



MF CHP Level 2 Analysis Tool

User Manual

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Manual developed by

U.S. Department of Energy, Oak Ridge National Laboratory
for
U.S. Department of Housing and Urban Development

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Acknowledgements

Continuing their efforts begun in 2003 to promote the use of combined heat and power in multifamily housing — an initiative of the HUD Energy Action Plan — the Department of Housing and Urban Development (HUD) and the Department of Energy/Oak Ridge National Laboratory (DOE/ORNL), have executed an Interagency Agreement (IAA) for an eight month effort to adapt the DOE/ORNL Level 2 Building Cooling, Heating and Power Screening Tool (BCHP) for use in multifamily housing.

The BCHP tool is used widely in the Federal Energy Management Program for office buildings, laboratories and other federal installations, and it was developed initially for evaluations of combined cooling, heating, and power systems in commercial buildings, under DOE's Energy's Distributed Energy Program.

Beta 3 of the MF CHP Level 2 Analysis Tool, which is a multifamily house version of the original BCHP Screening tool, was developed based on the DoeRayMe program of GARD Analytics in Park Ridge, IL, and was an extensive enhancement of DoeRayMe. The underlying DoeRayMe technology is distributed by Oak Ridge National Laboratory (ORNL) free of charge under license from GARD Analytics.

This manual provides user information on how to use beta version of the MF CHP Level 2 Analysis Tool.

Additional enhancements to this program are still desirable and are being pursued on a limited basis. Version 1.0 may become available depending on the fund available.

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**MF CHP Level 2 Analysis Tool
Beta 3**

Users Manual

Part 1, Installation

Introduction

The MF CHP Level 2 Analysis Tool is a computer program for assessing the economic potential of combined cooling, heating, and power (CHP) systems for multifamily buildings. The original program, the BCHP Screening Tool, which is the similar program for commercial buildings, was developed under Department of Energy funding by a collaborative effort between GARD Analytics of Park Ridge, Illinois and Oak Ridge National Laboratory in Oak Ridge, Tennessee. GARD Analytics delivered a fully-functional version of the program in October 2003 which has subsequently been modified by ORNL to incorporate graphical interfaces for data input and output.

The MF CHP Level 2 Analysis Tool consists of the executable program, databases for HVAC equipment, electric generators, thermal storage systems, prototypical multifamily buildings, and climate data. The program also includes DOE2.1e to calculate heating, cooling, and electrical loads.

The MF CHP Level 2 Analysis Tool is structured to perform parametric analyses between a baseline building, typically a conventional building without a CHP system, and up to 25 alternative scenarios with varying selections for building mechanical systems and operating schedules. Economic calculations are also performed, but the life-cycle economic parameters have not been kept current and may be out of date. If simple payback results are acceptable, the life-cycle economic parameters may not be an issue.

As of this writing, a host of CHP information resources can still be found at the DOE Distributed Energy Program website:

<http://www.eere.energy.gov/de/>

Program Installation

The MF CHP Level 2 Analysis Tool, beta 3, is distributed as a self-installing executable file that we currently recommend users download from:

http://eber.ed.ornl.gov/MF_CHP/

The choices at this site are:

- Download 24 MB program installation file
- Download PDF of MF CHP Level 2 Analysis Tool Draft Users Manual (2 MB) [this document]

Users must download the 24 MB installation executable file. There is no charge or registration at this time. To install the program, simply execute the setup program (double-click, or select and Enter). The Windows VISTA/7 operating system likely will ask at least one extra question.

The name of the file should be: *Setup-MF CHP Level 2 Analysis Tool-beta3.exe*. The file size should be 24,757,219 bytes (24,177 KB).

The setup screens that display during installation are shown next. The first setup screen, Welcome, is shown at the right.

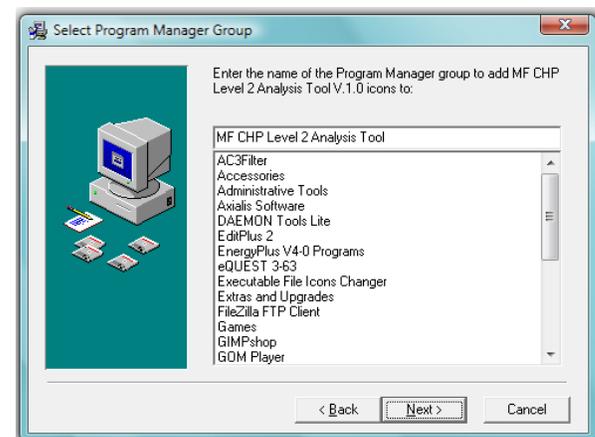
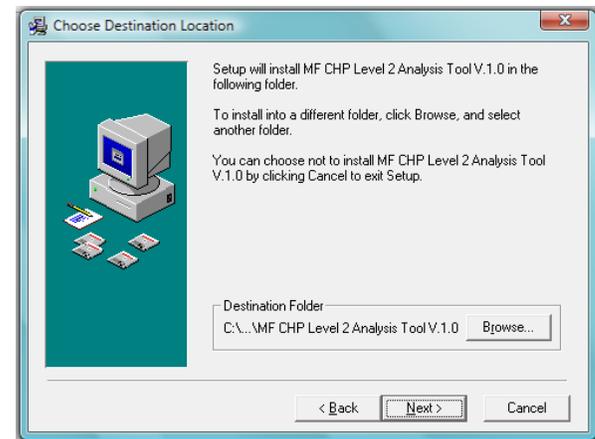
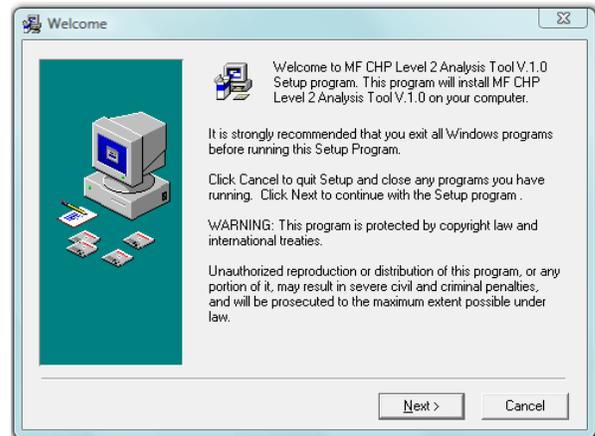
The second screen will indicate the destination directory for file installation and allow the user to change locations if desired by clicking the “Browse” button.

The third setup screen will ask a typically outdated question about the “Program Manager Group,” but really this choice ends up as the Start Menu Item when “All Programs” is selected following clicking on the Windows Start button or hitting the Windows key.

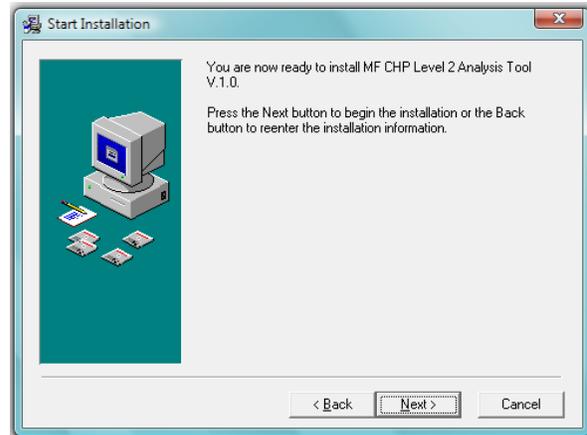
Once these selections are made, the fourth screen will indicate you are ready to “Start Installation,” and installation will begin if the user selects (clicks) the “Next” button. Installation progress is indicated on the next screen. Installation typically proceeds very quickly.

Once installation is complete, the “Installation Complete” screen will show, and users then complete the installation by selecting the “Finish” button (shown on next page).

Finishing the installation may take several seconds, after which typically the screen clears, the desktop reappears, and there is a new icon on the desktop for the “MF CHP Level 2 Analysis Tool-b3”

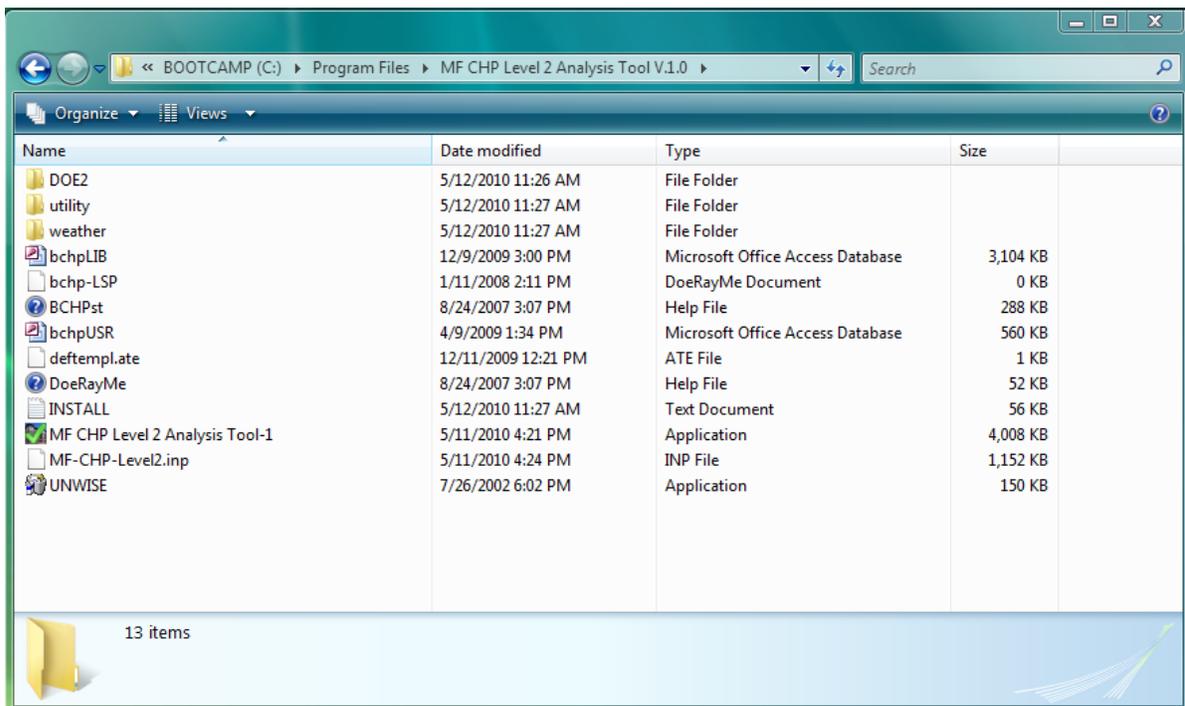


The files that are installed in the installation directory, as well as three new directories containing the weather, utility rate schedules¹, and DOE-2 program files are shown in the next figure below.



Uninstalling

If users wished to immediately uninstall the program, simply execute the “UNWISE.EXE” program shown in the figure below of the files directory, and the entire program will be removed. If a choice is made later to uninstall the program, the UNWISE.EXE program should still be executed, but any files modified by the user will still remain in the directories and have to be deleted manually. There are advantages and disadvantages to this older install / uninstall approach, but this approach seems most suited to this tool, which is still being developed. Uninstalling under VISTA may be quirky but should work.



Jump to Quick Start

At this point users may wish to jump ahead to the “Quick Start” section in Part 2, User Guide.

¹ The utility rate schedules are not used in this version of the tool. However, the folder cannot be removed for the program running.

Files and File Locations

When data for a new project are entered into the tool, users can save the data for later use. The default location for storing these files is in the same directory where the “MF CHP Level 2 Analysis Tool-1” file is installed (typically C:\Program Files\MF CHP Level 2 Analysis Tool, as seen in the files directory figure above), but users can select another location to store files for a specific project. Data files are stored with the extension “.drm” for later retrieval. The main temporary output files generated when a “named” or “titled” set of data (data previously stored in a “.drm” file) is “Run” by the program are stored in the same location as the “.drm” data file used. If no “.drm” file is saved, and the user simply modifies the input data and then “Runs” the data through the tool, temporary files will be saved in the same directory where the “MF CHP Level 2 Analysis Tool-1.exe” file is installed. Once a “.drm” file is saved in another directory, the tool will start using that directory to save files.

Saving a “.drm” file also creates a “title” for a specific set of data (typically a project title) that is the same as the “.drm” filename. The temporary output files created by “running” the tool will have a filename that begins with the same “title” as the “.drm” filename, while the last part of temporary filenames indicates the type of file and case or scenario (A, B, C, . . .). For example, if the “.drm” file is called “Project1,” then the DOE-2.1e sizing run output temporary file for Case A will be called “Project1-size-A.sim,” and the DOE-2.1e full simulation run output temporary file for Case B will be “Project1-B.sim.”

Further information on files and file locations is given in the “Advanced Users” section of *Part 2, User Guide*.

Documentation Files

Manuals used for the DOE-2.1e program are not necessarily needed by users, but advanced users will want to have them for reference. The zipped file, “DOE2 Documentation.zip,” at the download site:

<http://eber.ed.ornl.gov/bchpsc/>

contains the following PDF files:

Manual Name	File Date	Size, bytes
DOE-2 Basics Version 21E.pdf	6/3/2005 1:37 PM	8,268,775
DOE2 Engineers Manual.pdf	6/8/2005 10:57 AM	30,497,259
DOE2 Modeling Tips.pdf	3/7/2005 11:37 AM	372,012
DOE2 Reference Manual Part 1.pdf	6/10/2005 10:40 AM	32,494,827
DOE2 Reference Manual Part 2.pdf	12/15/2004 3:43 PM	10,975,492
DOE21e BDL Summary.pdf	6/3/2005 11:39 AM	7,860,939
DOE21e Supplement.pdf	12/16/2004 5:36 PM	41,690,899
2001weath.pdf	5/22/2000 9:56 PM	181,009
21e_update1.pdf	3/22/2000 8:09 PM	63,446
21e_update2.pdf	3/22/2000 9:24 PM	517,349
21e_update3.pdf	4/24/2000 5:38 PM	54,161

Some manuals are scanned from printed documents, so they are large.

This *Users Manual* (MF_CHP_Level2_Analysis_Tool_Version-1_Users_Manual.pdf) can also be downloaded at the same location.

**MF CHP Level 2 Analysis Tool
Beta 3**

Users Manual

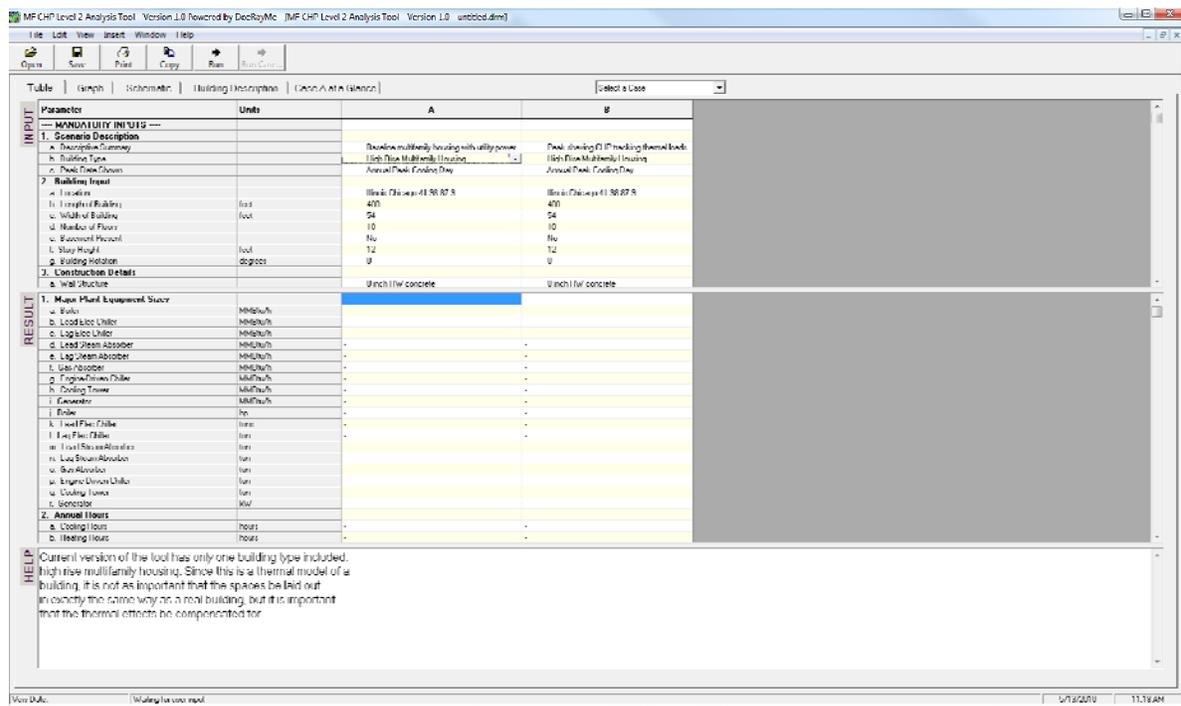
Part 2, User Guide

Quick Start

Once installed, the MF CHP Analysis Tool is ready to run. Starting the program from the desktop icon or Start Menu, the program loads the default template and the default multifamily building and comparison scenarios. If the "Run" button at the top of the program screen is clicked, the program executes a sizing run followed by a full simulation run using DOE-2.1e for both the Case A and Case B that are loaded as the default starting point. The cases run sequentially.

After the cases run, the results are displayed in the "RESULTS" pane of the main data form. The main data form is the "Table" tab of the main form that is displayed when the program starts. There are three panes to this Table: "INPUT," "RESULT," and "HELP." The HELP pane displays information on the item currently selected on the data form table. These panes can be resized vertically using the mouse. Making the "INPUT" pane larger when data is being entered, or making the "RESULT" pane larger when reviewing results, can be helpful.

Most of the time when using the MF CHP Analysis Tool users will interact with it using the "Table" tab on the main data form. A screen shot of how the program looks when it loads up is shown here.



The results are grouped into 70 separate groups, so there are a lot of results displayed. The Annual Electricity Consumption is the 4th group, the Annual Gas Consumption is in group 5, and the annual electricity generation (CHP) details are in group 6. These results may be of most interest initially for those interested in understanding program results.

When the DOE-2 program is executing the sizing and simulation runs, another window on your screen will open showing the activities and progress of the DOE-2 runs.

Try changing the building location or another parameter and pressing the **Run** button again. Do the fuel use numbers change?

The other tabs on the data form also display results and inputs in different formats. The “Schematic” tab shows a simplified diagram of energy system layout and an end-use breakout. The schematic displays correctly in most cases but may have difficulty replicating more complicated systems.

The input section of the main screen is where different parameters are set for the building and building systems to be compared. Normally, the first column, labeled “A”, is used for the baseline or standard building design and the second and remaining columns are for different alternative designs that may incorporate combined heating, cooling and power options.

The parameter name and the units for the entry are shown on the left side, and if a button appears at the right when the item is selected, users can select from the options in a data base dialog, by clicking on the button.

For parameters that require a number, simply type the number after clicking in the table cell — double-clicking also works. In column “B” and all columns other than the first column, in the pull down list there can be a “link to prev” option. If that is selected, the value of the cell will be the value of the cell directly to the left. This allows users to change the value of a single parameter in multiple columns simultaneously. A small arrow icon is shown on the left edge of the cell when the “link to prev” option is selected.

Many cells allow selection from a list of options. These cells usually have text shown. For some entries, the number of options is large and additional information is available to further describe each option. In these cases, clicking on the button at the right of the cell opens a data base dialog box, from which options are selected.

For some entries, the selection may be a file, such as when selecting a utility. In these cases, a normal “file dialog” box is opened. Usually the directory and the file extension are already chosen to make finding a file easier.

Key Acronyms

A few key acronyms must be known to use this manual.

CHP stands for cooling, heating, power systems, or systems that can generate electric power and thermal energy for heating or cooling purposes simultaneously

BCHP stands for Building CHP systems, or CHP systems used in buildings

MF CHPsc stands for MF CHP Analysis Tool

HVAC stands for heating, ventilating, and air-conditioning systems

TMY stands for typical meteorological year

DRM stands for DoeRayMe

Flow of the MF CHP Analysis Tool

As described in the next section, DOE-2.1e is a powerful building energy simulation tool. The MF CHP Analysis Tool runs DOE-2.1e in the background, using another powerful tool that provides all the input options, executes the other programs needed, and manages the production of results.

Enhanced abilities for simulating building energy use are needed since the energy flows in buildings are complicated, and difficult to calculate at the level needed for reasonable analysis of CHP systems. Thus, the aid of a building energy simulation tool is important.

The tool handles input and output for users and creates extensive default inputs for the default building types via the “Template” file. Key outputs are extracted and made available in the main Table tab or the graphic user interface (See Figure 1)

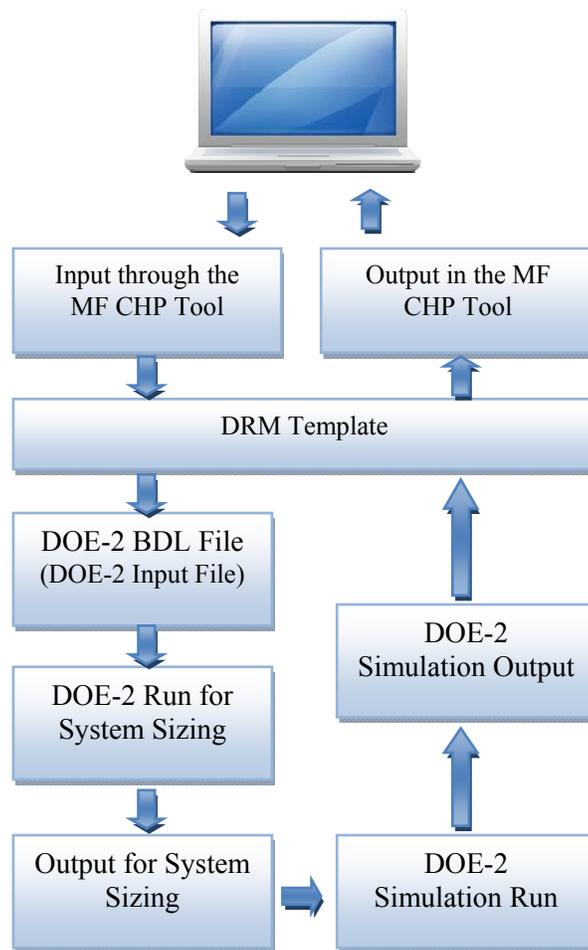


Figure 1: Sequence of the MF CHP Analysis Tool

DOE-2.1

DOE-2 is a widely used and accepted freeware building energy analysis program that can predict the energy use and cost for all types of buildings. DOE-2 uses a description of the building layout, constructions, operating schedules, conditioning systems (lighting, HVAC, etc.) and utility rates provided by the user, along with weather data, to perform an hourly simulation of the building and to estimate utility bills. DOE-2 simulates at an hourly time step, so data are available down to the hourly level.

The “plain” DOE-2 program is a “DOS box” or “batch” (or Command console) program that requires substantial experience to learn to use effectively while offering researchers and experts significant flexibility. The DOE-2.1e version of the program used in the MF CHP Analysis Tool runs in the “background” of the graphic interface for the tool.

Documentation on the DOE-2.1 program can be downloaded either from the BCHPsc website or:

<http://doe2.com/DOE2/index.html#doe21e> under DOE-2.1E Documentation files.

Users may also wish to check the website: <http://simulationresearch.lbl.gov/>

Weather Data

The MF CHP Analysis Tool uses TMY2 weather data files, which are provided for all 239 US locations for which these data are available.

TMY2 data are sets of hourly values of solar radiation and meteorological elements for a 1-year period. Their intended use is for computer simulations of building energy systems to facilitate performance comparisons of different system types, configurations, and locations in the United States and its territories. Because they represent typical rather than extreme conditions, they are not suited for designing systems to meet the worst case conditions occurring at a location.

Earlier TMY data sets (ca 1981) were derived from the 1952–1975 SOLMET/ERSATZ data base. To distinguish between the two TMY data sets, the new TMY data sets are referred to as TMY2s. The TMY2 data were derived from the 1961–1990 National Solar Radiation Data Base.

Other types of weather files can be used if needed, but for BCHP system screening purposes the TMY2 data are considered the most useful.

Weather data must be “compiled” into a binary format for DOE-2 to use them, and the files provided with the tool are the compiled versions (“.BIN”). The weather compiler can be downloaded from:

http://doe2.com/index_Wth.html#DOEWth

This DOE-2 weather processor can convert a variety of standard formats, obtained from NOAA/NCDC and other sources, into DOE-2 “BIN” files. This utility can process TMY2, WYEC2 CZ2 and other common formats, but the program is a “DOS box” (Command console) tool that does not include a windows user interface.

The “user manual” for the weather processor is part of the BChPsc website zipped documentation file, and can also be downloaded from:

<http://simulationresearch.lbl.gov/dirun/2001weath.pdf>

The weather processor user manual provides additional information on other formats and how to accommodate them.

See also the section “Weather,” in *Part 3, Reference Manual*, of this User Manual for information on changes needed to the User library data base if a weather file is added.

The “Template”

On startup, the MF CHP Analysis Tool reads in a large data file template (DRM Template) that defines the main input data form and most of the options available in the data form. The template also defines the results table and provides the macro-enhanced DOE-2 input file. The default template for beta 3 of the tool is over 23,000 lines of coding. Additional information on the template can be found in “The DOE-2 Template Input File Generator” section of *Part 3, Reference Manual*.

Using the Tool

An implied skill important to improving results obtained with the MF CHP Analysis Tool is ability to understand building energy use and simulation of that use. However, users with no skill at all can generate results using this tool, so be cautious about results generated before developing experience with the simulation results and how to change them.

Once the program is installed on a user’s computer, a new shortcut icon should be found on the desktop, like shown here, titled “MF CHP Level 2 Analysis Tool-1” The tool can be executed from this icon or from the text / icon item found in the Start Menu under “All Programs, MF CHP Level 2 Analysis Tool.” When the program loads, users will see a screen similar to that shown in the figure in the “Quick Start” section at the beginning of Part 2 of this manual.

The default multifamily building scenarios loaded with the program can be changed to simulate the buildings and systems desired. The main “Table” tab (or data form) is displayed on startup. Users may wish to switch to the “Building Description” tab to see descriptions of the six major zones in the building and key parameters related to these zones. A separate display is shown for each “case” or “scenario,” which will be “A” and “B” for the default data loaded on startup. Scenarios are switched on this form by selection the “radio button” on the left corresponding to the scenario displayed.

Keep in mind that this tool is not restricted to analyzing only CHP systems, and the energy use of two different versions of a building, with different building configurations, could also be analyzed.

In the main data table (“Table” tab), the data are displayed showing “Parameter” item, “Units” applicable to the parameter, if any, and the data for each scenario (Cases “A” and “B” High Rise Multifamily Housing data for Boston in the default startup table). The “HELP” window of the main screen displays information about assumptions on specific data items that are selected.

The input data has main two categories: 1) Mandatory inputs and 2) Additional inputs. If the user wants to simulate the building with minimum efforts, only the mandatory inputs needs to be entered.

For more detailed and advanced simulation, the user needs to change additional inputs. To define the scenario and building, data are entered for:

Scenario and Building Description
1. Scenario Description
a. Descriptive Summary
b. Building Type
c. Peak Date Shown
2. Building Input
a. Location
b. Length of Building
c. Width of Building
d. Number of Floors
e. Basement Present
f. Story Height
g. Building Rotation

The descriptive summary (1.a) can be changed at any time. Key building data that typically must be changed from the default under “2. Building Input” above are items a, b, c, d, e, and g. If a basement is present, item ‘e’ can be changed. Item “g. Building Rotation” can be changed if a building axis is oriented more than about 20 degrees from true north. 1-C “Peak Date Shown” has many options for selecting what peak is of interest, including any possible date in a 365-day year.

There are 239 weather locations available. Additional detail can be found in *Part 3, Reference Manual*, and “Input Parameters.”

2 Categories (Mandatory input and Additional inputs) have subcategories. The list of the input data is shown in the next table.

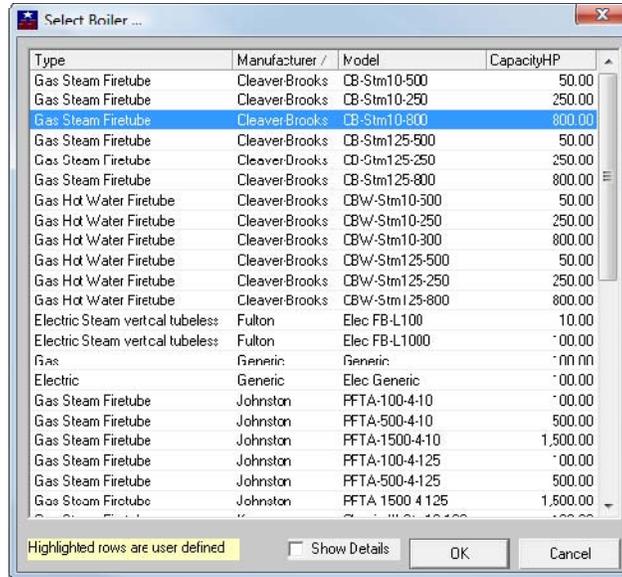
Input Data Categories
--- MANDATORY INPUTS ---
1. Scenario Description
2. Building Input
3. Construction Details
4. System Selection
5. Equipment Selection
6. Generator Details
7. Utility rates
8. Cooling Operation
--- ADDITIONAL INPUTS ---
I. BUILDING DETAILS
II. EQUIPMENT SIZING OPTIONS
III. PLANT EQUIPMENT OPERATION
IV. EMISSIONS FACTORS
V. ECONOMIC PARAMETERS

Building Types

The current version (beta 3) of the tool has one building type (i.e., high rise multifamily housing). More detail on the default data is provided in *Part 3, Reference Manual*.

Database Dialog

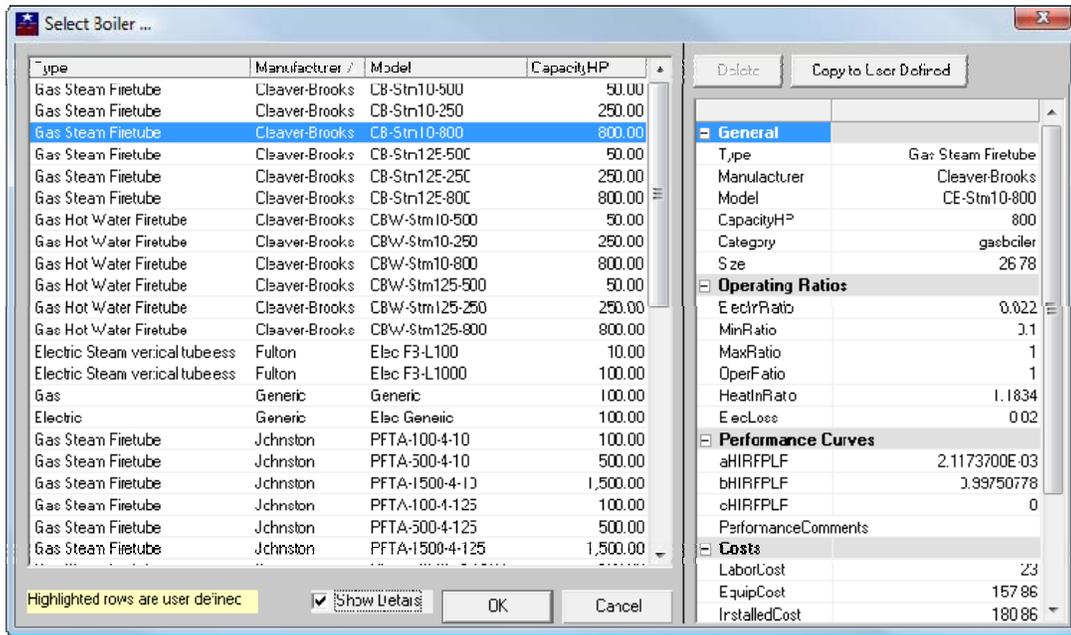
Some entries in the list of inputs from the “Table” tab have many different possible options and associated data. For these parameters, a database dialog box will be displayed, such as the one shown below.



You can choose an entry from the list and hit the “ok” button to select it. When you select it, an abbreviated version of the name and type are shown in the cell on the main screen. By clicking on the different column headers, the list can be sorted. Some rows may be highlighted in a different color. These rows are entries from the user-defined data base (the main data base cannot be modified directly by the user, but the user data base can have additional entries added by users that can be modified).

If you check the “Show Details” check box, additional information is displayed for the selected row as shown in the example below. Note the “Copy to User-Defined” button, which works for most data base tables and allows all the data fields to be copied to the user data base for a piece of equipment close to what is desired as a starting point for user editing.

If a user has chosen to install the optional bchpUSR.lib file, obtained from the website in the zip file, *weather and generator data bases-v2.zip*, to replace the user library that was installed with the program, then the generator data displayed in the database dialog for generators will be shown twice: at the top of the list in white and at the bottom of the list in yellow. Rows in yellow are user defined and can be edited using Access, by opening the bchpUSR.mdb file and then opening the Generator table.



