

HUD COMBINED HEAT AND POWER (CHP) GUIDE #3

**INTRODUCTION TO THE LEVEL 2 ANALYSIS TOOL FOR
MULTIFAMILY BUILDINGS PREPARED FOR U.S.
DEPARTMENT OF HOUSING AND URBAN
DEVELOPMENT BY U.S. DEPARTMENT OF ENERGY,
OAK RIDGE NATIONAL LABORATORY**

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HUD COMBINED HEAT AND POWER (CHP) GUIDE #3 Introduction to Level 2 Analysis Tool for Multifamily Buildings

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HUD COMBINED HEAT AND POWER (CHP) GUIDE #3 LEVEL 2 ANALYSIS TOOL FOR MULTIFAMILY BUILDINGS¹

I. INTRODUCTION AND SUMMARY

Promoting the use of combined heat and power (CHP) (cogeneration)² in multifamily housing is an initiative of the *HUD Energy Action Plan*. To help implement it, beginning in 2003 the Department of Housing and Urban Development (HUD) and the Department of Energy/Oak Ridge National Laboratory (DOE/ORNL), executed Interagency Agreements (IAA) to create feasibility screening software. ORNL created, expanded, and validated a Level 1 preliminary screening tool that gives the owners of multifamily housing a coarse assessment of the feasibility (cost, savings and paybacks) for installing CHP. HUD gave training and promoted its use by HUD staff, housing associations, and building managers. In May 2010 ORNL created for HUD a more refined Level 2 Multifamily CHP Analysis Tool (MF CHP) that adapts the Building, Heating, Cooling, Power (BCHP) tool used for the Federal Energy Management Program (FEMP) for use on multifamily buildings. The Level 2 analysis will help an owner determine whether to invite proposals for design of a system and for a financial analysis. Here is an introduction to the new software program, with a description of its development and advice on how it can be used. This includes material from the June 17, 2010 ORNL training webinar and a brief introductory exercise to the MF CHP Tool.

What is the market for a Level 2 CHP Analysis Tool? One assessment is that the tool is designed for engineers and designers of HVAC systems, not for the general public. This would certainly include the eight DOE Clean Energy Regional Application Centers (RACS)³. Another view is that facility managers / developers / engineers / property owners could all make use of it with some assistance by someone familiar with building simulation. The main benefit will be providing a consistent tool as a base for analysis, instead of individual customized spreadsheets.

¹ [NOTE: This Guide was edited by Robert Groberg, Sr. Energy Management Officer, HUD, CPD, OEE. Much of the following text is drawn from MacDonald, Michael, "BCHP Screening Tool Users Manual, Version 2, November 2007" and "MF CHP Level 2 Analysis Tool –User Manual," May 2010 by Piljae Im, both of the Oak Ridge National Laboratory.]

² Combined Heat and power (cogeneration) is the production of electricity on site and use of the heat created in that process that can achieve overall efficiencies of about 80% compared to the 45% of central power stations. [See EPA <http://www.epa.gov/chp/> and DOE <http://www1.eere.energy.gov/industry/distributedenergy/> web sites with basic information on CHP.] For profiles of CHP installed in multifamily housing, see: http://www1.eere.energy.gov/industry/distributedenergy/projects_sector.html#multifamily

³ <http://www1.eere.energy.gov/industry/distributedenergy/racs.html> RACS promote clean energy technologies and offer assistance for regional projects throughout the US.

Advice for Users of Level 2 Tool. The MF CHP User's Manual (page 2-4) has this advice: "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."

[A building simulation professional can help to understand what is happening during the operation of the tool and use it effectively. Ed.⁴]

"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 above).

As indicated in the MF CHP User's Manual (page 2-6, 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.*"

⁴ General building energy modelers can be found in the A/E firm or consulting firm. They perform building energy simulation modeling for new and existing buildings for the purpose of building equipment sizing, code compliant simulation, LEED certification, etc. Recently, ASHRAE developed the Building Energy Modeling Professional certification. See: <http://www.ashrae.org/certification/page/2491> with a list of the certified professionals in the website. But this list is the just little portion of the whole building modelers since the certification program is relatively new.

