

# Lawrence Berkeley National Laboratory

## Recent Work

### Title

RESEM: Retrofit Energy Savings Estimation Model reference manual - Version 1.00

### Permalink

<https://escholarship.org/uc/item/9fm8j5m3>

### Authors

Hitchcock, Robert J.

Carroll, William L.

Birdsall, Bruce E.

### Publication Date

1991-07-01



***Retrofit Energy Savings Estimation Model***

***Reference Manual***





***Retrofit Energy Savings Estimation Model***

***Reference Manual***

***Version 1.00***

***July, 1991***

Robert J. Hitchcock  
William L. Carroll  
Bruce E. Birdsall

Applied Science Division  
Lawrence Berkeley Laboratory  
University of California  
Berkeley, CA 94720

## **LEGAL NOTICE**

### **Disclaimer**

This manual was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

This manual was done with support from the Department of Energy. Any conclusions or opinions expressed in this manual represent solely those of the author(s) and not necessarily those of The Regents of the University of California, the Lawrence Berkeley Laboratory or the Department of Energy.

Reference to a company or product name does not imply approval or recommendation of the product by the University of California or the U.S. Department of Energy to the exclusion of others that may be suitable.

### **Copyright**

© 1991 Regents of the University of California - Lawrence Berkeley Laboratory

### **Acknowledgement**

This work was supported by the Assistant Secretary of Conservation and Renewable Energy, Office of State and Local Assistance Programs, Institutional Conservation Program Division, of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

---



---

## TABLE OF CONTENTS

WELCOME TO RESEM.....	1
EXECUTIVE SUMMARY .....	2
HOW TO USE THIS MANUAL.....	4
GETTING STARTED .....	5
Section Table of Contents.....	5
Section Overview.....	6
Installing RESEM on Your Hard Disk .....	6
Starting RESEM .....	8
Keystroke Summary.....	10
A Quick Tour of the Energy Savings Analysis Sequence .....	11
COMMAND SUMMARY.....	14
Section Table of Contents.....	14
Section Overview.....	15
RESEM Command Structure.....	16
Command Descriptions.....	17
ENERGY SAVINGS ANALYSIS TOPICS.....	33
Section Table of Contents.....	33
Section Overview.....	34
Gathering Information for Input .....	34
The Prototypical Building Generator.....	44
The Detailed Building Description Data Screens.....	52
Building Description Reconciliation .....	73
Describing Energy Conservation Measures (ECMs).....	76
Describing Other (non-ECM) Post-Retrofit Changes.....	78
Retrofit Modification Adjustment .....	79
Reports .....	81
REFERENCE TABLES.....	84
Section Table of Contents.....	84
Reconciliation Parameter Selection Guidelines.....	89
AN EXAMPLE TUTORIAL .....	95
Section Table of Contents.....	95
Step-by-Step Instructions.....	97
Technical Assistance Report Extracts.....	TA-1

## LIST OF TABLES

Table A-1	
Data Entry Screen Edit Keys .....	10
Table C-1	
Data Input Checklist .....	43
Table D-1	
Default Library Wall Constructions .....	45
Table D-2	
Default Library Roof Constructions .....	45
Table D-3	
Elementary School Prototypical Building Description Parameters .....	46
Table D-4	
Secondary School Prototypical Building Description Parameters .....	47
Table D-5	
University School Prototypical Building Description Parameters .....	48
Table D-6	
Vocational School Prototypical Building Description Parameters .....	49
Table D-7	
Hospital Prototypical Building Description Parameters .....	50
Table E-1	
Push-Button ECMs .....	77
Table R-1	
ASHRAE Wall Construction Group Code Descriptions .....	85
Table R-2	
ASHRAE Roof Construction Code Descriptions .....	86
Table R-3	
ASHRAE a Coefficient Design Values .....	87
Table R-4	
ASHRAE b Classification Design Values .....	87
Table R-5	
School Specific HVAC System Types Based on Generic Types .....	88
Table R-6	
Hospital Specific HVAC System Types Based on Generic Types .....	88
Table R-7	
Building Envelope Parameter Selection .....	90
Table R-8	
Electrical/Lighting Parameter Selection .....	91
Table R-9	
Mechanical Parameter Selection .....	92
Table R-10	
Additional Parameter Selection .....	94

---

---

## LIST OF FIGURES

How To Use This Manual.....	4
RESEM Command Structure.....	16










---

---

## WELCOME TO RESEM

RESEM, the Retrofit Energy Savings Estimation Model, is a PC-based tool that will allow Department of Energy (DOE) Institutional Conservation Program (ICP) staff and participants to reliably determine the energy savings directly caused by ICP-supported retrofit measures implemented in a building. RESEM incorporates several innovative techniques into an interactive tool designed to ease completion of this demanding analytical task. For maximum accuracy and validity, energy savings are calculated directly from actual utility data, with sophisticated corrections for weather and use variations between the pre-retrofit and post-retrofit utility data collection periods. Important features and capabilities of RESEM are briefly described below:

-  **PC Based:** RESEM is a self-contained software package that has been designed to run on any IBM-PC or 100% compatible with 640 Kbytes of RAM. RESEM executes fast enough that the session time for an interactive analysis consists primarily of the time to collect, organize, and input data. RESEM contains, or automatically accesses, all supporting information necessary for the analysis, such as weather data and engineering defaults.
-  **Interactive, User-Friendly Interface:** The RESEM interface has been designed to lead the unfamiliar user through the entire energy savings analysis process, while allowing the experienced user substantial freedom in accessing its full analysis capabilities. RESEM uses pull-down menus and pop-up data entry screens and dialog boxes. Descriptive hint lines and allowable choice lists appear on-screen to guide the user. Default values are automatically entered into most data fields prior to display for editing.
-  **Flexible Input Requirements:** RESEM can develop savings estimates from as little as the year of construction, total floor area, building type, utility data for both pre- and post-retrofit periods, and a description of the retrofit modifications. A default building generator creates a complete pre-retrofit description that includes all details of building geometry, envelope constructions, HVAC equipment, lighting, and usage schedules. RESEM also allows the user access to data screens that provide a detailed description of any or all of these aspects of the building where details are necessary for the most accurate savings estimates.
-  **Push-Button ECMs:** Many of the specific retrofit types recognized by the ICP program are direct menu selections that lead the user to minimal input screens and then automatically make the required building description modifications. For more unique or complex ECMs, the user can access detailed input screens containing all building description parameters. RESEM also allows additional non-ECM modifications to be described which may affect post-retrofit utility data.
-  **Comprehensive Outputs:** RESEM user-selectable reports include verification summaries of all inputs, analysis results including pre- and post-retrofit energy use broken out by fuel type and end-use, and retrofit energy savings estimates.

## EXECUTIVE SUMMARY

In order to improve the quality of aggregate energy savings estimates, a building-specific Retrofit Energy Savings Estimation Model (RESEM) has been developed by the Lawrence Berkeley Laboratory for the DOE Institutional Conservation Program (ICP). RESEM is a user-friendly tool which will allow ICP staff to reliably determine the energy savings directly caused by ICP-supported retrofit measures implemented in a building. For maximum accuracy and validity, energy savings are calculated from a combination of computer simulation and actual utility data. This tool has the technical capabilities to describe, simulate, and evaluate detailed building energy usage and savings for a variety of non-residential building types.

The RESEM interface has been designed to lead the unfamiliar user through the entire energy savings analysis process. However, RESEM allows the experienced user substantial freedom in accessing the simulation powers of this tool. RESEM runs on any IBM-PC or 100% compatible with 640 Kbytes of RAM. The program is written in Microsoft C and executes in conjunction with RAM-resident screen handling utilities.

Considerable development effort has been invested in the RESEM interface. Although text-based, RESEM uses pull-down menus and pop-up data entry screens and dialog boxes. These features assist the user in visually maintaining the context of detailed work within the overall savings analysis sequence. Descriptive hint lines appear onscreen to guide the user in selecting menu options and entering technical data. Default values are automatically entered into most data fields prior to display for editing. Pop-up windows dynamically list allowable choices for appropriate data fields.

Energy savings analysis begins with the development of a base (pre-retrofit) building description. RESEM will automatically generate a complete building description for primary, secondary, and university schools, and for hospitals. For these building types, the only required user input consists of: a building name, year of construction, total floor area, and building type. The complete building description is generated from this minimal input by applying a built-in set of production rules, for the given building type, to a modifiable external library of standard building elements. The generated building description includes all details regarding building geometry, envelope construction elements, HVAC system, lighting, equipment, occupancy, and usage schedules. All aspects of this building description can be accessed for review and modification. This building description will be used to perform an energy simulation of the pre-retrofit building.

RESEM is complex and sophisticated enough in its energy modeling to explicitly reflect the influence of a wide range of design, operation, and weather parameters. Energy simulation algorithms are based on the ASHRAE modified bin method, modified to use monthly bins and to simulate complete HVAC systems and plant equipment performance at each bin condition. Although based on existing public domain methods, all code has been designed and rewritten to provide maximum speed consistent with required accuracy. A twelve month simulation of a five thermal zone building takes less than 45 seconds on an IBM-PC/XT with an 8087 math coprocessor. The same simulation takes less than 5 seconds on an 80386 based machine. This extremely fast simulation engine encourages multiple iterations exploring the energy use consequences of modifications to the building description. A completed simulation can display building energy consumption for each fuel type and end use.

The next stage of the analysis sequence involves modifying the base building description so that its simulated energy use matches actual utility data collected for the building. RESEM allows the user to enter utility data for arbitrary consumption periods for each fuel type used in the building. An energy simulation is then performed using bin data (processed from NOAA weather data) for the time period(s) corresponding to the utility data. RESEM uses a unique approach for automatically modifying the building description to match the entered utility data. To perform RESEM's automatic reconciliation the user need only identify the "type" of modification desired. This means selecting from a list of 25 key building parameters to include in the automatic reconciliation process. Once the

---

parameters of interest have been selected, RESEM will determine the optimum amount of modification for each parameter and automatically make this modification.

Following reconciliation of the base building, the next stage of the analysis sequence involves describing the energy conservation retrofits which have been implemented in the base building. For many of the specific types of retrofits recognized in the ICP program (e.g., replacing the heating plant burner), RESEM menu options will lead the user to minimal input screens and then automatically make the required building description modifications. For more unique or complex retrofit measures, the user can access detailed input screens containing all building description parameters. RESEM also allows additional modifications to be described which may affect post-retrofit utility data, but which should not be considered in the calculation of energy savings. All post-retrofit modifications are then adjusted in a manner similar to the base building reconciliation so that the post-retrofit building simulation matches user entered post-retrofit utility data.

Based on all the above information, RESEM then calculates energy savings using monthly ratios between simulated performance for the utility data time periods and for long-term average weather. This approach bases savings estimates directly on the metered utility data. Savings estimates are reported for the overall retrofit building as well as the implemented ECM modifications in both natural units (e.g., kilowatt-hours) and in energy use index units of BTUs per square foot per year.

## HOW TO USE THIS MANUAL

This manual contains all written material pertinent to the RESEM software program. If you are new to RESEM, the following approach is recommended: review the Manual “Table of Contents”, read the “Welcome to RESEM” and “Executive Summary” items, read and perform the “Installing RESEM on Your Hard Disk” and “Starting RESEM” instructions, read the “Keystroke Summary” and “A Quick Tour of the Energy Savings Analysis Sequence” items, work through the step-by-step hands-on “An Example Tutorial” at the end of this manual, read “Gathering Information for Input”, and finally, perform your own project analysis while referring to “Energy Savings Analysis Topics” and “Reference Tables” as appropriate.

<b>For information on</b>	<b>See</b>
Reviewing the organization of this manual	<ul style="list-style-type: none"> <li>✍ Manual Table of Contents</li> <li>✍ Manual List of Tables</li> <li>✍ Individual Section Tables of Contents</li> </ul>
Installing and starting RESEM	Getting Started <ul style="list-style-type: none"> <li>✍ Installing RESEM on your Hard Disk</li> <li>✍ Starting RESEM</li> </ul>
Familiarizing yourself with the operation of RESEM	Getting Started <ul style="list-style-type: none"> <li>✍ Keystroke Summary</li> </ul> RESEM Command Summary <ul style="list-style-type: none"> <li>✍ RESEM Command Structure</li> </ul>
Familiarizing yourself with the energy savings analysis procedure	Getting Started <ul style="list-style-type: none"> <li>✍ A Quick Tour of the Energy Savings Analysis Sequence</li> </ul>
Learning the overall operation of RESEM in performing an energy savings analysis	<ul style="list-style-type: none"> <li>✍ An Example Tutorial</li> </ul>
Studying details related to RESEM commands	RESEM Command Summary <ul style="list-style-type: none"> <li>✍ Command Descriptions</li> </ul>
Learning how to begin your own project analysis	Energy Savings Analysis Topics <ul style="list-style-type: none"> <li>✍ Gathering Information for Input</li> </ul>
Learning technical details of important savings analysis issues	<ul style="list-style-type: none"> <li>✍ Energy Savings Analysis Topics</li> <li>✍ Reference Tables</li> </ul>

---

---

# GETTING STARTED

## Section Table of Contents

---

Section Overview.....	6
What is in this section? .....	6
Where is other pertinent information in this manual? .....	6
Installing RESEM on Your Hard Disk .....	6
The RESEM Software Package .....	6
System Requirements.....	6
Program Installation.....	7
Weather Data Installation .....	8
Starting RESEM .....	8
Removing RAM Resident Software .....	8
To Start RESEM .....	9
Retrieving Your Non-RESEM System Configuration.....	9
Keystroke Summary.....	10
A Quick Tour of the Energy Savings Analysis Sequence .....	11
Defining fundamental project and building information .....	11
Performing analysis of the base building description.....	11
Entering retrofit modifications made to the base building .....	12
Performing analysis for the post-retrofit building description .....	12
Performing energy savings estimation calculations.....	13
Saving an archival project file .....	13
Creating output report files.....	13

## Section Overview

---

### What is in this section?

This section of the RESEM manual contains instructions on installing RESEM from the distribution diskette(s) onto your hard disk. This is a required procedure since RESEM will not run from the distribution diskettes. Instructions are also included for properly configuring your computer system and starting execution of RESEM once it has been installed. Information on keystrokes which are used to operate within the RESEM program are in this section. Finally, a “quick tour” of the sequence of activities required for an energy savings analysis procedure is included to give you an overview of the entire process for which RESEM was designed.

### Where is other pertinent information in this manual?

For more details regarding the energy savings analysis process, see the topic of interest in the Energy Savings Analysis Topics section. For more information on the selection and execution of individual commands within the RESEM program, see the Command Summary section. For a hands-on exercise which takes you through the entire Retrofit Energy Savings Estimation Model procedure, see the Example Tutorial section.

## Installing RESEM on Your Hard Disk

---

### The RESEM Software Package

The RESEM software package consists of this manual, one RESEM program distribution diskette, and one or more RESEM weather data distribution diskettes. All files stored on distribution diskettes have been compressed to save disk space and ease installation of these files onto your hard disk. RESEM will not execute directly from the distribution diskettes; you must first install RESEM on your hard disk as described below.

The following files are contained in the compressed file named *INSTALL.EXE* located on the program distribution diskette. These files will consume approximately 1.1 megabytes of hard disk space.

1. *RESEMvvv.EXE* RESEM main program file (vvv indicates the version)
2. *RESEM.BAT* RESEM startup batch file
3. *PSRTLIB.EXE* Screen management runtime library
4. *SCRNSvvv.PS* RESEM screens database (vvv indicates the version)
5. *DEFAULT.LIB* RESEM default library components file
6. *AUTOEXEC.RES* Simple system startup file (see below)
7. *CONFIG.RES* Simple system configuration file (see below)
8. *DEMO.RSM* Example project archive file
9. *DEMO.IN* Example library and building input file
10. *MINNEAPO.\** Weather files for use with the RESEM Tutorial
11. *WXDUMMY.RXX* Empty files used to create subdirectories for each state

### System Requirements

The RESEM software package will run on any of the IBM-PC family of computers or 100% compatibles running the PC-DOS (or MS-DOS) operating system. The computer system must have 640 kilobytes of Random Access Memory (RAM).

RESEM uses special RAM-resident screen management software. No other RAM-resident software should be loaded into the system when RESEM will be executed (see below).

A hard (fixed) disk is required. The installation program contained on the RESEM Program Disk will automatically create a subdirectory structure on your hard disk and copy all necessary files

into it. RESEM will not execute directly from the distribution floppy diskettes. RESEM Version 1.0 requires approximately 1 megabyte of space on your hard disk. Weather data for sites in addition to the tutorial site (Minneapolis, MN) will require additional space.

A math coprocessor is highly recommended although RESEM will execute without one installed. Simulation calculations are approximately 50 times slower without a coprocessor.

RESEM supports both monochrome and color monitors in text-based mode. Most standard monitor modes are supported including: MDA, Hercules, CGA, EGA, and VGA.

A printer is required only if printed copies of RESEM reports are desired.

### Program Installation

As described above, all program files which are required for execution of RESEM are contained in compressed form on the distribution program diskette in a single file named *INSTALL.EXE*. These files must be installed on a hard disk in your computer. The uncompressed program files and tutorial weather data will use approximately 1 megabyte of hard disk space. To install RESEM on your hard disk, execute a command of the following general form.

```
s:install -d d:\path\
```

Where: *s:* represents the source drive in which the program disk is inserted

*d:* represents the destination drive on which you wish to install RESEM

*\path\* represents the destination path where RESEM program files will reside (you must include the backslash at the beginning and end of this path)

The following example command assumes that you have inserted the RESEM program distribution diskette into your A: floppy disk drive and that you wish to install RESEM on your C: hard disk within the C:\RESEM subdirectory. You may enter this command at any DOS prompt.

```
A:install -d C:\RESEM\
```

### Weather Data Installation

Weather data are required by RESEM for the simulation of the energy consumption of your building. Both long term average weather data and actual weather data for each year of pre and post retrofit analyses are required. Weather data which have been specially formatted for RESEM are currently available for approximately 200 locations within the United States. Actual year weather data are currently available for these locations for the years 1981 through 1990 and will become available for later years as new original weather data are collected and processed. Contact the source of your RESEM program distribution package for details on acquiring RESEM weather data for a location of interest to you.

Each weather data distribution diskette contains one or more compressed files. Each compressed file in turn contains one or more RESEM formatted weather data files which are either long term weather data based on Typical Meteorological Year (TMY) data or actual weather data for a specific year based on National Oceanic and Atmospheric Administration (NOAA) TD-3280 Surface Airways Hourly data. Each weather data filename begins with 1 to 8 characters indicating the location of the weather data collection site (e.g., *MINNEAPO* for Minneapolis, MN). Each of these filenames end with a 3 character extension indicating the type of data, either *.RMY* for RESEM long term data or *.Rnn* for RESEM actual year data where *nn* indicates the year (e.g., *R81* for the year 1981). Each weather distribution filename is indicative of the weather files which are compressed within it.



RESEM weather data files must be extracted (uncompressed) and transferred to the proper subdirectory on the hard disk in your computer. Each long term weather data file uses approximately 20 kilobytes of disk space and each year of actual weather data uses approximately 15 kilobytes. Instructions for installing RESEM weather data on your hard disk accompany each weather data distribution diskette.

## Starting RESEM

---

### Removing RAM Resident Software

RESEM's use of special RAM-resident screen management software, in combination with the need for maximum available memory, requires that no other RAM-resident software be loaded into your computer during RESEM execution. Examples of RAM-resident software include: utilities such as DOS interface shells, system device drivers such as mouse or graphics printer drivers, and network support software.

Experienced computer users may want to fine-tune their system configuration for running RESEM. In most instances, however, the optimal configuration for RESEM is a simple one. System configuration is normally established when the computer is first turned on and the operating system (DOS) is loaded. Two files which reside in your main (root) directory on your hard disk are automatically accessed during startup and define your system configuration. These two files are named *autoexec.bat* and *config.sys*. The RESEM installation procedure copies two files, named *autoexec.res* and *config.res*, to the RESEM subdirectory. If you are having difficulty running RESEM under your standard system configuration, these two files can be used to temporarily replace your standard startup files. Using these two files, which are customized for RESEM, is the easiest way to avoid conflicts with RAM-resident software and assure maximum available memory during execution of RESEM.

The following instructions are a procedure for temporarily replacing your existing system configuration files with the custom RESEM files. Instruction number 2 makes backup copies of your existing configuration files so that you can retrieve them for non-RESEM use of your computer. If you do not currently have versions of the *autoexec.bat* and *config.sys* files on your disk, then you can skip this step. These instructions assume that RESEM has already been installed on your hard disk. It is also assumed that this hard disk is drive *C* and that the RESEM subdirectory is named *C:\RESEM*. If you have installed RESEM on a different drive or in a different subdirectory, substitute your drive and subdirectory where indicated.

1. Move to the main (root) directory of your hard disk. Assuming your hard disk is the *C* drive, this is accomplished by entering the following DOS command:  

```
cd C:\
```
2. Make backup copies of your system configuration files (if they exist):  

```
copy autoexec.bat autoexec.bak  
copy config.sys config.bak
```
3. Copy (and rename) the RESEM configuration files to your main directory:  

```
copy C:\RESEM\autoexec.res C:\autoexec.bat  
copy C:\RESEM\config.res C:\config.sys
```
4. Reboot your computer by holding down the *Ctrl* and *Alt* keys and pressing the *Del* key.

### To Start RESEM

1. Move to the RESEM subdirectory.

2. Type *resem* to begin executing the RESEM program.
3. Press any key to remove the copyright screen which initially appears and replace it with the RESEM main menu.

### **Retrieving Your Non-RESEM System Configuration**

If you followed the procedure above for removing RAM resident software, you can return to your original system configuration by taking the following steps.

1. Move to the main (root) directory of your hard disk. Assuming your hard disk is the *C* drive, this is accomplished by entering the following DOS command:  
*cd C:\*
2. Retrieve your original versions of the *autoexec.bat* and *config.sys* files:  
*copy autoexec.bak autoexec.bat*  
*copy config.bak config.sys*
3. Reboot your computer by holding down the *Ctrl* and *Alt* keys and pressing the *Del* key.

## Keystroke Summary

RESEM is a menu driven software package. Pop-down menus offer program task options which, in general, provide access to specific operations such as displaying data entry/viewing screens, performing building analysis steps, and loading/saving datafiles. Certain keystroke conventions are used consistently throughout the RESEM interface.

Menu options may be selected in either of two ways. The keyboard arrow keys may be used to highlight a desired command. A hint line near the bottom of the screen suggests the action which will be taken if the highlighted option is selected. Pressing the ENTER (or RETURN) key will select the highlighted option. Alternatively, most menus display a bold uppercase letter somewhere within each option which may be pressed to select that option without first highlighting it. The user selects his or her path downward through the menu hierarchy in either manner until the desired task is reached. At any point along this downward path, the user may move backward one level by pressing the ESCAPE key. Upon escaping to a previous menu, the option highlighted is automatically reset to the first option in that menu. Menus which have too many options to fit in their display window are automatically scrolled when the highlighted menu bar selected by using the up/down arrow keys bumps against the top or bottom of the menu window.

Options which display static screens for viewing only, may be escaped from by pressing any key. Options which display dynamic screens for data entry/viewing provide the additional means of maneuvering shown in Table A-1.

<b>Table A-1: Data Entry Screen Edit Keys</b>	
<b>Keystroke</b>	<b>Action</b>
Up arrow	Move to the previous field in sequence
Down arrow	Move to the next field in sequence
Left arrow	Move the cursor one space to the left if possible
Right arrow	Move the cursor one space to the right if possible
Home	Move the cursor to the beginning of the field
End	Move the cursor to the end of the data in the field
Del	Delete the character at the cursor
Backspace	Move the cursor to the left and delete character
Enter	Move to the next field in sequence
Ins	Toggle between insert and replace mode
Ctrl-C	Clear the data from the cursor to the end of the field
Ctrl-U	Restore the previous data value to the field
Ctrl-W	Clear the data and move the cursor to the beginning of the field
Esc	Abort data entry and discard all changes to data fields
F10	Exit data screen and save all data as it is currently displayed

Certain data entry screens (e.g., the detailed screen for building thermal zones) are a hybrid of both data entry fields and menu options. Due to the complexity of these screens, slightly different maneuvering is required. To select menu options on this type of screen, the up/down arrow keys must be used to first highlight the arrow symbol (">") to the left of the desired option. That option may then be selected by pressing the ENTER (or RETURN) key. There are no single character selectors for these menu options.

---

## A Quick Tour of the Energy Savings Analysis Sequence

---

The overall analysis sequence necessary to reliably determine retrofit energy savings from measured utility data is conceptually complicated, whether done manually, or aided by an automated tool such as RESEM. The overall structure of the RESEM menus has been arranged to aid the user in following this sequence, generally moving from left to right across the main menu on the primary RESEM “background” screen, and down through each of the associated pop-down submenus in turn.

An example RESEM analysis sequence is listed below for a quick overview of the retrofit energy savings estimation process. This sequence is divided into several distinct parts for increased clarity. This sequence represents the minimum steps required for a complete RESEM analysis of energy savings. For detailed descriptions of these and additional operations which may be required for more complex analyses, see the command summary section of this document.

This sequence order is important for this version of RESEM since the capability to “back up and redo” parts of the analysis sequence is restricted.

### **Defining fundamental project and building information**

1. Select: **Project** from the Main Menu (Project Menu expands)
2. Select: **Project** information from the Project Menu - fill in and save (F10) summary information screen
3. Select: **Fuel types** from the Project Menu - identify end uses of all fuels used in the base building
4. Select: **Weather** location from the Project Menu - select appropriate climate location from submenu that appears

### **Performing analysis of the base building description**

1. Return to the Main Menu.
2. Select: **Base** analysis from the Main Menu (Base Analysis Menu expands)
3. Select: **Create** base building from the Base Analysis Menu (Create Base Building Submenu appears)
4. Select: **Generate** default building from the Create Base Building Submenu (default base building description is automatically defined)
5. Return to the Base Analysis Menu
6. Select: **Enter** base utility data from the Base Analysis Menu (Fuel Type Submenu appears)
7. Select: **Electricity** from the Fuel Type Submenu - enter electricity utility data for the base (pre-retrofit) period and save (F10) the electricity utility data screen
8. Select: **additional fuel types** used in the base building from the Fuel Type Submenu - enter and save utility data for each fuel type for the base (pre-retrofit) period
9. Return to the Base Analysis Menu
10. Select: **Reconcile** building from the Base Analysis Menu - use the "Reconciliation Parameter Selection Guidelines" included in this documentation

(Appendix A), to determine appropriate reconciliation modifications to the base building description.

11. Select: complete **Base** analysis from the Base Analysis Menu when you are satisfied with the match between RESEM simulation results and your entered utility data.

### **Entering retrofit modifications made to the base building**

1. Return to the Main Menu.
2. Select: **Retrofit** (Retrofit Menu expands)
3. Select: **Ecm** descriptions from the Retrofit Menu - Expand appropriate ECM choice submenus until final ECM selection has been made. Respond to any inquiry screens as necessary. Repeat to define as many ECMs as desired.
4. Select: save ecm **Retrofits** from the Retrofit Menu (a copy of the base building with ECM modifications is automatically made in RAM)
5. Select: **Non-ecm** modifications from the Retrofit Menu - Expand appropriate non-ECM choice submenus until final selection has been made. Respond to any inquiry screens as necessary. Repeat to define as many non-ECM modifications as desired.
6. Select: **Complete retrofit** from the Retrofit Menu .

### **Performing analysis for the post-retrofit building description**

1. Return to the Main Menu.
2. Select: post **Analysis** from the Main Menu (Post Analysis Menu expands)
3. Select: **Enter post utility data** from the Post Analysis Menu (Fuel Type Submenu appears)
4. Select: **Electricity** - enter and save electricity utility data for the post-retrofit period
5. Select: additional fuel types used in the post-retrofit building - enter and save utility data for the post-retrofit period
6. Select: **Adjust retrofit** from the Post Analysis Menu - use the "Reconciliation Parameter Selection Guidelines" included in this documentation (Appendix A), together with knowledge of the previously defined ECM and non-ECM retrofits to determine appropriate adjustments to the post-retrofit building description.
7. Select: complete **Post** analysis from the Post Analysis Menu to indicate that you are satisfied with the match between RESEM simulation results and the utility data entered for the post retrofit period.

### **Performing energy savings estimation calculations**

1. Return to the Main Menu.
2. Select: **Savings** from the Main Menu (final calculations are performed and a data viewing screen is displayed showing ECM savings)

**Saving an archival project file**

1. Return to the Main Menu.
2. Select: **F**ile from the Main Menu (File Menu expands).
3. Select: **S**ave project from the File Menu.
4. Select your desired project file name. The saved file will have *.rsm* appended to this name. Note that this file is decidedly different from a project report file.

**Creating output report files**

1. Return to the Main Menu.
2. Select: **F**ile from the Main Menu (File Menu expands)
3. Select: **R**eports from the File Menu - select desired report type, repeat as necessary for all report types and for each building description as desired.

---

---

# COMMAND SUMMARY

## Section Table of Contents

---

Section Overview.....	15
What is in this section? .....	15
Where is other pertinent information in this manual? .....	15
RESEM Command Structure.....	16
Command Descriptions.....	17
Project.....	17
Base analysis.....	19
Retrofit.....	22
post Analysis.....	23
Savings.....	25
File.....	25
Misc.....	27

---

## Section Overview

---

### **What is in this section?**

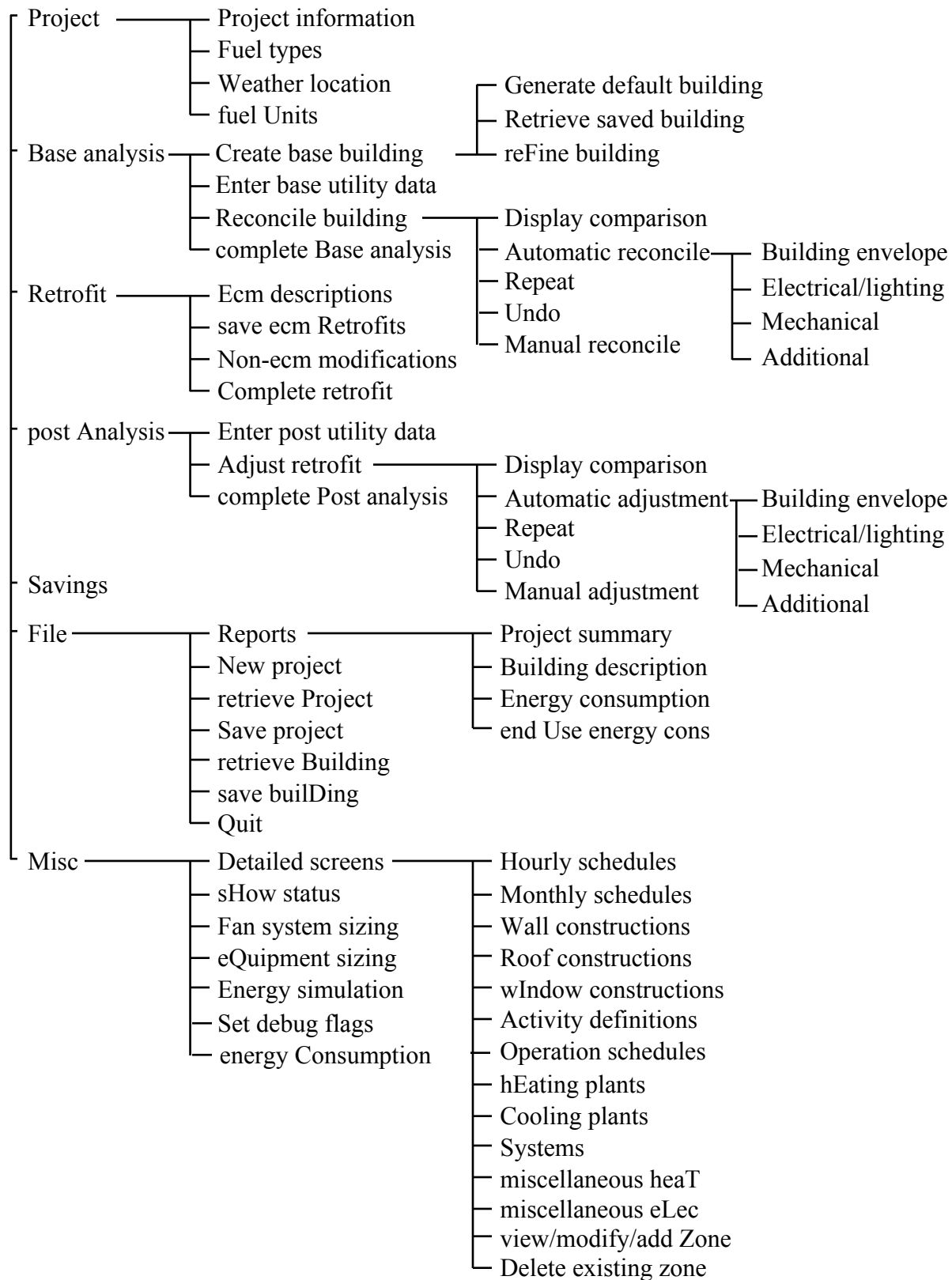
This section of the RESEM manual contains a tree diagram showing the RESEM command structure beginning at the Main Menu. Detailed descriptions of each command accessible through the top menu levels of RESEM are provided. These descriptions include the purpose and the results of performing each command. These descriptions are provided for reference to details regarding individual commands and are not intended to lead you through the energy savings analysis process.

### **Where is other pertinent information in this manual?**

For an overview of the retrofit energy savings estimation process, see “A Quick Tour of the Energy Savings Analysis Sequence.” For information on how to operate within the RESEM command structure, see the “Keystroke Summary” portion of the “Getting Started” section. For additional information on the “why’s, when’s, and how’s” of the savings analysis process, see the “Energy Savings Analysis Topics” section.



## RESEM Command Structure



---

## Command Descriptions

---

This section provides a summary of all the “major” commands accessible through the top menu levels of the RESEM desktop. Most of these commands have additional subbranches or screens that become accessible upon selection, and which are generally self-explanatory. A menu command may be selected by either of two methods. The keyboard arrow keys may be used to highlight the desired command. Pressing the ENTER (or RETURN) key will select the highlighted command. Alternatively, the bold uppercase letter within each command may be pressed to select without first highlighting. In general, each menu command and data field on every screen has an associated hint line that appears at the bottom of the screen when the command or field is selected.

