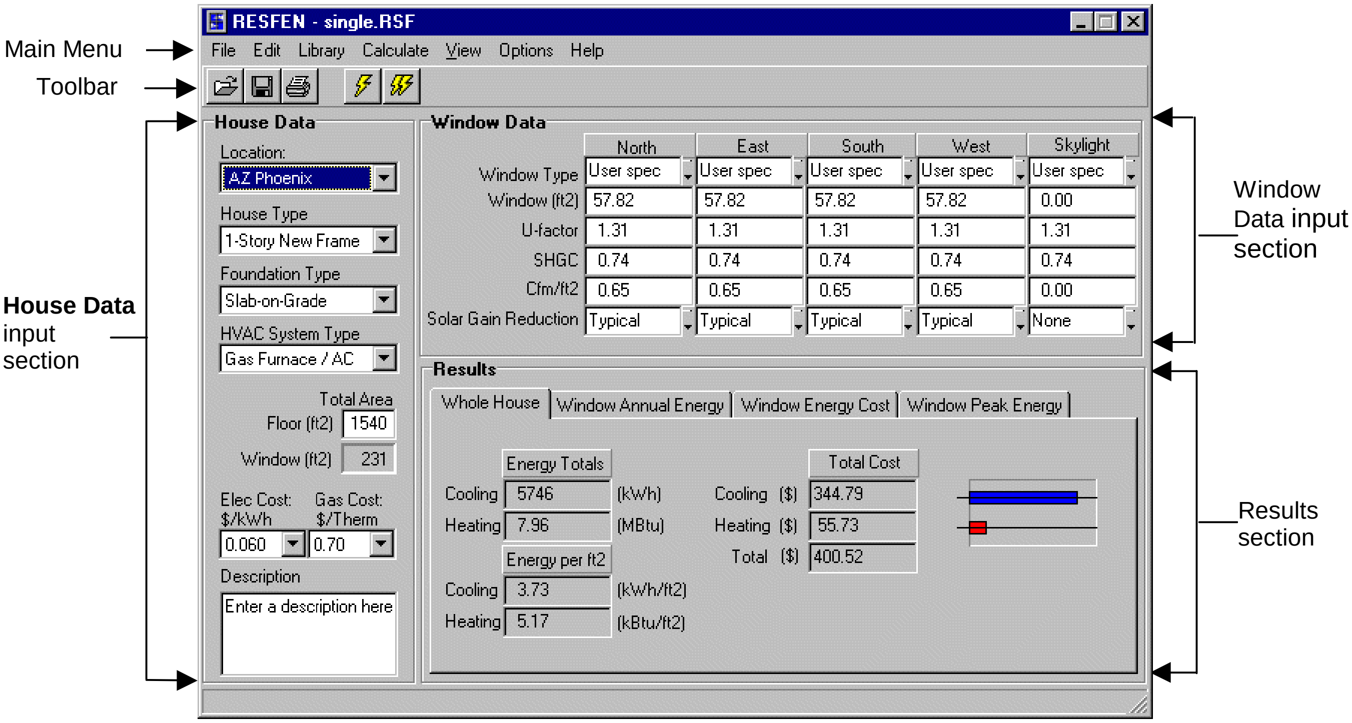
Please send E-mail to RESFENhelp@lbl.gov, or send a fax to (510) 486-4089 if you have any trouble running the program.

4. PROGRAM DESCRIPTION

4.1. Overview

RESFEN is a program with a simple user interface, shown in Figure 4-1, tied to a powerful analytical tool, DOE-2 (Lawrence Berkeley Laboratory, 1980; Winkelmann, 1993). The RESFEN main screen has several components:

- Main Menu
- Toolbar
- House Data input section
- Window Data input section
- Results section



House Data

Location: AZ Phoenix
House Type: 1-Story New Frame
Foundation Type: Slab-on-Grade
HVAC System Type: Gas Furnace / AC
Total Area
Floor (ft2) 1540
Window (ft2) 231
Elec Cost: $/kWh 0.060
Gas Cost: $/Therm 0.70
Description: Enter a description here

Window Data

	North	East	South	West	Skylight
Window Type	User spec	User spec	User spec	User spec	User spec
Window (ft2)	57.82	57.82	57.82	57.82	0.00
U-factor	1.31	1.31	1.31	1.31	1.31
SHGC	0.74	0.74	0.74	0.74	0.74
Cfm/ft2	0.65	0.65	0.65	0.65	0.00
Solar Gain Reduction	Typical	Typical	Typical	Typical	None

Results

	Energy Totals	
Cooling	5746	(kWh)
Heating	7.96	(MBtu)

	Total Cost
Cooling ($)	344.79
Heating ($)	55.73
Total ($)	400.52

	Energy per ft2	
Cooling	3.73	(kWh/ft2)
Heating	5.17	(kBtu/ft2)

Figure 4-1. Components of the Main RESFEN Screen

4.2. Steps to complete a RESFEN run:

The primary steps to complete a RESFEN calculation are:

- Describe your building scenario by entering the appropriate input values in the **House Data** section
- Describe the windows in your building by entering the appropriate input values in the **Window Data** section
- Click on one of the lightning bolt tool buttons to do either a **Whole House** or **Whole House + 4 Orientations** calculation.
- View the answers in the **Results** section when the simulation has finished.

The following sections of this chapter describe the program in detail.

4.3. Toolbar

RESFEN 3.1 has a toolbar with buttons for the most commonly used functions, shown below.

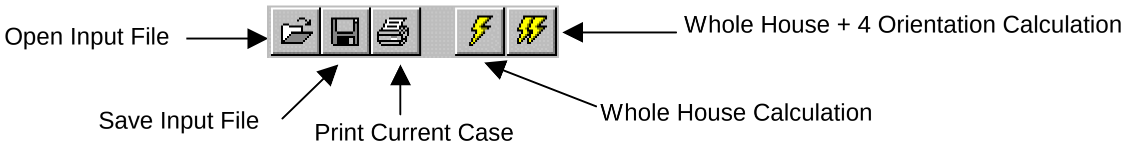


Figure 4-2. Toolbar

4.4. Pull-Down Menus

Each menu can be accessed with the mouse, by pointing and clicking on the menu choice, or with the keyboard, by pressing the **Alt** key and then typing the first letter of the menu name. For example, **Alt-F** would access the **File** menu. To select a menu choice, you can click on the choice with your mouse, type the underlined character of each menu choice, or use the **Up** and **Down** arrow keys. Keyboard shortcuts are indicated to the right of the menu item when available.

4.4.1. File

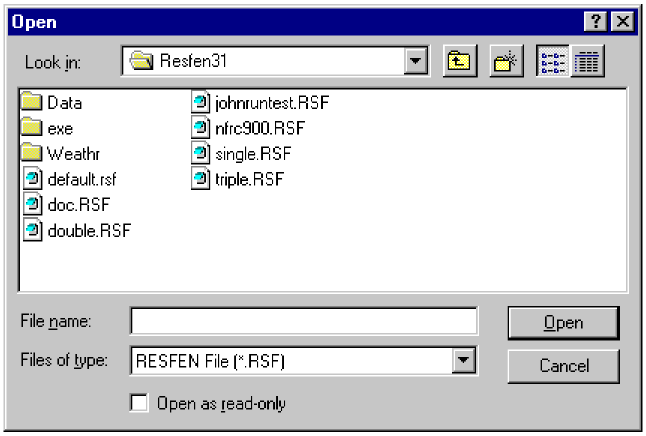
The **File** menu is used to manipulate the RESFEN input files, to print the current screen, and to exit the program. Each set of input values on the main screen makes up a file, and different input configurations can be saved with different file names, so you can retrieve the input values as well as the results by opening the files that you save. RESFEN automatically opens the input file named "default.rsf" when the program starts. You can make changes to this file and save the changes to a new file name. RESFEN automatically adds the "RSF" extension to the file name that you provide.

*Figure 4-3. The **File** menu*

Open

Open a previously saved file. The **Open** dialog box only looks for files with the RESFEN file extension "rsf".
(**Ctrl+O**)
Four files, which can be used as templates for new input files, are included with the RESFEN program:

- **Default.rsf:** this is the file that opens automatically when the program starts.
- **Single.rsf:** this file has clear, single-glazed windows on all four orientations.
- **Double.rsf:** this file has clear, double-glazed windows on all four orientations.
- **Triple.rsf:** this file has clear, triple-glazed windows on all four orientations.



Look in: Resfen31

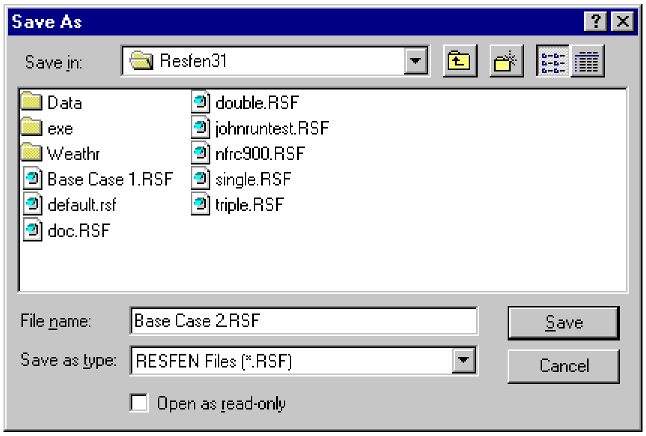
File name:

Files of type: RESFEN File (*.RSF)

☐ Open as read-only

*Figure 4-4. The **File Open** dialog box.*

Save	Save the current input configuration, with the current file name, for later access. (**Ctrl+S**)
Save As	Save the current input configuration with another file name. You can use this feature to develop different modeling scenarios and save them for future use. RESFEN 3.1 supports the Windows 95™, Windows 98™, and WindowsNT™ long file-naming convention.
	When the RESFEN program starts, it always opens a file called **default.rsf**. If changes are made to this file, you can save it under a different name, using the **Save As** menu choice. If you want to save certain settings so that they always appear when you start the program, you can use the **Save As** menu choice to overwrite the **default.rsf** file.



Save in: Resfen31

File name: Base Case 2.RSF

Save as type: RESFEN Files (*.RSF)

☐ Open as read-only

*Figure 4-5. Use the **Save As** feature to save files under different names for future use.*

Print Screen	Print a copy of the current screen.
Print File	*Not currently implemented.*
Export as Text...	*Not currently implemented.*
Exit	Quits the program. (**Ctrl+F4**)

4.4.2. Edit

The **Edit** menu is used to cut, copy, and paste values from one input box to another as well as to copy and paste data from one column to another.

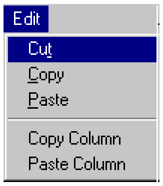


*Figure 4-6. The **Edit** menu*

Cut	Cut selected text to the Windows™ clipboard.
Copy	Copy selected text to the Windows™ clipboard.
Paste	Paste text from the Windows™ clipboard over selected text or to current cursor position.
Copy Column	Copy values of the current column to the Windows™ clipboard. Place your cursor on any field in the column, click on the **Edit/Copy Column** menu choice, and all the column field values will be copied into the computer's memory.
Paste Column	Paste column values stored in memory (using **Copy Column**) into the current column, which will overwrite all existing field values. Place your cursor on any field in the column, click on the **Edit/Paste Column** menu choice, and all the values will be pasted into the appropriate fields of the column where the cursor is currently placed. You must have copied a column just before using this feature.

4.4.3. Library

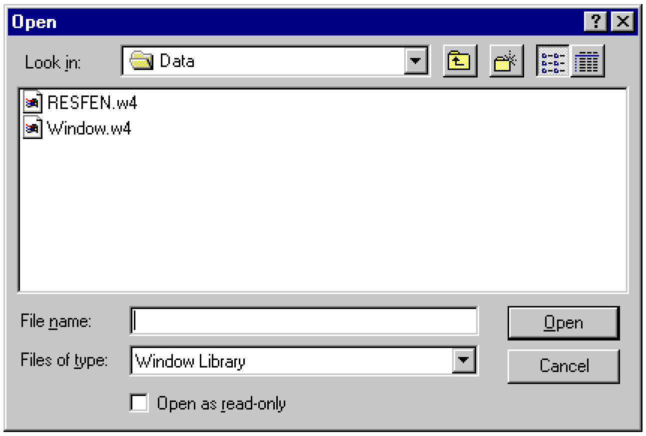
RESFEN can read a window library made from the WINDOW 4.1 software (see Chapter 1 for details about obtaining this additional software). RESFEN is shipped with a default window library, called **window.w4**, which contains many different generic windows, that you can use to make basic comparisons between different window. This library is based on casement windows, but can be used for sliders and fixed windows because their properties are essentially the same. Whenever possible, when looking at the performance of specific products, look for manufacturers' NFRC-certified data. You can also make custom window libraries if you are familiar with the WINDOW 4.1 program. (See Section 6-1, "Making Custom WINDOW 4.1 Libraries" for detailed instructions about this procedure).

The window library feature of RESFEN is useful for producing a fine-tuned analysis because it provides more detailed information about the window for the RESFEN simulation. However, it is not necessary to use this feature; in order to obtain basic trends in window performance, it is sufficient to enter the window properties by hand in the U-factor and SHGC input boxes.

Select File	Used to select a WINDOW 4.1 Library.

*Figure 4-7. The **Library** menu*

The **Library / Select File** menu choice displays an **Open** dialog box, which shows all WINDOW4.1 Library files that RESFEN can use in the **Window Type** pull-down list **Window4 Lib** choice. The program looks for all files that end in ".W4".



Look in: Data

RESFEN.w4
Window.w4

File name:

Files of type: Window Library

Figure 4-8. ***Window Library File Open*** *window.*

RESFEN comes with a default WINDOW 4.1 library, called **window.w4**, which the program looks for automatically in the RESFEN\DATA subdirectory. However, libraries with different names can be specified using the **Library/Select File** feature.

NOTE: Although you can change directories from this ***Open*** *dialog box, RESFEN will only recognize the ".W4" files in the RESFEN\DATA subdirectory*. Therefore, the WINDOW 4.1 files must always be copied into the RESFEN\DATA directory (using Windows™ Explorer) in order for RESFEN to access them properly. (See Section 6-1, "Making Custom WINDOW 4.1 Libraries" for detailed instructions about this procedure).

When you open a ".W4" file, you may see a dialog box with the message shown in Figure 4-9, saying that a "window.dat" file does not exist. This file is not required to use the "window.w4" file, it just adds more accuracy to the calculation. So the message is just informative but does not mean you have done something wrong. See Section 6-1, "Making Custom WINDOW 4.1 Libraries" for more information about creating a ".DAT" file.

"C:\Program Files\RESFEN 31\Data\window.dat" does not exist. Angular data will not used in simulation

Figure 4-9. ***RESFEN will display a message when loading a ".W4" file if the associated ".DAT" file does not exist. The ".DAT" file is not necessary to use the ".W4" file. See Section 6-1, "Making Custom WINDOW 4.1 Libraries" for more information****.*

4.4.4. Calculate

The calculate menu is used to specify the type of calculation to perform, either:

- **Whole House:** The program does a DOE2 simulation for the whole house and presents annual heating and cooling space conditioning energy consumption, including gains and losses from all the envelope components of the building, including windows, walls, roofs, and foundations.
- **Whole House + 4 Orientations:** The program does several simulations, one for the whole house and one for each of the four orientations; results are displayed for the whole house and the windows on each orientation. This option performs multiple DOE2 simulations and therefore may take several minutes to run, depending on the speed and

memory of your computer. Because calculation time may be long, a message will appear before the calculation starts asking if you are sure you want to continue.

*Figure 4-10. The **Calculate** menu*

4.4.5. View

The **View** menu displays the same choices as the tabs in the **Results** section of the main screen. When a menu choice is selected, the appropriate **Results** tab comes to the foreground. These tabs can also be accessed using the mouse; place your cursor on the desired tab and click the left mouse button. The **Results** section of this manual describes each of the output options.

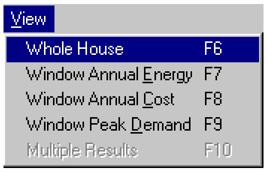


*Figure 4-11. The **View** menu*

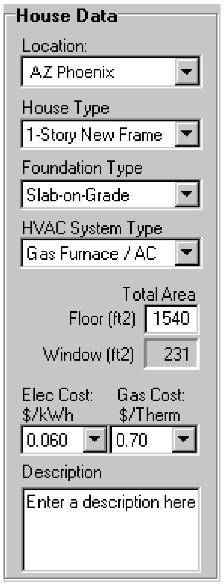
Whole House	Annual energy results for the whole house, broken down into heating and cooling values. See Section 4.7, "Results," for details about the values in this display. **(F6)**
Window Annual Energy	Annual energy output data broken down by the windows on each orientation. See Section 4.7, "Results," for details about the values in this display. **(F7)**
Window Annual Cost	Annual energy cost output data. See Section 4.7, "Results," for details about the values in this display. **(F8)**
Window Peak Demand	Peak demand output data. See Section 4.7, "Results," for details about the values in this display. **(F9)**
Multiple Results	*Currently not implemented.*

4.4.6. Help

About	Information about RESFEN, including the version number of the program.

4.5. House Data

The left side of the main screen contains the **House Data** section, a series of pull-down lists that allow you to specify geographic location, house type, foundation type, HVAC type, floor area, and utility costs.