II. UNDERSTANDING FEASIBILITY SCREENING FOR CHP

Background: How does the Level 1 Tool work? Using monthly utility costs and rates and some basic information about a building's size, occupants and equipment, the Level 1 Tool provides a coarse economic assessment of the feasibility of installing CHP powered by natural [http://eber.ed.ornl.gov/HUD CHP Guide version 2.1](http://eber.ed.ornl.gov/HUD_CHP_Guide_version_2.1).

It is linked to HUD CHP Guide #1, Q&A on CHP for Multifamily Housing” and #2 “Level 1 Feasibility Screening” at www.hud.gov/offices/cpd/library/energy/index.cfm.

It is also cited by EPA's Local Climate and Energy Guide.⁵

The best prospects are buildings with at least 80 units and master-metered for electricity.⁶ The tool was characterized as “user friendly” by a manager for one of the larger non-profit assisted housing owners who downloaded and applied it. A major CHP engineering, monitoring company found the final version “closest to what their analysis produced”. Building owners can decide whether the potential payback is attractive enough to warrant proceeding to a more precise Level 2 analysis.

HUD public and assisted multifamily housing and HOME program guides recognize the Level 1 Tool. HUD demonstrated and promoted its use on line, in HUD programs and with housing associations and building managers. This stage also involved the eight DOE-supported Clean Energy Regional CHP Application Centers. The effort is described in a paper delivered at the 2008 ACEEE Summer Study on Energy Efficiency in Buildings.⁷

How does a Level 2 Analysis Work? A Level 2 analysis is based on detailed site examination, hourly utility usage and heat consumption. The key is that there is a much more thorough analysis of annual heating and cooling loads, building electrical loads, and CHP system performance performed in a Level 2 tool and it does a much more rigorous calculation of dollar savings. It eliminates simplification errors associated with using monthly building averages by capturing hourly fluctuations in building performance. These capabilities are especially important in determining the potential benefits of CHP. But this analysis can cost \$5,000-10,000 in engineering charges. One means of keeping the analysis costs down is to provide a Level 2 tool for owners and for analysts that can facilitate the effort.

⁵ <http://www.epa.gov/statelocalclimate/documents/pdf/combinedheatpower.pdf>

⁶ See: HUD CHP Guide #2, page 15 Checklist.

⁷ Groberg, MacDonald and Garland, “Promoting Combined Heat and Power (CHP) for Multifamily Properties,” 2008 ACEEE Summer Study on Energy Efficiency in Buildings: SCALING UP: Building Tomorrow's Solutions. [See www.hud.gov/ linked above for this paper; click “pdf”.]

The ORNL already has a [Level 2 Tool: Building Cooling, Heating and Power \(BCHP\) Screening Tool](#) used widely in the Federal Energy Management Program for federal installations:⁸

http://www1.eere.energy.gov/femp/technologies/derchp_chpscreenings.html

In addition to federal facilities, the BCHP screening tool can serve fourteen building types (e.g. hotels, office buildings, hospitals and nursing homes). ***But BCHP does not contain screens for multifamily housing.*** According to ORNL, “the original tool was developed only for commercial buildings. The multifamily building is something between commercial and residential building types, so the original developer may not have included the multifamily building as one of the options. The other building types cannot be used for the multifamily simulation since all the default values and schedules from the other buildings are quite different from multifamily ones. The diurnal load profile in multifamily housing is unique and significantly influential in CHP analysis. That is why ORNL developed the multifamily option.” In addition, the multifamily tool now has updated generator database and other improvements.

The differences between the two levels were outlined for HUD in 2008:⁹

“The hourly calculations give the MF CHP Screening Tool several significant capabilities that the HUD Level 1 program does not have:

- 1) “BCHP uses building dimensions, materials, insulation, internal heat and humidity loads, etc. with ‘typical’ weather conditions to calculate heating, cooling, and hot water loads. The HUD program makes much cruder estimates of those loads from the energy consumption information from a single year’s electric and fuel bills.”
- 2) “BCHP uses a database of operating efficiencies and cost parameters for generating equipment. Fuel consumption is adjusted for part load and temperature dependent variations.) The HUD program uses curve fits to the full-load steady-state efficiency to estimate fuel consumption and curve fits for first cost and operating and maintenance costs.”
- 3) “BCHP uses a database of heating and air conditioning equipment to estimate electrical consumption for a typical year’s operation while the HUD program uses a single built-in assumed annual operating efficiency for boilers, water heaters, and air conditioning.”
- 4) “The BCHP Screening Tool has “typical” commercial building types (e.g. hospitals, retail store, office building) built into it for the user to select. These building configurations were developed by Lawrence Berkeley Laboratory for the Department of Energy and are based on the U.S. inventory of commercial buildings.”