Menu Reference – File Menu

[FILE] [OPEN]

The [FILE][OPEN] menu item is used to select an existing file from your computer. Existing files include both template files (*.D2T, or encoded-unchangeable, and *.INP) and parameter or settings files (*.DRM). Settings files indicate changes to the default data to arrive at a new data set. Many files can be opened at one time. If multiple files are open, use the [WINDOW] menu to switch between them. When you open a settings file, the MF CHP Analysis Tool also opens the corresponding MF CHP Analysis Tool template file, named BCHP-LSP.D2T. To open a new window select the MF CHP Analysis Tool template file and a file with two columns with all values set to default will be shown. Template files with the “.INP” extension are text files that can be modified, and users should be careful with these, as an unacceptable modification may cause the program to abort. Only one template file is applied to each “project” that is open.

[FILE] [OPEN MF CHP ANALYSIS TOOL TEMPLATE]

The [FILE][OPEN MF CHP Analysis Tool Template] menu item is a short cut to opening the MF CHP Analysis Tool template file named MF-CHP-Level2.inp. You can use this to start a new file with two columns with all values set to default values for the default high rise multifamily housing analysis in Boston. The new file will be shown as an “untitled” settings or parameter file until you are ready to save it and set the file name.

[FILE] [CLOSE]

The [File] [Close] menu item will close the active file. If the file has not been saved recently, the program will ask if you would like the opportunity to save the file before closing the file. If other files are also open at the same time, one of them will be displayed. If only one file is open when you choose [FILE][CLOSE], the MF CHP Analysis Tool will show a blank window with only a file menu available.

[FILE] [SAVE]

The [File] [Save] menu item saves the existing settings file (DRM) using the existing name of the settings file. Invoking this menu item is the same as pressing the [SAVE] button on the tool bar. If the settings file has not yet been named, it will bring up a dialog box to allowing you to name the settings file.

[FILE] [SAVE AS]

Saves the settings file (DRM) using a filename specified by the user. This is a good way to make another copy of the existing settings file but under a different name.

[FILE] [PRINT INPUTS]

The [File] [Print Inputs] menu selection allows you to print out the input portion of the “Table” tab on the main screen. It is a good way to document all of the assumptions for a given simulation run. The table is printed directly as shown on the screen so it is a good idea to reformat the columns by dragging the line between the column headers such as “A” and “B” in order to see multiple columns on your print out. You may also choose to print in landscape orientation to allow more columns to be shown. The [VIEW][SMALL TEXT] option may also help to get as much on a page as possible.

[FILE] [PRINT RESULTS]

The [File] [Print Results] menu selection allows you to print out the results portion of the “Table” tab on the main screen. It is a good way to document all of the results for a given simulation run. Like the [FILE][PRINT INPUTS] menu item, you may want to reformat the columns, text size (see VIEW menu below), and page orientation to maximize the number of columns and rows shown on each page.

[FILE] [PRINT GRAPH]

The [File] [Print Graph] menu item allows you to print out the current graph shown on the “graph” tab. It simply prints out the single graph taking up one page.

[FILE] [CREATE HOURLY FILES]

The [File] [Create Hourly Files] menu item appears checked when you select it the first time and unchecked when you select it again. The check toggles back and forth. When the [Create Hourly Files] is checked, files are created in the same directory as your settings file. The files will have the same file name as the settings file with the extension of CSV and with a -A, -B, etc.. after the name. These files contain the hour-by-hour results for an entire year for heating load, cooling load and electrical load. The CSV file format is very easy for spreadsheets to open since the file is a list of all of the values separated by commas. This option does create many files so you should not check it unless you are going to look at the CSV files. Remember that the CSV files will be overwritten during the next simulation of that case. See the “Hourly CSV Files” section of *Part 3, Reference Manual*, for more information on the values found in the CSV files. Also see the “Data Table Results” sections, “Hourly Cooling Load, item 28”, “Hourly Heating Load, item 29” and “Hourly Electric Load, item 30.”

[FILE] [RUN SIMULATION]

The [File] [Run Simulation] command is used to run a simulation and is the same as simply pressing the [RUN] button on the toolbar. When either method is used to start the simulation process, the program will proceed on a column-by-column basis and run the building energy simulation using DOE-2.1e and then extract and display results from the simulation. If the values in the input portion of the column have not changed since the last time that column was simulated, it will be skipped. If the input parameters that are related to the building shell and internal loads description (the loads portion of DOE-2) have not changed since the previously run column, then only the portion of DOE-2 that relates to equipment (the system and plant portion of DOE-2) will be invoked, this is done to speed up the simulation process when very often the building description is the same from column to column.

[FILE] [EXIT]

The [File] [Exit] command exits the MF CHP Analysis Tool program. If the settings file has been changed since the last time it was saved, the program will ask if you are sure you want to exit. Another way to exit is to use the [x] button in the top right corner of the window.

Menu Reference – Edit Menu

[EDIT] [COPY]

The [Edit] [Copy] menu command will copy the highlighted cells to the clipboard so that they can be pasted into another program such as a spreadsheet. To highlight multiple cells, click and drag the mouse over the cells. You may copy from the input area or from the result area but not both at the same time. When you use this menu command, the headings are not copied, just the values. If you want to copy with the headings, use the [EDIT][COPY WITH HEADINGS] command described in the next paragraph.

[EDIT] [COPY WITH HEADINGS]

The [Edit] [Copy with Headings] menu command will copy the highlighted cells to the clipboard along with the headings so that they can be pasted into another program such as a spreadsheet. To highlight multiple cells, click and drag the mouse over the cells. You may copy from the input area or from the result area but not both at the same time. When you use this menu command, the row and column headings are copied along with the values. If you want to copy just the values without the headings, use the [EDIT][COPY] command described in the previous paragraph.

[EDIT] [DELETE COLUMN]

The [Edit] [Delete Column] menu command will delete the column that currently contains the highlighted cell. Only select one cell when using this command. To insert columns see the commands below under the [INSERT] menu item.

Menu Reference – View Menu

[VIEW] [TABLE]

The most common way to switch between the tabs for the table, graph, schematic, and building description on the main screen is simply to click on the small tabs that contain the words “Table,” “Graph,” “Schematic,” and “Building Description.” You may also use this menu command to switch directly to the Table tab.

[VIEW] [GRAPH]

The most common way to switch between the tabs for the table, graph, schematic, and building description on the main screen is simply to click on the small tabs that contain the words “Table,” “Graph,” “Schematic,” and “Building Description.” You may also use this menu command to switch directly to the Graph tab.

[VIEW] [SCHEMATIC]

The most common way to switch between the tabs for the table, graph, schematic, and building description on the main screen is simply to click on the small tabs that contain the words “Table,” “Graph,” “Schematic,” and “Building Description.” You may also use this menu command to switch directly to the Schematic tab.

[VIEW] [BUILDING SPEC'S]

The most common way to switch between the tabs for the table, graph, schematic, and building description on the main screen is simply to click on the small tabs that contain the words “Table,” “Graph,” “Schematic,” and “Building Description.” You may also use this menu command to switch directly to the Building Description tab.

[VIEW] [LARGE TEXT]

The [View] [Large Text] menu command changes the font size used in the main screen in the “input” and “results” areas on the “table” tab to the large font setting. The default when the program is started is to display these areas using the large text option. To switch to using small text in the “table” use the next command described [VIEW][SMALL TEXT].

[VIEW] [SMALL TEXT]

The [View] [Small Text] menu command changes the font size used in the main screen in the “input” and “results” areas on the “table” tab to the small font setting. The default when the program is started is to display these areas using the large text option. This setting will increase the number of possible

rows and columns that can be seen in the window at the same time. Another method to display more columns on the screen at the same time is to adjust the width of the columns by dragging the line separating them in the column headings. To switch to using large text in the “table” use the previous command described [VIEW][LARGE TEXT].

[VIEW] [TEXT TAB]

An additional tab can also be displayed on the main screen called “Text.” This menu command causes the Text tab to be displayed (check mark is shown next to menu item) or not displayed (no check mark). This display shows either system messages or the “Text” version of the input template (INP file) if a text-readable version of the input template is used. Note that the default “INP” template is over 20,000 lines long. Also note that the DoeRayMe End User License Agreement or EULA is contained in the beginning of the “INP” template. The MF CHP Analysis Tool is an expansion and enhancement of DoeRayMe.

Menu Reference – Insert Menu

When the MF CHP Analysis Tool is first started only two columns are shown. The first column is the baseline configuration for the building and the second column is the alternative. The MF CHP Analysis Tool can actually analyze up to 26 columns, i.e., 26 different scenarios, at the same time. The [INSERT] menu items can be used to add a new column.

[INSERT] [COPY OF CURRENT COLUMN]

The [INSERT] [COPY OF CURRENT COLUMN] command adds a new column directly to the left of the current column with the same values that are currently in the current column. The new column may be used just like the original columns to define another scenario.

[INSERT] [COLUMN LINKED TO CURRENT VALUES]

The [INSERT] [COLUMN LINKED TO CURRENT VALUES] command adds a new column directly to the left of the current column with links to the current column for many of the input parameters. The links make it easy to change the values in multiple columns at the same time since they always take the value that appears in the column just to the left of the item with the link. The new column may be used just like the original columns to define another scenario.

[INSERT] [COLUMN OF DEFAULT VALUES]

The [INSERT] [COLUMN OF DEFAULT VALUES] command adds a new column directly to the left of the current column that contains default values. The default values for the input parameters are the same value shown in columns when you first opened the MF CHP Analysis Tool with a blank file. The new column may be used just like the original columns to define another scenario.

Menu Reference – Window Menu

Displays the names of the files that are currently open, each with its own window, and allows you to switch between the different files. If the settings file (“drm” file) is not saved with a name, multiple “untitled” window data sets may be open at the same time, which may lead to confusion.

Menu Reference – Help Menu

[HELP] [MF CHP ANALYSIS TOOL CONTENTS]

The [Help] [MF CHP Analysis Tool Contents] command displays the table of contents for the help file that describes the MF CHP Analysis Tool.

[HELP] [SEARCH MF CHP ANALYSIS TOOL FOR]

The [Help] [Search MF CHP Analysis Tool For] command displays the search dialog box for the help file that describes the MF CHP Analysis Tool.

[HELP] [ABOUT MF CHP ANALYSIS TOOL]

The [Help] [About MF CHP Analysis Tool] command displays information about the MF CHP Analysis Tool itself. The information includes the version number of the MF CHP Analysis Tool, the license information, a brief description of the MF CHP Analysis Tool, and copyright information.

[HELP] [DOERAYME CONTENTS]

The [Help] [DoeRayMe Contents] command displays the table of contents for the help file that describes the DoeRayMe program.

[HELP] [SEARCH FOR DOERAYME HELP ON]

The [Help] [Search for DoeRayMe Help On] command displays the search dialog box for the help file that describes the DoeRayMe program.

[HELP] [ABOUT DOERAYME]

The [Help] [About DoeRayMe] command displays information about the DoeRayMe program. The information includes the version number of the DoeRayMe program and copyright information.

Function Keys

The original version of the MF CHP Analysis Tool made use of some of the keyboard function keys, and one or two will still do something, but users are cautioned not to use the function keys.

Results

“Running” a simulation generates results that are displayed in the “RESULT” part of the main screen data form, on the Graph tab, and on the Schematic tab. The RESULT window can be resized. Users should consult the “Data Forms,” “Generating Results,” and “Data Table Results” sections of *Part 3, Reference Manual* for more information and details on program output.

Known Limitations and Issues in Beta 3

Several limitations and issues remain with Beta 3. Some key items are:

- Desiccant systems do not appear to allow use of recovered heat from CHP systems, and changes appear necessary to correct the algorithms
- Life-cycle economic data such as fuel price escalation factors have not been updated, so life-cycle economic results must be approached with caution — simple paybacks are not affected
- Domestic hot water use is calculated based on energy use per person and cannot be changed except by modifying the input template
- The “Schematic” tab display may not draw correctly at times
- Help menu may not work in some version of Windows.

Financial Calculations

As indicated above, life-cycle economic factors may be out of date.

If users wish to verify economic results, or feel more comfortable with other tools, they may wish to extract specific data needed. One such tool is the Building Life-Cycle Cost (BLCC) Program tool, that is updated annually. The current version is 5.3-07 and is available for PCs only:

http://www1.eere.energy.gov/femp/information/download_blcc.html.

The most useful data to extract may be contained in the simple hourly files that can be generated. See the section “Hourly CSV Files” in *Part 3, Reference Manual*.

Other supporting programs are also available, such as ERATES 1.11, which is used to calculate the monthly and annual electricity costs for a facility, building, or system under a wide range of electric

utility rate schedules, and EERC 1.0-07, which computes an average annual escalation rate for fuel prices from the annual energy price forecasts of the DOE Energy Information Administration, based on user input for project location, fuel usage, industry sector, and the beginning and end dates of the period of interest. All these program downloads can be found at the link given in this section.

Checking Results

As indicated in “Using the Tool” above, an implied skill important for good results with the MF CHP Analysis Tool is ability to understand building energy use and simulation of that use. But in order to check results, users must have information to check against, which is where previous experience with building energy use can be critical. Users should not use results without first checking them against some type of expected values (e.g., compare results against simple Rules-of-Thumb calculations).

Checking results can be considered a low-level “calibration” of results against expectations. If measured energy data are available for a building, the simulated results can be compared against the measured data.

One problem with simulations is that they assume systems and equipment run perfectly, which is often not the case with HVAC systems, so some adjustments of input data may be needed to obtain desired output data.

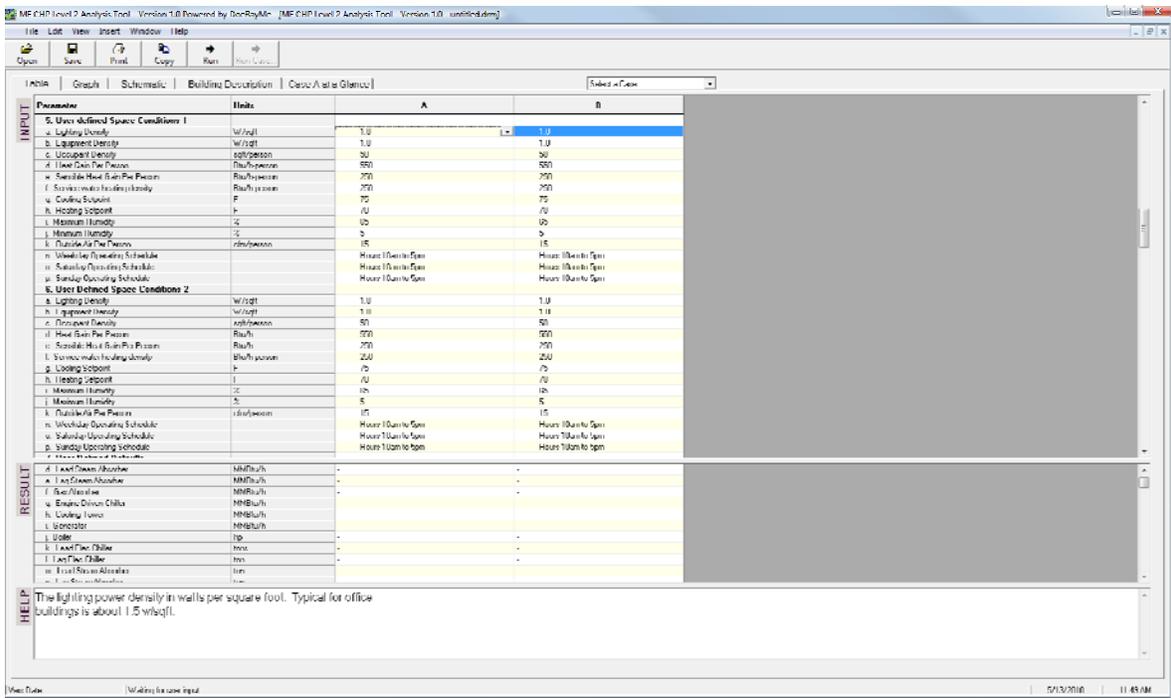
After results are generated, users should check first items 4.k, annual electricity use, 5.h, annual gas use, and items 6.a and 6.b, as applicable, utility-supplied electricity and on-site generation. These values should be checked first against expected annual totals. The *2007 ASHRAE Handbook, HVAC Applications*, Chapter 35, has tables of total energy use per square foot and electricity use per square foot, with mean, median, and some key distribution percentiles, for about 50 building types. These data are based on real buildings and the sampling weights from the 2003 Commercial Buildings Energy Consumption Survey (CBECS) of the US Department of Energy, Energy Information Administration, public use data.

(http://www.eia.doe.gov/emeu/cbecs/cbecs2003/public_use_2003/cbecs_pudata2003.html)

Users may also want to check electricity use for lights, equipment, and other end uses, as tabulated in item 4 of the RESULT frame of the main screen Table tab against quick engineering calculations. As an example, lighting energy kWh/yr might be estimated as 1 W/sq-ft times total sq-ft times 2,500 hr/yr divided by 1,000, for a typical office building. Similarly, gas use can be compared against simple engineering estimates.

In addition, the graphing capabilities of the tool (Graph Tab) should be used to check some basic items such as load duration curves and electric use profiles.

One key area of the input data for this tool covers user-defined space conditions as shown below:



These User-Defined Conditions are typically important to better definition of a building to be analyzed, since lighting and equipment power densities, people density, ventilation air, and other important parameters can be specified. In order for these data inputs to have effect though, either the “User Defined 1” or “User Defined 2” options must be specified in input item 4, *Zone Details*, for the “Use” of each of the six major zones where these conditions apply.

Manual sizing of some equipment items is also available in the Input table. See *Part 3, Reference Manual*, Input Parameters sections on manual size of equipment. A zero value indicates that automatic sizing should be used. Since equipment sizing can affect results, users may wish to first run a simulation with automatically sized equipment and check the sizes in the results section, before selecting any manually-sized equipment.

Advanced Users

Advanced users may have need for use of the extensive hourly data that is generated by this tool. In addition to the temporary files (DAT, rso, and SIM files) created in the same directory that the “drm” file came from, or if no “drm” file was loaded, where the input template or default input template is located, users can check the menu item [File][Create Hourly Files] to create the hourly CSV files for each case. See the “Hourly CSV Files” and “Additional SIM, rso, and Hourly Data Files” sections of *Part 3, Reference Manual*.

In addition to these files, other files can also be made available. Installation of the tool causes a new directory to be created, “C:\temp\drm.” If the text version of the input template, “bchp-LSP.INP” is opened to be used as the DRM template, many files are generated that are KEPT in the C:\temp\drm” directory. Advanced users may find some of these files useful, including:

- CEC3_02.DAT — important hourly data outputs from DOE-2 “meters”
- fort.22 — echo of the actual input to DOE-2 (5,000 lines instead of 20,000+)

- Several macro “Include” INP files that are separate from the fort.22 input

HOWEVER, only the last simulation run is kept, so if these files are needed for a specific case, only that one case should be run (i.e., only have a Column ‘A’ left on the Table tab form for running the simulation). These files are not automatically deleted when exiting the program if the bchp-LSP.INP template is used, but are deleted upon completion of the DOE-2 simulations whenever the bchp-LSP.D2T template is used.

Some of these data are also extracted to the “DAT” files that the tool generates.

**MF CHP Level 2 Analysis Tool
Beta 3**

Users Manual

Part 3, Reference Manual

Users should note that some of the information in this manual can also be found in the HELP files for the MF CHP Analysis Tool, sometimes in a different format, and sometimes in different arrangements.

Input Parameters

Introduction

The MF CHP Analysis Tool uses the DoeRayMe program, which employs DOE2.1e to calculate heating, cooling, air conditioning, and electrical loads using a simplified "thermal model" of the building. The DoeRayMe program reads a single file, called a template, that describes the DOE-2 input and output parameters displayed on the screen. In addition, the template includes the DOE-2 input file used by the simulation program. The MF CHP Analysis Tool template is called BCHP-LSP.D2T and is automatically loaded when the program starts. The MF CHP Analysis Tool template is encoded, as indicated by the "d2t" file extension, so that it is not viewable or modifiable by the user. Templates that are viewable and modifiable by the user have the file extension "inp." The following sections describe the details of the input parameters that you can change.

The template file handles all the types of buildings that can be simulated, and switches the actual input data used depending on the user input to BCHP Screener. Instead of specific purpose zones and zone descriptions, this flexible building has up to 12 zones that can be classified into different space categories. This input file is flexible since it takes overall building dimensions and space descriptions and creates a system load.

Weather

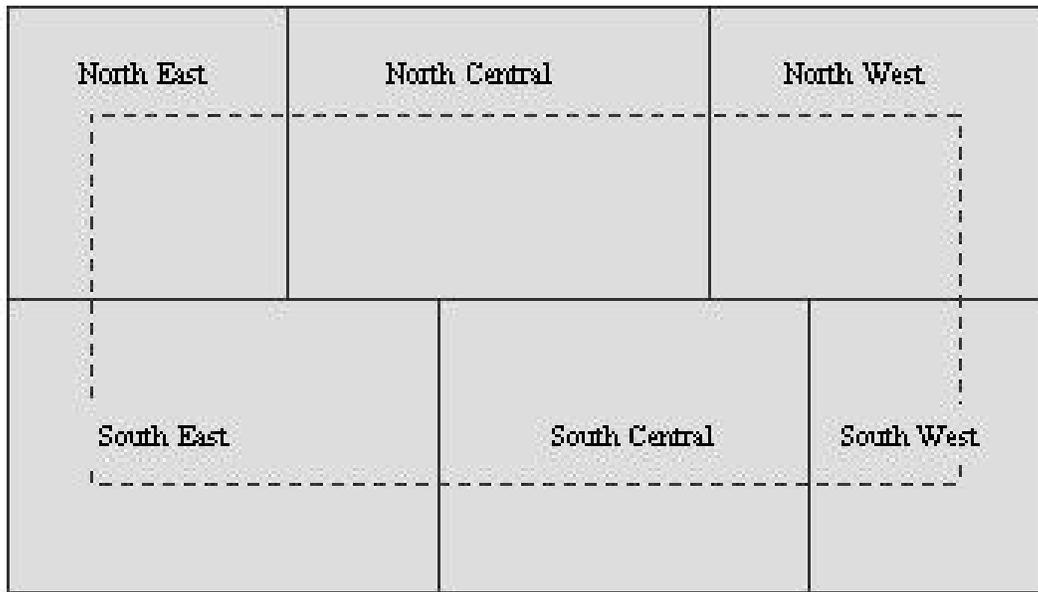
TMY2 weather data files, packed in the binary format used by the DOE-2 program, are provided with this tool, covering 239 locations in the United States. The weather data are fixed by the "location" of the case scenarios. Additional packed (binary) files can be added by users to the Weather directory under the main MF CHP Analysis Tool main directory, where the executable program resides, if users are able to generate or obtain such files. See also Part 1, *User Guide*, Weather Data. In addition, users would need to add an entry to the bchpUSR.mdb file (USER Library), WEATHER Table, using Microsoft Access, which has a sample entry for Illinois that copied the Rockford data. (The "Copy to User-Defined" button will not work and will cause the program to abort.) The best approach for adding a weather file is not certain, but the weather data for all sites from the password-protected library has been exported to an Excel file that can be made available upon request to use to copy data from similar locations to the USER library WEATHER table. (Contact Piljae Im, impl@ornl.gov.)

At this time, addition of other weather files has not been tested in order to verify all details required.

MANDATORY INPUTS

Building Input

The building description input parameters are used to set the overall characteristics for the building. The building has six zones where each zone can have a different use. Further, the six zones are subdivided into internal and external sub-zones. Research showed that all the building types could be described as a combination of six different uses. The zones extend from the basement floor to the roof vertically. The perimeter sub-zone is all area within 15 ft of the wall and the core sub-zone is the rest of the area with a minimum of 25% of the total space area. So the underlying assumption for modeling purposes is that the building can be treated as being composed of six zones, as illustrated in the figure below.



The zone designation are for convenience only and do not have anything to do with compass directions. The zones do not need to be the same size, and they usually are not. The perimeter and core sub-zones are depicted by the dashed line in the figure. The core and the perimeter naturally have different thermal behaviors, with heat losses and solar gains occurring on the perimeter.

The data "template" for the MF CHP Analysis Tool is set up to assign default uses for each zone for the building. The default space allocations for high rise multifamily housings are:

- There are two space types for the high rise multifamily housings: Corner apartments and Inside apartments.
- North East, North West, South East and South West spaces are assigned to the corner apartments.
- North Central and South Central spaces are assigned to the inside apartments.

Default values for the “thermal characteristics” of each type of zone end use (e.g. thermostat settings, lighting and plug loads, occupancy) are also assigned and data values are covered in the remainder of this section.

The specific input parameters are described below. Please note that many of the input parameters in this group may affect other parameter values indirectly.

Building Type – Choose a predefined building which will set the default values for each of the zones. Current version of the tool support only one building type: High rise multifamily housing.

High rise multifamily housings

<i>Zone</i>	<i>Space Type</i>	<i>Building Fraction (%)</i>	<i>Window/Wall Ratio (%)</i>
North East	Corner Apartments	5	21
North Central	Inside Apartments	40	23
North West	Corner Apartments	5	21
South East	Corner Apartments	5	21
South Central	Inside Apartments	40	23
South West	Corner Apartments	5	21

The building fraction percentages are based on values from ASHRAE publications. Window to wall ratios are based on judgment.

Peak Date Shown – Select the 24-hour period to be displayed in the tabular results section and on the graph tab. The date can be any of the 365 days in the year or a special day such as the day when the annual peak cooling load occurs.

Hours of Operation –The normal operating hours are shown below. It was assumed the building is operated 24 hours 365 days.

Normal Hours of Operation

<i>Building</i>	<i>Weekday</i>	<i>Saturday</i>	<i>Sunday</i>
High Rise Multifamily Housing	24 hrs	24 hrs	24 hrs

Location – Select the location of the building. If none of the locations on the list exactly match the building location then select the city with the most similar weather to the location of the building. When selecting the location, many parameters from the climate database are used including the ASHRAE heating and cooling design day information and the TMY2 weather data file.

Length of Building – The overall length of the building in feet. For a rectangular or almost rectangular building, the length of the building should be the physical length of the actual building. For a non-rectangular building, the length should be chosen so that when multiplied by the width of the building and the number of floors, the result is the actual overall floor area. Further, the length should be chosen that approximates that length of wall that points approximately west.

Width of Building – The overall width of the building in feet. For a rectangular or almost rectangular building, the width of the building should be the physical width of the actual building. For a non-rectangular building, the width should be chosen so that when multiplied by the length of the building and the number of floors, the result is the actual overall floor area. Further, the width should be chosen that approximates that width of wall that points approximately south.

Number of Floors – The number of aboveground stories for the building. For a building where not all stories have the same floor area, choose the number of floors so that the proper overall floor area is achieved when multiplying by the width and length of building input.

Basement Present – Choose either yes or no depending on if a basement is present in the building and covers the majority of the footprint of the building. If the basement covers only a small portion of the footprint of the building, answer no for this parameter.

Story Height – The average floor to floor distance in the building in feet. It should include any plenum area between floors. The floor to ceiling height is not what should be entered because the thermal heat transfer through the walls is based on the story height multiplied by the number of floors.

Building Rotation – If your building is oriented so that most of the walls face directly at the cardinal directions of north, south, east and west then enter zero for this value. If the building is slightly angled from the cardinal directions, enter the angle that the wall facing closest to north is to true north. This input parameter should be viewed as the amount the building should be rotated before the walls would face directly toward the cardinal directions. It is the same as the rotation in degrees between the plan north and the true north in degrees.

Construction Details

The wall and roof information group of input parameters describes the thermal characteristics of the envelope, also called shell or fabric, of the building. The thermal loads and response of the building envelope are one of the most important factors for determining the loading of installed equipment in a building. The group describes the walls, including windows, and the roof of the building.

Wall Structure – The walls of a building are supported internally by some sort of structure. The materials that make up this structure can vary considerably from wood to concrete to other materials. This structure has an important thermal property of thermal capacitance, also called thermal mass. Thermal capacitance is the amount of heat a material can absorb and determines the timing of how quickly temperature changes outside a building turn into thermal loads inside the building. Higher thermal capacitance options like thick concrete delay the transmission of heat from the outside to the inside of the building. The options for the wall structure parameter are: 2 inch wood, 4 inch wood, 4 inch Clay tile, 8 inch Clay tile, 4 inch common brick, 8 inch common brick, 4 inch LW concrete, 6 inch LW concrete, 8 inch LW concrete, 4 inch LW concrete block, 8 inch LW concrete block, 8 inch LW concrete block (filled), 12 inch LW concrete block(filled), 2 inch HW concrete, 4 inch HW concrete, 6 inch HW concrete, 8 inch HW concrete, 12 inch HW concrete, 4 inch HW concrete block, 8 inch HW concrete block, 8 inch HW concrete block(filled), and 12 inch HW concrete block(filled). These options are based on the list of common wall types that appear in the ASHRAE Handbook of Fundamentals.

Wall Insulation – All modern construction includes some insulation in the walls. The amount of insulation varies by climate and local building code. The performance of the insulation layer is expressed as an R-value. The higher the R-value the greater the insulation effect and the less heat transferred through the wall. The amount of insulation in the walls of a building can vary; if that is the case, enter the average R-value or the most typical R-value for the building. Units of R-value are in ft²-F-

Roof Structure – The roof of a building is supported internally by some sort of structure. The materials that make up this structure can vary considerably from wood to concrete. This structure has an important thermal property of thermal capacitance, also called thermal mass. Thermal capacitance is the amount of heat a material can absorb and determines the timing of how quickly temperature changes outside a building turn into thermal loads inside the building. Higher thermal capacitance options like thick concrete delay the transmission of heat from the outside to the inside of the building. The options for the roof structure parameter are: 4 inch wood, 4 inch LW concrete, 6 inch LW concrete, 8 inch LW concrete, 2 inch HW concrete, 4 inch HW concrete, 6 inch HW concrete, 8 inch HW concrete, 12 inch HW concrete. These options are

based on the list of common roof types that appear in the ASHRAE Handbook of Fundamentals.

Roof Insulation – All modern construction includes some insulation in the roof. The amount of insulation varies by climate and local building code. The performance of the insulation layer is expressed as an R-value. The higher the R-value the greater the insulation effect and the less heat transferred through the roof. Almost always, the roof has more insulation than the walls, so a higher R-value should be specified here compared the value entered for the wall insulation. The amount of insulation in a roof may vary within the building; if that is the case, enter the average R-value or the most typical R-value for the building. Units of R-value are in ft²-F-hr/Btu. Choices range from R-3 to R-49.

Window Type – The windows, or glazing system, used in a building have a very significant affect on the amount of heating and cooling load the building experiences. Depending on the quantity of windows, they can often be one of the largest sources of heat loss in a building during the heating season. During the summer, the heat gain from sunlight through the windows usually is the indirect cause of the peak cooling load on the building and often sets the peak electrical demand. A large number of options are available for the glazing system. These options include the number of panes of glass, coatings on the surfaces of the panes of glass, and the type of gas used to fill any gaps between the panes of the glass. For many jurisdictions in the U.S. a minimum standard for the thermal effectiveness of the glazing system is required by the building code. The basis for the options available for this input parameter is from the Windows 4.0 library. For more information on the Windows 4.0 program and even newer versions see: <http://windows.lbl.gov/software/window/window.html>

Window Overhangs – One very common energy conservation feature is to provide overhangs above the windows on the outside of a building. This reduces the amount of direct light (and heat) that enters the building through the windows during the cooling season. Because less light and heat enter the building, this reduces the amount of cooling the space needs. Because the angle of the sun is different in the summer and winter, if the overhang is designed properly, the amount of sunlight entering the space during the winter can remain the same. Another benefit of an overhang is to decrease the amount of glare inside the building for the occupants. The width of the overhang is assumed to be two feet wider than the width of the window i.e., extends one foot beyond each side of the window. The depth of the overhang can range from 0 to 10 feet as measured away from the wall.

System Selection

System Type – Select the type of air distribution used throughout the building. If there are several types used, select the most common. The options include variable air volume systems (VAV) with either reheat at the terminal boxes or baseboard heat. Fan powered VAV boxes with reheat can also be chosen. Another option is constant volume air distribution with or without baseboard radiant heating. Fan coil units can also be specified.

Fan Type – If a VAV system is chosen with the system type input parameter (see previous parameter), then the type of fan control system used to modulate the air volume in the system can be specified as either variable speed, inlet vanes or discharge dampers. Each control method has different characteristic curves for fan performance. A VAV system can reduce air volumes down to 30% and follows the warmest strategy of satisfying the cooling load of the zone in the system.