### **Project**

Commands in this menu provide access to fundamental inputs which define a project. The term *project* is used in this documentation to refer to *all* data related to an energy savings estimation process. This data includes a comprehensive collection of information regarding: descriptions of physical building components, utility bills, weather data, energy use simulation calculations, and energy savings calculations. The term *building description* is used in this documentation to refer to a complete set of parameters which define one or more physical buildings in sufficient detail to perform a computer simulation of their energy use. RESEM energy calculations are performed for individual portions of a building which may be uniformly characterized by parameters such as occupancy levels, scheduled use, lighting levels, thermostat settings, and construction materials. These uniform portions of a building are referred to as *zones*. Since a RESEM simulation is based on the concept of thermal zones instead of buildings, a single *building description* may, in theory, describe more than one physical building. This provides the flexibility of including more than one building in a project analysis. There are three distinct versions of building descriptions which are included in a completed project savings estimation analysis. A **base** or pre-retrofit description version of the project building(s), defines zones as they existed prior to energy conservation measure (ECM) or other modifications. This **base** version will be reconciled with utility data entered for the pre-retrofit period. This reconciled description version is used as the basis for determining ECM savings. An **ecm** building description version defines zones as they would exist with only those modifications made which are related to ECMs. Finally, a **post**-retrofit description version defines zones with all ECM modifications *and* any non-ECM modifications which may have been entered.

#### **Project information**

This command accesses a data entry screen which collects the basic project information necessary to “label” a RESEM analysis so that the project can be identified. This screen must be completed first. Not all data is required, but all known data should be entered. Required fields include the following: building name, state, initial construction year, floor area, building type, and building function. The building name will be used to generate filenames for reports and other files which may be saved to disk. For this reason, it is recommended that the first 5 characters of the “Building Name” field be unique for each project for which a RESEM analysis is performed. The two character state field will be used to restrict the list of possible weather locations. All basic building information and building type data fields are used as clues to define default base building description parameters. The more accurately these values represent the actual base building, the more closely the automatically generated base building description will match reality. See the generate default building command below for more details.

Data from this screen is saved (i.e. recorded internally in RAM) by pressing the F10 function key. All data will be saved as it currently appears on the data screen. To exit this screen without saving the data, press the Escape key. This screen

may be displayed at any later point for viewing the project information. However, once the default base building description has been generated, changes to this screen will *not* be reflected in the base building description.

### ***Fuel types***

This command displays a submenu containing all possible types of fuel with which RESEM is capable of dealing. The Yes/No field next to each fuel type name reflects whether or not the fuel is used in the project. Selecting an individual fuel type displays a submenu containing all possible end uses for this fuel. The Yes/No field next to each end use name reflects whether or not the selected fuel is used for this purpose. Selecting a particular end use will toggle between Yes and No. For example, to change *space Cooling* from a No to a Yes, simply select this menu option either by highlighting it and pressing RETURN, or by pressing the uppercase C. To switch back from Yes to No simply select this menu option again.

All known end uses for all fuel types used in the base (pre-retrofit) building of a project should be entered by the user. This information is used as clues during the generation of a default building description. In particular, the presence of an air conditioning system in the building is determined from a Yes for the end use of space cooling. Electricity is assumed to be used for all projects. Consequently, upon first selecting this command, *Electricity* will have a Yes alongside. The user should still, however, correctly identify all end uses of electricity within the base building of the project.

The user may return to these submenus at any point during analysis to view the currently defined end uses for all fuel types. Additional fuel type end uses which may be associated with retrofit modifications made to the original base building will be reflected upon return. However, once the default base building description has been generated, changes to this screen will not be reflected in the base building description.

The two most important end uses to correctly identify are space heating and space cooling (if applicable).

### ***Weather location***

This command allows the user to select a RESEM weather location. A submenu is displayed which lists all available weather locations within the state which was entered on the project information screen. A limit of 25 locations can be listed on this submenu. The submenu can be scrolled to access locations which may not be visible on the screen. Long term weather data for the selected location will be loaded from the disk following this selection. To access locations in a different state, return to the project information screen, change to the desired state, save this screen, and reselect the *Weather location* command. Only one weather location can be used during a RESEM analysis.

### ***fuel Units***

This command allows the user to select from a variety of units of measurement for each fuel type used in the project. Upon selection of this command, a submenu is displayed showing all possible fuel types. Only those fuel types which have been indicated as being in use in the project can be accessed. The default units for each fuel type are displayed to the right of the fuel type name. To change the default units, select the desired fuel type. A submenu will be displayed showing all

---

possible units recognized by RESEM. Only those units appropriate for the selected fuel type will be accessible. Select the desired units from this submenu.

### **Base analysis**

Commands in this menu provide access to operations related to analysis of the base (pre-retrofit) building.

#### ***Create base building***

This command displays a submenu offering optional methods for creating a building description of the base building. This description can be generated from data entered on the project information screen. Alternatively, a building description which has been previously saved to disk may be retrieved. Subsequent to either action, the resulting building description can be refined (i.e. modified) to more accurately match reality. The following three commands discuss these operations, displayed in the submenu, in more detail.

#### ***Generate default building***

This command will create a complete description of a “default building” with characteristics typical of the class of buildings as determined from information entered on the project information screen, the fuel type submenus, and the selected weather location described above under the *Project* commands. A default library of building description components such as operation schedules and wall construction types will be retrieved from disk. Data entered on the project information screen will be used as clues in determining building parameters such as occupancy schedules, wall areas, and HVAC system types. Fuel type end uses entered on the fuel type submenus will be used as clues in determining building components such as heating and cooling plants. Automatic sizing of building system equipment will be performed for the selected weather location.

The default building description automatically generated by this process represents a best guess as to the detailed parameters which fully define a building for computer simulation. This description should not be taken as the last word. See the *refine building* command below.

#### ***Retrieve saved building***

This command offers an alternative method of creating the base building description. This command loads a complete library *and* building input description in “batch” format from the user specified input file which has been previously saved to disk. A submenu will be displayed listing all such input files currently stored on the disk. These files have a file extension of “.in”, and reside in the main C:\RESEM directory. See the example batch file “demo.in” for the structure of the batch library and building inputs. A limit of 25 files can be displayed on this submenu. Selections not visible onscreen may be accessed through scrolling. To retrieve a listed file, simply select the desired name from the submenu. This retrieved base building description may be modified using the *refine building* command below.

Additional input files of this format may be saved to disk using the *save builDing* command under the *File* menu described below.

#### ***reFine building***

This command allows access to detailed data screens containing all parameters for a building library and building description. This command may be used to view any and all detailed data for the base building. More importantly, this command may be used to modify any of this data. All known information regarding the base building (e.g. data contained in a TA report) should be carefully reviewed. Parameters for the current building description should be modified to match this known data. Further modifications may be made to the base building description later in the analysis process (see *Reconcile building* below). However, any known parameters which are unique to a particular project, such as fan and equipment capacities, should be entered at this point. Particular attention should be given to those parameters which will be affected by ECM retrofit modifications.

### ***Enter base utility data***

This command provides access to utility data entry screens. A submenu is displayed which lists all possible fuel types. Only those fuel types which have currently defined end uses are accessible. Upon selection, a screen appears for entering utility data for the selected fuel type. Data for up to 36 billing periods may be entered. From and To dates for each billing period may be entered to span any length of time. When all data appears onscreen as desired, the screen information must be saved by pressing F10.

Data should be entered for all fuel types used in the base building. Upon exit from the fuel type submenu, weather data will be automatically loaded which corresponds to the selected weather location and the time period spanned by all fuel type utility billing periods.

### ***Reconcile building***

This command accesses the submenus that are used to perform the simulation-utility data matching process known as “reconciliation.” The sub-menu commands are described below:

#### ***Display comparison***

This command displays a screen showing a comparison of simulation results, using the current base building description, and the utility data which has been entered for the entire billing period for each fuel type used in the building.

#### ***Automatic reconcile***

The automatic reconcile is one of RESEM's most powerful capabilities. It allows the user to simply and quickly make a set of directed modifications to the base building that will make the simulation match the utility data, and generally to end up with a base building description that is an accurate representation of the actual building that generated the utility bills. Use the “Reconciliation Parameter Selection Guidelines” included in this documentation (Appendix A), to determine appropriate base building description parameters for modification. The following submenus can then be expanded as shown to do the actual parameter selection. These submenus are structured according to the same general categories as the ECM selection submenus. After parameter selection, if the user confirms the reconciliation step, it is automatically performed and an updated comparison screen is

displayed. This screen shows the improvement in the match between the simulation results of the modified building description and the utility data. A summary list of the parameters that were selected and the amount each was modified is also displayed.

### ***Building envelope***

The building modification parameters accessible under this category are:

- window Area
- window U-value
- window Shading
- occ Infiltration
- uno iNfiltration
- Wall u-value
- Roof u-value

### ***Electrical/lighting***

The building modification parameters accessible under this category are:

- Lighting
- Electric

### ***Mechanical***

The building modification parameters accessible under this category are:

- chiller Cop
- chiller cAcapacity
- Supply min OA
- Fan supply cfm
- occ Heating tstat
- uno hEating tstat
- occ Cooling tstat
- uno coolIng tstat
- boiler effIciency
- boiler caPacity
- econo limit Temp
- hot Water/person

### ***Additional***

The building modification parameters accessible under this category are:

- Occupancy
- misc Sensible
- misc Electric
- misc Heat

### ***Repeat***

The reconciliation step described above may be performed any number of times, and should be repeated until the simulation-utility differences are

acceptably small (less than 0.25 percent) for all fuel types. The repeat command makes this iterative process possible with a single keystroke, and assumes that the previously selected modification parameters are to be used again. If a different parameter modification selection is desired, the user can accomplish this by going back to the "Automatic reconcile" and making a new set of parameter selections.

### **Undo**

This command will undo the *previous only* automatic reconciliation step.

### **Manual reconcile**

In special cases where the desired reconciliation modification is not describable using one of the 25 pre-defined parameters above, this menu selection will give the user access to the "Detailed screens" (described completely under the "Misc" menu below), so that any arbitrary modification can be described. This option may also be used to set a parameter at a specific desired value as opposed to the value determined by the automatic reconciliation step.

### ***complete Base analysis***

Selection of this command indicates that the user has completed the analysis of the base building description. This command should only be selected after the user is comfortable with the match between the base building simulation and utility data. When this command is selected, an energy simulation using long term weather data is performed for the base building description. The results of this simulation will be used as the basis for determining energy savings. This command may be repeated any number of times prior to moving on to the next stage in the project analysis (see the **Retrofit** command below).

Selection of this command also results in the initial creation of the ECM version of the building description. This ECM version will be subsequently modified to reflect those retrofit modifications which qualify for ECM grants. Note that returning to this step after retrofit modifications have been described using the commands below, has the effect of *undoing* all retrofit modifications.

## **Retrofit**

Commands in this menu provide access to operations related to describing modifications to the base (pre-retrofit) building. Separate commands allow description of ECM modifications and non-ECM modifications. Those modifications which constitute ECM descriptions are stored internally in the ECM version of the building description. Those modifications which constitute *both* ECM and non-ECM descriptions are stored in the POST version of the building description.

### ***Ecm descriptions***

This command accesses a hierarchical menu selector that allows quick descriptions of the Energy Conservation Measures that were installed to determine the ECM building description version. Submenus within this hierarchical selector structure are arranged according to GTS ECM categories. The user is prompted to enter pertinent data when a submenu path has been followed to the point where a specific ECM can be defined. Not all ECMs can be defined in this manner. For

---

complex or ambiguous ECMs, the user must resort to implementing the necessary modifications by accessing the detailed library and building data screens. Thus, several of the GTS ECM category submenu paths result in the display of these screens. The detailed screens for the ECM building description are also available under the **X: Detailed Screens** option in the first ECM submenu. Modifications which pertain only to ECM retrofit measures *must* either be entered here or into the ECM building description version accessible under the **Detailed screens** command located under the **Misc** main menu command. See the descriptions of these commands below for a discussion of these data screens.

### ***save ecm Retrofits***

This command indicates that all building modifications related to ECMs have been defined. The ECM building description version is saved internally for use in subsequent energy savings calculations, and the *post-retrofit* version of the building description is created as the next "active" version in which to describe non-ECM modifications. This **post** version will also be used for matching the energy simulation results with the post-retrofit utility data.

### ***Non-ecm modifications***

This command allows descriptions of additional modifications made to the base building, which are not within the category of Energy Conservation Measures. Selection of this command displays a submenu allowing access to the most commonly occurring non-ECM modifications. This includes numerous aspects of the way in which the building usage has changed as well as building additions which have been built since the base period utility data was collected. Detailed screens are also accessible under this submenu for directly modifying the **post** building description version.

### ***Complete retrofit***

This command indicates that all building modifications have been defined which changed the base building description since the base period utility data was collected. Selection of this command indicates that this phase of the RESEM analysis sequence is completed, and that the user is ready to proceed to the "post-retrofit" phase.

## ***post Analysis***

Commands in this menu provide access to operations related to analysis of the post-retrofit building, and are similar to the corresponding base-case analysis commands.

### ***Enter post utility data***

This command provides access to utility data entry screens. A submenu is displayed which lists all possible fuel types. Only those fuel types which have currently defined end uses are accessible. Upon selection, a screen appears for entering utility data for the selected fuel type. Data for up to 36 billing periods may be entered. From and To dates for each billing period may be entered to span any length of time. When all data appears onscreen as desired, the screen must be saved by pressing F10.

Data should be entered for all fuel types used in the post building. Upon exit from the fuel type submenu, weather data will be automatically loaded which corresponds to the selected weather location and the time period spanned by all fuel type utility billing periods.



***Adjust retrofit***

This menu selection gives access to a suite of commands that allow the user to adjust either the ECM or non-ECM descriptions in the post-retrofit building description in order to match the simulation results with the utility data. The fundamental matching mechanisms are the same as the ones used for the pre-retrofit reconciliation. Thus, the sub-menus and screens will appear quite similar. The sub-menu commands are described below:

***Display comparison***

This command displays a screen showing a comparison of simulation and utility data, for the entire billing period for which post-retrofit utility data has been entered for each fuel type used in the building.

***Automatic adjustment***

Use the "Reconciliation Parameter Selection Guidelines" included in this documentation, to determine appropriate base building description parameters for modification. Assuming that the base building parameters were correctly defined during base analysis reconciliation, only those parameters affected by ECM or non-ECM modifications should be included in this post-retrofit adjustment process. The following submenus can then be expanded as shown to do the actual parameter selection. For each parameter selected, the user is asked to specify whether the selected parameter is to be assumed to be related to an ECM or a NON-ECM change. These submenus are structured according to the same general categories as the ECM selection submenus. After parameter selection, if the user confirms the adjustment step, it is automatically performed and an updated comparison screen is displayed. This screen shows the improvement in the match between the simulation results of the modified building description and the utility data. A summary list of the parameters that were selected and the amount each was modified is also displayed.

***Building envelope***

The submenu choices for this category are the same as for pre-retrofit reconciliation.

***Electrical/lighting***

The submenu choices for this category are the same as for pre-retrofit reconciliation.

***Mechanical***

The submenu choices for this category are the same as for pre-retrofit reconciliation.

***Additional***

The submenu choices for this category are the same as for pre-retrofit reconciliation.

***Repeat***

This command performs the same operation as described for the pre-retrofit reconciliation.

***Undo***

This command performs the same operation as described for the pre-retrofit reconciliation.

### ***Manual adjustment***

Similar to the pre-retrofit reconciliation case, this menu selection will give the user access to the "Detailed screens" (described completely under the "Misc" menu below), so that any arbitrary modification can be described. One important difference occurs if the user needs to access these detailed screens to adjust an ECM-related modification. In this case, the user will first be presented with detailed screens for modifying the "post-retrofit" building description. After the user has completed modification of the "post-retrofit" building description, he or she will be presented with a *second* set of detailed screens and be asked to *repeat* the same modification description over again. This is necessary so that the "ECM" version of the building description can also be suitably modified. (Note: This repetition step is *not* necessary when *Automatic adjustment* is used.)

### ***complete Post analysis***

Selection of this command indicates that the user has completed the analysis of the post-retrofit building description. This command should only be selected after the user is comfortable with the match between the post-retrofit building simulation and utility data.

### ***Savings***

This main menu selection is the final step in the RESEM analysis sequence. Its selection causes several necessary energy simulations to be completed, and resulting long-term average annual energy savings to be calculated separately for each fuel type used in the building. Total savings are separated into ECM and non-ECM components. Results are displayed on screen, and can be saved to a file as one of the report choices described below.

### ***File***

This command accesses assorted disk file retrieve and save operations.

### ***Reports***

This command will display a reports submenu. The reports submenu provides the options for getting results from a RESEM analysis written to DOS files on disk so that they may be viewed or printed after a RESEM analysis has been completed. In some cases, data in a particular report will differ depending on the desired building version (base, ecm, or post) and weather type (long term average or actual monthly). If necessary, the desired version is queried from the user. Each individual report that is requested is written to a separate file in the RESEM directory on the disk. The individual report filenames are constructed from the "Building Name" field on the summary project information screen described earlier. This name is truncated, if necessary, to as few as 5 characters so that report filenames can be created which meet the 8 character maximum limit of DOS file naming conventions. For this reason, it is recommended that the first 5 characters of the "Building Name" field be unique for each project for which a RESEM analysis is performed. Appropriate filename extensions are appended to these first five characters for each report type, as described below.

### ***Project summary***

This report provides an overall summary of a completed RESEM savings analysis. The report includes information entered on the project information screen, a summary list of ECMs applied to the building, and calculated savings estimates in both user selected units and energy use index (EUI) units of Btus/ft<sup>2</sup>-year. The filename extension is “.prj”. **NOTE:** This report is decidedly different from the Project archive file saved to disk using the *Save project* menu option described below. Do not confuse these two project output files.

### ***Building description***

This report provides a complete labelled output of all building description parameters. The filename extension is “0.bld” for a base building description version, “1.bld” for a post-retrofit building description version, and “2.bld” for an ECM building description version. It is best to use compressed print mode when printing this report due to the length of some data lines. **NOTE:** This building description report differs from the building description input file described below under the *File* menu *save buildIng* option. Do not confuse this report which is formatted for visual review, with the input file which is formatted for retrieval.

### ***energy Consumption***

This report provides a formatted output listing the RESEM simulated building monthly energy consumption. The filename extension is of the form “\_bwegy” where the single digit *b* signifies the building version and takes on the values: 0=“base”, 1=“post”, and 2=“ecm”, and the single digit *w* signifies the type of weather data used in the simulation and takes on the values: 0=“long term”, and 1=“actual”. Thus, the filename extension “\_11.egy” indicates a post-retrofit building description version simulated using actual weather data. Note that since the ECM building version cannot be simulated using actual weather data, this combination is not available for reporting.

### ***end Use energy cons***

This report provides a formatted output giving detailed energy consumption for each month for each fuel type and each energy end use component. The filename extension is of the form “\_bw.eg2” where the single digits *b* and *w* are determined in the same way as for the energy consumption report above. Note that since the ECM building version cannot be simulated using actual weather data, this combination is not available for reporting.

It is best to use compressed print mode when printing this report due to the length of some data lines.

For further analysis of the data displayed in this report, or to generate graphs from this data, import the disk file into a spreadsheet package. See your spreadsheet documentation for details regarding importing text (ASCII) files.

### ***New project***

This command reinitializes all RESEM data storage structures and status indicators in RAM. It should *only* be used when a RESEM analysis sequence has been totally completed and reports written, and the user wants to start a new RESEM savings analysis for a different project in the same computer session.

***retrieve Project***

This command retrieves a previously saved project file. This project file contains all data which had been entered and/or generated during an analysis sequence at the point at which the project file was saved. This allows the user to return to a project analysis which was not fully completed during a prior session. This will also allow review of a previously completed project analysis.

***Save project***

This command allows the user to save a project file to disk. This project file contains all data which had been entered and/or generated during an analysis sequence up to the point at which the project file is saved. This allows the user to interrupt analysis at any point in the sequence and later return to this point by retrieving the saved project file. This command may also be used to archive a completed project analysis. **NOTE:** This archive file is decidedly different from the Project Summary Report file saved to disk using the *Project summary* menu option under the *Reports* submenu described above. Do not confuse these two project files.

***retrieve Building***

This command retrieves a complete library *and* building input description in “batch” format from the specified input file which has been previously saved to disk. The user may retrieve this data to create or replace any of the three building versions required for a RESEM analysis. The most common use of this command should be to begin a RESEM analysis by retrieving a base building description. In this case, use the **Retrieve saved building** command discussed under the **Base analysis** menu above. This previously discussed command has exactly the same action as retrieving a building for the base building version here.

A submenu will be displayed listing all such input files currently stored on the disk. These files have a file extension of “.in”. See the example batch file “*demo.in*” for the structure of the batch library and building inputs. A limit of 25 files can be displayed on this submenu. Selections not visible onscreen may be accessed through scrolling. To retrieve a listed file, simply select the desired name from the submenu.

***save buiDing***

This command saves the library and building description of the user specified version (base, post, or ecm) to an external file. The user is prompted to enter a 1 to 8 character filename which will have the extension “.in” automatically appended to it. This library and building description can be retrieved into RESEM with the previously described *retrieve buiDing* command. **NOTE:** This building input file differs from the building input report file which cannot be retrieved using the above command. Do not confuse the report (formatted for visual review) with this input file (formatted for retrieval).

**Quit**

This command will quit RESEM and return to DOS. The user will be queried to confirm this intention since all analysis data which has not been saved to disk will be lost. RESEM may also be terminated by pressing the Escape key when selecting from the Main Menu.

**Misc**

The commands in this menu are used to perform various miscellaneous tasks. These commands are generally meant to be used for RESEM program development and testing. They may

also be useful to those users wishing to experiment with the simulation capabilities of RESEM without proceeding through an entire analysis sequence.

### ***Detailed screens***

This command allows access to detailed data screens containing all parameters for the user specified building description. Selection of this command displays a submenu listing all library and building components. A preliminary submenu queries the user for the desired building version to access. The screens accessed through these submenu commands provide a means for getting at all aspects of the specified building description at the most exacting descriptive levels.

### ***Hourly schedules***

This command displays a submenu listing each hourly profile name contained in the library. At most, five hourly profile names are displayed in this submenu. Up to 25 hourly profiles can be contained in a library and may be accessed by using the keyboard arrow keys to scroll through the submenu. Selection of a specific hourly profile name from this submenu accesses a data entry screen for viewing or modifying the data for that hourly profile. Selection of a blank name entry from this submenu allows a new hourly profile to be added to the library. These library hourly profiles are subsequently referenced by name for inclusion in a particular component of a building description.

### ***Monthly schedules***

This command displays a submenu listing each monthly profile name contained in the library. At most, five monthly profile names are displayed in this submenu. Up to 25 monthly profiles can be contained in a library and may be accessed by using the keyboard arrow keys to scroll through the submenu. Selection of a specific monthly profile name from this submenu accesses a data entry screen for viewing or modifying the data for that monthly profile. Selection of a blank name entry from this submenu allows a new monthly profile to be added to the library. These library monthly profiles are subsequently referenced by name for inclusion in a particular component of a building description.

### ***Wall constructions***

This command displays a submenu listing each wall construction name contained in the library. At most, five wall construction names are displayed in this submenu. Up to 25 wall constructions can be contained in a library and may be accessed by using the keyboard arrow keys to scroll through the submenu. Selection of a specific wall construction name from this submenu accesses a data entry screen for viewing or modifying the data for that wall construction. Selection of a blank name entry from this submenu allows a new wall construction to be added to the library. These library wall constructions are subsequently referenced by name for inclusion in a building description.

### ***Roof constructions***

This command displays a submenu listing each roof construction name contained in the library. At most, five roof construction names are displayed in this submenu. Up to 25 roof constructions can be contained in a library

and may be accessed by using the keyboard arrow keys to scroll through the submenu. Selection of a specific roof construction name from this submenu accesses a data entry screen for viewing or modifying the data for that roof construction. Selection of a blank name entry from this submenu allows a new roof construction to be added to the library. These library roof constructions are subsequently referenced by name for inclusion in a building description.

#### ***w*indow constructions**

This command displays a submenu listing each window construction name contained in the library. At most, five window construction names are displayed in this submenu. Up to 25 window constructions can be contained in a library and may be accessed by using the keyboard arrow keys to scroll through the submenu. Selection of a specific window construction name from this submenu accesses a data entry screen for viewing or modifying the data for that window construction. Selection of a blank name entry from this submenu allows a new window construction to be added to the library. These library window constructions are subsequently referenced by name for inclusion in a building description.

#### ***A*ctivity definitions**

This command displays a submenu listing each activity definition name contained in the library. Activity elements contribute to utility demands and to space internal loads, such as occupancy, lighting, electrical and non-electrical equipment. At most, five activity definition names are displayed in this submenu. Up to 25 activity definitions can be contained in a library and may be accessed by using the keyboard arrow keys to scroll through the submenu. Selection of a specific activity definition name from this submenu accesses a data entry screen for viewing or modifying the data for that activity definition. Selection of a blank name entry from this submenu allows a new activity definition to be added to the library. Activity and use factor elements are subsequently referenced by name for inclusion in a building description. Activity attributes such as peak rates and variable hourly profiles can be defined for each library entry.

#### ***O*peration schedules**

This command assigns hourly profiles to the weekday, Saturday, and Sunday operation schedules for the HVAC equipment and fan systems for a building description version.

#### ***h*eating plants**

This command displays a submenu listing each heating plant name defined for a building version. As many heating plant names as will fit on the screen will be displayed in this submenu. Up to 25 heating plants can be contained in a building description and may be accessed by using the keyboard arrow keys to scroll through the submenu. Selection of a specific heating plant name from this submenu accesses a data entry screen for viewing or modifying the definition for that heating plant. Selection of a blank name entry from this submenu allows a new heating plant to be defined for a building version. Detailed plant equipment operating characteristics (capacities, efficiencies, auxiliary power requirements, etc.) can be viewed,

modified, or defined with this data entry screen. Note that with the exception of capacities, most of the other parameters are provided with reasonable engineering defaults.

### ***Cooling plants***

This command displays a submenu listing each cooling plant name defined for building version. As many cooling plant names as will fit on the screen will be displayed in this submenu. Up to 25 cooling plants can be contained in a building description and may be accessed by using the keyboard arrow keys to scroll through the submenu. Selection of a specific cooling plant name from this submenu accesses a data entry screen for viewing or modifying the definition for that cooling plant. Selection of a blank name entry from this submenu allows a new cooling plant to be defined for a building version. Detailed plant equipment operating characteristics (capacities, efficiencies, auxiliary power requirements, etc.) can be viewed, modified, or defined with this data entry screen. Note that with the exception of capacities, most of the other parameters are provided with reasonable engineering defaults.

### ***Systems***

This command displays a submenu listing each HVAC system name defined for a building version. As many HVAC system names as will fit on the screen will be displayed in this submenu. Up to 25 HVAC systems can be contained in a building description and may be accessed by using the keyboard arrow keys to scroll through the submenu. Selection of a specific HVAC system name from this submenu accesses a data entry screen for viewing or modifying the definition for that HVAC system. Selection of a blank name entry from this submenu allows a new HVAC system to be defined for a building version. Detailed HVAC system characteristics can be viewed, modified, or defined with this data entry screen. Note that most of the parameters are provided with reasonable engineering defaults.

### ***miscellaneous heaT***

This command displays a submenu listing each miscellaneous heating source name defined for a building version. As many miscellaneous heating source names as will fit on the screen will be displayed in this submenu. Up to 25 miscellaneous heating sources can be contained in a building description and may be accessed by using the keyboard arrow keys to scroll through the submenu. Selection of a specific miscellaneous heating source name from this submenu accesses a data entry screen for viewing or modifying the definition for that miscellaneous heating source. Selection of a blank name entry from this submenu allows a new miscellaneous heating source to be defined for a building version.

### ***miscellaneous eLec***

This command displays a submenu listing each miscellaneous electric source name defined for a building version. As many miscellaneous electric source names as will fit on the screen will be displayed in this submenu. Up to 25 miscellaneous electric sources can be contained in a building description and may be accessed by using the keyboard arrow keys to scroll through the submenu. Selection of a specific miscellaneous electric source name from

this submenu accesses a data entry screen for viewing or modifying the definition for that miscellaneous electric source. Selection of a blank name entry from this submenu allows a new miscellaneous electric source to be defined for a building version.

#### ***view/modify/add Zone***

This command displays a submenu listing each thermal zone name defined for a building version. As many thermal zone names as will fit on the screen will be displayed in this submenu. Up to 25 thermal zones can be contained in a building description and may be accessed by using the keyboard arrow keys to scroll through the submenu. Selection of a specific thermal zone name from this submenu accesses a data entry screen for viewing or modifying the definition for that thermal zone. Characteristics include floor area; thermostat settings; infiltration; specification of activity types; specification of types, areas, and orientations for all exterior walls, roofs, and windows; and specification of the HVAC and service HW systems that serve the zone. Selection of a blank name entry from this submenu allows a new thermal zone to be defined for a building version. The user is asked whether the definition of a new thermal zone should be initialized with a copy of a (selectable) previously defined zone.

Definitions for thermostat settings, infiltration rates, and activity, wall, roof, and window specifications each require passage through a further submenu. For each of these zone components, a submenu lists each previously defined component. Selection of a specific component from a submenu accesses a data entry screen for viewing or modifying the definition of that component. Any modifications to a component definition at this level *must* be saved by pressing the F10 function key. *NOTE: If any modifications are made to components at this lower level, then the zone screen **MUST ALSO BE TRANSMITTED** by pressing the F10 key to return to the detailed data screen submenu.*

#### ***Delete existing zone***

This command displays a submenu listing each thermal zone name defined for a building version. Selection of a specific thermal zone name from this submenu will delete that thermal zone from the building version description after making certain that this action is, in fact, the user's intent.

#### ***sHow status***

This command displays a screen showing the current status of a RESEM analysis sequence. Caution should be exercised about its accuracy if the user has had to “double back” and repeat earlier completed steps of the analysis sequence. At this time, the status screen should only be consulted if the user has adhered to the linear sequence of a RESEM analysis.

#### ***Fan system sizing***

This command performs automatic HVAC fan system cfm sizing calculations, based on peak zone loads determined from the building description and the weather extremes for a particular location. These sizes can be input manually if desired, in which case auto-sizing is not needed. Automatic fan system sizing can be done separately for each building description version if desired. However, the post-retrofit fan system cfm rates would normally be the same as the base building



description, unless they had explicitly been changed as part of an ECM, or some other retrofit system change. Therefore, unless a retrofit modification has altered the fan system *and* the new cfm rates are not known for manual input, then this sizing should only be performed for the base building description. Note that sizing is automatically performed if the user creates the base building description by generating a default building. *Note: Fan system sizing **cannot** be accomplished until a weather location has been selected through the Project summary screen (State) and the Weather location menu (city).*

### ***e*Equipment sizing**

This command is analogous to automatic fan system sizing, except for additional calculations of chiller and boiler capacities. Equipment autosizing can be done separately for each building description, with the same caution as for fan system autosizing of the post-retrofit configurations. Equipment sizing is automatically performed during generation of a default base building description. *Note: Equipment sizing **cannot** be accomplished until a weather location has been selected through the Project summary screen (State) and the Weather location menu (city), and the fan system has been properly sized, either manually or with the previous command.*

### **Energy simulation**

This command calculates the building annual energy consumption for the specified building description version (base, post, or ecm). This simulation may be performed using long term average weather data for any of the building versions. If actual weather data is to be used, it must first be loaded by entering utility data with a time period corresponding to the desired actual weather period for either the base or post-retrofit building. Actual weather data may not be used for simulation of an ecm building version. Following a simulation, results are displayed onscreen and may also be saved to disk using the report options described above.

Note that this command provides the flexibility to use RESEM as an energy simulation tool for predicting energy savings for various retrofit scenarios. First, establish an accurate base building description either from experience or by matching simulation results to available utility data. Second, use the Retrofit command options to describe a possible retrofit scenario. Finally, use this command option to perform long term average simulations to compare performance of the base building version with the appropriate ecm or post version.

### **Set debug flags**

This option provides access to on/off toggle switches for low level aids in debugging problems with RESEM. These so-called debug flags are primarily meant to be used by RESEM support personnel or experienced RESEM users. Version 1.00 of RESEM only allows access to a switch for setting program operation in “verbose” mode. This mode causes RESEM to display numerous low level feedback messages during program execution. The verbose switch is turned on by selecting the Set debug flags option and then selecting the Verbose option on the displayed submenu. This should turn the 0 (off) next to Verbose to a 1 (on). From this point on, RESEM will display messages related to its operation. To turn the Verbose switch back off, reselect the Set debug flags and Verbose menu options so that a switch setting of 0 is again shown.

### **energy Consumption**

This command will save a detailed energy consumption report to disk for a selected building version and weather type. This report is similar to the End Use Energy Consumption report with the additional breakdown of end use energy consumption for occupied and unoccupied periods of the day for each month. Filename creation for these reports follow the same derivation and for the End Use Energy Consumption reports, but with an extension of “egd”.