⁸ BCHP can be used to evaluate conventional energy conservation measures (ECMS) by not specifying a power generation system and instead specifying different “cases” of ECM’s. It can also be used to evaluate more complex measures such as reduction of ventilation rate or changes in window type. For more detailed information about the BCHP Screening Tool Program Installation, including a PowerPoint used for Energy Assessment Training, see: <http://eber.ed.ornl.gov/bchpsc/> For further information contact Melissa Madgett by e-mail at madgettmg@ornl.gov

⁹ Comparing Level 2 BCHP to Level 1 HUD Feasibility Screening tool for Combined Heat and Power, (February 21, 2008). Per Steve Fischer, ORNL, retired.

III. DEVELOPING THE HUD LEVEL 2 TOOL

One “Major Challenge” identified in the ACEEE paper cited above (footnote 4) was “Making the more advanced (Level 2) ORNL BCHP software ready for use for apartment buildings.” Continuing their joint effort with another IAA in 2009¹⁰, HUD commissioned ORNL to adapt BCHP for use for multifamily housing, including development of standard input files that owners or analysts should only have to modify slightly. The five completed tasks were:

- 1) Developing the criteria for the tool capabilities, including the “adaptable multifamily building model”;
- 2) Updating the BCHP Screening Tool to a beta version of the defined capabilities;
- 3) Testing the beta version using data to be provided by HUD on specific properties to verify the types of results achieved and determine refinements needed. This testing task was used to develop a “reference case” of data for the tool that serves as the default multifamily building startup scenario;
- 4) Developing a multifamily-specific User Manual; and
- 5) Providing training in the use of the new tool.

Review and revision of the beta version. A beta version of the MF CHP Level 2 Analysis Tool (MF CHP) was prepared and shared with reviewers from the CHP industry and the DOE Regional Clean Energy Centers. Here are a few more common review comments:

- 1) “Generally, the model contains much more detail than should be necessary for multifamily CHP screening, and thus takes way too long to use. ...There's no way I'd have time to plug a complete model of a system we've built or proposed at the level of detail the model requires.” (ESCO)
- 2) “Default utility rates have changed a lot since 2002-3 and should be updated to 2008-9. But, since rates are so different around the country, is a default rate even of any use? (Engineer)
- 3) “Equipment keeps changing with new manufacturers entries into the market and with product changes, improvements from existing manufacturers. A listing helps but the assessor should be told to check the latest available equipment. Most equipment now requires a higher rate of fuel input per kWh developed than it did several years ago due to more stringent effluent restrictions. (Engineer)
- 4) “I found those ‘HELP’ descriptions very well done and concise. It was nice not to have to open up another window to see them. Adding a few more (such as in the Utility Selection section) would be good. The results I was getting with the ‘electric demand’ generation option were reasonable and seemed to track changes to the generator sizing in a manner that was anticipated.” (Engineer)

¹⁰ DOE Proposal 2094-V170-09. HUD IAA I-OPC-23500

Based on the reviewers' feedbacks and other needs, several changes, were made. The key ones dealt with the input screen, utility rates and defaults for multifamily buildings.

Input screen layout. The original BCHP and the MF CHP tool beta version had 19 input categories and each input category has several input parameters. Users were asked to input all the input values, which can be too complicated and time consuming procedure. Beta version 3 has 7 mandatory input categories and 5 optional input categories. For quick simulation, users are asked to input only the mandatory input portion. Advanced detailed simulation can be performed using all the optional input categories. For the list of Mandatory Inputs, see below.

Mandatory Inputs

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

3. Construction Details

- a. Wall Structure
- b. Wall Insulation (R-value)
- c. Roof Structure
- d. Roof Insulation (R-value)
- e. Window Type
- f. Window Overhangs

4. System Selection

- ...a. System Type (HVAC type)
-b. Fan Type
 - c. Air Handler Layout
 - d. Economizer

5. Equipment Selection

- a. Lead Space Cooling
- b. Lag Space Cooling
- c. Desiccant System
- d. Heating Boiler
- e. Service Water Heater
- f. Generator
- g. Chilled Water Pumps
- h. Hot Water Pumps
- i. Cooling Tower
- j. Cool Storage
- k. Hot Storage