Air Handler Layout – The air handler layout in real buildings can be quite complex. Several simplified options are provided in the software but you will need to make a choice that is the closest, thermally, to the building being modeled. The possible layouts are described below. Remember that the building is zoned into six areas that represent all above ground floors. Each of the six areas are divided into perimeter and interior spaces. The air handlers for the building serve these 12 different spaces in a variety of configurations. The options for this parameter are: ‘Each Space’ – this creates a model of one air handler for each of the 12 spaces in the building resulting in 12 air handlers. ‘Each Area’ – this creates six air handlers that serve both the interior and exterior spaces for each of the six areas. ‘Core and Perimeter’ – this creates a model of two air handlers, one serves all interior spaces and one serves all perimeter spaces. ‘One for Building’ – this creates a single air handler that serves all 12 spaces. ‘Core and Each Perimeter’ – this creates a model of seven air handlers, one air-handler serves all six core spaces and each of the six perimeter spaces has its own air handler. If the ‘Building Default’ is used, it uses the each-space approach.

Economizer – The economizer parameter sets the use of an airside economizer in the building. The economizer can be turned off with the “none” option. A temperature-controlled economizer allows more outside air into the air distribution system if the temperature is lower than 60F. The enthalpy controlled economizer option also allows extra outside air into the air distribution system but only if the enthalpy (a combined measure of temperature and humidity) of the outside is below a threshold where it reduces the cooling load on the cooling coil. Choosing the default option is the same as choosing the Temperature option since this is the most common type of economizer.

Equipment Selection

The most significant selection made when comparing CHP systems is the type of cooling, heating, air treatment and generation equipment included in both the baseline and alternative cases. Column A is considered the baseline case with alternatives in columns B to Z. The baseline equipment is usually a selection of equipment in the current design or the current actual building. Alternatives are usually different equipment selection options that are under consideration although, at times, only equipment sizing or operation (see later groups) may change between alternatives. All savings reported later are based on the difference between the alternative and the baseline case.

Lead Space Cooling – Lead or main cooling equipment used in the building. The detailed properties of the equipment are shown when you click the button to chose equipment and use ‘Show Details’. The size of the equipment selected is not used in the simulation. Instead, the sizing is based on the peak load and the sizing specification discussed in the next section. The size is used as an indicator for the particular unit that was chosen to characterize the equipment performance. The full load and part load performance characteristics of the equipment are tied to this selection along with the costs per ton. If DX cooling equipment is needed, it should be specified in this entry.

Lag Space Cooling – For chillers, this input parameter should be set to the chiller equipment that will lag in a lead-lag control system. If using direct-expansion (DX) cooling equipment in the building, the DX equipment should be specified in the 'lead space cooling' field, then this field is ignored. The size of the equipment selected is not used in the simulation. Instead the sizing is based on the peak load and the sizing specification discussed in the next section. The size is used as an indicator for the particular unit that was chosen to characterize the equipment performance. The full

load and part load equipment performance are tied to this selection along with the costs per ton.

- Desiccant System** – Select the desiccant system to be used, if any. The space conditioning exiting supply air temperature and humidity performance is determined by the unit selected. The size shown is used as indicator to characterize the performance of the type of equipment selected. The size of the unit selected is not used in the simulation. The simulation size is based on the combined estimated airflow of the zones. The desiccant system pre-treats outside air only. Some desiccant systems with low regeneration temperatures may be used with low-temperature heat recovered from the cooling water of a generator.
- Heating Boiler** – Boilers are only allowed in buildings that use chillers for cooling. Packaged DX systems and heat pumps are assumed to use furnaces. so for these cases this input should be set to none. The part load and full load performance of the boiler is tied to the type of equipment selected. The size shown is used as an indicator for the particular unit that was used to characterize the performance. The size of the unit selected is not used as the basis for the size of the unit in the simulation. The simulation size is based on the estimated total heat load.
- Service Water Heater** – A separate hot water heater for service hot water is only used when the building does not have a boiler. If a boiler is present, the simulation assumes that a tank and heat exchanger are used to supply hot water. The simulation size is based on the estimated total service hot water load, not on the unit size selected.
- Generator** – If a generator is selected, it is assumed that as much heat recovery as possible will be utilized from the waste heat of the generator. The selection of generator is used to determine the full load and part load performance including the amount of waste heat that is available from the exhaust versus the jacket (for fuel cells this equates to high and low temperature streams). Heat recovery is only possible in buildings with a generator. Only the higher temperature heat stream (approximately 345F or higher) may be used for heat into an absorption chiller or high-temperature desiccant regeneration. The low temperature stream (around 180F) may be used for space heating and low temperature desiccant regeneration. The size of the unit selected is not used as the basis for the size of the unit in the simulation.
- Chilled Water Pumps** – The type of chilled water pump used if a chilled water plant is specified. If a DX cooling system is used rather than a chiller, then this parameter is ignored. The choices here are constant or variable speed pumps with either normal or high efficiency. For normal efficiency pumps, the motor efficiency is assumed to be 90% and the impellor efficiency is 77%. For high efficiency pumps, the motor efficiency is assumed to be 93% and the impellor efficiency is 82%. The pump head is a linear function of the number of floors. For variable speed pumps, their capacity can be reduced to as low as 50%.
- Hot Water Pumps** – The type of hot water pump used if a boiler plant is specified. If a furnace or heat pump is used rather than a boiler, this parameter is ignored. The choices here are constant or variable speed pumps with either normal or high efficiency. For normal efficiency pumps, the motor efficiency is assumed to be 90% and the impellor efficiency is 77%. For high efficiency pumps, the motor efficiency is assumed to be 93% and the impellor efficiency is 82%. The pump head is a linear function of the number of floors. For variable speed pumps, their capacity can be reduced to as low as 50%.
- Cooling Tower** – The cooling tower used in the simulation is a generic cooling tower and is not tied to a specific manufacturer. The way that thermodynamic properties of a specific type of cooling tower vary at different conditions is not dependent on the manufacturer. The type of tower, design approach and overall efficiency are retrieved

from the database when a cooling tower is being simulated. One speed, two speed and variable speed tower fans are simulated. The design wet-bulb of a tower is based on ASHRAE design data for the selected design condition.

Cool Storage – Cool storage may only be used if a low temperature chiller is also specified. If no low temperature chiller is specified but cool storage is enabled, the storage system may never charge. The water storage system uses a 50F tank set point and a 10F temperature range. The simulation program automatically sizes the cool storage system supply and storage rates.

Hot Storage – Hot storage is optional whenever heat recovery can occur; this is when a generator is present in the design. The water storage system uses a 140F tank set point and a 40F temperature range. The heat storage system supply and storage rates are set to fully recharge the storage in 4 hours if the amount of heat is available. Only low-temperature equipment can use the heat that is stored. This includes space and water heating and lower temperature desiccant systems.

TURBINE SUPPLIED EXHAUST FIRED ABSORPTION SYSTEMS

To simulate an integrated energy system that uses a turbine tightly coupled with an absorption chiller some special selections should be made. These systems use the exhaust stream directly from a turbine to feed into the absorber without an intermediate heat exchanger to transfer heat into water. To select such a system, the “lead space cooling” should be set to “Generic Exhaust Driven” model under the sfdeAbs detailed equipment type. In addition, to simulate this system, the “generator” should be set to “Integrated Turbine-Absorber” under Turbine subtype. Also set the “Link Lead Absorber to Generator” option to “Yes” under “Cooling Operation. The equipment will be automatically sized unless it is specifically specified. Often the economics of a system can be optimized by specification of details of the system such as sizing.

Generator Detail

Number of Generators – Enter the number of generators. Zero to 10 generators may be entered. If a generator is specified but this entry is zero, it is automatically assumed that one generator is available. ‘Auto’ assumes three generators. This entry is important to how the building electrical load is tracked with the generators. The more generators specified, the more likely that they will be nearly fully loaded during operation. It is very common to have just a single generator.

Generator Sizing (as Peak %) – Enter the size of the total generation capacity as a fraction of the total building peak power draw. For a generator plant that supplies half the peak building power draw, enter a value of 50%. Range is from 0% to 150%

Generator Sizing (Direct Input) – Set to zero for automatic sizing. Any other value besides zero overrides the automatic sizing for the generator.

Utility rates

Standard electricity and gas rate (i.e., \$/kWh and \$/Therm) need to be entered for the cost analysis. For the electricity rate, the blended rate would be entered if needed.

ADDITIONAL INPUTS

BUILDING DETAILS: Construction Details

Wall Inside Surface – A wall can be thought of as composed of layers of materials. The layer that is seen inside by occupants of a building is usually gypsum, also called wallboard.

For other buildings that have no interior surface treatment set this parameter to none. For other buildings that have a face brick interior, chose 4-inch face brick. These options are based on the list of common wall types that appear in the ASHRAE Handbook of Fundamentals.

Wall Insulation Location – Insulation can be installed on either side of the interior structure of the wall depending on the type of insulation. Some rigid panel insulation installs on the outside of the structure and is very common in buildings that are extensively remodeled. In most other cases, the insulation is on the inside of the building structure. The values for the wall insulation location parameter can be set to one of the following choices: Outside of Structure or Inside of Structure.

Wall Outside Surface – Most walls have an exterior surface treatment. The impact of this surface treatment is similar to the impact of the wall structure because it affects the thermal capacitance of the wall. Thermal capacitance is a measure of the delay of heat transfer through a wall. If your exterior wall outside surface treatment is not listed, choose the option that has most similar weight per square foot. The value for the wall outside surface can be set to one of the following choices: None, 1 inch Stucco, or 4 inch Face brick. These options are based on the list of common wall types that appear in the ASHRAE Handbook of Fundamentals.

Ceiling – The roof and ceiling system, like a wall, can be thought of as composed of layers of materials. The ceiling layer that is seen inside by occupants of a building is often gypsum, also called wallboard. For buildings that have no interior surface treatment, set this parameter to ‘None’. Other buildings may acoustic tile with an air space behind it. The options given are based on the list of common ceiling types that appear in the ASHRAE Handbook of Fundamentals.

Roof Insulation Location – Insulation can be installed on either side of the interior structure of the roof depending on the type of insulation. Some rigid panel insulation installs on the outside of the structure and is very common in buildings that are extensively remodeled. In most other cases, the insulation is on the inside of the building structure. The values for the roof insulation location parameter can be set to one of the following choices: Above Structure or Below Structure.

Air Infiltration Value – The amount of infiltration into a space expressed as a ratio of air change rate per hour. It does not correct for wind speed.

BUILDING DETAILS: Zone Area (Percent of Total Floor Area)

The percent of each six spaces could be defined in this section. Building default % was presented earlier in this manual.

BUILDING DETAILS: Glazing Area (Window-to-Wall Ratio)

The windows-to-wall ratio for each six spaces could be defined in this section. Building default % was presented earlier in this manual.

BUILDING DETAILS: Zone Details

The input parameters in the zone details group should normally be allowed to default. If any value is changed from the default then you should check the details discussed here to make sure that the change is consistent with other parameters. The building consists of six zones: north east, north central, north west, south east, south central and south west. Each zone contains two sub-zones, one

for the interior and one for the exterior. The exterior sub-zone is 15 feet deep and the remaining area is in the interior subzone. Six zones were chosen since that number of different space conditions is adequate to describe a simplified model of most buildings. Even though the definitions below are just for ‘Use’, ‘Area%’ and ‘Glazing%’ they can be applied to the six different zones.

Use – The use of the zone is another way of saying the use of the space by the occupants. For most users of the software this value should be allowed to default. Only when a detailed building design that is significantly different than the default building should these be changed. If user decides to change the default values of the space use, the user is required to select either User Defined 1, or User Defined 2. If one of the user defined options is selected, than the valued in the User Defined Conditions groups will be used. The details of each of these choices are described below:

Internal Loads

<i>Use</i>	<i>Area/Person (sqft/person)</i>	<i>Lighting (W/sqft)</i>	<i>Plug Load (W/sqft)</i>	<i>Person Heat Gain (Btuh/person)</i>	<i>Sensible Person Heat (Btuh/person)</i>
High Rise Multifamily Housing	424	0.8	1	500	250

System Control

<i>Use</i>	<i>Heat Set Point (F)</i>	<i>Cool Set Point (F)</i>	<i>Max Humidity (%RH)</i>	<i>Min Humidity (%RH)</i>	<i>Outside air (CFM/person)</i>
High Rise Multifamily Housing	70	75	100	0	15

The assumptions for this table are from the

- 1) ASHRAE Standard 90.1 - 2004,
- 2) ASHRAE Handbook of Fundamentals,
- 3) "Estimating Water Heating and Aggregate Electricity Loads in Multifamily Buildings," R. L. Ritschard, Y. J. Huang, J. M. Fay, ASHRAE Transactions 1990, Volume 96, Pt. 1, pp. 796-802
- 4) "Impact Evaluation of the Energy Retrofits Installed in the Margolis High-Rise Apartment Building, Chelsea Housing Authority" M.M. Abraham, H.A. McLain. And J.M. MacDonald, Technical report ORNL/CON-413, 1995.
- 5) and professional judgment.

Area % – The area percentage parameter is the percent of the total building floor space for this zone. The sum of each of the six zones area percentages should add to 100% and all six zones need some area defined, i.e., must be greater than 0%. If the values don't add up to 100% then they will be adjusted proportionally by the software to add up 100%. This parameter can be set to the either the building default or a value from 2% to 30%. See the ‘building type’ documentation for typical values. For most users of the software this value should be allowed to default. Only when a detailed building design is significantly different than the default building should these be changed.

Glazing % – The glazing percentage is also called the window to wall ratio. The amount of glazing area in the building can significantly impact both the heating and cooling load on the

building. The larger the fraction of window area, general the larger both the heating and cooling loads will be. See the ‘building type’ input parameter for typical values for the glazing percentage. For most uses of the software this value should be allowed to default. Only when a detailed building design is significantly different than the default building should these be changed. The glazing percentage can be set to the either the building default or from 0% to 50%.

User Defined Conditions

If none of the predefined zone conditions are adequate (see Zone Details, above), you can define your own conditions for the zone with user defined conditions. First step is to select the zone that will set the User Defined conditions. Two different sets of user-defined conditions are possible, so your choice in Zone Details, Use is either User Defined 1 or User Defined 2. Two groups described here correspond to those selections.

Lighting Density – The lighting power density in watts per square foot. Typical for multifamily housings is about 0.8 W/sqft.

Equipment Density – The equipment power density in watts per square foot. This would include typical house appliances, washer and dryer or equipment plugged.

Occupant Density – The number of square feet per person on average occupying the building.

Heat Gain Per Person – Total heat gain per person in the space including sensible and latent.

Sensible Heat Gain Per Person – Sensible heat gain per person in the space not including latent.

Service water heating density – The Service water heating density in Btuh per person.

Cooling Setpoint – The setpoint temperature during the cooling season in degrees F. This temperature must be greater than the heating temperature used to control the heating. The difference between the cooling and heating setpoint is usually 5 F for commercial applications.

Heating Setpoint – The setpoint temperature during the heating season in degrees F. This temperature must be less than the cooling temperature used to control the cooling. The difference between the cooling and heating setpoint is usually 5 F for commercial applications.

Maximum Humidity – The maximum space humidity allowed. Above this point the equipment attempts to dehumidify the air. Setting this value to 100 indicates no humidity control.

Minimum Humidity – The minimum space humidity allowed. Below this point the equipment attempts to humidify the air.

Outside Air Per Person – The amount of outside air for each person in the building in cubic feet per minute.

Weekday Operating Schedule – The weekday operating times for the zone including when the people are present, when lights are on, when equipment is operated, when set points are used. During other hours the lights and equipment are reduced to only 5% of their normal level, heating and cooling set points are widened by 10F.

Saturday Operating Schedule – The Saturday operating times for the zone including when the people are present, when lights are on, when equipment is operated, when set points are used. During other hours the lights and equipment are reduced to only 5% of their normal level, heating and cooling set points are widened by 10F.

Sunday Operating Schedule – The Sunday and holiday operating times for the zone including when the people are present, when lights are on, when equipment is operated, when set points are used. During other hours the lights and equipment are reduced to only 5% of their normal level, heating and cooling set points are widened by 10F.

BUILDING DETAILS: User Defined Defaults

Exhaust Flow Rate - The flow rate of direct exhaust from the zone. This data entry can be omitted if there is no exhaust from the zone, or if there is only central exhaust by way of the system return fan.

Exhaust kW - The kW used to run the exhaust fan in the zone. This data entry can be omitted if there is no exhaust from the zone, or if there is only central exhaust by way of the system return fan.

EQUIPMENT SIZING OPTIONS

EQUIPMENT SIZING OPTIONS: Automatic Plant Equipment Sizing

Determining the capacity of equipment in the MF CHP Analysis Tool is done automatically by the simulation program. It is important to remember that the sizes for the selected equipment in the previous section are **not** used in sizing the equipment. The only reason that the equipment sizes are shown in the database is to inform you about the source of the data. Matching the piece of equipment performance to an appropriately sized piece of equipment is left up to you. To override the automatic equipment sizing in this group, you can specify specific sizing manually. For manual sizing of equipment and fans, see groups “Generator Detail”, “Manual Equipment Size”, “Manual Packaged Cooling Size”, “Manual Packaged Heating Size”, and “Manual Fan System Volume.”

Cooling Equip Oversizing % – The range of oversizing that can be input is from 0% to 25%. Since the sizing is based on ASHRAE design conditions, and the demand for cooling is based on a typical year of weather, often oversizing is not necessary to satisfy the entire cooling load. This is not always the case though; sometimes the load based on the annual simulation of typical weather exceeds the automatically sized equipment. In those cases, it is a good idea to include some oversizing. In reality, most mechanical designers include some degree of oversizing.

Heating Equip Oversizing % – The range of oversizing that can be input is from 0% to 25%. Since the sizing is based on ASHRAE design conditions, and the demand for heating is based on a typical year of weather, often oversizing is not necessary to satisfy the entire heating load. This is not always the case though; sometimes the load based on the annual simulation of typical weather exceeds the automatically sized equipment. In those cases, it is a good idea to include some oversizing. In reality, most mechanical designers include some degree of oversizing, especially for heating equipment.

Lead Chiller % – The fraction of the capacity that the lead chiller (or chillers controlled together) is of the total chiller plant. The remaining capacity is in the lag chiller (or chillers). For DX equipment this is forced to 100% no matter what you select. Range is from 5% to 100%. It is very common to put about 2/3 of the total cooling plant capacity in the lead chiller, and in this case enter 65%. It is also common to have two chillers about equally sized, in that case enter 50%.

Number of Lead Chillers – Range is 1 to 3. ‘Auto’ assumes three lead chillers. This entry is important because it will control how the chillers track the building load. The more chillers specified, the more likely that the chillers will be nearly fully loaded during operation. It is very common to have a single lead chiller.

Number of Lag Chillers – Range is from 0 to 3. ‘Auto’ assumes three lag chillers. This entry is important because it will control how the chillers track the building load. The more

- chillers specified, the more likely that the chillers will be nearly fully loaded during operation. It is very common to have a single lag chiller.
- Number of Boilers – Range is 1 to 3. ‘Auto’ assumes three boilers. This entry is important to how the building load is tracked with the boilers. The more boilers specified, the more likely that the boilers will be nearly fully loaded during operation. It is very common to have a single boiler.
- Cool Storage Sizing % – The DOE-2 simulation program will determine the peak day integrated cooling demand on the cool storage system but you can control how much of the capacity is actually installed with this input parameter. Ranges from 10% to 130%. This is not an oversizing fraction but a fraction of the total needed capacity.
- Heat Storage Sizing % – The DOE-2 simulation program will determine the peak day integrated heating demand on the hot storage system but you can control how much capacity is actually installed with this input parameter. Ranges from 10% to 130%. This is not an oversizing fraction but a fraction of the total needed capacity.
- Winter Design Condition – ASHRAE design data that is present in its most recent Handbook of Fundamentals has been incorporated into a database used for simulating the design conditions in the building. The data includes temperature, humidity, windspeed and other pertinent data. Since ASHRAE has different levels of design conditions, you need to select the level you wish to design to for the actual building. The choices for winter design conditions are 99.6% percentile or 99.0% percentile.
- Summer Design Condition – ASHRAE design data that is present in its most recent Handbook of Fundamentals has been incorporated into a database used for simulating the design conditions in the building. The data includes temperature, humidity, windspeed and other pertinent data. Since ASHRAE has different levels of design conditions, you need to select the level you wish to design to for the actual building. The choices for summer design conditions are Drybulb 0.4%, Drybulb 1.0%, Drybulb 2.0%, Dewpoint 0.4%, Dewpoint 1.0%, Dewpoint 2.0%. The values for the dewpoint design conditions should be used in applications and climates likely to face significant humidity loads.

EQUIPMENT SIZING OPTIONS: Manual Plant Equipment Size

Central plant equipment can be sized with this group of inputs. Any values, other than zero, entered with these parameters are used to size the central plant equipment. A zero value indicates that automatic sizing should be used. Since equipment sizing is vital to a reasonable simulation, do not manually size equipment without first running a simulation with automatically sized equipment and checking the sizes in the results section.

- Lead Chiller – Set to zero for automatic sizing. Any other value besides zero overrides the automatic sizing for the lead chiller.
- Lag Chiller – Set to zero for automatic sizing. Any other value besides zero overrides the automatic sizing for the lag chiller.
- Boiler – Set to zero for automatic sizing. Any other value besides zero overrides the automatic sizing for the boiler.
- Cool Storage – Set to zero for automatic sizing. Any other value besides zero overrides the automatic sizing for the cool storage system.
- Heat Storage – Set to zero for automatic sizing. Any other value besides zero overrides the automatic sizing for the heat storage system.

EQUIPMENT SIZING OPTIONS: Manual Packaged Cooling Size

For each zone in the building, enter the size of the packaged cooling equipment, either air conditioning or the cooling side of the heat pump. These values override the automatic sizing and force the equipment to be the specified capacity. If a zero value is entered then automatic sizing is used instead.

EQUIPMENT SIZING OPTIONS: Manual Packaged Heating Size

For each zone in the building, enter the size of the packaged heating equipment, either a furnace that would come with unitary system or the heating side of the heat pump. For a heat pump this value is the capacity of the backup heater. The heating from the heat pump cycle is tied to the cooling capacity. These values override the automatic sizing and force the equipment to be the specified capacity. If a zero value is entered then automatic sizing is used instead.

EQUIPMENT SIZING OPTIONS: Manual Fan System Volume

For each zone in the building, enter the air volume of the fan system. These values override the automatic sizing and force the equipment to be the specified volume. If a zero value is entered then automatic sizing is used instead.

PLANT EQUIPMENT OPERATION

PLANT EQUIPMENT OPERATION: Cooling Operation

Chiller Weekend Operation – Operation during the weekend for chillers is often different than the operation during weekdays. This parameter can either set the chillers to operate the same on the weekends as during the weekdays or simply to operate the chiller that is normally the lag chiller as the lead chiller on Sundays or on both Saturdays and Sundays. Weekend operation also specifies the operation of the chiller on holidays.

Tower Setpoint Control – The cooling tower in a chilled water plant can be controlled using a number of strategies. If the cooling tower is controlled at a fixed set point, some tower cells do not operate or are bypassed in order to supply a fixed leaving water temperature even when the outside wetbulb temperature drops. A variety of fixed set points may be selected. If the chiller set point varies depending on the wet bulb temperature and gets reduced if lower wetbulb temperatures are available, that is called wetbulb reset. Wetbulb reset supplies the chiller with lower cooling temperature water during parts of the year but not all chillers can function with lower temperature cooling water.

Summer Cool Store Charge Time – The cooling storage system, if present, can be charged using different schedules. The length and timing of charging for the cool storage system can have a significant affect on the maximum electrical demand seen by the building. This command provides a list of options to control the timing for charging of the cooling storage system during the summer period. The options include never charging, charging only during hours when the building is not occupied or charging the cool storage system only for specific ranges of hours.

Winter Cool Store Charge Time – The cooling storage system, if present, can be charged using different schedules. The length and timing of charging for the cool storage system can have a significant affect on the maximum electrical demand seen by the building. This command provides a list of options to control the timing for charging of the cooling storage system during the winter period. The options include never charging, charging only during hours when the building is not occupied or charging the cool

storage system only for specific ranges of hours. Another option is to charge during the winter following the same schedule as used during the summer.

Storage Weekend Operation – Operation during the weekend for the cool storage system is often different than the operation during weekdays. This parameter can either set the cool storage system to operate the same on the weekends as during the weekdays or simply to not use cool storage on Sundays or on both Saturdays and Sundays. Weekend operation also specifies the operation of the cool storage system on holidays.

Link Lead Absorber to Generator – Link the operation of the heat-driven absorption chiller (if in lead) with the operation of the generator so that the absorption chiller is driven by waste heat and does not draw on the boiler unless the total cooling load on the plant cannot be satisfied by the waste heat driven absorption chiller and any electric chillers present. It only applies when heat-driven absorption chillers and non-heat-driven chillers are both used in the plant, absorption chillers are used as lead, and a generator is present that provides waste heat. (also see Turbine Supplied Exhaust Fired Absorption Systems).

PLANT EQUIPMENT OPERATION: Generator Operation

The parameters in the Generator Operation group specify how the generator will be operated. The control strategy for a generator can be to either track the building thermal load or its electrical load or some combination. Also, the timing of when different control strategies are implemented can be changed.

Summer Mid Day Definition – The generator can operate differently during the mid-day and this option specifies how this mid-day period should be defined in the simulation model for the summer season. The options available include a wide range of specific operating hour ranges that are typical for peak shaving. In addition, the mid-day definition can be the same hours as the building is typically occupied. Another option is to choose only the core hours of building occupancy which are defined to begin two hours later and end two hours earlier. For continuous operation at the same mode, an unusual practice for building generation systems except in some continually operated buildings, the mid-day period can be defined to last all 24 hours also.

Summer Mid Day Track – The method of operation of the generator during the mid-day period defined in the previous command for the summer can vary. One of five operating modes can be selected. The generator could be turned off during the summer mid-day period with the ‘Don’t Run’ option. The track ‘Electrical Demand’ will attempt to satisfy the building’s electrical load but may result in providing too much or too little thermal energy. The track ‘Thermal Demand’ will attempt to satisfy the thermal load of the building but may provide too much or too little electrical energy. The generator can respond to a combination of the two previous options and either satisfy the ‘Greater’ or the ‘Lesser’ of the thermal or electrical building demands. Finally, the generator can be run for ‘Maximum Output’, continuously delivering as much power and thermal energy as it can.

Summer Other Hours Track – The method of operation of the generator in the summer can vary during the hours that are not part of the mid-day period. Seven options are available. The generator can be set to be controlled the same as it would during the summer mid-day period. The generator could be turned off during this period with the ‘Don’t run’ option. The track ‘Electrical Demand’ will attempt to satisfy the building’s electrical load but may result in providing too much or too little thermal energy. The track ‘Thermal Demand’ will attempt to satisfy the thermal load of the building but may provide too much or too little electrical energy. The generator can respond to a

combination two of the previous options and either satisfy the ‘Greater’ or the ‘Lesser’ of the thermal and electrical building demands. Finally, the generator can be run for ‘Maximum Output’, continuously delivering as much power and thermal energy as it can.

Winter Mid Day Definition – The generator can operate differently during the mid-day and this option specifies how this mid-day period should be defined in the simulation model for the winter season. The options available include a wide range of specific operating hour ranges that are typical for peak shaving. In addition the mid-day definition can be the same hours as the building is typically occupied. Another option is to choose only the core hours of building occupancy which are defined to begin two hours later and end two hours earlier. For continuous operation at the same mode, an unusual practice for building generation systems except in some continually operated buildings, the mid-day can be defined to last all 24 hours also.

Winter Mid Day Track – The method of operation of the generator during the mid-day period defined in the previous command for the winter can vary. One of five operating modes can be selected. The generator could be turned off during this period with the ‘Don’t run’ option. The track ‘Electric Load’ can attempt to satisfy the building’s electrical load but may result in providing too much or too little thermal energy. The track ‘Thermal Load’ will attempt to satisfy the thermal load of the building but may provide too much or too little electrical energy. The generator can respond to a combination of the two previous options and either satisfy the greater or the lesser of the thermal or electrical building demands. Finally, the generator can be run for ‘Maximum Output’, continuously delivering as much power and thermal energy as it can.

Winter Other Hours Track – The method of operation of the generator in the winter can vary during the hours that are not part of the mid-day period. Seven options are available. The generator can be set to be controlled the same as it would during the summer mid-day period. The generator could be turned off during this period with the ‘Don’t Run’ option. The track ‘Electrical Demand’ can attempt to satisfy the buildings electrical load but may result in providing too much or too little thermal energy. The track ‘Thermal Demand’ will attempt to satisfy the thermal load of the building and may provide too much or too little electrical energy. The generator can respond to a combination of the two previous options and either satisfy the ‘Greater’ or the ‘Lesser’ of the thermal and electrical building demands. Finally, the generator can be run for ‘Maximum Output’, continuously delivering as much power and thermal energy as it can.

Weekend Operation – Operation during the weekend for generator is often different than the operation during weekdays. This parameter can either set the generator to operate the same as during the weekdays or simply not allow the use of the generator on Sundays or on both Saturdays and Sundays.

Heat Used for Space Heating – If this parameter is set to ‘Yes’, the heat from the generator is recovered and used for satisfying space heating requirements. If a plant has a generator and either an absorption chiller (that is not direct-fired) or a desiccant system, then heat recovered from the generator is always used for either the absorber or desiccant system.

Heat Used for Service Hot Water – If this parameter is set to ‘Yes’, the heat from the generator is recovered and used for satisfying service hot water requirements of the building. If a plant has a generator and either an absorption chiller (that is not direct-fired) or a desiccant system, then heat recovered from the generator is always used for either the absorber or desiccant system.

Desiccant Use If Available

<<< NOTE: Desiccant algorithms do not appear to be incorporated correctly to use recovered heat from CHP systems for desiccant regeneration. >>> For each zone in the building, choose if desiccant equipment is utilized in this zone (default is 'Yes'). This only applies if desiccant equipment is selected in the Equipment group above. If no desiccant equipment is selected in the Equipment group then this parameter is ignored

EMISSIONS FACTORS

EMISSIONS FACTORS: Site Generator Emissions Factors mission

Entry of factors used in emission calculations. The emission calculations include CO, CO₂, NO_x and SO_x. The factors are for both the site equipment and the utility generation. The factors are used in the calculations as multipliers for the natural gas consumption of the building and the electricity delivered by the utility. The default values are:

Default Emission Factors

Emission	Generator (lb/MMBtu)	Engine Chiller (lb/MMBtu)	Other Site (lb/MMBtu)	Utility (lb/MWh)
NO _x	4.08	4.08	0.0980	2.967
SO _x	0.000588	0.000588	0.00059	6.044
CO	0.317	0.317	0.0824	0.4
CO ₂	110	110	118	1392

These default values are based on EPA's AP-42 and EGRID publications.

Site Generator NO_x Factor – The factor used for calculating the emissions of NO_x from the generating equipment located at the building site. It should match the performance characteristics of the generator chosen. NO_x are emissions of nitrogen oxides typically created during the combustion of fuels. The default value is based on EPA AP-42 Table 3.2-1 and Table 3.1-1. For natural gas 4-stroke engine generators a reasonable value to use 4.08 lb/MMBtu for 90-105% load and 0.847 lb/MMBtu for <90% load. For natural gas turbines a reasonable value to use 0.32 lb/MMBtu for uncontrolled, 0.13 lb/MMBtu for water-steam injection and 0.099 lb/MMBtu for lean-premix. All factors use MMBtu to refer to the heat content of fuel input.

Site Generator SO_x Factor – The factor used for calculating the emissions of SO_x from the generating equipment located at the building site. It should match the performance characteristics of the generator chosen. SO_x, or sulfur oxides, are a precursor for acid rain and are a typical emission created during the combustion of fuels that contain sulfur. The default value is based on EPA AP-42 Table 3.2-2 and Table 3.1-2a. For natural gas 4-stroke engine generators a reasonable value to use is 0.000588 lb/MMBtu. For natural gas turbines a reasonable value to use 0.0034 lb/MMBtu. All factors use MMBtu to refer to the heat content of fuel input.

Site Generator CO Factor – The factor used for calculating the emissions of CO from the generating equipment located at the building site. It should match the performance characteristics of the generator chosen. CO is carbon monoxide and is a product of the combustion of fuels. The default value is based on EPA AP-42 Table 3.2-2 and Table 3.1-1. For natural gas 4-stroke engines use 0.317 lb/MMBtu for 90-105% load and 0.557 lb/MMBtu for <90% load. For natural gas turbines a reasonable default is 0.082 lb/MMBtu for uncontrolled, 0.030 lb/MMBtu for water-steam injection and

0.015 lb/MMBtu for lean-premix. All factors use MMBtu to refer to the heat content of fuel input.

Site Generator CO₂ Factor – The factor used for calculating the emissions of carbon dioxide, CO₂, from the generating equipment located at the building site. It should match the performance characteristics of the generator chosen. Carbon dioxide is a green house gas. The default value is based on EPA AP-42 Table 3.2-2 and Table 3.1-2a. For natural gas 4-stroke engines and turbines a reasonable default is 110 lb/MMBtu. All factors use MMBtu to refer to the heat content of fuel input.