# ENERGY SAVINGS ANALYSIS TOPICS

## Section Table of Contents

Section Overview .....	34
What is in this section? .....	34
Where is other pertinent information in this manual? .....	34
Gathering Information for Input.....	34
Required Information for a Complete Analysis .....	35
Recommended Information.....	38
Data Input Checklist .....	43
The Prototypical Building Generator .....	44
What is a Prototypical Building Description?.....	44
Prototypical Defaults .....	45
Building Retrieval, an Alternative Approach.....	51
Refining a Building Description .....	52
The Detailed Building Description Data Screens.....	52
Library Components .....	53
Hourly Schedules.....	53
Monthly Schedules .....	53
Wall Constructions .....	54
Roof Constructions .....	54
Window Constructions .....	55
Activity Definitions .....	55
Building Components .....	58
HVAC Operation Schedules.....	58
Heating Plants.....	59
Cooling Plants.....	61
HVAC Systems.....	63
Miscellaneous Heat Sources .....	66
Miscellaneous Electric Sources .....	67
Thermal Zones .....	68
Thermostat.....	69
Infiltration.....	70
Activities .....	70
Walls.....	71
Roofs .....	72
Windows .....	73
Building Description Reconciliation.....	73
What is Reconciliation? .....	74
Performing Reconciliation .....	74
Limitations of Automatic Reconciliation .....	76
Describing Energy Conservation Measures (ECMs) .....	76
Push-Button ECMs .....	76
Detailed Screens ECMs .....	78
Describing Other (non-ECM) Post-Retrofit Changes .....	78
Retrofit Modification Adjustment.....	79
What is Retrofit Modification Adjustment?.....	79
Performing Retrofit Modification Adjustment.....	80
Limitations of Automatic Retrofit Modification Adjustment .....	81
Reports .....	81
Report Descriptions .....	81
Viewing Reports .....	82
Printing Reports .....	83

---

## Section Overview

---

### What is in this section?

This section of the RESEM Reference Manual contains detailed explanations of key topics within the Retrofit Energy Savings Estimation Model analysis process. These topics are organized in the order in which they would be encountered while working through an entire project analysis, beginning with collecting the data and information required for a RESEM analysis and ending with details on viewing and printing RESEM reports.

A great deal of information is contained in this section. Some of this information is meant to provide a conceptual understanding of critical portions of the analysis process. Other information is meant to make details related to important assumptions and calculation methods built in to the RESEM program explicit. Details regarding data entry screens and their individual input fields (parameters) are also included.

### Where is other pertinent information in this manual?

Details regarding specific RESEM commands are contained in the “Command Summary” section. An overview of the energy savings analysis process is presented in the “Executive Summary.” The overall sequence of steps involved in a savings analysis is described in “A Quick Tour of the Energy Savings Analysis Sequence.” The “Reference Tables” section contains tabular information and data related to many of the topics presented in this section.

## Gathering Information for Input

---

The most time-consuming task involved in completing a RESEM analysis is likely to be the gathering of information required for input to the program. The common source for this input data is the Technical Assistance Energy Audit (TA) and Grant Application collection of documents. This documentation is not organized into a standard format and both the quantity and quality of information presented varies from project to project. This section discusses the information which is either required or recommended for completing a RESEM analysis.

RESEM attempts to minimize the amount of data required for a complete analysis. This is accomplished by incorporating many default assumptions and data values into the program and its supporting library and weather data files. The accuracy of final energy savings estimates is therefore dependent on the accuracy of both the data the user inputs and the underlying defaults which RESEM uses. Subsequent sections of this reference manual describe RESEM prototypical defaults. You should familiarize yourself with these defaults so that you understand the assumptions which RESEM makes.

The user input information required for a *complete* RESEM analysis is not necessarily the same as the information required for an *accurate* RESEM analysis. Your best approach to attaining the latter is to begin by entering the former and then carefully reviewing intermediate results (e.g., the prototypical building description, simulated energy consumption, and automated ECM descriptions) as you proceed through the analysis stages. If these intermediate results seem reasonable, then you will be more assured that the final results are also reasonable.

There will be situations in which required information is not readily available in your project documentation. This may be the case for absolutely critical information such as post-retrofit utility data or for helpful information such as specific details related to an accurate description of an ECM. In the former case, the absence of the information will make a complete RESEM analysis impossible. The latter case may require that you make some assumptions, input a reasonable approximation, or again decide that a complete analysis is not possible. It will be worth your while, during information collection, to attempt to identify whether or not the candidate project is appropriate for RESEM analysis. There will be instances where the limitations of either RESEM or the available information

make a complete analysis infeasible. Deciding that this is the case up-front can save the effort of completing three fourths of an analysis before running into a brick wall.

### **Required Information for a Complete Analysis**

As mentioned above, RESEM attempts to minimize the amount of data required for a complete analysis. By making default assumptions regarding typical characteristics of the project under analysis, RESEM makes best use of a limited amount of user input. This section describes the required input, acceptable values, value units of measurement (if appropriate), the location within RESEM that the value is entered, and how this information is used.

The data described below is the minimum required for a complete RESEM analysis. This list includes specific parameter names whenever possible (e.g., building total floor area) and general categories when specifics are too project dependent (e.g., ECM descriptions). This list is meant to guide your initial foray into the potentially daunting Technical Assistance (TA) Report. This list does not include potential alteration of any RESEM default values such as: fuel type units of measurement, recommended refinement or reconciliation of the prototypical building, or adjustment of the retrofit modifications. See subsequent topics within this section of the manual for details regarding these input topics.

#### ***Building/Project Name***

**Description:** name used to uniquely identify the building and project being analyzed

**Acceptable Values:** any alpha-numeric character string from 1 to 25 characters long; use an underscore '\_' or dash '-' instead of blank spaces (e.g., UCB\_9)

**Input Location:** project information data screen; from the main menu select: **Project, Project information**

**Use of Value:** the first 1 to 8 characters are used to define default file names for saving analysis data and final reports to disk; in some instances only the first 5 characters are used with additional characters automatically appended by RESEM; the first 5 characters should therefore uniquely identify each project so that saved files can be more easily recognized and associated with a particular project at a later time

#### ***State***

**Description:** state in which the building is located

**Acceptable Values:** 2 character uppercase state abbreviation (e.g., VT)

**Input Location:** project information data screen; from the main menu select: **Project, Project information**

**Use of Value:** identifies location of building; restricts list of available RESEM weather data locations to the entered state

#### ***Initial Construction Year***

**Description:** year in which the building was initially constructed; if the current building is the result of several construction stages, then choose the year in which the majority of floor area was constructed; see the use of this value to determine the importance of an accurate value

**Acceptable Values:** 4 digit year (e.g., 1950)

**Input Location:** project information data screen; from the main menu select: **Project, Project information**

**Use of Value:** used in determining numerous prototypical building description values including: building envelope construction types, building geometry, percent glass, infiltration rates, HVAC system type, outside air quantities, and lighting levels.

#### ***Total Floor Area***

**Description:** the total floor area of the building including all stories

**Acceptable Values:** any positive numeric value

**Units:** ft<sup>2</sup>

**Input Location:** project information data screen; from the main menu select: **Project, Project information**

**Use of Value:** used in determining geometry and volume of prototypical building description and its thermal zones

### ***ICP Building Type***

**Description:** ICP GTS code for building type

**Acceptable Values:** A = school; B = hospital

**Input Location:** project information data screen; from the main menu select: **Project, Project information**

**Use of Value:** used in determining prototypical building description defaults

### ***ICP Building Function***

**Description:** ICP GTS code for building function

**Acceptable Values:** 11 = elementary; 12 = secondary; 13 = university; 14 = vocational; 31 = general hospital

**Input Location:** project information data screen; from the main menu select: **Project, Project information**

**Use of Value:** used in determining prototypical building description defaults

### ***Space Heating Fuel Type***

**Description:** the type of fuel used for space heating

**Acceptable Values:** electricity, gas, #2 oil, #6 oil, coal, district heat

**Input Location:** the Yes/No toggle switch on the Fuel types submenu; from the main menu select: **Project, Fuel types, desired fuel type, space Heating**

**Use of Value:** used in determining heating plant type for the prototypical building description; adds indicated fuel type to requested list for utility data; determines conversion factors for simulation of heating (NOTE: only one fuel type can be associated with a single heating plant; if a heating plant uses dual fuel types, then the primary type should be indicated here and utility data for the secondary type must be converted to this type for entry under utility data discussed below)

### ***Additional Building Fuel Types***

**Description:** other types of fuel used in the building for any of the following end uses: space cooling, fans, lights, equipment, hot water, and miscellaneous

**Acceptable Values:** electricity, gas, #2 oil, #6 oil, coal, district heat, district cool, other, heating plant

**Input Location:** the Yes/No toggle switches on the Fuel types submenu; from the main menu select: **Project, Fuel types, desired fuel type, desired end use**

**Use of Value:** used in determining characteristics of the prototypical building description (e.g., if space cooling is assigned a fuel type, this helps identify cooling plant type); adds indicated fuel type(s) to requested list for utility data; determines conversion factors for energy simulation

### ***Weather Location***

**Description:** location (city) of the RESEM weather data

**Acceptable Values:** any of the city names listed for the state entered above (see weather locations listing in the Reference Tables section of this manual)

**Input Location:** from the main menu select: **Project, Weather location**, desired weather location name

**Use of Value:** identifies the weather location used for performing both actual and long-term average energy simulations; this location should be selected for similarity of weather, not necessarily for geographic proximity

### ***Base (Pre-Retrofit) Period Utility Data***

**Description:** pre-retrofit energy consumption data, based on utility bills, for each fuel type used in the building; data includes beginning and ending dates and amount of consumption for appropriate utility billing period(s)

**Acceptable Values:** data can be entered for arbitrary length time periods (e.g., one week, 11 days, one month, etc.); beginning and ending dates are entered in short American form (e.g., 07/16/84); any positive numerical value can be entered for consumption amount

**Units:** RESEM assigns user-modifiable default units for each fuel type; to view/modify the current units, from the main menu select: **Project, fuel Units**, desired fuel type, desired units

**Input Location:** from the main menu select: **Base analysis, Enter base utility data**, desired fuel type

**Use of Value:** RESEM performs energy simulations using actual weather data, for the entered utility data time period(s), to reconcile the detailed pre-retrofit building description; different individual and overall time periods can be entered for each fuel type since RESEM uses the overall period for each fuel type for reconciliation (NOTE: only a single fuel type can be associated with each heating plant or cooling plant; if a plant is a dual fuel type, then the secondary type must be converted to the primary type and added to it for entry into the utility data input screens)

### ***ECM Descriptions***

**Description:** categorization and description of Energy Conservation Measures implemented in the building under analysis; categorization is done by identifying the 3 letter ICP GTS code for each ECM; description is dependent on the particular ECM being described, input requirements range from just the 3 letter code to manual entry using the detailed building description screens

**Acceptable Values:** dependent on individual ECM

**Input Location:** from the main menu select: **Retrofit, Ecm descriptions**, appropriate ECM categorization code

**Use of Value:** each 3 letter ECM code is listed onscreen for future user reference; modifications to specific building description parameters which define each implemented retrofit measure are made to the ECM version of the building description which is subsequently used for energy simulations and energy savings estimates

### ***Non-ECM Modification Descriptions***

**Description:** description of changes in the building under analysis, which took place between the pre-retrofit and post-retrofit utility data periods, and which do not constitute ICP supported ECM modifications; description is dependent on the particular non-ECM modification being described

**Acceptable Values:** dependent on individual non-ECM modification

**Input Location:** from the main menu select: **Retrofit, Non-ecm modifications**, appropriate non-ECM type

**Use of Value:** changes to specific building description parameters which define non-ECM modifications are made to the POST version of the building description; this building description is subsequently used to separate the impacts on post-retrofit energy consumption between ECM and non-ECM changes to the building

### ***Post-Retrofit Period Utility Data***

**Description:** post-retrofit energy consumption data, based on utility bills, for each fuel type used in the building; data includes beginning and ending dates and amount of consumption for appropriate utility billing period(s)

**Acceptable Values:** data can be entered for arbitrary length time periods (e.g., one week, 11 days, one month, etc.); beginning and ending dates are entered in short American form (e.g., 07/16/84); any positive numerical value can be entered for consumption amount

**Units:** RESEM assigns user-modifiable default units for each fuel type; to view/modify the current units, from the main menu select: **Project**, fuel **Units**, desired fuel type, desired units

**Input Location:** from the main menu select: post **Analysis**, **Enter post utility data**, desired fuel type

**Use of Value:** RESEM performs energy simulations using actual weather data, for the entered utility data time period(s), to adjust the retrofit modifications (ECM and non-ECM) to the pre-retrofit building; different individual and overall time periods can be entered for each fuel type since RESEM uses the overall period for each fuel type for retrofit adjustment

### **Recommended Information**

The data values and categories discussed in the previous section are required for a complete RESEM analysis. This data is used in a variety of ways to make informed decisions about pre-retrofit, ECM, and post-retrofit building descriptions. Again, these decisions are based on prototypical default assumptions. The accuracy of these assumptions for your specific analysis should always be evaluated and improved where possible.

This section makes recommendations regarding additional information which should be gathered, if available, to aid you in evaluating intermediate RESEM analysis results and providing more accurate input where appropriate.

There are three values which are not required, but which, if input prior to generation of the prototypical building description, may improve the accuracy of this initial building description. These three values are as follows.

#### ***Number of Floors***

**Description:** the number of stories in the building; if the number of stories varies throughout the building a floor area weighted average can be entered

**Acceptable Values:** any positive numeric value

**Input Location:** project information data screen; from the main menu select: **Project**, **Project information**

**Use of Value:** used to override default value in determining geometry and volume of the prototypical building description and its thermal zones

#### ***Percent Glass***

**Description:** the percentage of glass to total wall area in the building

**Acceptable Values:** any positive numeric value

**Input Location:** project information data screen; from the main menu select: **Project**, **Project information**

**Use of Value:** used to override default window areas of the prototypical building description and its thermal zones

#### ***Space Cooling Fuel Type***

**Description:** the type of fuel used for space cooling

**Acceptable Values:** electricity, gas, #2 oil, #6 oil, coal, district cool



**Input Location:** the Yes/No toggle switch on the Fuel types submenu; from the main menu select: Project, Fuel types, desired fuel type, space Cooling

**Use of Value:** used in determining cooling plant type for the prototypical building description; if no fuel type is assigned this end use, then no cooling plant is included in the description; adds indicated fuel type to requested list for utility data; determines conversion factors for simulation of cooling

Having generated the prototypical building description, it is still likely that this initial building description will have to be modified to improve the match between simulated and measured (utility data) pre-retrofit energy consumption. This modification can take place at two points in the analysis sequence, building refinement and/or building reconciliation. Refinement is a manual approach, while reconciliation is a partially automated approach. Either approach requires that the user have at least some notion of which building description modifications are appropriate. To this end, the following building description parameters are listed and described primarily for reference during manual refinement. For further discussion and advice on automated reconciliation, see the Reconciliation Parameter Selection Guidelines section of this manual. Research into correct values for these parameters is recommended within the limitations of available time and documentation.

### ***HVAC System Type***

**Description:** the generic type of HVAC system

**Acceptable Values:** *sum, cvct, cvvt, vav*. See Reference Tables R-5 and R-6 for explicit lists of specific system types, and how they can be represented by these generic types.

*sum*: For simulation diagnostic purposes only.

*cvct*: Constant Volume Constant Temperature. Typical of reheat systems.

*cvvt*: Constant Volume Variable Temperature. Typical of single-zone type systems

*vav*: Variable Air Volume.

**Input Location:** the System detailed building description data screen; from the main menu select: Base analysis, Create base building, reFine building, Systems, desired HVAC system

**Use of Value:** used in simulation of HVAC system

### ***HVAC System Fan Supply CFM***

**Description:** the design capacity of the system air supply fan. This value takes precedence over the sum of the specified zone air requirements for those zones served by this HVAC system if that sum is not equal to this specified value.

**Acceptable Values:** positive number

**Units:** cubic feet per minute (cfm)

**Input Location:** the System detailed building description data screen; from the main menu select: Base analysis, Create base building, reFine building, Systems, desired HVAC system

**Use of Value:** used in simulation of HVAC system

### ***HVAC System Fan Power***

**Description:** the fan power requirement

**Acceptable Values:** positive number

**Units:** W/cfm

**Input Location:** the System detailed building description data screen; from the main menu select: Base analysis, Create base building, reFine building, Systems, desired HVAC system

**Use of Value:** used in simulation of HVAC system

### ***HVAC Operation Schedules***

**Description:** the basic mechanism for defining the hours of operation of the building fan system(s); there are three types of such schedules for weekday, Saturday, and Sunday operation; if more than one fan system is defined and used in a building, all will have the same hours of operation, as defined by these schedules.

**Acceptable Values:** any currently defined hourly schedule name; hourly schedules can contain fractional values (e.g., 0.5) to signify a partial hour of operation

**Input Location:** the Operation Schedules detailed building description data screen; from the main menu select: **B**ase analysis, **C**reate base building, **r**eF**i**ne building, **O**peration schedules, desired schedule type (weekday, Saturday, Sunday)

**Use of Value:** used in simulation of building system(s)

### ***Heating Plant Rated Capacity***

**Description:** the rated heating capacity of each unit of the heating plant

**Acceptable Values:** positive number

**Units:** kBtu/hr

**Input Location:** the Heating Plant detailed building description data screen; from the main menu select: **B**ase analysis, **C**reate base building, **r**eF**i**ne building, **h**eating plants, desired Heating Plant

**Use of Value:** used in simulation of heating plant and HVAC system

### ***Cooling Plant Rated Capacity***

**Description:** the rated cooling capacity of each unit of the cooling plant

**Acceptable Values:** positive number

**Units:** tons

**Input Location:** the Cooling Plant detailed building description data screen; from the main menu select: **B**ase analysis, **C**reate base building, **r**eF**i**ne building, **C**ooling plants, desired Cooling Plant

**Use of Value:** used in simulation of cooling plant and HVAC system

### ***Heating Plant Pump Power Requirements***

**Description:** the electricity power of the boiler pump

**Acceptable Values:** positive or negative number

positive number or zero: Actual plant auxiliary power requirement

negative number: Any negative number will result in an automatic calculation of the auxiliary power, which is based on plant demand and is calculated for each unit in the plant as  $0.01 * \text{unit capacity} * (.33 + .67 * \text{unit part load ratio})$ .

**Units:** kW

**Input Location:** the Heating Plant detailed building description data screen; from the main menu select: **B**ase analysis, **C**reate base building, **r**eF**i**ne building, **h**eating plants, desired Heating Plant

**Use of Value:** used in simulation of heating plant and HVAC system

### ***Cooling Plant Pump Power Requirements***

**Description:** the electricity power of the chiller plant auxiliaries

**Acceptable Values:** positive or negative number

positive number or zero: Actual plant auxiliary power requirement

negative number: Any negative number will result in an automatic calculation of the auxiliary power, which is based on plant demand and is calculated for each unit in the plant as (auxiliary factor)\*(unit capacity), where the auxiliary factor is 0.015 for DX units, 0.02 for district cooling, 0.05 for all central compressor types, and 0.15 for absorption chillers.

**Units:** kW

**Input Location:** the Cooling Plant detailed building description data screen; from the main menu select: **Base analysis**, **Create base building**, **reFine building**, **Cooling plants**, desired **Cooling Plant**

**Use of Value:** used in simulation of cooling plant and HVAC system

### ***Activity Definition Hourly Schedules***

**Description:** the hourly schedules for defining levels of occupancy, lighting, electric equipment, miscellaneous sensible, and hot water use

**Acceptable Values:** any currently defined hourly schedule name; hourly schedules can contain fractional values

**Input Location:** the Activity Definitions detailed building description data screen; from the main menu select: **Base analysis**, **Create base building**, **reFine building**, **Activity definitions**, desired activity definition name

**Use of Value:** used in simulation of building occupancy and use

### ***Activity Definition Monthly Schedules***

**Description:** the monthly schedules for defining levels of occupancy, lighting, electric equipment, miscellaneous sensible, and hot water use

**Acceptable Values:** any currently defined monthly schedule name; monthly schedules can contain fractional values

**Input Location:** the Thermal Zone detailed building description data screen; from the main menu select: **Base analysis**, **Create base building**, **reFine building**, **view/modify/add Zone**, desired thermal zone name, **>ACTIVITIES**, desired activity for the selected zone

**Use of Value:** used in simulation of building occupancy and use

### **Data Input Checklist**

The following checklist is provided to guide your gathering of input data for a RESEM analysis. It is recommended that you copy this form and use a copy for each project analysis undertaken. Required data is indicated in the leftmost column on the form. In those instances where a parameter is not defined with a single value, use the rightmost column to note the location within your TA documentation to use for reference.

<b>Table C-1: Data Input Checklist</b>			
<b>Req</b>	<b>Parameter</b>	<b>Value</b>	<b>TA Page</b>
<b>X</b>	Building/Project Name		
<b>X</b>	State		
<b>X</b>	RESEM Weather Location		
<b>X</b>	Year of Construction		
	Number of Floors		
<b>X</b>	Total Floor Area		
	Percent Glass		
<b>X</b>	ICP Building Type		
<b>X</b>	ICP Building Function		
<b>X</b>	Base (Pre-Retrofit) Period Utility Data		
<b>X</b>	Post-Retrofit Period Utility Data		
<b>X</b>	ECM Descriptions		
<b>X</b>	Non-ECM Descriptions		
	HVAC System		
	Type		
	Fan Supply CFM		
	Fan Power		
	Weekday Operation Schedule		
	Saturday Operation Schedule		
	Sunday Operation Schedule		
	Heating Plant		
<b>X</b>	Fuel Type		
	Rated Capacity		
	Pump Power		
	Cooling Plant (if applicable)		
<b>X</b>	Fuel Type		
	Rated Capacity		
	Pump Power		
<b>X</b>	Additional Fuel Types Used in Bldg		
	Activity Definition Hourly Schedules		
	Occupancy		
	Lighting		
	Electric Equipment		
	Miscellaneous Sensible		
	Hot Water Use		
	Activity Definition Monthly Schedules		
	Occupancy		
	Lighting		
	Electric Equipment		
	Miscellaneous Sensible		
	Hot Water Use		

---

## The Prototypical Building Generator

---

Each RESEM analysis makes repeated use of computer simulations of the energy consumption of the building(s) being analyzed. These simulations require detailed descriptions of all energy related characteristics of a building including: building geometry; envelope construction components; HVAC system types and operation; thermal zones; and lighting, equipment, occupancy, and usage levels and schedules. This is a complex set of data which must accurately describe the specific building of interest. For a typical simplified elementary school description, this data set can easily contain 300 data values (e.g., wall U-Value, heating plant boiler efficiency, daytime thermostat set point, classroom lighting level, etc.). RESEM eases the burden on the user of collecting and entering this myriad data set for a given building by generating a prototypical building description from a handful of required input values including: building age, size, type, location, and consumed fuel types.

### What is a Prototypical Building Description?

A prototypical building description is the starting point for an accurate description of your specific building based on typical values for a building of the same type. The term *building description* in RESEM refers to the collection of data which fully describes the energy related characteristics of a building, as discussed above. A *prototypical building description* contains assigned values for all elements of a building description based on *typical* defaults for the indicated building age, size, type, location, and consumed fuel types. RESEM contains decision-making rules-of-thumb and numeric methods which are capable of assigning intelligent default values to all elements of a building description using information entered on the initial project information data screens. For example, an elementary school constructed in 1945 will be assigned walls with a typical U-Value different from one constructed in 1970. RESEM generates the prototypical building description when the user selects the *Generate default building* menu option under the *Create base building* submenu as a step in the *Base analysis* sequence (see the Command Summary section of this manual). The user must have previously entered all required fields on the project information data screens.

The project information data fields used during generation of the prototypical building description which *must* be entered by the user include: state, initial construction year, total floor area, ICP building type, and ICP building function. A weather location must be selected prior to generation (primarily used in sizing heating and cooling equipment). Also, unless a specific fuel type (e.g., gas) is assigned an end use of *space heating*, the prototypical building will be generated with a generic boiler with an unknown energy source (simulation results will be reported in Btus). If no specific fuel type is assigned an end use of *space cooling*, the building will be generated without a cooling plant.

During generation of the prototypical building description, RESEM will make use of additional project information entered by the user to more accurately describe the building. These optional data fields include the number of floors and percent glass.

RESEM uses the project information entered by the user in conjunction with a modifiable database of basic building description components, decision-making rules-of-thumb, and numeric methods, to generate the complete prototypical building description. It is important to keep in mind that the building description data values assigned by RESEM are *typical* values modified to conform to the project information entered by the user. These values may not be sufficiently accurate for your specific building. However, they do represent a reasonable starting point which will be subjected to analytical review to check for accuracy at later stages in the RESEM analysis sequence.

*Accuracy* in the context of a RESEM analysis is related only to the energy consuming characteristics of the building. An accurate building description need not precisely match the real building in all details. This is particularly true for the geometric description of a building. A real

building is generally divided into several floors, with numerous rooms on each floor. However, the energy consumption of such a building can often be accurately simulated by combining all thermally similar rooms in the building into a single thermal zone described with only four walls, a ceiling, and a roof. This is especially true for non-residential buildings like schools and hospitals in which energy consumption is more dependent on internal loads (e.g., occupants, lights, and equipment) than on envelope loads (e.g., heat loss through walls). This is not to say that envelope loads are unimportant; rather, that they can be accurately estimated by using simplifying assumptions in a building description. The prototypical building descriptions rely on simplifications of this sort.

Certain elements within a building description, however, can be critical to the accuracy of retrofit energy savings estimates. In particular, those aspects of a building which will be altered by implemented energy conservation measures should be as accurately described as possible.

See the *Refining a Building Description* subsection below for details on modifying the prototypical building description. See the *Detailed Building Description Data Screens* section below for information regarding each data field contained in a RESEM building description. See the *Building Description Reconciliation* section below for a discussion of the analytical review which checks the accuracy of your building description.

### Prototypical Defaults

A prototypical building description generated by RESEM is meant to be a reasonable starting point in the development of an accurate description of your building. Each prototype is based on the minimal input data required from the user, and default values and assumptions built in to RESEM. This means that many building description data values will be unique for each building generated, such as zone floor areas and heating and cooling plant capacities. However, other data values will be consistent, depending on the building type, age, and size. To make these built-in default values and assumptions more explicit, they are listed in the following tables for the types of buildings which RESEM is currently capable of generating prototypical building descriptions.

Wall Name	U-Value	Construction Group <sup>a</sup>	Color Correction
12Br0	0.350	E	0.83
8B4br0	0.274	D	0.83
6B4br1	0.250	C	0.83
6B4br5	0.100	B	0.83

<sup>a</sup> See Reference Table Section of this manual for descriptions of these groups

Roof Name	U-Value	Construction Code <sup>a</sup>	Color Correction	Ceiling Plenum <sup>b</sup>
6Cr3	0.192	12	0.83	No
Mr6	0.124	1	0.83	No
Mr10	0.090	1	0.83	No
6Cr6	0.117	12	0.83	No

<sup>a</sup> See Reference Table Section of this manual for descriptions of these codes

<sup>b</sup> This parameter is not currently operational within the RESEM program

Parameter	Pre-1950	1950 -1965	1965-1975	Post-1975
Walls	12Br0	8B4br0	6B4br1	6B4br5
Roofs	6Cr3	Mr6	Mr6	Mr10
Windows	1p-1/8c <sup>a</sup>	1p-1/8c	1p-1/8c	1p-1/8c
Percent Glass	30	60	40	30
Weekday Hours of Operation	7AM-3PM	7AM-3PM	7AM-3PM	7AM-3PM
Saturday Hours of Operation	none	none	none	none
Sunday Hours of Operation	none	none	none	none
Months of System Equipment Operation	Sept-May	Sept-May	Sept-May	Sept-May
Months of Occupancy	all <sup>b</sup>	all <sup>b</sup>	all <sup>b</sup>	all <sup>b</sup>
Infiltration rate (air changes per hour)	1.0	1.0	0.8	0.5
Heating Plant Type	boiler	boiler	boiler	boiler
Heating Plant Efficiency (percent)	75	75	75	75
Cooling Plant Type (if applicable)	centrifugal <sup>c</sup>	centrifugal <sup>c</sup>	centrifugal <sup>c</sup>	centrifugal <sup>c</sup>
Cooling Plant COP	4.5 <sup>c</sup>	4.5 <sup>c</sup>	4.5 <sup>c</sup>	4.5 <sup>c</sup>
HVAC System Type	CVVT <sup>d</sup>	CVVT <sup>d</sup>	CVVT <sup>d</sup>	VAV <sup>e</sup>
Percent Outside Air	100	30	30	20
System Air Changes per Hour	2.0	6.0	6.0	6.0
System Fan Power (W/cfm)	0.4	0.4	0.4	1.2
Occupied/Unoccupied Heating Setpoints	72/55	72/55	72/55	72/55
Occupied/Unoccupied Cooling Setpoints	76/90	76/90	76/90	76/90
Classroom Zone % of Total Floor Area	90	90	80	80
Classroom Zone Floor to Floor Height <sup>f</sup>	12	12	12	12
Classroom Zone Number of Floors	2	1	1	1
Classroom Zone Occupancy (ft <sup>2</sup> /per) <sup>g</sup>	100	100	100	100
Classroom Zone Lighting (W/ft <sup>2</sup> ) <sup>g</sup>	1.5	1.5	1.5	1.5
Classroom Zone Elec Equipment(W/ft <sup>2</sup> ) <sup>g</sup>	0.1	0.1	0.1	0.1
Classroom Zone Hot Water (gal/day) <sup>g</sup>	0.6	0.6	0.6	0.6
Multipurpose Zone % of Totl Floor Area	10	10	20	20
Multipurpose Zone Floor - Floor Height <sup>f</sup>	24	24	24	24
Multipurpose Zone Number of Floors	1	1	1	1
Multipurpose Zone Occupancy (ft <sup>2</sup> /per) <sup>g</sup>	100	100	100	100
Multipurpose Zone Lighting (W/ft <sup>2</sup> ) <sup>g</sup>	0.8	1.0	0.8	1.0
Multipurpose Zone Elec Equip (W/ft <sup>2</sup> ) <sup>g</sup>	0.1	0.1	0.1	0.1
Multipurpose Zone Hot Water (gal/day) <sup>g</sup>	0.6	0.6	0.6	0.6

<sup>a</sup> This window type is Single Pane, 1/8 inch Clear glass with a U-Value of 1.1 and a Shading Coefficient of 1.0

<sup>b</sup> Occupancy, lighting, and electrical equipment levels are adjusted by applying the multipliers found in monthly schedule *sch-occ*(i.e., 1.0 from September through May and 0.1 from June through August)

<sup>c</sup> For small schools with air conditioning, the cooling plant type will be reciprocating with a COP of 3.6

<sup>d</sup> Constant Volume Variable Temperature

<sup>e</sup> Variable Air Volume

<sup>f</sup> This floor to floor height is corrected for a hung ceiling in zone volume calculations

<sup>g</sup> Listed values are varied over a 24 hour day by applying the multipliers found in hourly schedule *se2-wkd*(i.e., 1.0 from 9AM to 3PM and 0.0 from 3PM to 9AM)

Parameter	Pre-1950	1950 -1965	1965-1975	Post-1975
Walls	12Br0	8B4br0	6B4br1	6B4br5
Roofs	6Cr3	Mr6	Mr6	Mr10
Windows	1p-1/8c <sup>a</sup>	1p-1/8c	1p-1/8c	1p-1/8c
Percent Glass	20	30	20	20
Weekday Hours of Operation	7AM-6PM	7AM-6PM	7AM-6PM	7AM-6PM
Saturday Hours of Operation	none	none	none	none
Sunday Hours of Operation	none	none	none	none
Months of System Equipment Operation	Sept-May	Sept-May	Sept-May	Sept-May
Months of Occupancy	all <sup>b</sup>	all <sup>b</sup>	all <sup>b</sup>	all <sup>b</sup>
Infiltration Rate (air changes per hour)	1.0	1.0	0.8	0.5
Heating Plant Type	boiler	boiler	boiler	boiler
Heating Plant Efficiency (percent)	75	75	75	75
Cooling Plant Type (if applicable)	centrifugal <sup>c</sup>	centrifugal <sup>c</sup>	centrifugal <sup>c</sup>	centrifugal <sup>c</sup>
Cooling Plant COP	4.5 <sup>c</sup>	4.5 <sup>c</sup>	4.5 <sup>c</sup>	4.5 <sup>c</sup>
HVAC System Type	CVVT <sup>d</sup>	CVVT <sup>d</sup>	CVVT <sup>d</sup>	VAV <sup>e</sup>
Percent Outside Air	100	30	30	30
System Air Changes per Hour	2.0	6.0	6.0	6.0
System Fan Power (W/cfm)	0.4	0.4	0.4	1.2
Occupied/Unoccupied Heating Setpoints	72/55	72/55	72/55	72/55
Occupied/Unoccupied Cooling Setpoints	76/90	76/90	76/90	76/90
Classroom Zone % of Total Floor Area	70	60	60	60
Classroom Zone Floor to Floor Height <sup>f</sup>	12	12	12	12
Classroom Zone Number of Floors	3	2	2	2
Classroom Zone Occupancy (ft <sup>2</sup> /per) <sup>g</sup>	100	100	100	100
Classroom Zone Lighting (W/ft <sup>2</sup> ) <sup>g</sup>	1.5	1.5	1.5	1.5
Classroom Zone Elec Equipment(W/ft <sup>2</sup> ) <sup>g</sup>	0.1	0.1	0.1	0.1
Classroom Zone Hot Water (gal/day) <sup>g</sup>	4.2	4.2	4.2	4.2
Multipurpose Zone % of Totl Floor Area	30	40	40	40
Multipurpose Zone Floor - Floor Height <sup>f</sup>	24	24	24	24
Multipurpose Zone Number of Floors	1	1	1	1
Multipurpose Zone Occupancy (ft <sup>2</sup> /per) <sup>g</sup>	100	100	100	100
Multipurpose Zone Lighting (W/ft <sup>2</sup> ) <sup>g</sup>	0.8	0.8	0.8	1.0
Multipurpose Zone Elec Equip (W/ft <sup>2</sup> ) <sup>g</sup>	0.1	0.1	0.1	0.1
Multipurpose Zone Hot Water (gal/day) <sup>g</sup>	4.2	4.2	4.2	4.2

<sup>a</sup> This window type is Single Pane, 1/8 inch Clear glass with a U-Value of 1.1 and a Shading Coefficient of 1.0

<sup>b</sup> Occupancy, lighting, and electrical equipment levels are adjusted by applying the multipliers found in monthly schedule *sch-occ*(i.e., 1.0 from September through May and 0.1 from June through August)

<sup>c</sup> For small schools with air conditioning, the cooling plant type will be reciprocating with a COP of 3.6

<sup>d</sup> Constant Volume Variable Temperature

<sup>e</sup> Variable Air Volume

<sup>f</sup> This floor to floor height is corrected for a hung ceiling in zone volume calculations

<sup>g</sup> Listed values are varied over a 24 hour day by applying the multipliers found in hourly schedule *ss2-wkd*(i.e., 1.0 from 10AM to 3PM and 0.0 from 3PM to 10AM)