Location: AZ Phoenix
House Type: 1-Story New Frame
Foundation Type: Slab-on-Grade
HVAC System Type: Gas Furnace / AC
Total Area
Floor (ft2): 1540
Window (ft2): 231
Elec Cost: $/kWh: 0.060
Gas Cost: $/Therm: 0.70
Description: Enter a description here

*Figure 4-12. The **House Data** portion of the main screen*

Location

A pull-down list of fifty-two geographic locations (see Section 6.1, "Locations Available for Analysis with RESFEN 3.1"). The location you specify is used by RESFEN to automatically specify Typical Meteorological Year (TMY2) weather data used for the DOE-2 simulation. The location selection determines the default values for:

- Foundation Type
- Electricity Cost
- Gas Cost

The default utility data for each location is from the National Association of Regulatory Utility Commissioners (NARUC) -- "Residential Gas Bills, Summer 1995", published Jan. 18, 1996; "Residential Electric Bills, Winter 1994-95", published May 31, 1996.

House Type

A pull-down list for specifying whether the building is one story or two story, new or existing construction, and what the predominant construction type is – either frame or masonry. For a two-story building case, the program assumes an equal floor area on each floor, based on the total floor area that you specify in the **Floor Area** input box.

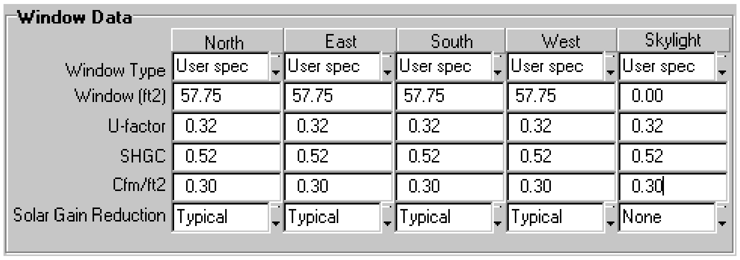
- 1-Story New Frame
- 1-Story New Masonry
- 1-Story Existing Frame
- 1-Story Existing Masonry
- 2-Story New Frame
- 2-Story New Masonry
- 2-Story Existing Frame
- 2-Story Existing Masonry

Default: 1-Story New Frame

Foundation Type	A pull-down list for specifying the predominant type of foundation construction. The values in the list are only the foundation types commonly found in the location you specify, so the list will not always contain all three choices. (see Section 6.2, "RESFEN Modeling Assumptions" for a complete listing of the Foundation Type assumptions). ■ Basement ■ Slab-on-Grade ■ Crawlspace **Default:** dependent on the location selected. (See Section 6.2, "RESFEN Modeling Assumptions").
HVAC System Type	A pull-down list for specifying the house's heating and cooling system. The efficiencies are different for New and Existing Construction (see Section 6.2, "RESFEN Modeling Assumptions" for details). ■ Gas Furnace / AC ■ Electric Heat Pump
Total Area Floor (ft2)	The total floor area of the house. **Units:** square feet (ft^2) **Legal values***:* 1,000 to 4,000 square feet
Total Area Window (ft2 or %)	*Feedback only*. This box displays the total window area of all the building orientations, including skylights; this total is calculated automatically by the program. **Units:** square feet (ft^2) or percentage of floor area (%), depending on the settings in the **Options** menu choice for **Window Area**.
Electric Cost	The average cost of electricity for the location. This number is multiplied by the energy consumption to calculate total cost. **Legal Values***:* Vary from $0.040/kWh to $0.150/kWh in increments of $0.002/kWh. **Default:** The default value is based on the location selected. The default value can be changed if it is not appropriate for the situation being modeled.
Gas Cost	The average cost of gas for the location. This number is multiplied by the energy consumption to calculate total cost. **Legal Values:** Vary from $0.30/therm to $1.00/therm in increments of $0.05/therm.
Description	An optional field that can be used to record information about the case being modeled. **Legal Values:** Any character or number, up to 50 characters.

4.6. Window Data

The upper right-hand section of the screen is used to input information about the windows in the house for each of the four orientations, **North**, **East**, **South** and **West**, as well as **Skylights**, as shown in the figure below. Use your mouse, the **Tab** key or the **arrow** keys to move between the fields.



Window Data

	North	East	South	West	Skylight
Window Type	User spec	User spec	User spec	User spec	User spec
Window (ft2)	57.75	57.75	57.75	57.75	0.00
U-factor	0.32	0.32	0.32	0.32	0.32
SHGC	0.52	0.52	0.52	0.52	0.52
Cfm/ft2	0.30	0.30	0.30	0.30	0.30
Solar Gain Reduction	Typical	Typical	Typical	Typical	None

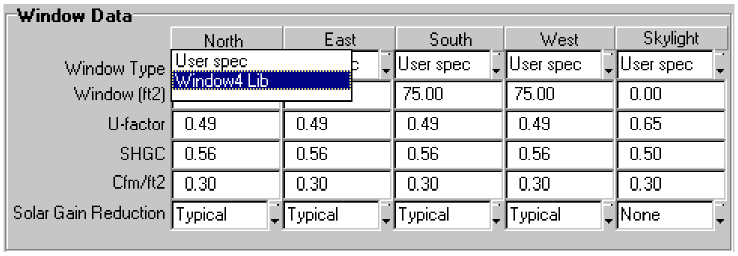
*Figure 4-13. The **Window Data** portion of the screen*

When modeling the windows in your house, group the windows on an orientation together to determine the total area by orientation. If your windows do not face the exact cardinal orientations (north, south, east and west), use the closest orientations. The program has the capability of varying fenestration system parameters for each orientation. The NFRC total product properties, which include the glazing and frame, should be used for the area, U-factor, solar heat gain coefficient (SHGC), and infiltration (CFM per unit area). The **Area** parameter represents the total window area on any one facade in square feet or as a percentage of the total floor area (see detailed **Area** explanation below).

Skylights are modeled as vertical glazing in the roof of the building, with solar heat gain reduced by 50% to account for skylight-well effects. This correction factor is a placeholder; research is ongoing to improve the skylight well solar correction.

Because it is necessary to group windows by orientation, use the window properties for the window type that predominates on an orientation if the building has different types of windows on the same orientation. Input the total window area. For example, if all the windows on the west orientation are wood casements except for one aluminum frame picture window or one patio door with an area significantly less than the sum of the wood windows, model the west-facing windows as all wood casements. You could also obtain the properties for each window type on a given orientation and area-weight these values based on the square footage of each window type.

Window Type There are two choices for **Window Type**, which are accessed by clicking on the **Window Type** field for each orientation:



Window Data

	North	East	South	West	Skylight
Window Type			User spec	User spec	User spec
Window (ft2)			75.00	75.00	0.00
U-factor	0.49	0.49	0.49	0.49	0.65
SHGC	0.56	0.56	0.56	0.56	0.50
Cfm/ft2	0.30	0.30	0.30	0.30	0.30
Solar Gain Reduction	Typical	Typical	Typical	Typical	None

Figure 4-14. *Two **Window Type** choices, **User specified** or **Window4 Lib**.*

- **User spec:** allows you to enter the U-factor and SHGC window properties for each orientation. This choice can be used when you are comparing windows to get general trends about window technologies, but are not concerned about a detailed analysis for a particluar window.

- **Window4 Lib:** allows you to pick a window from a window library created by the WINDOW4.1 program (see the *WINDOW4.1 User Manual*); the U-factor and SHGC values from that library are automatically used by RESFEN. This choice will produce more accurate analysis results. Section 6-5, "Making Custom WINDOW 4.1 Libraries" contains detailed instructions about how to make this library in WINDOW 4.1. This choice displays the WINDOW4.1 Library (shown in Figure 4-14) that is specified using the **Library/Select** menu option. A default window library, **window.w4,** is distributed with the program. The values contained in this library are for casement windows, but can be used for sliders and fixed windows because their properties are essentially the same. In this example, the **window.w4** library entries are displayed.

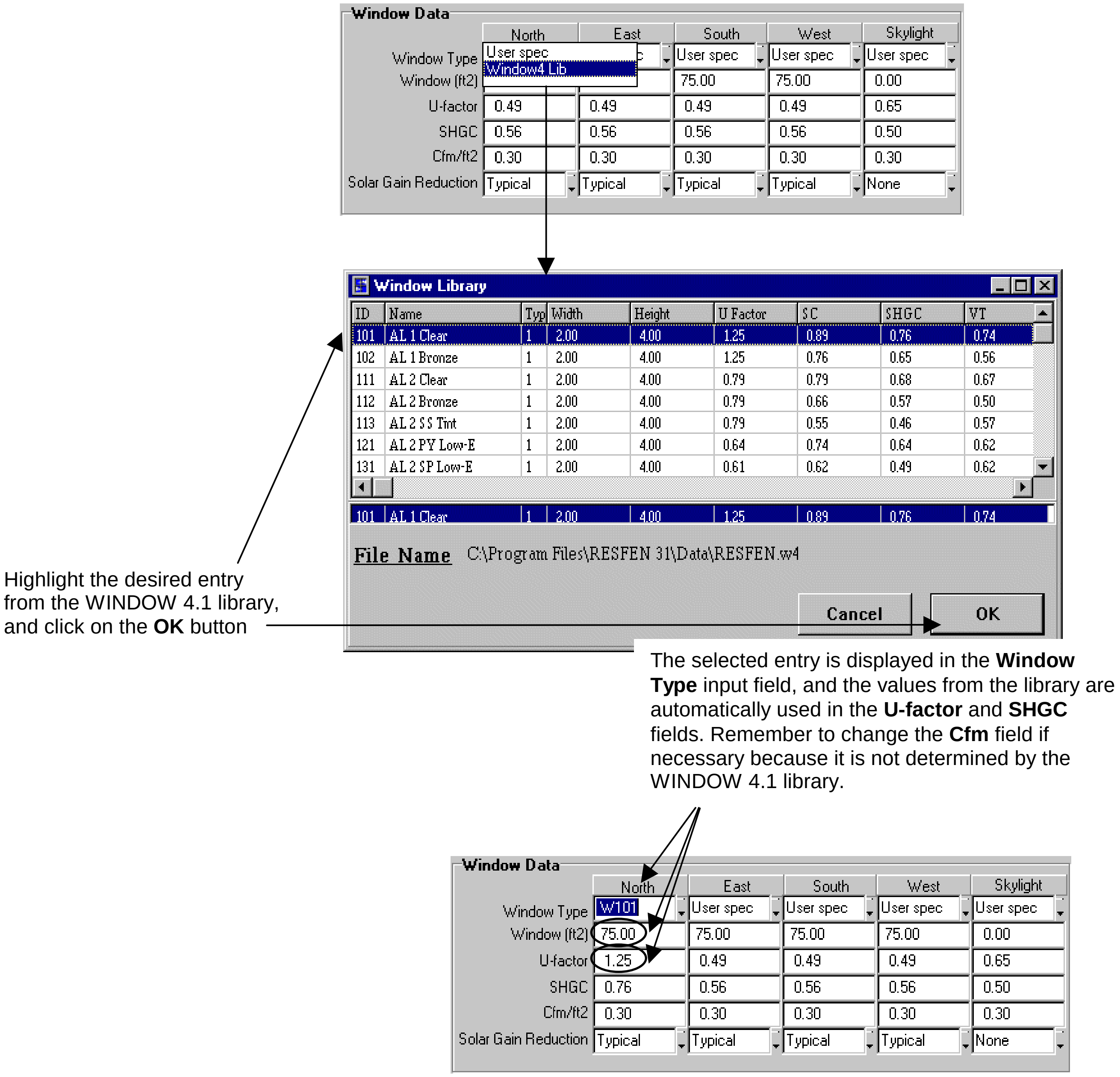


*Figure 4-15. If **Window Type** = **Window4 Lib**, RESFEN displays a list of the windows in the WINDOW4.1 library, and a window can be selected.*

Window Data

	North	East	South	West	Skylight
Window Type	User spec Window4 Lib	c	User spec	User spec	User spec
Window (ft2)			75.00	75.00	0.00
U-factor	0.49	0.49	0.49	0.49	0.65
SHGC	0.56	0.56	0.56	0.56	0.50
Cfm/ft2	0.30	0.30	0.30	0.30	0.30
Solar Gain Reduction	Typical	Typical	Typical	Typical	None

Window Library

ID	Name	Typ	Width	Height	U Factor	SC	SHGC	VT
101	AL 1 Clear	1	2.00	4.00	1.25	0.89	0.76	0.74
102	AL 1 Bronze	1	2.00	4.00	1.25	0.76	0.65	0.56
111	AL 2 Clear	1	2.00	4.00	0.79	0.79	0.68	0.67
112	AL 2 Bronze	1	2.00	4.00	0.79	0.66	0.57	0.50
113	AL 2 S S Tint	1	2.00	4.00	0.79	0.55	0.46	0.57
121	AL 2 PY Low-E	1	2.00	4.00	0.64	0.74	0.64	0.62
131	AL 2 SP Low-E	1	2.00	4.00	0.61	0.62	0.49	0.62

101	AL 1 Clear	1	2.00	4.00	1.25	0.89	0.76	0.74

File Name C:\Program Files\RESFEN 31\Data\RESFEN.w4

Highlight the desired entry from the WINDOW 4.1 library, and click on the **OK** button

The selected entry is displayed in the **Window Type** input field, and the values from the library are automatically used in the **U-factor** and **SHGC** fields. Remember to change the **Cfm** field if necessary because it is not determined by the WINDOW 4.1 library.

Window Data

	North	East	South	West	Skylight
Window Type	W101	User spec	User spec	User spec	User spec
Window (ft2)	75.00	75.00	75.00	75.00	0.00
U-factor	1.25	0.49	0.49	0.49	0.65
SHGC	0.76	0.56	0.56	0.56	0.50
Cfm/ft2	0.30	0.30	0.30	0.30	0.30
Solar Gain Reduction	Typical	Typical	Typical	Typical	None

A record from the **Window Library** can be selected by either double clicking on it with the mouse or highlighting it and clicking the **OK** button. The **up** and **down arrow** keys can also be used to move between records in the library.

See Section 4.4.3, "Library" for more information on using the **Library/Select** menu to select another window library.

Area (% Flr Area or ft2)

Total window area given as either percent of total house floor area or total square feet for each of four orientations. For example, if you want to model four windows that are 3’ x 4’ on the south orientation, the total window area for that orientation is 36 square feet, which is 2.3% for a house whose floor area is 1,560 ft^2 (36/1540).
Default: 3.75 % of floor area (in **default.rsf** file).
Units: square feet (ft2) or % of floor area (% Flr Area), depending on the settings in the **Options** menu.
Legal values: 0% to 12% per orientation; 0 to 480 square feet (4,000 square feet maximum floor area * 0.12 = 480); the sum of the percentages for the four orientations cannot exceed 48% of the floor area.

U-Factor

The U-factor of the total fenestration product at standard NFRC winter conditions, which includes the frame as well as the glazing, from a source such as the window NFRC label, manufacturer's literature, or a WINDOW 4.1 analysis.

Units: Btu/hr-ft^2-$^{\circ}$F.

Legal values: between 0.05 and 1.40 Btu/hr-ft^2-$^{\circ}$F at standard NFRC winter conditions.

SHGC

The Solar Heat Gain Coefficient of the total fenestration product, which includes the frame as well as the glazing, from a source such as the window NFRC label, manufacturer's literature, or a WINDOW 4.1 analysis.

Legal values: between 0.05 and 0.90.

CFM/Area

The infiltration of the total fenestration product (from ASTM E283 tests or equivalent), which includes the frame as well as the glazing.

Units: CFM/ft^2.

Legal values: between 0.05 and 2.0 CFM/ft^2.

Solar Gain Reduction

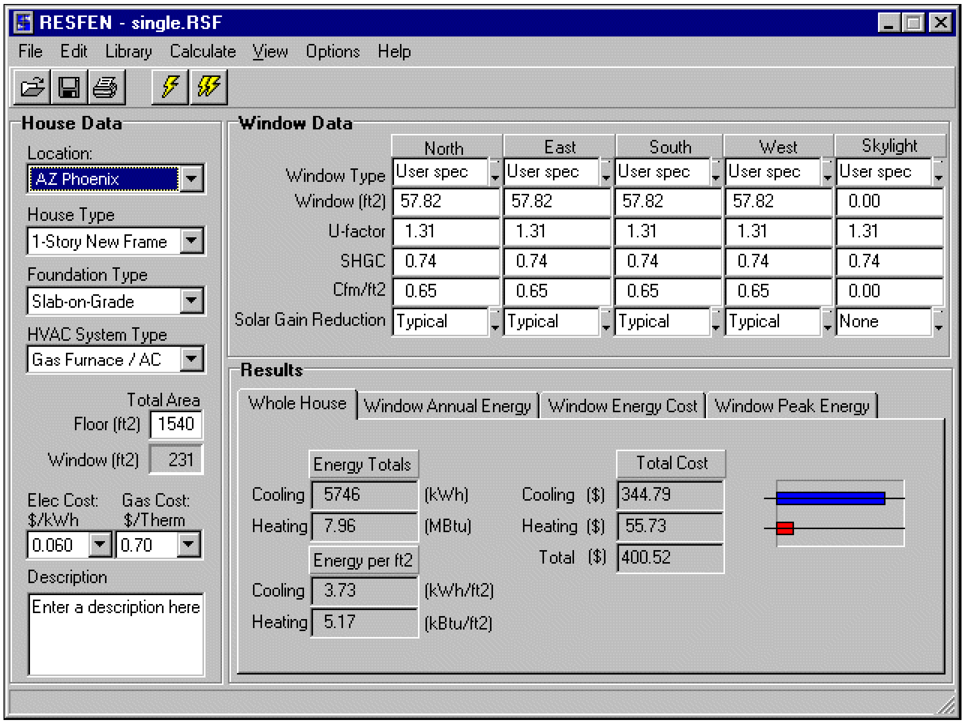
The type of solar gain reduction for the building, from the following list:

- **Typical:** A statistically average solar gain reduction which includes some interior shade, overhangs, exterior obstructions and screens. See Section 6.2, "RESFEN Modeling Assumptions" for specific details.
- **None:** No interior shading, exterior overhangs, or obstructions.
- **Interior:** Interior drapes. See Section 6.2, "RESFEN Modeling Assumptions" for specific details.
- **Overhang:** two-foot exterior overhang at roof line.
- **Obstruction:** Used to model large obstructions, such as neighboring houses or other buildings. See Section 6.2, "RESFEN Modeling Assumptions" for details.
- **Int+Ovh:** A combination of the Interior and Overhang options.
- **Ovh + Obs:** A combination of the Overhang and Obstruction options.
- **Int + Obs:** A combination of the Interior and Obstruction options.
- **All:** A combination of the Interior, Overhang, and Obstruction options.