Engine Chiller NO_x Factor – The factor used for calculating the emissions of NO_x from any natural gas engine-driven chiller located at the building site. It should match the performance characteristics of the engine-driven chiller chosen. NO_x are emissions of nitrogen oxides typically created during the combustion of fuels. The default value is based on EPA AP-42 Table 3.2-2. For natural gas 4-stroke engine driven chillers a reasonable default is 4.08 lb/MMBtu for 90-105% load and 0.847 lb/MMBtu for <90% load. All factors use MMBtu to refer to the heat content of fuel input.

Engine Chiller SO_x Factor – The factor used for calculating the emissions of SO_x from any natural gas engine-driven chiller located at the building site. It should match the performance characteristics of the engine-driven chiller chosen. SO_x, or sulfur oxides, are a precursor for acid rain and are a typical emission created during the combustion of fuels that contain sulfur. The default value is based on EPA AP-42 Table 3.2-2. For natural gas 4-stroke engine driven chillers a reasonable default is 0.000588 lb/MMBtu. All factors use MMBtu to refer to the heat content of fuel input.

Engine Chiller CO Factor – The factor used for calculating the emissions of CO from any natural gas engine-driven chiller located at the building site. It should match the performance characteristics of the engine-driven chiller chosen. CO is carbon monoxide and is a product of the combustion of fuels. The default value is based on EPA AP-42 Table 3.2-1. For natural gas 4-stroke engine driven chillers a reasonable default to use is 0.317 lb/MMBtu for 90-105% load and 0.557 lb/MMBtu for <90% load. All factors use MMBtu to refer to the heat content of fuel input.

Engine Chiller CO₂ Factor– The factor used for calculating the emissions of carbon dioxide, CO₂, from any natural gas engine-driven chiller located at the building site. It should match the performance characteristics of the engine-driven chiller chosen. Carbon dioxide is a green house gas. The default value is based on EPA AP-42 Table 3.2-2. For natural gas 4-stroke engine driven chillers a reasonable default to use is 110 lb/MMBtu. All factors use MMBtu to refer to the heat content of fuel input.

Other Site NO_x Factor– The factor used for calculating the emissions of NO_x from natural gas fueled equipment located at the building site including boilers and service water heaters. The factor should not include natural gas fueled generators or chillers – those have their own factors. It should match the performance characteristics of the equipment chosen. NO_x are emissions of nitrogen oxides typically created during the combustion of fuels. The default value is based on EPA AP-42 Table 1.4-1 for small boilers. A reasonable default to use is 0.0980 lb/MMBtu for boilers with no emissions control, 0.0490 lb/MMBtu for low NO_x and 0.0314 lb/MMBtu for low NO_x with flue gas recirculation. All factors use MMBtu to refer to the heat content of fuel input.

Other Site SO_x Factor – The factor used for calculating the emissions of SO_x from natural gas fueled equipment located at the building site including boilers and service water heaters. The factor should not include natural gas fueled generators or chillers – those have their own factors. It should match the performance characteristics of the equipment chosen. SO_x, or sulfur oxides, are a precursor for acid rain and are a typical emission created during the combustion of fuels that contain sulfur. The default value is based on based on EPA AP-42 Table 1.4-2. A reasonable default to

use is 0.00059 lb/MMBtu. All factors use MMBtu to refer to the heat content of fuel input.

Other Site CO Factor – The factor used for calculating the emissions of CO from natural gas fueled equipment located at the building site including boilers and service water heaters. The factor should not include natural gas fueled generators or chillers – those have their own factors. It should match the performance characteristics of the equipment chosen. CO is carbon monoxide and is a product of the combustion of fuels. The default value is based on EPA AP-42 Table 1.4-1 for small boilers. A reasonable default to use is 0.0824 lb/MMBtu. All factors use MMBtu to refer to the heat content of fuel input.

Other Site CO₂ Factor – The factor used for calculating the emissions of carbon dioxide, CO₂, from natural gas fueled equipment located at the building site including boilers and service water heaters. The factor should not include natural gas fueled generators or chillers – those have their own factors. It should match the performance characteristics of the equipment chosen. Carbon dioxide is a green house gas. The default value is based on EPA AP-42 Table 1.4-2 for natural gas combustion and is 118 lb/MMBtu. All factors use MMBtu to refer to the heat content of fuel input.

Utility NO_x Factor – The factor used for calculating the emissions of NO_x from utility generation equipment not located at the building site. NO_x are emissions of nitrogen oxides typically created during the combustion of fuels. The default value is based on EGRID 2002 Year 2000 data for entire U.S. and is 2.967 lb/MWh. Depending on your NERC region this value can range from 1.5 to 5.3 lb/MWh.

Utility SO_x Factor – The factor used for calculating the emissions of SO_x from utility generation equipment not located at the building site. SO_x, or sulfur oxides, are a precursor for acid rain and are a typical emission created during the combustion of fuels that contain sulfur. The default value is based on EGRID 2002 Year 2000 data for SO₂ in the entire U.S. 6.044 lb/MWh. Depending on your NERC region this value can range from nearly 0 to 12.5 lb/MWh.

Utility CO Factor – The factor used for calculating the emissions of CO from utility generation equipment not located at the building site. CO is carbon monoxide and is a product of the combustion of fuels. The default value of 0.4 lb/MWh is based on multiplier of 0.0003 applied to CO₂ factor from EGRID.

Utility CO₂ Factor – The factor used for calculating the emissions of carbon dioxide, CO₂, from utility generation equipment not located at the building site. Carbon dioxide is a green house gas. The default value is based on EGRID 2002 Year 2000 data for entire U.S. is 1392 lb/MWh. Depending on your NERC region this value can range from 900 to 2000 lb/MWh.

ECONOMIC PARAMETERS

Caution on Financial Calculations

Users are cautioned that the financial calculations can be affected by the utility rate data, which are old and may be out of date. Fuel cost escalation factors may also be incorrect. Users may wish to extract specific data and perform economic calculations outside the MF CHP Analysis Tool.

The financial group is used for inputs only to the life cycle cost calculations. The life cycle cost calculations are based on real discount rates that ignore the affect of inflation. This approach is also called constant dollar. The first cost of equipment is included in the calculation each time that it reaches its service life until the end of the study period. Any remaining value of the equipment at the end of the study period is its salvage value. The salvage value is based on its original value and the depreciation that it would face based on IRS 7 year property. After eight years into its service life,

equipment is assumed to be fully depreciated and having minimal (zero) salvage value. The 2002 NIST 135 fuel escalation factors are used to modify the price of electricity and gas assuming the national average (see NISTIR 85-3273-17 Rev 4/02 - Table Ca-5).

Discount Rate – In the life cycle cost calculations, the discount rate is used to indicate how much less something is worth in the future compared to the present day. The entry should be for the real discount rate excluding inflation because the life cycle cost calculations are based on constant dollars. The discount rate is expressed as a percentage. The U.S. government discount rate is 3.2% based on the NIST 135 publication. Private companies often use higher discount rates although an investment in its primary business often requires greater risk taking than building components and may mean that the discount rate used in its primary business investments is higher than in building components.

Study Length – In life cycle cost calculations, the length of the study period should be the length that the property held. Common study lengths include 10 years, 20 years and 30 years. The government generally uses 30 years for most calculations. Corporations often use the time expected to occupy the building as a study length.

Depreciation Factors – the factors used in version 2 are shown in the table at the right, but a 39-yr schedule may be required.

Depreciation factors	
year 1	0.1429
year 2	0.2449
year 3	0.1749
year 4	0.1249
year 5	0.0893
year 6	0.0892
year 7	0.0893
year 8	0.0446

Data Forms

The MF CHP Analysis Tool is a pre- and post-processor for calculations performed using two external stand-alone programs (DOE2.1e and RateScriptEditor) and internal algorithms for financial calculations. These processes and calculations are essentially transparent to the user who sees data forms displayed on his computer monitor showing data sent to or received from these independent programs. Users view the forms inside the program, and descriptions are provided below.

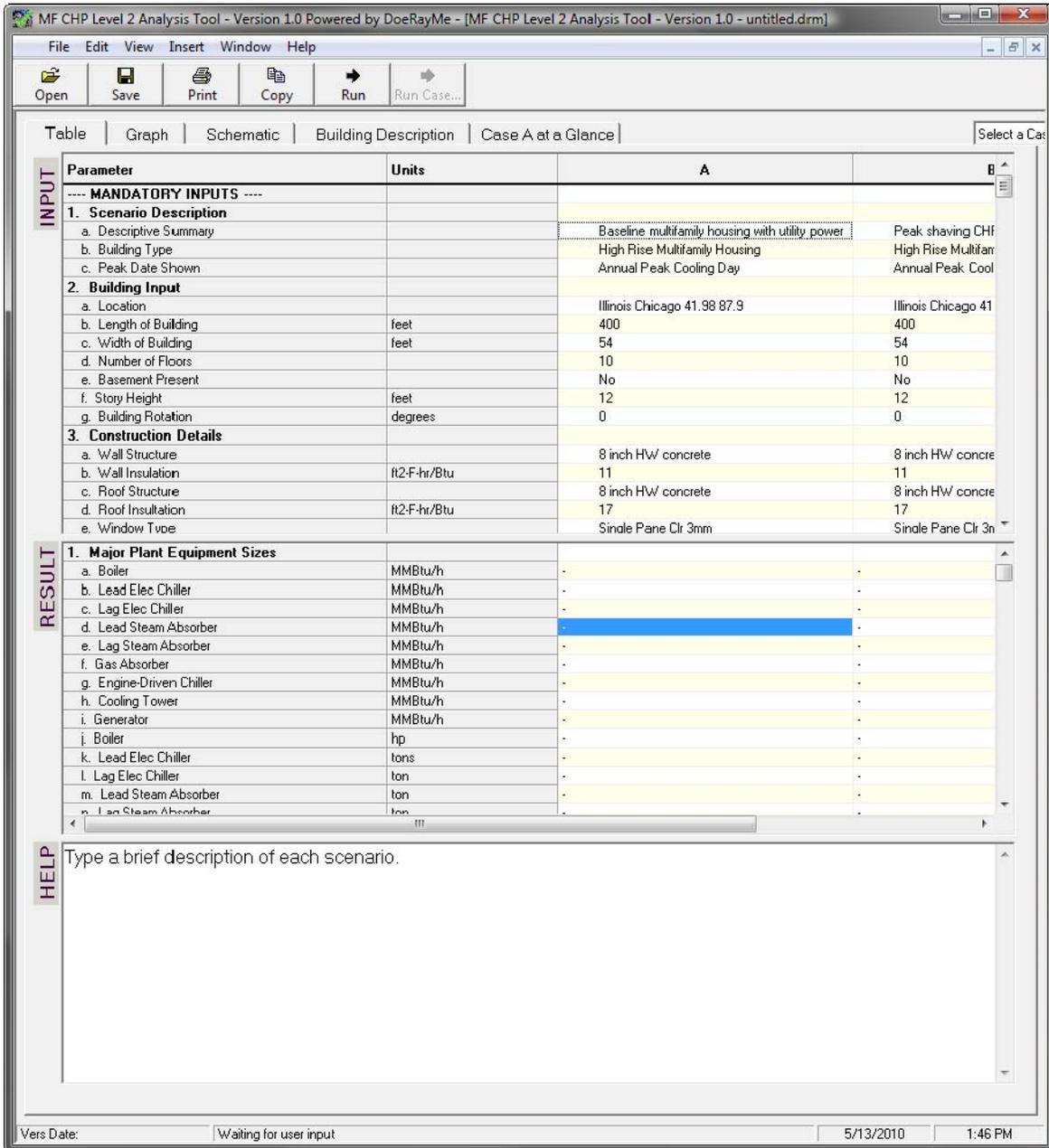
Main Data Form

The main data form, that users see when the program starts, has five main tabs: Table, Graph, Schematic, Building Description, and Case “A” at a Glance (really Case “X” at a Glance). This data form is shown in the next figure below. Case “A” is usually used as the baseline case, and multiple comparison cases can be generated. By default a Case “B” is also included for comparison with Case “A.” Help is provided, when available, on the item selected on the form. The Case “X” at a Glance tab will display information about the specific case selected on the Schematic tab for display.

The Graph tab displays load duration curves of electric demand for each case by default, but users have the ability to plot a wide array of parameters for checking data and results, at annual, monthly, and 24-hr time steps, in addition to the load duration for 8,760 hr.

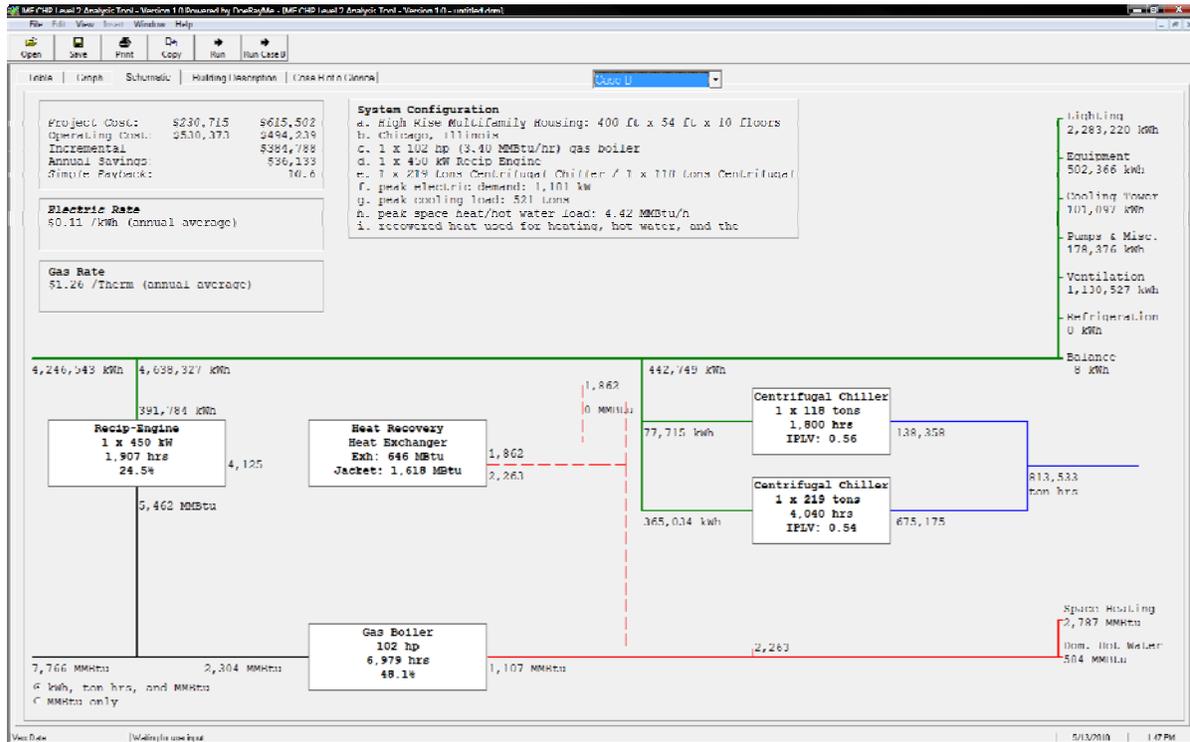
The Schematic tab attempts to graph all the key energy flows for a specific case, and the case is user selectable. The case selected will determine the Case “X” at a Glance case to be displayed.

The main input and outputs are provided in the Table part of the form. Note that the HELP, RESULT, and INPUT windows can be resized vertically by the user.



The Schematic tab draws a schematic of the energy flows for the selected case and provides a summary of key information for the specific case modeled against the baseline case (and if Case A is the baseline case, that comparison shows no difference). Users must click on the “Run” key at the top (or go to the menu item: file, Run Simulation) to run the sizing and simulation DOE-2 modeling for

each case. Results for the default high rise multifamily housing are as shown in the next figure for the Case B CHP case compared to the Case A baseline case.



The Schematic form also provides links to several other data results forms by “mousing over” specific parts of the schematic, and then clicking on the colored text or text box with colored text, e.g., the “Recip-Engine” box will give access to the generator data form.

Forms Tree and Use of “Selection Form”

So the two main types of forms are data input and results. This portion of this document deals mainly with the data input forms. A forms “tree list” showing the categories of forms is:

- a. Main Data Form
 - i. Input and Result Data Grids
 - ii. Graph Tab
 - iii. Schematic Tab
 - iv. Building Description Tab
- b. System Comparison Form
- c. Gas & Electric Utility Rate Forms
- d. Generator Forms
 - i. Generator Selection Form
 - ii. Generator Hourly Data
 - iii. Database Information
- e. Air Conditioning Equipment Forms
 - i. chiller selection form
 - ii. chiller hourly data
- f. Boiler Forms
 - i. boiler selection form

- ii. steam plant hourly data
- g. Water Heater Form
- h. Economic Calculations
 - i. Present value factor data form
 - ii. Depreciation schedules
 - iii. Cash flow schedule

Although there are forms designated “Selection Form” in this tree, the recommended method of input is to use the Table tab on the main data form. The “Selection” forms can be accessed via the Schematic tab as shown above, but we recommend using the Table tab input instead. The “Selection” forms do provide useful equipment information though, and these forms can be helpful for verifying what the input data are.

The water heater form may not be available, as the water heater symbol is displayed only for systems using a packaged rooftop system (air conditioner or heat pump). It is not displayed for systems using chilled water for air conditioning. The only way to activate this form at this time from the Schematic tab is by clicking the mouse on the rectangle on the Schematic diagram representing the water heater. Fortunately, the information can also be viewed, in a compact form, from the Table tab input form, by selecting the “Service Water Heater” item in the input table, clicking on the button that appears on the right of the input field, and then checking the “Show Details” box at the bottom of the “Select ServiceHotWater” form that comes up. But users should note that the water heater size is not really used in the tool, and hot water load is determined from the number of people in the building.

Economic Calculations

Users must recognize that keeping economic analysis factors up-to-date is impossible without continuous revision. Resources are not currently available to keep these factors viable. Thus, the factors affecting the economic calculations in BCHP Screener are out of date and should be approached with caution. Users may wish to extract specific data needed from the program and perform economic calculations outside BCHP Screener in a separate tool, such as the Building Life-Cycle Cost (BLCC) Program tool, that is updated annually. The current version is 5.3-07 and is available for PCs only: http://www1.eere.energy.gov/femp/information/download_blcc.html.

Other supporting programs are also available, such as ERATES 1.11, which is used to calculate the monthly and annual electricity costs for a facility, building, or system under a wide range of electric utility rate schedules, and EERC 1.0-07, which computes an average annual escalation rate for fuel prices from the annual energy price forecasts of the DOE Energy Information Administration, based on user input for project location, fuel usage, industry sector, and the beginning and end dates of the period of interest. All these program downloads can be found at the link given above.

Data Files

The default data loaded when the MF CHP Analysis Tool starts is for a comparison of a high rise multifamily housing in Boston, with and without a CHP system. Users can modify the default data and save the modified data in a new file that can be used later as needed. The data files have the extension “.drm” and are saved by default in the same directory where the tool executable program is installed (by default “C:\Program Files\MF CHP Analysis Tool,” unless changed by the user when installing). These data files can also be saved elsewhere, as needed.

Generator Data Base

The generator database has two purposes:

- Provides values to the MF CHP Analysis Tool and the DOE-2.1e simulation engine needed in the simulation of the specified equipment such as operating ratios and performance curve coefficients.
- Provides information displayed by the MF CHP Analysis Tool to aid the user in selecting which type of generator equipment to use.

These two purposes require many different fields in the database that are described below. The database is a single table (also called a flat file database). To add new generator types the database may be opened in a database program such as Microsoft Access or by using the built in “add a generator” option in the software.

In DOE-2, the plant equipment TYPE that is used for the MF CHP Analysis tool is DIESEL-GEN for all generators. The DIESEL-GEN model it is actually capable of simulating any type of generating equipment that uses any fuel including natural gas. Since some enhancements to the standard DOE-2.1e program have been made for the MF CHP Analysis Tool, not all fields of this database will be usable with a standard DOE-2.1e.

All fields are described below.

General Information

MANUFACTURER

The “Manufacturer” field contains either the name of the manufacturer if the record describes a unique commercially available model or a brief description of the equipment category if the record describes a generic class of commercially available models. This field is for information only and is not a direct input into the DOE-2 engine.

MODEL

The “Model” field contains either the model of the unit if the record describes a unique commercially available model or a brief description of the unit if the record describes a generic model. The latter description includes the source of the data, the capacity of the unit being characterized, and whether the record is for a model that is currently commercially available or expected to become available in the foreseeable future. Unless specifically stated otherwise, all records characterize commercially available units. This field is for information only and is not a direct input into the DOE-2 engine.

DESCRIPTION

The “Description” field contains a brief description of the unit being characterized, including the duty class and fuel type. This is for information only and is not input into the DOE-2 engine.

EQUIPCATEGORY

The “EquipCategory” field contains the general category of the BCHP system component being characterized. Input values are limited to the following options:

Generator,
Boiler,
Chiller,
Packaged A/C,
Cooling tower, and
Desiccant.

For the generator database the value for this field is always generator.

EQUIPTYPE

The “EquipType” field contains the broad equipment classification within the category defined in the EquipCategory field. For generators, input options are limited to:

ICE (internal combustion engine),
Turbine,
Microturbine,
Fuel cell, and
Fuel cell/MT (combination fuel cell and microturbine).

This field is for information only and is not a direct input into the DOE-2 engine.

DETEQUIPTYPE

The “DetEquipType” field contains data that further clarifies the information provided in EquipType. For any records with an EquipType of “fuel cell” or “fuel cell/MT” the DetEquipType field indicates the type of fuel cell but for other values of EquipType it contains the same value as EquipType. The values for this field may be:

MCFC (molten carbonate fuel cell),
PAPC (phosphoric acid fuel cell),
SOFC (solid oxide fuel cell),
ICE,
Turbine, or
Microturbine.

This field is for information only and is not a direct input into the DOE-2 engine.

RATEDSIZE

The “RatedSize” field contains the capacity of the equipment. If the record describes a unique commercially available model it is the rated capacity. If the record describes a generic class of commercially available models, it is a typical capacity. For generators, this data is input in kilowatts (kW).

NOMDATASOURCE

The “NomDataSource” field contains the data source for the nominal information contained in the preceding seven fields. The data source will generally be the equipment manufacturer or a research organization that published the data. This data is for information only and is not a direct input into the DOE-2 engine.

Generator Operating Characteristics

MINRATIO

The “MinRatio” field contains the minimum operating ratio of the equipment being characterized. The minimum ratio is the fraction of the smallest load at which the equipment being specified can operate continually divided by the nominal rated load. Generators will turn off, not cycle, below the minimum ratio. This data is input into the DOE-2 engine as the MIN-RATIO.

MAXRATIO

The “MaxRatio” field contains the maximum operating ratio of the equipment being characterized. The maximum ratio is the fraction of the highest loading or overloading allowed divided by the nominal rated load. For many types of equipment that cannot be overloaded, this would have the value of 1.0. This data is input into the DOE-2 engine as the MAX-RATIO.

OPERATRATIO

The “OperatRatio” field contains the operating ratio of the equipment being characterized. This is the point, usually taken from a performance curve that represents the most desirable operating condition divided by the nominal rated load. This data is input into the DOE-2 engine as the OPERATING-RATIO.

PLRDATA_SOURCE

The “PLRDataSource” field contains the data source for the information contained in the preceding three part load ratio fields. The data source will generally be the equipment manufacturer or a research organization that published the data. This data is for information only and is not a direct input into the DOE-2 engine.

ELEC_EFF

The value in the “ElecEff” field specifies the conversion efficiency of fuel to electricity at full load when both are expressed in the same units and converted into a percent. The acceptable range is from 0 to 100. This data is input into the DOE-2 engine as the DIESEL-GEN-EFF.

ELEC_EFF_SOURCE

The “ElecEffSource” field contains the data source for the information contained in the ElecEff field. The data source will generally be the equipment manufacturer or a research organization that published the data. If it is the manufacturer, the value of the field will simply be “manufacturer”. This data is for information only and is not a direct input into the DOE-2 engine.

JLEFF

The value in the “JLEff” field specifies the conversion efficiency of fuel to recovered energy from the jacket and lube-oil in the case of an internal combustion engine generator and lower temperature recovered heat for a fuel cell. The value is entered at full load when both are expressed in the same units and converted into a percent. Generally this is the lower grade (lower temperature) of heat recovered for all generators. The acceptable range is from 0 to 100% although the typical range is 5% to 40% for internal combustion engine generators and 25% to 40% for a fuel cell. Turbines and microturbines don’t normally have a lower grade heat recovery option and this value is set to zero for these types. This data is input into the DOE-2 engine as the DIESEL-J/L-EFF.

EXH_EFF

The data in the “ExhEff” field specifies the conversion efficiency of fuel to recovered energy from exhaust gases at full load for turbines, microturbines and internal combustion engine generators. It also represents the higher temperature heat recovery from fuel cells. This represents high quality (high temperature) recovered heat. The value is entered at full load when both are expressed in the same units and converted into a percent. The acceptable range is from 0% to 100% although typical values range from 10% to 30% for engine generators, 40% to 50% for turbines, and 25% to 60% for microturbines. While some fuel cells may have two temperature levels of waste heat, the current database does not have data for the higher level and all waste heat is assumed to take place at the lower temperature level (see JLEff). This data is input into the DOE-2 engine as the DIESEL-EXH-EFF.

TOT_EFF

The data in the “TotEff” field specifies the total conversion efficiency of fuel to electricity and recovered energy at full load. The value is entered at full load when both are expressed in the same units and converted into a percent. The acceptable range is from 0% to 100% and generally ranges from 50% to 85%. This data is for information only and is not a direct input into the DOE-2 engine.

HREFF_SOURCE

The “HREffSource” field contains the data source for the information contained in the JLEff and ExhEff fields. The data source will generally be the equipment manufacturer or a research organization that published the data. If it is the manufacturer, the value of the field will simply be “manufacturer”. This data is for information only and is not a direct input into the DOE-2 engine.

Generator Performance Curves

CFAIOFPLR, CFBIOFPLR AND CFCIOFPLR

The three fields, CfaIOFplr, CfbIOFplr and CfcIOFplr, contain the coefficients that define a quadratic equation. The equation correlates full load fuel consumption to the fraction of that consumption consumed at other loads as a function of part load ratio. The equation is used to calculate the amount

of fuel energy required to generate a given electrical load. The first field is the value of the constant, the second field is the linear term, and the third field contains the value for the squared term. This data is input into the DOE-2 engine using the DIESEL-I/O-FPLR command.

IOFPLR SOURCE

The “IOFplr Source” field contains the data source for the information contained in the CfaIOFplr, CfbIOFplr and CfcIOFplr fields. The data source will generally be the equipment manufacturer, a research organization that published the data, or the default values contained in DOE-2. If it is the manufacturer, the value of the field will simply be “manufacturer”. This data is for information only and is not a direct input into the DOE-2 engine.

CFACAPFT, CFBCAPFT AND CFCCAPFT

The three fields, CfaCapFt, CfbCapFt and CfcCapFt, contain the coefficients that define a quadratic equation. The equation adjusts the nominal capacity rating of the generator as a function of outdoor drybulb temperature. The first field is the value of the constant, the second field is the linear term, and the third field contains the value for the squared term. This data is input into the DOE-2 engine using the DIESEL-CAP-FT command. For most versions of DOE-2, the DIESEL-CAP-FT command is non-functional but enhancements have been made with the version of DOE-2.1e that comes with the MF CHP Analysis Tool including enabling the use of this performance curve.

CAPFT SOURCE

The “CapFt Source” field contains the data source for the information contained in the CfaCapFt, CfbCapFt and CfcCapFt fields. The data source will generally be the equipment manufacturer, a research organization that published the data, or the default values contained in DOE-2. If it is the manufacturer, the value of the field will simply be “manufacturer”. This data is for information only and is not a direct input into the DOE-2 engine.

CFAEXHFPLR, CFBEXHFPLR AND CFCEXHFPLR

The three fields, CfaExhFplr, CfbExhFplr and CfcExhFplr, contain the coefficients that define a quadratic equation. The equation correlates the full load exhaust heat recovery to the fraction of that recovery at other loads as a function of part load ratio. The equation is used to calculate the amount of exhaust heat recovered at a given electrical load. The first field is the value of the constant, the second field is the linear term, and the third field contains the value for the squared term. This data is input into the DOE-2 engine using the DIESEL-EXH-FPLR command.

EXHFPLR SOURCE

The “ExhFplr Source” field contains the data source for the information contained in the CfaExhFplr, CfbExhFplr and CfcExhFplr fields. The data source will generally be the equipment manufacturer, a research organization that published the data, or the default values contained in DOE-2. If it is the manufacturer, the value of the field will simply be “manufacturer”. This data is for information only and is not a direct input into the DOE-2 engine.

CFAJCLBFPLR, CFBJCLBFPLR AND CFCJCLBFPLR

The three fields, CfaJclbFplr, CfbJclbFplr and CfcJclbFplr, contain the coefficients that define a quadratic equation. The equation correlates the full load jacket and lube oil heat recovery to the fraction of that recovery at other loads as a function of part load ratio. The equation is used to calculate the amount of jacket and lube oil heat recovered at a given electrical load. The first field is the value of the constant, the second field is the linear term, and the third field contains the value for the squared term. This data is input into the DOE-2 engine using the DIESEL-JCLB-FPLR command.

JCLBFPLR SOURCE

The “JclbFplr Source” field contains the data source for the information contained in the CfaJclbFplr, CfbJclbFplr and CfcJclbFplr fields. The data source will generally be the equipment manufacturer, a research organization that published the data, or the default values contained in DOE-2. If it is the manufacturer, the value of the field will simply be “manufacturer”. This data is for information only and is not a direct input into the DOE-2 engine.

CFATEXFPLR, CFBTEXFPLR AND CFCTEXFPLR

The three fields, CfaTexFplr, CfbTexFplr and CfcTexFplr, contain the coefficients that define a quadratic equation. The equation correlates the temperature of the exhaust gases to the load being met as a function of part load ratio. This data is input into the DOE-2 engine using the DIESEL-TEX-FPLR command but it is not used in the current model in the MF CHP Analysis Tool.

TEXFPLR SOURCE

The "TexFplr Source" field contains the data source for the information contained in the CfaTexFplr, CfbTexFplr and CfcTexFplr fields. The data source will generally be the equipment manufacturer, a research organization that published the data, or the default values contained in DOE-2. If it is the manufacturer, the value of the field will simply be "manufacturer". This data is for information only and is not a direct input into the DOE-2 engine.

Generator Modeling

The DOE2 simulations of natural gas-fired electric generators are described in the DOE2 Engineers Manual (see DOE2 documentation), starting on page V.88 (page 623 of the PDF file). Additional information can be found in the "DOE2 Reference Manual Part 1, including:

- descriptions of DOE2 chiller control parameters, p. V.30 (page 466 in the PDF file),
- DOE2 load assignment parameters, p. V.51 (page 487 in the PDF file),
- DOE2 load management parameters, p. V.57 (page 493 in the PDF file)

DOE-2.1E has three types of electric generator models with the following features:

- *"Diesel" Generator*
The "diesel" generator model (DIESEL-GEN) may be fueled by diesel fuel, natural gas, fuel oil, LPG, coal, methanol, or biomass. This generator has two waste heat streams available, exhaust and jacket/lube. The electrical power generation efficiency and the availability of both waste heat streams are user controlled by inputs for nominal efficiency and a part-load curve.
- *Gas Turbine Generator*
The gas turbine generator model (DIESEL-GEN) may be fueled by diesel fuel, natural gas, fuel oil, LPG, coal, methanol, or biomass. This generator has one waste heat stream available, the turbine exhaust. The electrical power generation efficiency and the availability of the waste heat stream are user controlled by inputs for nominal efficiency and a part-load curve.
- *Steam Turbine Generator*
The steam turbine generator model (STURB-GEN) has one waste heat stream available, the steam exhaust. The steam consumption and electrical power generation are computed from a user-input steam rate curve as a function of inlet and outlet steam pressures and a user-input nominal efficiency and part load curve. Electrical power generation efficiency and the availability of the waste heat stream are user controlled by inputs for nominal efficiency and a part-load curve.

Since the diesel generator model is set up to handle two different waste heat streams, this model will be used for all generator types. The appropriate inputs for nominal performance and part-load performance will be set according to the selected generator type.

The information in these references is primarily of interest to users creating their own database entries for water chillers or users modifying the data templates to create their own default values or over-ride basic parameters.