Parameter	Pre-1950	1950 -1965	1965-1975	Post-1975
Walls	12Br0	8B4br0	6B4br1	6B4br5
Roofs	6Cr3	Mr6	Mr6	Mr10
Windows	1p-1/8c <sup>a</sup>	1p-1/8c	1p-1/8c	1p-1/8c
Percent Glass	20	30	20	20
Weekday Hours of Operation	7AM-10P	7AM-10P	7AM-10P	7AM-10P
Saturday Hours of Operation	7AM-2PM	7AM-2PM	7AM-2PM	7AM-2PM
Sunday Hours of Operation	none	none	none	none
Months of System Equipment Operation	Sept-May	Sept-May	Sept-May	Sept-May
Months of Occupancy	all <sup>b</sup>	all <sup>b</sup>	all <sup>b</sup>	all <sup>b</sup>
Infiltration Rate (air changes per hour)	1.0	1.0	0.8	0.5
Heating Plant Type	boiler	boiler	boiler	boiler
Heating Plant Efficiency (percent)	75	75	75	75
Cooling Plant Type (if applicable)	centrifugal <sup>c</sup>	centrifugal <sup>c</sup>	centrifugal <sup>c</sup>	centrifugal <sup>c</sup>
Cooling Plant COP	4.5 <sup>c</sup>	4.5 <sup>c</sup>	4.5 <sup>c</sup>	4.5 <sup>c</sup>
HVAC System Type	CVVT <sup>d</sup>	CVVT <sup>d</sup>	CVVT <sup>d</sup>	VAV <sup>e</sup>
Percent Outside Air	100	30	30	30
System Air Changes per Hour	2.0	6.0	6.0	6.0
System Fan Power (W/cfm)	0.4	0.4	0.4	1.2
Occupied/Unoccupied Heating Setpoints	72/55	72/55	72/55	72/55
Occupied/Unoccupied Cooling Setpoints	76/90	76/90	76/90	76/90
Classroom Zone % of Total Floor Area	70	60	60	60
Classroom Zone Floor to Floor Height <sup>f</sup>	12	12	12	12
Classroom Zone Number of Floors	3	2	2	2
Classroom Zone Occupancy (ft <sup>2</sup> /per) <sup>g</sup>	100	100	100	100
Classroom Zone Lighting (W/ft <sup>2</sup> ) <sup>g</sup>	2.5	2.5	2.5	1.5
Classroom Zone Elec Equipment(W/ft <sup>2</sup> ) <sup>g</sup>	0.5	0.5	0.5	0.5
Classroom Zone Hot Water (gal/day) <sup>g</sup>	4.2	4.2	4.2	4.2
Multipurpose Zone % of Totl Floor Area	30	40	40	40
Multipurpose Zone Floor - Floor Height <sup>f</sup>	24	24	24	24
Multipurpose Zone Number of Floors	1	1	1	1
Multipurpose Zone Occupancy (ft <sup>2</sup> /per) <sup>g</sup>	100	100	100	100
Multipurpose Zone Lighting (W/ft <sup>2</sup> ) <sup>g</sup>	2.0	2.0	2.0	1.0
Multipurpose Zone Elec Equip (W/ft <sup>2</sup> ) <sup>g</sup>	0.5	0.5	0.5	0.5
Multipurpose Zone Hot Water (gal/day) <sup>g</sup>	4.2	4.2	4.2	4.2

<sup>a</sup> This window type is Single Pane, 1/8 inch Clear glass with a U-Value of 1.1 and a Shading Coefficient of 1.0

<sup>b</sup> Occupancy, lighting, and electrical equipment levels are adjusted by applying the multipliers found in monthly schedule *sch-occ*(i.e., 1.0 from September through May and 0.1 from June through August)

<sup>c</sup> For small schools with air conditioning, the cooling plant type will be reciprocating with a COP of 3.6

<sup>d</sup> Constant Volume Variable Temperature

<sup>e</sup> Variable Air Volume

<sup>f</sup> This floor to floor height is corrected for a hung ceiling in zone volume calculations

<sup>g</sup> Listed values are varied over a 24 hour day by applying the multipliers found in hourly schedule *su1-wkd*(i.e., 1.0 from 7AM to 10PM and 0.0 from 10PM to 7AM)

<b>Table D-6: Vocational School Prototypical Building Description Parameters</b>				
Parameter	Pre-1950	1950 -1965	1965-1975	Post-1975
Walls	12Br0	8B4br0	6B4br1	6B4br5
Roofs	6Cr3	Mr6	Mr6	Mr10
Windows	1p-1/8c <sup>a</sup>	1p-1/8c	1p-1/8c	1p-1/8c
Percent Glass	20	30	20	20
Weekday Hours of Operation	7AM-10P	7AM-10P	7AM-10P	7AM-10P
Saturday Hours of Operation	7AM-2PM	7AM-2PM	7AM-2PM	7AM-2PM
Sunday Hours of Operation	none	none	none	none
Months of System Equipment Operation	Sept-May	Sept-May	Sept-May	Sept-May
Months of Occupancy	all <sup>b</sup>	all <sup>b</sup>	all <sup>b</sup>	all <sup>b</sup>
Infiltration Rate (air changes per hour)	1.0	1.0	0.8	0.6
Heating Plant Type	boiler	boiler	boiler	boiler
Heating Plant Efficiency (percent)	75	75	75	75
Cooling Plant Type (if applicable)	centrifugal <sup>c</sup>	centrifugal <sup>c</sup>	centrifugal <sup>c</sup>	centrifugal <sup>c</sup>
Cooling Plant COP	4.5 <sup>c</sup>	4.5 <sup>c</sup>	4.5 <sup>c</sup>	4.5 <sup>c</sup>
HVAC System Type	CVVT <sup>d</sup>	CVVT <sup>d</sup>	CVVT <sup>d</sup>	VAV <sup>e</sup>
Percent Outside Air	100	30	40	40
System Air Changes per Hour	2.0	6.0	6.0	6.0
System Fan Power (W/cfm)	0.4	0.4	0.4	1.2
Occupied/Unoccupied Heating Setpoints	72/55	72/55	72/55	72/55
Occupied/Unoccupied Cooling Setpoints	76/90	76/90	76/90	76/90
Classroom Zone % of Total Floor Area	70	60	50	50
Classroom Zone Floor to Floor Height <sup>f</sup>	12	12	12	12
Classroom Zone Number of Floors	3	2	2	2
Classroom Zone Occupancy (ft <sup>2</sup> /per) <sup>g</sup>	100	100	100	100
Classroom Zone Lighting (W/ft <sup>2</sup> ) <sup>g</sup>	2.5	2.5	2.5	1.5
Classroom Zone Elec Equipment(W/ft <sup>2</sup> ) <sup>g</sup>	0.5	0.5	0.5	0.5
Classroom Zone Hot Water (gal/day) <sup>g</sup>	4.2	4.2	4.2	4.2
Multipurpose Zone % of Totl Floor Area	30	40	50	50
Multipurpose Zone Floor - Floor Height <sup>f</sup>	24	24	24	24
Multipurpose Zone Number of Floors	1	1	1	1
Multipurpose Zone Occupancy (ft <sup>2</sup> /per) <sup>g</sup>	100	100	100	100
Multipurpose Zone Lighting (W/ft <sup>2</sup> ) <sup>g</sup>	2.0	2.0	2.0	1.0
Multipurpose Zone Elec Equip (W/ft <sup>2</sup> ) <sup>g</sup>	0.5	0.5	0.5	0.5
Multipurpose Zone Hot Water (gal/day) <sup>g</sup>	4.2	4.2	4.2	4.2

<sup>a</sup> This window type is Single Pane, 1/8 inch Clear glass with a U-Value of 1.1 and a Shading Coefficient of 1.0

<sup>b</sup> Occupancy, lighting, and electrical equipment levels are adjusted by applying the multipliers found in monthly schedule *sch-occ*(i.e., 1.0 from September through May and 0.1 from June through August)

<sup>c</sup> For small schools with air conditioning, the cooling plant type will be reciprocating with a COP of 3.6

<sup>d</sup> Constant Volume Variable Temperature

<sup>e</sup> Variable Air Volume

<sup>f</sup> This floor to floor height is corrected for a hung ceiling in zone volume calculations

<sup>g</sup> Listed values are varied over a 24 hour day by applying the multipliers found in hourly schedule *sch-wkd*(i.e., 1.0 from 7AM to 10PM and 0.0 from 10PM to 7AM)

Parameter	Pre-1965		Post-1965	
	<200000ft <sup>2</sup>	>200000ft <sup>2</sup>	<200000ft <sup>2</sup>	>200000ft <sup>2</sup>
Walls	8B4br0 <sup>a</sup>	8B4br0 <sup>a</sup>	6B4br1	6B4br1
Roofs	6Cr6 <sup>b</sup>	6Cr6 <sup>b</sup>	6Cr6	6Cr6
Windows	1p-1/8c <sup>c</sup>	1p-1/8c	1p-1/8c	1p-1/8c
Percent Glass	20	20	30	30
Weekday hours of operation	all	all	all	all
Saturday hours of operation	all	all	all	all
Sunday hours of operation	all	all	all	all
Months of operation	all	all	all	all
Infiltration rate (air changes per hour)	0.5	0.5	0.4	0.4
Heating Plant Type	boiler	boiler	boiler	boiler
Heating Plant Efficiency (percent)	75	75	75	75
Cooling Plant Type	centrifugal	centrifugal	centrifugal	centrifugal
Cooling Plant COP	4.5	4.5	4.5	4.5
Occupied/Unoccupied Heating Setpoints	72/55	72/55	72/55	72/55
Occupied/Unoccupied Cooling Setpoints	76/90	76/90	76/90	76/90
Patient Zone Percent of Total Floor Area	70	55	70	55
Patient Zone Floor to Floor Height <sup>d</sup>	12	12	12	12
Patient Zone Number of Floors	4	8	4	8
Patient Zone Occupancy (ft <sup>2</sup> /person) <sup>e</sup>	100	100	100	100
Patient Zone HVAC System Type	CVVT <sup>f</sup>	CVVT	CVVT	CVVT
Patient Zone Percent Outside Air	30	30	30	30
Patient Zone System Fan Power(W/cfm)	0.3	0.3	0.3	0.3
Patient Zone Lighting (W/ft <sup>2</sup> ) <sup>e</sup>	1	1	1	1
Patient Zone Electric Equipment (W/ft <sup>2</sup> ) <sup>e</sup>	0.25	0.25	0.25	0.25
Patient Zone Hot Water Use (gal/day) <sup>e,i</sup>	5.0	5.0	5.0	5.0
Clinic Zone Percent of Total Floor Area	30	45	30	45
Clinic Zone Floor to Floor Height <sup>d</sup>	12	12	12	12
Clinic Zone Number of Floors	4	8	4	8
Clinic Zone Occupancy (ft <sup>2</sup> per person) <sup>g</sup>	100	100	100	100
Clinic Zone HVAC System Type	CVCT <sup>h</sup>	CVCT	CVCT	CVCT
Clinic Zone Percent Outside Air	90	90	90	90
Clinic Zone System Fan Power (W/cfm)	0.7	0.7	0.7	0.7
Clinic Zone Lighting (W/ft <sup>2</sup> ) <sup>g</sup>	2	3	3	4
Clinic Zone Electric Equipment (W/ft <sup>2</sup> ) <sup>g</sup>	1.5	1.5	1.5	1.5
Clinic Zone Hot Water Use (gal/day) <sup>g,i</sup>	5.0	5.0	5.0	5.0

<sup>a</sup> Pre 1950 walls are of type 12Br0

<sup>b</sup> Pre 1950 roofs are of type 6Cr3

<sup>c</sup> This window type is Single Pane, 1/8 inch Clear glass with a U-Value of 1.1 and a Shading Coefficient of 1.0

<sup>d</sup> This floor to floor height is corrected for a hung ceiling in zone volume calculations

<sup>e</sup> Listed values are varied over a 24 hour day by applying the multipliers found in hourly schedule *h1-p* (i.e., 0.5 from 9PM to 12NOON, 0.75 from 12NOON to 6PM, and 1.0 from 6PM to 9PM)

<sup>f</sup> Constant Volume Variable Temperature

<sup>g</sup> Listed values are varied over a 24 hour day by applying the multipliers found in hourly schedule *h1-cl* (i.e., 0.25 from 6PM to 7AM and 1.0 from 7AM to 6PM)

<sup>h</sup> Constant Volume Constant Temperature

<sup>i</sup> Laundry requirements estimated separately(see your hospital Miscellaneous Heat Source)

## Building Retrieval, an Alternative Approach

The prototypical building generator creates a complete building description from minimal user input and built-in assumptions and defaults regarding typical parameter values for a building of the indicated type, age, and location. Some users may wish to develop their own prototypical building descriptions which provide less general and hence more accurate starting points for the types of buildings with which they commonly work. This could be accomplished over time by noting the building description refinements which are needed to fine tune the prototypical descriptions for your use. If there are specific refinements which are often required, this is indicative of the fact that typical values for your buildings consistently differ from the prototype. RESEM provides an alternative to prototypical building generation by allowing you to retrieve a building description from disk which has been modified to represent a building typical to your experience.

Any building description created in RESEM can be saved to disk at any point in a RESEM analysis. This description can then be retrieved from disk for use at any later time, even during a different analysis. This process is analogous to creating a spreadsheet template, saving it to disk, and later retrieving it for viewing and modification. While saving and retrieving can be done with any of the three building description versions used during a RESEM analysis (i.e., base, ecm, and post), the following discussion assumes that you wish to save only the base building description for later retrieval as an alternative to prototypical building description generation.

To create and save a building description, first make certain that all parameters are set to your preferred values. This could be accomplished by generating a prototypical building description and then manually refining this prototype to your specifications. If desired, you could also use the building description reconciliation process described in a later section of this manual to further modify the original prototype. Presumably, your aim here is not to precisely match energy performance for a specific building, but rather to establish a description which represents the type of buildings which you encounter in your work, more closely than the prototypical descriptions generated automatically by RESEM. Once you are satisfied with your typical description, select the *File* option from the RESEM main menu, then select the *Save Building* option from the File submenu. You will be prompted to select the version of the building description you wish to save. Select the *pre-retrofit* (base) building. You will now be prompted to select a name for your building description disk file. The name which you select should uniquely describe the building description you are saving so that you will recognize it for retrieval. The first name in the list will correspond to the building name entered on the initial project information screen and is meant to be a default. If you wish to name the file something else, select any blank slot on the list of names. Once a filename has been selected or entered, the building description will be saved to disk with the extension *.in* appended.

To retrieve a building description from disk for use as your alternate prototypical building description, select the *Retrieve Saved Building* option on the *Create Base Building* submenu under the *Base Analysis* menu. A list of building description filenames currently on the hard disk will be displayed for your selection. Selecting the filename of your choice will cause the building description to be retrieved from disk for use as the base building description. This process will automatically fill in certain data fields on the project information screens. However, these screens should be manually reviewed to assure proper values for the current analysis. In particular, a weather location will **not** be automatically selected. Additional information such as a building name, address, and contact should also be entered either before or after base building description retrieval for completeness of the current analysis.

## Refining a Building Description

Whether you have chosen to have RESEM generate a prototypical building description or retrieved your own typical description, there will invariably be modifications required to accurately describe a specific building for analysis. RESEM provides a uniquely powerful approach to performing this modification so that simulated energy consumption matches utility data entered for a

specific building. However, this approach, referred to as *building description reconciliation* and described in a later section, remains something of a black art method. Building description reconciliation modifications are quantified and applied using mathematical techniques which are limited in their ability to assure correct results. These results can be *mathematically* correct without correctly describing your actual building. This state of affairs calls for user attention to critical building description parameters. This is particularly true for those parameters which will be directly affected by either Energy Conservation Measures or other modifications which occur in the building between pre-retrofit and post-retrofit periods.

To maximize accuracy in a RESEM analysis, all Technical Assistance documentation should be reviewed. Effort should be made to ascertain correct pre-retrofit period values for critical building description parameters. If these values differ from those established by prototypical generation or typical building retrieval, then they should be manually modified prior to building description reconciliation. This process is referred to as building description refinement.

To perform building description refinement, select the *Refine building* option on the *Create base building* submenu. This selection will access the detailed data screens described under the *Miscellaneous* command summary and the Detailed Building Description Data Screens section below.

## The Detailed Building Description Data Screens

---

The term *building description* in RESEM refers to the collection of data which describes all details related to building geometry; envelope construction components; HVAC system types and operation; thermal zones; and lighting, equipment, occupancy, and usage levels and schedules. This is a considerable amount of information which must be organized for storage and access within RESEM. For a complete RESEM analysis, three distinct building description versions must be maintained. These are the *pre-retrofit* (or base) version, an *ecm* version which describes all ECM modifications to the pre-retrofit building, and a *post-retrofit* version which describes both ECM and non-ECM modifications.

All of the data fields which make up a building description are accessible for review and editing using the RESEM detailed data screens. These screens logically organize and display fields for each of the various components of a building description. For information on accessing the detailed data screens containing these fields, refer to the *Miscellaneous* menu options portion of the command summary section of this manual. There are two categories of components, library and building. Library component types include: hourly and monthly schedules; wall, roof, and window constructions; and activity definitions. Building component types include: building operation schedules, heating and cooling plants, HVAC systems, miscellaneous heat and electric sources, and thermal zones. Each component type is defined by one or more data fields which describe the component. Each individual component description within a building description is assigned a name for reference. For example, wall constructions are described with the following data fields: user name, U-Value, ASHRAE construction group code, and ASHRAE color correction value. A wall constructed of 8 inch concrete block with a 4 inch brick facade and no insulation might be assigned a user name of 8B4br0. This wall construction has a U-Value of 0.27, a construction group code of D, and a color correction value of 0.83. Once this wall construction has been added to the library (defined), it can be included in a thermal zone description by referring to its user name (8B4br0). The data fields for each library and building component type are described below.

### Library Components

#### *Hourly Schedules*

Hourly schedules are used to define time and/or rate profiles, on an hourly basis, for a variety of activity definition elements such as occupancy and lighting, and building description components such as miscellaneous electric sources.

For example, an hourly schedule might be referenced by a lighting level within an activity definition. An hourly profile value of 0.5 for the hour from 7:00 AM to 8:00 AM would indicate either of the equivalent situations where all lights are turned off for half an hour and under full power for half an hour, or half the lights are turned off and half are under full power for the entire hour.

**User Name**

**Description:** name used to reference a defined hourly schedule

**Acceptable Values:** any alpha-numeric character string from 1 to 8 characters long

**24 Hourly Profile Values**

**Description:** the fraction of time and/or rate, during a given hour, that a component is in effect

**Acceptable Values:** 0.0 to 1.0

**Units:** unitless fraction

***Monthly Schedules***

Monthly schedules are used to define time and/or rate profiles, on a monthly basis, for a variety of building description components such as heating plant availability and miscellaneous electric sources.

For example, a monthly schedule might be referenced by a miscellaneous electric source such as exterior lighting. A monthly profile value of 0.75 for the month of December might indicate that exterior lighting is turned off for one quarter of the month.

**User Name**

**Description:** name used to reference a defined monthly schedule

**Acceptable Values:** any alpha-numeric character string from 1 to 8 characters long

**12 Monthly Profile Values**

**Description:** the fraction of time and/or rate, during a given month, that a component is in effect

**Acceptable Values:** 0.0 to 1.0

**Units:** unitless fraction

***Wall Constructions*****User Name**

**Description:** name used to reference a defined wall construction

**Acceptable Values:** any alpha-numeric character string from 1 to 8 characters long

**U-Value**

**Description:** time rate of heat flow per unit area across a surface

**Acceptable Values:** 0.0 to 20.0 (see Reference Tables Section)

**Units:** Btu/hr-ft<sup>2</sup>-°F

**ASHRAE Construction Group Code**

**Description:** ASHRAE Fundamentals Handbook Chapter 26 wall construction group code

**Acceptable Values:** A to G (see Reference Tables Section)

#### **ASHRAE Color Correction**

**Description:** ASHRAE Fundamentals Handbook Chapter 26 color adjustment figure

**Acceptable Values:** 1.0 if dark color or in an industrial area, 0.83 if medium, 0.65 if light

**Units:** unitless multiplier

### ***Roof Constructions***

#### **User Name**

**Description:** name used to reference a defined roof construction

**Acceptable Values:** any alpha-numeric character string from 1 to 8 characters long

#### **U-Value**

**Description:** time rate of heat flow per unit area across a surface

**Acceptable Values:** 0.0 to 20.0 (see Reference Tables Section)

**Units:** Btu/hr-ft<sup>2</sup>-°F

#### **ASHRAE Roof Construction Code**

**Description:** ASHRAE Fundamentals Handbook Chapter 26 roof construction code number

**Acceptable Values:** 1 to 13 (see Reference Tables Section)

#### **ASHRAE Color Correction**

**Description:** ASHRAE Fundamentals Handbook Chapter 26 color adjustment figure

**Acceptable Values:** 1.0 if dark color or in an industrial area, 0.83 if medium, 0.65 if light  
(NOTE: Use light color roof only where permanence of light color is established by experience, as in rural areas or where there is little smoke.)

**Units:** unitless multiplier

#### **Suspended Ceiling Plenum**

**Description:** binary No/Yes code answering the question: Is there a suspended ceiling below this roof?

**Acceptable Values:** 0 = No suspended ceiling; 1 = Yes suspended ceiling

### ***Window Constructions***

#### **User Name**

**Description:** name used to reference a defined window construction

**Acceptable Values:** any alpha-numeric character string from 1 to 8 characters long

#### **U-Value**

**Description:** time rate of heat flow per unit area across a surface

**Acceptable Values:** 0.0 to 20.0 (see ASHRAE Fundamentals Handbook Chapter 27)

**Units:** Btu/hr-ft<sup>2</sup>-°F

### Shading Coefficient

**Description:** the ratio of solar heat gain through a glazing system under a specific set of conditions to solar gain through single-pane, clear, 1/8 inch, double-strength sheet glass with 0.86 transmittance, 0.08 reflectance, and 0.06 absorptance at normal incidence under the same conditions

**Acceptable Values:** 0.0 to 1.0 (see ASHRAE Fundamentals Handbook Chapter 27)

### Activity Definitions

Activity definitions are used to define occupancy, lighting, electric equipment, miscellaneous sensible, and hot water use levels within a thermal zone (see below) in a building description. More than one activity definition can be referenced within a single zone, in which case, the various levels indicated for each activity type will be combined for the zone. Each level has an hourly profile schedule associated with it to allow daily scheduling. When an activity definition is associated with a thermal zone (see below), a monthly schedule is attached to it to allow annual scheduling for the activity definition as a whole, as well.

For example, a single zone might be used for one activity during the day and a different activity in the evening. Creating two activity definitions with different hourly schedules and referencing both within the single thermal zone would account for this variation in use.

As another example, two different lighting systems with different hourly schedules might be installed in a single zone. One activity definition could be created to describe occupancy, electric equipment, miscellaneous sensible, hot water use, and the first lighting system. A second activity definition describing the second lighting system and with all other levels at zero could be associated with the same thermal zone to combine the lighting systems.

### Activity Name

**Description:** name used to reference a defined activity definition

**Acceptable Values:** any alpha-numeric character string from 1 to 8 characters long

### Floor/person

**Description:** floor area per person for a given activity definition; this number is used to determine occupancy levels from zone floor areas

**Acceptable Values:** any positive numeric value

**Units:** ft<sup>2</sup>

### SensLd/person

**Description:** sensible heat load per person

**Acceptable Values:** any positive numeric value (e.g., seated very light work = 245; moderately active office work = 250; standing light work = 250; light factory bench work = 275; walking 3 mph = 375; heavy work = 580)

**Units:** Btu/hr

### LatLd/person

**Description:** latent heat load per person



**Acceptable Values:** any positive numeric value (e.g., seated very light work = 155; moderately active office work = 200; standing light work = 200; light factory bench work = 475; walking 3 mph = 625; heavy work = 870)

**Units:** Btu/hr

### Hrly Profile

**Description:** user name of the hourly schedule associated with occupancy levels for this activity definition

**Acceptable Values:** any currently defined hourly schedule name

### Lighting

**Description:** installed lighting power level for this activity definition

**Acceptable Values:** positive number

**Units:** Watts/ft<sup>2</sup>

### Heat->Space

**Description:** fraction of lighting heat released into the space (i.e., not vented away from zone)

**Acceptable Values:** 0.0 to 1.0

**Units:** unitless fraction

### ASHRAE "A"

**Description:** ASHRAE "a" coefficient used in lighting heat load calculation

**Acceptable Values:** see Reference Table Section

**Units:** unitless fraction

### ASHRAE "B"

**Description:** ASHRAE "b" classification used in lighting heat load calculation

**Acceptable Values:** see Reference Table Section

### Hrly Profile

**Description:** user name of the hourly schedule associated with lighting levels for this activity definition

**Acceptable Values:** any currently defined hourly schedule name

### Elec Equipment

**Description:** installed electrical equipment power level for this activity definition

**Acceptable Values:** positive number

**Units:** Watts/ft<sup>2</sup>

### Hooded

**Description:** the fraction of heat from electrical equipment that is exhausted through a hood

**Acceptable Values:** 0.0 to 1.0

**Units:** unitless fraction

#### **Hrly Profile**

**Description:** user name of the hourly schedule associated with electric equipment levels for this activity definition

**Acceptable Values:** any currently defined hourly schedule name

#### **Misc Sensible**

**Description:** miscellaneous sensible load level for this activity definition

**Acceptable Values:** positive number

**Units:** Btu/ft<sup>2</sup>

#### **Hooded**

**Description:** the fraction of heat from the miscellaneous sensible heat load that is exhausted through a hood

**Acceptable Values:** 0.0 to 1.0

**Units:** unitless fraction

#### **Hrly Profile**

**Description:** user name of the hourly schedule associated with miscellaneous sensible heat load levels for this activity definition

**Acceptable Values:** any currently defined hourly schedule name

#### **Hot Water Use**

**Description:** the amount of hot water consumed per day by each occupant in the thermal zone to which this activity type is associated

**Acceptable Values:** positive number

**Units:** gallons per day

#### **Hrly Profile**

**Description:** user name of the hourly schedule associated with hot water use levels for this activity definition

**Acceptable Values:** any currently defined hourly schedule name

### **Building Components**

#### ***HVAC Operation Schedules***

Operation schedules are the basic mechanism for defining the hours of operation of the building fan system(s). There are three types of such schedules, as shown below, depending on the day type (weekday, Saturday, or Sunday). If more than one fan system is defined and used in a building, all will have the same hours of operation, as defined by these schedules. Fractional values are acceptable, and signify a partial hour of operation.

#### **Weekday Schedule**

**Description:** user name of the hourly schedule associated with fan systems in effect during weekdays

**Acceptable Values:** any currently defined hourly schedule name

#### Saturday Schedule

**Description:** user name of the hourly schedule associated with fan systems in effect during Saturdays

**Acceptable Values:** any currently defined hourly schedule name

#### Sunday Schedule

**Description:** user name of the hourly schedule associated with fan systems in effect during Sundays

**Acceptable Values:** any currently defined hourly schedule name

### *Heating Plants*

Heating plants are the primary equipment that use energy to provide heating to a building. All parameters required to simulate the energy consumption of a heating plant are accessible on this detailed data screen. Several heating plants may be defined for each building description. Heating plant input fuel consumption will automatically be allocated to the specified energy type if it has been defined to exist. Demands on the heating plant are defined by assignment as part of the definition of various heat-using components, e.g., HVAC systems (see *HVAC Systems* below), domestic hot water demands, and miscellaneous process heat requirements.

#### Htg Plant Name

**Description:** name used to reference a defined heating plant

**Acceptable Values:** any alpha-numeric character string from 1 to 8 characters long

#### Htg Plant Type

**Description:** the type of heating plant

**Acceptable Values:** *sum, boiler, furnace, disth*

*sum:* heating demand is a simple sum of all defined demand sources, at 100% efficiency and infinite capacity, and no auxiliary energy requirements.

*boiler:* plant input calculated using DOE-2 part load curves; assumes finite boiler capacity and auxiliary power requirements, if defined. Other characteristics are defined with parameters discussed immediately below.

*furnace:* similar to boiler, but uses DOE-2 furnace part load efficiency curves.

*disth:* District heating plant type assumes 100% efficiency, but allows for the calculation of auxiliary power requirements for circulating pumps.

#### Energy Source

**Description:** the type of energy consumed by the heating plant

**Acceptable Values:** *elec, gas, #2oil, #6oil, coal, disth, other*

*elec, gas, #2oil, #6oil, coal* Self-explanatory.

*disth:* district heating.

*other:* Either an undefined fuel type, or can be used as an “alternate meter” for one or more components that use one of the previously defined fuels.

### Monthly Avail

**Description:** user name of the monthly schedule associated with the heating plant

**Acceptable Values:** any currently defined monthly schedule name

### # of Units

**Description:** the number of units of the type and capacity of the heating plant

**Acceptable Values:** positive integer

### Capacity

**Description:** the heating capacity of each unit of the heating plant

**Acceptable Values:** positive number

**Units:** kBtu/hr

### Peak Margin

**Description:** an additional safety margin to be used for equipment sizing (NOTE: this value has no importance after sizing has been performed or a capacity has been manually entered)

**Acceptable Values:** 0.0 to 100.0

**Units:** unitless percent

### Design Eff

**Description:** the design (rated) efficiency of the heating plant (NOTE: part load ratio performance curves are used during simulation to adjust the design efficiency for off-design (off-rated) operating conditions)

**Acceptable Values:** 0.0 to 100.0

**Units:** unitless percent

### Staged

**Description:** binary 0/1 code indicating the configuration of a multiple-unit heating plant

**Acceptable Values:** 0 = parallel; 1 = staged

*parallel:* All heating plant units are on simultaneously and equally share the total demand.

*staged:* Plant units come on one at a time, as necessary to satisfy the total demand. Thus, of all active units, one is partially loaded and the rest are at full capacity.

### Operation Type

**Description:** binary 1/2 code indicating the operation type of the heating plant

**Acceptable Values:** 1 = continuous; 2 = as needed

### Pump Elec

**Description:** the electricity power of the boiler pump

**Acceptable Values:** positive or negative number

positive number or zero: Actual plant auxiliary power requirement

negative number: Any negative number will result in an automatic calculation of the auxiliary power, which is based on plant demand and is calculated for each unit in the plant as  $0.01 * \text{unit capacity} * (.33 + .67 * \text{unit part load ratio})$ .

**Units:** kW

### Pilot Consump

**Description:** the gas consumption of the boiler pilot

**Acceptable Values:** positive number

**Units:** kBtu/hr

## Cooling Plants

Cooling plants are the primary equipment that use energy to provide cooling to a building. All parameters required to simulate the energy consumption of a cooling plant are accessible on this detailed data screen. Several cooling plants may be defined for each building description. Each cooling plant must then be associated with an HVAC system for its energy consumption to be included in simulation results (see *HVAC Systems* below).

### Clg Plant Name

**Description:** name used to reference a defined cooling plant

**Acceptable Values:** any alpha-numeric character string from 1 to 8 characters long

### Clg Plant Type

**Description:** the type of cooling plant

**Acceptable Values:** *sum, centr, recip, screw, absorp, dxac, distc*

*sum*: Simple sum of input demands at 100% efficiency and no auxiliary power requirements.

*centr*: Centrifugal compressor chiller (DOE-2 part load curve).

*recip*: Reciprocating compressor chiller (DOE-2 part load curve).

*screw*: Screw type compressor chiller (DOE-2 part load curve).

*absorp*: Absorption chiller (DOE-2 part load curve).

*dxac*: Direct expansion air cooled condensing unit. (DOE-2 part load curve).

*distc*: District cooling plant type. Assumes 100% efficiency, but allows for the calculation of auxiliary power requirements for circulating pumps.

### Energy Source

**Description:** the type of energy consumed by the cooling plant

**Acceptable Values:** *elec, gas, #2oil, #6oil, coal, distc, other, hplant*

*elec, gas, #2oil, #6oil, coal* self-explanatory.

*distc* district cooling.

*other*: either an undefined fuel type, or can be used as an “alternate meter” for one or more components that use one of the previously defined fuels.

*hplant* heating plant

### Monthly Avail

**Description:** user name of the monthly schedule associated with the cooling plant

**Acceptable Values:** any currently defined monthly schedule name

### Heating Plant

**Description:** name used to assign absorption chiller demand to a heating plant.

**Acceptable Values:** any currently defined heating plant name

### # of Units

**Description:** the number of units of the type and capacity of the cooling plant

**Acceptable Values:** positive integer

### Capacity

**Description:** the cooling capacity of each unit of the cooling plant

**Acceptable Values:** positive number

**Units:** tons

### Peak Margin

**Description:** an additional safety margin to be used for equipment sizing (NOTE: this value has no importance after sizing has been performed or a capacity has been manually entered)

**Acceptable Values:** 0.0 to 100.0

**Units:** unitless percent

### Design COP

**Description:** the design (rated) coefficient of performance of the cooling plant (NOTE: part load ratio performance curves are used during simulation to adjust the design COP for off-design (off-rated) operating conditions)

**Acceptable Values:** positive number

**Units:** unitless ratio

### Staged

**Description:** binary 0/1 code indicating multiple-unit plant operation scheme

**Acceptable Values:** 0 = parallel; 1 = staged

*parallel*: All cooling plant units are on simultaneously and equally share the total demand.

*staged*: Plant units come on one at a time, as necessary to satisfy the total demand. Thus, of all active units, one is partially loaded and the rest are at full capacity.

### Operation Type

**Description:** binary 1/2 code indicating the operation type of the cooling plant

**Acceptable Values:** 1 = continuous; 2 = as needed

### Pump Elec

**Description:** the electricity power of the chiller plant auxiliaries

**Acceptable Values:** positive or negative number

positive number or zero: Actual plant auxiliary power requirement

negative number: Any negative number will result in an automatic calculation of the auxiliary power, which is based on plant demand and is calculated for each unit in the plant as (auxiliary factor)\*(unit capacity), where the auxiliary factor is 0.015 for DX units, 0.02 for district cooling, 0.05 for all central compressor types, and 0.15 for absorption chillers.