4.7. Results

The lower portion of the screen shows the results of the calculations, in the **Results** section. There are four tabs in this section, which display the following results:

- **Whole House:** the total annual energy consumption for the building, including conduction gains and losses from windows, walls, roof, and foundations.
- **Window Annual Energy:** the portion of the annual energy consumption attributed to the windows, broken down by four window orientations.
- **Window Energy Cost:** the portion of the annual energy cost attributed to the windows, broken down by four window orientations.
- **Window Peak Energy:** the portion of the peak energy consumption attributed to the windows, broken down by four window orientations.



Location: AZ Phoenix
House Type: 1-Story New Frame
Foundation Type: Slab-on-Grade
HVAC System Type: Gas Furnace / AC
Total Area
Floor (ft2): 1540
Window (ft2): 231
Elec Cost: $/kWh: 0.060
Gas Cost: $/Therm: 0.70
Description: Enter a description here

	North	East	South	West	Skylight
Window Type	User spec	User spec	User spec	User spec	User spec
Window (ft2)	57.82	57.82	57.82	57.82	0.00
U-factor	1.31	1.31	1.31	1.31	1.31
SHGC	0.74	0.74	0.74	0.74	0.74
Cfm/ft2	0.65	0.65	0.65	0.65	0.00
Solar Gain Reduction	Typical	Typical	Typical	Typical	None

	Energy Totals	
Cooling	5746	(kWh)
Heating	7.96	(MBtu)
	Energy per ft2	
Cooling	3.73	(kWh/ft2)
Heating	5.17	(kBtu/ft2)

	Total Cost
Cooling ($)	344.79
Heating ($)	55.73
Total ($)	400.52

*Figure 4-16. The **Results** section contains four different sets of results.*

When you have input all the appropriate values into the **House Data** and **Window Data** sections, use the **Calculate** menu or press the **Whole House Calculation or Whole House + 4 Orientations** toolbar buttons to start the simulations. There are two different calculation types:

- **Whole House:** this option calculates the energy consumption for the entire house. It includes energy use attributable to the building windows, walls, roof, and foundation (including infiltration). It does not include lighting or appliance or hot water energy consumption.

- **Whole House + 4 orientations:** this option calculates the energy consumption of the entire house and also the energy attributed to only the windows, for each orientation. Because separate simulations are run for the whole house and each window orientation, this calculation can take some time, depending on the speed of your computer.

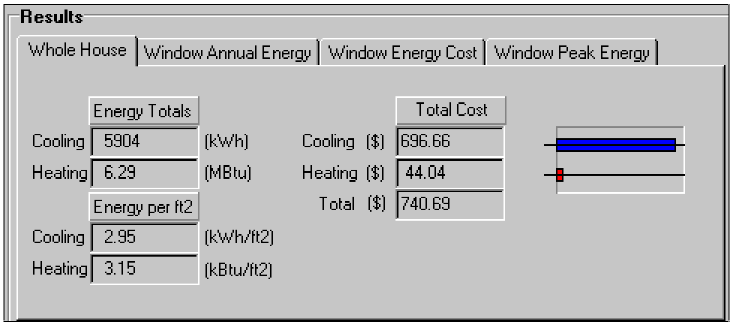
  The window results by orientation are all relative to a standard insulated windowless wall. Positive values mean that the window uses *more* energy than an insulated wall with no windows; negative values mean that the window uses *less* energy than an insulated wall with no windows. All cooling results will be positive, but heating energy use can be either positive or negative. If the results are positive, the smallest value will be the most energy-efficient window configuration. If the results are negative, the largest negative value will be the most energy-efficient window configuration. When comparing positive and negative results, the window configurations with negative results will be the most energy efficient. It is possible for a window configuration to use less heating energy than an insulated wall (and thus have a negative result) because the solar heat gain from the window provides heat to the space and reduces the heating requirements of the building.

The results are reset to 0 whenever any changes are made to the input values, so you must recalculate the results.

4.7.1. Whole House

The **Whole House** results show the total annual energy consumption for the building, broken into the following results:

- Energy Totals
- Energy per ft^2
- Total Cost



Energy Totals
Cooling 5904 (kWh)
Heating 6.29 (MBtu)

Energy per ft2
Cooling 2.95 (kWh/ft2)
Heating 3.15 (kBtu/ft2)

Total Cost
Cooling ($) 696.66
Heating ($) 44.04
Total ($) 740.69

*Figure 4-17. The **Results** tab for the **Whole House calculation**.*

Energy Totals Total annual energy consumption for the entire house, broken into the following components:

- **Cooling:** The cooling energy consumption for the entire house.
  Units: kWh/year.

- **Heating:** The heating energy consumption for the entire house.
  Units: MBtu/year

Energy per ft2 The annual energy consumption for the entire house divided by the square footage of the house, broken into the following components:

- **Cooling:** The annual cooling energy consumption for the entire house per square foot of floor area.
  Units: kWh/ft^2-year

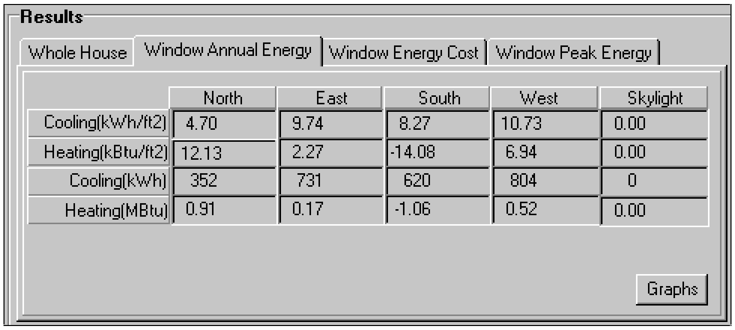
- **Heating:** The annual heating energy consumption for the entire house per square foot of floor area.
  Units: kBtu/ft^2-year

Total Cost The cost of the annual energy consumption for the entire house, which is the energy totals multiplied by electricity and gas prices, broken into the following components:

- **Cooling:** The cost of the annual cooling energy consumption for the entire house. This value should equal the **Cooling Energy Total** multiplied by the **Electricity** cost.
  Units: $/year
- **Heating:** The cost of the annual heating energy consumption for the entire house. This value is the **Heating Energy Total** multiplied by either the **Gas** cost for gas furnaces or the **Electricity** cost for heat pumps.
  Units: $/year
- **Total:** The total cost of the annual energy consumption for the entire house. This value is the sum of the heating and cooling costs.
  Units: $/year

4.7.2. Window Annual Energy

The **Window Annual Energy** results show the portion of the annual energy consumption of a building that can be attributed to the window being modeled. Positive values mean that the window adds that amount to the energy consumption of the house on an annual basis. Negative values can occur for heating, meaning that the window provides heating in the form of useful solar gain, which more than compensates for heat lost, and helps to lower the house's heating energy consumption. The first four columns represent the four window orientations (north, east, south and west). The fifth column represents skylights.



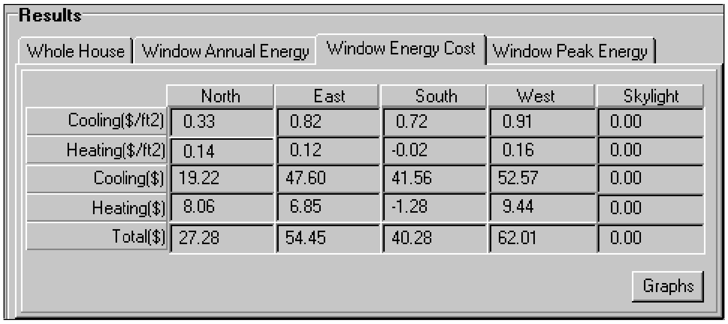
	North	East	South	West	Skylight
Cooling(kWh/ft2)	4.70	9.74	8.27	10.73	0.00
Heating(kBtu/ft2)	12.13	2.27	-14.08	6.94	0.00
Cooling(kWh)	352	731	620	804	0
Heating(MBtu)	0.91	0.17	-1.06	0.52	0.00

Figure 4-18. The ***Results*** *tab for* ***Window Annual Energy****.*

Cooling/ft^2	Cooling energy per unit window area. **Units**: kWh/ft^2-year.
Heating/ft^2	Heating energy per unit window area. **Units:** kBtu/ft^2-year for **Gas Furnace** or kWh/ft^2-year for **HeatPump**.
Cooling Energy	Cooling energy attributed to windows. **Units:** kWh/year
Heating Energy	Heating energy attributed to windows. **Units:** kBtu/year for **Gas Furnace**, or kWh/year for **HeatPump**.

4.7.3. Window Annual Cost

The **Window Annual Cost** result shows the difference between the annual energy cost of a building with the window being modeled and with a windowless wall. The energy use values in the **Window Annual Energy** result are converted to costs using the input values for electricity and gas. Positive values mean that the window uses *more* energy than a standard insulated wall with no windows; negative values for heating mean that the window uses *less* energy than a standard insulated wall with no windows. Negative values represent economic savings that will offset other energy-consuming features in the house, thus reducing the total home heating bill.



	North	East	South	West	Skylight
Cooling($/ft2)	0.33	0.82	0.72	0.91	0.00
Heating($/ft2)	0.14	0.12	-0.02	0.16	0.00
Cooling($)	19.22	47.60	41.56	52.57	0.00
Heating($)	8.06	6.85	-1.28	9.44	0.00
Total($)	27.28	54.45	40.28	62.01	0.00

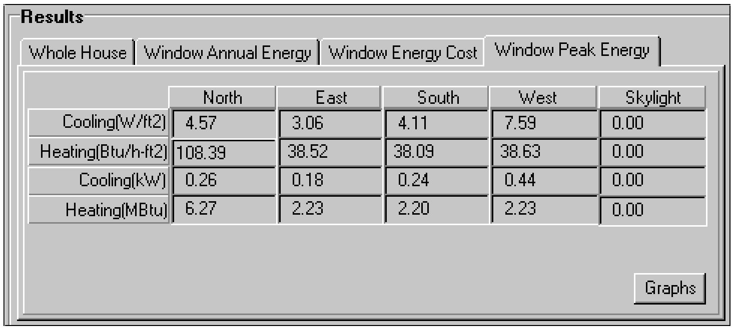
*Figure 4-19. The **Results** tab for **Window Energy Cost**.*

Cooling ($\$/ft^2$)	Cooling energy per unit window area. **Units**: IP: $\$/ft^2$-year.
Heat ($\$/ft^2$)	Heating energy per unit window area. **Units**: IP: $\$/ft^2$-year.
Cooling ($)	Cooling energy attributed to windows. **Units**: $/year.
Heating ($)	Heating energy attributed to windows. **Units**: $/year.
Total Energy ($)	Sum of the Cooling and Heating Energy Cost. **Units**: $/year.

4.7.4. Window Peak Demand

The **Window Peak Demand** result shows the difference between the peak energy demand of a building with the window being modeled and with a windowless wall. Positive values mean that the window has a higher peak demand than a standard insulated wall with no windows; negative values mean that the window has a lower peak demand than a standard insulated wall with no windows.

Peak heating and cooling loads determine the required size of the furnace and air conditioner needed to meet maximum thermal loads. Lower peak demand means smaller, less expensive equipment. Peak heating conditions typically occur on cold winter nights, and peak cooling conditions typically occur on hot, sunny summer afternoons. Make sure that the equipment sizing calculations done by your HVAC contractor take into account the benefits of high-performance windows.



	North	East	South	West	Skylight
Cooling(W/ft2)	4.57	3.06	4.11	7.59	0.00
Heating(Btu/h-ft2)	108.39	38.52	38.09	38.63	0.00
Cooling(kW)	0.26	0.18	0.24	0.44	0.00
Heating(MBtu)	6.27	2.23	2.20	2.23	0.00

Figure 4-20. The ***Results*** *tab for* ***Window Peak Energy****.*

Cool Peak/ Unit Area	Cooling peak per unit window area. **Units**: W/ft^2.
Heat Peak/ Unit Area	Heating peak per unit window area. **Units**: Btu/ft^2 or kW for HeatPump.
Cooling Peak	Cooling peak attributed to windows. **Units**: kW.
Heating Peak	Heating peak attributed to windows. **Units**: kBtu/hr or kW for HeatPump.

5. EXAMPLES

The following examples show how RESFEN can be used to help select energy efficient-windows for a home. All of the buildings used in these examples are single story and have a floor area of 2,000 ft^2. The window properties listed are for the total window product, which includes the glazing and frame. These properties can be found on a standard NFRC label.

When analyzing the windows for your house, you can either use the window library provided with RESFEN (see Section 4.8, "Window Data") or get specific values for your windows. Using the library provided with the program is a good first strategy for looking at energy consumption differences among generic window technologies. However, if you want accurate results for your specific windows, you can obtain their properties from a variety of sources (see Section 6.6, "Resources"), including the NFRC label on the window, the NFRC *Certified Products Directory*, or manufacturers' literature. The following examples are based on the generic window library that comes with RESFEN.

The window properties you need for a RESFEN analysis − U-factor, SHGC, and infiltration (CFM/ft^2) − depend on the window's frame, type of operation (casement, slider, or fixed), and the glazing. Different types of operation can have significantly different thermal properties because of their different frame area to window area ratios. For example, casement and slider windows of the same size have fairly similar ratios of frame to window, in comparison to a fixed window, which has a much smaller frame area and larger window area than the same size casement window. Because in RESFEN you must aggregate the windows on each orientation into one set of properties, you will have to decide what properties to use if you have different window types that occur on the same orientation. One option is to decide which window type is dominant and use the properties for that type of window. Another option is to obtain the window properties for each different window type, and then calculate an area-weighted value for each of the properties based on the square footage of each window type. For example, to calculate an area-weighted U-factor for the case where 25% of the windows on the north side of the building were wood, and the other 75% were aluminum, you could multiply the U-factor for the wood window by 0.25, and the U-factor for the aluminum window by 0.75, and add the results together. This result would be an area-weighted U-factor. In determining the values to use, keep in mind that differences of 0.04 in U-factor values and 0.05 in SHGC values are considered insignificant when modeling energy-efficiency impacts on your building.

A RESFEN file for Case 1 of each example is provided on the installation CD. These files are named **Example1-1.rsf**, **Example2-1.rsf**, and **Example3-1.rsf**.

5.1. Example 1: Window Selection in a Heating Climate, Madison WI

Four possible window choices are compared for a typical existing house in Madison, Wisconsin. Madison's climate is dominated by heating in the winter and some cooling is required in the summer. The house, described in Figure 5-1 and on the RESFEN screen in Figure 5-3, is a new construction wood-frame home with a basement. Heating is supplied by a gas furnace and cooling by a central air conditioner. Gas utility cost for heating is $0.60/therm, and electric utility cost for cooling is $0.084/kWh.