The electrical capacity of gas turbine and microturbine generators degrades at elevated ambient temperatures. The MF CHP Analysis Tool accommodates this by passing coefficients from the generator data base to DOE2 so the capacity above 59 F can be expressed as a quadratic function of the ambient temperature:

$$Q_{\text{capacity}} = Q_{\text{nominal}} \times [A_1 + (B_1 \times T_{\text{ambient}}) + (C_1 \times T_{\text{ambient}}^2)]$$

The set of coefficients is from a fit to manufacturer's data with the condition that $F(59) = 1$. At each time step in the calculations, the part load ratio, PLR, is specified as the current electrical load divided by the generator capacity at the current ambient conditions.

$$\text{PLR} = Q_{\text{load}} / Q_{\text{capacity}}$$

PLR is bounded by upper and lower limits that are specified in the generator database. Users should bear in mind that the generators have a minimum operating load and there will be hours when the gen-set is not operated, even though there is a thermal load, because the load is below the thermal capacity at the lower operating limit.

Generator fuel consumption is computed from the the bounded part load ratio, the generator capacity, and the generator efficiency. The efficiency is calculated using a quadratic fit to part load performance using manufacturer's with the condition that at full load $f(1) = 1$:

$$\text{Engine Efficiency} = \text{Engine Efficiency}_{\text{rated}} \times [A_2 + (B_2 \times \text{PLR}) + (C_2 \times \text{PLR}^2)]$$

$$Q_{\text{fuel}} = \text{PLR} \times Q_{\text{capacity}} / \text{Engine Efficiency}$$

Finally, heat recovered from engine exhaust and the jacket cooling water (lube oil and cooling water) are calculated as fits to fractions of the engine input energy (i.e. fuel consumption):

$$Q_{\text{exhaust}} = Q_{\text{fuel}} \times \text{Exhaust Efficiency} \times [A_3 + (B_3 \times \text{PLR}) + (C_3 \times \text{PLR}^2)]$$

$$Q_{\text{jacket}} = Q_{\text{fuel}} \times \text{Jacket Efficiency} \times [A_4 + (B_4 \times \text{PLR}) + (C_4 \times \text{PLR}^2)]$$

Generator waste heat can be recovered from the engine exhaust, the jacket cooling water, and the lube oil cooler.

Engine heat recovery, both for gen-sets and engine-driven chillers, is calculated from the engine fuel consumption. Generator fuel consumption, in turn, is dependent on the ambient temperature (particularly for gas turbines and microturbines) and whether or not the engine is operating at full load. The full load generator capacity is capacity dependent on the ambient temperature:

$$Q_{\text{full load}}(T) = Q_{\text{rated capacity}} \text{ for } T < T_{\text{rating point}}$$

and

$$Q_{\text{full load}}(T) = (a_0 - b_0 T) \times Q_{\text{rated capacity}} \text{ for } T > T_{\text{rating point}}$$

Fuel consumption, then, is calculated using the rated electrical efficiency:

$$Q_{\text{fuel, full load}}(T) = Q_{\text{full load}}(T) / \eta_{\text{electric}}$$

Part load capacity is calculated using a quadratic fit to manufacturers' data for part load ratios (PLR) between specified minimum and maximum operating conditions, PLR_{min} and PLR_{max} :

$$Q(\text{PLR}, T) = (a_1 + b_1\text{PLR} + c_1\text{PLR}^2) \times Q_{\text{full load}}(T)$$

Engine heat recovery is divided between heat recovered from the exhaust and heat recovered from the engine jacket cooling water and lube oil cooler. At full load conditions:

$$Q_{\text{exhaust}}(T) = \eta_{\text{exhaust}} \times Q_{\text{fuel, full load}}(T)$$

At part load operation:

$$Q_{\text{exhaust}}(\text{PLR}, T) = \eta_{\text{exhaust}} \times (a_2 + b_2\text{PLR} + c_2\text{PLR}^2) \times Q_{\text{fuel, full load}}(T)$$

and consequently:

$$Q_{\text{exhaust}}(\text{PLR}, T) = \eta_{\text{exhaust}} \times (a_2 + b_2\text{PLR} + c_2\text{PLR}^2) \times Q_{\text{full load}}(T) / \eta_{\text{electric}}$$

A similar expression is used for heat recovered from the engine jacket and lube oil cooler:

$$Q_{\text{jacket}}(\text{PLR}, T) = \eta_{\text{jacket}} \times (a_3 + b_3\text{PLR} + c_3\text{PLR}^2) \times Q_{\text{full load}}(T) / \eta_{\text{electric}}$$

Similar expressions are used for heat recovery from engine-driven chillers.

The generator and chiller databases contain values for:

- generator rated capacity, $Q_{\text{rated capacity}}$
- electric efficiency, η_{electric}
- exhaust heat recovery efficiency, η_{exhaust}
- jacket and lube oil heat recovery efficiency, η_{jacket}
- part load range of operation, PLR_{min} and PLR_{max}
- and the curve fit parameters, a_i , b_i , and c_i

The default equipment Access data base, bchpLIB.mdb, is password protected, so the user cannot access or change the values for these parameters. However, users can copy entries from an Excel version of the default database into the bchpUSR.mdb database (tables are by equipment type).

Do not attempt this copy operation on the Main Data Form Table tab entry for the generator, where if users click on the entry for generator for any case visible, then click on the button that appears at the right of the field, then check the “Show Details” box at the bottom, which will display all data parameters for that piece of equipment on the right — in addition to a button that is available for copying data from the default data to the user data. For generators, if the user clicks on the “Copy to User-Defined” button at the top of Details side of this equipment data form, a runtime error will be generated and BCHP Screener will close, causing any data entered and not saved to be lost.

The “Copy to User-Defined” button does work for some items, but not for generators.

Instead, an Excel file has been created that has the correct number of data fields for copying to the bchpUSR.mdb Generator table as a template close to what might be needed for a new entry. (Contact Piljae Im, imp1@ornl.gov)

The Equipment Selection Data Form, with the "Show Details" box checked, does allow users to view and modify values for any of the parameters. When changing the curve fits, note that each of the part load functions is specifying performance relative to full load operation ($\text{PLR}=1$), so in each case coefficients should be chosen so that $a_i + b_i + c_i = 1$.

Generator Costs

EQUIPCOST

The “EquipCost” field contains the equipment first cost in dollars per kilowatt. If the record describes a unique commercially available model it is the first cost of the equipment expressed as a unit cost. If the data describes a generic model it is a typical equipment cost. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool.

EQUIPCOSTSOURCE

The “EquipCostSource” field contains the data source for the information contained in the EquipCost field. The data source will generally be the equipment manufacturer, a manufacturer’s representative or dealer, or a research organization that published the data. If it is the manufacturer, the value of the field will simply be “manufacturer”. If the “EquipCost” is derived, the source and method for how it was derived is indicated. This data is for information only and is not a direct input into the MF CHP Analysis tool.

INSTALLCOST

The “InstallCost” field contains the installation cost in dollars per kilowatt. If the data set describes a unique commercially available model it is the installation cost including the equipment cost expressed as a unit cost. If the data describes a generic model it is a typical installation cost. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool.

INSTALLCOSTFACT

The “InstallCostFact” field contains the installation cost factor of the unit specified, expressed as the fraction of total cost to equipment cost. This data is for information only and is not a direct input into the MF CHP Analysis tool.

COSTFACTSOURCE

The “CostFactSource” field contains the data source for the information contained in the InstallCostFact field. The data source will generally be the equipment manufacturer, a manufacturer’s representative or dealer, or a research organization that published the data. If it is the manufacturer, the value of the field will simply be “manufacturer”. This data is for information only and is not a direct input into the MF CHP Analysis tool.

TOTCOST

The “TotCost” field contains the total cost in dollars per kilowatt. If the data set describes a unique commercially available model it is the total cost expressed as a unit cost. If the data describes a generic model it is a typical total cost. The value must be set equal to the sum of the values entered in the EquipCost and InstallCost fields. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool.

TOTCOSTSOURCE

The “TotCostSource” field contains the data source for the information contained in the TotCost field. The data source will generally be the equipment manufacturer, a manufacturer’s representative or dealer, or a research organization that published the data. If it is the manufacturer, the value of the field will simply be “manufacturer”. This data is for information only and is not a direct input into the DOE-2 engine.

SERVLIFE

The “ServLife” field contains the service life, in years, of the unit specified. The service life is the anticipated economic life of the equipment rather than the mean time before failure. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool.

SERVLIFESOURCE

The “ServLifeSource” field contains the data source for the information contained in the ServLife field. The data source will generally be the equipment manufacturer, a manufacturer’s representative or dealer, or a research organization that published the data. This data is for information only and is not a direct input into the MF CHP Analysis tool.

MAINTCOST

The “MaintCost” field contains the annual maintenance cost, in dollars per kilowatt-hour, of the specified equipment. This value should include both routine maintenance costs and the annualized value of non-routine major maintenance costs. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool.

MAINTDATASOURCE

The “MaintDataSource” field contains the data source for the information contained in the MaintCost field. The data source will generally be the equipment manufacturer, a manufacturer’s representative or dealer, or a research organization that published the data. This data is for information only and is not a direct input into the MF CHP Analysis tool.

HVAC Database

The HVAC database has two purposes:

- Provides values to the MF CHP Analysis Tool and the DOE-2.1e simulation engine needed in the simulation of the specified equipment such as operating ratios and performance curve coefficients.
- Provides information displayed by the MF CHP Analysis Tool to aid the user in selecting which type of HVAC equipment to use.

These two purposes require many different fields in the database that are described below. The database consists of four unrelated tables (also called a flat file database). To add new HVAC equipment the database may be opened in a database program such as Microsoft Access or by using the built in “add HVAC equipment” option in the software.

The HVAC Database consists of four separate tables corresponding to cooling, heating, cooling towers and desiccant systems. Many of the variables included in these tables are common for all of the equipment types and are described below under “General Information”. Variables that are unique to one of the four specific equipment types are described under “Cooling Equipment”, “Heating Equipment”, “Cooling Towers” or “Desiccant Equipment” respectively.

The default equipment Access data base, bchpLIB.mdb, is password protected, so the user cannot access or change the values for these parameters. However, users can copy entries from the default database into the bchpUSR.mdb database (tables are by equipment type). In the Main Data Form Table tab entry for the specific HVAC equipment type, where if users click on the entry for that equipment type for any case visible, then click on the button that appears at the right of the field, and then check the “Show Details” box at the bottom, a display of all data parameters for that piece of equipment will be shown on the right of that form. To copy the item selected on the left of the form from the default data base into the user data base, click on the “Copy to User-Defined” button at the top of the right of the form. Entries in the user data base are shown at the bottom of the equipment list and are highlighted in yellow. Users can open this data base with Access and modify data fields, or the data fields for a specific entry can be changed on the right of the form when the “Show Details” box at the bottom of the left of the form is checked.

All fields for each equipment type that can be changed from the default in BCHP Screener are described below.

General Information

CATEGORY

The “Category” field contains information that further classifies the equipment characterized by the data set. Cooling categories include absorption water chillers, electric reciprocating water chillers, electric screw water chillers, electric scroll water chillers, natural gas engine-driven water chillers, rooftop air conditioners, and electric centrifugal chillers. Heating categories are limited to gas-fired boiler or rooftop air conditioner. Cooling towers and desiccant systems do not include any subcategories. This field is for information only and is not a direct input into the DOE-2.1e engine.

TYPE

The “Type” field contains information corresponding with the TYPE parameter in DOE-2.1e, which identifies the type of equipment to be used in the simulation calculations. Cooling types, depending on the selected category, include:

- Direct-fired double-effect (DFDE), indirect-fired double-effect (IFDE) and indirect-fired single-effect (IFSE) for absorption water chillers;
- Air-cooled condenser, air-cooled condenser w/ no unloading and water-cooled condenser for electric reciprocating water chillers; air-cooled condenser, air-cooled condenser w/ no unloading and water-cooled condenser for electric reciprocating water chillers;
- Air-cooled condenser, air-cooled condenser w/ slide valve unloading and water-cooled condenser w/ slide valve unloading for electric screw water chillers;
- Air-cooled condenser, air-cooled condenser w/ no unloading and water-cooled condenser w/ no unloading for electric scroll water chillers;
- Air-cooled or water-cooled condenser for natural gas engine-driven water chillers;
- Air-cooled electric cooling/gas heating or air-cooled electric cooling/electric heating for rooftop air conditioners; and
- Water-cooled w/ no unloading, water-cooled w/ inlet vane unloading and water-cooled w/ variable speed drive (VSD) unloading for electric centrifugal chillers.

Heating types, depending on the selected category, include:

- Steam firetube, steam firebox and hot water firetube for gas-fired boilers; and
- Air-cooled electric cooling/gas heating or air-cooled electric cooling/electric heating for rooftop air conditioners.

Thermal energy storage types include chilled water, ice-on-coil, ice-harvester, ice-slurry and eutectic.

Domestic hot water options include heat transfer package with one-pump system, heat transfer package with two-pump system, electric hot water boiler and gas-fired hot water boiler. The first two options require a boiler to have been previously defined for space heating, while the last two options are stand-alone domestic hot water systems.

Open tower is the only type available for cooling towers, solid is the only type available for desiccant systems, and air-cooled is the only type available for heat pumps.

MANUFACTURER

The “Manufacturer” field contains either the name of the manufacturer if the record describes a unique commercially available model or the word “generic” if the record describes a generic class of commercially available models. This field is for information only and is not a direct input into the DOE-2.1e engine.

MODEL

The “Model” field contains either the model of the unit if the record describes a unique commercially available model or “N/A” if the record describes a generic model. Unless specifically stated

otherwise, all records characterize commercially available units. This field is for information only and is not a direct input into the DOE-2.1e engine.

Cooling Equipment Operating Characteristics

CAPACITY

The “Capacity” field contains the capacity of the equipment. If the record describes a unique commercially available model it is the nominal capacity. If the record describes a generic class of commercially available models, it is a typical capacity. For all cooling equipment, this data is input in refrigerant tons. For some chillers the capacity may be at different conditions than the typical ARI rating conditions.

SIZE

The “SIZE” field contains information corresponding with the SIZE parameter in DOE-2.1e, which is the nominal rated output capacity, expressed in units of one million Btu's per hour (Mbtu/hr) for the item of equipment being specified. For example, a 100-ton chiller should be specified as SIZE = 1.20 since the conversion factor is 12,000 Btu/hr-ton. For all cooling equipment, this is the capacity at rated conditions.

SH-CAP

The “SH-CAP” field contains information corresponding with the COOL-SH-CAP parameter in DOE-2.1e, which is the sensible heat removal capacity of the cooling device at Air-Conditioning and Refrigeration Institute (ARI) rated conditions. At non-ARI rated conditions, the value will be corrected for entering wet-bulb temperature and outdoor dry-bulb temperature (or entering water temperature for heat pumps). The sensible capacity is always less than or equal to the total capacity. The SH-CAP parameter is only applicable to the rooftop air conditioner category.

EIR

The “EIR” field contains information corresponding with the ELEC-INPUT-RATIO parameter in DOE-2.1e, which is the electric input to nominal capacity ratio expressed as electric power input to electric motor and auxiliaries divided by the nominal capacity of equipment being defined, both in Btu/h. This entry should include the electric power to move and control the working fluid flowing through the equipment plus the primary power input to the equipment itself. For an absorption chiller, the electric power input to the absorber pump must be considered. However, the user should ignore the electric power delivered to chilled water and condenser water pumps.

COP

The “COP” field contains information corresponding with the ENG-CH-COP parameter in DOE-2.1e, which is the standard condition coefficient of performance. Standard conditions are defined as 44° F leaving chilled water temperature and 85° F entering condenser temperature. The COP parameter is only applicable to the natural gas engine-driven water chiller category.

MIN-RATIO

The “MIN-RATIO” field contains information corresponding with the MIN-RATIO parameter in DOE-2.1e, which is the minimum fraction of nominal rated load at which the equipment item being specified can operate continually. That is, if the item of equipment is scheduled to operate and the demand is more than zero but less than the MIN-RATIO, the program will cycle the machine on and off.

MAX-RATIO

The “MAX-RATIO” field contains information corresponding with the MAX-RATIO parameter in DOE-2.1e, which is the maximum fraction of loading or overloading allowed. For many types of equipment that cannot be overloaded, this would have the value of 1.0.

HIR

The “HIR” field contains information corresponding with the ABSOR1-HIR, ABSOR2-HIR and AGSORG-HIR parameters in DOE-2.1e, for single-stage and double-stage absorption chillers. HIR

specifies the full-load heat input ratio for an absorption chiller, or the ratio of heat energy input to cooling energy output both expressed in Btuh.

HCAPR

The “HCAPR” field contains information corresponding with the ABSORG-HCAPR parameter in DOE-2.1e, which is the heat capacity ratio (the heat capacity of the unit in Btuh divided by the cooling capacity in Btuh) of a direct-fired absorption chiller.

COND-TYPE

The “COND-TYPE” field contains information corresponding with the CONDENSER-TYPE parameter in DOE-2.1e, and is either air-cooled or water-cooled.

UNLOADMECH

The “UnloadMech” field identifies the unloading mechanism used by the cooling equipment selected, if any. Depending on the equipment selected, this may be a slide valve, inlet vanes, variable speed drive (VSD) or none at all. This field is for information only and is not a direct input into the DOE-2.1e engine.

REFRIGERANT

The “REFRIGERANT” field identifies the refrigerant used with the selected cooling equipment. Depending on the equipment selected this may be HCFC-22, HFC-134a, R-410a or lithium-bromide (LiBr). This field is for information only and is not a direct input into the DOE-2.1e engine.

COND-PWR

The “COND-PWR” field contains information corresponding with the OPEN-REC-COND and HERM-REC-COND parameters in DOE-2.1e, which is the ratio of fan electric energy (Btu) to the operating capacity (Btu) of the selected cooling equipment. The parameter is only applicable if an air-cooled condenser is selected (see COND-TYPE).

UNL-RAT

The “UNL-RAT” field contains information corresponding with the OPEN-REC-UNL-RAT and HERM-REC-UNL-RAT parameters in DOE-2.1e, which is the maximum part-load ratio of the selected cooling equipment at which hot gas bypass occurs. Above this value, the equipment adjusts capacity by unloading. Between MIN-RATIO and this ratio, the equipment has unloaded as far as it can and is artificially loading the equipment using hot gas bypass to make up the difference. Below MIN-RATIO, the machine cycles on and off. The parameter is only applicable if an air-cooled condenser is selected (see COND-TYPE).

OPER-RAT

The “OPER-RAT” field contains information corresponding with the OPERATING-RATIO parameter in DOE-2.1e, which is defined as the operating point expressed as a part load ratio with the highest COP. The parameter is only applicable if a natural gas engine-driven water chiller is selected (see CATEGORY).

IDLE-RAT

The “IDLE-RAT” field contains information corresponding with the ENG-CH-IDLE-RAT parameter in DOE-2.1e. The parameter is only applicable if a natural gas engine-driven water chiller is selected (see CATEGORY).

COIL-BF

The “COIL-BF” field contains information corresponding with the COIL-BF parameter in DOE-2.1e, which is defined as the coil bypass factor and is applicable only to direct-expansion cooling and heat pump systems.

SUPPLY-CFM

The “SUPPLY-CFM” field contains information corresponding with the SUPPLY-CFM parameter in DOE-2.1e, which is the design capacity (in standard, or sea level, cfm) of the system air supply fan and is applicable only to direct-expansion cooling and heat pump systems.

OUTSIDE-FAN-KW

The “OUTSIDE-FAN-KW” field contains information corresponding with the OUTSIDE-FAN-KW parameter in DOE-2.1e, which is the amount of electrical energy, measured in kW, used to operate the

outside fan (condenser fan when cooling or evaporator fan when heating). The parameter is only applicable if an air-cooled condenser is selected (see COND-TYPE).

MINCHWS

The “MinCHWS” field contains the minimum chilled water supply temperature for which the performance curves for the selected cooling equipment is valid. This field is for information only and is not a direct input into the DOE-2.1e engine.

MAXCHWS

The “MaxCHWS” field contains the maximum chilled water supply temperature for which the performance curves for the selected cooling equipment is valid. This field is for information only and is not a direct input into the DOE-2.1e engine.

MINCWS

The “MinCWS” field contains the minimum condenser water supply temperature for which the performance curves for the selected cooling equipment is valid. This field is for information only and is not a direct input into the DOE-2.1e engine.

MAXCWS

The “MaxCWS” field contains the maximum condenser water supply temperature for which the performance curves for the selected cooling equipment is valid. This field is for information only and is not a direct input into the DOE-2.1e engine.

RATEDCHWS

The “ratedCHWS” field contains the nominal rated chilled water supply temperature for which the performance curves for the selected cooling equipment is valid. This field is for information only and is not a direct input into the DOE-2.1e engine.

RATEDCWS

The “ratedCWS” field contains the nominal rated condenser water supply temperature for which the performance curves for the selected cooling equipment is valid. This field is for information only and is not a direct input into the DOE-2.1e engine.

Cooling Equipment Performance Curves

CAP-FT

The six “CAP-FT” fields, a through f, contain the coefficients of bi-quadratic equation that defines the operating capacity correction factor as a function of the exiting chilled water temperature and the entering condenser water temperature. That is, the dependent variable, z, is the capacity and the independent variables, x and y, are exiting chilled water temperature and entering condenser water temperature. The function is normalized so that at design conditions the capacity correction factor is equal to 1.0. This data is input into the DOE-2.1e engine depending on the cooling equipment selected.

CAP-FT-REF

The “CAP-FT-REF” field contains the value of the CAP-FT curve evaluated at the rating point based the coefficients defined above. The value should be close to 1.0 and measures how well the curve fit comes to the nominal value at rated conditions. This data is for information only and is not a direct input into the DOE-2.1e engine.

COOL-SH-FT

The six “COOL-SH-FT” fields, a through f, contain the coefficients of a bi-quadratic equation that adjusts the sensible heat removal capacity of the cooling equipment as a function of the supply cfm and supply air discharge temperature. This data is applicable to rooftop air conditioners only and is input into the DOE-2.1e engine using the COOL-SH-FT command.

HIR-FT

The six “HIR-FT” fields, a through f, contain the coefficients of a bi-quadratic equation that defines the heat input ratio at full load as a function of the exiting chilled water temperature and entering condenser water temperature. This data is applicable to absorption chillers only and is input into the

DOE-2.1e engine using the ABSOR1-HIR-FT, ABSOR2-HIR-FT or ABSORG-HIR-FT command, depending on the cooling equipment selected. For direct-fired absorption chillers, there is no sensitivity to condenser water temperature since it is handled with HIR1-FTI.

HIR1-FTI

The three “HIR1-FTI” fields, a through c, contain the coefficients of a linear or quadratic equation that defines the heat input ratio at full load as a function of the entering condenser water temperature. This data is applicable to direct-fired absorption chillers only and is input into the DOE-2.1e engine using the ABSORG-HIR-FT command.

HIR-FPLR

The four “HIR-FPLR” fields, a through d, contain the coefficients of a cubic equation that defines the heat input ratio at full load for the selected cooling equipment. For the given equipment, the heat input at full load will be multiplied by the function of the part-load ratio to obtain the heat input to the equipment at part load. The curve should evaluate to near 1.0 at full load. This data is applicable to absorption chillers only and is input into the DOE-2.1e engine using the ABSOR1-HIR-FPLR, ABSOR2-HIR-FPLR or ABSORG-HIR-FPLR command, depending on the cooling equipment selected.

EIR-FT

The six “EIR-FT” fields, a through f, contain the coefficients of a bi-quadratic equation that defines the electric input ratio at full load as a function of the exiting chilled water temperature and entering condenser water temperature. This data is applicable to electric chillers only and is input into the DOE-2.1e engine for the cooling equipment selected.

EIR-FT-REF

The “EIR-FT-REF” field contains a reference point corresponding to the coefficients defined above. This data is for information only and is not a direct input into the DOE-2.1e engine.

EIR-FPLR

The three “EIR-FPLR” fields, a through c, contain the coefficients of a quadratic equation that defines the electric input ratio at full load for the selected cooling equipment. For the given equipment, the electric input at full load will be multiplied by the function of the part-load ratio to obtain the electric input to the equipment at part load. This data is applicable to electric chillers only and is input into the DOE-2.1e engine using the OPEN-CENT-EIR-FPLR, OPEN-REC-EIR-FPLR, HERM-CENT-EIR-FPLR or HERM-REC-EIR-FPLR command, depending on the cooling equipment selected.

EIR-FPLR-REF

The “EIR-FPLR-REF” field contains a reference point corresponding to the coefficients defined above. The value should be close to 1.0 and measures how well the curve fit comes to the nominal value at rated conditions. This data is for information only and is not a direct input into the DOE-2.1e engine.

COP-FT

The six “COP-FT” fields, a through f, contain the coefficients of a bi-quadratic equation that defines the coefficient of performance (COP) correction factor as a function of the exiting chilled water temperature and the entering condenser water temperature. That is, the dependent variable, z, is the capacity and the independent variables, x and y, are exiting chilled water temperature and entering condenser water temperature. The function is normalized so that at design conditions the capacity correction factor is equal to 1.0. This data is applicable to natural gas engine-driven chillers only and is input into the DOE-2.1e engine using the ENG-CH-COP-FT command.

COP-FPLR1

The two “COP-FPLR1” fields, a and b, contain the coefficients of a linear equation that together with “COP-FPLR2” and “COP-FPLRS” modifies the COP as a function of the part load ratio. This data is applicable to natural gas engine-driven chillers only and is input into the DOE-2.1e engine using the ENG-CH-COP-FPLR1 command.

COP-FPLR2

The two “COP-FPLR2” fields, a and b, contain the coefficients of a linear equation that together with “COP-FPLR1” and “COP-FPLRS” modifies the COP as a function of the part load ratio. This data is applicable to natural gas engine-driven chillers only and is input into the DOE-2.1e engine using the ENG-CH-COP-FPLR2 command.

COP-FPLRS

The two “COP-FPLRS” fields, a and b, contain the coefficients of a linear equation that together with “COP-FPLR1” and “COP-FPLR2” modifies the COP as a function of the part load ratio. This data is applicable to natural gas engine-driven chillers only and is input into the DOE-2.1e engine using the ENG-CH-COP-FPLRS command.

HREJ-FT

The two “HREJ-FT” fields, a and b, contain the coefficients of a linear equation that defines the heat rejection at full load as a function of the entering condenser water temperature. This data is applicable to natural gas engine-driven chillers only and is input into the DOE-2.1e engine using the ENG-CH-HREJ-FT command.

PERF. DATA SOURCE

The “Perf. Data Source” field contains the data source for the information contained in the cooling equipment performance curve fields. The data source will generally be the equipment manufacturer, a manufacturer’s representative or dealer, or a research organization that published the data. If it is the manufacturer, the value of the field will simply be “manufacturer”. This data is for information only and is not a direct input into the DOE-2.1e engine.

PERFORMANCE COMMENTS

The “Performance Comments” field contains information to clarify the values contained in the other cooling equipment performance curve fields. This data is for information only and is not a direct input into the DOE-2.1e engine.

Cooling Equipment Modeling

CHILLERS

The DOE2 simulations of electric, gas, and steam-fired chillers are described in the DOE2 Engineers Manual, starting on page V.26 (page 561 of the PDF file). Additional information can be found in the DOE2 Reference Manual Part 1, including:

- descriptions of DOE2 chiller control parameters, p. V.21 (page 457 in the PDF file),
- DOE2 load assignment parameters, p. V.51 (page 487 in the PDF file),
- DOE2 load management parameters, p. V.57 (page 493 in the PDF file)

The information in these references is primarily of interest to users creating their own database entries for water chillers or users modifying the data templates to create their own default values or over-ride basic parameters.

Chiller simulations are performed using several algebraic equations. These equations describe the chiller off design capacity and energy inputs (see p. V.26 of the DOE2 Engineers Manual, page 561 in the PDF file). The equipment part load ratio, PLR, is defined as the ratio of the load, LOAD, to the system capacity, CAP.

$$PLR = LOAD/CAP$$

The energy input (i.e. electricity, natural gas, steam, or recovered heat) is then defined as the capacity times the heat or electricity input ratio at design conditions (HIR_{des} or EIR_{des}) times a correction factor based on the part load ratio, $HIR(PLR)$:

$$\text{Energy} = (\text{CAP}) \times (\text{HIR}_{\text{des}}) \times [\text{HIR}(\text{PLR})]$$

the chiller capacity is calculated by:

$$\text{CAP} = \text{CAP}_{\text{des}} \times [A_1 + (B_1 \times T_{\text{chilled water out}}) + (C_1 \times T_{\text{chilled water out}}^2) + (D_1 \times T_{\text{cooling tower out}}) + (E_1 \times T_{\text{cooling tower out}}^2) + (F_1 \times T_{\text{chilled water out}} \times T_{\text{cooling tower out}})]$$

and the coefficients are selected so that the off design correction factor is 1 for $T_{\text{chilled water out}} = 44$ F and $T_{\text{cooling tower out}} = 85$ F. The part load correction is computed using:

$$\text{HIR}(\text{PLR}) = A_2 + (B_2 \times \text{PLR}) + (C_2 \times \text{PLR}^2)$$

where $\text{HIR}(1) = 1$. The coefficients "A_i" "B_i" and "C_i" are from fits to manufacturer's data for off design capacity and energy input.

The cooling equipment database contains values for these coefficients for a broad range of commercially available chillers. Users interested in creating or changing database entries should note that HIR_{des} and EIR_{des} for thermally activated and electrically driven chillers are heat and electricity input **ratios**: unit of energy in per unit of cooling out, both in Btu/h (even for electrically driven chillers).

ROOFTOP AIR CONDITIONERS & ELECTRIC HEAT PUMPS

Packaged heating and cooling systems, such as rooftop air conditioners and electric heat pumps, are treated differently than chilled water systems in the DOE2 simulations. These types of equipment are considered part of the "System" calculations instead of being part of the "Plant" calculations. The rationale behind the decision to separate the types of equipment in this manner is explained on page IV.1 of the DOE2 Reference Manual Part 1 (page 202 in the PDF file). The principal reason behind the choice appears to be due to the difficulty of separating the "primary" system from "secondary" systems in packaged units dedicated to serving a single zone (e.g. fans, pumps).

Additional information on packaged systems can be located on page IV.53 in the DOE2 Engineers Manual (page 336 in the PDF file).

It should be noted that equipment configurations using packaged rooftop air conditioners or electric heat pumps are presumed to be using commercial hot water heaters for potable hot water (buildings with chilled water systems are assumed to use boilers to produce steam or hot water for both space heating and service hot water needs).

Cooling Equipment Costs

LABOR COST

The "Labor Cost" field contains the installation cost, in dollars, for the selected equipment. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For all cooling equipment, the units are dollars per refrigerant-ton.

EQUIP. COST

The "Equip. Cost" field contains the equipment first cost, in dollars, for the selected equipment. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For all cooling equipment, the units are dollars per refrigerant-ton.

INSTALLED COST

The “Installed Cost” field contains the installed cost, in dollars, for the selected equipment including both labor and equipment costs. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For all cooling equipment, the units are dollars per refrigerant-ton.

FIRST COST SOURCE

The “First Cost Source” field contains the data source for the information contained in the “Labor Cost”, “Equip. Cost” and “Installed Cost” fields. The data source will generally be a published estimating guide or a research organization that published the data. This data is for information only and is not a direct input into the MF CHP Analysis tool.

COMMENTS

The “Comments” field contains information to clarify the values contained in the labor and equipment cost fields. This data is for information only and is not a direct input into the MF CHP Analysis tool.

SERVICE LIFE

The “Service Life” field contains the service life of the unit specified. The service life is the anticipated economic life of the equipment rather than the mean time before failure. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For all cooling equipment, the units are years.

REPAIR COST

The “Repair Cost” field contains the annual repair cost of the specified equipment. This value should include only the annualized value of non-routine major maintenance costs. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For all cooling equipment, the units are dollars per refrigerant-ton per year.

REPAIR COST SOURCE

The “Repair Cost Source” field contains the data source for the information contained in the “Repair Cost” field. The data source will generally be a published estimating guide or a research organization that published the data. This data is for information only and is not a direct input into the MF CHP Analysis tool.

COMMENTS

The “Comments” field contains information to clarify the values contained in the repair cost fields. This data is for information only and is not a direct input into the MF CHP Analysis tool.

MAINT. COST

The “Maint. Cost” field contains the annual maintenance cost for the specified equipment. This value should include only routine maintenance costs. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For all cooling equipment, the units are dollars per refrigerant-ton per year.

MAINTENANCE COST SOURCE

The “Maintenance Cost Source” field contains the data source for the information contained in the maintenance cost fields. The data source will generally be a published estimating guide or a research organization that published the data. This data is for information only and is not a direct input into the MF CHP Analysis tool.

COMMENTS

The “Comments” field contains information to clarify the values contained in the maintenance cost fields. This data is for information only and is not a direct input into the MF CHP Analysis tool.

Heating Equipment Operating Characteristics

CAPACITY

The “Capacity” field contains the capacity of the equipment. If the record describes a unique commercially available model it is the rated capacity. If the record describes a generic class of commercially available models, it is a typical capacity. For all heating equipment, this data is input in

boiler horsepower (HP), which is 33479 Btu/h. This field is for information only and is not a direct input into the DOE-2.1e engine.