**Units:** kW

### Cooling Tower

**Description:** the electricity power of the cooling tower

**Acceptable Values:** positive number

**Units:** kW

## *HVAC Systems*

HVAC systems constitute the basic fan-driven air circulation systems in the building. Air circulates through the supply ducts to occupied spaces. The circulation loop is completed through return air ducts. Heating and cooling coils in the air stream transfer the energy to or from the air stream necessary to provide specified comfort conditions in the individual rooms or thermal zones. The heating and cooling coil energy requirements appear as energy demands on the appropriately specified boiler or chiller plant equipment. In RESEM, the HVAC systems are generically defined for the “air side.” Standard system types, as recognized within the industry, also require an explicit choice of mechanical cooling. This is discussed below.

### System Name

**Description:** name used to reference a defined HVAC system

**Acceptable Values:** any alpha-numeric character string from 1 to 8 characters long

### System Type

**Description:** the generic type of HVAC system

**Acceptable Values:** *sum*, *cvct*, *cvvt*, *vav*. See Reference Tables R-5 and R-6 for an explicit list of specific system types, and how they can be represented by these generic types.

*sum*: For simulation diagnostic purposes only.

*cvct*: Constant Volume Constant Temperature. Typical of reheat systems.

*cvvt*: Constant Volume Variable Temperature. Typical of single-zone type systems

vav: Variable Air Volume.

### Cooling Plant

**Description:** user name of the cooling plant associated with the HVAC system

**Acceptable Values:** any currently defined cooling plant name (NOTE: Leaving this field blank indicates that no cooling plant is associated with the HVAC system.)

### Heating Plant

**Description:** user name of the heating plant associated with the HVAC system

**Acceptable Values:** any currently defined heating plant name (NOTE: specification of a heating plant is required for each defined HVAC system.)

### Clg Avail Sch

**Description:** user name of the monthly schedule associated with the cooling plant in the HVAC system

**Acceptable Values:** any currently defined monthly schedule name (NOTE 1: schedule values must be 0 or 1. NOTE 2: if no cooling plant is associated with the HVAC system, then a monthly schedule of *off* (i.e., 0.0 for all months) should be entered)

### Htg Avail Sch

**Description:** user name of the monthly schedule associated with the heating plant in the HVAC system

**Acceptable Values:** any currently defined monthly schedule name (see NOTE 1 above)

### Supply cfm

**Description:** the design capacity of the system air supply fan. This value takes precedence over the sum of the specified zone air requirements for those zones served by this HVAC system if that sum is not equal to this specified value.

**Acceptable Values:** positive number

**Units:** cubic feet per minute (cfm)

### Fan Power

**Description:** the fan power requirement

**Acceptable Values:** positive number

**Units:** W/cfm

### Fan Control

**Description:** a numeric code indicating the fan control method

**Acceptable Values:** 0 = constant volume; 1 = speed (i.e.,modulating the speed of the fan); 2 = inlet (i.e.,modulating inlet vanes on both the supply and return fan); 3 = discharge (i.e.,modulating discharge vanes on both the supply and return fan); 4 = cycling (i.e., cycling the fan in response to the load)

### Econo Limit T



**Description:** the outside air temperature above which the economizer returns to minimum outside air operation

**Acceptable Values:** positive number (NOTE: a value of 0.0 indicates that no economizer is present)

**Units:** °F

#### Econ Enth Ctrl

**Description:** binary 0/1 code indicating whether or not economizer enthalpy control is in effect

**Acceptable Values:** 0 = No; 1 = Yes

#### Supply Min OA

**Description:** the minimum acceptable constant flow rate of fresh air, expressed as a percentage of the *Supply cfm* discussed above

**Acceptable Values:** 0.0 to 100.0

**Units:** unitless percent

#### VV: min Air

**Description:** the minimum air flow rate, caused by the stop position on the VAV boxes, expressed as a percentage of the *Supply cfm* discussed above

**Acceptable Values:** 0.0 to 100.0

**Units:** unitless percent

#### VV: Control

**Description:** a numeric code indicating the VAV fan control method (currently ignored)

**Acceptable Values:** 1 = variable speed; 2 = discharge dampers; 3 = inlet vanes

#### Minimum %RH

**Description:** the minimum allowable relative humidity in thermal zones (NOTE: a value of 0.0 indicates no minimum humidity control)

**Acceptable Values:** 0.0 to 100.0

**Units:** unitless percent

#### Clg Coil des T

**Description:** designed exit air temperature of the system cooling coil, typically in the range of 50 - 60 °F.

**Acceptable Values:** positive number

**Units:** °F

#### Temp Reset

**Description:** indicator that the cooling coil exit temperature can be raised (i.e., reset) in response to some external criterion.

**Acceptable Values:** 0 = none; 1 = OA schedule (i.e., reset temperature is a function of outside air temperature between the high and low limits, as specified below); 2 = discriminator (i.e., is a reset scheme that finds the highest supply air temperature that will still satisfy the cooling requirements of the warmest zone served by this system)

#### **Reset Hi Limit**

**Description:** outside high limit temperature at which coil reset begins; typically in the range of 60 - 80 °F

**Acceptable Values:** positive number

**Units:** °F

#### **Reset Lo Limit**

**Description:** outside low limit temperature at which coil reset stops; typically in the range of 30 - 40 °F

**Acceptable Values:** positive number

**Units:** °F

#### **Clg Coil max T**

**Description:** maximum coil exit air temperature achievable by reset or discriminator; typically in the range 60 - 70 °F

**Acceptable Values:** positive number

**Units:** °F

#### **Htg Coil des T**

**Description:** designed exit air temperature of the system heating coil; typically in the range 100 - 120 °F

**Acceptable Values:** positive number

**Units:** °F

### ***Miscellaneous Heat Sources***

Miscellaneous heat sources are additional requirements for heat above and beyond thermal zone heating. Laundry facilities requiring significant amounts of heat are an example of a miscellaneous heat source.

#### **Name**

**Description:** name used to reference a defined miscellaneous heat source

**Acceptable Values:** any alpha-numeric character string from 1 to 8 characters long

#### **Rate**

**Description:** the peak rate required by the heat source

**Acceptable Values:** positive number

**Units:** kBtu/hr

#### **Hourly Sched**

**Description:** user name of the hourly schedule associated with the miscellaneous heat source

**Acceptable Values:** any currently defined hourly schedule name

#### **Monthly Sched**

**Description:** user name of the monthly schedule associated with the miscellaneous heat source

**Acceptable Values:** any currently defined monthly schedule name

#### **Heating Plant**

**Description:** user name of the heating plant which provides the heat for this miscellaneous heat source

**Acceptable Values:** any currently defined heating plant name

### ***Miscellaneous Electric Sources***

Miscellaneous electric sources are additional requirements for electricity above and beyond those for heating, cooling, fans, lighting, and electrical equipment specified elsewhere. These sources allow RESEM to account for electricity consumption which is not associated with these requirements and which do not produce additional heat loads in thermal zones. Exterior lighting would be an example of a miscellaneous electric source.

#### **Name**

**Description:** name used to reference a defined miscellaneous electric source

**Acceptable Values:** any alpha-numeric character string from 1 to 8 characters long

#### **Rate**

**Description:** the peak rate required for the electric source

**Acceptable Values:** positive number

**Units:** kW

#### **Hourly Sched**

**Description:** user name of the hourly schedule associated with the miscellaneous electric source

**Acceptable Values:** any currently defined hourly schedule name

#### **Monthly Sched**

**Description:** user name of the monthly schedule associated with the miscellaneous electric source

**Acceptable Values:** any currently defined monthly schedule name

### ***Thermal Zones***

Thermal zones are collections of data which bring together the components of a building description that represent conditioned spaces in a building. Thermal zones include: walls, windows, roofs, activity definitions, thermostat set points, infiltration rates, and other parameters which describe the thermal characteristics of a portion of the building(s) under analysis.

RESEM currently allows up to 25 thermal zones to be defined for a single analysis. This gives RESEM the capability to analyze more than one building at one time, although this may complicate reconciliation with utility bills.

A thermal zone does not necessarily correspond to a physical room or even a collection of rooms in a building. A thermal zone can be an abstract entity which accurately defines energy consumption requirements within a collection of areas, in one or more buildings, which behave in thermally similar ways. This concept is particularly important in regard to the prototypical building descriptions generated by RESEM. These prototypical buildings cannot be drawn to scale from the thermal zone descriptions. However, they do accurately represent the energy consumption characteristics of these types of buildings.

**PLEASE NOTE:** The detailed data screen for thermal zones includes sub-menus and additional data sub-screens for the multiple zone components of: thermostat set points, infiltration rates, activity definitions, walls, roofs, and windows. If an item such as the surface area of one wall is edited, **first** the data for the wall data screen must be transmitted (by pressing the **F10** key), and **secondly** the zone data screen must also be transmitted (**F10**) in order to save the edited wall changes.

#### **Existing Zone Number**

**Description:** sequential number of the thermal zone

**Acceptable Values:** automatically assigned internally; this value is for reference only and cannot be changed by the user

#### **Zone Name**

**Description:** name used to reference a defined thermal zone

**Acceptable Values:** any alpha-numeric character string from 1 to 8 characters long

#### **Floor Area**

**Description:** the total floor area of the thermal zone

**Acceptable Values:** positive number

**Units:** ft<sup>2</sup>

#### **Height**

**Description:** the floor to floor height of the thermal zone

**Acceptable Values:** positive number

**Units:** ft

#### **Space Mass Code**

**Description:** ASHRAE space mass code (not implemented)

**Acceptable Values:** 1 = light (i.e., wood construction); 2 = medium (i.e., steel or wood construction, with concrete floors); 3 = heavy (i.e., all reinforced concrete)

#### **HVAC System**

**Description:** user name of the HVAC system which provides conditioning to the thermal zone

**Acceptable Values:** any currently defined HVAC system name

**Zone CFM**

**Description:** the zone supply air rate (see fan system “supply cfm” description)

**Acceptable Values:** positive number

**Units:** cfm

**Minimum OA**

**Description:** the minimum allowable outside air ventilation rate per person for the zone

**Acceptable Values:** positive number

**Units:** cfm/person

**Hot Water Plant**

**Description:** user name of the heating plant which provides hot water to the thermal zone

**Acceptable Values:** any currently defined heating plant name

**Misc Plant**

**Description:** user name of the heating plant which satisfies the energy demands made by any miscellaneous heat sources, that are caused by the specification of zone activities. (See “Activities” definitions)

**Acceptable Values:** any currently defined heating plant name

**Thermostat**

There are four thermostat set points defined for each thermal zone; heating and cooling set points for “system-on” hours and heating and cooling set points for “system-off” hours (i.e., hours that the HVAC fan systems are specified as on or off, respectively, according to the building operation schedule).

**HeatUnoc**

**Description:** the heating set point for system-off hours for the zone

**Acceptable Values:** positive number

**Units:** °F

**HeatOc**

**Description:** the heating set point for system-on hours for the zone

**Acceptable Values:** positive number

**Units:** °F

**CoolUnoc**

**Description:** the cooling set point for system-off hours for the zone

**Acceptable Values:** positive number

**Units:** °F

**CoolOc**

**Description:** the cooling set point for system-on hours for the zone

**Acceptable Values:** positive number

**Units:** °F

### Infiltration

There are two infiltration rates defined for each thermal zone; one rate for system-on hours and one rate for system-off hours.

#### RateUnoc

**Description:** the infiltration rate for unoccupied hours for the zone

**Acceptable Values:** positive number

**Units:** air changes per hour

#### RateOc

**Description:** the infiltration rate for occupied hours for the zone

**Acceptable Values:** positive number

**Units:** air changes per hour

### Activities

One or more activity definitions may be associated with a thermal zone. Defined levels for occupancy, lighting, electric equipment, miscellaneous sensible load, and hot water use will be combined for all associated activity definitions. Refer to the description of the detailed data screen for *Activity Definitions* above for more information.

#### Name

**Description:** sequentially coded name for each activity definition associated with the thermal zone

**Acceptable Values:** automatically assigned internally; this code is for reference only and cannot be changed by the user

#### Type

**Description:** user name of an activity definition associated with the thermal zone

**Acceptable Values:** any currently defined activity definition name

#### Area

**Description:** the fraction of the total zone floor area in which this activity definition applies

**Acceptable Values:** 0.0 to 1.0

**Units:** unitless fraction

#### Mon Avail

**Description:** user name of the monthly schedule associated with the activity definition

**Acceptable Values:** any currently defined monthly schedule name

## Walls

### Name

**Description:** sequentially coded name for each wall construction associated with the thermal zone

**Acceptable Values:** automatically assigned internally (e.g., the first wall defined within the first zone will be named *z1w1*); this code is for reference only and cannot be changed by the user

### Type

**Description:** user name of a wall construction associated with the thermal zone

**Acceptable Values:** any currently defined wall construction name

### Orientation

**Description:** orientation of the wall

**Acceptable Values:** 0.00 to 360.00

**Units:** degrees clockwise from true North

### Tilt

**Description:** tilt of the wall, as measured by the direction of the wall's outward-pointing normal vector

**Acceptable Values:** 0.00 to 180.00 (0.00 = horizontal-up; 90.0 = vertical; 180.0 = horizontal-down)

**Units:** degrees from horizontal

### Area

**Description:** gross surface area of the wall including windows

**Acceptable Values:** positive number

**Units:** ft<sup>2</sup>

## Roofs

### Name

**Description:** sequentially coded name for each roof construction associated with the thermal zone

**Acceptable Values:** automatically assigned internally (e.g., the first roof defined within the first zone will be named *z1r1*); this code is for reference only and cannot be changed by the user

### Type

**Description:** user name of a roof construction associated with the thermal zone

**Acceptable Values:** any currently defined roof construction name

### Orientation

**Description:** orientation of the roof

**Acceptable Values:** 0.00 to 360.00

**Units:** degrees clockwise from true North

#### Tilt

**Description:** tilt of the roof, as measured by the direction of the roof's outward-pointing normal vector

**Acceptable Values:** 0.00 to 180.00 (0.00 = horizontal-up; 90.0 = vertical; 180.0 = horizontal-down)

**Units:** degrees from horizontal

#### Area

**Description:** gross surface area of the roof including windows (e.g., skylights)

**Acceptable Values:** positive number

**Units:** ft<sup>2</sup>

#### Windows

##### Name

**Description:** sequentially coded name for each window construction associated with the thermal zone

**Acceptable Values:** automatically assigned internally (e.g., the first window defined within the first zone will be named *z1wi1*); this code is for reference only and cannot be changed by the user

##### Type

**Description:** user name of a window construction associated with the thermal zone

**Acceptable Values:** any currently defined window construction name

##### Host name

**Description:** sequentially coded name of the wall or roof within the thermal zone which contains the window

**Acceptable Values:** any currently defined wall or roof sequential name within the thermal zone

##### Host type

**Description:** the type of surface (i.e., wall or roof) which contains the window

**Acceptable Values:** wall or roof

##### Area

**Description:** gross surface area of the window

**Acceptable Values:** positive number



Units: ft<sup>2</sup>

Leak coeff

Description: not implemented

## Building Description Reconciliation

---

Options under the *Create base building* submenu allow the user to either generate a prototypical base building description or retrieve a preferred building description, as discussed in the previous section. A third menu option allows manual refinement of the base building description. This portion of the RESEM analysis sequence establishes an initial description of the pre-retrofit building capable of being simulated for its energy consumption. The simulated energy consumption must then be compared to actual utility data to determine the accuracy with which this building description matches the real building. If the correspondence between simulated and measured (i.e., utility data) energy consumption is not acceptably close, then the building description must be appropriately modified. Modifying the building description to match simulated and measured energy consumption is referred to as reconciliation.

### What is Reconciliation?

Building description reconciliation is the process of appropriately modifying a building description so that its simulated energy consumption is equivalent to the actual energy consumption represented by user entered utility data. To allow comparison, RESEM simulates the current building description using weather data for the same time period as the entered utility data. To be considered equivalent, simulated and measured energy consumption must correspond not only in absolute quantity, but also in patterns of variation over time and under changing weather conditions. For example, simulated and measured energy consumption for a school building should have equivalent variations over the course of: an academic school day, a weekend day, an academic month (e.g., October), and a non-academic month (e.g., July). Patterns of variation should also match for typical differences between a cold December and a warm May as well as potential differences between an unseasonably cold December and an unusually warm December. Ensuring a match under these varying pre-retrofit circumstances improves the accuracy of determining the impacts of ECMs and other post-retrofit modifications, on long-term average energy consumption.

Appropriate modification of a building description means assuring that the correct building parameters are modified by the correct amount. For example, if simulated electricity consumption is higher than measured utility data, this difference could be reduced by lowering either the lighting level or the HVAC system required air supply (cfm). Both reduced lighting and reduced air supply (and therefore reduced system fan use) would result in lower simulated electricity consumption. A variety of other building description modifications might also produce the desired reduction in electricity use. Determining which combination of these parameters to modify, and by what amount, can be a difficult process.

### Performing Reconciliation

The majority of energy simulation tools currently available require the user to accomplish the reconciliation process manually. It is left up to the user to determine and implement the appropriate modifications. This manual approach is available to experienced building engineers using RESEM through use of the detailed building description data screens discussed in numerous locations throughout this reference manual.

A unique, alternative, partially automated approach to reconciliation has been developed for RESEM. The user is still required to select the appropriate parameter(s) to be considered for reconciliation modification from a list of 25 possible candidates. One or more parameters may be selected at a given time. RESEM will then automatically calculate and implement the appropriate amount of modification for each selected parameter using a sophisticated mathematical method. The

process of the user selecting a set of parameters and allowing RESEM to automatically implement modifications to these parameters is referred to as a reconciliation iteration. The results of each reconciliation iteration are presented onscreen for user review and acceptance or rejection. Any number of iterations can be performed and the results accepted or rejected (in which case RESEM will undo the modifications). This provides a highly powerful and flexible tool to aid in the matching of simulated and measured energy consumption.

Base building reconciliation options are presented in the *Reconcile building* submenu under the *Base analysis* menu. These options include: *Display comparison*, *Automatic reconcile*, *Repeat*, *Undo*, and *Manual reconcile*.

The *Display comparison* option can be selected at any time during base building reconciliation to view current differences between simulated and measured (i.e., utility) energy consumption. Similar comparative information is displayed automatically following each reconciliation iteration.

Candidate parameters are identified by the user for reconciliation by selecting the *Automatic reconcile* menu option. A submenu is displayed listing four categories of reconciliation parameters: building envelope, electrical/lighting, mechanical, and additional. Selecting one of these categories will display a final submenu listing individual reconciliation parameters. Building envelope parameters include: window area, window U-value, window shading coefficient, occupied infiltration rate, unoccupied infiltration rate, wall U-value, and roof U-value. Electrical/lighting parameters include lighting and electrical equipment. Mechanical parameters include: chiller COP, chiller capacity, supply minimum outside air percentage, fan supply rate, occupied heating thermostat set point, unoccupied heating thermostat set point, occupied cooling thermostat set point, unoccupied cooling thermostat set point, boiler efficiency, boiler capacity, economizer limit temperature, and hot water usage per person. Additional parameters include: occupancy, miscellaneous sensible, miscellaneous electric, and miscellaneous heat. For guidance in selecting appropriate parameters for your situation, refer to the Reconciliation Parameter Selection Guidelines Appendix in this reference manual.

To the right of each individual parameter is a Yes/No switch indicating whether or not you wish to include that parameter in a reconciliation iteration. To the far right, the current building-wide average value for each parameter is displayed for reference. Each switch is initially set to *No* and must be changed to *Yes* for RESEM to include the parameter in the next iteration. Once you have selected all of the parameters you wish to include, return to the *Reconcile building* submenu. As you do so RESEM will ask if you wish to include all selected parameters in a reconciliation iteration. An affirmative response will cause the automatic calculation and modification of each selected parameter. Displayed results include current simulated and measured energy consumption for each fuel type, percent differences before and after the current iteration, before and after values for each selected parameter, and a coefficient of merit for the current energy consumption match. The coefficient of merit is a unitless measure of how well energy consumption figures match for all fuel types. A perfect match will have a value of 0.0. This value is meant only to give you a target to shoot for and to help you evaluate each reconciliation iteration.

The displayed results should be evaluated for reasonableness. Although sophisticated, the mathematical techniques employed are not infallible and require user review.

Often the results of a first iteration will be reasonable without bringing the differences between simulated and measured energy consumption within an acceptably small margin. The target percent difference should be less than 0.5% (one half of one percent). If you feel that the current set of selected parameters is correct, simply repeating the previous reconciliation iteration may further reduce the differences. The previous iteration can be repeated by selecting the *Repeat* menu option.

If you feel that the modifications made to any of the selected parameters is not reasonable or that perhaps you have selected the parameters incorrectly, choose the *Undo* menu option. This option will reverse the modifications made in the previous iteration and allow you to select a different set for

the next iteration. This option allows experimentation with automatic reconciliation. Select a parameter set, try it out, evaluate the results, undo the modifications, and try another set.

A final menu option, *Manual reconcile*, allows access to the detailed building description data screens for manual modification of any of the building description data fields. Transmitting any modification of one or more of these fields will cause RESEM to perform a new simulation and display energy consumption differences. Any modification can be made in this manner and manually undone if desired. Be warned, this is the **hard** way to do things, but in certain circumstances may be the only way.

### Limitations of Automatic Reconciliation

Automatic reconciliation is a *mathematically* automated method for modifying building description parameters to minimize differences between simulated and measured energy consumption. This means that guidelines and safeguards related to modifying the user selected set of parameters must be implemented using mathematical means.

RESEM implements guidelines and safeguards in the automatic reconciliation method in several ways. Absolute boundaries are placed on each parameter value to assure that it is not modified beyond reasonable limits (e.g., the unoccupied heating thermostat set point may only range from 40°F to 80°F). Each parameter is also assigned a preferred value which anchors modification (e.g., the preferred value for unoccupied heating thermostat set point is 55°F). Mathematical solutions which are further from a parameter's preferred value are less likely to be reached than solutions which are closer. Finally, each parameter, as well as each fuel type's difference between simulated and measured consumption, is assigned a relative level of "attention" in the overall mathematical solution. For example, infiltration rates tend to be more suspect than thermostat set points. Therefore, infiltration rates are assigned a higher level of attention and are more likely to be modified, by a greater proportional amount, than thermostat set points. Of course, these relative levels only come into play if the user selects both an infiltration rate and a thermostat set point in the same iteration.

Despite these automatic reconciliation safeguards, the RESEM approach remains fundamentally mathematical. This situation requires the user to review and evaluate the solutions produced automatically.

Furthermore, there may be situations in which the automatic reconciliation procedures are unable to attain acceptable results. Under these circumstances the user may be required to resort to manual reconciliation as described above.

### Describing Energy Conservation Measures (ECMs)

---

Initial stages of a RESEM analysis generate and reconcile a description of the pre-retrofit building which then accurately matches the energy consuming characteristics of the pre-retrofit version of the building under analysis. The next stage of analysis is the description of those modifications to the pre-retrofit building which constitute the implemented energy conservation measures (ECMs).

The Institutional Conservation Program (ICP) has established a categorization of 74 ECMs which are identified by three letter codes such as BFD for **B**uilding envelope **F**enestration/windows **D**ouble glazing. RESEM contains a hierarchical submenu structure which duplicates this categorization for organizing the ECM description process. The user navigates through this menu structure until the appropriate three letter code has been identified. At that point, the user is presented with input screens which elicit the information required for the complete description of the indicated ECM.

All modifications to the pre-retrofit building which describe the implemented ECMs are stored by RESEM in a separate building description version known as the ECM version.

### **Push-Button ECMs**

Several ECM categories can be easily described by making simplifying assumptions about the nature of their retrofit characteristics. For example, if we assume that the BFD (double glazing) ECM applies to all windows in the building and that the new windows have standard characteristics, then we can simply (and automatically) replace all existing pre-retrofit windows with standard double glazing.

RESEM uses simplifying assumptions to automatically describe 23 of the more common ECM categories. Since the description of these ECMs only requires menu selection, and in some cases minimal input, they are referred to as push-button ECMs.

The simplifying assumptions made by RESEM will not always be correct for your situation. In these instances, you will have to manually describe the characteristics which make your ECM unique (see section below). The assumptions used by RESEM for automating push-button ECM descriptions are listed in the following table.

<b>Table E-1: Push-Button ECMs</b>		
<b>ECM</b>	<b>Required Input</b>	<b>Automated Modification</b>
BFD	none	Replace existing windows with new window: name=2-pane; U-value=0.55, Shading coefficient=0.88.
BFF	none	Replace existing windows with new window: name=1-p/ref, U-value=1.10, Shading coefficient=0.50.
BFI	Percent of glass to panel; Panel U-value	Reduce each window area by specified percent and replace with new wall of specified U-value, name=wi-panel.
BFS	none	Replace existing windows with new window: name=storms, U-value=0.55, Shading coefficient=0.88.
BFT	none	Replace existing windows with new window: name=3-pane; U-value=0.35, Shading coefficient=0.75.
BFW	Percent of glass walled up or closed off	Reduce each window area by specified percent and replace with surrounding surface (wall or roof).
BIZ	Percent of infiltration reduction	Reduce all infiltration rates in all thermal zones by specified percent.
BRR	Select roof; R-value added to selected roof	Replace selected roof with new roof: name=oldname*e; U-value=new calculated value.
BRW	Select wall; R-value added to selected wall	Replace selected wall with new wall: name=oldname*e; U-value=new calculated value.
ECE ECF ECH ECX	Percent lighting efficiency increase	Replace activity definitions in all thermal zones with new activity: name=zone#actv#*e, lighting=new calculated level.
MDO	Select HVAC system; New % outside air	Update selected HVAC system with the specified percent outside air.
MDS	Select thermal zone; New occupied tstat set point	Update selected thermal zone with the specified occupied thermostat set point.
MDV	Select HVAC system	Update selected HVAC system with VAV system type.
MHA	none	Update all heating plants so that pilot consumption = 0.0
MHB MHO	Select heating plant; New capacity; New efficiency	Update selected heating plant with the specified capacity and efficiency.
MHD	Select heating plant; New capacity	Update selected heating plant with the specified efficiency.
MHF MHT	New boiler efficiency	Update all heating plant boilers with the specified efficiency.
MKE	none	Update all HVAC systems to include enthalpy control.
MKT	Type of temperature reset device	Update all HVAC systems with specified temperature reset device (OA schedule or discriminator).

### Detailed Screens ECMs

For those ECMs which cannot be generalized or simplified enough to be implemented as push-buttons, the user is required to access the detailed building description screens for manual ECM description. Navigating the ECM menu selections to one of the ECM categories not listed in the

above table, will result in the display of the detailed building description screens menu (this menu and the data screens which it accesses are discussed in detail in other sections of this manual). The user is then required to locate the appropriate building description parameter(s) and manually describe the effects of the specific ECM.

It is important that you follow the correct submenu path to the particular ECM being described since this procedure properly registers the ECM category as having been implemented. This is important for future reference to the ECMs which are part of the post-retrofit building.

Note that the detailed screens can be accessed from the *O: Other* menu option on the top-level *ECM Descriptions* submenu. ECMs which are manually described using this option will be registered with the generic category of *OTH*. This option can be used to describe push-button ECMs where the assumptions behind the automated modifications (described in the table above) do not fit your situation.

It may be difficult or impossible to represent some ECMs, even through manual description, using the detailed screens. For example, infrared or motion occupancy sensors on lighting systems which dynamically respond to conditions which are not able to be detected in a RESEM energy simulation cannot be properly described. Instances such as these will reduce the accuracy with which RESEM can estimate energy savings due to ECMs, perhaps to the point where the entire analysis becomes ineffective.

## **Describing Other (non-ECM) Post-Retrofit Changes**

---

Modifications to the pre-retrofit building which are not part of implemented ECMs, but which have an impact on differences between pre and post-retrofit utility data, must be accurately described as part of a complete RESEM analysis. For example, electricity consumption of new outdoor lighting added to a recreational field adjacent to a school may be included in the post-retrofit electric utility data. To avoid considering this impact on electricity consumption in the estimate of ECM savings, it must be attributed to the outdoor lighting. Changes such as this which occur between the pre and post-retrofit periods are referred to as *Other* or *non-ECM* changes.

As with push-button ECMs (discussed above) RESEM eases the process of describing common non-ECM changes by using a menu structure to identify the type of change, followed by one or more minimal input screens which elicit required information. RESEM categorizes non-ECM changes under either *Usage Modifications* or *Building Additions*. There is also a *Detailed Screens* option on the top-level non-ECM menu to allow access to the detailed building description data screens for manual description of non-ECM changes.

Selection of the building additions menu option displays a screen prompting you to enter: the name of the existing thermal zone which is most similar to the addition, the additional floor area, the number of stories in the addition, and whether or not the addition is integrated with (i.e., adjacent to) the existing building. RESEM will then automatically create a new thermal zone using the information entered along with data taken from the indicated similar zone. This new zone can be viewed and/or manually modified by selecting the *Detailed Screens* option on the top-level non-ECM menu.

Usage modifications are subcategorized as follows: building operation, people, lighting, electric equipment, heat source, heating plant operation, cooling plant operation, miscellaneous heat, and miscellaneous electric.

The *Building Operation* option allows you to change the hourly schedules associated with the operation of the building fan systems.

Selecting the *People*, *Lighting*, *Electric Equipment*, or *Heat Source* options causes RESEM to warn you that new hourly schedules must be defined before undertaking these non-ECM descriptions. Following this warning, RESEM will display, for modification, all activity definitions which are referenced by thermal zones in the building. Definition of new hourly schedules is only required if

the selected aspect of building usage adheres to a schedule which differs from all currently existing hourly schedules. For example, assume that a school auditorium is now being used for regular evening meetings from 7:00 PM to 10:00 PM, which were not in session during the pre-retrofit period. A new hourly schedule which includes all pre-retrofit hours of auditorium use **plus** the new 7-10 PM meeting time must first be manually created using the *Detailed Screens* menu option. Following this operation, the *People* and *Lighting* menu options can be used to describe non-ECM changes in these activity levels within the auditorium zone by changing their referenced hourly schedules to the newly created one.

Selecting the *Heating Plant Operation* option displays a list of existing heating plants. Selecting a specific plant in this list will display its current monthly availability schedule. Selecting, in turn, this monthly schedule will cause RESEM to display a list of all currently defined monthly schedules. If you wish to replace the current availability schedule with an existing schedule, simply select the new schedule from the list. If you wish to define a new monthly schedule, select the first blank item in the list. You will be prompted to enter data for a new monthly schedule. When this data is transmitted, the new schedule name will be assigned to the monthly availability of the heating plant.

The *Cooling Plant Operation* option functions in the same manner as for heating plant operation changes.

Selecting either *Miscellaneous Heat* or *Miscellaneous Electric* causes RESEM to display a list of all currently defined miscellaneous heat or electric demands. Existing demands can be modified and new demands can be added.

## Retrofit Modification Adjustment

---

Describing Energy Conservation Measures and other (non-ECM) post retrofit changes can be an inexact process. Particularly for push-button ECMs and quickly described non-ECM changes, the modifications made to the appropriate building description (i.e., either ECM or POST) may include generalized assumptions and less than precise estimates.

The analysis step referred to as retrofit modification adjustment is undertaken to assure a more accurate final description of the modifications made to alter the pre-retrofit building version.

### What is Retrofit Modification Adjustment?

Retrofit modification adjustment is very similar to the building description reconciliation process described above. It is the process of appropriately modifying both the ECM and the final POST-Retrofit building descriptions so that simulated post-retrofit energy consumption is equivalent to the actual energy consumption represented by user entered utility data. To allow comparison, RESEM simulates the current post-retrofit building description using weather data for the same time period as the entered utility data. To be considered equivalent, simulated and measured energy consumption must correspond not only in absolute quantity, but also in patterns of variation over time and under changing weather conditions. For example, simulated and measured energy consumption for a school building should have equivalent variations over the course of: an academic school day, a weekend day, an academic month (e.g., October), and a non-academic month (e.g., July). Patterns of variation should also match for typical differences between a cold December and a warm May as well as potential differences between an unseasonably cold December and an unusually warm December. Ensuring a match under these varying post-retrofit circumstances improves the accuracy of determining the impacts of ECMs and other post-retrofit modifications, on long-term average energy consumption.

The key difference between pre-retrofit building description *reconciliation* and post-retrofit modification *adjustment* is that **all adjustment modifications made to the post-retrofit building description must be restricted to only those aspects of the building which have changed between the pre-retrofit and post-retrofit periods.** The operating assumption behind this difference is that

pre-retrofit building description reconciliation has resulted in an accurate description of the pre-retrofit building. Therefore, any discrepancies between simulated and measured post-retrofit energy consumption must be attributable to inaccuracies in describing either ECM or other non-ECM changes to the pre-retrofit building description.

A second difference between post-retrofit adjustment and pre-retrofit reconciliation is that adjustments must be associated with either an ECM modification or an other non-ECM change.

### **Performing Retrofit Modification Adjustment**

The RESEM menu structure for performing retrofit modification adjustment is nearly identical to that for performing building description reconciliation. One visible difference is the substitution of the word “adjustment” for the pre-retrofit term of “reconciliation.” See the description of performing the reconciliation process above for details related to this activity.

Candidate parameters are identified by the user for adjustment by selecting the *Automatic adjustment* menu option. It is up to you, the user, to restrict selection of automatic building adjustment parameters to only those aspects affected by post-retrofit changes.

A second visible difference between pre-retrofit reconciliation and post-retrofit modification adjustment appears in the toggle switch to the right of each individual adjustment parameter. For reconciliation, this is a simple Yes/No switch indicating whether or not you wish to include the parameter in a reconciliation iteration. For adjustment, this becomes a three-way switch with values of *No*, *ECM*, and *NON*. Each switch is initially set to *No* and must be changed either to *ECM* or to *NON* for RESEM to include the parameter in the next adjustment iteration. This is a sequential switch; selecting a parameter when the switch is set at *No* will change the switch to *ECM*. Selecting the parameter a second time will change the switch from *ECM* to *NON*. Selecting the parameter again will change the switch back to *No*.