Input Description	Input Value
Location	WI Madison
Electricity Cost	$0.084/kWh
Gas Cost	$0.60/therm
House Type	1-Story Existing Frame
Foundation Type	Basement
HVAC System Type	Gas Furnace / AC

Figure 5-1. Example 1 House Data Input Values

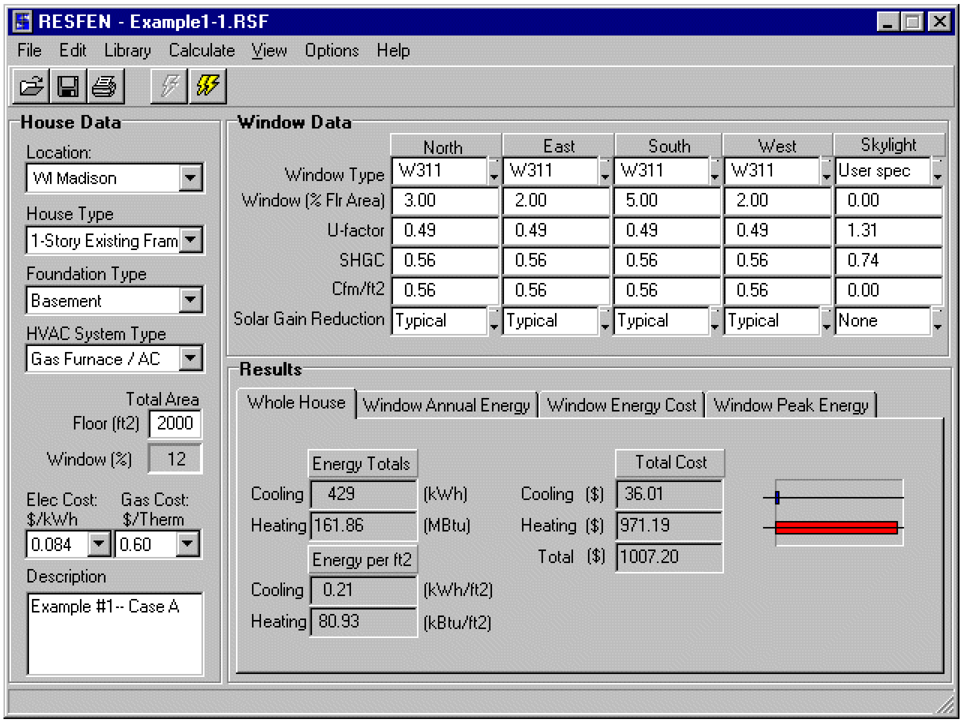
The four windows to be analyzed are listed in Figure 5-2. All the windows selected have relatively high visible transmittance (TVIS), and are 2'x4' casements. (2'x4' casements are used to represent typical operable windows in residential buildings). Although the air leakage varies somewhat by frame type, it has a very small effect on heating and cooling.

Window Description (including Window Library Number)		U-Factor	SHGC	TVIS	Air Leakage (cfm/ft^2)
A.	Double-glazed clear (# 311) 1/8" clear, ½" air, 1/8" clear wood or vinyl frame	0.49	0.56	0.58	0.56
B.	Double-glazed low-E (#321) 1/8" clear, ½" argon, 1/8" low-E (0.20) wood or vinyl frame	0.36	0.52	0.53	0.15
C.	Double-glazed spectrally selective low-E (#341) 1/8" low-E (0.04), 1/2" argon, 1/8" clear wood or vinyl frame	0.32	0.30	0.50	0.15
D.	Triple-glazed low-E superwindow (#451) 1/8" low-E (0.08), 1/2" argon, 1/8" clear 1/2" argon, 1/8" low-E (0.08) insulated vinyl frame	0.18	0.39	0.49	0.08

Figure 5-2. Example 1 Window Input Values

Window A represents what is currently being used in the house. It is the typical clear, double-glazed unit most commonly used in cold climates. Window B has a high-transmission low-E coating, and Window C has a spectrally selective low-E coating (a low SHGC combined with a relatively high visible transmittance). Window B is designed to reduce winter heat loss (low U-factor) and provide winter solar heat gain (high SHGC). Window C also reduces winter heat loss (low U-factor), but it reduces solar heat gain as well (low SHGC), an asset in the summer and a detriment in the winter. Window D, with triple glazing and two low-E coatings, is representative of the most efficient window on the market today with respect to winter heat loss (very low U-factor). In addition, because it has three glazing layers and two low-E coatings, the window has a solar heat gain coefficient that minimizes summer cooling.

The windows are distributed as shown on the RESFEN input screen in Figure 5-3, based on a real building design: 3% facing north, 2% facing east and west, and 5% facing south. The building is modeled with "typical" solar gain reduction, which represents a combination of some interior shades, overhangs, and an exterior obstruction (see Section 6.2, "RESFEN Modeling Assumptions" for details). RESFEN runs were made for each of the window types; the energy cost results are presented in the summary table in Figure 5-4.



House Data

Location: WI Madison

House Type: 1-Story Existing Fram

Foundation Type: Basement

HVAC System Type: Gas Furnace / AC

Total Area Floor (ft2): 2000

Window (%): 12

Elec Cost: $/kWh: 0.084

Gas Cost: $/Therm: 0.60

Description: Example #1 -- Case A

Window Data

	North	East	South	West	Skylight
Window Type	W311	W311	W311	W311	User spec
Window (% Flr Area)	3.00	2.00	5.00	2.00	0.00
U-factor	0.49	0.49	0.49	0.49	1.31
SHGC	0.56	0.56	0.56	0.56	0.74
Cfm/ft2	0.56	0.56	0.56	0.56	0.00
Solar Gain Reduction	Typical	Typical	Typical	Typical	None

Results

	Energy Totals	
Cooling	429	(kWh)
Heating	161.86	(MBtu)

	Energy per ft2	
Cooling	0.21	(kWh/ft2)
Heating	80.93	(kBtu/ft2)

	Total Cost
Cooling ($)	36.01
Heating ($)	971.19
Total ($)	1007.20

Figure 5-3. Example 1 Input Screen for Glazing Type A.

				Whole House Energy Cost ($/yr)		
Case	**Window Description**	**U-factor**	**SHGC**	**Cooling**	**Heating**	**Total**
1. Window A, N/S/E/W Typical shading	A – Double-glazed clear (#311)	0.49	0.56	36.01	971.19	1,007.20
2. Window B, N/S/E/W Typical shading	B – Double-glazed low-E (#321)	0.36	0.52	32.89	923.83	956.72
3. Window C, N/S/E/W Typical shading	C – Double-glazed spectrally selective low-E (#341)	0.32	0.30	17.46	963.36	980.82
4. Window D, N/S/E/W Typical shading	D – Triple-glazed low-E superwindow (#451)	0.18	0.39	23.25	885.72	908.97
5. Window B on E & S Window C on W Window D on N Typical shading	B – Double-glazed low-E (#321) C – Double-glazed spectrally selective low-E (#341) D – Triple- glazed low-E superwindow (#451)	Multiple values	Multiple values	27.71	914.47	942.19

Figure 5-4. Example 1 RESFEN Results

Cases 1-4 have the same windows on all four orientations. Case 5 varies the window type on different orientations to maximize the benefits of the window thermal characteristics. In Figure 5-4, we see that there are significant savings in annual heating costs by using windows with low U-values (Cases 2 and 4, using Windows B and D) instead of double-glazed, clear units (Case 1, Window A). The high-transmission low-E unit (Case 2, Window B) is better than the spectrally selective low-E unit (Case 3, Window C) in heating season performance. The benefit of reducing cooling costs in this climate from Window C must be examined in terms of whether air conditioning is installed in the house and operated full time; however, the increased comfort of a window with a low SHGC should be considered whether or not the homeowner pays for cooling. The triple-glazed unit (Case 4, Window D), with its very low U-value, results in even greater heating season savings. Case 5 shows that using a combination of different windows on different orientations (double-glazed low-E on the east and south, double-glazed spectrally selective low-E on the west, and triple-glazed superwindow on the North) results in more energy savings that either window type B or C installed on all orientations. This may be a more cost-effective option than installing Window D on all orientations.

The table in Figure 5-5 shows the breakdown of window-related heating and cooling by orientation; it is clear that a larger glazing percentage on the south orientation makes a significant difference in heating savings, particularly for cases 2 and 4, which use windows B & D with low U-factors and relatively high SHGCs. By studying the results by orientation, you can use RESFEN to determine the optimal glazing distribution as well as glazing type by orientation for a new building.

			Cooling ($/yr)				**Heating ($/yr)**			
Case	**U-factor**	**SHGC**	**N** (3%)	**E** (2%)	**S** (5%)	**W** (2%)	**N** (3%)	**E** (2%)	**S** (5%)	**W** (2%)
1. Window A	0.49	0.56	5.98	7.41	15.80	9.19	37.34	14.77	6.33	16.94
2. Window B	0.36	0.52	5.37	6.86	14.29	8.45	24.32	6.90	-11.46	8.70
3. Window C	0.32	0.30	2.40	2.84	5.81	3.60	25.47	11.17	11.06	12.17
4. Window D	0.18	0.39	3.89	4.67	9.26	5.72	10.22	-0.26	-22.93	0.86
5. Combination	--	--	3.84	6.40	12.95	4.51	10.17	6.82	-12.32	12.83

Figure 5-5. Example 1 RESFEN results by window orientation (N=North, E=East, S=South, W=West).

5.2. Example 2: Window Selection in a Cooling Climate, Phoenix AZ

Four possible window choices are compared for a house planned for construction in Phoenix, Arizona. The house, described in the table in Figure 5-6 and the RESFEN screen in Figure 5-8, is a one-story new construction home with a slab-on-grade floor and frame construction. Heating is supplied by a gas furnace and cooling by a central air conditioner. Gas utility cost for heating is $0.70/therm, and electric utility cost for cooling is $0.118/kWh.

Input Description	**Input Value**
Location	AZ Phoenix
Electricity Cost	$0.118/kWh
Gas Cost	$0.70/therm
House Type	1-Story New Frame
Foundation Type	Slab-on-Grade
HVAC System Type	Gas Furnace / AC

Figure 5-6. Example 2 House Data Input Values

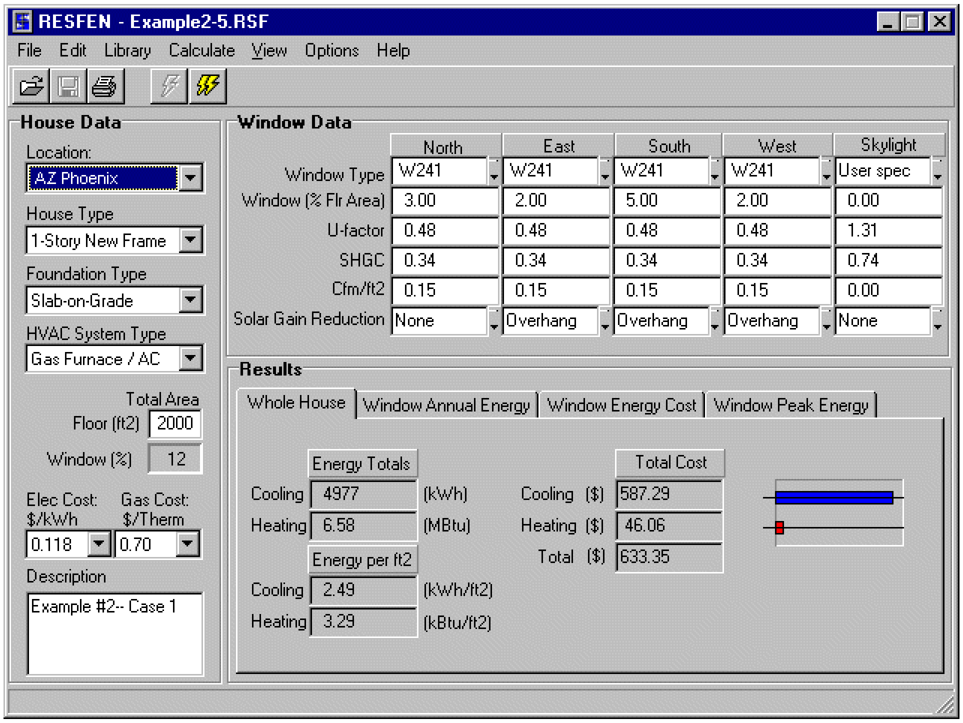
The four windows to be analyzed are listed on the following table (all windows are 3’x5’ horizontal sliders, but the window properties are essentially the same as for casements, so we can use RESFEN window library values):

Window Description (including Window Library Number)	**U-Factor**	**SHGC**	**TVIS**	**Air Leakage (cfm/ft^2)**
A. Double-glazed clear (#111) 1/8" clear, 1/2" air, 1/8" clear aluminum frame	0.79	0.68	0.67	0.56
B. Double-glazed bronze (#112) 1/8" bronze, 1/2" air, 1/8" clear aluminum frame	0.79	0.57	0.50	0.56
C. Double-glazed spectrally selective low-E (#241) 1/8" low-E (0.04), 1/2" argon, 1/8" clear thermally broken aluminum frame	0.48	0.34	0.53	0.15
D. Double-glazed spectrally selective low-E (#341) 1/8" low-E (0.04), 1/2" argon, 1/8" clear vinyl frame	0.32	0.30	0.50	0.15

Figure 5-7. Example 2 Window Input Values

Window A is a typical clear, double-glazed unit with a standard aluminum frame. Window B, with bronze-tinted glass, represents a traditional approach to reducing solar heat gain (note the slightly reduced SHGC that results from tinting). Window C has a spectrally selective low-E coating (a low SHGC combined with a high visible transmittance) and a thermally broken aluminum frame, resulting in a lower U-factor compared to the standard aluminum frames of Windows A and B. Window D also has a spectrally selective low-E coating but a vinyl frame, resulting in the lowest U-factor and SHGC of all the windows studied while maintaining a reasonably high visible transmittance.

The windows are distributed as shown on the RESFEN input screen in Figure 5-8: 3% facing the north, 2% facing east and west, and 5% facing south. RESFEN runs were made for each of the windows; the whole house energy cost results from RESFEN are presented in Figure 5-9. The first four cases examine the window options while the cases 5 and 6 examine the energy impact of adding overhangs to the building



Location: AZ Phoenix
House Type: 1-Story New Frame
Foundation Type: Slab-on-Grade
HVAC System Type: Gas Furnace / AC
Total Area Floor (ft2) 2000
Window (%) 12
Elec Cost: $/kWh 0.118
Gas Cost: $/Therm 0.70
Description: Example #2-- Case 1

	North	East	South	West	Skylight
Window Type	W241	W241	W241	W241	User spec
Window (% Flr Area)	3.00	2.00	5.00	2.00	0.00
U-factor	0.48	0.48	0.48	0.48	1.31
SHGC	0.34	0.34	0.34	0.34	0.74
Cfm/ft2	0.15	0.15	0.15	0.15	0.00
Solar Gain Reduction	None	Overhang	Overhang	Overhang	None

Energy Totals
Cooling 4977 (kWh)
Heating 6.58 (MBtu)
Energy per ft2
Cooling 2.49 (kWh/ft2)
Heating 3.29 (kBtu/ft2)
Total Cost
Cooling ($) 587.29
Heating ($) 46.06
Total ($) 633.35

Figure 5-8. Example 2 Input Screen for Case 5, Window C with 2' overhangs on the east, south, and west.

		Energy Cost ($/yr)		
Case	**Window Description**	**Cooling**	**Heating**	**Total**
1. Window A, N/S/E/W No shading	A – Double-glazed clear, aluminum frame	879.22	39.77	918.99
2. Window B, N/S/E/W No shading	B – Double-glazed bronze, aluminum frame	809.88	44.24	854.12
3. Window C, N/S/E/W No shading	C – Double-glazed spectrally selective low-E, thermally broken aluminum frame	649.90	43.36	693.26
4. Window D, N/S/E/W No shading	D – Double-glazed spectrally selective low-E, vinyl frame	617.91	38.10	656.01
5. Window C, N/S/E/W 2' overhang S/E/W	C – Double-glazed spectrally selective low-E, thermally broken aluminum frame	587.29	46.06	633.35
6. Window D, N/S/E/W 2' overhang S/E/W	D – Double-glazed spectrally selective low-E, vinyl frame	560.47	40.61	601.08

Figure 5-9. Example 2 RESFEN Results

Cooling loads are dominant in this climate, and the results show significant savings in annual cooling costs from using windows with a low SHGC (Window C) instead of double-glazed, clear units or bronze-tinted glass (Windows A and B). Window D, which has a vinyl frame rather than a thermally-broken aluminum frame, results in the lowest heating and cooling loads of the four glazing types, because of both its low solar heat gain factor and low U-value. Cases 5 and 6 show that the lowest energy costs result from the combination of high-performance glazing (Windows C and D) and a two-foot overhang on the south, east and west orientations.

5.3. Example 3: Window Selection in a Mixed Heating and Cooling Climate, Kansas City MO

Four possible window choices are compared for a house planned for construction in Kansas City, Missouri, which has both heating and cooling loads. The house, described in the table in Figure 5-10 and shown in the RESFEN screen in Figure 5-12, is a one-story new home with a basement and wood frame construction. Heating is supplied by a gas furnace and cooling by a central air conditioner. Gas utility cost for heating is $0.40/therm, and electricity cost for cooling is $0.086/kWh.