SIZE

The “SIZE” field contains information corresponding with the SIZE parameter in DOE-2.1e, which is the nominal rated output capacity, expressed in units of one million Btu's per hour (Mbtu/hr) for the item of equipment being specified. For example, a 100 HP boiler should be specified as SIZE = 3.35 since the conversion factor is 0.033479 Mbtu/HP.

EIR

The “EIR” field contains information corresponding with the ELEC-INPUT-RATIO parameter in DOE-2.1e, which is the electric input to nominal capacity ratio expressed as electric power input to electric auxiliaries divided by the nominal capacity of equipment being defined, both in Btuh. This entry should include the electric power to move and control the working fluid flowing through the equipment plus the primary power input to the equipment itself. For a fossil-fueled boiler, the electric power input to the boiler draft fan and stokers must be considered. However, the user should not include the electric power delivered to hot water pumps.

MIN-RATIO

The “MIN-RATIO” field contains information corresponding with the MIN-RATIO parameter in DOE-2.1e, which is the minimum fraction of nominal rated load at which the equipment item being specified can operate continually. That is, if the item of equipment is scheduled to operate and the demand is more than zero but less than the MIN-RATIO, the program will cycle the machine on and off.

MAX-RATIO

The “MAX-RATIO” field contains information corresponding with the MAX-RATIO parameter in DOE-2.1e, which is the maximum fraction of loading or overloading allowed. For many types of equipment that cannot be overloaded, this would have the value of 1.0.

HIR

The “HIR” field contains information corresponding with the STM-BOILER-HIR, HW-BOILER-HIR and FURNACE-HIR parameters in DOE-2.1e, for steam boilers, hot water boilers and forced-air furnaces, respectively. HIR specifies the ratio of fuel input (Btu) to heat energy output at full load.

SUPPLY-CFM

The “SUPPLY-CFM” field contains information corresponding with the COIL-BF parameter in DOE-2.1e, which is the design capacity (in standard, or sea level, cfm) of the system air supply fan. The parameter is only applicable if a rooftop air-conditioner is selected.

Heating Equipment Performance Curves

HIR-FPLR

The three “HIR-FPLR” fields, a through c, contain the coefficients of a quadratic equation that defines the heat input ratio at full load for the selected heating equipment. For the given equipment, the heat input at full load will be multiplied by the function of the part-load ratio to obtain the heat input to the equipment at part load. This data is applicable to boilers only and is input into the DOE-2.1e engine using either the STM-BOILER-HIR-FPLR and HW-BOILER-HIR-FPLR command, depending on the heating equipment selected.

COMMENTS

The “Comments” field contains information to clarify the values contained in the other heating equipment performance curve fields. This data is for information only and is not a direct input into the DOE-2.1e engine.

Heating Equipment Modeling

BOILERS

Data sets that include water chillers for space cooling (i.e. electric chillers, gas-fired or recovered-heat fired absorption chillers, engine-driven chillers) are assumed to include a boiler plant that provides both space heating and service hot water for domestic hot water uses and process heating. Boiler plant specifications are specifically addressed in the *DOE2 Engineers Manual* beginning on page V.16 (page 551 of the PDF file) and as part of a general simulation description on page V.5 (page 541 of the PDF file). Boilers are also discussed in the *DOE2 Reference Manual Part 1* on page V.23 (page 459 of the PDF file).

Boiler fuel consumption is calculated using a curve fit for boiler efficiency to adjust for part load operation using:

$$PLR = Q_{\text{load}}/Q_{\text{rated capacity}}$$

$$Q_{\text{fuel}} = Q_{\text{rated capacity}} \times HIR_{\text{rated}} \times [A + (B \times PLR) + (C \times PLR^2)]$$

where HIR_{rated} is the boiler heat input ratio (input energy / output energy), the inverse of the efficiency, at the rated design conditions.

The equipment database for commercial boilers includes entries for both gas-fired and electric boilers.

GAS AND ELECTRIC FURNACES

Gas and electric furnace specifications are part of the rooftop air conditioning selections in the equipment database. Database entries with equipment type "ac" have heating system fields for:

- heating size (10^6 Btu's/h),
- heat input ratio (Btu's input/Btu's output), and
- turn-down ratio.

Furnace performance is not degraded for part load operation. Gas furnace simulations are described on page V.22 of the *DOE Engineers Manual* (page 557 in the PDF file) and on page V.23 of the *DOE2 Reference Manual Part 1* (page 459 in the PDF file).

Heating Equipment Costs

LABOR COST

The "Labor Cost" field contains the installation cost, in dollars, for the selected equipment. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For boilers, the units are dollars per horsepower, and for furnaces, the units are dollars per refrigerant-ton.

EQUIP. COST

The "Equip. Cost" field contains the equipment first cost, in dollars, for the selected equipment. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For boilers, the units are dollars per horsepower, and for furnaces, the units are dollars per refrigerant-ton

INSTALLED COST

The "Installed Cost" field contains the installed cost, in dollars, for the selected equipment including both labor and equipment costs. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For boilers, the units are dollars per horsepower, and for furnaces, the units are dollars per refrigerant-ton.

FIRST COST SOURCE

The “First Cost Source” field contains the data source for the information contained in the “Labor Cost”, “Equip. Cost” and “Installed Cost” fields. The data source will generally be a published estimating guide or a research organization that published the data. This data is for information only and is not a direct input into the MF CHP Analysis tool.

SERVICE LIFE

The “Service Life” field contains the service life of the unit specified. The service life is the anticipated economic life of the equipment rather than the mean time before failure. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For all heating equipment, the units are years.

REPAIR COST

The “Repair Cost” field contains the annual repair cost of the specified equipment. This value should include only the annualized value of non-routine major maintenance costs. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For boilers, the units are dollars per MBH per year, and for furnaces, the units are dollars per refrigerant-ton per year.

REPAIR COST SOURCE

The “Repair Cost Source” field contains the data source for the information contained in the “Repair Cost” field. The data source will generally be a published estimating guide or a research organization that published the data. This data is for information only and is not a direct input into the MF CHP Analysis tool.

MAINT. COST

The “Maint. Cost” field contains the annual maintenance cost of the specified equipment. This value should include only routine maintenance costs. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For all heating equipment, the units are dollars per MBH per year.

MAINTENANCE COST SOURCE

The “Maintenance Cost Source” field contains the data source for the information contained in the maintenance cost fields. The data source will generally be a published estimating guide or a research organization that published the data. This data is for information only and is not a direct input into the MF CHP Analysis tool.

Cooling Tower Operating Characteristics

SIZE

The “SIZE” field contains information corresponding with the SIZE parameter in DOE-2.1e, which is the nominal rated output capacity, expressed in both units of one million Btu's per hour (Mbtu/hr) and refrigerant-tons for the item of equipment being specified.

DESIGNAPPROACH

The “DesignApproach” field contains information corresponding with the TOWER-DESIGN-APPROACH parameter in DOE-2.1e, which is the approach temperature used in the cooling tower design calculations.

EIR

The “EIR” field contains information corresponding with the ELEC-INPUT-RATIO parameter in DOE-2.1e, which is the electric input to nominal capacity ratio expressed as electric power input to electric auxiliaries divided by the nominal capacity of equipment being defined, both in Btu/h. This entry should include the electric power to move and control the working fluid flowing through the equipment plus the primary power input to the equipment itself. The user should ignore the electric power delivered to chilled and condenser water pumps.

Cooling Tower Modeling

The equipment database contains entries for "generic" cooling towers with single-speed, two-speed, and variable-speed fans. Record fields are limited to:

- nominal size,
- design approach temperature,
- the electricity input ratio,
- equipment and installation costs,
- service life, and
- repair and maintenance costs.

Cooling towers are discussed on page V.45 of the *DOE2 Engineers Manual* (page 580 of the PDF file), page V.22 of the *DOE2 Reference Manual Part 1* (page 458 in the PDF file), and page 4.37 of the *DOE-2 Supplement, Version 2.1E*.

Cooling Tower Costs

LABORCOST

The "LaborCost" field contains the installation cost, in dollars, for the selected equipment. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For all cooling towers, the units are dollars per refrigerant-ton.

EQUIPCOST

The "EquipCost" field contains the equipment first cost, in dollars, for the selected equipment. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For all cooling towers, the units are dollars per refrigerant-ton.

INSTALLED COST

The "InstalledCost" field contains the installed cost, in dollars, for the selected equipment including both labor and equipment costs. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For all cooling towers, the units are dollars per refrigerant-ton.

FIRSTCOSTSOURCE

The "FirstCostSource" field contains the data source for the information contained in the "LaborCost", "EquipCost" and "InstalledCost" fields. The data source will generally be a published estimating guide or a research organization that published the data. This data is for information only and is not a direct input into the MF CHP Analysis tool.

SERVICELIFE

The "ServiceLife" field contains the service life of the unit specified. The service life is the anticipated economic life of the equipment rather than the mean time before failure. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For all cooling towers, the units are years.

REPAIRCOST

The "RepairCost" field contains the annual repair cost of the specified equipment. This value should include only the annualized value of non-routine major maintenance costs. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For all cooling towers, the units are dollars per refrigerant-ton per year.

REPAIRCOSTSOURCE

The "RepairCostSource" field contains the data source for the information contained in the "RepairCost" field. The data source will generally be a published estimating guide or a research organization that published the data. This data is for information only and is not a direct input into the

MF CHP Analysis tool. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool.

MAINTCOST

The “MaintCost” field contains the annual maintenance cost of the specified equipment. This value should include only routine maintenance costs. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For all cooling towers, the units are dollars per refrigerant-ton per year.

MAINTCOSTSOURCE

The “MaintCostSource” field contains the data source for the information contained in the maintenance cost fields. The data source will generally be a published estimating guide or a research organization that published the data. This data is for information only and is not a direct input into the MF CHP Analysis tool.

Desiccant Equipment Operating Characteristics

USERS SHOULD NOTE THAT THE DESICCANT ROUTINES DO NOT APPEAR TO BE WORKING CORRECTLY IN THIS VERSION OF THE TOOL.

WHEEL TYPE

The “Wheel Type” field contains information regarding the energy transfer wheel used in the selected desiccant equipment. Novelaire equipment utilizes two different wheel types for commercial desiccant systems, designated LT3 and LCIX. LT3 wheels are comprised of a high capacity low regeneration temperature "premium" desiccant in a high temperature fiber substrate. LT3 wheels are generally used in commercial desiccant cooling systems, where the availability of lower temperature regeneration energy provides rapid payback. LCIX wheels are comprised of a "next generation" 1M desiccant in a high temperature fiber substrate. LCX wheels are used for dehumidification of outdoor summer air and in compact higher reactivation temperature desiccant cooling systems. For generic desiccant equipment, for which no detailed wheel type information is available, the field contains the term “Commercial”. This field is for information only and is not a direct input into the DOE-2.1e engine.

WHEEL SPECIFICATION

Is a summary of the Velocity, Heater Temperature, R/P, and Regen fields for display use only.

SIZE RANGE

The supply air CFM range for the equipment

REGEN

The “Regen” field contains the regeneration or reactivation air ratio for the selected desiccant equipment, which is defined as the reactive air volume divided by the process air volume. This field is for information only and is not a direct input into the DOE-2.1e engine.

PROCESS

The “Process” field contains the process air volume for the selected desiccant equipment, expressed in standard cubic feet per minute (SCFM). This field is for information only and is not a direct input into the DOE-2.1e engine.

WHEEL DIAMETER

The “Wheel Diameter” field contains the selected desiccant equipment wheel dimension, expressed in millimeters (mm) and inches (in), which describes the outside diameter of the circumference of the main body of the desiccant wheel band. This field is for information only and is not a direct input into the DOE-2.1e engine.

WHEEL DEPTH

The “Wheel Depth” field contains the selected desiccant equipment wheel dimension, expressed in millimeters (mm) and inches (in), which describe the outside depth of the main body of the desiccant wheel. This field is for information only and is not a direct input into the DOE-2.1e engine.

WHEEL AREA

The “Wheel Area” field contains the area of the selected desiccant equipment wheel, expressed in square meters (m²) and square feet (ft²). This field is for information only and is not a direct input into the DOE-2.1e engine.

VELOCITY

The “Velocity” field contains the face velocity through the wheel for the selected desiccant equipment, expressed in feet per minute (FPM). This field is for information only and is not a direct input into the DOE-2.1e engine.

HEATER TEMP

The “Heater Temp” field contains the regeneration/reactivation heated temperature for the selected desiccant equipment, expressed in degrees Fahrenheit (° F).

R/P

The “R/P” field contains the ratio of the regeneration or reactivation air ratio for the selected desiccant equipment to the difference between the process outlet and process inlet air temperatures. This field is for information only and is not a direct input into the DOE-2.1e engine.

COMMENTS

The “Comments” field contains information to clarify the values contained in the other desiccant equipment operating characteristics fields. This data is for information only and is not a direct input into the DOE-2.1e engine.

Desiccant Equipment Performance Curves

OUTLET TEMP

The six “OUTLET TEMP” fields, a through f, contain the coefficients of a bi-quadratic equation that calculates the full-load leaving dry bulb temperature (°F) as a function of the entering dry bulb temperature (°F) and entering humidity ratio (gr/lb) for the selected desiccant equipment. A seventh field, R², returns the square of the Pearson product moment correlation coefficient through the selected data points (R²). This data is input into the DOE-2.1e engine using the DESC-T-FTW command.

HEATER OUTPUT

The six “HEATER OUTPUT” fields, a through f, contain the coefficients of a bi-quadratic equation that calculates the full-load regeneration energy (Btu/hr per cfm of process air) as a function of the entering dry bulb temperature (°F) and entering humidity ratio (gr/lb) for the selected desiccant equipment. As implemented in the solid desiccant model, this curve represents the energy added to the regeneration air stream. If a gas regeneration heater is specified, then an efficiency of 0.85 is assumed to convert the regeneration energy to gas input. A seventh field, R², returns the square of the Pearson product moment correlation coefficient through the selected data points (R²). This data is input into the DOE-2.1e engine using the DESC-GAS-FTW command.

OUTLET HUMIDITY

The six “OUTLET HUMIDITY” fields, a through f, contain the coefficients of a bi-quadratic equation that calculates the full-load leaving humidity ratio (gr/lb) as a function of the entering dry bulb temperature (°F) and entering humidity ratio (gr/lb) for the selected desiccant equipment. A seventh field, R², returns the square of the Pearson product moment correlation coefficient through the selected data points (R²). This data is input into the DOE-2.1e engine using the DESC-W-FTW command.

WATER REMOVED

The six “WATER REMOVED” fields, a through f, contain the coefficients of a bi-quadratic equation that calculates the total amount of moisture removed for the selected desiccant equipment. A seventh field, R², returns the square of the Pearson product moment correlation coefficient through the selected data points (R²). This data is for information only and is not a direct input into the DOE-2.1e engine.

Desiccant Equipment Costs

LABOR COST

The “Labor Cost” field contains the installation cost, in dollars, for the selected equipment. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For all desiccant equipment, the units are dollars per CFM.

EQUIP. COST

The “Equip. Cost” field contains the equipment first cost, in dollars, for the selected equipment. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For all desiccant equipment, the units are dollars per CFM.

INSTALLED COST

The “Installed Cost” field contains the installed cost, in dollars, for the selected equipment including both labor and equipment costs. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For all desiccant equipment, the units are dollars per CFM.

FIRST COST SOURCE

The “First Cost Source” field contains the data source for the information contained in the “Labor Cost”, “Equip. Cost” and “Installed Cost” fields. The data source will generally be a published estimating guide or a research organization that published the data. This data is for information only and is not a direct input into the MF CHP Analysis tool.

COMMENTS

The “Comments” field contains information to clarify the values contained in the labor and equipment cost fields. This data is for information only and is not a direct input into the MF CHP Analysis tool.

SERVICE LIFE

The “Service Life” field contains the service life of the unit specified. The service life is the anticipated economic life of the equipment rather than the mean time before failure. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For all desiccant equipment, the units are years.

SERVICE LIFE SOURCE

The “Service Life Source” field contains the data source for the information contained in the service life fields. The data source will generally be a published estimating guide or a research organization that published the data. This data is for information only and is not a direct input into the MF CHP Analysis tool.

REPAIR COST

The “Repair Cost” field contains the annual repair cost of the specified equipment. This value should include only the annualized value of non-routine major maintenance costs. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For all desiccant equipment, the units are dollars per refrigerant-ton per year.

REPAIR COST SOURCE

The “Repair Cost Source” field contains the data source for the information contained in the “Repair Cost” field. The data source will generally be a published estimating guides or a research organization that published the data. This data is for information only and is not a direct input into the MF CHP Analysis tool.

COMMENTS

The “Comments” field contains information to clarify the values contained in the repair cost fields. This data is for information only and is not a direct input into the MF CHP Analysis tool.

MAINT. COST

The “Maint. Cost” field contains the annual maintenance cost of the specified equipment. This value should include only routine maintenance costs. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For all desiccant equipment, the units are dollars per refrigerant-ton per year.

MAINTENANCE COST SOURCE

The “Maintenance Cost Source” field contains the data source for the information contained in the maintenance cost fields. The data source will generally be a published estimating guide or a research organization that published the data. This data is for information only and is not a direct input into the MF CHP Analysis tool.

Thermal Energy Storage System Operating Characteristics

A minimalist approach was taken to modeling thermal energy storage (TES).

SIZE

The “SIZE” field is the total storage capacity in ton-hr for cooling and million Btu/hr for heating.

Additional details on modeling TES can be found beginning on page 4.15 of the *DOE-2 Supplement, Version 2.1E*. If users have a need to adjust additional TES modeling parameters, a modified version of the input template file (as an INPUT file for DOE-2) would have to be created and then specified on line 2 of a “drm” file first created using BCHP Screener and saved to disk.

Thermal Energy Storage System Performance Curves

There are no manufacturer specific or DOE.2.1e default performance curves available for thermal energy storage systems.

Thermal Energy Storage System Modeling

All modeling is based on DOE-2.1e default parameters, with the only descriptions available in the *DOE-2 Supplement, Version 2.1E*, pp 4.15–4.36.

Thermal Energy Storage System Costs

LABOR COST

The “Labor Cost” field contains the installation cost, in dollars, for the selected equipment. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. Labor costs are not available for thermal energy storage systems.

EQUIP. COST

The “Equip. Cost” field contains the equipment first cost, in dollars, for the selected equipment. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. Equipment costs are not available for thermal energy storage systems.

INSTALLED COST

The “Installed Cost” field contains the installed cost, in dollars, for the selected equipment including both labor and equipment costs. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For all thermal energy storage systems, the units are dollars per ton-hour.

FIRST COST SOURCE

The “First Cost Source” field contains the data source for the information contained in the “Labor Cost”, “Equip. Cost” and “Installed Cost” fields. The data source will generally be a published estimating guide or a research organization that published the data. This data is for information only and is not a direct input into the MF CHP Analysis tool.

SERVICE LIFE

The “Service Life” field contains the service life of the unit specified. The service life is the anticipated economic life of the equipment rather than the mean time before failure. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For all thermal energy storage systems, the units are years.

REPAIR COST

The “Repair Cost” field contains the annual repair cost of the specified equipment. This value should include only the annualized value of non-routine major maintenance costs. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For all thermal energy storage systems, the units are dollars per year.

MAINT. COST

The “Maint. Cost” field contains the annual maintenance cost of the specified equipment. This value should include only routine maintenance costs. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For all thermal energy storage systems, the units are dollars per year.

MAINTENANCE & REPAIR COST SOURCE

The “Maintenance & Repair Cost Source” field contains the data source for the information contained in the maintenance cost fields. The data source will generally be a published estimating guide or a research organization that published the data. This data is for information only and is not a direct input into the MF CHP Analysis tool.

Domestic Hot Water System Operating Characteristics

A minimalist approach to modeling domestic hot water systems was also taken.

RATED SIZE

The “Rated SIZE” field contains information corresponding with the DHW-HSUP-RATE parameter in DOE-2.1e, which is the maximum rate at which heat can be supplied by the domestic hot water unit, expressed in units of Btu's per hour (Btu/hr) for the item of equipment being specified.

The efficiency and electric loss factors can also be set in the “Show Details” side of the equipment form.

Domestic Hot Water System Performance Curves

No are no manufacture-specific or DOE.2.1e default performance curves available for domestic hot water systems.

Domestic Hot Water System Modeling

A separate hot water heater for service hot water is only used when the building does not have a boiler. If a boiler is present, the simulation assumes that a tank and heat exchanger are used to supply hot water. The simulation size is based on the estimated total service hot water load not on the unit size selected. Hot water load is currently calculated from the number of people in the building.

Commercial water heaters are discussed on page V.23 of the DOE2 Reference Manual Part 1 (page 459 in the PDF file). The equipment database contains 80 individual entries for gas and electric water heaters. Each unit is characterized by whether it is gas or electric, its rated capacity (MMBtu/h), electrical losses, rated efficiency, equipment lifetime, and cost factors (i.e. equipment, installation, maintenance, major repairs). System modeling does not account for part-load or off-design performance degradation. Each of the gas water heaters has an assumed efficiency of 80% with no electricity losses; electric water heaters are assumed to have a 100% efficiency with 0.03 electrical losses (only used to display information about the water heater losses, but not used by DOE-2 directly).

Domestic Hot Water System Costs

LABOR COST

The “Labor Cost” field contains the installation cost, in dollars, for the selected equipment. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For domestic hot water systems, the units are dollars per Btu’s per hour.

EQUIP. COST

The “Equip. Cost” field contains the equipment first cost, in dollars, for the selected equipment. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For domestic hot water systems, the units are dollars per Btu’s per hour.

INSTALLED COST

The “Installed Cost” field contains the installed cost, in dollars, for the selected equipment including both labor and equipment costs. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For domestic hot water systems, the units are dollars per Btu’s per hour.

FIRST COST SOURCE

The “First Cost Source” field contains the data source for the information contained in the “Labor Cost”, “Equip. Cost” and “Installed Cost” fields. The data source will generally be a published estimating guide or a research organization that published the data. This data is for information only and is not a direct input into the MF CHP Analysis tool.

SERVICE LIFE

The “Service Life” field contains the service life of the unit specified. The service life is the anticipated economic life of the equipment rather than the mean time before failure. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For all domestic hot water systems the units are years.

REPAIR COST

The “Repair Cost” field contains the annual repair cost of the specified equipment. This value should include only the annualized value of non-routine major maintenance costs. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For all domestic hot water systems the units are years.

REPAIR COST SOURCE

The “Repair Cost Source” field contains the data source for the information contained in the “Repair Cost” field. The data source will generally be a published estimating guide or a research organization that published the data. This data is for information only and is not a direct input into the MF CHP Analysis tool.

MAINT. COST

The “Maint. Cost” field contains the annual maintenance cost of the specified equipment. This value should include only routine maintenance costs. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For all domestic hot water systems the units are years.

MAINTENANCE & REPAIR COST SOURCE

The “Maintenance & Repair Cost Source” field contains the data source for the information contained in the maintenance and repair cost fields. The data source will generally be a published estimating guide or a research organization that published the data. This data is for information only and is not a direct input into the MF CHP Analysis tool.

Heat Pump Operating Characteristics

NOMCAP

The “NomCap” field contains the capacity of the equipment. If the record describes a unique commercially available model it is the rated capacity. If the record describes a generic class of commercially available models, it is a typical capacity. For all heat pumps, this data is input in thousands of Btu per hour (kBtuH). This data is for information only and is not a direct input into the MF CHP Analysis tool.

COOLING-CAPACITY

The “COOLING-CAPACITY” field contains information corresponding with the COOLING-CAPACITY parameter in DOE-2.1e, which is the nominal rated output cooling capacity (at ARI rated conditions), expressed in units of Btu’s per hour (BtuH) for the heat pump being specified. For example, a 10-ton heat pump should be specified as COOLING-CAPACITY = 120000 since the conversion factor is 12,000 Btu/hr-ton.

HEATING-CAPACITY

The “HEATING-CAPACITY” field contains information corresponding with the HEATING-CAPACITY parameter in DOE-2.1e, which is the nominal rated output heating capacity, expressed in units of Btu’s per hour (BtuH), for the heat pump being specified. The input value is a negative value. If the minus sign is omitted, an ERROR will occur. The program-designed HEATING-CAPACITY does not include fan power and heat, if specified separately.

SUPPLY-CFM

The “SUPPLY-CFM” field contains information corresponding with the SUPPLY-CFM parameter in DOE-2.1e, which is the design capacity (in standard, or sea level, cfm) of the system air supply fan. The program uses this value as the basis determining part-load fan operation and fan horsepower.

COOL-SH-CAP

The “COOL-SH-CAP” field contains information corresponding with the COOL-SH-CAP parameter in DOE-2.1e, which is the sensible heat removal capacity of the heat pump, expressed in units of Btu’s per hour (BtuH), at Air-Conditioning and Refrigeration Institute (ARI) rated conditions. At non-ARI rated conditions, the value will be corrected for entering wet-bulb temperature and outdoor dry-bulb temperature (or entering water temperature for HP). The sensible capacity is always less than or equal to the total capacity.

MIN-RATIO

The “MIN-RATIO” field contains information corresponding with the MIN-RATIO parameter in DOE-2.1e, which is the minimum fraction of nominal rated load at which the heat pump being specified can operate continually. That is, if the heat pump scheduled to operate and the demand is more than zero but less than the MIN-RATIO, the program will cycle the heat pump on and off.

MAX-RATIO

The “MAX-RATIO” field contains information corresponding with the MAX-RATIO parameter in DOE-2.1e, which is the maximum fraction of loading or overloading allowed.

COOLING-EIR

The “COOLING-EIR” field contains information corresponding with the COOLING-EIR parameter in DOE-2.1e, which is the electric input to nominal cooling capacity ratio expressed as electric power input to electric motor and auxiliaries divided by the nominal cooling capacity of equipment being defined, both in BtuH. This entry should include the electric power to move and control the working fluid flowing through the equipment plus the primary power input to the equipment itself.

HEATING-EIR

The “HEATING-EIR” field contains information corresponding with the HEATING-EIR parameter in DOE-2.1e, which is the electric input to nominal heating capacity ratio expressed as electric power input to electric motor and auxiliaries divided by the nominal heating capacity of equipment being defined, both in BtuH. This entry should include the electric power to move and control the working fluid flowing through the equipment plus the primary power input to the equipment itself.

CAP

The “CAP” field contains information corresponding with the HP-SUPP-HT-CAP parameter in DOE-2.1e, which is the supplemental heating capacity for a heat pump, expressed in units of Btu’s per hour (BtuH) but as a negative number. The program will size this to the maximum heating load since this usually occurs when the heat pump is unavailable.

KW

The “KW” field contains information corresponding with the OUTSIDE-FAN-KW parameter in DOE-2.1e, which is the amount of electrical energy, measured in kW, used to operate the outside fan (condenser fan when cooling or evaporator fan when heating).

Heat Pump Performance Curves

COOL-CAP-FT

The six “COOL-CAP-FT” fields, a through f, contain the coefficients of bi-quadratic equation that defines the operating capacity correction factor as a function of the entering evaporator air wet bulb temperature and the entering condenser air temperature. That is, the dependent variable, z, is the capacity and the independent variables, x and y, are entering evaporator air wet bulb temperature and the entering condenser air temperature. The function is normalized so that at design conditions the capacity correction factor is equal to 1.0. This data is input into the DOE-2.1e engine depending on the heat pump selected.

COOL-EIR-FT

The six “COOL-EIR-FT” fields, a through f, contain the coefficients of a bi-quadratic equation that defines the electric input ratio at full load as a function of the entering evaporator air wet bulb temperature and the entering condenser air temperature. This data is input into the DOE-2.1e engine for the heat pump selected.

COOL-SH-FT

The six “COOL-SH-FT” fields, a through f, contain the coefficients of a bi-quadratic equation that calculates adjusts the sensible heat removal capacity of the heat pump as a function of the entering evaporator air wet bulb temperature and the entering condenser air temperature. This data is input into the DOE-2.1e engine using the COOL-SH-FT command.

HEAT-CAP-FT

The six “HEAT-CAP-FT” fields, a through f, contain the coefficients of bi-quadratic equation that defines the operating capacity correction factor as a function of the outside dry bulb temperature and the indoor unit entering air dry bulb temperature. That is, the dependent variable, z, is the capacity and the independent variables, x and y, are outside dry bulb temperature and the indoor unit entering air dry bulb temperature. The function is normalized so that at design conditions the capacity correction factor is equal to 1.0. This data is input into the DOE-2.1e engine depending on the heat pump selected.

HEAT-EIR-FT

The six “HEAT-EIR-FT” fields, a through f, contain the coefficients of a bi-quadratic equation that defines the electric input ratio at full load as a function of the outside dry bulb temperature and the indoor unit entering air dry bulb temperature. This data is input into the DOE-2.1e engine for the heat pump selected.

PERF. DATA SOURCE

The “Perf. Data Source” field contains the data source for the information contained in the heat pump performance curve fields. The data source will generally be the equipment manufacturer, a manufacturer’s representative or dealer, or a research organization that published the data. If it is the manufacturer, the value of the field will simply be “manufacturer”. This data is for information only and is not a direct input into the DOE-2.1e engine.

COMMENTS

The “Performance Comments” field contains information to clarify the values contained in the other heat pump performance curve fields. This data is for information only and is not a direct input into the DOE-2.1e engine.

Heat Pump Modeling

SEE “Rooftop Air Conditioners & Electric Heat Pumps” under “Cooling Equipment Modeling” previously in this manual.

Heat Pump Costs

LABOR COST

The “Labor Cost” field contains the installation cost, in dollars, for the selected equipment. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For all heat pumps, the units are dollars per Btuh.

EQUIP. COST

The “Equip. Cost” field contains the equipment first cost, in dollars, for the selected equipment. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For all heat pumps, the units are dollars per Btuh.

INSTALLED COST

The “Installed Cost” field contains the installed cost, in dollars, for the selected equipment including both labor and equipment costs. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For all heat pumps, the units are dollars per Btuh.

FIRST COST SOURCE

The “First Cost Source” field contains the data source for the information contained in the “Labor Cost”, “Equip. Cost” and “Installed Cost” fields. The data source will generally be a published estimating guide or a research organization that published the data. This data is for information only and is not a direct input into the MF CHP Analysis tool.

SERVICE LIFE

The “Service Life” field contains the service life of the unit specified. The service life is the anticipated economic life of the equipment rather than the mean time before failure. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For all heat pumps, the units are years.

REPAIR COST

The “Repair Cost” field contains the annual repair cost of the specified equipment. This value should include only the annualized value of non-routine major maintenance costs. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For all heat pumps, the units are dollars per year.

MAINT. COST

The “Maint. Cost” field contains the annual maintenance cost of the specified equipment. This value should include only routine maintenance costs. This data is an input into the life cycle cost analysis portion of the MF CHP Analysis tool. For all heat pumps, the units are dollars per year.

MAINTENANCE & REPAIR COST SOURCE

The “Maintenance & Repair Cost Source” field contains the data source for the information contained in the maintenance cost fields. The data source will generally be a published estimating guide or a research organization that published the data. This data is for information only and is not a direct input into the MF CHP Analysis tool.

Generating Results

The “Run” button or the “File, Run Simulation” menu item causes the calculations to execute. The tool uses the inputs in the data table to create an input file for each case or scenario to submit to run under the DOE-2.1e building energy simulation program. For each case or scenario (each column of the data table), first a DOE-2 sizing run executes to determine equipment sizes. Using the sizing results, a full simulation of the building and systems by DOE-2.1e is run for each case (in the

background). Cases run sequentially, and the progress bars indicates progress of program execution. One case typically runs in a matter of seconds.

The DOE-2.1e BDL compiler and simulation program used in the MF CHP Analysis Tool are based on LBNL/ESTSC DOE2.1EWIN, Version 110. This is the latest and final release of the LBNL version of DOE2.1e from June 2000. It was compiled by LBNL using Digital Visual FORTRAN (DVF) and both the source code and a fully functional exe file are included on the ESTSC CD.

Data Table Results

Key summary results are displayed in the bottom part (RESULTS) of the Table tab of the main data form following execution of all cases in the DOE-2 program. A description of the Table tab results are given next. The “item” number indicates the section of the results on the tabular output.

Annual Electricity Consumption, item 4

- Lights – The total annual electrical consumption due to using area lights in the building.
- Equipment – The total annual electrical consumption due to non-lighting plug loads in the building.
- Heating – The total annual electrical consumption associated with equipment whose primary purpose is heating. This includes electrical consumption of a boiler with an electric draft fan even if the boiler is used to supply an absorption chiller. From DOE-2.1e report PS-E.
- Cooling – The total annual electrical consumption due to space cooling. From DOE-2.1e report PS-E.
- Tower – The total annual electrical consumption due to heat rejection equipment including cooling towers and condenser fans. From DOE-2.1e report PS-E.
- Pump and Misc – From DOE-2.1e report PS-E.
- Ventilation Fans – From DOE-2.1e report PS-E.
- Refrigeration – From DOE-2.1e report PS-E.
- Supplemental Heat – From DOE-2.1e report PS-E.
- Service Water Heat – From DOE-2.1e report PS-E.
- Total – From DOE-2.1e report PS-E.