This three-way switch implements a conceptual difference between pre-retrofit reconciliation and post-retrofit adjustment. RESEM must know whether you wish to adjust a parameter because you suspect an inaccuracy in an ECM description modification or an other non-ECM change. This requirement relates to RESEM’s ability to separate impacts on energy consumption due to ECMs from non-ECMs. To fulfill this requirement, RESEM maintains three distinct building description versions: the *pre-retrofit* (or base) version, an *ecm* version which describes all ECM modifications to the pre-retrofit building, and a *post-retrofit* version which describes both ECM and non-ECM modifications. Reconciliation, appropriately modifies the *pre-retrofit* building description version to match pre-retrofit utility data. Retrofit adjustment, must appropriately modify either the *ecm* or the *post-retrofit* building descriptions depending on the suspected inaccuracy in retrofit description.

If you suspect an inaccuracy in an ECM modification, set the adjustment iteration switch for the appropriate parameter to *ECM*. If you suspect an inaccuracy in a non-ECM modification, set the adjustment iteration switch for the appropriate parameter to *NON*. For example, assume that you suspect inaccuracies in two aspects of your school building retrofit modifications; an ECM modification to unoccupied infiltration rates and a non-ECM related addition of exterior electric lighting to an adjacent ball field. Within a single adjustment iteration you could set the building envelope adjustment switch for unoccupied infiltration rate to *ECM* and the additional adjustment switch for miscellaneous electric to *NON*. RESEM would then determine the appropriate amount of adjustment modification for each of these parameters. RESEM would also automatically modify the *post-retrofit* building description to reflect both of these adjustments. The *ecm* building description version would be automatically modified to reflect only the infiltration rate adjustment.

If you choose to manually perform retrofit modification adjustment, you still must indicate to RESEM whether your adjustment relates to an ECM or non-ECM change. If you indicate that you wish to make a non-ECM adjustment, RESEM will display the detailed building description data screens for the *post-retrofit* version. If you indicate that you wish to make an ECM adjustment, RESEM will first display the detailed screens for the *post-retrofit* version, followed immediately by



the detailed screens for the *ecm* building description version. You *must* exactly duplicate the adjustment modifications for both building description versions.

### Limitations of Automatic Retrofit Modification Adjustment

Automatic retrofit modification adjustment exhibits all limitations associated with pre-retrofit reconciliation. See the discussion of these limitations presented under the Building Description Reconciliation topic above.

The requirement of associating a retrofit adjustment with either an ECM modification or a non-ECM change places an additional limitation on automatic adjustment. This occurs in the case where both an ECM modification and a non-ECM change impact a single adjustment parameter which you wish to include in an adjustment iteration. For example, a lighting conversion ECM might lower electric consumption due to lights while a non-ECM building addition increases overall consumption of electricity due to lighting. Under circumstances like this, you may be forced to resort to manual adjustment. To aid your determination of how much overall adjustment is required, you could perform an automatic adjustment iteration, note the calculated parameter change, undo this automatic iteration, and manually apportion the calculated change between ECM and non-ECM effects.

## Reports

---

RESEM provides several formatted reports for the purpose of documenting, viewing, and printing both the intermediate and final results of a retrofit savings analysis procedure. These reports include: a project summary report, a building description report, and two types of energy consumption reports.

RESEM report menu options allow you to save each report to a file on your hard disk as described under the Command Summary section of this manual. This section provides information on viewing and printing the various reports which you may create in this manner.

### Report Descriptions

The Project Summary Report contains the information entered on the project information screen, the beginning and ending dates for both pre and post-retrofit utility data, a list of the Energy Conservation Measure codes for the ECMs which were implemented in this project, and energy savings estimates. The energy savings estimates are presented in both the form displayed onscreen following the final savings estimate calculations and in energy use index (EUI) units of kBtus/ft<sup>2</sup>-yr. **NOTE:** The Project Summary Report is decidedly different from the project archive file saved to disk using the *Save project* option under the *File* menu. The report file is formatted for visual inspection. The project archive file contains all data required to recreate a completed energy savings analysis or pick up where you left off in the middle of an analysis. Do not confuse these two files. If you fail to save the Project Summary Report file, you can quickly recreate it by retrieving a saved project archive file. If you fail to save a project archive file, you will have to repeat your analysis from the beginning.

The Building Description Report contains a complete description of all library and building component parameters for a selected building description version (i.e., pre, post, or ecm). This includes all defined library components of hourly schedules, monthly schedules, activity definitions, walls, roofs, and windows; even if they are not referenced by building components. Listed building components include: building operation schedules, heating plants, cooling plants, HVAC systems, thermal zones, miscellaneous heating requirements, and miscellaneous electric requirements. Each thermal zone includes: floor area, height, ASHRAE mass code, HVAC system name, zone cfm, zone minimum outside air percentage, hot water plant, miscellaneous plant, heating and cooling thermostat set points, infiltration rates, activity definitions, walls, roofs, and windows. **NOTE:** The Building Description Report is formatted differently than the building description input file saved to disk using the *save building* option under the *File* menu. The report file is formatted for visual inspection. The

building description input file contains all data required to retrieve a library and building description which has been saved to disk into an ongoing savings analysis process. Do not confuse these two files.

The Energy Consumption Summary contains total monthly consumption for a selected building version (i.e., pre, post, or ecm), for each fuel type, for each month of the selected weather type (i.e., long term or actual). Totals for each fuel type for the selected weather type period are also included.

The End Use Energy Consumption report contains total monthly consumption for a selected building version (i.e., pre, post, or ecm), for each end use (e.g., space heating, fans, lights), for each fuel type, for each month of the selected weather type (i.e., long term or actual). Monthly totals for each fuel type are included. Totals for each end use, for each fuel type for the selected weather type period are also included.

### Viewing Reports

Each report is saved to a file in the RESEM subdirectory on your hard disk in standard text (ASCII) format. You can perform a directory listing (using the DOS *dir* command) to see which files you have saved. All project summary reports have the *.prj* filename extension. All building description reports have the *.bld* filename extension. All energy consumption summary reports have the *.egy* filename extension. All end use energy consumption reports have the *.eg2* filename extension.

The contents of these text files can be viewed in a variety of ways. All popular word processors are capable of opening standard text files. Refer to the documentation for your word processor to learn details regarding this straightforward operation. The smaller files (the project summary and two energy consumption reports) can be viewed on your monitor screen using the *type* and *more* DOS commands. For example, to view a report file named *demo.prj* onscreen, enter the following command at the DOS prompt in your RESEM directory. (The *|* symbol is called a pipe and is generally typed by using the SHIFT-\*\* (i.e., “uppercase” backslash) keystroke on most keyboards.)

```
type demo.prj | more
```

For purposes of both viewing and manipulating the End Use Energy Consumption report, import the file into a spreadsheet package like Lotus 123 or Microsoft Excel. Refer to your spreadsheet documentation for details regarding importing text files. The advantage of this operation is that you can not only view the report file contents, but also manipulate the row and column formatted data to perform your own data analysis or generate visually effective graphs of the results.

### Printing Reports

As described above, all report files are saved to disk in standard text (ASCII) format. If you have imported a text file into your word processor or spreadsheet, you can use that software’s printing capabilities to produce a printed report.

The most straightforward approach to printing a report, however, is to use the DOS *print* command. Refer to your DOS documentation for details regarding this command. Refer to your printer documentation for details regarding printing text documents in compressed print mode. This print mode allows more characters per line (e.g., 132 characters per line on a standard 80 character per line dot matrix printer). In particular, the Building Description Report and the End Use Energy Consumption report benefit from being printed using compressed print mode. To print a report file named *demo.prj* using a standard printer connected to your computer, enter the following command at the DOS prompt in your RESEM directory.

```
print demo.prj
```

The first time you use the DOS *print* command, the size of DOS in RAM increases until your computer is restarted. Since RESEM requires as much free RAM memory as possible, you may

experience insufficient memory problems when using RESEM after using the *print* command. To remove the *print* command from memory, restart your computer.

---

---

## REFERENCE TABLES

### Section Table of Contents

---

Table R-1	
ASHRAE Wall Construction Group Code Descriptions .....	85
Table R-2	
ASHRAE Roof Construction Code Descriptions .....	86
Table R-3	
ASHRAE a Coefficient Design Values .....	87
Table R-4	
ASHRAE b Classification Design Values .....	87
Table R-5	
School Specific HVAC System Types Based on Generic Types .....	88
Table R-6	
Hospital Specific HVAC System Types Based on Generic Types.....	88
Table R-7	
Building Envelope Parameter Selection .....	90
Table R-8	
Electrical/Lighting Parameter Selection .....	91
Table R-9	
Mechanical Parameter Selection.....	92
Table R-10	
Additional Parameter Selection .....	94

<b>Table R-1: ASHRAE Wall Construction Group Code Descriptions<sup>†</sup></b>		
Group Code	Description of Construction	U-Value
<b>4 inch Face brick plus (brick)</b>		
C	air space + 4 inch face brick	0.36
D	4 inch common brick	0.42
C	1 inch insulation or air space plus 4 inch common brick	0.17-0.30
B	2 inch insulation + 4 inch common brick	0.11
B	8 inch common brick	0.30
A	insulation or air space + 8 inch common brick	0.15-0.24
<b>4 inch Face brick plus (heavyweight concrete)</b>		
C	air space + 2 inch concrete	0.35
B	2 inch insulation + 4 inch concrete	0.12
A	air space or insulation + 8 inch or more concrete	0.11
<b>4 inch Face brick plus (light or heavyweight concrete block)</b>		
E	4 inch block	0.32
D	air space or insulation + 4 inch block	0.15-0.25
D	8 inch block	0.27
C	air space or 1 inch insulation + 6 or 8 inch block	0.22-0.28
B	2 inch insulation + 8 inch block	0.10-0.11
<b>4 inch Face brick plus (clay tile)</b>		
D	4 inch tile	0.38
D	air space + 4 inch tile	0.28
C	insulation + 4 inch tile	0.17
C	8 inch tile	0.28
B	air space or 1 inch insulation + 8 inch tile	0.14-0.22
A	2 inch insulation + 8 inch tile	0.10
<b>Heavyweight concrete wall plus (finish)</b>		
E	4 inch concrete	0.58
D	4 inch concrete + 1 or 2 inch insulation	0.12-0.20
C	2 inch insulation + 4 inch concrete	0.12
C	8 inch concrete	0.49
B	8 inch concrete + 1 or 2 inch insulation	0.12-0.19
A	2 inch insulation + 8 inch concrete	0.12
B	12 inch concrete	0.42
A	12 inch concrete + insulation	0.11
<b>Light and heavyweight concrete block plus (finish)</b>		
F	4 inch block + air space/insulation	0.16-0.26
E	2 inch insulation + 4 inch block	0.10-0.11
E	8 inch block	0.29-0.40
D	8 inch block + air space/insulation	0.15-0.17
<b>Clay tile plus (finish)</b>		
F	4 inch tile	0.42
F	4 inch tile + air space	0.30
E	4 inch tile + 1 inch insulation	0.18
D	2 inch insulation + 4 inch tile	0.11
D	8 inch tile	0.30
C	8 inch tile + air space/1 inch insulation	0.15-0.23
B	2 inch insulation + 8 inch tile	0.10
<b>Metal curtain wall</b>		
G	with/without air space + 1 to 3 inch insulation	0.09-0.23
<b>Frame wall</b>		
G	1 to 2 inch insulation	0.08-0.18

<sup>†</sup> Data in this table derives from 1989 ASHRAE Handbook of Fundamentals Chapter 26 Table 30

<b>Roof No.</b>	<b>Description of Construction</b>	<b>U-Value No Suspended Ceiling</b>	<b>U-Value Suspended Ceiling</b>
<b>1</b>	Steel sheet with 1 inch insulation	0.21	0.13
<b>2</b>	1 inch wood with 1 inch insulation	0.17	0.12
<b>3</b>	4 inch lightweight concrete	0.21	0.13
<b>4</b>	2 inch heavyweight concrete with 1 inch insulation	0.21	0.13
<b>5</b>	1 inch wood with 2 inch insulation	0.11	0.08
<b>6</b>	6 inch lightweight concrete	0.16	0.11
<b>7</b>	2.5 inch wood with 1 inch insulation	0.13	0.10
<b>8</b>	8 inch lightweight concrete	0.13	0.09
<b>9</b>	4 inch heavyweight concrete with 1 inch insulation	0.20	0.13
<b>10</b>	2.5 inch wood with 2 inch insulation	0.09	0.07
<b>11</b>	Roof terrace system	0.11	0.08
<b>12</b>	6 inch heavyweight concrete with 1 inch insulation	0.19	0.12
<b>13</b>	4 inch wood with 1 inch insulation	0.11	0.08

<sup>†</sup> Data in this table derives from 1989 ASHRAE Handbook of Fundamentals Chapter 26 Table 28

<i>a</i>	Furnishings	Air Supply and Return	Type of Light Fixture
0.45	Heavyweight, simple furnishings, no carpet	Low rate; supply and return below ceiling (air supply rate $\leq 0.5$ cfm/ft <sup>2</sup> )	Recessed, not vented
0.55	Ordinary furniture, no carpet	Medium to high ventilation rate; supply and return below ceiling or through ceiling grill and space (air supply rate $\geq 0.5$ cfm/ft <sup>2</sup> )	Recessed, not vented
0.65	Ordinary furniture, with or without furniture	Medium to high ventilation rate or fan coil or induction type air-conditioning terminal unit; supply through ceiling or diffuser; return around light fixtures and through ceiling space (air supply rate $\geq 0.5$ cfm/ft <sup>2</sup> )	Vented
0.75	Any type of furniture	Ducted returns through light fixtures	Vented or free-hanging in air stream with ducted returns

<sup>†</sup> Data in this table derives from 1989 ASHRAE Handbook of Fundamentals Chapter 26 Table 41

Floor Construction <sup>a</sup>	Room Air Circulation and Type of Supply and Return <sup>b</sup>			
	Low	Medium	High	Very High
2 inch Wood Floor (10 lb/ft <sup>2</sup> )	B	A	A	A
3 inch Concrete Floor (40 lb/ft <sup>2</sup> )	B	B	B	A
6 inch Concrete Floor (75 lb/ft <sup>2</sup> )	C	C	C	B
8 inch Concrete Floor (120 lb/ft <sup>2</sup> )	D	D	C	C
12 inch Concrete Floor (160 lb/ft <sup>2</sup> )	D	D	D	D

<sup>†</sup> Data in this table derives from 1989 ASHRAE Handbook of Fundamentals Chapter 26 Table 42

<sup>a</sup> Floor covered with carpet and rubber pad; for a floor covered only with floor tile take next classification to the right in the same row.

<sup>b</sup> *Low*: Low ventilation rate - minimum required to cope with cooling load from lights and occupants in interior zone. Supply through floor, wall, or ceiling diffuser. Ceiling space not vented and  $h = 0.4$  Btu/hr•ft<sup>2</sup>•°F (where  $h$  = inside surface convection coefficient used in calculation of  $b$ ).

*Medium*: Medium ventilation rate. Supply through floor, wall, or ceiling diffuser. Ceiling space not vented and  $h = 0.6$  Btu/hr•ft<sup>2</sup>•°F

*High*: Room air circulation induced by primary air of induction unit or by fan coil unit. Return through ceiling space and  $h = 0.8$  Btu/hr•ft<sup>2</sup>•°F

*Very High*: High room air circulation used to minimize temperature gradients in a room. Return through ceiling space and  $h = 1.2$  Btu/hr•ft<sup>2</sup>•°F

<b>Specific HVAC System Description</b>	<b>Generic Type<sup>a</sup></b>	<b>Fan Power (W/cfm)</b>	<b>Economizer Limit Temperature</b>
Auditorium Air Conditioning	CVVT	0.7	70
Auditorium Heating and Ventilation <sup>b</sup>	CVVT	0.7	80
Classroom Unit Vent - Chilled Water Coil	CVVT	0.4	70
Classroom Unit Vent - Packaged AC (DX) <sup>c</sup>	CVVT	0.4	60
Classroom Unit Vent - (no AC) <sup>b</sup>	CVVT	0.4	80
Rooftop Air Conditioner <sup>cd</sup>	CVVT	0.7	60
Central Heating and Ventilation (Columbus) <sup>b</sup>	CVVT	0.7	80
Central VAV	VAV	1.2	70
Central Dual Duct/VAVE <sup>e</sup>	VAV	1.0	70
Central Air Conditioning	CVVT	0.8	70
Classroom Fan Coil <sup>f</sup>	CVVT	0.3	0
Gymnasium Heating and Ventilation (no AC) <sup>b</sup>	CVVT	0.4	80

<sup>a</sup> CVCT = Constant Volume Constant Temperature; CVVT = Constant Volume Variable Temperature; VAV = Variable Air Volume

<sup>b</sup> Set cooling availability to “off”

<sup>c</sup> Select cooling plant type “dxac”

<sup>d</sup> Select heating plant type “furnace” and heating fuel type “gas”

<sup>e</sup> Set VV: min Air at 50%

<sup>f</sup> Select heating and cooling availabilities for no overlap

<b>Specific HVAC System Description</b>	<b>Generic Type<sup>a</sup></b>	<b>Fan Power (W/cfm)</b>	<b>Economizer Limit Temperature</b>
Clinic Area Reheat	CVCT	1.0	70
Clinic Area VAV	VAV	1.2	70
Clinic Area Powered Induction Units	VAV	1.3	70
Patient Room Reheat	CVCT	0.7	70
Patient Room Fan Coil - 2 Pipe <sup>b</sup>	CVVT	0.3	0
Patient Room Fan Coil - 4 Pipe <sup>c</sup>	CVVT	0.3	0
Patient Room Corridor Make-Up Air <sup>d</sup>	CVVT	0.8	70
Patient Room Packaged AC Units (Window) <sup>ef</sup>	CVVT	0.3	0
Patient Room Radiators Only <sup>gh</sup>	CVVT	0.01	0

<sup>a</sup> CVCT = Constant Volume Constant Temperature; CVVT = Constant Volume Variable Temperature; VAV = Variable Air Volume

<sup>b</sup> Select heating and cooling availabilities for no overlap

<sup>c</sup> Heating and cooling availabilities overlap is OK

<sup>d</sup> Set supply minimum outside air at 100%

<sup>e</sup> Select cooling plant type “dxac”

<sup>f</sup> Select electric resistance heating plant: type “furnace”, fuel “elec”, efficiency 100%, pump electric 0.0, pilot consumption 0.0

<sup>g</sup> Set cooling availability to “off”

<sup>h</sup> Set supply cfm to average exterior air flow rate; set minimum outside air at 100%



## Reconciliation Parameter Selection Guidelines

---

The following four tables summarize the primary characteristics of each of the 25 reconciliation parameters that are available under the automatic reconciliation command. These tables also indicate how important the parameter is likely to be as a determinant of energy use in a given building. Use these tables and the circumstances of your specific RESEM analysis to make judicious selections. Try not to include parameters in the reconciliation unless you are fairly certain that they actually play some role in causing the observed differences between the simulation results and the utility data. Not all building characteristics are amenable to parameterization. Other inputs that are strong determinants of energy use and therefore must be correct, are as follows:

- The selection of system type. (See Tables R-5 and R-6)
- The assignment of zones that are air-conditioned versus those that are only heated. For example, a school with only the classrooms air-conditioned.
- The assignment of the domestic hot water (including laundries and kitchens) to the central boilers or to separate domestic hot water heaters. The default building assigns these loads to the central boiler.
- The scheduling of fan operating hours.
- The scheduling of the use of the building, not only for daily use but on a yearly basis. Again a school is a good example as the default school is scheduled for 9 months operation, but some schools are operated all year.

**TABLE R-7: BUILDING ENVELOPE PARAMETER SELECTION**

<u>PRIORITY</u>	<u>PARAMETER</u>	<u>CONSIDERATIONS THAT APPLY</u>
High	Window area	Most of the heat gains/losses occur through the windows. The default building is representative of schools with classroom glass from 30" sill height to ceiling. Many middle schools only have a single strip of glass 3 feet wide in each classroom.
Med	Window U-value	The heating is affected most by the glass U-value. The default building is representative of schools with single pane glass. Newer buildings and those that have been retrofitted often have double or even triple pane glass.
Low	Window shade coef	The cooling is affected most by the shaded coefficient of the glass. Buildings with overhangs and other shading devices need a shade coefficient adjustment to represent these factors.
Med	Occ infil rate	The occupied infiltration rate can be very different from the default building when there is a great deal of traffic in and out of the building. A building with a central ventilation system can pressurize a building, thus effectively eliminating occupied infiltration.
High	Uno infil rate	The unoccupied infiltration rate can be much higher than the default building when unit ventilators have very leaky dampers. Conversely, middle schools with a central system and few windows can have a much lower rate than the default.
Low	Wall U-value	Very seldom will wall U-values be much different than the default building.
High	Roof U-value	The problems with roof water leakage that ruin the insulation are well known. Many buildings have been re-roofed and their U-value can differ from that of the default building.

**TABLE R-8: ELECTRICAL/LIGHTING PARAMETER SELECTION**

<u>PRIORITY</u>	<u>PARAMETER</u>	<u>CONSIDERATIONS THAT APPLY</u>
High	Lighting	Even though most schools have reduced their lighting levels, there are still buildings with lighting levels above 3 watts/sqft. The level used for the default building is an average value, assuming that as classrooms are emptied, the lights are turned off. This is often not the case.
Med	Equipment	Vocational schools with auto, carpentry, metal, and ceramic shops can have much higher equipment levels than used for the default building.

**TABLE R-9: MECHANICAL PARAMETER SELECTION**

<u>PRIORITY</u>	<u>PARAMETER</u>	<u>CONSIDERATIONS THAT APPLY</u>
Low	Chiller COP	Since the cooling for schools is used very little the chiller efficiency will not affect energy very much. For hospitals just the opposite is true.
Low	Chiller capacity	The same statement as for Chiller COP applies.
High	Supply min OA	The minimum outside air rate is important as all of this air must be heated or cooled. The default value is a fraction of the supply cfm; therefore the two items must be coordinated.
High	Fan supply cfm	The amount of air supply can vary greatly from the values given for the default building. Many old schools have no ventilation systems or one that only meets the minimum code requirements. New schools can have high ventilation rates, especially when they are air conditioned. The amount of air supplied determines the fan motor size and its energy, use which can be as high as 40% of total electric. See Supply min OA above.
Low	Occ heating setpt	The temperatures in many schools is much different than the value for default building. The reason is that many old schools are overheated because there is no thermostat control on radiators.
High	Uno heating setpt	The unoccupied temperatures can also be much different than the value for the default building. A good example are finned radiators that keep the space temperatures comfortable even though the unit ventilators are off. Most all of the heating of a building occurs at night.
Med	Occ cooling setpt	Buildings are often kept much cooler than the reported thermostat settings, or the value for the default building.
Low	Uno cooling setpt	Buildings are seldom cooled when unoccupied.

---

High	Boiler efficiency	The value for boiler efficiency is often reported much higher than actually possible on a long term basis. The actual boiler efficiency may be much lower than the default value.
Med	Boiler capacity	The installed capacity for many buildings is often much greater than needed for normal operation. For example, many schools will have two boilers, both of which can handle normal operating loads. In many instances only one will be operated and the other will be standby. A good reading on this important because it affects the part load operating efficiency of the simulation.
Med	Econo limit temp	The limit temperature at which the outside air economizer dampers are returned to minimum is very important for buildings that are air conditioned.
Med	Hot water/person	In the schools that have very active athletic programs, especially if they continue in the summer, this value can be important for estimating the energy for heating hot water. Attention should also be given to when there are cooking kitchens (rather than serving only) and to whether the domestic hot water heaters are separate from the central boilers.

**TABLE R-10: ADDITIONAL PARAMETER SELECTION**

<u>PRIORITY</u>	<u>PARAMETER</u>	<u>CONSIDERATIONS THAT APPLY</u>
Low	Occupancy	The number of people in a building affects the hot water requirements, but also the cooling requirements.
Low	Misc sensible	On occasion, high schools will have swimming pools which require considerable heat.
Med	Misc electric	On occasion, there are outside electric loads that can be significant such as athletic field lighting, or parking lot lighting.
High	Misc heat	Attention should be given to when there are cooking kitchens (versus serving only). Another requirement that must not be overlooked are hospital laundries which can increase building energy use by 25%.

# AN EXAMPLE TUTORIAL

## Section Table of Contents

Step-by-Step Instructions.....	97
1. RESEM Start-up, Project Save/Retrieve, and Termination.....	97
1.1.Access the DOS prompt.....	97
1.2.Move to the RESEM directory .....	97
1.3.Begin executing RESEM .....	98
1.4.Saving a project file .....	98
1.5.Retrieving a project file .....	99
1.6.Terminating execution of RESEM.....	99
2. Project.....	100
2.1.Project information .....	100
2.2.Fuel types.....	101
2.3.Weather location .....	103
2.4.fuel Units.....	103
3. Base analysis.....	104
3.1.Create base building.....	104
3.1.1.Generate default building.....	105
3.1.2.reFine building.....	105
3.1.2.1.hEating plants .....	106
3.1.2.2.view/modify/add Zone .....	106
3.2.Enter base utility data .....	107
3.2.1.Electricity.....	108
3.2.2.Gas .....	108
3.3.Reconcile building .....	109
3.3.1.Display comparison .....	109
3.3.2.Automatic reconcile.....	110
3.3.2.1.Building envelope.....	110
3.3.2.2.Mechanical.....	111
3.3.2.3.Esc to perform reconciliation step .....	111
3.3.3.Repeat .....	111
3.4.complete Base analysis .....	112
4. Retrofit.....	112
4.1.Ecm descriptions.....	113
4.1.1.M: Mechanical .....	113
4.1.2.M: Mechanical .....	114
4.1.3.M: Mechanical .....	114
4.1.4.O: Other .....	115
4.2.save ecm Retrofits.....	116
4.3.Non-ecm modifications.....	116
4.3.1.Usage modifications.....	117
4.4.Complete retrofit.....	118
5. post Analysis.....	118
5.1.Enter post utility data.....	119
5.1.1.Electricity.....	119
5.1.2.Gas .....	119

---

---

5.2.Adjust retrofit.....	120
5.2.1.Display comparison .....	120
5.2.2.Automatic adjustment .....	121
5.2.2.1.Building envelope .....	121
5.2.2.2.Esc to perform automatic adjustment .....	122
5.2.3.Repeat .....	122
5.3.complete Post analysis .....	122
6. Savings.....	123
7. File .....	123
7.1.Reports .....	123
7.1.1.Project summary .....	124
7.1.2.end Use energy cons .....	124
7.1.2.1.Version 1: pre.....	124
7.1.2.2.Version 3: ecm .....	125
7.1.2.3.Version 2: post .....	125
7.2.Save project.....	125
Technical Assistance Report Extracts.....	TA-1




---

## Step-by-Step Instructions

---

This tutorial is designed to introduce RESEM within the context of an actual energy savings estimation analysis. This exercise is based on an analysis of a Minnesota secondary school. Following RESEM start-up and termination instructions, each step in the tutorial is identified by the appropriate menu option to be selected from the RESEM menu structure. The option is shown in the manner in which it appears on-screen. An explanation of the reason for performing each step is given. Detailed instructions on completing the step are included. The overall analysis proceeds from entering initial project information, to creating and analyzing a base (pre-retrofit) building description, on to describing the retrofit modifications to the base building, next to analyzing a post-retrofit building description, then to calculating energy savings estimates, and lastly to saving reports to your disk. For several steps the results of RESEM calculations are given to allow you to compare them with your results. The results displayed on your screen may not match the given results exactly. This is not cause for thinking that you have incorrectly performed the tutorial unless your results are dramatically different. Several of the instructions here refer to Technical Assistance (TA) documentation. This documentation is required for all projects submitted to the Institutional Conservation Program (ICP). For users of RESEM that are not part of the ICP program, these references should be interpreted as referring to the best available source of information regarding the building project at hand.

Certain print typefaces are used in this tutorial with consistent meaning. **Boldface** is used to indicate single keys which should be used to perform an action. For example, **Enter** refers to pressing the key labeled Enter, Return, or with a left pointing arrow that has a vertical line attached to its right end. **F10** refers to pressing the function key labeled F10 (either at the top or extreme left of your keyboard). **Esc** refers to the Escape key (generally in the upper left of the keyboard) which is used to move from one menu back to the previous menu or to abort input into a data entry screen. Menu options within RESEM can be selected by pressing the boldface uppercase letter shown on the screen; these selection letters are shown in this tutorial in similar boldface fashion. When a menu option is embedded in text, quotation marks are used to enclose all words in the option. ***Boldface italics*** are used to identify the explanation and instruction subsections for each analysis step and to place emphasis within the text. A  symbol is used to mark the beginning of each individual instruction. *Italics* are used to identify input data that you will be entering as shown.

### 1. RESEM Start-up, Project Save/Retrieve, and Termination

#### 1.1. Access the DOS prompt

***Explanation:***

To begin execution of the RESEM program you must first access the DOS prompt. This is generally accomplished by turning on your PC and waiting until the DOS prompt (e.g., C:\>) appears on-screen. If your PC automatically turns control over to a specialized menu interface, you will need to exit this program to DOS. If possible, you should make certain that no RAM resident software other than DOS is loaded when your computer is turned on. For more details on this step, see the *Starting RESEM* section of this manual.


#### 1.2. Move to the RESEM directory

***Explanation:***

RESEM installation automatically creates a subdirectory on your C: drive hard disk. You can move to this directory from anywhere on your C: drive by using

the Change Directory DOS command. The following instruction assumes that RESEM is installed in C:\RESEM

**Instructions:**

 Enter the following DOS command at the DOS prompt: `cd \resem`


### 1.3. Begin executing RESEM

**Explanation:**

From within the RESEM directory, load and begin execution of RESEM. After a brief delay during which the RESEM software is loaded, a copyright window will appear onscreen. Pressing any key will cause the RESEM Main Menu to appear on-screen.

**Instructions:**

 Enter the following command at the DOS prompt: `resem`


 Press any key to remove the copyright screen which appears and continue on to the RESEM Main Menu.


### 1.4. Saving a project file


**Explanation:**

A complete RESEM energy savings analysis may require considerable time and effort. To avoid having to duplicate effort from one RESEM session to the next, you may save a project at any stage of an analysis (after filling out the initial Project information screen) and later retrieve that project to continue working on it. All necessary data and the status of each analysis stage is saved to your hard disk. The save project command can also be used to save an archival copy of a completed RESEM analysis.

**Instructions:**

 Select the “File” option from the Main menu.

 Select the “Save project” option from the File menu. This causes a menu list to appear. The first item in this list will be the default name for your project file taken from the “Building Name” field on the Project Information screen. The remainder of the names on this list, if any, are those of previously saved RESEM project files on your disk.




 Select the desired project file name from the displayed list. If you wish to enter a unique name, select the first blank name in the list and you will be prompted to enter a name. The 1-8 character name appearing in the list will have a file extension of “.rsm” appended to it when the file is saved to disk.

### 1.5. Retrieving a project file

**Explanation:**

Once a project file has been saved to disk, it may be retrieved at any later time. This retrieved file may then be reviewed and/or the analysis continued at the point at which you left off when it was saved. NOTE: Retrieving a project file first removes any project data which may currently be stored in RAM. This means that if you are currently working on a project analysis, first save your current project to disk before retrieving another.

***Instructions:***




-  Select the “File” option from the Main menu.
-  Select the “retrieve Project” option from the File menu. This causes a menu list to appear showing the names of previously saved RESEM project files on your disk.
-  Select the desired project file name from the displayed list. The selected project file will be retrieved from disk into RAM so that you can work with it.

## 1.6. Terminating execution of RESEM

***Explanation:***

You may quit from RESEM and return to DOS at any point during a RESEM analysis session. Be sure to save any current project work to disk before quitting as data in RAM will be lost.

***Instructions:***


-  Select this “File” option from the Main menu.
-  Select this “Quit” option from the File menu.
  
-  Alternatively, you may simply press the **Esc** key when selecting from the Main menu.

## 2. Project

***Explanation:***

A project analysis begins by entering fundamental project data for the building(s) being analyzed. This data generally includes information related to the building location, age, size, and type; the types of fuels used and their end uses within the building; and the nearest location for which RESEM weather data is available. This information will subsequently be used by RESEM to generate a detailed description of the building for further analysis.

***Instructions:***

 Select the “Project” option from the main menu. This can be accomplished in two ways. Use the **left** and **right** arrow keys to highlight the **Project** menu option and then press either the **Enter** key or the **F10** (transmit) key. This method has the advantage of displaying a hint line for the highlighted option near the bottom of the screen, allowing exploration of the RESEM menu structure. Alternatively, from anywhere on the main menu press the boldface letter **P** (either uppercase or lowercase will work).

## 2.1. Project information


### *Explanation:*


This step displays a data entry screen into which you will enter basic project information. This data will be subsequently used in the automatic generation of a base building description. You should fill in this screen as completely as possible, however there are only a few absolutely required data fields: building name, state, initial year of construction, total floor area, building type, and building function.


The more information available at the time of building description generation, the more accurately the base building description will match your real building. For this example we will enter data for two fields in addition to those required: number of floors and percent glass. The values for these fields were gleaned from the Technical Assistance (TA) documentation for this project. Dividing the floor area of 83202 sq.ft., listed in the TA documentation, by the listed roof area of 50705 sq.ft. gives a calculated number of floors of 1.64. Dividing the sum of all listed window areas (1340 sq.ft.) by the sum of all gross wall areas (26092 sq.ft.) gives a calculated fractional glass area of 0.0514 which will be entered as 5 percent. These values will override the default values of 2.00 floors and a percent glass of 20.

The value entered for state on the project information screen will subsequently be used to list the RESEM weather data available for locations within this state. If you wish to use weather data for a location in a state different from the address of the building, enter the desired state here.


### *Instructions:*

 Select the “Project information” option either by using the **up** and **down** arrow keys to first highlight this option and then pressing **Enter** or **F10**, or from anywhere on the Project pull-down menu pressing the boldface letter in this option. This causes a data entry screen to appear.

 Use the **down** arrow, **Enter** key, or **Tab** key to move sequentially from one field to the next on the data entry screen. Use the **up** arrow or **Shift-Tab** to move to the previous field. The **right** and **left** arrow keys allow you to position the cursor within the current field. Refer to the RESEM documentation for details on other data entry screen edit keys. You may not pass through or leave a required field until a value has been entered into it.

 Enter the following values in the indicated fields: Building Name = *tutor* (do not include any spaces in this name since the first 5 to 8 letters will be used by RESEM when saving report files to disk as described in part 7 below), State = *MN*,

Initial Construction Year = 1966, Number of Floors = 1.64, Total Floor Area = 83202, Percent Glass = 5, ICP Building Type = A, ICP Building Function = 12.