Input Description	Input Value
Location	MO Kansas City
Electricity cost	$0.086/kWh
Gas Cost	$0.40/therm
House Type	1-Story New Frame
Foundation Type	Basement
HVAC System Type	Gas Furnace / AC

Figure 5-10. Example 3 House Data Input Values

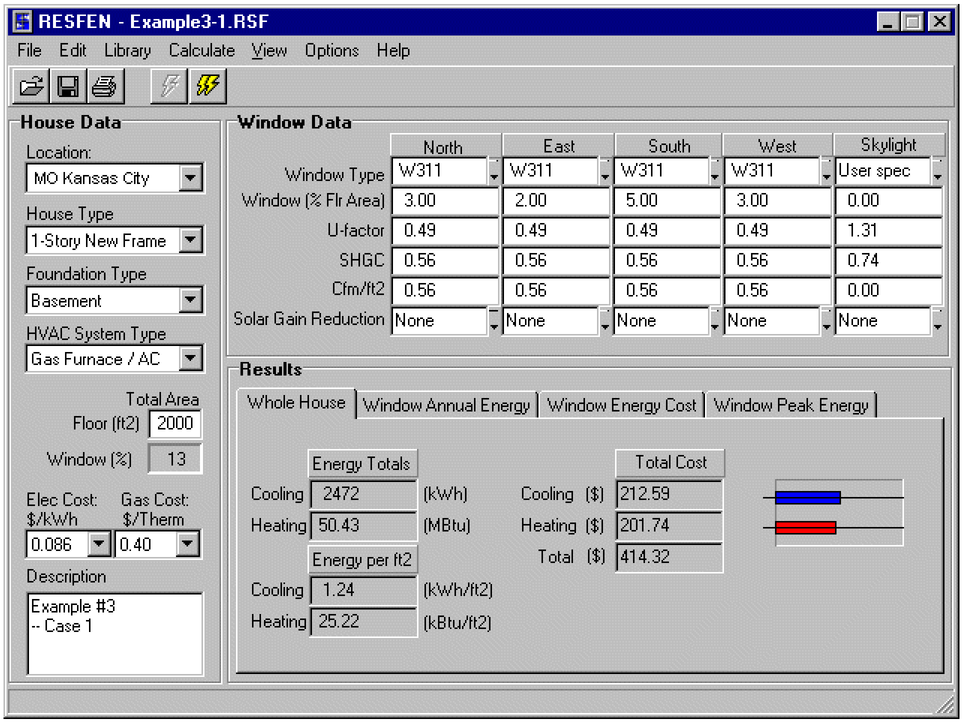
The four windows to be analyzed are listed in the table in Figure 5-11 (all windows are 2'x4' casements):

	U-Factor	SHGC	TVIS	Air Leakage (cfm/ft^2)
A. Double-glazed clear (#311) 1/8" clear, 1/2" air, 1/8" clear wood or vinyl frame	0.49	0.56	0.58	0.56
B. Double-glazed low-E (#321) 1/8" clear, 1/2" argon, 1/8" low-E (0.20) wood or vinyl frame	0.36	0.52	0.53	0.15
C. Double-glazed spectrally selective low-E (#341) 1/8" low-E (0.04), 1/2" argon, 1/8" clear wood or vinyl frame	0.32	0.30	0.50	0.15
D. Triple-glazed low-E superwindow (#451) 1/8" low-E (0.08), 1/2" argon, 1/8" clear 1/2" argon, 1/8" low-E (0.08) insulated vinyl frame	0.18	0.39	0.49	0.08

Figure 5-11. Example 3 Window Input Values

Window A represents what is currently being used in the house. It is the typical clear, double-glazed unit commonly used in many climates. Window B has a high-transmission low-E coating while Window C has a spectrally selective low-E coating (a low SHGC combined with a relatively high visible transmittance). Window B is designed to reduce winter heat loss (low U-factor) and provide winter solar heat gain (high SHGC). Window C also reduces winter heat loss (low U-factor), but it reduces solar heat gain as well (low SHGC), an asset in summer and a detriment in winter. Window D, with triple glazing and two low-E coatings, is representative of the most efficient window on the market today for preventing winter heat loss (very low U-factor).

The windows are distributed as shown on the RESFEN screen in Figure 5-12: 3% facing north, 2% facing east and west, and 5% facing south. RESFEN runs were made for each of the windows; the energy cost results are presented below.



Location: MO Kansas City

House Type: 1-Story New Frame

Foundation Type: Basement

HVAC System Type: Gas Furnace / AC

Total Area

Floor (ft2): 2000

Window (%): 13

Elec Cost: $/kWh: 0.086

Gas Cost: $/Therm: 0.40

Description: Example #3 -- Case 1

	North	East	South	West	Skylight
Window Type	W311	W311	W311	W311	User spec
Window (% Flr Area)	3.00	2.00	5.00	3.00	0.00
U-factor	0.49	0.49	0.49	0.49	1.31
SHGC	0.56	0.56	0.56	0.56	0.74
Cfm/ft2	0.56	0.56	0.56	0.56	0.00
Solar Gain Reduction	None	None	None	None	None

Energy Totals

Cooling: 2472 (kWh)

Heating: 50.43 (MBtu)

Energy per ft2

Cooling: 1.24 (kWh/ft2)

Heating: 25.22 (kBtu/ft2)

Total Cost

Cooling ($): 212.59

Heating ($): 201.74

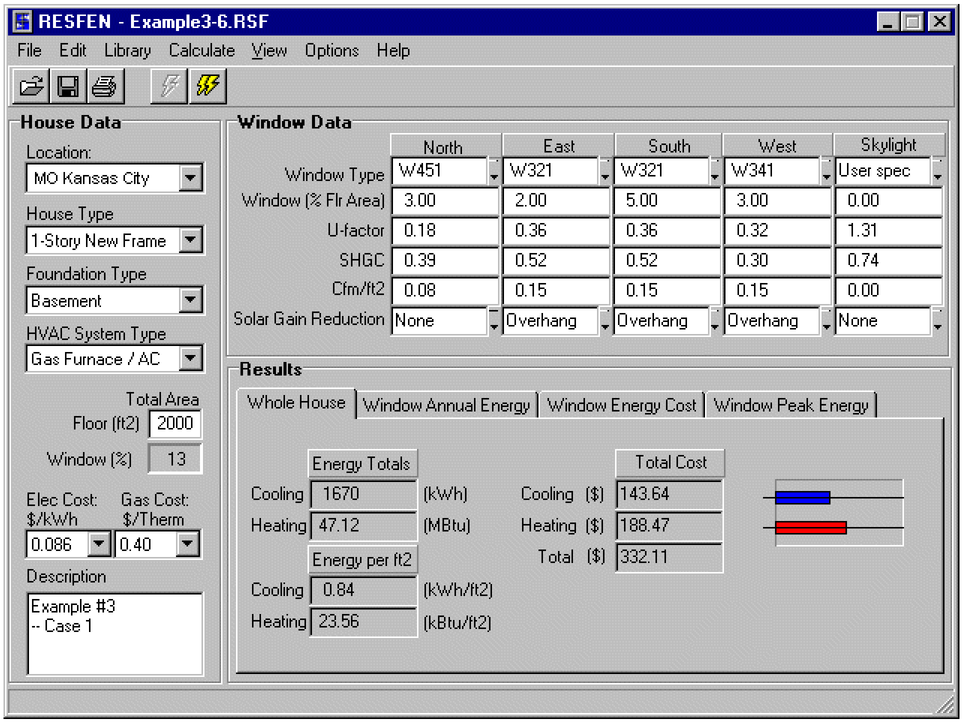
Total ($): 414.32

Figure 5-12. Example 3 Input Screen for Window A.

Case	Window Description	U-value	SHGC	Whole House Energy Cost ($/yr)		
				Cooling	Heating	Total
1. Window A, N/S/E/W No shading	A – Double-glazed clear	0.49	0.56	212.59	201.74	414.32
2. Window B, N/S/E/W No shading	B – Double-glazed low-E	0.36	0.52	201.85	182.47	384.32
3. Window C, N/S/E/W No shading	C – Double-glazed spectrally selective low-E	0.32	0.30	138.70	207.04	345.75
4. Window D, N/S/E/W No shading	D – Triple-glazed low-E superwindow	0.18	0.39	167.36	169.86	337.23
5. Window B on E & S Window C on W Window D on N No shading	B – Double-glazed low-E C – Double-glazed spectrally selective low-E D – Triple-glazed low-E superwindow	Multiple values	Multiple values	179.38	180.85	360.23
6. Window B on E & S Window C on West Window D on North 2' overhang, E/S/W	B – Double-glazed low-E C – Double-glazed spectrally selective low-E D – Triple-glazed low-E superwindow	Multiple values	Multiple values	143.64	188.47	332.11

Figure 5-13. Example 3 RESFEN Results

We see that there are significant savings in annual heating costs from using windows with low U-values (Cases 2 and 3, Windows B and C) instead of double-glazed, clear units (Case 1, Window A). The high-transmission low-E unit (Case 2, Window B) has better heating season performance than the spectrally selective low-E unit (Case 3, using Window C), but Window C is clearly better during the cooling season. The triple-glazed unit (Case 4, using Window D), with its very low U-value, results in even greater heating season savings. Case 5 shows that using a combination of different windows on different orientations (double-glazed low-E on the east and south, double-glazed spectrally selective low-E on the west, and triple-glazed superwindow on the north) results in more energy savings than either window type B or C installed on all orientations. This combination approach may be more cost effective than using Window D on all orientations. Case 6 shows the lowest energy cost case that is also probably cost effective, which results from the combination of high-performance glazing (the same combination of windows as in Case 5) and a two- foot overhang on the south, east and west orientations.



House Data

Location: MO Kansas City

House Type: 1-Story New Frame

Foundation Type: Basement

HVAC System Type: Gas Furnace / AC

Total Area

Floor (ft2): 2000

Window (%): 13

Elec Cost: $/kWh: 0.086

Gas Cost: $/Therm: 0.40

Description: Example #3 -- Case 1

Window Data

	North	East	South	West	Skylight
Window Type	W451	W321	W321	W341	User spec
Window (% Flr Area)	3.00	2.00	5.00	3.00	0.00
U-factor	0.18	0.36	0.36	0.32	1.31
SHGC	0.39	0.52	0.52	0.30	0.74
Cfm/ft2	0.08	0.15	0.15	0.15	0.00
Solar Gain Reduction	None	Overhang	Overhang	Overhang	None

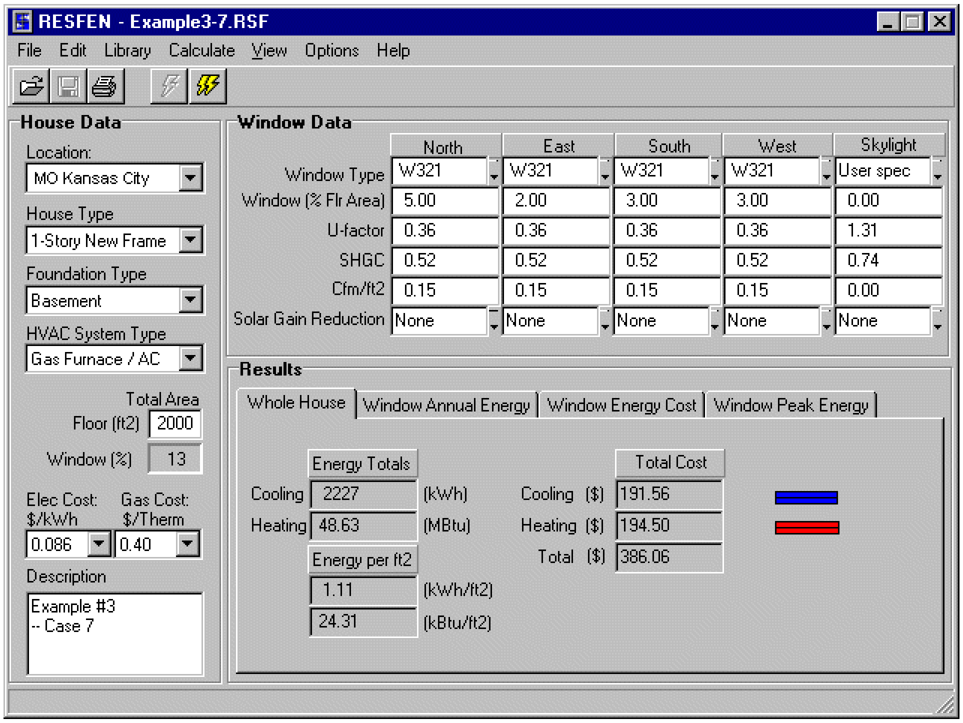
Results

	Energy Totals	
Cooling	1670	(kWh)
Heating	47.12	(MBtu)
	Energy per ft2	
Cooling	0.84	(kWh/ft2)
Heating	23.56	(kBtu/ft2)

	Total Cost
Cooling ($)	143.64
Heating ($)	188.47
Total ($)	332.11

Figure 5-14. Example 3 Input Screen for Case 6, a combination of high-performance windows on different orientations with 2' overhangs on the east, south, and west.

Another way to use RESFEN is to evaluate different building designs in terms of the glazing percentage on different orientations. For example, if you were in the process of designing your house and wanted to determine the energy impact of rotating it 180 degrees (because the great view was really to the north, not the south), you could do another run using RESFEN with the new glazing orientation, as shown in input screen in Figure 5-15 and listed as Case 7 in the table in Figure 5-13. The window type in this case is Window B (double glazed, low-E), but now there is 5% glazing on the north and 3% glazing on the south. You can see that the total energy cost is greater than in Case 2. The cooling cost is reduced somewhat because there is less glazing on the south, but the increased heating cost (because there is less heat gain in the winter from the south-facing windows) results in an overall increase in energy cost. At this point, you could begin analyzing this new configuration with different window and shading options as we have done in the previous examples, in order to maximize the energy savings for the new orientation of the building.



House Data

Location: MO Kansas City

House Type: 1-Story New Frame

Foundation Type: Basement

HVAC System Type: Gas Furnace / AC

Total Area Floor (ft2): 2000

Window (%): 13

Elec Cost: $/kWh: 0.086

Gas Cost: $/Therm: 0.40

Description: Example #3 -- Case 7

Window Data

	North	East	South	West	Skylight
Window Type	W321	W321	W321	W321	User spec
Window (% Flr Area)	5.00	2.00	3.00	3.00	0.00
U-factor	0.36	0.36	0.36	0.36	1.31
SHGC	0.52	0.52	0.52	0.52	0.74
Cfm/ft2	0.15	0.15	0.15	0.15	0.00
Solar Gain Reduction	None	None	None	None	None

Results

Energy Totals

Cooling 2227 (kWh)

Heating 48.63 (MBtu)

Energy per ft2

1.11 (kWh/ft2)

24.31 (kBtu/ft2)

Total Cost

Cooling ($) 191.56

Heating ($) 194.50

Total ($) 386.06

Figure 5-15. Example 3 Input Screen for Case 2, but with the north glass area = 5% and the south glass area = 3%.

				Whole House Energy Cost ($/yr)		
Case	**Window Description**	**U-value**	**SHGC**	**Cooling**	**Heating**	**Total**
2. Window B, N/S/E/W No shading 5% on South,	B – Double-glazed low-E	0.36	0.52	201.85	182.47	384.32
7. Window B, N/S/E/W No shading 5% on North 3% on South	B – Double-glazed low-E	0.36	0.52	191.56	194.50	386.06

Figure 5-16. Example 3 RESFEN Results comparing Cases 2 and 7, which is the same as Case 2 except that the north and south glass areas are reversed.

6. TECHNICAL REFERENCE

6.1. Locations Available for Analysis with RESFEN 3.1

Table 6-1. RESFEN 3.1 Locations

United States Locations			
AK	Juneau	NM	Albuquerque
AL	Birmingham	NV	Las Vegas
AZ	Phoenix	NV	Reno
CA	Fresno	NY	Buffalo
CA	Los Angeles	NY	New York
CA	San Diego	OH	Cincinnati
CA	San Francisco	OK	Oklahoma City
CO	Denver	OR	Medford
DC	Washington	OR	Portland
FL	Jacksonville	PA	Philadelphia
FL	Miami	PA	Pittsburgh
GA	Atlanta	SC	Charleston
HI	Honolulu	TN	Memphis
ID	Boise	TN	Nashville
IL	Chicago	TX	Brownsville
LA	Lake Charles	TX	El Paso
MA	Boston	TX	Forth Worth
ME	Portland	TX	San Antonio
MN	Minneapolis	UT	Salt Lake City
MO	Kansas City	VT	Burlington
MT	Great Falls	WA	Seattle
ND	Bismarck	WI	Madison
NE	Omaha	WY	Cheyenne
Canadian Locations			
AB	Edmonton	ON	Toronto
NS	Halifax	PQ	Montreal

6.2. RESFEN Modeling Assumptions

The following table compares the input value assumptions used for the DOE2 simulations in RESFEN versions 3.0 and 3.1. The 3.1 assumptions are consistent with efforts by NFRC Annual Energy Rating Subcommittee to develop an Annual Energy Rating Procedure (1998). These assumptions are under review and may be updated in the next version of RESFEN.

Table 6-2. RESFEN 3.0 and 3.1 Modeling Assumptions

PARAMETER	**RESFEN Ver. 3.0**	**RESFEN Ver. 3.1**
Floor Area (ft^2 & dimensions)	1,540(a) 41.5 x 41.5 x 8	Variable, from 1,000 to 4,000 square feet, input by user.
House Type	New Construction	▪ New Construction ▪ Existing Construction
Foundation	Slab, Crawlspace	Foundation is based on location. There are a maximum of three options per climate zone, chosen from: ▪ Basement ▪ Slab-on-Grade ▪ Crawlspace See Table 6-2. (b)
Insulation	Wall: R19 Roof: R30	Envelope insulation levels are based on location. ▪ **New construction:** See Table 6-4. (Council of American Building Officials, 1993) (c) ▪ **Existing construction:** See Table 6-5. (Ritschard, et al. 1992)
Infiltration	ELA=0.77 ft^2 (0.58 ACH)	▪ **New Construction:** ELA=0.77 ft^2 (0.58 ACH) ▪ **Existing Construction:** ELA=1.00 ft^2 (0.70 ACH)
Structural Mass (lb/ft^2)	≅ 4.3 lb/ft^2	3.5 lb/ft^2 of floor area, in accordance with the Model Energy Code and NFRC Annual Energy Performance Subcommittee recommendation (September 1998).
Internal Mass Furniture (lb/ft^2)	5.5 lb/ft^2	8.0 lb/ft^2 of floor area, in accordance with the Model Energy Code and NFRC Annual Energy Performance Subcommittee recommendation (September 1998).