Annual Gas Consumption, item 5

- Heating – From DOE-2.1e report PS-E.
- Cooling – From DOE-2.1e report PS-E.
- Supplemental Heat – From DOE-2.1e report PS-E.
- Service Water Heat – From DOE-2.1e report PS-E.
- Miscellaneous – From DOE-2.1e report PS-E.
- Generator – From DOE-2.1e report PS-E.
- Total – From DOE-2.1e report PS-E.

Annual Generation Details, item 6

- Utility Supplied – From DOE-2.1e report PS-D.
- On-site Generation – From DOE-2.1e report PS-D.
- Boiler Heat – From DOE-2.1e report PS-D.
- Exhaust Heat – From DOE-2.1e report PS-D.
- Jacket Heat – From DOE-2.1e report PS-D.

Emission Calculations, item 10

Results in pounds of emissions from annual operation of equipment.

Electric Use Profile, item 11

Results in kWh included for each month of the year. The results fare from PS-B report out of DOE-2.1e.

Electric Demand Profile, item 12

Results in kW included for each month of the year. The results fare from PS-B report out of DOE-2.1e.

Gas Use Profile, item 13

Results in therms included for each month of the year. The results fare from PS-B report out of DOE-2.1e.

Cooling Peak Hour, item 14

Time – From DOE-2.1e report LS-C.
Outside Temp – From DOE-2.1e report LS-C.
Outside Wetbulb – From DOE-2.1e report LS-C.
Outside Solar – In Btuh/sqft. From DOE-2.1e report LS-C."
Wall Conduct – In kBtuh. From DOE-2.1e report LS-C.
Roof Conduct – In kBtuh. From DOE-2.1e report LS-C.
Window Cond – In kBtuh. From DOE-2.1e report LS-C.
Window Solar – In kBtuh. From DOE-2.1e report LS-C.
Underground – In kBtuh. From DOE-2.1e report LS-C.
Occupant Sens – In kBtuh. From DOE-2.1e report LS-C.
Occupant Lat – In kBtuh. From DOE-2.1e report LS-C.
Light – In kBtuh. From DOE-2.1e report LS-C.
Equipment – In kBtuh. From DOE-2.1e report LS-C.
Infiltration – In kBtuh. From DOE-2.1e report LS-C.
Infilt. Lat. – In kBtuh. From DOE-2.1e report LS-C.
Total Sens. – In kBtuh. From DOE-2.1e report LS-C.
Total – In kBtuh. From DOE-2.1e report LS-C.

Heating Peak Hour, item 15

Time –From DOE-2.1e report LS-C.
Outside Temp –From DOE-2.1e report LS-C.
Outside Solar –From DOE-2.1e report LS-C.
Wall Conduct – In kBtuh. From DOE-2.1e report LS-C.
Roof Conduct – In kBtuh. From DOE-2.1e report LS-C.
Window Cond – In kBtuh. From DOE-2.1e report LS-C.
Window Solar – In kBtuh. From DOE-2.1e report LS-C.
Underground – In kBtuh. From DOE-2.1e report LS-C.
Occupant Sens – In kBtuh. From DOE-2.1e report LS-C.
Light – In kBtuh. From DOE-2.1e report LS-C.
Equipment – In kBtuh. From DOE-2.1e report LS-C.
Infiltration – In kBtuh. From DOE-2.1e report LS-C.
Total – In kBtuh. From DOE-2.1e report LS-C.

Annual Hours, item 2

Cooling Hours – From DOE-2.1e report SS-E.
Heating Hours – From DOE-2.1e report SS-E.
Fan Hours – From DOE-2.1e report SS-E.

Fan Electricity, item 17

During Cooling – In kWh. From DOE-2.1e report SS-M.
During Heating – In kWh. From DOE-2.1e report SS-M.
During Floating – In kWh. From DOE-2.1e report SS-M.

Chilled Water Energy in MMBtu (item 18) and Ton-hr (item 19)

Results included for each month of the year. From SS-D report out of DOE-2.1e.

Peak Chilled Water Use in kBtu (item 20) and Ton (item 21)

Results included for each month of the year. From SS-D report out of DOE-2.1e.

DX Cooling Energy in MMBtu (item 22) and Ton-hr (item 23)

Results included for each month of the year. From SS-Q report out of DOE-2.1e.

Furnace/HP Heating Energy, item 24

Results in MMBtu included for each month of the year. From SS-Q report out of DOE-2.1e.

Hot Water Load, item 25

Results in MMBtu included for each month of the year. From SS-D report out of DOE-2.1e.

Peak Hot Water Use, item 26

Results in kBtu included for each month of the year. From SS-D report out of DOE-2.1e.

Hourly Display Properties, item 27

Date – The month and day corresponding to the criteria selected with the [Peak Day Shown] input parameters. If “annual peak cooling day” was chosen, the date would be the day during the year when the peak cooling load occurred. The data shown in the “Hourly Cooling Load” group, the “Hourly Heating Load” group, and the “Hourly Electric Load” group all are based on the date shown here.

Type – Displays the criteria selected with the [Peak Day Shown] input parameter or indicates that the date was a “selected” using the [Peak Day Shown] input parameter.

Hourly Cooling Load, item 28

The 24 values shown for the hourly cooling load, Btu, are for the peak cooling day and are based on the DOE-2.1e simulation program hourly output variables called:

- SYSTEM/PLANT-ASSIGNMENT/QCLOAD(102) which is the output of all dx and hp units.
- PLANT/PLANT/PDEM2(9) total cooling load to be met by plant.

The hourly cooling load represents the total cooling load imposed on all packaged or central cooling systems. These data for all hours of the year are provided as the cooling load that appears in the CSV files which are created when the “File, Create Hourly Files” option is checked in the File menu.

Hourly Heating Load, item 29

The 24 values shown for the hourly heating load, Btu, are based on the DOE-2.1e simulation program hourly output variables called:

- SYSTEM/PLANT-ASSIGNMENT/QHLOAD(112) - output of all dx and hp units (expressed negative)
- SYSTEM/PLANT-ASSIGNMENT/QHGSLD(115) - load on all supplemental heat units for dx and hp systems (expressed negative)
- PLANT/PLANT/PDEM1(8) total heating load to be met by plant

The first two values are expressed as negative values so they are converted to positive values before summed with the last value. The last value is the same as what results from the PS-A report in DOE-2.1e and is described as:

Total heating energy = load from SYSTEMS + load from PLANT (absorption + steam turbine + heat dissipated from storage tanks + domestic hot water + heat stored in tanks but not used) + circulation loop losses. The values here are identical to those in the heating energy column of the SYSTEMS SS-D report except that the heat energy delivered to an absorption chiller, steam turbine, domestic hot water, and circulation losses is included. Also included is the heat input to a storage tank from a boiler.

The hourly heating load represents the total heating load imposed on all packaged or central heating systems. These data for all hours of the year are provided as the heating load that appears in the CSV files which are created when the “File, Create Hourly Files” option is checked in the File menu.

Hourly Electric Load, item 30

The 24 values shown for the hourly electric load, kWh, are based on the DOE-2.1e simulation program hourly output variables called:

- PLANT/END-USE/ELMTR(23) electrical meter 1
- PLANT/END-USE/EGEN(35) cogeneration meter

The hourly electric load is the difference between these two variables. It represents the total electric load imposed on the electric utility and specifically does not include the electrical energy provided by any generating facilities in the building. These data for all hours of the year are provided as the electric load, kWh/h, that appears in the CSV files which are created when the “File, Create Hourly Files” option is checked in the File menu.

Loads Satisfied, item 36

The percentage of the load satisfied by cooling, heating equipment in the building and the percentage of the load satisfied by either the generating equipment in the building or from outside sources.

Equipment Sizes in MMBtuh, items 37 and 1

- Boiler – From PV-A report out of DOE-2.1e.
- Lead Elec Chiller – From PV-A report out of DOE-2.1e.
- Lag Elec Chiller – From PV-A report out of DOE-2.1e.
- Lead Steam Absorber – From PV-A report out of DOE-2.1e.

Lag Steam Absorber – From PV-A report out of DOE-2.1e.
Gas Absorber – From PV-A report out of DOE-2.1e.
Engine Chlr – From PV-A report out of DOE-2.1e.
Storage Chiller – From PV-A report out of DOE-2.1e.
Cooling Tower – From PV-A report out of DOE-2.1e.
Generator – From PV-A report out of DOE-2.1e.

Equipment Sizes - Standard Units, items 38 and 1

Boiler – In boiler HP. Calculated from value extracted from DOE-2.1e report PV-A.
Lead Elec Chiller – In refrigeration tons. Calculated from value extracted from DOE-2.1e report PV-A.
Lead Steam Absorber – In refrigeration tons. Calculated from value extracted from DOE-2.1e report PV-A.
Lag Elec Chiller – In refrigeration tons. Calculated from value extracted from DOE-2.1e report PV-A.
Lag Steam Absorber – In refrigeration tons. Calculated from value extracted from DOE-2.1e report PV-A.
Gas Absorber – In refrigeration tons. Calculated from value extracted from DOE-2.1e report PV-A.
Engine Chlr – In refrigeration tons. Calculated from value extracted from DOE-2.1e report PV-A.
Storage Chiller – In refrigeration tons. Calculated from value extracted from DOE-2.1e report PV-A.
Storage Chiller – In refrigeration tons. Calculated from value extracted from DOE-2.1e report PV-A.
Cooling Tower – In refrigeration tons. Calculated from value extracted from DOE-2.1e report PV-A.
Generator – In kW. Calculated from value extracted from DOE-2.1e report PV-A.

Packaged Cooling Sizes, item 39

The result of either the automatic sizing for each zone used in the building or the manual size that overrides the automatic sizing procedure.

Packaged Heating Sizes, item 40

The result of either the automatic sizing for each zone used in the building or the manual size that overrides the automatic sizing procedure.

Unit Costs, items 41–47

For the boiler, chillers/cooling system, desiccant unit, cooling tower, cool storage and hot storage equipment the costs for the equipment, installation, and maintenance are taken from the database described in a later section of the manual.

Building Equipment Costs, item 48

The equipment costs, not including installation, based on the unit costs and the installed capacity of the equipment are shown.

Equipment Installed Costs, item 49

The total installed costs of the equipment based on the unit costs and the installed capacity of the equipment.

Maintenance Costs, item 50

The annual cost of maintenance based on the installed capacity of the equipment.

Repair Costs, item 51

The annualized cost of repairs based on the installed capacity of the equipment.

Standard Electric Costs, item 52

The components of the electric utility bill not including any sell back credit.

Monthly Standard Electric Costs, item 53

The monthly total values of the electric utility bill not including any sell back credit.

Electric Sell Back Credit, item 54

The components of the electric utility credit for selling electricity to the utility.

Monthly Elec Sell Credit, item 55

The monthly total values of the electric utility credit for selling electricity to the utility.

Standard Gas Costs, item 56

The components of the gas utility bill not including any separately billed gas cooling costs in applicable.

Monthly Standard Gas Costs, item 57

The monthly values of the gas utility bill not including any separately billed gas cooling costs in applicable.

Gas Cooling Costs, item 58

If a separate gas cooling utility rate was used, this group includes the components of the gas utility bill for separately billed gas cooling costs.

Monthly Gas Cooling Costs, item 59

The monthly values of the gas cooling utility bill if a separate gas cooling utility rate was used.

Total Electric Utility Costs, item 60

The standard electric utility costs minus the sell back credit.

Total Monthly Electric Costs, item 61

The monthly values of the standard electric utility costs minus the sell back credit.

Total Gas Utility Costs, item 62

The standard gas utility costs plus the gas cooling costs.

Total Monthly Gas Costs, item 63

The monthly values of the standard gas utility costs plus the gas cooling costs.

Total Utility Costs, item 64

The electric utility costs plus the gas utility costs.

Total Monthly Utility Costs, item 65

The monthly values of the electric utility costs plus the gas utility costs.

Install/Replace Present Value, item 66

The present value using a simple life cycle cost methodology of the installation and replacement costs.

Repair/Maint Present Value, item 67

The present value using a simple life cycle cost methodology of the repair and maintenance costs.

Life Cycle Economic Summary, item 68

The present value of the utility and operating costs.

Payback Economic Summary, item 69

The incremental operating and first costs compared to the values in the first column and the resulting payback period.

CHP Metrics, item 70

Some key metrics often of use in considering CHP and other system potential are provided: average cost of energy, spark spread data, thermal-to-electric ratios, and several load factors.

Hourly CSV Files

The hourly CSV files generated for each case when the “File, Create Hourly Files” option is checked in the File menu provide the key energy (not cost) data typically needed to evaluate each specific option for CHP, and these data can be used to generate additional parametric data outside the MF CHP Analysis Tool. The data for the Base Case (A) default input file in the tool are shown below.

Case A, baseline csv data

Month	Day	Hour	DST	Heat	Cool	Elec
Jan	1	1	0	3229700	187597	832.034
Jan	1	2	0	3088390	164815	783.422
Jan	1	3	0	3188325	188840	794.434
Jan	1	4	0	3118434	162993	782.52
Jan	1	5	0	3199017	188332	793.75
Jan	1	6	0	3165743	171023	890.157
Jan	1	7	0	3313500	196921	906.928
Jan	1	8	0	3373623	197709	1234.333
-	-	-	-	-	-	-
-	-	-	-	-	-	-
-	-	-	-	-	-	-
Dec	31	20	0	4597422	150152	937.278

Dec	31	21	0	3576717	150139	898.975
Dec	31	22	0	3616338	147884	895.746
Dec	31	23	0	3671880	144266	813.99
Dec	31	24	0	3748407	143345	813.656

The “Heat” entries, again, are the total heating load imposed on all packaged or central heating systems in the building, Btu/h. The “Cool” entries are the total cooling load imposed on all packaged or central cooling systems, Btu/h. The “Elec” entries are the total electric load imposed on the electric utility and specifically do not include the electrical energy provided by any generating facilities in the building, kWh/h.

These files are not deleted, but they may need to be saved under another name if users wish to make multiple runs that might have the same name. Otherwise only the most recent run results will be saved with the one name used.

Additional SIM, rso, and Hourly Data Files

Version 2 of the MF CHP Analysis Tool also creates several additional hourly data files, for each case or scenario, by extracting data from hourly output files requested in the DOE-2 input file that the tool creates. In addition, the DOE-2 printed output file, the “SIM” file, is also created for each case. A “generic” listing of these hourly files and the SIM files created for a typical Case A and Case B is shown below. The actual location of the program file directory on a user’s computer is shown as:

“[Installation Directory for MF CHP Analysis Tool]\”

and the title of the “project” or facility is shown as “Project,” although if a user has not yet saved a data file and given the “project” a name, the title of the “Project” will be “untitled.”

```
[ Installation Directory for MF CHP Analysis Tool ] \"Project\"-A.sim
[ Installation Directory for MF CHP Analysis Tool ] \"Project\"-A-averagepowerrates.rso
[ Installation Directory for MF CHP Analysis Tool ] \"Project\"-A-elecStdrateRun.rso
[ Installation Directory for MF CHP Analysis Tool ] \"Project\"-A-gasStdrateRun.rso
[ Installation Directory for MF CHP Analysis Tool ] \"Project\"-A-genset.dat
[ Installation Directory for MF CHP Analysis Tool ] \"Project\"-A-lagchiller.dat
[ Installation Directory for MF CHP Analysis Tool ] \"Project\"-A-leadchiller.dat
[ Installation Directory for MF CHP Analysis Tool ] \"Project\"-A-LoadStatistics.dat
[ Installation Directory for MF CHP Analysis Tool ] \"Project\"-A-power.dat
[ Installation Directory for MF CHP Analysis Tool ] \"Project\"-A-steamplant.dat
[ Installation Directory for MF CHP Analysis Tool ] \"Project\"-A-utilityservices.dat
[ Installation Directory for MF CHP Analysis Tool ] \"Project\"-B.sim
[ Installation Directory for MF CHP Analysis Tool ] \"Project\"-B-averagepowerrates.rso
[ Installation Directory for MF CHP Analysis Tool ] \"Project\"-B-elecStdrateRun.rso
[ Installation Directory for MF CHP Analysis Tool ] \"Project\"-B-gasStdrateRun.rso
[ Installation Directory for MF CHP Analysis Tool ] \"Project\"-B-genset.dat
[ Installation Directory for MF CHP Analysis Tool ] \"Project\"-B-lagchiller.dat
[ Installation Directory for MF CHP Analysis Tool ] \"Project\"-B-leadchiller.dat
[ Installation Directory for MF CHP Analysis Tool ] \"Project\"-B-LoadStatistics.dat
[ Installation Directory for MF CHP Analysis Tool ] \"Project\"-B-power.dat
[ Installation Directory for MF CHP Analysis Tool ] \"Project\"-B-steamplant.dat
[ Installation Directory for MF CHP Analysis Tool ] \"Project\"-B-utilityservices.dat
[ Installation Directory for MF CHP Analysis Tool ] \"Project\"-size-A.sim
[ Installation Directory for MF CHP Analysis Tool ] \"Project\"-size-B.sim
```

These additional files can be useful for advanced users, but this feature has not completed debugging yet, and users must approach the hourly data files with care. Most of the key data from the “SIM” files is extracted and shown in the tabular output of the tool, as described above. The “rso” files provide the output of the Rate Script Editor calculations for each case and can be helpful to examine in order to check economic calculations and understand the economic impacts of rate schedules better. The DOE-2 sizing run simulation outputs are saved in the “-size-A.sim” and “size-B.sim” files here.

These files are DELETED when the user answers “Yes” to the question box that comes up when exiting the tool, “Do you want to delete the temporary SIM, rso, and hourly load files?” If users wish to save these files for later use, either the exit question must be answered “No,” or the files needed must be saved with another name or in another location before exiting the tool. If the exit question is answered “No,” all the files shown above will be saved, along with the hourly CSV data if requested.

The DOE-2 Template Input File Generator

The MF CHP Analysis Tool (BCHPSc) is an extension of a previous computer program, called DoeRayMe (DRM, © Copyright GARD Analytics), used for parametric building energy analyses. DRM generates the input table on the main data form from a large input template file (23,000+ lines of coding for the BCHPSc template used in version 2). The input template file is also used to generate the input stream to the DOE-2 program. The default input template file used by BCHPSc is called “bchp-LSP.D2T,” which is encoded to prevent accidental changes. A text version of the input file is also available: “bchp-LSP.INP.” Both these files are installed in the BCHPSc program installation directory.

DRM is used under license from GARD Analytics, with differing license provisions applying to different parts of the program, but if templates are distributed free, they can be distributed without restriction. If templates have a cost, an additional licensing arrangement must be completed with GARD. Templates that wish to be distributed with DoeRayMe should be sent to jglazer@gard.com with documentation similar to what is available in this section.

For advanced users or developers who may be interested in more detail on this template, or in developing a new template, possibly for other purposes, please read this section. Otherwise, if you are simply using existing DRM templates such as the BCHPSc template, then reading this section is unnecessary.

Overall Concepts

The DRM program reads a specially formatted DOE-2 input file called a template file. A template file starts simply as a DOE-2 input file that has used macros such as the `##set1` and `##if` to be flexible. Such a parameterized file usually has the parameters (macro variables) specified near the top of the file with `##set1` or in an `##include` file. When used with DRM, the template file should not set the values for the parameters that the ultimate user would like to change, instead a description of how those variables can change is included in special comments in the template file, also usually near the top. The template file can have a large number of parameters that the user can specify but must have at least one (selecting the weather file). This system is designed so that many different screening tools may be developed quickly and easily that all share a common user interface. This also makes screening tool development very easy since DRM already has all the routines needed to run a simulation, extract and display results, and allows the user to change parameters. The intention is to

allow any author of DOE-2 input files that is familiar with macros (see the DOE-2.1e Supplement) to create a screening tool.

DRM is useful for creating a screening tool but it is also very useful in debugging a parameterized file. In the debugging role, many authors of DOE-2 input files know that considerable time can be spent trying various combinations of parameter values to make sure a file is working properly. DRM may be used in that situation also, to quickly check the values of the specified parameters. For a small parametric analysis, you may find that using the DRM program makes it quick and easy to gather the set of results that you need.

Command Reference

The format for the file is an extension to the standard DOE-2 input file format. Special comments are interpreted by DRM which then generate the list of parameters that are displayed. The special comments must start with a \$> and always start with the first character of the line. Since these special comments start with the DOE-2 comment character '\$' they are ignored by the DOE-2 program.

A DOE-2 like syntax has been chosen to describe the special input. All special input would appear on special comment lines that use \$> to indicate that they are comments that should be read by the DRM program. A brief summary of the commands follow. Like DOE-2 the commands are terminated with ".." and are made up of keyword and value pairs. The values can be numbers or text but if they are text that contain spaces they must be enclosed in quotes. Unlike DOE-2, no values contain lists of items separated by commas. All commands have a "U-Name" that is also the name of the macro variable. It is common practice to start these macro variable names with a lowercase "p" such as "pWallLength" or "pUValue" so that they can be easily identified in the rest of the DOE-2 file as input parameters. The keyword value pairs can have a space or a equals sign. Abbreviations are permitted (as shown). The keyword-value pairs can be in any order and may default if missing. OPTION is associated with the previously defined LIST and may be repeated multiple times similar to how WINDOWS are associated with EXTERIOR-WALL in DOE-2. No SET-DEFAULT or LIKE or use of macros is supported at this time. The GROUP command creates a heading for a group of variables that follow before the next GROUP command. The easiest way to include comments is simply to have them on their own line that has simply a \$ instead of the \$> format.

The commands and associated keywords available are shown below, the abbreviation for the commands and keywords are shown on the right:

<prog-name> ABOUT	A
HELP-FILE <help-file>	H-F
DESCRIPTION <description>	D
AUTHOR	AUTH
COPYRIGHT	CR
LICENSE	LIC
SIZING <yes no>	SIZ
VERSION ..	VER
<group-name> GROUP	G
DISPLAY	DIS
UNITS	U
HELP <help-text>	H
KIND <INPUT,RESULT,MONTHLY, HOURSOFDAY> ..	K
<variable> LIST	LIST
TYPE text number	T
UNITS <units>	U
PROG loads system plant economics	P
DISPLAY "<display>"	DIS
HELP "<help-text>"	H

```

    DEFAULT "<default>"                DEF
    BASELINE-DEFAULT "<default>" ..    BL-DEF

<option> OPTION                        O
    DISPLAY "<display>" ..            DIS

<variable> NUMERIC                     N
    UNITS <units>                      U
    PROG loads|system|plant|economics P
    DISPLAY "<display>"                DIS
    HELP "<help-text>"                H
    MINIMUM <minimum>                  MIN
    MAXIMUM <maximum>                  MAX
    DEFAULT <default>                  DEF
    BASELINE-DEFAULT "<default>" ..    BL-DEF

<variable> FILE                        FILE
    PROG loads|system|plant|economics P
    DISPLAY "<display>"                DIS
    HELP "<help-text>"                H
    EXTENSION <file-extension>         EXT
    DEFAULT "<default>"                DEF
    BASELINE-DEFAULT "<default>" ..    BL-DEF
    PATH "<path>" ..                  PATH

<variable> EXTRACT                     E
    DISPLAY "<display>"                DIS
    UNITS <units>                      U
    REPORT <report-name>                R
    REPORT-SEARCH <report text to search> R-S
    ITEM-SEARCH <item text to search>   I-S
    ROW-OFFSET <number>                 R-O
    START-COLUMN <number>               S-C
    END-COLUMN <number>                 E-C
    SEARCH-AFTER <search window start>  S-A
    SEARCH-BEFORE <search window end>   S-B
    HELP "<help-text>" ..            H

<variable> COMPUTE                     COMPUTE
    UNITS <units>                      U
    DISPLAY "<display>"                DIS
    HELP "<help-text>"                H
    EXPRESSION <expression string>      EXP
    ..

<variable> EXTERNAL                    EXTERNAL
    UNITS <units>                      U
    DISPLAY "<display>"                DIS
    HELP "<help-text>"                H
    FILE <path with file name>          FILE
    ..

```

The following command is currently only supported when used with the MF CHP Analysis Tool extensions.

```

<variable> DATABASE                    D
    UNITS <units>                      U
    PROG loads|system|plant|economics P
    DISPLAY "<display>"                DIS
    HELP "<help-text>"                H
    FILE "<path-and-file>"             FILE
    TABLE "<table>"                   TBL
    PREFIX "<prefix>"                 PRE
    DEFAULT "<default>"                DEF
    BASELINE-DEFAULT "<default>" ..    BL-DEF

```

ABOUT COMMAND

The ABOUT command has keywords that describe overall properties of the template. The ABOUT command should only occur once in the template file. Many of the keywords should contain text that gets displayed in the HELP-ABOUT dialog box of the DRM program.

- HELP-FILE (H-F) – Contains text that contains the name of the help file. The help file should have a HLP extension. If the help file is located in the same directory as the executable file, no path is necessary.
- DESCRIPTION (D) – Text, in double quotes, should be entered here that is an overall description of the features and benefits of the template. The description gets displayed in the HELP-ABOUT dialog box. Remember that a multiple line description is possible if enclosed in double quote marks.
- AUTHOR (AUTH) – The name of the author or authors of the template file should be entered here as text in double-quotes. This gets displayed in DRM in the HELP-ABOUT dialog box.
- COPYRIGHT (CR) – The copyright notice text should be entered with this keyword. The text should be in double quotes. The copyright notice should include any copyright restrictions. It is also displayed in the HELP-ABOUT dialog box.
- LICENSE (LIC) – The license notice text should be entered with this keyword. The text should be in double quotes. The license notice should include any restrictions on the distribution or use of the DRM template file. It is also displayed in the HELP-ABOUT dialog box.
- VERSION (VER) – The version number for the template file should be entered here. If the version is a beta version then that can also be indicated. It is displayed in the HELP-ABOUT dialog box.
- SIZING (SIZ) – If a sizing run should be performed by the template than this value should be set to YES otherwise it should be set to NO.

GROUP COMMAND

The GROUP command is simply a way to organize a group of parameters together. In addition, for monthly results, the group name is used to indicate that it is data available to be displayed on the graph tab. All parameters must be in a group so one input group command and one result group command are the minimum needed.

- KIND (K) – Four different kinds of GROUP commands are possible. The groups can either be input, result, monthly or hoursOfDay. The input groups contain parameters that are set by the user. Result groups are values taken from the resulting simulation or from the economic calculations. Monthly groups contain results that are monthly results. HoursOfDay are taken from the peak hour of the day.
- DISPLAY (DIS) – The DISPLAY keyword contains the text that should be displayed by the DRM user interface on the table tab under the “Parameter” heading.
- UNITS (U) – For groups that contain items that are all in the same units, this keyword can be used to display the units next to the parameter under the “units” heading. This is mostly used for groups that are for monthly results.
- HELP (H) – A paragraph of text describing the parameter can be entered here and will be displayed in the “help” section of the table tab when the item gets selected by the user.

LIST COMMAND

The LIST command is the most common input LIST command. The list command gives the user a list of options that they can pull down from the cell that they are using. Use the DOE-2 macro variable name where the “u-name” would go in a DOE-2 command.

- TYPE (T) – Lists can have two different types, containing either text options or numeric options. The numeric options show up in the list of items that can be put on a graph.
- DISPLAY (DIS) – The DISPLAY keyword contains the text that should be displayed by the DRM user interface on the table tab under the “Parameter” heading.

- UNITS (U) – Enter the units that will appear on the table tab under the “units” heading. Providing units to the user of a template makes them much more likely to understand the inputs.
- PROG (P) – Enter the DOE-2 program (LOADS, SYSTEM, PLANT, or ECONOMICS) that this parameter will first affect. If no parameters are changed between columns that affect the loads portion of DOE-2, then the loads portion of DOE-2 will not be re-simulated. This increases the speed of running a group of alternatives. To determine if a parameter does affect the LOADS portion of the template file, look at the how the macro is used.
- HELP (H) – A paragraph of text describing the parameter can be entered here and will be displayed in the “help” section of the table tab when the item gets selected by the user. The help text is displayed in the help box on the main window. The help text can be very long. Although help text is usually made to be as informative and concise as possible, since users read it while trying to get what they want done, any template file developed for distribution should have help text added to at least the inputs that may be ambiguous.
- DEFAULT (DEF) – The default value that should be selected is entered here. It is the value when a blank copy of the template is opened and also the value when the user selects insert-column-of-default-values.
- BASELINE-DEFAULT (BL-DEF) – The default value for the first column should be entered here. When a blank copy of the template is opened this is the original value displayed. If baseline-default is not entered then the default value is used.

OPTION COMMAND

Following each LIST command is a group of OPTION commands. These are the actual options displayed in the pull down list to the user. The OPTION commands are associated with the LIST command that precedes them just like windows are associated with walls in DOE-2. The “u-name” associated with the option is what is actually passed to the DOE-2 file.

- DISPLAY (DIS) – The DISPLAY keyword contains the text that is actually displayed when the user pulls down the list of options.

NUMERIC COMMAND

The NUMERIC command is an input command that accepts a number from the user and assigns the value to the associated DOE-2 macro variable. Use the DOE-2 macro variable name where the “u-name” would go in a DOE-2 command. The UNITS, PROG, DISPLAY, HELP, DEFAULT, and BASELINE-DEFAULT keywords are identical to the keywords in the LIST command previously described. Additional keywords are:

- MINIMUM – The minimum value that can be accepted by the user. If the user enters a lower number, the DRM program will not accept it.
- MAXIMUM – The maximum value that can be accepted by the user. If the user enters a higher number, the DRM program will not accept it.

FILE COMMAND

The FILE command is an input command that requests that the user identify a file and assigns the value to the associated DOE-2 macro variable. In fact, four macros variables are created when a file is specified: the entire file name with path, the file name only, the path only and the extension only. Use the DOE-2 macro variable name where the “u-name” would go in a DOE-2 command. The PROG, DISPLAY, HELP, DEFAULT, and BASELINE-DEFAULT keywords are identical to the keywords in the LIST command previously described. Additional keywords are:

- EXTENSION (EXT) – The default extension displayed when selecting the file.
- PATH – The original path used when the file dialog box is originally displayed.

EXTRACT COMMAND

DRM scans through the output file generated from DOE-2 and creates a set of values for display after a DOE-2 run is completed. Unlike other extraction utilities, the system can only handle one instance of each value extracted. It is well suited for extracting the BUILDING level reports out of DOE-2 such

as LS-C, LS-D, SS-D, SS-E, PS-B, BEPU. But it can also extract other reports by looking for the "REPORT-SEARCH" term in the title line of the report. The DISPLAY, UNITS, and HELP keywords are identical to the keywords in the LIST command previously described. Additional keywords are:

REPORT (R) – The name of the DOE-2 report such as SS-Q. This keyword is required when the extract command is used.

REPORT-SEARCH (R-S) – The REPORT-SEARCH is a term searched for in the title line prior to using the report. The title line is the last line of DOE-2 titles that includes the report name.

ITEM-SEARCH (I-S) - This is a item searched for in the body of the report that changes the row used by ROW-OFFSET to the row where the item search string is found.

ROW-OFFSET (R-O) - This is the number of rows below (or negative for above) that the value should be extracted. All rows including blank rows are counted. Starts with top row of title block initially.

START-COLUMN (S-C) - This is the column number for the beginning of the value

END-COLUMN (E-C) - This is the column number for the end of the value

SEARCH-AFTER (S-A) – Text here is used to define the first line that will be searched by the ITEM-SEARCH text to find the item in the report.

SEARCH-BEFORE (S-B) - Text here is used to define the last line that will be searched by the ITEM-SEARCH text to find the item in the report.