 Press the **F10** (function key) to transmit the data when it all appears as shown below. The values displayed on-screen are not stored by RESEM until you press the **F10** key to transmit the data. This is an important key to remember for transmitting data from *all* RESEM data entry screens. Pressing the **Esc** (escape) key at any time will abort data entry and return you to the previous menu *without* saving the values currently displayed on-screen. Instead, the values (if any) which had been previously stored in these fields will remain unchanged.


## 2.2. Fuel types


### *Explanation:*


A RESEM analysis accounts for individual fuel types used in the project building(s). Consumption quantities are calculated for each end use of each fuel type. The automatic generation of a base building description will make default assumptions regarding the project fuel types and their end uses. However, end uses entered at this stage will override these assumptions to produce the most accurate description of your building fuel types. Of particular importance are the fuel types used for space heating and space cooling (if provided in the building). This menu option allows you to indicate the end uses of all fuel types used in the building which RESEM is capable of recognizing. Only those fuel types which you identify here (or are assumed by default) will be accessible later when entering utility data.









For this tutorial building both gas and oil are used for heating fuels since the building uses a dual fuel boiler. Because there is no meaningful way to separately assign the end use of space heating to two fuel types for the same boiler, we will combine these into a single fuel type of gas for heating and hot water. Electricity is used for lighting, distribution fans, and electrical equipment. There is no air conditioning (space cooling) in this building.

### *Instructions:*

 Select the “Fuel types” option from the Project pull-down menu. This causes a Fuel types submenu to be displayed.

 Select “Electricity” from the Fuel types menu. This is accomplished in the usual manner of either first highlighting the option and then pressing **Enter**, or pressing the boldface option selection letter. This action causes an End use submenu to be displayed for electricity. Note that the value next to the end use option of “None” is currently set to *Yes*. This is a default setting made by RESEM which always assumes that electricity is used in the building whether or not it is associated with a particular end use. This is the reason electricity is set to *Yes* when the Fuel types menu first appears.

 Select the “Fans” option from the End use menu. This has the effect of changing the *No* value beside Fans to *Yes*. Selecting the same option again would switch the value from *Yes* back to *No*.

-  Select the “**L**ights” option to set its value to *Yes*.
-  Select the “**E**quipment” option to set its value to *Yes*.
-  Press the **Esc** key to return to the Fuel types menu.
-  Select the “**G**as” option from the Fuel types menu. This action causes an End use submenu to be displayed for Gas.
-  Select the “space **H**eating” option to set its value to *Yes*.
-  Select the “hot **W**ater” option to set its value to *Yes*.
-  Press the **Esc** key to return to the Fuel types menu. Note that the value next to Gas has now changed to *Yes* to indicate that this fuel type is used in the building.
-  Press the **Esc** key to return to the Project menu.

### 2.3. Weather location



#### ***Explanation:***

A RESEM analysis is based in large part on computer simulations of descriptions of base and post-retrofit buildings. The building descriptions and their subsequent simulations are made to closely match actual utility consumption billings. This can only be accomplished if actual weather data corresponding in date and location are used in the simulation. In addition, final energy savings estimates are based on long-term average weather data which again must correspond to the location of the project under analysis.

National Oceanic and Atmospheric Administration (NOAA) weather data is specially processed for use by RESEM. This data is only available for certain locations and time periods.

Selecting the weather location at this point in the analysis sequence informs RESEM which weather data to load as the analysis proceeds. Long-term weather for the selected location is also loaded as a consequence of this command.

#### ***Instructions:***

-  Select the “**W**eather location” option from the Project menu. This action causes the display of a menu listing all long-term weather data files on your hard disk which are located in the state you entered on the Project information screen. In this case the only location listed is “MINNEAPO” (all location names are derived from the NOAA location name and limited to 8 characters which reflect their DOS filenames).
-  Select the “**A**: MINNEAPO” location. This causes long-term weather data to be loaded for Minneapolis, Minnesota. This location will be used throughout the rest of the analysis. The Please Wait signal at the bottom left of the screen will stop flashing when the long-term weather data has been loaded.

### 2.4. fuel Units


***Explanation:***


RESEM allows considerable flexibility in the units of measure used to enter and display values of energy use. The most commonly used units for each fuel type are displayed by default. However, if the values available in the TA documentation vary from these units, the defaults can be changed.


This menu option allows you to select from a variety of units which RESEM recognizes for each fuel type.


The default unit of measure for gas is therms. Gas data is listed in the TA documentation is in units of C.C.F. standing for hundreds of cubic feet.


***Instructions:***

 Select the “fuel Units” option from the Project menu. This causes a Fuel type submenu to be displayed.

 Select the “Gas” option from the fuel type menu. This causes a fuel units submenu to be displayed for gas. Note that only certain of these units are accessible using the **up** and **down** arrow keys. This is to restrict selection to only those units of measure which RESEM recognizes for a fuel type of gas.

 Select the “100 Cubic ft.” option from the fuel units menu. This causes the units displayed next to Gas to change from *therms* to *100 cuft*. From this point on, values for gas will be entered and displayed in units of hundreds of cubic feet. This procedure may be performed at any time during analysis to change to another unit of measure. All energy values are stored internally by RESEM as Btus.

 Press the **Esc** key to return to the Project menu.


 Press the **Esc** key a second time to return to the Main Menu.

### 3. Base analysis

***Explanation:***

Once fundamental project data has been entered, the next step focuses on the base building description and analysis. This portion of the analysis sequence includes: creating a base building description, entering actual utility consumption data for the base period, performing a reconciliation process which matches the base building description to the measured utility data, and completing the base analysis to set the stage for entering Energy Conservation Measure (ECM) and other retrofit modification descriptions. The term base building description refers to the project building(s) prior to any retrofit modifications. This is equivalent to the term *pre-retrofit* building description.

***Instructions:***


 Select the “Base analysis” option from the Main Menu. This causes the Base analysis pull-down menu to be displayed.

### 3.1. Create base building

***Explanation:***

A base building description can be created by two different methods. This building description must include all details regarding building geometry, envelope construction elements, HVAC system, lighting, equipment, occupancy, and usage schedules. RESEM includes a default building description generator which creates a building description from the project data input above by applying a built-in set of production rules, for the given building type, to a modifiable external library of standard building elements. A second method is to retrieve a building description which has been previously saved to disk. This method is useful for experienced RESEM users who recognize the current base building's closer similarity to an earlier created and saved building description than to the automatically generated description

***Instructions:***


 Select the "Create base building" option from the Base analysis menu. This causes a submenu to be displayed.

#### 3.1.1. Generate default building

***Explanation:***

We will choose the first method described above to create the base building description. This automatic generation will be followed by a refinement of the default description to incorporate information gleaned from the TA documentation. This method first retrieves a copy of the external library of standard building elements and then applies the production rules for a secondary school (the building type and function entered above) to generate a complete building description.

***Instructions:***

 Select the "Generate default building" option from the Create base building submenu. The Please Wait signal at the bottom left of the screen will stop flashing when the description has been generated.

#### 3.1.2. reFine building

***Explanation:***

The default building description generated by the previous step makes numerous assumptions based on building type, function, and age. These assumptions represent informed guesses regarding building geometry, construction, occupancy, and environmental systems (e.g., lighting and HVAC). The resulting building description is for a typical building of the




indicated type. It is not meant to be an exact description of your specific building. This description can be tailored to precisely match your building, but a precise match of all building components is not necessarily required for an accurate analysis. However, certain features of the building description are significant. In particular, those aspects of a building which relate to the HVAC system(s), the lighting system(s), or other features which will be modified to describe the ECMs under analysis should be refined according to any known data. This refinement is not critical at this stage in the analysis and will be addressed again in later steps. However, a perusal of the TA documentation looking for pertinent information is appropriate now.

We will refine the descriptions of the heating plant and the thermal zone HVAC system control for this exercise. To gain access to the parameters describing these building elements we will display a series of detailed data entry screens. The instruction below displays a submenu which lists all detailed building description component categories. The first six categories are associated with *library* components (e.g., hourly schedules). The last eight categories allow access to various *building* components which describe the base building. Library components are referenced in a particular building description by using the specific library component name. For example, a monthly schedule exists in the library which represents 100% use of a building resource during the months of September through May, and 0% usage in June, July, and August. The name of this monthly schedule is “sch-eq” (mnemonic for school equipment). This general monthly schedule can be applied to any building component operation by using the name “sch-eq” as a reference. For example, the base building heating plant could be indicated as operating only during academic months by including the monthly schedule name “sch-eq” in its description.

The detailed screens used during this step will be revisited in later steps so familiarity gained here will also be useful then.

***Instructions:***






 Select the “reFine building” option from the Create base building submenu. This results in a submenu listing all component categories for a building description.

3.1.2.1. hEating plants

***Explanation:***

Within the TA documentation there is a description of the heating plant boiler which indicates a design efficiency of 83%.

***Instructions:***










-  Select the “hEating plants” menu option from the Refine building submenu. This displays a list of the heating plants currently defined for the base building.
-  Select the “A: hplant1” option from the heating plants item list. This displays a data entry screen showing all parameter values for hplant1.
-  Move to the “Design eff” field. Change the value to 83.
-  Transmit the new data for hplant1 by pressing the **F10** key.
-  Press the **Esc** key to return to the Refine building submenu.

### 3.1.2.2. view/modify/add Zone

#### *Explanation:*

Within the TA documentation the occupied thermostat setting is stated to be 68 F.

#### *Instructions:*

-  Select the “view/modify/add **Z**one” menu option from the Refine building submenu.
-  Select the “A: z1-clsrn” option from the zones item list. This displays a new type of data entry screen containing both data fields and special menu fields.
-  Move sequentially through the data fields at the top of the screen using the **down** arrow or **Tab** key until the “>” symbol to the left of the special menu field “THERMOSTAT” is highlighted.
-  Press **Enter** to select this special menu field. This displays a submenu listing all thermostat setting names defined for this zone.
-  Select the “B: HeatOc” option from the thermostat setting list. This displays the current heating thermostat setting for the z1-clsrn zone for occupied times of the day. Change this value to 68.
-  Transmit the new data for HeatOc by pressing the **F10** key.
-  Press the **Esc** key to return to the z1-clsrn data entry screen.
-  Transmit the new data for zone z1-clsrn by pressing the **F10** key. *This is a critically important step to perform.* If the zone data entry screen is not transmitted, then any changes to thermostat settings will be ignored. Remember: press **F10** to transmit data and return from *all* data entry screens in RESEM; press **Esc** to abort data entry and ignore all changes.
-  Select the “B: z2-multp” option from the zones item list. This displays the data entry screen for the multi-purpose thermal zone.

- ✍ Repeat the above steps to change the occupied thermostat setting for z2-multp to 68.
- ✍ Press **F10** to properly transmit this data for z2-multp.
- ✍ Press the **Esc** key to return to the Refine building submenu.
- ✍ Press the **Esc** key again to return to the Create base building submenu.
- ✍ Press the **Esc** key a third time to return to the Base analysis pull-down menu.

### 3.2. Enter base utility data

#### ***Explanation:***

Following creation of a base building description, the next step in the base building analysis is to enter actual utility data for the project. This data is entered individually for each fuel type used in the project. The data can be entered for arbitrary periods with any beginning and ending dates allowing any level of detail in the recorded data (e.g., monthly, quarterly, or annual data). The dates for these periods should represent the time in which the fuel was consumed, as opposed to when it was purchased. Weather data for the corresponding period(s) will be automatically loaded as part of this step. If weather data is not available for the entered period(s), you will be informed of this fact.

#### ***Instructions:***

✍ Select the “Enter base utility data” option from the Base analysis menu. This displays a submenu listing all fuel types known by RESEM. Only those fuel types used in this project will be accessible.

#### 3.2.1. *Electricity*

##### ***Explanation:***

The Technical Assistance documentation gives monthly consumption data for electricity. This data can be entered separately for each month or one combined entry for the full year of data can be made. RESEM simulates fuel consumption on a monthly basis. However, the comparison screen which is displayed following the next step gives one value for each fuel type for the entire period corresponding to the utility data entered here. For this exercise we will therefore make only one utility entry for each fuel type. The period is assumed to begin on July 1, 1981 and end on June 30, 1982 during which 215,700 kWhrs were consumed.

##### ***Instructions:***

- ✍ Select the “Electricity” option from the fuel type menu. This displays a data entry screen for electricity showing the proper units of measurement at the top.
- ✍ Type *7/1/81* into the field labeled From. The slash marks which initially appear may be typed over.
- ✍ Move to the To field by pressing **Enter**, **down** arrow, or **Tab**.
- ✍ Type *6/30/82* into the field labeled To.
- ✍ Move to the Amount field by pressing **Enter**, **down** arrow, or **Tab**.
- ✍ Type *215700* into the field labeled Amount.
- ✍ Transmit the utility data for electricity by pressing the **F10** key.

### 3.2.2. Gas

#### *Explanation:*

Data for both natural gas and fuel oil are given in the Technical Assistance documentation. This data is given for the same time period as electricity. RESEM does not require this to be true and can deal with different periods for each fuel type. We will enter one value for gas only. The fuel oil consumption is converted to its equivalent in gas of 10244 C.C.F. This makes a total value of 49250 + 10244 or 59494.

#### *Instructions:*

- ✍ Select the “Gas” option from the fuel type menu.
- ✍ Type *7/1/81* into the field labeled From.
- ✍ Move to the To field.
- ✍ Type *6/30/82* into the field labeled To.
- ✍ Move to the Amount field.
- ✍ Type *59494* into the field labeled Amount.
- ✍ Transmit the utility data for gas by pressing the **F10** key.
- ✍ Press the **Esc** key to return to the base analysis menu. There will a brief delay while weather data is loaded from your hard disk for the time period(s) corresponding to all utility data entered.


### 3.3. Reconcile building

#### *Explanation:*

A fundamental aspect of a RESEM analysis is the simulation of the various base and post-retrofit building descriptions. For the most accurate estimate of energy savings it is important that the simulated energy use of the base building description closely match the actual energy use as measured by the utility data. Modifying the building description so that simulated energy use matches utility data is referred to as **reconciliation**. A manual reconciliation process can be tedious and may require a simulation expert. The manual process requires the user to identify and quantify each necessary building modification and then enter the detailed screens to make the change. RESEM includes a unique capability to automate certain aspects of this process. To perform RESEM's automatic reconciliation the user need only identify the "type" of modification desired. This means selecting from a list of 25 key building parameters to include in the automatic reconciliation process. Once the parameters of interest have been selected, RESEM will determine the optimum amount of modification for each parameter and automatically make this modification. The goal of reconciliation is to have building simulation and utility data match within a tolerance of 0.5% (one half of one percent). Using only manual reconciliation techniques, this goal would probably result in total hair loss prior to attainment.

Appendix A contains reconciliation parameter selection guidelines. The user should refer to this guide and judiciously select one or more parameters for inclusion in an automatic reconciliation step. Each selected parameter requires a complete simulation for the utility data billing period entered. On an XT class microcomputer with a math coprocessor chip each simulation will take approximately 45 seconds. On an 80386 based machine with a coprocessor each simulation takes approximately 5 seconds.

***Instructions:***

 Select the "Reconcile building" option from the Base analysis menu. An initial simulation of the current base building description will be performed followed by the display of a submenu offering various options associated with the reconciliation process.

***3.3.1. Display comparison***


***Explanation:***

The match between the current base building description simulation and the entered utility data can be displayed at any point in the reconciliation process by selecting the first Reconcile submenu option. A data viewing screen will appear listing: each project fuel type with units, the summed results of the current simulation, your entered utility data, and the percent difference between these last two values. At this point in this tutorial, initial differences should show electricity consumption approximately 12% high (i.e., the simulation indicates 12% greater electric consumption than the corresponding utility data).

---

Gas consumption should be approximately 20% high. A negative difference would indicate that simulated consumption is lower than utility data.

***Instructions:***

 Select the “**D**isplay comparison” option from the Reconcile building submenu. This causes a data viewing screen to be displayed. Press any key to remove the data screen when you have finished viewing.


**3.3.2. Automatic reconcile**

***Explanation:***

The results of the previous step show that the simulated energy use of electricity is above the utility data (~+12%) and that of gas is also above the utility data (~+20%). We must modify the base building description to bring these values closer.

We will use the RESEM automatic reconciliation capabilities to perform the required modifications. In a first review of the Appendix A parameter selection guidelines we see that many of the high priority parameters either have accurate default values or have been set during base building refinement (step 3.1.2 above). In the interest of reducing the total number of parameters included in this automatic reconciliation we will therefore restrict our selection to three: unoccupied infiltration rates, HVAC system fan supply cfm, and unoccupied heating thermostat set point.

***Instructions:***


 Select the “**A**utomatic reconcile” option from the Reconcile building submenu. This results in the display of a reconciliation parameter category submenu. These categories correspond to top level ECM categories including: building envelope, electrical/lighting, and mechanical. Another category entitled “additional” is used to group parameters which do not correspond to an ECM category.

**3.3.2.1. Building envelope**


***Explanation:***


The parameter named “unoccupied infiltration rate” falls under the building envelope category. We wish to select this parameter for automatic reconciliation.

***Instructions:***

 Select the “**B**uilding envelope” option from the parameter category menu. This results in a submenu listing all parameters under this category.

To the right of each parameter name is a selection field indicating that *No* the parameter is not to be included in the subsequent automatic reconciliation step. We will switch this field to *Yes* for the desired parameters. Switching between *Yes* and *No* is a simple matter of selecting the desired parameter from the submenu. To the far right of each parameter name is its value within the current base building description.

 Select the “uno iNfiltration” option from the Building envelope menu. This results in changing the *No* to a *Yes*.


 Press **Esc** to return to the parameter category menu


#### 3.3.2.2. Mechanical


##### ***Explanation:***


The parameters named “fan supply cfm” and “unoccupied heating set point” fall under the mechanical category.

##### ***Instructions:***

 Select the “**M**echanical” option from the parameter category menu. This results in a submenu listing all parameters under this category.

 Select the “uno h**E**ating tstat” option from the Mechanical menu to change the *No* to a *Yes*.

 Select the “**F**an supply cfm” option from the Mechanical menu to change the *No* to a *Yes*.


 Press **Esc** to return to the parameter category menu.


#### 3.3.2.3. Esc to perform reconciliation step

##### ***Explanation:***


We have now selected all desired parameters to include in automatic reconciliation. We are ready to turn control over to RESEM for the automatic reconciliation step.

##### ***Instructions:***

 Press **Esc** to return from the parameter category menu. This results in a dialog box asking if you wish to perform a reconciliation using the currently selected parameters.

 Type *y* and press the **F10** key to transmit your consent. RESEM will now perform a series of simulations ultimately resulting in the display of two data viewing screens showing the reconciliation results. In reviewing these screens you should note the following items: unoccupied infiltration rate has been modified from a value of 0.8 to 0.59, fan supply cfm has been modified from 103337 to 76005.9, unoccupied heating thermostat has been modified from 55 to 52.48, and these modifications have reduced the

differences in electric consumption from ~12% to ~0.1% and gas consumption from ~20% to ~0.8%.


 Press any key to remove the data screens when you have finished viewing.


### 3.3.3. Repeat


#### *Explanation:*

We will now become obsessive in our desire to reduce fuel reconciliation differences to less than 0.5%. This will give us the opportunity to explore the Repeat reconciliation option. Often the mathematics of the automatic reconciliation algorithm will not produce the complete fuel match on the first try. In this instance, the desired match can often be achieved by simply repeating the algorithm using the same selected parameters.

#### *Instructions:*

 Select the **Repeat** option from the Reconcile building submenu. RESEM will again perform a series of simulations and display the screens showing the reconciliation results. In the repeated reconciliation: unoccupied infiltration rate has been modified to a value of 0.57, fan supply cfm has been modified to 76398.8, unoccupied heating thermostat has been modified to 52.69, and these modifications have reduced the differences in electric consumption from 0.27% and gas consumption to 0.01%. Close enough?

 Press any key to remove the data screens when you have finished viewing.

 Press **Esc** to return to the Base analysis menu.

### 3.4. complete Base analysis

#### *Explanation:*



The comparisons between our current building description and the entered utility data are within the desired tolerance. This should give us enough confidence in the base building description to complete the base analysis and move on to the description of retrofit modifications.

Completing the base analysis causes RESEM to perform a twelve month energy simulation of the base building description using long-term average weather data. This calculates the energy consumption of the base building, operating in average weather conditions, which will be used in the final estimate of energy savings.

Completing the base analysis also causes RESEM to create a copy of the current base building description which will be subsequently modified to describe the ECM modifications implemented in this project. This copy is referred to as the *ecm* version of the building description.



**Instructions:**

-  Select the “complete **Base analysis**” option from the Base analysis menu. A simulation monitor will appear on-screen showing the months as they are simulated. When the simulation is finished, control will be returned to the Base analysis menu.
-  Press **Esc** to return to the Main menu.

## 4. Retrofit

**Explanation:**

Having completed the analysis of the base building, it is now time to describe the ECM retrofit modifications implemented in this project. There are two methods available for describing these ECMs. For many of the specific types of retrofits recognized in the ICP program (e.g., replace heating plant boiler), **push-button** ECM menu options will lead you to minimal input screens and then automatically make the required ecm building description modifications. For more unique or complex retrofit measures, you must access the detailed building component screens to directly describe the modifications.

Of the four ECMs implemented in this project, three can be described using the push-button ECM menu options. The fourth option requires accessing the detailed screens.

**Instructions:**


-  Select the “**Retrofit**” option from the Main menu. This causes the Retrofit menu to be pulled down.

### 4.1. Ecm descriptions

**Explanation:**

We will enter those ECMs which can be described using the “push-button” menu options first. These ECMs include: reducing ventilation, modifying the heating plant boiler, and preventing air stratification.

**Instructions:**







-  Select the “Ecm descriptions” option from the Retrofit menu. This causes a menu to be displayed listing the first level of ECM categories as described by their GTS code letters. An implemented ECMs window is also displayed showing no currently described ECMs.

#### 4.1.1. M: Mechanical

**Explanation:**

We will describe the ventilation reduction under GTS category MDO for Mechanical Distribution system damper modification. This ECM description requires knowing which HVAC system is being modified and the new supply minimum outside air fraction which results from the modification. We will modify the only HVAC system in the project *hvac1*. Within the Technical Assistance documentation, the engineer proposes a reduction of 50%. The default value for the minimum outside air was 30%. To reduce this by 50% we now input a value of 15%.

***Instructions:***



-  Select the “**M**: Mechanical” option from the first level ECM push-button menu. This results in the display of the Mechanical second level menu.
-  Select the “**D**: Distribution System” option from the second level ECM menu. This results in the display of a third level menu.
-  Select the “**O**: Damper Modification” option from the third level ECM menu. This results in a menu list of all currently defined HVAC systems in the building.
-  Select the “**A**: hvac1” choice from the menu list. This results in a minimal input dialog box requesting a new minimum outside air percentage of supply air.
-  Type the requested input as *15* .
-  Press **F10** to transmit this data. The result should be that *MDO* now appears in the Implemented ECMs box and you are returned to the first level ECM push-button menu.







**4.1.2. M: Mechanical**

***Explanation:***

We will describe the boiler modification under GTS category MHO for Mechanical Heating modification replace boiler. This ECM description requires knowing which heating plant is being modified, the new capacity, and the new efficiency of this heating plant which result from the modification. We will modify the only heating plant in the project *hplant1*. The capacity of this plant remains unchanged, but the new efficiency will be 86% as indicated in the Technical Assistance documentation.

***Instructions:***

-  Select the “**M**: Mechanical” option from the first level ECM push-button menu.
-  Select the “**H**: Heating Modification” option from the second level ECM menu.

-  Select the “**O**: Replace Boiler” option from the third level ECM menu. This results in a menu listing of all currently defined heating plants in the building.
-  Select the “**A**: hplant1” choice from the menu list. This results in a minimal input dialog box showing the current value and requesting a new value for heating plant capacity.
-  Enter the current value to leave capacity unchanged.
-  Press **F10** to transmit this data. This results in another dialog box requesting a new value for design efficiency.
-  Type the requested input as 86 .
-  Press **F10** to transmit this data. The result should be that *MHO* is added to the Implemented ECMs box.





#### 4.1.3. *M*: Mechanical



##### ***Explanation:***

We will describe the prevention of air stratification modification under GTS category MDS for Mechanical Distribution system prevent air Stratification. This ECM description requires knowing which thermal zone is being modified and the new heating thermostat set point for occupied hours. We will modify the multipurpose zone *z2-multp*.

The new set point is a difficult value to determine from the TA documentation. However, one page of this documentation states a 13 degree temperature difference between floor and ceiling in the 9600 sq.ft. gymnasium. This floor to ceiling temperature difference indicates an average temperature difference of 6 degrees. The overall floor area of zone *z2-multp* is 30000 sq.ft. This ECM only impacts one third of this area. We will therefore reduce the zone occupied thermostat set point by 2 degrees.

##### ***Instructions:***

-  Select the “**M**: Mechanical” option from the first level ECM push-button menu.
-  Select the “**D**: Distribution System” option from the second level ECM menu.
-  Select the “**S**: Prevent Air Stratification” option from the third level ECM menu. This results in a menu list showing all currently defined thermal zones in the building.
-  Select the “**B**: z2-multp”. This results in a dialog box requesting a new occupied thermostat set point and indicating that the current value is 68. We wish to decrease this value by 2 degrees.













-  Type the requested input as 66 .
-  Press **F10** to transmit this data. The result should be that *MDS* is added to the Implemented ECMs box.







#### 4.1.4. *O: Other*

##### ***Explanation:***

Although there is an infiltration control ECM under category BIZ (Building Infiltration control), the push-button approach modifies infiltration rates for both unoccupied and occupied periods. We will describe the modification to stop ventilation during unoccupied hours by using the detailed screens introduced earlier in the context of refining and modifying a building description. This ECM modification requires knowing which thermal zone(s) to modify and the new infiltration rate(s) for unoccupied hours. We will modify the infiltration rates for both the classroom and the multipurpose zones. The ECM description in the Technical Assistance documentation discusses a reduction in ventilation which would reduce the overall infiltration rate by something on the order of 0.25 air changes per hour. We will therefore reduce the current base building unoccupied period infiltration rates by 0.25.

##### ***Instructions:***

-  Select the “**O: Other**” option from the first level ECM push-button menu. This results in the display of the now familiar (hopefully) menu of building description component categories.
-  Select the “view/modify/add **Zone**” option from the component categories menu.
-  Select the “**A: z1-clsrn**” option from the thermal zones menu.
-  Select the “INFILTRATION” special menu field option from the z1-clsrn data entry screen.
-  Select the “**A: RateUnoc**” option from the infiltration rates menu.
-  Subtract 0.25 from the current “infiltration” field value and enter the result as the new value.
-  Press **F10** to transmit this data.
-  Press **Esc** to return to the z1-clsrn data entry screen.
-  Press **F10** to transmit the modified data for z1-clsrn.
-  Select the “**B: z2-multp**” option from the thermal zones menu.
-  Select the “INFILTRATION” special menu field option from the z2-multp data entry screen.
-  Select the “**A: RateUnoc**” option from the infiltration rates menu.

-  Subtract 0.25 from the current “infiltration” field value and enter the result as the new value.
-  Press **F10** to transmit this data.
-  Press **Esc** to return to the z2-multp data entry screen.
-  Press **F10** to transmit the modified data for z2-multp.
-  Press **Esc** to return to the component categories menu.
-  Press **Esc** to return to the first level ECM push-button menu. The result should be that *OTH* is added to the Implemented ECMs box indicating an ECM entered using the detailed screens.

#### 4.2. save ecm Retrofits

##### ***Explanation:***

We have now fully described the modifications to the ecm building description which represent the implemented ECMs for this grant. We will indicate this fact to RESEM by saving the ECM retrofits. This step causes RESEM to create a copy of the ecm building description so that we can go on to describe other (non-ECM) modifications which may have taken place in the project. This new copy becomes the *post* version of the building description since it will contain all post-retrofit modifications (i.e., both ECM and non-ECM modifications). This step is necessary so that RESEM can distinguish between those energy consumption differences attributable to ECM modifications and those attributable to other post-retrofit modifications such as changes in operation, maintenance, occupancy, building function, or building form.

##### ***Instructions:***


-  Select the “save ecm Retrofits” option from the Retrofit menu.

#### 4.3. Non-ecm modifications

##### ***Explanation:***

There is one significant post-retrofit modification which was implemented in this project prior to the collection of post-retrofit utility data. This change was the addition of outdoor lighting for an adjacent athletic field. We need to describe this modification so that we can later appropriately match the post-retrofit building description simulated energy use with the corresponding utility data. We want to describe this change in a manner that will exclude its impact on energy consumption from the final estimate of energy savings due to ECM modifications.

##### ***Instructions:***


 Select the “Non-ecm modifications” option from the Retrofit menu. This results in the display of a menu listing non-ecm modification categories. There are two categories usage modifications and building additions. An option allowing access to the detailed screens is also included in this menu.


#### 4.3.1. Usage modifications


##### ***Explanation:***


We will enter the outdoor lighting for the athletic field as a miscellaneous electric usage modification. There is no hard data for this modification. However, this is the only known modification which would account for the increase in electric consumption indicated by the post-retrofit utility data. We will therefore size this miscellaneous electric source to fit the increase in electricity. Our initial estimate will be represented by one hour of lighting at a peak rate of 95 kWatts.

##### ***Instructions:***


 Select the “Usage modifications” option from the non-ECM categories menu. This results in the display of a submenu listing usage modifications categories.


 Select the “Miscellaneous electric” option from the usage modifications submenu. This results in the display of a menu listing all currently defined miscellaneous electric components in the *post* version of the building description. There are currently no miscellaneous electric components defined.


 Select the “A.” option from the miscellaneous electric submenu. This will allow us to define a new miscellaneous electric energy use. The result is the display of a miscellaneous electric data entry screen.

 Enter *athletic* in the Name field.


 Move to the Rate field and enter 95.

 Move to the “HOURLY SCHED” special menu field and select it. This results in the display of a menu listing all currently defined hourly schedules in the library. We wish to define a new hourly schedule.

 Press the **down** arrow key repeatedly to scroll to the first empty hourly schedule slot (this should be slot **K:**).

 Select this empty slot either by pressing **Enter** or **K**. This results in the display of an empty hourly schedule data entry screen.

 Enter *fieldlts* into the user name field for this hourly schedule.

 Press **Enter** or the **down** arrow to move to the hourly profile value for Midnight to 1 AM.

- ✍ Enter *0.0* and press **Enter** or the **down** arrow to move to the next hourly profile value for 1 AM to 2 AM. (This same result can be accomplished by simply pressing **Enter** or the **down** arrow to move to the next hourly profile field since *0.0* is the default value placed in the field as you pass through it.)
- ✍ Repeat the previous instruction to enter *0.0* into each hourly profile field up to 7 PM to 8 PM.
- ✍ Enter *1.0* into the hourly profile field for 7 PM to 8 PM.
- ✍ Press **F10** to automatically enter *0.0* into the remaining hourly profile fields and to transmit the data for this hourly schedule. The final result of this is that the name *fieldts* should now appear on the miscellaneous electric data entry screen next to “HOURLY SCHED”.
- ✍ Move to the “MONTHLY SCHED” special menu field and select it.
- ✍ Select the “**B**: all” option from the monthly schedule submenu to choose the predefined schedule with profile values of *1.0* for all months of the year. The result of this action is to place the name *all* next to “MONTHLY SCHED” on the miscellaneous electric data entry screen.
- ✍ Transmit the newly entered data for the *athletic* miscellaneous electric energy use by pressing **F10**. This name will now appear on the miscellaneous electric submenu.
- ✍ Press **Esc** to return to the usage modifications submenu.
- ✍ Press **Esc** again to return to the non-ECM modifications submenu.
- ✍ Press **Esc** a third time to return to the Retrofit menu.

#### 4.4. Complete retrofit

##### ***Explanation:***

We have now fully described all modifications to the base building description which were implemented or occurred prior to collection of the post-retrofit utility data. We will indicate this fact to RESEM by selecting the complete retrofit option.

##### ***Instructions:***

- ✍ Select the “Complete retrofit” option from the Retrofit menu.
- ✍ Press **Esc** to return to the Main menu.

#### 5. post Analysis

##### ***Explanation:***

Having fully described all post-retrofit modifications, we are now ready to perform an analysis of the post-retrofit building description. This portion of the analysis sequence includes: entering actual utility consumption data for the post-retrofit period, performing an adjustment process which matches the post-retrofit building description to the measured utility data, and completing the post-retrofit analysis to set the stage for calculating the energy savings estimates.

***Instructions:***


 Select the “post Analysis” option from the Main Menu. This causes the post-retrofit analysis pull-down menu to be displayed. □

**5.1. Enter post utility data**

***Explanation:***

Post-retrofit utility data is entered individually for each fuel type used in the project in the same manner in which base utility data was entered. The data can be entered for arbitrary periods with any beginning and ending dates. The dates for these periods should represent the time in which the fuel was consumed, as opposed to when it was purchased. Weather data for the corresponding period(s) will be automatically loaded as part of this step. If weather data is not available for the entered period(s), you will be informed of this fact.

***Instructions:***


 Select the “Enter post utility data” option from the post Analysis menu.


**5.1.1. Electricity**

***Explanation:***

The Technical Assistance documentation gives annual post-retrofit utility data. The period is assumed to begin on July 1, 1985 and end on June 30, 1986 during which 258,030 kWhrs of electricity were consumed.


***Instructions:***

 Select the “Electricity” option from the fuel type menu. This displays a data entry screen for electricity showing the proper units of measurement at the top.

 Type 7/1/85 into the field labeled From.

 Move to the To field by pressing **Enter**, **down arrow**, or **Tab**.

 Type 6/30/86 into the field labeled To.

 Move to the Amount field by pressing **Enter**, **down arrow**, or **Tab**.



- ✍ Type *258030* into the field labeled Amount.
- ✍ Transmit the utility data for electricity by pressing the **F10** key.

### 5.1.2. Gas

#### ***Explanation:***

The Technical Assistance documentation gives a 1985-1986 natural gas consumption of 42723 C.C.F.