Solar Gain Reduction	**Options:**
	▪ None
	▪ 2' Exterior Overhangs
	▪ Exterior Obstructions a completely opaque (τ=0.0), same-height obstruction 20 feet away, intended to represent adjacent buildings.
	▪ Interior Shades: Shading coefficient multiplier of 0.60 when solar gain > 30 BTU/ft^2.
		Options:
		▪ **None:** No solar gain reduction
		▪ **Overhang:** 2' Exterior Overhangs
		▪ **Obstruction:** Exterior Obstructions, a completely opaque (τ=0.0), same-height obstruction 20 feet away, intended to represent adjacent buildings.
		▪ **Interior:** Interior shades with a Seasonal SHGC multiplier, summer value = 0.80, winter value = 0.90.
		▪ **Int+Ovh:** Interior shades & 2' overhangs
		▪ **Ovh+Obs:** 2' overhangs & obstructions
		▪ **All:** Interior shades, 2' overhangs, & obstructions
		▪ **Typical(d):** to represent a statistically average solar gain reduction for a generic house, this option includes:
		  ▪ Interior shades (Seasonal SHGC multiplier, summer value = 0.80, winter value = 0.90);
		  ▪ 1' overhang;
		  ▪ a 67% transmitting same-height obstruction 20' away intended to represent adjacent buildings.
		  ▪ To account for other sources of solar heat gain reduction (insect screens, trees, dirt, building & window self-shading), the SHGC multiplier was further reduced by 0.1. This results in a final winter SHGC multiplier of 0.8 and a final summer SHGC multiplier of 0.7.

Window Area (% Floor Area)	Variable (base case is 3% of floor area)	Variable
PARAMETER	**RESFEN Ver. 3.0**	**RESFEN Ver. 3.1**
Window Type	Variable	Variable

Window Distribution	Variable	Variable
HVAC System	Furnace & A/C, Heat Pump	Furnace & A/C, Heat Pump
HVAC System Sizing	DOE-2 autosizing	For each climate, system sizes are fixed for all window options. Fixed sizes are based on the use of DOE-2 auto-sizing for the same house as defined in the analysis, with the most representative window for that specific climate. An auto-sizing multiplier of 1.3 used to account for a typical safety factor. (e)
HVAC Efficiency	AFUE = 0.78 A/C SEER = SEER=10.0	**New Construction:** ▪ AFUE = 0.78, A/C SEER=10.0 **Existing Construction:** ▪ AFUE = 0.70, A/C SEER= 8.0
Duct Losses	Heating: 10% (fixed) Cooling: 10% (fixed)	Heating: 10% (fixed) Cooling: 10% (fixed)
Part-Load Performance	Default DOE-2 heating, cooling Part Load Ratios	New part-load curves for DOE2 (Henderson 1998) for both new and existing house types
Thermostat Settings	Heating: 70°F, Cooling: 78°F	Heating: 70°F, Cooling: 78°F Basement (partially conditioned): Heating 62°F, Cooling 85°F
Night Heating Setback	60°F (11 PM – 6 AM)	65°F (11 PM – 6 AM(f))
Internal Loads	Sensible: 56.1 kBtu/day Latent: 12.2 kBtu/day	Sensible: 43,033 Btu/day + (floor area * 8.42 Btu/ft^2-day for lighting) Latent: 12.2 kBtu/day
Natural Ventilation	Enthalpic – Sherman-Grimsrud (78°F / 72°F based on 4 days' history(g))	Enthalpic – Sherman-Grimsrud (78°F / 72°F based on 4 days' history(g))
Weather Data	13 TMY2, 33 WYEC2(h)	All TMY2(h)
Number of Locations	46	48 US cities(i) 4 Canadian cities
Calculation Tool	DOE-2.1E	DOE-2.1E

Footnotes:

(a) RESFEN 3.0 modeled two building types – a 1,540 ft^2 one-story ranch house, and a 2,240 ft^2 two-story house. The RESFEN 3.0 values in this table show the dimensions, interior wall area, and internal loads levels for the one-story house only. RESFEN 3.1 allows the floor area to vary, so floor-area-dependent parameters (such as exterior and interior wall area, perimeter area, internal gains, infiltration, and so forth) are calculated for each specific case.

(b) In Table 2, the default foundation option is the most common foundation type in that location; the other options are other foundation types found in more than 10% of the houses according to a National Association of Homebuilder's survey (Labs et al. 1988).

(c) The wall insulation R-values listed in the 1993 MEC (Council of American Building Officials, 1993) are the same for frame and masonry walls, as stated in the documentation for Prescriptive Packages: "Wall R-values represent the sum of the wall cavity insulation plus insulating sheathing (if used). Do not include exterior siding, structural sheathing, and interior drywall. For examples, an R-19 requirement could be met EITHER by R-19 cavity insulation OR R-13 cavity insulation plus R-6 insulating sheathing. Wall requirements apply to wood-frame or mass (concrete, masonry, log) wall constructions, but do not apply to metal-frame construction."

(d) These assumptions are intended to represent the average solar heat gain reduction for a large sample of houses. A one-foot overhang is assumed on all four orientations in order to represent the average of a two-foot overhang and no overhang. A 67% transmitting obstruction 20 feet away on all four orientations represents the average of obstructions (such as neighboring buildings and trees) 20 feet away on one-third of the total windows and no obstructions in front of the remaining two-thirds of windows. An interior shade is assumed to have a Solar Heat Gain Coefficient multiplier of 0.9 during the winter and 0.8 during the summer. To account for solar heat gain reducing effects from other sources such as screens, trees, dirt, and self-shading of the building, the SHGC multiplier was further reduced by 0.1 throughout the year. This amounts to a 12.5% decrease in the summer and an 11.1% decrease in the winter. The final SHGC multipliers (0.8 in the winter and 0.7 in the summer) thus reflect the combined effects of shading devices and other sources.

(e) For each climate, DOE-2's auto-sizing feature was used with the window most likely to be installed in new construction (assumed to be the MEC default). Tables 6.4 and 6.5 show the required prescriptive U-factors for windows for the 52 climates. For climates where the U-factor requirement is greater than or equal to 1.0, an aluminum frame window with single glazing (U-factor = 1.30; SHGC = 0.74) is used. For climates where the U-factor requirement is between 0.65 and 1.0, an aluminum frame window with double glazing (U-factor = 0.87; SHGC = 0.66) is used. For climates where the U-factor requirements are below 0.65, as well as in the four Canadian climates, a vinyl frame window with double glazing (U-factor = 0.49; SHGC = 0.57) is used for the sizing calculation.

(f) RESFEN 3.1 models a moderate setback of 65° F in recognition that some but not all houses may use night setbacks. Recent studies of residential indoor conditions have shown that, during the heating season, nighttime temperatures are significantly lower than daytime temperatures (Ref: “Occupancy Patterns and Energy Consumption in New California Houses,” Berkeley Solar Group for the California Energy Commission, 1990).

(g) RESFEN 3.0 and 3.1 use a feature in DOE-2 that allows the ventilation temperature to switch between a higher heating (or winter) and a lower cooling (or summer) temperature based on the cooling load over the previous four days.

(h) RESFEN 3.0 used a mix of Typical Meteorologcal Year (TMY2) weather tapes from the National Renewable Energy Laboratory and WYEC2 weather tapes from ASHRAE. There are 239 TMY2 locations with average weather data compiled from 30+ years of historical weather data. (National Renewable Energy Laboratory, 1995), but only 55 WYEC2 locations (American Society of Heating, Refrigerating, and Air-Conditioning Engineers, 1997). The two weather data sets are of comparable reliability, but RESFEN 3.1 uses only TMY2 weather tapes to maintain internal consistency. (Huang, Memorandum to NFRC 900 Working Group, "Weather data for use in NFRC900", August 5, 1998).

(i) This list of locations is based primarily on a list of 45 cities chosen in a previous LBNL project to define representative U.S. climates for simulating residential building energy use (Huang et al. 1987).

6.3. Foundation Types by Location

Table 6-3. RESFEN 3.1 Foundation Type Options by Location. (Ritschard, et. Al. 1992)

State	City	Default Foundation Type	2nd Foundation Option	3rd Foundation Option
AK	Anchorage	Basement	--	--
AL	Birmingham	Slab-on-Grade	Crawlspace	Basement
AZ	Phoenix	Slab-on-Grade	--	--
CA	Fresno	Slab-on-Grade	Crawlspace	Basement
CA	Los Angeles	Slab-on-Grade	Crawlspace	Basement
CA	Red Bluff	Slab-on-Grade	Crawlspace	Basement
CA	San Diego	Slab-on-Grade	Crawlspace	Basement
CA	San Francisco	Slab-on-Grade	Crawlspace	Basement
CO	Denver	Basement	Crawlspace	--
DC	Washington	Basement	--	--
FL	Jacksonville	Slab-on-Grade	--	--
FL	Miami	Slab-on-Grade	--	--
GA	Atlanta	Slab-on-Grade	Basement	Crawlspace
HI	Honolulu	Slab-on-Grade	--	--
ID	Boise	Basement	Crawlspace	--
IL	Chicago	Basement	--	--
LA	Lake Charles	Slab-on-Grade	--	--
MA	Boston	Basement	--	--
ME	Portland	Basement	--	--
MN	Minneapolis	Basement	--	--
MO	Kansas City	Basement	--	--
MT	Great Falls	Basement	--	--
NC	Raleigh	Crawlspace	Slab-on-Grade	Basement
ND	Bismarck	Basement	--	--
NE	Omaha	Basement	--	--
NM	Albuquerque	Slab-on-Grade	--	--
NV	Las Vegas	Slab-on-Grade	Crawlspace	--
NV	Reno	Slab-on-Grade	Crawlspace	--
NY	Buffalo	Basement	--	--
NY	New York City	Basement	Slab-on-Grade	--
OH	Dayton	Basement	Slab-on-Grade	Crawlspace
OK	Oklahoma City	Slab-on-Grade	--	--
OR	Medford	Crawlspace	Basement	--
OR	Portland	Crawlspace	Basement	--
PA	Philadelphia	Basement	--	--
PA	Pittsburgh	Basement	--	--
SC	Charleston	Crawlspace	Slab-on-Grade	--
TN	Memphis	Crawlspace	Basement	Slab-on-Grade
TN	Nashville	Crawlspace	Basement	Slab-on-Grade
TX	Brownsville	Slab-on-Grade	--	--
TX	El Paso	Slab-on-Grade	--	--
TX	Fort Worth	Slab-on-Grade	--	--
TX	San Antonio	Slab-on-Grade	--	--
UT	Salt Lake City	Basement	--	--
VT	Burlington	Basement	--	--
WA	Seattle	Basement	Crawlspace	--
WI	Madison	Basement	--	--
WY	Cheyenne	Basement	--	--
ON	Toronto	Basement	--	--
PQ	Montreal	Basement	--	--
AB	Edmonton	Basement	--	--
NS	Halifax	Basement	--	--

6.4. Simulation Envelope Insulation Values

Table 6-4. RESFEN 3.1 New Construction Insulation Values (Default fndn. in bold.) (Council of American Building Officials, 1993)

ST	City	MEC Zone	Pkg #	Glz %	Window U-value	Ceil. R-value	Wall R-value	Floor R-value	Basement R-value	Slab R-value	Crawl. R-value
AK	Anchorage	17	3	15	0.400	38	19	30	**30**	--	--
AL	Birmingham	6	4	15	0.700	38	14	19	6	**6**	7
AZ	Phoenix	3	3	15	0.900	30	11	11	--	**0**	--
CA	Fresno	6	4	15	0.700	38	14	19	6	**6**	7
CA	Los Angeles	4	2	15	0.750	26	11	11	5	**0**	5
CA	Red Bluff	6	4	15	0.700	38	14	19	6	**6**	7
CA	San Diego	3	3	15	0.900	30	11	11	0	**0**	5
CA	San Francisco	6	4	15	0.700	38	14	19	6	**6**	7
CO	Denver	13	2	15	0.400	38	19	26	**11**	--	22
DC	Washington	10	3	15	0.550	38	19	19	**9**	--	--
FL	Jacksonville	3	3	15	0.900	30	11	11	--	**0**	--
FL	Miami	1	2	15	1.100	19	11	11	--	**0**	--
GA	Atlanta	7	4	15	0.650	38	19	13	5	**2**	6
HI	Honolulu	1	2	15	1.100	19	11	11	--	**0**	--
ID	Boise	12	3	15	0.400	38	19	19	**9**	--	14
IL	Chicago	14	3	15	0.400	38	19	30	**14**	--	--
LA	Lake Charles	4	2	15	0.750	26	11	11	--	**0**	--
MA	Boston	13	2	15	0.400	38	19	26	**11**	--	--
ME	Portland	15	3	15	0.400	38	19	30	**15**	--	--
MN	Minneapolis	15	3	15	0.400	38	19	30	**15**	--	--
MO	Kansas City	11	3	15	0.450	38	19	19	**8**	--	--
MT	Great Falls	15	3	15	0.400	38	19	30	**15**	--	--
NC	Raleigh	7	4	15	0.650	38	19	13	5	2	**6**
ND	Bismarck	16	3	15	0.400	38	19	30	**28**	--	--
NE	Omaha	13	2	15	0.400	38	19	26	**11**	--	--
NM	Albuquerque	9	3	15	0.600	38	19	19	--	**3**	--
NV	Las Vegas	5	3	15	0.700	30	14	11	--	**0**	6
NV	Reno	12	3	15	0.400	38	19	19	--	**4**	14
NY	Buffalo	14	3	15	0.400	38	19	30	**14**	--	--
NY	New York City	10	3	15	0.550	38	19	19	**9**	5	--
OH	Dayton	12	3	15	0.400	38	19	19	**9**	4	14
OK	Oklahoma City	8	3	15	0.650	38	19	19	--	**2**	--
OR	Medford	11	3	15	0.450	38	19	19	8	--	**12**
OR	Portland	10	3	15	0.550	38	19	19	9	--	**16**
PA	Philadelphia	10	3	15	0.550	38	19	19	**9**	--	--
PA	Pittsburgh	12	3	15	0.400	38	19	19	**9**	--	--
SC	Charleston	5	3	15	0.700	30	14	11	--	0	**6**
TN	Memphis	7	4	15	0.650	38	19	13	5	2	**6**
TN	Nashville	8	3	15	0.650	38	19	19	7	2	**8**
TX	Brownsville	2	2	15	1.100	19	13	11	--	**0**	--
TX	El Paso	6	4	15	0.700	38	14	19	--	**6**	--
TX	Fort Worth	5	3	15	0.700	30	14	11	--	**0**	--
TX	San Antonio	4	2	15	0.750	26	11	11	--	**0**	--
UT	Salt Lake City	12	3	15	0.400	38	19	19	**9**	--	--
VT	Burlington	15	3	15	0.400	38	19	30	**15**	--	--
WA	Seattle	10	3	15	0.550	38	19	19	**9**	--	16
WI	Madison	15	3	15	0.400	38	19	30	**15**	--	--
WY	Cheyenne	15	3	15	0.400	38	19	30	**15**	--	--
ON	Toronto	16	3	15	0.400	38	19	30	**28**	--	--
PQ	Montreal	16	3	15	0.400	38	19	30	**28**	--	--
AB	Edmonton	16	3	15	0.400	38	19	30	**28**	--	--
NS	Halifax	16	3	15	0.400	38	19	30	**28**	--	--

Table 6-5. RESFEN 3.1 Existing Construction Insulation Values. (Ritschard, et. al. 1992)

State	City	Window U-value	Ceiling R-value	Wall R-value	Floor R-value	Basement R-value	Slab R-value	Crawlspace R-value
AK	Anchorage	0.650	22	7	0	0	0	0
AL	Birmingham	0.650	19	7	0	0	0	0
AZ	Phoenix	0.650	11	7	0	0	0	0
CA	Fresno	1.100	11	7	0	0	0	0
CA	Los Angeles	1.100	11	7	0	0	0	0
CA	Red Bluff	1.100	11	7	0	0	0	0
CA	San Diego	1.100	11	7	0	0	0	0
CA	San Francisco	1.100	11	7	0	0	0	0
CO	Denver	0.650	11	7	0	0	0	0
DC	Washington	0.650	11	7	0	0	0	0
FL	Jacksonville	0.650	11	7	0	0	0	0
FL	Miami	0.650	11	7	0	0	0	0
GA	Atlanta	0.650	11	7	0	0	0	0
HI	Honolulu	0.650	11	7	0	0	0	0
ID	Boise	0.650	19	7	0	0	0	0
IL	Chicago	0.650	19	7	0	0	0	0
LA	Lake Charles	0.650	19	7	0	0	0	0
MA	Boston	0.650	22	7	0	0	0	0
ME	Portland	0.650	22	7	0	0	0	0
MN	Minneapolis	0.650	22	7	0	0	0	0
MO	Kansas City	0.650	22	7	0	0	0	0
MT	Great Falls	0.650	19	7	0	0	0	0
NC	Raleigh	0.650	11	7	0	0	0	0
ND	Bismarck	0.650	22	7	0	0	0	0
NE	Omaha	0.650	19	7	0	0	0	0
NM	Albuquerque	0.650	11	7	0	0	0	0
NV	Las Vegas	0.650	11	7	0	0	0	0
NV	Reno	0.650	11	7	0	0	0	0
NY	Buffalo	0.650	11	7	0	0	0	0
NY	New York City	0.650	11	7	0	0	0	0
OH	Dayton	0.650	19	7	0	0	0	0
OK	Oklahoma City	0.650	19	7	0	0	0	0
OR	Medford	0.650	19	7	0	0	0	0
OR	Portland	0.650	19	7	0	0	0	0
PA	Philadelphia	0.650	11	7	0	0	0	0
PA	Pittsburgh	0.650	11	7	0	0	0	0
SC	Charleston	0.650	11	7	0	0	0	0
TN	Memphis	0.650	11	7	0	0	0	0
TN	Nashville	0.650	11	7	0	0	0	0
TX	Brownsville	0.650	19	7	0	0	0	0
TX	El Paso	0.650	19	7	0	0	0	0
TX	Fort Worth	0.650	19	7	0	0	0	0
TX	San Antonio	0.650	19	7	0	0	0	0
UT	Salt Lake City	0.650	11	7	0	0	0	0
VT	Burlington	0.650	22	7	0	0	0	0
WA	Seattle	0.650	19	7	0	0	0	0
WI	Madison	0.650	22	7	0	0	0	0
WY	Cheyenne	0.650	11	7	0	0	0	0
ON	Toronto	0.650	22	7	0	0	0	0
PQ	Montreal	0.650	22	7	0	0	0	0
AB	Edmonton	0.650	22	7	0	0	0	0
NS	Halifax	0.650	22	7	0	0	0	0

6.5. Making Custom WINDOW 4.1 Libraries

RESFEN is shipped with a generic window library, called **window.w4**, that was generated with the WINDOW 4.1 computer program (Arasteh, et. al., 1994). This library contains a variety of energy-efficient window technologies that you can use for your analysis. However, the values in the library are based on one window size and operation type, 2' x 4' casements. These values are typical for common residential operable (slider, double hung, and casement) windows. Window properties often vary with size and will be different for fixed windows and patio doors. If the products you are analyzing are significantly different from the assumptions made in the **window.w4** window library, and you have reliable properties (from the NFRC label, NFRC product directory, or manufacturer), you should use them.