Appendix

Cities and Associated Weather Files

	State	City	Latitude	Longitude	Weather File Name
1	Alabama	Birmingham	33.57	86.75	AL-Birmingham-TMY2.BIN
2	Alabama	Huntsville	34.65	86.77	AL-Huntsville-TMY2.BIN
3	Alabama	Mobile	30.68	88.25	AL-Mobile-TMY2.BIN
4	Alabama	Montgomery	32.3	86.4	AL-Montgomery-TMY2.BIN
5	Alaska	Anchorage	61.17	150.02	AK-Anchorage-TMY2.BIN
6	Alaska	Annette	55.03	131.57	AK-Annette-TMY2.BIN
7	Alaska	Bethel	60.78	161.8	AK-Bethel-TMY2.BIN
8	Alaska	Big Delta	64	145.73	AK-BigDelta-TMY2.BIN
9	Alaska	Cold Bay	55.2	162.73	AK-ColdBay-TMY2.BIN
10	Alaska	Fairbanks	64.82	147.87	AK-Fairbanks-TMY2.BIN
11	Alaska	Gulkana	62.15	145.45	AK-Gulkana-TMY2.BIN
12	Alaska	King Salmon	58.68	156.65	AK-KingSalmon-TMY2.BIN
13	Alaska	Kodiak	57.75	152.5	AK-Kodiak-TMY2.BIN
14	Alaska	McGrath	62.97	155.62	AK-McGrath-TMY2.BIN
15	Alaska	Nome	64.5	165.43	AK-Nome-TMY2.BIN
16	Alaska	St. Paul Island	57.15	170.22	AK-StPaulIsland-TMY2.BIN
17	Alaska	Talkeetna	62.3	150.1	AK-Talkeetna-TMY2.BIN
18	Alaska	Yakutat	59.52	139.67	AK-Yakutat-TMY2.BIN
19	Arizona	Flagstaff	35.13	111.67	AZ-Flagstaff-TMY2.BIN
20	Arizona	Phoenix	33.43	112.02	AZ-Phoenix-TMY2.BIN
21	Arizona	Prescott	34.65	112.42	AZ-Prescott-TMY2.BIN
22	Arizona	Tucson	32.12	110.93	AZ-Tucson-TMY2.BIN
23	Arkansas	Fort Smith	35.33	94.37	AR-FortSmith-TMY2.BIN
24	Arkansas	Little Rock	34.92	92.15	AR-LittleRock-TMY2.BIN
25	California	Arcata	40.98	124.1	CA-Arcata-TMY2.BIN
26	California	Bakersfield	35.43	119.05	CA-Bakersfield-TMY2.BIN
27	California	Daggett	34.85	116.78	CA-Daggett-TMY2.BIN
28	California	Fresno	36.77	119.72	CA-Fresno-TMY2.BIN
29	California	Long Beach	33.82	118.15	CA-LongBeach-TMY2.BIN
30	California	Los Angeles	33.93	118.4	CA-LosAngeles-TMY2.BIN
31	California	Sacramento	38.7	121.58	CA-Sacramento-TMY2.BIN
32	California	San Diego	32.73	117.17	CA-SanDiego-TMY2.BIN
33	California	San Francisco	37.62	122.38	CA-SanFrancisco-TMY2.BIN
34	California	Santa Maria	34.9	120.45	CA-SantaMaria-TMY2.BIN
35	Colorado	Alamosa	37.45	105.87	CO-Alamosa-TMY2.BIN
36	Colorado	Boulder	39.75	104.87	CO-Boulder-TMY2.BIN
37	Colorado	Colorado Springs	38.82	104.72	CO-ColoradoSprings-TMY2.BIN
38	Colorado	Eagle	39.65	106.92	CO-Eagle-TMY2.BIN
39	Colorado	Grand Junction	39.12	108.53	CO-GrandJunction-TMY2.BIN
40	Colorado	Pueblo	38.28	104.52	CO-Pueblo-TMY2.BIN
41	Connecticut	Bridgeport	41.17	73.13	CT-Bridgeport-TMY2.BIN
42	Connecticut	Hartford	41.93	72.68	CT-Hartford-TMY2.BIN
43	Delaware	Wilmington	39.68	75.6	DE-Wilmington-TMY2.BIN
44	Florida	Daytona Beach	29.18	81.05	FL-DaytonaBeach-TMY2.BIN
45	Florida	Jacksonville	30.5	81.7	FL-Jacksonville-TMY2.BIN
46	Florida	Key West	24.55	81.75	FL-KeyWest-TMY2.BIN
47	Florida	Miami	25.82	80.28	FL-Miami-TMY2.BIN
48	Florida	Tallahassee	30.38	84.37	FL-Tallahassee-TMY2.BIN
49	Florida	Tampa	27.97	82.53	FL-Tampa-TMY2.BIN
50	Florida	West Palm Beach	26.68	80.12	FL-WestPalmBeach-TMY2.BIN
51	Georgia	Athens	33.95	83.32	GA-Athens-TMY2.BIN

	State	City	Latitude	Longitude	Weather File Name
52	Georgia	Atlanta	33.65	84.42	GA-Atlanta-TMY2.BIN
53	Georgia	Augusta	33.37	81.97	GA-Augusta-TMY2.BIN
54	Georgia	Columbus	32.52	84.93	GA-Columbus-TMY2.BIN
55	Georgia	Macon	32.7	83.65	GA-Macon-TMY2.BIN
56	Georgia	Savannah	32.13	81.2	GA-Savannah-TMY2.BIN
57	Hawaii	Hilo	19.72	155.07	HI-Hilo-TMY2.BIN
58	Hawaii	Honolulu	21.35	157.93	HI-Honolulu-TMY2.BIN
59	Hawaii	Kahului	20.9	156.43	HI-Kahului-TMY2.BIN
60	Hawaii	Lihue	21.98	159.35	HI-Lihue-TMY2.BIN
61	Idaho	Boise	43.57	116.22	ID-Boise-TMY2.BIN
62	Idaho	Pocatello	42.92	112.6	ID-Pocatello-TMY2.BIN
63	Illinois	Chicago	41.98	87.9	IL-Chicago-TMY2.BIN
64	Illinois	Moline	41.45	90.52	IL-Moline-TMY2.BIN
65	Illinois	Peoria	40.67	89.68	IL-Peoria-TMY2.BIN
66	Illinois	Rockford	42.2	89.1	IL-Rockford-TMY2.BIN
67	Illinois	Springfield	39.85	89.67	IL-Springfield-TMY2.BIN
68	Indiana	Evansville	38.05	87.53	IN-Evansville-TMY2.BIN
69	Indiana	Fort Wayne	41	85.2	IN-FortWayne-TMY2.BIN
70	Indiana	Indianapolis	39.73	86.27	IN-Indianapolis-TMY2.BIN
71	Indiana	South Bend	41.7	86.32	IN-SouthBend-TMY2.BIN
72	Indiana	Terre Haute	39.35	87.42	IN-Indianapolis-TMY2.BIN
73	Iowa	Des Moines	41.53	93.65	IA-DesMoines-TMY2.BIN
74	Iowa	Mason City	43.15	93.33	IA-MasonCity-TMY2.BIN
75	Iowa	Sioux City	42.4	96.38	IA-SiouxCity-TMY2.BIN
76	Iowa	Waterloo	42.55	92.4	IA-Waterloo-TMY2.BIN
77	Kansas	Dodge City	37.77	99.97	KS-DodgeCity-TMY2.BIN
78	Kansas	Goodland	39.37	101.7	KS-Goodland-TMY2.BIN
79	Kansas	Topeka	39.07	95.62	KS-Topeka-TMY2.BIN
80	Kansas	Wichita	37.65	97.43	KS-Wichita-TMY2.BIN
81	Kentucky	Covington	39.05	84.67	KY-Covington-TMY2.BIN
82	Kentucky	Lexington	38.03	84.6	KY-Lexington-TMY2.BIN
83	Kentucky	Louisville	38.18	85.73	KY-Louisville-TMY2.BIN
84	Louisiana	Baton Rouge	30.53	91.15	LA-BatonRouge-TMY2.BIN
85	Louisiana	Lake Charles	30.12	93.22	LA-LakeCharles-TMY2.BIN
86	Louisiana	Monroe	32.52	92.05	LA-Shreveport-TMY2.BIN
87	Louisiana	New Orleans	29.98	90.25	LA-NewOrleans-TMY2.BIN
88	Louisiana	Shreveport	32.47	93.82	LA-Shreveport-TMY2.BIN
89	Maine	Caribou	46.87	68.02	ME-Caribou-TMY2.BIN
90	Maine	Portland	43.65	70.32	ME-Portland-TMY2.BIN
91	Maryland	Baltimore	39.18	76.67	MD-Baltimore-TMY2.BIN
92	Massachusetts	Boston	42.37	71.03	MA-Boston-TMY2.BIN
93	Massachusetts	Worcester	42.27	71.88	MA-Worcester-TMY2.BIN
94	Michigan	Alpena	45.07	83.57	MI-Alpena-TMY2.BIN
95	Michigan	Detroit	42.23	83.33	MI-Detroit-TMY2.BIN
96	Michigan	Flint	42.97	83.75	MI-Flint-TMY2.BIN
97	Michigan	Grand Rapids	42.88	85.52	MI-GrandRapids-TMY2.BIN
98	Michigan	Houghton	47.17	88.5	MI-Houghton-TMY2.BIN
99	Michigan	Lansing	42.77	84.6	MI-Lansing-TMY2.BIN
100	Michigan	Muskegon	43.17	86.25	MI-Muskegon-TMY2.BIN
101	Michigan	Sault Ste. Marie	46.47	84.37	MI-SaultSteMarie-TMY2.BIN
102	Michigan	Traverse City	44.73	85.58	MI-TraverseCity-TMY2.BIN
103	Minnesota	Duluth	46.83	92.18	MN-Duluth-TMY2.BIN
104	Minnesota	International Falls	48.57	93.38	MN-InternationalFalls-TMY2.BIN
105	Minnesota	Minneapolis	44.88	93.22	MN-Minneapolis-TMY2.BIN
106	Minnesota	Rochester	43.92	92.5	MN-Rochester-TMY2.BIN
107	Minnesota	Saint Cloud	45.55	94.07	MN-SaintCloud-TMY2.BIN
108	Mississippi	Jackson	32.32	90.08	MS-Jackson-TMY2.BIN
109	Mississippi	Meridian	32.33	88.75	MS-Meridian-TMY2.BIN

	State	City	Latitude	Longitude	Weather File Name
110	Missouri	Columbia	38.82	92.22	MO-Columbia-TMY2.BIN
111	Missouri	Kansas City	39.32	94.72	MO-KansasCity-TMY2.BIN
112	Missouri	Springfield	37.23	93.38	MO-Springfield-TMY2.BIN
113	Missouri	St. Louis	38.75	90.37	MO-StLouis-TMY2.BIN
114	Montana	Billings	45.8	108.53	MT-Billings-TMY2.BIN
115	Montana	Cut Bank	48.6	112.37	MT-CutBank-TMY2.BIN
116	Montana	Glasgow	48.22	106.62	MT-Glasgow-TMY2.BIN
117	Montana	Great Falls	47.48	111.37	MT-GreatFalls-TMY2.BIN
118	Montana	Helena	46.6	112	MT-Helena-TMY2.BIN
119	Montana	Kalispell	48.3	114.27	MT-Kalispell-TMY2.BIN
120	Montana	Lewistown	47.05	109.47	MT-Lewistown-TMY2.BIN
121	Montana	Miles City	46.43	105.87	MT-MilesCity-TMY2.BIN
122	Montana	Missoula	46.92	114.08	MT-Missoula-TMY2.BIN
123	Nebraska	Grand Island	40.97	98.32	NE-GrandIsland-TMY2.BIN
124	Nebraska	Norfolk	41.98	97.43	NE-Norfolk-TMY2.BIN
125	Nebraska	North Platte	41.13	100.68	NE-NorthPlatte-TMY2.BIN
126	Nebraska	Omaha	41.3	95.9	NE-Omaha-TMY2.BIN
127	Nebraska	Scottsbluff	41.87	103.6	NE-Scottsbluff-TMY2.BIN
128	Nevada	Elko	40.83	115.78	NV-Elko-TMY2.BIN
129	Nevada	Ely	39.28	114.85	NV-Ely-TMY2.BIN
130	Nevada	Las Vegas	36.08	115.17	NV-LasVegas-TMY2.BIN
131	Nevada	Reno	39.5	119.78	NV-Reno-TMY2.BIN
132	Nevada	Tonopah	38.05	117.08	NV-Tonopah-TMY2.BIN
133	Nevada	Winnemucca	40.9	117.8	NV-Winnemucca-TMY2.BIN
134	New Hampshire	Concord	43.2	71.5	NH-Concord-TMY2.BIN
135	New Hampshire	Manchester	43	71.4	NH-Concord-TMY2.BIN
136	New Jersey	Atlantic City	39.45	74.57	NJ-AtlanticCity-TMY2.BIN
137	New Jersey	Dover	40.7	74.17	NJ-Newark-TMY2.BIN
138	New Jersey	Newark	40.7	74.17	NJ-Newark-TMY2.BIN
139	New Mexico	Albuquerque	35.05	106.62	NM-Albuquerque-TMY2.BIN
140	New Mexico	Tucumcari	35.18	103.6	NM-Tucumcari-TMY2.BIN
141	New York	Albany	42.75	73.8	NY-Albany-TMY2.BIN
142	New York	Binghamton	42.22	75.98	NY-Binghamton-TMY2.BIN
143	New York	Buffalo	42.93	78.73	NY-Buffalo-TMY2.BIN
144	New York	Long Island	40.77	73.9	NY-NewYorkCity-TMY2.BIN
145	New York	Massena	44.93	74.85	NY-Massena-TMY2.BIN
146	New York	New York City	40.77	73.9	NY-NewYorkCity-TMY2.BIN
147	New York	Rochester	43.12	77.67	NY-Rochester-TMY2.BIN
148	New York	Syracuse	43.12	76.12	NY-Syracuse-TMY2.BIN
149	North Carolina	Asheville	35.43	82.55	NC-Asheville-TMY2.BIN
150	North Carolina	Cape Hatteras	35.27	75.55	NC-CapeHatteras-TMY2.BIN
151	North Carolina	Charlotte	35.22	80.93	NC-Charlotte-TMY2.BIN
152	North Carolina	Greensboro	36.08	79.95	NC-Greensboro-TMY2.BIN
153	North Carolina	Raleigh	35.87	78.78	NC-Raleigh-TMY2.BIN
154	North Carolina	Wilmington	34.27	77.9	NC-Wilmington-TMY2.BIN
155	North Dakota	Bismarck	46.77	100.75	ND-Bismarck-TMY2.BIN
156	North Dakota	Fargo	46.9	96.8	ND-Fargo-TMY2.BIN
157	North Dakota	Minot	48.27	101.28	ND-Minot-TMY2.BIN
158	Ohio	Akron	40.92	81.43	OH-Akron-TMY2.BIN
159	Ohio	Cincinnati	39.15	84.52	OH-Dayton-TMY2.BIN
160	Ohio	Cleveland	41.42	81.87	OH-Cleveland-TMY2.BIN
161	Ohio	Columbus	40	82.88	OH-Columbus-TMY2.BIN
162	Ohio	Dayton	39.9	84.2	OH-Dayton-TMY2.BIN
163	Ohio	Mansfield	40.82	82.52	OH-Mansfield-TMY2.BIN
164	Ohio	Toledo	41.6	83.8	OH-Toledo-TMY2.BIN
165	Ohio	Youngstown	41.27	80.67	OH-Youngstown-TMY2.BIN
166	Oklahoma	Oklahoma City	35.4	97.6	OK-OklahomaCity-TMY2.BIN
167	Oklahoma	Tulsa	36.2	95.9	OK-Tulsa-TMY2.BIN

	State	City	Latitude	Longitude	Weather File Name
168	Oregon	Astoria	46.15	123.88	OR-Astoria-TMY2.BIN
169	Oregon	Burns	43.58	118.9	OR-Burns-TMY2.BIN
170	Oregon	Eugene	44.12	123.22	OR-Eugene-TMY2.BIN
171	Oregon	Medford	42.37	122.87	OR-Medford-TMY2.BIN
172	Oregon	North Bend	43.42	124.25	OR-NorthBend-TMY2.BIN
173	Oregon	Pendleton	45.68	118.85	OR-Pendleton-TMY2.BIN
174	Oregon	Portland	45.6	122.6	OR-Portland-TMY2.BIN
175	Oregon	Redmond	44.25	121.15	OR-Redmond-TMY2.BIN
176	Oregon	Salem	44.92	123	OR-Salem-TMY2.BIN
177	Pennsylvania	Allentown	40.65	75.43	PA-Allentown-TMY2.BIN
178	Pennsylvania	Bradford	41.8	78.63	PA-Bradford-TMY2.BIN
179	Pennsylvania	Erie	42.08	80.18	PA-Erie-TMY2.BIN
180	Pennsylvania	Harrisburg	40.2	76.77	PA-Harrisburg-TMY2.BIN
181	Pennsylvania	Philadelphia	39.88	75.25	PA-Philadelphia-TMY2.BIN
182	Pennsylvania	Pittsburgh	40.5	80.22	PA-Pittsburgh-TMY2.BIN
183	Pennsylvania	Wilkes-Barre	41.33	75.73	PA-WilkesBarre-TMY2.BIN
184	Pennsylvania	Williamsport	41.25	76.92	PA-Williamsport-TMY2.BIN
185	Rhode Island	Providence	41.73	71.43	RI-Providence-TMY2.BIN
186	South Carolina	Charleston	32.9	80.03	SC-Charleston-TMY2.BIN
187	South Carolina	Columbia	33.95	81.12	SC-Columbia-TMY2.BIN
188	South Carolina	Greenville	34.9	82.22	SC-Greenville-TMY2.BIN
189	South Dakota	Huron	44.38	98.22	SD-Huron-TMY2.BIN
190	South Dakota	Pierre	44.38	100.28	SD-Pierre-TMY2.BIN
191	South Dakota	Rapid City	44.05	103.07	SD-RapidCity-TMY2.BIN
192	South Dakota	Sioux Falls	43.58	96.73	SD-SiouxFalls-TMY2.BIN
193	Tennessee	Bristol	36.48	82.4	TN-Bristol-TMY2.BIN
194	Tennessee	Chattanooga	35.03	85.2	TN-Chattanooga-TMY2.BIN
195	Tennessee	Knoxville	35.82	83.98	TN-Knoxville-TMY2.BIN
196	Tennessee	Memphis	35.05	90	TN-Memphis-TMY2.BIN
197	Tennessee	Nashville	36.13	86.68	TN-Nashville-TMY2.BIN
198	Texas	Abilene	32.42	99.68	TX-Abilene-TMY2.BIN
199	Texas	Amarillo	35.23	101.7	TX-Amarillo-TMY2.BIN
200	Texas	Austin	30.3	97.7	TX-Austin-TMY2.BIN
201	Texas	Brownsville	25.9	97.43	TX-Brownsville-TMY2.BIN
202	Texas	Corpus Christi	27.77	97.5	TX-CorpusChristi-TMY2.BIN
203	Texas	El Paso	31.8	106.4	TX-ElPaso-TMY2.BIN
204	Texas	Fort Worth	32.9	97.03	TX-FortWorth-TMY2.BIN
205	Texas	Houston	29.97	95.35	TX-Houston-TMY2.BIN
206	Texas	Lubbock	33.65	101.82	TX-Lubbock-TMY2.BIN
207	Texas	Lufkin	31.23	94.75	TX-Lufkin-TMY2.BIN
208	Texas	Midland	31.95	102.18	TX-Midland-TMY2.BIN
209	Texas	Port Arthur	29.95	94.02	TX-PortArthur-TMY2.BIN
210	Texas	San Angelo	31.37	100.5	TX-SanAngelo-TMY2.BIN
211	Texas	San Antonio	29.53	98.47	TX-SanAntonio-TMY2.BIN
212	Texas	Victoria	28.85	96.92	TX-Victoria-TMY2.BIN
213	Texas	Waco	31.62	97.22	TX-Waco-TMY2.BIN
214	Texas	Wichita Falls	33.98	98.5	TX-WichitaFalls-TMY2.BIN
215	Utah	Cedar City	37.7	113.1	UT-CedarCity-TMY2.BIN
216	Utah	Salt Lake City	40.78	111.97	UT-SaltLakeCity-TMY2.BIN
217	Vermont	Burlington	44.47	73.15	VT-Burlington-TMY2.BIN
218	Virginia	Lynchburg	37.33	79.2	VA-Lynchburg-TMY2.BIN
219	Virginia	Norfolk	36.9	76.2	VA-Norfolk-TMY2.BIN
220	Virginia	Richmond	37.5	77.33	VA-Richmond-TMY2.BIN
221	Virginia	Roanoke	37.32	79.97	VA-Roanoke-TMY2.BIN
222	Virginia	Sterling	38.95	77.45	VA-Sterling-TMY2.BIN
223	Washington	Olympia	46.97	122.9	WA-Olympia-TMY2.BIN
224	Washington	Quillayute	47.95	124.55	WA-Quillayute-TMY2.BIN
225	Washington	Seattle	47.45	122.3	WA-Seattle-TMY2.BIN

	State	City	Latitude	Longitude	Weather File Name
226	Washington	Spokane	47.62	117.65	WA-Spokane-TMY2.BIN
227	Washington	Yakima	46.57	120.53	WA-Yakima-TMY2.BIN
228	West Virginia	Charleston	38.37	81.6	WV-Charleston-TMY2.BIN
229	West Virginia	Elkins	38.88	79.85	WV-Elkins-TMY2.BIN
230	West Virginia	Huntington	38.37	82.55	WV-Huntington-TMY2.BIN
231	Wisconsin	Eau Claire	44.87	91.48	WI-EauClaire-TMY2.BIN
232	Wisconsin	Green Bay	44.48	88.13	WI-GreenBay-TMY2.BIN
233	Wisconsin	La Crosse	43.87	91.25	WI-LaCrosse-TMY2.BIN
234	Wisconsin	Madison	43.13	89.33	WI-Madison-TMY2.BIN
235	Wisconsin	Milwaukee	42.95	87.9	WI-Milwaukee-TMY2.BIN
236	Wyoming	Casper	42.92	106.47	WY-Casper-TMY2.BIN
237	Wyoming	Cheyenne	41.15	104.82	WY-Cheyenne-TMY2.BIN
238	Wyoming	Lander	42.82	108.73	WY-Lander-TMY2.BIN
239	Wyoming	Rock Springs	41.6	109.07	WY-RockSprings-TMY2.BIN
240	Wyoming	Sheridan	44.77	106.97	WY-Sheridan-TMY2.BIN

Available Weather Files

1	AK-Anchorage-TMY2.BIN	121	MT-Lewistown-TMY2.BIN
2	AK-Annette-TMY2.BIN	122	MT-MilesCity-TMY2.BIN
3	AK-Barrow-TMY2.BIN	123	MT-Missoula-TMY2.BIN
4	AK-Bethel-TMY2.BIN	124	NC-Asheville-TMY2.BIN
5	AK-Bettles-TMY2.BIN	125	NC-CapeHatteras-TMY2.BIN
6	AK-BigDelta-TMY2.BIN	126	NC-Charlotte-TMY2.BIN
7	AK-ColdBay-TMY2.BIN	127	NC-Greensboro-TMY2.BIN
8	AK-Fairbanks-TMY2.BIN	128	NC-Raleigh-TMY2.BIN
9	AK-Gulkana-TMY2.BIN	129	NC-Wilmington-TMY2.BIN
10	AK-KingSalmon-TMY2.BIN	130	ND-Bismarck-TMY2.BIN
11	AK-Kodiak-TMY2.BIN	131	ND-Fargo-TMY2.BIN
12	AK-Kotzebue-TMY2.BIN	132	ND-Minot-TMY2.BIN
13	AK-McGrath-TMY2.BIN	133	NE-GrandIsland-TMY2.BIN
14	AK-Nome-TMY2.BIN	134	NE-Norfolk-TMY2.BIN
15	AK-StPaulIsland-TMY2.BIN	135	NE-NorthPlatte-TMY2.BIN
16	AK-Talkeetna-TMY2.BIN	136	NE-Omaha-TMY2.BIN
17	AK-Yakutat-TMY2.BIN	137	NE-Scottsbluff-TMY2.BIN
18	AL-Birmingham-TMY2.BIN	138	NH-Concord-TMY2.BIN
19	AL-Huntsville-TMY2.BIN	139	NJ-AtlanticCity-TMY2.BIN
20	AL-Mobile-TMY2.BIN	140	NJ-Newark-TMY2.BIN
21	AL-Montgomery-TMY2.BIN	141	NM-Albuquerque-TMY2.BIN
22	AR-FortSmith-TMY2.BIN	142	NM-Tucumcari-TMY2.BIN
23	AR-LittleRock-TMY2.BIN	143	NV-Elko-TMY2.BIN
24	AZ-Flagstaff-TMY2.BIN	144	NV-Ely-TMY2.BIN
25	AZ-Phoenix-TMY2.BIN	145	NV-LasVegas-TMY2.BIN
26	AZ-Prescott-TMY2.BIN	146	NV-Reno-TMY2.BIN
27	AZ-Tucson-TMY2.BIN	147	NV-Tonopah-TMY2.BIN
28	CA-Arcata-TMY2.BIN	148	NV-Winnemucca-TMY2.BIN
29	CA-Bakersfield-TMY2.BIN	149	NY-Albany-TMY2.BIN
30	CA-Daggett-TMY2.BIN	150	NY-Binghamton-TMY2.BIN
31	CA-Fresno-TMY2.BIN	151	NY-Buffalo-TMY2.BIN

32	CA-LongBeach-TMY2.BIN	152	NY-Massena-TMY2.BIN
33	CA-LosAngeles-TMY2.BIN	153	NY-NewYorkCity-TMY2.BIN
34	CA-Sacramento-TMY2.BIN	154	NY-Rochester-TMY2.BIN
35	CA-SanDiego-TMY2.BIN	155	NY-Syracuse-TMY2.BIN
36	CA-SanFrancisco-TMY2.BIN	156	OH-Akron-TMY2.BIN
37	CA-SantaMaria-TMY2.BIN	157	OH-Cleveland-TMY2.BIN
38	CO-Alamosa-TMY2.BIN	158	OH-Columbus-TMY2.BIN
39	CO-Boulder-TMY2.BIN	159	OH-Dayton-TMY2.BIN
40	CO-ColoradoSprings-TMY2.BIN	160	OH-Mansfield-TMY2.BIN
41	CO-Eagle-TMY2.BIN	161	OH-Toledo-TMY2.BIN
42	CO-GrandJunction-TMY2.BIN	162	OH-Youngstown-TMY2.BIN
43	CO-Pueblo-TMY2.BIN	163	OK-OklahomaCity-TMY2.BIN
44	CT-Bridgeport-TMY2.BIN	164	OK-Tulsa-TMY2.BIN
45	CT-Hartford-TMY2.BIN	165	OR-Astoria-TMY2.BIN
46	DE-Wilmington-TMY2.BIN	166	OR-Burns-TMY2.BIN
47	FL-DaytonaBeach-TMY2.BIN	167	OR-Eugene-TMY2.BIN
48	FL-Jacksonville-TMY2.BIN	168	OR-Medford-TMY2.BIN
49	FL-KeyWest-TMY2.BIN	169	OR-NorthBend-TMY2.BIN
50	FL-Miami-TMY2.BIN	170	OR-Pendleton-TMY2.BIN
51	FL-Tallahassee-TMY2.BIN	171	OR-Portland-TMY2.BIN
52	FL-Tampa-TMY2.BIN	172	OR-Redmond-TMY2.BIN
53	FL-WestPalmBeach-TMY2.BIN	173	OR-Salem-TMY2.BIN
54	GA-Athens-TMY2.BIN	174	PA-Allentown-TMY2.BIN
55	GA-Atlanta-TMY2.BIN	175	PA-Bradford-TMY2.BIN
56	GA-Augusta-TMY2.BIN	176	PA-Erie-TMY2.BIN
57	GA-Columbus-TMY2.BIN	177	PA-Harrisburg-TMY2.BIN
58	GA-Macon-TMY2.BIN	178	PA-Philadelphia-TMY2.BIN
59	GA-Savannah-TMY2.BIN	179	PA-Pittsburgh-TMY2.BIN
60	HI-Hilo-TMY2.BIN	180	PA-WilkesBarre-TMY2.BIN
61	HI-Honolulu-TMY2.BIN	181	PA-Williamsport-TMY2.BIN
62	HI-Kahului-TMY2.BIN	182	Pigutmy2.bin
63	HI-Lihue-TMY2.BIN	183	Prsjtmy2.bin
64	IA-DesMoines-TMY2.BIN	184	RI-Providence-TMY2.BIN
65	IA-MasonCity-TMY2.BIN	185	SC-Charleston-TMY2.BIN
66	IA-SiouxCity-TMY2.BIN	186	SC-Columbia-TMY2.BIN
67	IA-Waterloo-TMY2.BIN	187	SC-Greenville-TMY2.BIN
68	ID-Boise-TMY2.BIN	188	SD-Huron-TMY2.BIN
69	ID-Pocatello-TMY2.BIN	189	SD-Pierre-TMY2.BIN
70	IL-Chicago-TMY2.BIN	190	SD-RapidCity-TMY2.BIN
71	IL-Moline-TMY2.BIN	191	SD-SiouxFalls-TMY2.BIN
72	IL-Peoria-TMY2.BIN	192	TN-Bristol-TMY2.BIN
73	IL-Rockford-TMY2.BIN	193	TN-Chattanooga-TMY2.BIN
74	IL-Springfield-TMY2.BIN	194	TN-Knoxville-TMY2.BIN
75	IN-Evansville-TMY2.BIN	195	TN-Memphis-TMY2.BIN
76	IN-FortWayne-TMY2.BIN	196	TN-Nashville-TMY2.BIN
77	IN-Indianapolis-TMY2.BIN	197	TX-Abilene-TMY2.BIN
78	IN-SouthBend-TMY2.BIN	198	TX-Amarillo-TMY2.BIN
79	KS-DodgeCity-TMY2.BIN	199	TX-Austin-TMY2.BIN

80	KS-Goodland-TMY2.BIN	200	TX-Brownsville-TMY2.BIN
81	KS-Topeka-TMY2.BIN	201	TX-CorpusChristi-TMY2.BIN
82	KS-Wichita-TMY2.BIN	202	TX-ElPaso-TMY2.BIN
83	KY-Covington-TMY2.BIN	203	TX-FortWorth-TMY2.BIN
84	KY-Lexington-TMY2.BIN	204	TX-Houston-TMY2.BIN
85	KY-Louisville-TMY2.BIN	205	TX-Lubbock-TMY2.BIN
86	LA-BatonRouge-TMY2.BIN	206	TX-Lufkin-TMY2.BIN
87	LA-LakeCharles-TMY2.BIN	207	TX-Midland-TMY2.BIN
88	LA-NewOrleans-TMY2.BIN	208	TX-PortArthur-TMY2.BIN
89	LA-Shreveport-TMY2.BIN	209	TX-SanAngelo-TMY2.BIN
90	MA-Boston-TMY2.BIN	210	TX-SanAntonio-TMY2.BIN
91	MA-Worchester-TMY2.BIN	211	TX-Victoria-TMY2.BIN
92	MD-Baltimore-TMY2.BIN	212	TX-Waco-TMY2.BIN
93	ME-Caribou-TMY2.BIN	213	TX-WichitaFalls-TMY2.BIN
94	ME-Portland-TMY2.BIN	214	UT-CedarCity-TMY2.BIN
95	MI-Alpena-TMY2.BIN	215	UT-SaltLakeCity-TMY2.BIN
96	MI-Detroit-TMY2.BIN	216	VA-Lynchburg-TMY2.BIN
97	MI-Flint-TMY2.BIN	217	VA-Norfolk-TMY2.BIN
98	MI-GrandRapids-TMY2.BIN	218	VA-Richmond-TMY2.BIN
99	MI-Houghton-TMY2.BIN	219	VA-Roanoke-TMY2.BIN
100	MI-Lansing-TMY2.BIN	220	VA-Sterling-TMY2.BIN
101	MI-Muskegon-TMY2.BIN	221	VT-Burlington-TMY2.BIN
102	MI-SaultSteMarie-TMY2.BIN	222	WA-Olympia-TMY2.BIN
103	MI- TraverseCity-TMY2.BIN	223	WA-Quillayute-TMY2.BIN
104	MN-Duluth-TMY2.BIN	224	WA-Seattle-TMY2.BIN
105	MN-InternationalFalls-TMY2.BIN	225	WA-Spokane-TMY2.BIN
106	MN-Minneapolis-TMY2.BIN	226	WA-Yakima-TMY2.BIN
107	MN-Rochester-TMY2.BIN	227	WI-EauClaire-TMY2.BIN
108	MN-SaintCloud-TMY2.BIN	228	WI-GreenBay-TMY2.BIN
109	MO-Columbia-TMY2.BIN	229	WI-LaCrosse-TMY2.BIN
110	MO-KansasCity-TMY2.BIN	230	WI-Madison-TMY2.BIN
111	MO-Springfield-TMY2.BIN	231	WI-Milwaukee-TMY2.BIN
112	MO-StLouis-TMY2.BIN	232	WV-Charleston-TMY2.BIN
113	MS-Jackson-TMY2.BIN	233	WV-Elkins-TMY2.BIN
114	MS-Meridian-TMY2.BIN	234	WV-Huntington-TMY2.BIN
115	MT-Billings-TMY2.BIN	235	WY-Casper-TMY2.BIN
116	MT-CutBank-TMY2.BIN	236	WY-Cheyenne-TMY2.BIN
117	MT-Glasgow-TMY2.BIN	237	WY-Lander-TMY2.BIN
118	MT-GreatFalls-TMY2.BIN	238	WY-RockSprings-TMY2.BIN
119	MT-Helena-TMY2.BIN	239	WY-Sheridan-TMY2.BIN
120	MT-Kalispell-TMY2.BIN		