#### ***Instructions:***

- ✍ Select the “**Gas**” option from the fuel type menu.
- ✍ Type *7/1/85* into the field labeled From.
- ✍ Move to the To field.
- ✍ Type *6/30/86* into the field labeled To.
- ✍ Move to the Amount field.
- ✍ Type *42723* into the field labeled Amount.
- ✍ Transmit the utility data for gas by pressing the **F10** key.
- ✍ Press the **Esc** key to return to the post analysis menu. There will a brief delay while weather data is loaded from your hard disk for the time period(s) corresponding to all post-retrofit utility data entered.

### 5.2. Adjust retrofit

#### ***Explanation:***


For the most accurate estimate of energy savings it is important that the simulated energy use of the post-retrofit building description closely match the actual energy use as measured by the utility data. We will achieve this goal in similar fashion to the reconciliation of the base building description to the base period utility data. However, there is a critical conceptual difference at this stage of the RESEM analysis. We are assuming that we correctly reconciled our base building description and that it therefore accurately describes “reality” prior to retrofit modifications. This means that any differences between our post-retrofit building description simulation and the entered post period utility data should be attributable to inaccuracies in describing either the ECM retrofits, the non-ECM modifications, or both. We should therefore restrict our adjustment of the post building description to those parameters altered by retrofit modifications.

To enable RESEM to correctly attribute final energy savings estimates to ECM retrofits, we must make a distinction, during post-retrofit adjustment, between adjustments meant to refine the descriptions of ECMs and those meant to refine

---

non-ECM modifications. We begin this process by selecting the post Analysis Adjust retrofit option.

***Instructions:***


 Select the “Adjust retrofit” option from the post Analysis menu. This displays a submenu presenting the adjustment options following an initial simulation of the post-retrofit building description.

**5.2.1. Display comparison**

***Explanation:***

The match between the current post building description simulation and the entered utility data can be displayed at any point in the adjustment process. At this point in this tutorial, initial post-retrofit differences should show electricity consumption ~0.1% (high). Gas consumption should be ~13% high.

***Instructions:***

 Select the “Display comparison” option from the Adjust retrofit submenu. Press any key to remove the data screen when you have finished viewing.


**5.2.2. Automatic adjustment**

***Explanation:***

The results of the previous step show that the simulated energy use of electricity is only slightly above the utility data (~0.1%) and that of gas is above the utility data (~13%). We must modify the post building description to bring the gas values closer. Also, if we feel that a modification is required to adjust possible inaccuracies in describing an ECM we must *also* modify the ecm building description.

We will use the RESEM automatic adjustment capabilities to perform the required modifications. We are reasonably confident in most of our retrofit descriptions. We will identify unoccupied infiltration rates as our culprit and select this parameter for adjustment. Since it is a parameter affected by an ECM description we want the adjustment reflected in the ecm building description as well as the post building description.

***Instructions:***


 Select the “Automatic adjustment” option from the Adjust retrofit submenu. This results in the display of the adjustment parameter category submenu.

### 5.2.2.1. Building envelope


#### ***Explanation:***

The parameter named “unoccupied infiltration rate” falls under the building envelope category. We wish to select this parameter for automatic adjustment related to an ECM description. A single automatic adjustment step can include some parameters selected for ECM adjustment and some for non-ECM adjustment, however an individual parameter cannot be selected for both ECM and non-ECM adjustment at the same time.

#### ***Instructions:***

 Select the “**B**uilding envelope” option from the parameter category menu. This results in a submenu listing all parameters under this category. To the right of each parameter name is a selection field indicating that *No* the parameter is not to be included in the subsequent automatic adjustment step. We will switch this field to *ECM* for the desired parameter. This is somewhat different from the action of the corresponding base reconciliation selection field. Instead of simply *No* or *Yes*, the adjustment selection field can be switched between *No*, *ECM*, and *NON*. The *ECM* value indicates that this is an adjustment of an ECM description. The *NON* value indicates that this is an adjustment of a non-ECM description. Switching between *No*, *ECM* and *NON* is still just a matter of selecting the desired parameter from the submenu to loop through the three alternate values.

 Select the “uno iNfiltration” option from the Building envelope menu. This results in changing the *No* to *ECM*.


 Press **Esc** to return to the parameter category menu.


### 5.2.2.2. **Esc** to perform automatic adjustment

#### ***Explanation:***


We have now selected all desired parameters and are ready to turn control over to RESEM for the automatic adjustment step.

#### ***Instructions:***

 Press **Esc** to return from the parameter category menu. This results in a dialog box asking if you wish to perform an adjustment using the currently selected parameters.

 Type *y* and press the **F10** key to transmit your consent. RESEM will now perform a series of simulations ultimately resulting in the display of two data viewing screens showing the adjustment results. Note that unoccupied infiltration rate has been adjusted to a value of 0.19 and this

adjustment has reduced the difference in electric consumption somewhat and gas consumption to less than 2%.


 Press any key to remove the data screens when you have finished viewing.


### 5.2.3. Repeat


#### *Explanation:*

We will repeat the same adjustment again seeking less than 0.5% differences for both fuel types.

#### *Instructions:*

 Select the **Repeat** option from the Adjust retrofit submenu. RESEM will again perform a series of simulations and display the screens showing the adjustment results. In the repeated adjustment unoccupied infiltration rate has been modified to a value of 0.17 and the difference in electric consumption has dropped to ~0.04% and in gas consumption to 0.16%.

 Press any key to remove the data screens when you have finished viewing.


 Press **Esc** to return to the post Analysis menu.


### 5.3. complete Post analysis

#### *Explanation:*

The match between our current post building description and the entered utility data is sufficiently good. We can now complete the post analysis and move to the calculation of energy savings estimates.

#### *Instructions:*

 Select the “complete Post analysis” option from the post Analysis menu.


 Press **Esc** to return to the Main menu.

## 6. Savings

### *Explanation:*

Our analysis is now complete. We are ready to calculate and evaluate the energy savings estimates. The final results of these calculations should produce the following information: estimated percent savings due to ECMs are +0.39 for electricity and +27.66 for gas, savings for non-ECM modifications are -19.98% for electricity and 0.00% for gas, total overall savings for post-retrofit long-term energy consumption are -19.58% for electricity and +27.66% for gas.


***Instructions:***

 Select the “Savings” option from the Main menu. This results in two final long-term weather simulations, one for the ecm building description and one for the post building description. Following these simulations, savings estimates are calculated and displayed onscreen.

**7. File*****Explanation:***

RESEM currently has the capability of saving several forms of report files to your hard disk. It is expected over time that these reports will increase in number and change considerably in format. It is also expected that the capability to directly print these reports will be added. For the present, to view these reports, you must first follow the procedures given below to save your desired report to your hard disk as a plain text file. This text file can then be viewed (and printed if desired) by using any word or text processor with the ability to read ASCII text files. Virtually all of today’s word processors have this ability although you may have to read their documentation to discover it. An alternative for both viewing and printing these files can be found in the PC-DOS *type* and *print* commands. Refer to your DOS manual for instructions on using these commands.


***Instructions:***

 Select the “File” option from the Main menu. This results in the display of the File submenu.

**7.1. Reports*****Explanation:***

The formatted report files are listed in a Reports submenu.


***Instructions:***

 Select the “Reports” option from the File menu. This results in the display of the Reports submenu.

**7.1.1. Project summary*****Explanation:***

The Project Summary report shows a summary fundamental project information and the RESEM savings estimates separately by fuel type. Energy consumption figures are shown in both natural units (e.g., kilowatt-hours) and in Energy Use Index (EUI) units of kBtus per square foot per year.


**Instructions:**

 Select the “Project summary” option from the Reports menu. This results in the creation of a project summary file on disk. The name of this file will be the first 8 non-blank characters of the building name taken from the Project information data entry screen, with the 3 character prj extension (*tutor.prj*).

**7.1.2. end Use energy cons****Explanation:**

The end use energy consumption report lists simulated energy consumption for the selected building description version (i.e., pre, ecm, or post) and weather data type (i.e., long term or actual). This report includes data for each fuel type and each end use category. Consumption values are given for each month of the simulation along with simulation period totals.

**Instructions:**


 Select the “end Use energy cons” option from the Reports menu. This results in the display of a menu listing each building description version.


**7.1.2.1. Version 1: pre****Explanation:**

The end use energy consumption report is available for each combination of building description version (i.e., base (pre), ecm, or post) and weather data type (i.e., long term or actual). We will save reports only for long-term weather for the base, ecm, and post building description versions.

The filenames for these files will be derived from the building name field on the Project information data screen. For the base building long-term weather simulation this filename will be *tutor\_00.eg2*.

**Instructions:**

 Select the “Version 1: pre” option from the building description version menu. This indicates that you wish to save a report for the pre (base) building simulation. This action results in the display of a weather version menu.

 Select the “Version 1: LongTerm” option from the weather version menu. This indicates that you wish to save a report for the long-term average weather data simulation.



#### 7.1.2.2. Version 3: ecm

**Explanation:**

For the ecm building description there is only an end use energy consumption report for long-term weather. The following instructions will save simulated energy use for the project with ECM modifications only.

For the ecm building long-term weather simulation the filename will be *tutor\_20.eg2*.

**Instructions:**

-  Select the “end Use energy cons” option from the Reports menu
-  Select the “Version 3: ecm” option from the building description version menu.




#### 7.1.2.3. Version 2: post

**Explanation:**

We will now save an end use energy consumption report for the post-retrofit building description and long-term weather. This will save simulated energy use for the project with all post-retrofit modifications.

For the ecm building long-term weather simulation the filename will be *tutor\_10.eg2*.

**Instructions:**


-  Select the “end Use energy cons” option from the Reports menu
-  Select the “Version 2: post” option from the building description version menu.
-  Select the “Version 1: LongTerm” option from the weather version menu.


## 7.2. Save project

**Explanation:**

We will now save a project file as an archival copy of our completed analysis. The resulting disk file can be retrieved at any later time to review the overall analysis. It could also be copied to a floppy disk for safekeeping or for sharing with other RESEM users. Ultimately, files of this type can be collected from all RESEM users and used for further aggregate analysis of ECM retrofits.

**Instructions:**

 Select the “Save project” option from the File menu. This results in a menu listing the default project filename and any other project file names found on your hard disk.

 Select the desired project file name. This results in all project data currently stored in RAM, and the current status of the analysis sequence, to be saved to disk under the selected file name with an extension of “.rsm”. Note that any contents of an existing file of this name will be overwritten.



Technical Assistance Report Extracts

This section contains pages extracted from the actual Technical Assistance document used as the basis for the Example Tutorial. Each page has been reproduced from copies of the original TA document. The page numbers shown at the top of these extracted pages are those referenced in the step-by-step instructions of the tutorial.

I.S.D. #858 UPDATE

TABLE OF CONTENTS

SECTION 1 - HIGH SCHOOL

PAGE NO	DESCRIPTION
1.001	Plan View
1.002	Building Construction & Use Profile BUILDING
1.003	Electrical & Mechanical Systems Profile
1.005	Building Heating Load Survey
1.006	ECM Summary Sheet
	ECM's
1.007	· Eliminate Night Ventilation
1.009	· Reduce Ventilation
1.011	· Reduce Lighting Levels
1.013	· Boiler Modification
1.015	· Stratification Fans - BUILDING
1.017	· Roof Insulation - BUILDING
1.019	· Panels on Single Pane - BUILDING
1.021	· Single to Double Pane - BUILDING
1.023	· Window Frame Insulation - BUILDING
1.025	· Wall Insulation - BUILDING
1.027	· Solar

BUILDING CONSTRUCTION AND USE PROFILE

	---WALLS---		---DOORS---				---WINDOWS---					
	LENGTH	HEIGHT	NO	WIDTH	HT	FIT	TYPE	NO	WIDTH	HT	FIT	*
NORTH	254.0	22.0	6	3.0	7.0	Medium	Vestibule	15	4.0	11.0	Tight	1
	120.0	32.0	3	3.0	7.0	Medium	Single					
	44.0	26.0										
EAST	72.0	11.0	2	3.0	7.0	Medium	Single	2	4.0	5.5	Tight	1
	104.0	28.0										
SOUTH	260.0	24.0	1	3.0	7.0	Medium	Single	13	4.0	11.0	Tight	1
	120.0	36.0	1	7.0	8.0	Medium	Single					
	44.0	14.0	1	12.0	12.0	Loose	Single					
WEST	72.0	12.0	3	3.0	7.0	Medium	Single	4	4.0	4.0	Tight	1
	84.0	38.0										
	20.0	32.0										

	NORTH	EAST	SOUTH	WEST
GROSS WALL AREA	9,428.0	792.0	11,176.0	4,696.0
DOOR AREA	189.0	42.0	221.0	63.0
WINDOW AREA	660.0	44.0	572.0	64.0
NET WALL AREA	8,579.0	706.0	10,383.0	4,569.0
WALL U FACTOR	.27	.27	.27	.27

FLOOR AREA.....	83,202	square feet
ROOF AREA.....	50,705	square feet
ROOF U FACTOR.....	0.18	
OCCUPIED HOURS PER WEEK.....	50	hours
NUMBER OF OCCUPANTS.....	650	
OCCUPIED HOURS TEMPERATURE.....	68	F
UNOCCUPIED HOURS TEMPERATURE.....	65	F
OCCUPIED HOURS VENTILATION.....	24,325	cfm
UNOCCUPIED HOURS VENTILATION.....	8,500	cfm
USEFUL LIFE.....	25	years

\* NUMBER OF PANES

**ELECTRICAL & MECHANICAL SYSTEMS PROFILE**

-----  
**INTERIOR LIGHTING WATTAGES**

	INCANDESCENT	FLUORESCENT
PRIMARY	9,000	176,000
SECONDARY	18,000	10,000
TOTAL WATTS	213,000	WATTS/SQ. FT. 2.56

**SECURITY LIGHTING**

TYPE - INCANDESCENT	TOTAL WATTAGE	4,800
OPERATING HOURS 12	CONTROL - Photo cell	

-----  
**HEATING AND AIR DISTRIBUTION SYSTEMS**

**PRIMARY BOILER**

TYPE - Fire Tube Boiler	MFG - Kewanee
RATING (MBTU/hr) - Fuel 1 - 102000	Fuel 2 - 102000
MEASURED EFFICIENCY 83 %	TEST FUEL - Natural Gas
	OXYGEN - 6 %
	STACK TEMP - 350 degs F

MEDIUM OF HEAT TRANSFER - Low Pressure Steam  
 LIQUID TO AIR CONVERSION - 2 Pipe Fan Coil

**AUXILLARY EQUIPMENT**

FIN TUBE RADIATION  
 HOT WATER PIPING  
 SUPPLY AND RETURN DUCTS  
 OUTSIDE AIR DAMPERS  
 STEAM PIPING  
 EXHAUST DUCT WORK

---



---

MECHANICAL SYSTEMS PROFILE continued

---

FAN SCHEDULE

USE	TYPE	CFM	HP	NO	
SUPPLY AIR	BACKWARD CURVED VANE	1,000	0.08	15	
	BACKWARD CURVED VANE	1,250	0.12	2	
	BACKWARD CURVED VANE	1,500	0.25	6	
	BACKWARD CURVED VANE	4,000	2.00	1	
	BACKWARD CURVED VANE	5,600	2.00	1	
	BACKWARD CURVED VANE	6,400	3.00	1	
	BACKWARD CURVED VANE	7,600	3.00	1	
	BACKWARD CURVED VANE	24,000	10.00	1	
	EXHAUST AIR	BACKWARD CURVED VANE	750	0.25	2
		BACKWARD CURVED VANE	1,000	0.25	1
BACKWARD CURVED VANE		1,600	0.25	1	
BACKWARD CURVED VANE		2,000	0.33	2	
BACKWARD CURVED VANE		2,800	0.33	4	
BACKWARD CURVED VANE		3,180	0.75	1	
BACKWARD CURVED VANE		3,200	7.50	1	
FORWARD CURVED VANE		4,370	1.00	1	

---

## PUMP SCHEDULE

TYPE	HORSEPOWER
CONDENSATE RETURN	2.00
HOT WATER FOR HEATING	4.00
DOMESTIC HOT WATER	0.20

BUILDING LOAD SURVEY

GROSS ANNUAL FUEL AND ENERGY USAGE

FUEL TYPE	UNITS	\$/UNIT	MMBTU	%	USER COST	%
GAS (100 CUBIC FEET)	45,714	\$0.459	4,571.40	88	\$20,983	64
ELECTRICITY (KWH)	178,200	\$0.065	608.20	12	\$11,583	36
TOTALS			5,179.60		\$32,566	

AREA 83,202 square feet  
 ENERGY USAGE PER SQUARE FOOT 62.3 MBTU/sq. ft.  
 UNIT COST OF HEATING ENERGY \$6.56 per MBTU

HEATING LOAD DATA

ITEM NAME	UNITS	MMBTU/UNIT	MMBTU	%
WINDOWS				
SINGLE GLAZED				
NORTH	660	0.1573	103.80	1.7
EAST	44	0.1273	5.60	0.1
SOUTH	572	0.1070	61.20	1.0
WEST	64	0.1266	8.10	0.1
DOUBLE GLAZED				
NORTH	0	0.0000	0.00	0.0
EAST	0	0.0000	0.00	0.0
SOUTH	0	0.0000	0.00	0.0
WEST	0	0.0000	0.00	0.0
INFILTRATION	160	0.2133	34.30	0.6
WALLS				
NORTH	8,579	0.0447	383.50	6.2
EAST	706	0.0394	27.80	0.4
SOUTH	10,383	0.0346	359.30	5.8
WEST	4,569	0.0394	180.00	2.9
ROOF	50,705	0.0256	1,298.00	20.9
DAY VENTILATION	24,325	0.0635	1,543.80	24.9
NIGHT VENTILATION	8,500	0.1498	1,273.10	20.5
HOT WATER	0	0.0000	0.00	0.0
SUBTOTAL			5,278.50	
LIGHTING	190,000	0.0049	933.80	15.0
TOTAL HEATING LOAD			6,212.30	

## ECM SUMMARY SHEET

Item No	Description	Electrical Savings KWH	Energy Savings MMBTU	Energy Savings Dollars	Modification Cost	Payback Years
1	Eliminate Night Ventilation	0	1,818.74	\$8,348	\$16,500	2.0
2	Reduce Ventilation	0	1,422.08	\$6,527	\$16,500	2.5
3	Reduce Lighting Levels	30,400	0.00	\$1,976	\$5,000	2.5
4	Boiler Modification	0	120.02	\$551	\$1,600	2.9
5	Stratification Fans - BUILDING	-2,016	150.94	\$562	\$1,950	3.5
6	Roof Insulation - BUILDING	0	1,441.47	\$6,616	\$55,705	8.4
7	Panels on Single Pane - BUILDING	0	120.55	\$554	\$6,030	10.9
8	Single to Double Pane - BUILDING	0	179.79	\$825	\$11,390	13.8
9	Window Frame Insulation - BUILDING	0	345.61	\$1,586	\$34,316	21.6
10	Wall Insulation - BUILDING	0	855.86	\$3,929	\$102,643	26.1
11	Solar	0	1,213.65	\$5,571	\$488,040	87.6

**ENERGY CONSERVATION MEASURE  
DEVELOPMENT SHEET**

**ENERGY CONSERVATION MEASURE - Stop Unoccupied Hours Ventilatic**

Description of existing equipment:

This building has excessive ventilation.

Some of the ventilators, exhaust fans continue to run evenings

Description of energy conservation measure:

This ventilation can be reduced by changes to the equipment.

Provide scheduling device for positive shut-off on schedule.

Useful life 25 years

**ENGINEERING ANALYSIS:**

Source: DOE/CS-0132 ENERGY CONSERVATION IN EXISTING BUILDINGS

Page 114

Annual heating degree days 8227

Langleys 340

Annual cooling degree hours 474

Fuel 1 GAS

units of measure ccf

Percent of Total Energy= 88

Fuel 2

units of measure

Existing ventilation is 8,500 CFM for 118 hours per week

$$\text{MMBTU/YR} = \text{Ventilation rate (1000 CFM)} \times (\text{Degree days}) \times \\ (24 \text{ hours/day}) \times (1.08) \times (\text{Hours per week}/168) / 1,000$$

$$\text{Existing} = 8.5000 \times 8,227 \times 24 \times 1.08 \times 118 / 168 / 1000 \\ = 1,273.12 \text{ MMBTU/YR}$$

$$\text{TOTAL MMBTU SAVINGS} = 1,273.12$$

$$\text{-----} = 1,818.74 \text{ MMBTU}$$

[seasonal efficiency].7

GAS:  $1,818.74 / 0.100000 = 18,187 \text{ ccf/year}$

Electrical savings	0 kwh/year	0% of Usage
Fuel 1 savings	18,187 ccf/year	40% of Usage
Fuel 2 savings	0 /year	0% of Usage
Net Energy Savings	1,818.74 MMBTU/year	35% of Total Energy

## ENERGY CONSERVATION MEASURE DEVELOPMENT SHEET

### ENERGY CONSERVATION MEASURE - Ventilation Reduction

Description of existing equipment:

This building has excessive ventilation.

Ventilators continue to operate in unoccupied spaces.

Description of energy conservation measure:

This ventilation can be reduced by changes to the equipment.

Provide unit control and scheduling device to all ventilators.

Useful life 25 years

### ENGINEERING ANALYSIS:

Source: DOE/CS-0132 ENERGY CONSERVATION IN EXISTING BUILDINGS

Page 114

Annual heating degree days 8227

Langley's 340

Annual cooling degree hours 474

Fuel 1 GAS

units of measure ccf

Percent of Total Energy = 88

Fuel 2

units of measure

Existing ventilation is 24325 CFM for 50 hours per week

Proper ventilation is 650 people times 6 CFM per person = 12,000 CFM  
for 36 hours per week

MMBTU/YR = Ventilation rate (1000 CFM) x (Degree days) x  
(24 hours/day) x (1.08) x (Hours per week/168) / 1,000

Existing =  $24.3250 \times 8,227 \times 24 \times 1.08 \times 50 / 168 / 1000$   
= 1,543.80 MMBTU/YR

New =  $12.0000 \times 8,227 \times 24 \times 1.08 \times 36 / 168 / 1,000$   
= 548.34 MMBTU/YR

TOTAL MMBTU SAVINGS =  $1,543.80 - 548.34$   
----- = 1,422.08 MMBTU  
[seasonal efficiency] .7

GAS:  $1,422.08 / 0.100000 = 14,221 \text{ ccf/year}$

Electrical savings	0 kwh/year	0% of Usage
Fuel 1 savings	14,221 ccf/year	31% of Usage
Fuel 2 savings	0 /year	0% of Usage
Net Energy Savings	1,422.08 MMBTU/year	27% of Total Energy



**ENERGY CONSERVATION MEASURE  
DEVELOPMENT SHEET**

**ENERGY CONSERVATION MEASURE - Boiler Modification**

Description of existing equipment:

This building is operating it's burner at 83 % efficiency.

Description of energy conservation measure:

The burner could be made to operate at 86 % efficiency.

Change existing time clock to optimum start device & sensor.

Useful life 15 year

**ENGINEERING ANALYSIS:**

Source: DOE/CS-0132 ENERGY CONSERVATION IN EXISTING BUILDINGS

Page 105

Annual heating degree days 8227                      Lansleys 340

Annual cooling degree hours 474

Fuel 1 GAS                      units of measure ccf      Percent of Total Energy= 88

Fuel 2                      units of measure

We use the buildings conduction load as a base not the fuel usage  
We also use best distribution efficiency in present operations.  
Therefore the savings is not influenced by O & M shortcomings.  
Best distribution efficiency is 85%

Present usage = load (MMBTU) / .85 / Boiler efficiency  
= 2,427 / .85 / 0.83 = 3,440 MMBTU

Future usage = load (MMBTU) / .85 / Boiler efficiency  
= 2,427 / .85 / 0.86 = 3,320 MMBTU

GAS:                      120.02 / 0.100000 = 1,200 ccf/year

Electrical savings	0 kwh/year	0% of Usage
Fuel 1 savings	1,200 ccf/year	3% of Usage
Fuel 2 savings	0 /year	0% of Usage
Net Energy Savings	120.02 MMBTU/year	2% of Total Energy

## ENERGY CONSERVATION MEASURE DEVELOPMENT SHEET

### ENERGY CONSERVATION MEASURE - Stratification Fans

**Description of existing equipment:**

The Main Gymnasium now has temperature stratification at the ceiling.  
The excess temperature is 13 degrees.  
This area is 9,600 square feet.

**Description of energy conservation measure:**

This stratification could be reduced to zero by installation of slow moving fans. These fans should be installed every 2,500 square feet  
Useful life 15 years

### ENGINEERING ANALYSIS:

Source: DOE/CS-0132 ENERGY CONSERVATION IN EXISTING BUILDINGS

Annual heating degree days 8227

Langleys 340

Annual cooling degree hours 474

Fuel 1 GAS

units of measure ccf

Percent of Total Energy= 88

Fuel 2

units of measure

$$\text{No of fans} = \text{Square feet} / 2500 = 9,600 / 2500 = 4$$

$$\text{Factor} = [(\text{Temp} - \text{Seasonal avg. temp}) / (65 \text{ deg} - \text{Seasonal avg. temp})] - 1$$

$$= [(78 - 35) / (65 - 35)] - 1 = 0.430$$

$$\text{Heat waste} = (\text{Addition \%}) \times (\text{Total addition heat loss}) \times (\text{Factor})$$

$$= 18.9/100 \times 1,298.05 \times 0.430 = 105.6 \text{ MMBTU}$$

$$\text{TOTAL MMBTU SAVINGS} = 105.66$$

$$\text{-----} = 150.94 \text{ MMBTU}$$

[seasonal efficiency] .7

$$\text{Electricity} = \# \text{ fans} \times 140 \text{ Watts/fan} \times 24 \text{ hours} \times 150 \text{ Days / year}$$

$$= 4 \times 140 \times 24 \times 150 = 2,016 \text{ KWH Increase}$$

$$\text{GAS: } 150.94 / 0.100000 = 1,509 \text{ ccf/year}$$

Electrical savings	-2,016 kwh/year	1% of Usage
Fuel 1 savings	1,509 ccf/year	3% of Usage
Fuel 2 savings	0 /year	0% of Usage
Net Energy Savings	144.06 MMBTU/year	3% of Total Energy

- 5.4 Insulating existing masonry walls where brick and block construction does not allow insulation in the cavity or where finish wall requires non-destructive finish cannot be justified.
- 5.5 The Athletic field which is located adjacent to the high school has recently been relighted with 75-1500 W quartz lamps. This quantity of lights provides a lighting level which may normally be considered high for typical high school football. However, because this is an all purpose field used for community services with league softball and baseball during the summer as well as all public skating in the winter, reducing the lighting quantity for energy reduction would, in the opinion of this writer and the School Superintendent, adversely affect the function of the facility and therefore has not been independently studied.
6. The following items were investigated during the walk-thru inspection of the buildings and were found to be operating properly or upgraded to present energy conserving technology.
- 6.1 Supply fans for lunchroom, shops, music areas, and gymnasium have mixed air controller adjusted to limit outside air quantities to minimums during cold outside temperatures.
- 6.2 Supply fans are manually operated and switched off after the areas which they serve are no longer being used.
7. Energy Conservation Cost/Benefit Summary.
- 7.1 Life expectancy based on guidelines given in Minnesota Building Appraisal Manual (MBAM 68/75 Edition) considering that school buildings in the School District are in "normal" condition, resulting in a 95-year life, therefore:
- 7.1.1 High School.
- The St. Charles High School building is 13 years old with little appreciable upgrading to date.
- 95 years less 13 years actual age yields an 82-year "remaining useful life."
- 7.1.2 Elementary School.
- The original St. Charles Elementary School building is 56 years old. An addition to the building built in 1954 and other remodeling done has improved 30% of the total building as it stands today. This results in an estimated effective age of the building of 46 years.
- 75 years less 46 years effective age yields a 49 year "remaining useful life."

## E. Study for Boiler System.

## 1. Burner Replacement.

1.1 Two Kewanee Type C boilers equipped with combination gas/oil fired, forced draft, rotary cup burners and draft controls provide low pressure steam for domestic hot water, heating, and ventilation requirements. Burners are rated at 76 GPH oil and 11,250 MBH of natural gas.

1.2 Study to replace existing burners with pressure atomizing burners to increase the overall boiler/burner efficiency by an average of 7%.

## 1.2.1 Energy Conserved:

1.2.1.1 Over the past three years the school has been fairly consistent in its use of gas and oil, burning an average of 1.02 MMBTUs of fuel per degree day. Average number of degree days for a school year is 8,143.

## 1.2.1.2 Average year fuel consumption:

$$8143 \text{ DD} \times (1.02 \times 10^6) \text{ BTU/DD} = 8.306 \times 10^9 \text{ BTU/SY}$$

$$\text{Savings: } 8.306 \times 10^9 \text{ BTU/SY} \times 7\% = 5.81 \times 10^8 \text{ BTU/SY}$$

## 1.3 Economic Analysis.

$C_f$  = \$22,000 to provide (2) new pressure atomizing gas/oil burners.

$$C_m = 0$$

$$S_1 = 0$$

$$S_2 = \$1311.36$$

$$S_3 = \$274.45$$

$$S_j = \$1585.81$$

## 1.3.1 Simple Payback.

$$T = 13.87$$

## 1.3.2 Alternate Payback With Interest and Escalation Considered.

$$i = 0.11$$

$$T = 11.35$$

DOLS ENERGY REPORT  
DOL YEAR 1981-1982

MAY 10 1984

STRICT # 858  
TYPE ( ) ELEM ( ) VO-TECH  
(X) SEC ( ) OTHER  
FLOOR AREA 85,000 SC

FUEL AND ELECTRIC CONSUMPTION REPORT

**A** Instructions: Enter the organization name, date, building name, building address, city, and zip code as used on the prior report, mini-audit report, and/or maxi-audit report.

BUILDING NAME \_\_\_\_\_ NAME OF ORGANIZATION \_\_\_\_\_ DATE \_\_\_\_\_

**B** Instructions: Complete this section of fuel consumption as accurately as possible. Indicate the fuel types used by the fuel code as listed. The fuel code number describes the fuel type and the units of measure.

Electricity, kwh	10	No. 6 fuel oil, gallons	34
Natural gas, therms	21	Hard coal, tons	41
Natural gas, CCF	22	Soft coal, tons	42
Natural gas, MCF	23	Street steam, Mlbs	51
Natural gas, CF	24	Solar, hours	52
LPG, gallons	25	Wind, kwh	53
No. 2 fuel oil, gallons	31	Wood, tons	54
No. 4 fuel oil, gallons	32	Other (specify), MBTU	55
No. 5 fuel oil, gallons	33		

If the fuel used comes under the heading of OTHER, enter the code number 55 and specify the fuel type. For the units of measure convert the units as stipulated from the supplier to MBTU using the conversion factors as listed in the Maxi-Audit Manual or other engineering reference text. Enter the storage capacities of each fuel type for the building. Enter the year the data is being completed for. Enter the monthly quantities used, if it is measured, and the cost corresponding with the quality used. Otherwise enter the purchased quantities and costs. If more than two fuels are used make additional copies of this form.

Month	Year	FUEL TYPE	UNIT OF MEASURE	FUEL TYPE	UNIT OF MEASURE
		Natural Gas FUEL CODE 22	C.C.F. STORAGE CAPACITY	Fuel Oil FUEL CODE 31	Gallons STORAGE CAPACITY 10,000 gals.
		Quantity Used	Cost	Quantity Used	Cost
July	1981	---	---		
August	1981	---	---		
September	1981	---	---		
October	1981	4,520	683.15		
November	1981	7,040	2,163.78		
December	1981	9,840	3,007.69	1,504	1,353.60
January	1982	11,200	4,185.44	3,000	2,700.00
February	1982	4,690	1,653.33	3,000	2,700.00
March	1982	5,640	1,986.03		
April	1982	5,420	1,910.89		
May	1982	880	323.07		
June	1982	20	27.03		
Year Total		49,250	15,940.41	7,540	6,753.60

FUEL CONSUMPTION

+ 10,274  
39,194

C

Instructions: Complete this section on electrical consumption as accurately as possible. Enter the electrical utility name supplying electrical power to the building and the rate classification utilized. Enter the year that the data is being completed for. Use the same months and year for this section as were used in the fuel consumption section. Enter the electrical energy consumed in kilowatt-hours. Enter the total electric bill for each month. If the building has a demand meter, enter the maximum kilowatt demand for each month. Enter the power factor also, if it is included in the utility metering.

Utility Name: Interstate Power

Rate Classification:

Month	Year	Energy Kilowatt Hours	Maximum Demand Kilowatts	Power Factor	Cost (\$)
July	19 81	6,900	90		575.00
August	19 81	6,600	15		287.06
September	19 81	18,900	90		951.11
October	19 81	19,200	105		1,024.31
November	19 81	22,800	105		1,148.83
December	19 81	21,300	105		1,066.44
January	19 82	18,600	114		1,036.29
February	19 82	24,600	114		1,261.72
March	19 82	23,400	120		1,239.70
April	19 82	19,200	105		1,060.59
May	19 82	22,500	120		1,203.93
June	19 82	11,700	90		732.09
Year Total		215,700	1,173		11,587.07

ELECTRICAL  
CONSUMPTION

The following includes three years of fuel and electric consumption data, as submitted by the school districts, following implementation of their Cycle VI ECM grants. Please let me know if you have any questions.

**Building: St. Charles High School - Grant # 9332**

	<u>85-86</u>	<u>86-87</u>	<u>87-88</u>
Nat. Gas (CCF)	42723	35084	36186
Fuel Cost (\$)	15,800	9833	9609
Elect. Cons.(kwh)	258030	284400	314400
Elect. Cost (\$)	18773	20647	21794
Deg. Days (N=8277)	8679	7195	8152

**Building: Elbow Lake - West Central High School - Grant # 9321**

	<u>85-86</u>	<u>86-87</u>	<u>87-88</u>
Fuel Oil (gal)	28000	24804	31129
Fuel Cost (\$)	19863	12487	23069
Elect. Cons.(kwh)	343000	378800	371800
Elect. Cost (\$)	20676	22020	21693
Deg. Days (N=9235)	9267	7453	8434

Please note: 85-86 fuel oil consumption appears to be purchased quantity, rather than consumed quantity.