Users familiar with the WINDOW 4.1 program may want to use it to make window library files with very specific fenestration products to use with RESFEN. (For a description of WINDOW 4.1, visit the web site at http://windows.lbl.gov. To obtain WINDOW 4.1, fax your address and phone number to: Fax: (510) 486-4089 or email: RESFENHelp@lbl.gov.)

Using the values in a window library made from WINDOW 4.1 will increase the accuracy of the DOE-2 simulation because the library contains solar and visible properties of the window as a function of angle of incidence and U-values as a function of temperature and wind speed.

When you choose a WINDOW4.1 library, RESFEN automatically uses one of two possible calculation methods, depending on what files are available. *Method (b) is recommended for experienced WINDOW4.1 users only* (see Section 6.5, Making Custom WINDOW 4.1 Libraries" for more detailed information about creating these files):

- *WINDOW4.1 Window Library(e.g., **window.w4**) only:*
  if only the standard WINDOW4.1 window library file (*e.g.*, ***window.w4***) exists RESFEN will use the U-factor and SHGC from that file. Air infiltration values must be entered by the user.
- *WINDOW4.1 Window Library (**W4** file, such as **window.w4**) and additional WINDOW4.1 DOE-2.1E output(ASCII) file (**DAT** file, such as window.dat),* **recommended for experienced WINDOW4.1 users only:**
  if both files exist, RESFEN will use the values from these files for the window properties. RESFEN automatically determines whether there is an associated **DAT** file for the window library (which have the same name before the extension) and will use the additional values if they exist. The following discussion includes steps for making these **DAT** files. *(Note: The DOE-2.1 **DAT** file can only be made for windows with one glazing system, such as casements. It cannot be made for horizontal or vertical sliders.)*

  The window IDs in the "**.W4**" file and the "**.DAT**" file must be identical – if the program automatically detects a "**.DAT**" file, and finds windows in the "**.W4**" file that are not in the "**.DAT**" file, a program error will occur. So it is important to make sure that the W4 and DAT files are kept current with each other.

  If the DAT file does not exist when the W4 library is selected in RESFEN, a message will appear saying that the program can't find the DAT file. RESFEN will still use the W4 file; the message is informational only and does not indicate a problem.

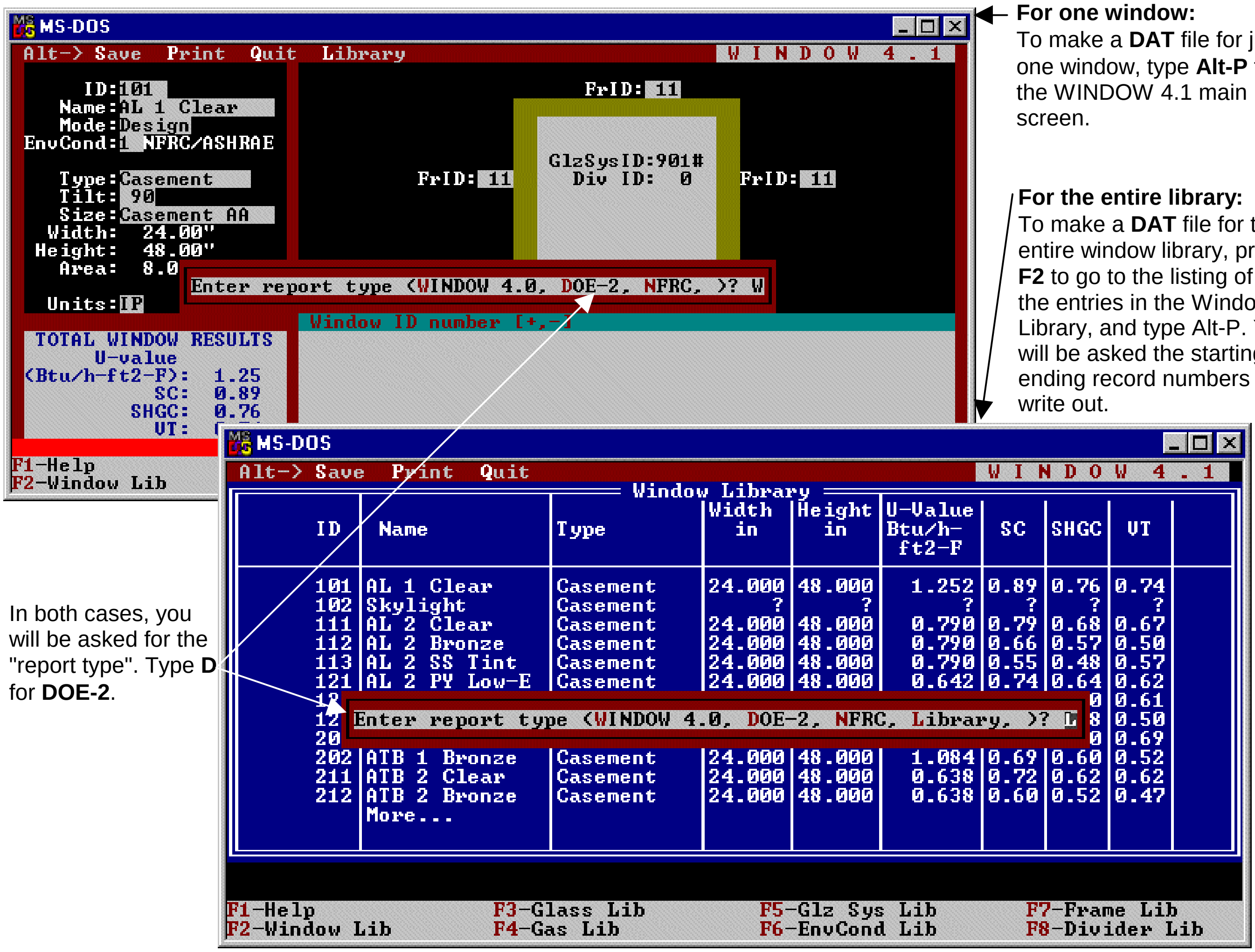
"C:\Program Files\RESFEN 31\Data\window.dat" does not exist. Angular data will not used in simulation

*Figure 6-1. An informational error message appears if the DAT file does not exist for the *.W4 file. This is not an error, and the program can use the library even without this DAT file.*

You can make a window library in WINDOW 4.1, which is called ***window.w4***, and then copy it to the RESFEN\DATA directory so that RESFEN can read it. RESFEN looks in this directory for any file with a “.W4” extension, so you can rename the ***window.w4*** file to something more descriptive, such as a manufacturer or product line name. (However, remember that WINDOW 4.1 can only read files called ***window.w4***, so you must keep that name in the WINDOW 4.1 program directories.)

6.5.1. Make WINDOW 4.1 Window Library Files

From WINDOW 4.1 you can also make a DOE2 input file for each window, which contains detailed information about the optical properties of the window. In WINDOW 4.1, these DOE2 files can be generated for one window at a time, for a range of records in the window library, or for the entire window library. To create these files in WINDOW4.1, go to either the main screen (for one window at a time), or **the Window Library** (**F2**) for a range of records in the library or the entire library. From either place, use **Alt-Print** and select the **Report Type** of “DOE-2” (from the **Window Library**, you first have to enter the range of windows for which the report is to be created. The default is the first through the last window record).



```
   ID:101                       FrID: 11
 Name:AL 1 Clear
 Mode:Design
EnvCond:1 NFRC/ASHRAE
                                       GlzSysID:901#
 Type:Casement           FrID: 11       Div ID:  0     FrID: 11
 Tilt: 90
 Size:Casement AA
Width:  24.00"
Height:  48.00"
 Area:  8.0      Enter report type (WINDOW 4.0, DOE-2, NFRC, )? W

Units:IP                 Window ID number [+,-]
 TOTAL WINDOW RESULTS
   U-value
(Btu/h-ft2-F):  1.25
          SC:   0.89
        SHGC:   0.76
          VT:
```

```
                               Window Library
                                        Width   Height  U-Value
  ID  Name          Type                  in      in    Btu/h-   SC   SHGC  VT
                                                        ft2-F

 101 AL 1 Clear     Casement          24.000  48.000    1.252  0.89  0.76  0.74
 102 Skylight       Casement               ?       ?        ?     ?     ?     ?
 111 AL 2 Clear     Casement          24.000  48.000    0.790  0.79  0.68  0.67
 112 AL 2 Bronze    Casement          24.000  48.000    0.790  0.66  0.57  0.50
 113 AL 2 SS Tint   Casement          24.000  48.000    0.790  0.55  0.48  0.57
 121 AL 2 PY Low-E  Casement          24.000  48.000    0.642  0.74  0.64  0.62
 12                                                                    0  0.61
 12 Enter report type (WINDOW 4.0, DOE-2, NFRC, Library, )? L          8  0.50
 20                                                                    0  0.69
 202 ATB 1 Bronze   Casement          24.000  48.000    1.084  0.69  0.60  0.52
 211 ATB 2 Clear    Casement          24.000  48.000    0.638  0.72  0.62  0.62
 212 ATB 2 Bronze   Casement          24.000  48.000    0.638  0.60  0.52  0.47
     More...
```

For one window:
To make a **DAT** file for just one window, type **Alt-P** from the WINDOW 4.1 main screen.

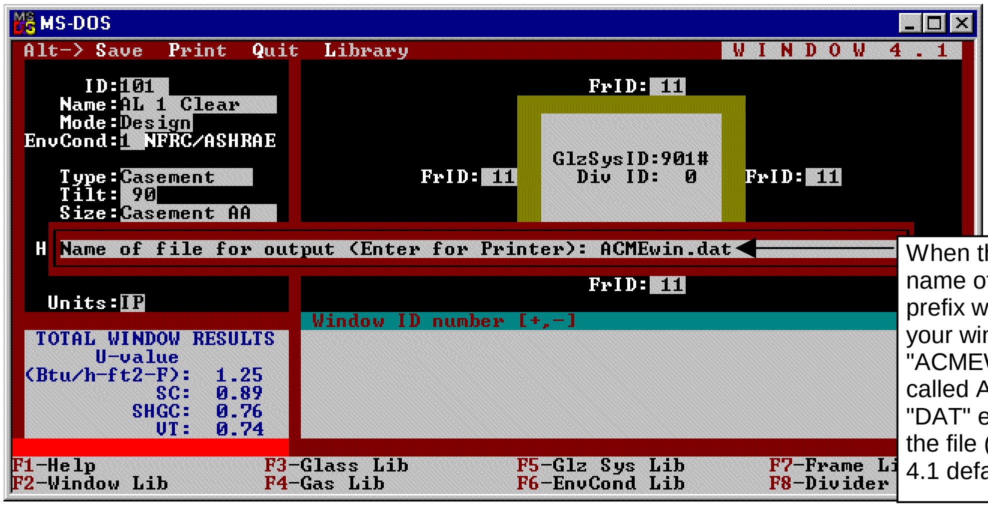
For the entire library:
To make a **DAT** file for the entire window library, press **F2** to go to the listing of all the entries in the Window Library, and type Alt-P. You will be asked the starting and ending record numbers to write out.

In both cases, you will be asked for the "report type". Type **D** for **DOE-2**.

Figure 6-2. Making the DOE-2 DAT file in WINDOW 4.1.

6.5.2. Name the DOE-2 DAT File

The WINDOW 4.1 program will then ask you for a file name for this output file; type a name that will correspond to the name of the **Window Library**, and give it the extension "**.DAT**", for example, "**ACMEWIN.DAT**". In order for RESFEN to connect the two files, the "**.W4**" file and the "**.DAT**" file must have the same prefix. So for the "**ACMEWIN.DAT**" file, there would have to be a corresponding "**ACMEWIN.W4**" WINDOW4.1 Window Library file, with the same windows as the **ACMEWIN.DAT** file. Also keep in mind that WINDOW4.1 will only save windows with one glazing system to the DOE2 output file, so you cannot create WINDOW 4.1 library files for horizontal or vertical sliders, or double doors, which all have two glazing systems even if the two glazing systems are the same. In this version of RESFEN, the window IDs in the "**.W4**" file and the "**.DAT**" file must be identical – if the program automatically detects a "**.DAT**" file, and finds windows in the "**.W4**" file that are not in the "**.DAT**" file, a program error will occur. If you have trouble making this feature work, email RESFENHelp@lbl.gov. (See Section 3.4, Troubleshooting).



ID: 101
Name: AL 1 Clear
Mode: Design
EnvCond: 1 NFRC/ASHRAE

Type: Casement
Tilt: 90
Size: Casement AA

Name of file for output (Enter for Printer): ACMEwin.dat

Units: IP

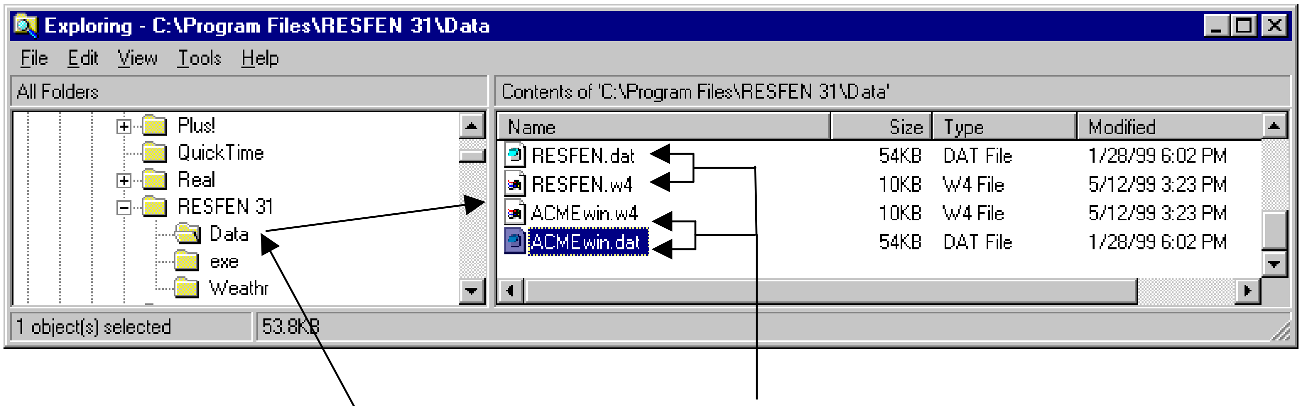
TOTAL WINDOW RESULTS
U-value
(Btu/h-ft2-F): 1.25
SC: 0.89
SHGC: 0.76
VT: 0.74

When the program asks for the name of the output file, type a prefix which matches the prefix of your window library, such as "ACMEWIN" if your library is called ACMEWIN.W4. Add the "DAT" extension to the name of the file (overwrite the WINDOW 4.1 default extension of "PRN).

Figure 6-3. Naming the DAT file from WINDOW 4.1.

6.5.3. Move WINDOW 4.1 Libraries to RESFEN Directory

Now you have two matching files, a "**DAT**" file (found in the main W4 directory) and a "**W4**" file (found in the W4\W4LIB subdirectory), created from the same data. Move these two files to the RESFEN/DATA directory so that RESFEN can access them.



Name	Size	Type	Modified
RESFEN.dat	54KB	DAT File	1/28/99 6:02 PM
RESFEN.w4	10KB	W4 File	5/12/99 3:23 PM
ACMEwin.w4	10KB	W4 File	5/12/99 3:23 PM
ACMEwin.dat	54KB	DAT File	1/28/99 6:02 PM

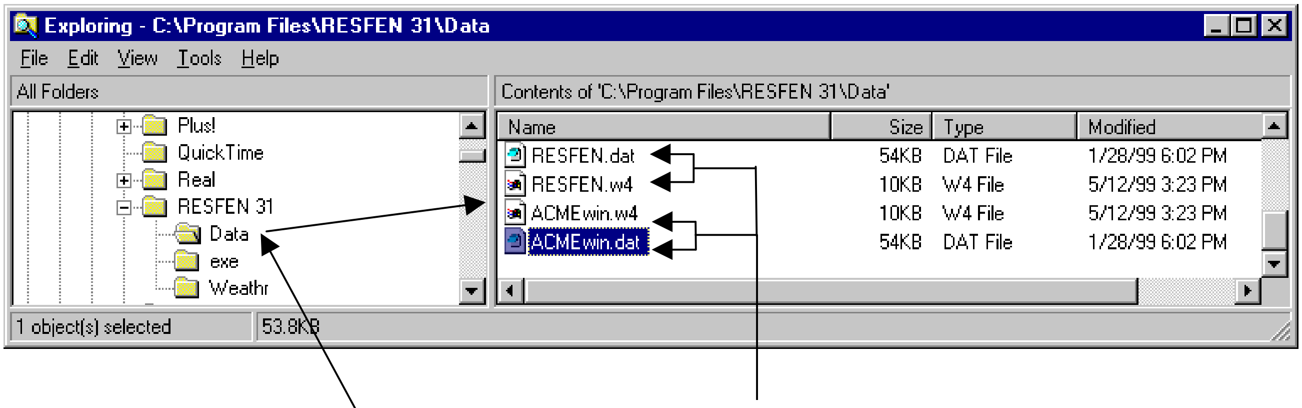
There can be more than one pair of W4 and DAT files, as in this example. In WINDOW 4.1 the library file is called "**window.w4**", but in the RESFEN\DATA directory, it can be as long as the W4 extension is kept and the DAT file has a matching prefix name.

Copy the file pairs *.DAT (from the main W4 directory) and *.W4 (from the W4/W4LIB directory) to the RESFEN\DATA directory.

Figure 6-4. Move the DAT and W4 files into the RESFEN\DATA directory.

6.5.4. Select the WINDOW 4.1 Window Library in RESFEN

Start RESFEN, and use the **Library/Select File** menu to choose the appropriate WINDOW 4.1 library.

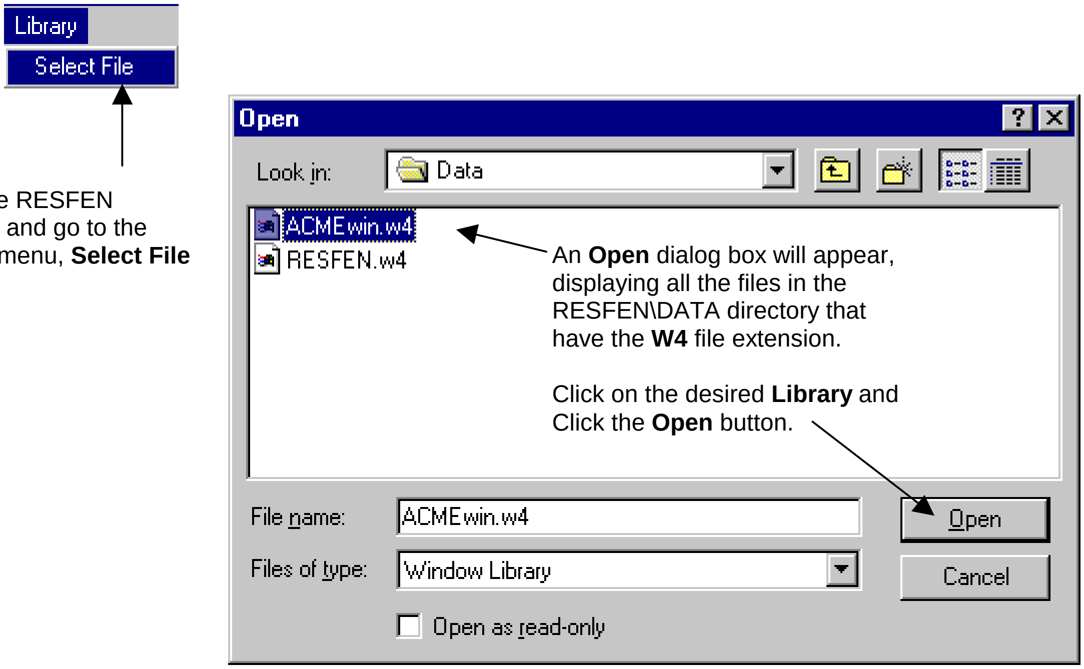


Name	Size	Type	Modified
RESFEN.dat	54KB	DAT File	1/28/99 6:02 PM
RESFEN.w4	10KB	W4 File	5/12/99 3:23 PM
ACMEwin.w4	10KB	W4 File	5/12/99 3:23 PM
ACMEwin.dat	54KB	DAT File	1/28/99 6:02 PM

Copy the file pairs *.DAT (from the main W4 directory) and *.W4 (from the W4/W4LIB directory) to the RESFEN\DATA directory.

There can be more than one pair of W4 and DAT files, as in this example. In WINDOW 4.1 the library file is called "**window.w4**", but in the RESFEN\DATA directory, it can be as long as the W4 extension is kept and the DAT file has a matching prefix name.

Figure 6-5. Move the DAT and W4 files into the RESFEN\DATA directory.



File name: ACMEwin.w4

Files of type: Window Library

☐ Open as read-only

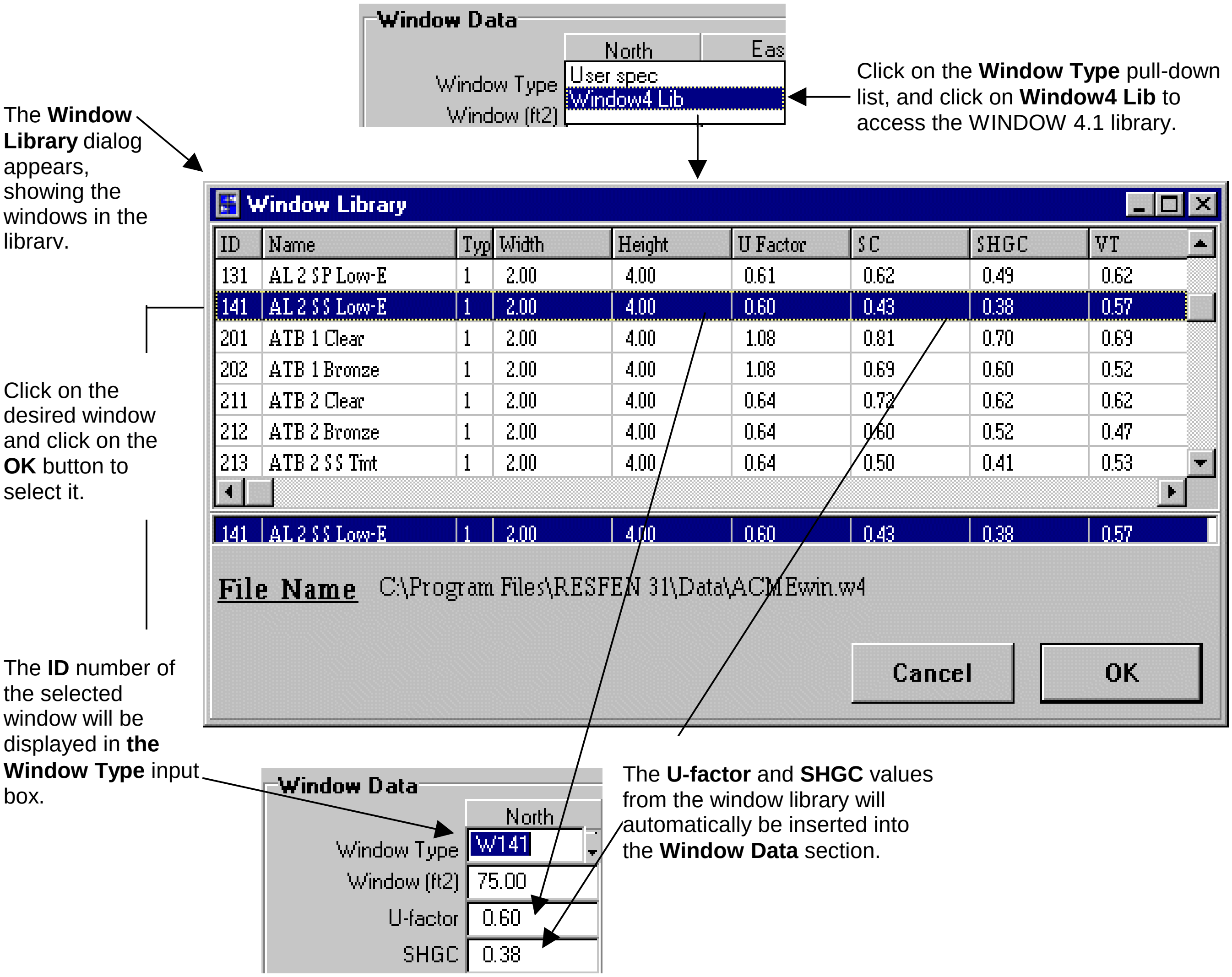
Open the RESFEN program and go to the **Library** menu, **Select File** choice.

An **Open** dialog box will appear, displaying all the files in the RESFEN\DATA directory that have the **W4** file extension.

Click on the desired **Library** and Click the **Open** button.

*Figure 6-6. From the RESFEN **Library/Select File** menu, choose the custom WINDOW library.*

Now when you select the **Window4 Lib** choice in the **Window Type** pull-down list, the windows from the library you selected will be available.



Click on the **Window Type** pull-down list, and click on **Window4 Lib** to access the WINDOW 4.1 library.

The **Window Library** dialog appears, showing the windows in the librarv.

ID	Name	Typ	Width	Height	U Factor	SC	SHGC	VT
131	AL 2 SP Low-E	1	2.00	4.00	0.61	0.62	0.49	0.62
141	AL 2 SS Low-E	1	2.00	4.00	0.60	0.43	0.38	0.57
201	ATB 1 Clear	1	2.00	4.00	1.08	0.81	0.70	0.69
202	ATB 1 Bronze	1	2.00	4.00	1.08	0.69	0.60	0.52
211	ATB 2 Clear	1	2.00	4.00	0.64	0.72	0.62	0.62
212	ATB 2 Bronze	1	2.00	4.00	0.64	0.60	0.52	0.47
213	ATB 2 SS Tint	1	2.00	4.00	0.64	0.50	0.41	0.53

141	AL 2 SS Low-E	1	2.00	4.00	0.60	0.43	0.38	0.57

File Name C:\Program Files\RESFEN 31\Data\ACMEwin.w4

Click on the desired window and click on the **OK** button to select it.

The **ID** number of the selected window will be displayed in **the Window Type** input box.

Window Type W141
Window (ft2) 75.00
U-factor 0.60
SHGC 0.38

The **U-factor** and **SHGC** values from the window library will automatically be inserted into the **Window Data** section.

Figure 6-7. The entries from the custom WINDOW library can now be used in a RESFEN calculation.

6.6. RESFEN Window Library Documentation

ID #	Frame Type	# of glazings	Glazing Description	Gap (inch)	Gas (see Note for Air/Argon)	Total Window U-factor (Btu/hr-ft^2-^{o}F)	Shading Coefficient (SC)	Total Window Solar Heat Gain Coefficient (SHGC)	Total Window Visible Transmittance (VT)
101	AL	1	Clear	n/a	n/a	1.25	0.89	0.76	0.74
102	AL	1	Bronze	n/a	n/a	1.25	0.76	0.65	0.56
111	AL	2	Clear	0.375	Air	0.79	0.79	0.68	0.67
112	AL	2	Bronze	0.375	Air	0.79	0.66	0.57	0.50
113	AL	2	SS Tint	0.375	Air	0.79	0.55	0.46	0.57
121	AL	2	PY Low-E	0.50	Argon	0.64	0.74	0.64	0.62
131	AL	2	SP Low-E	0.50	Argon	0.61	0.62	0.49	0.62
141	AL	2	SS Low-E	0.50	Argon	0.60	0.43	0.38	0.57
201	ATB	1	Clear	n/a	n/a	1.08	0.81	0.70	0.69
202	ATB	1	Bronze	n/a	n/a	1.08	0.69	0.60	0.52
211	ATB	2	Clear	0.50	Air	0.64	0.72	0.62	0.62
212	ATB	2	Bronze	0.50	Air	0.64	0.60	0.52	0.47
213	ATB	2	SS Tint	0.50	Air	0.64	0.50	0.41	0.53
221	ATB	2	PY Low-E	0.50	Argon	0.52	0.67	0.58	0.57
231	ATB	2	SP Low-E	0.50	Argon	0.49	0.56	0.45	0.58
241	ATB	2	SS Low-E	0.50	Argon	0.48	0.39	0.34	0.53
301	W/V	1	Clear	n/a	n/a	0.90	0.73	0.63	0.64
302	W/V	1	Bronze	n/a	n/a	0.90	0.62	0.54	0.48
311	W/V	2	Clear	0.50	Air	0.49	0.65	0.56	0.58
312	W/V	2	Bronze	0.50	Air	0.49	0.54	0.46	0.44
313	W/V	2	SS Tint	0.50	Air	0.49	0.44	0.37	0.49
321	W/V	2	PY Low-E	0.50	Argon	0.36	0.60	0.52	0.53
331	W/V	2	SP Low-E	0.50	Argon	0.33	0.50	0.40	0.53
341	W/V	2	SS Low-E	0.50	Argon	0.32	0.34	0.30	0.50
351	W/V	3	HT Super	0.50	Argon	0.26	0.44	0.38	0.46
352	W/V	3	SS Super	0.50	Argon	0.24	0.29	0.25	0.40
411	INS	2	Clear	0.50	Air	0.44	0.69	0.59	0.62
412	INS	2	Bronze	0.50	Air	0.44	0.56	0.49	0.47
413	INS	2	SS Tint	0.50	Air	0.44	0.46	0.38	0.53
421	INS	2	PY Low-E	0.50	Argon	0.30	0.64	0.55	0.57
431	INS	2	SP Low-E	0.50	Argon	0.27	0.52	0.42	0.58
441	INS	2	SS Low-E	0.50	Argon	0.26	0.35	0.31	0.53
451	INS	3	HT Super	0.50	Argon	0.18	0.46	0.39	0.49
452	INS	3	SS Super	0.50	Argon	0.17	0.30	0.26	0.43

NOTES:

FRAME TYPE CODES:

- **AL** = Aluminum
- **ATB** = Aluminum, Thermally Broken
- **W/V** = Wood/Vinyl
- **INS** = Insulated Frame

GLAZING TYPE CODES:

- **SS** = Spectrally Selective (e ≈ 0.04, low solar gain)
- **PY** = Pyrolitic coating (e ≈ 0.15 - 0.20, high solar gain)
- **SP** = Sputter low-E coating (e ≈ 0.10, moderate solar gain)
- **SS Super** = 3-layer insulating glazing, two layers with Spectrally Selective low-E coatings
- **HT Super** = 3-layer insulating glazing, two layers with high solar transmitting low-E coatings.

ARGON GAS:

Consists of 90% air, 10% argon

The data presented here and in RESFEN are average properties for several commercially available products. Specific products will perform slightly above or below the average products defined here. Users are encouraged to only use these numbers as a general guide and to use specific manufacturer's product data (i.e. NFRC U-factors and Solar Heat Gain Coefficients) whenever possible.

6.7. Resources

The following listings are resources for learning more about energy-efficient windows:

6.7.1. Books

Residential Windows, A Guide to New Technologies and Energy Performance
by John Carmody, Stephen Selkowitz, and Lisa Heschong
W.W.W. Norton & Company, 1996.
Updated material from this book can be found at the web site www.efficientwindows.org.

6.7.2. Organizations

Efficient Windows Collaborative
Alliance to Save Energy
1200 18th Street N.W., Suite 900
Washington, DC 20036
Phone: (202) 857-0666
Fax: (202) 331-9588
Web site: www.efficientwindows.org

National Fenestration Rating Council
1300 Spring Street, Suite 500
Silver Spring, MD 20910
Phone: (301) 589-NFRC
Web site: www.nfrc.org

Windows and Daylighting Group
Lawrence Berkeley National Laboratory
MS 90-3111
1 Cyclotron Road
Berkeley, CA 94720
Web site: windows.lbl.gov

6.8. References

American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) 1997. *WYEC2 User's Manual*, Atlanta GA.

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