6. Generator Detail

- a. Number of Generators
- b. Generator Sizing (as Peak %)
- c. Generator Sizing (direct input)

7. Utility Rates

- a. Standard Electric Rate
- b. Standard Gas Rate

Utility Rates. The previous version has a complex utility rate structure by utility company and location. However, the whole set of utility rates is out of date. Beta version 3 has only standard (or blended) single utility rate for electricity (\$/kWh), and Natural Gas (\$/Therm). Users are asked to input the rate directly. If user needs to do the calculation based on complex utility rates (e.g., peak demand, block charge, etc.), the hourly or monthly energy use can be generated from the tool, and the utility cost can be calculated outside of the toolkit using spreadsheet, etc. Default value in the tool is from the 2008 national average rate.

Building Defaults for Multifamily Buildings. All the building space default values were updated for multifamily buildings based on numerous resources. Those are:

- ASHRAE Standard 90.1 – 2004;
- ASHRAE Handbook of Fundamentals;
- Residential Energy Consumption Survey (RECS)
 - “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
 - “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.
- Plus professional judgment

IV.DESCRPTION OF THE DEVELOPED MF CHP LEVEL 2 TOOL BETA 3

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 weather data. The program also includes DOE-2.1e to calculate heating, cooling, and electrical loads. DOE-2 is a widely used and accepted freeware building energy analysis program that can predict 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.

Use of DOE-2 in the MF CHP Level 2 Analysis Tool. The original program, the BCHP Screening Tool, 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 engine for the MF CHP tool is DOE-2.1, which is one of the most well known building energy simulation programs, and the origin of the eQuest simulation program, which is one of the most widely used building simulation programs in the building energy industry.

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.

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. The current Beta version has only standard (or blended) single utility rate for electricity (\$/kWh), and Natural Gas (\$/Therm).

How to access the MF CHP Level 2 Analysis Tool. The current working beta version (beta 3) was completed in May 2010, and can be downloaded from the Oak Ridge Lab web site along with the DOE-2 documentation, the 107 page Users Manual and the training PowerPoint material: http://eber.ed.ornl.gov/MF_CHP¹¹

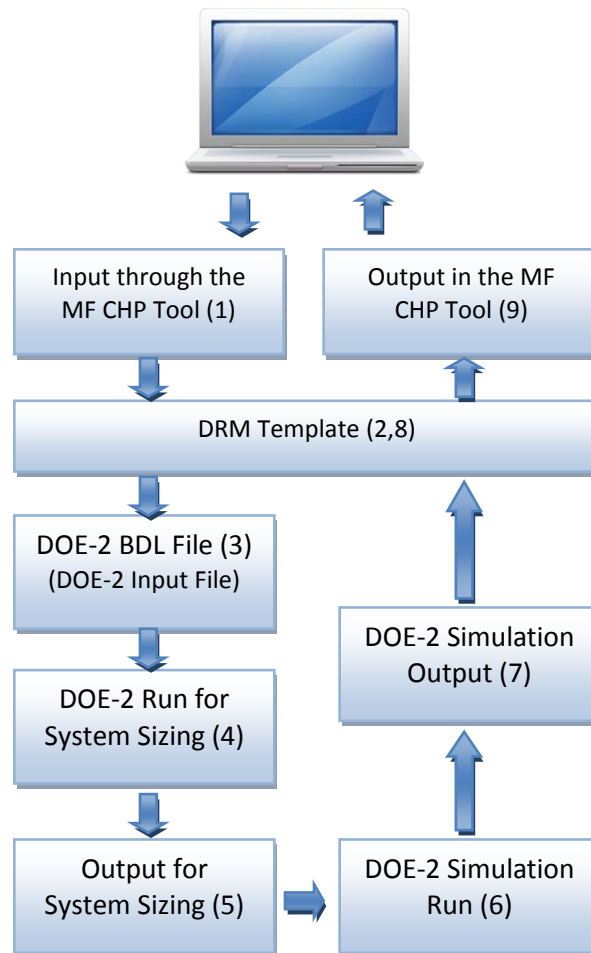
How the MF CHP Level 2 Tool Works. The tool handles input and output for users and creates extensive default inputs for the multifamily building types via the “Template” file. Key outputs are extracted and made available in the main Table tab or the graphic user interface.

There will be three components in the analysis:

1. Develop an initial simulation which is an as-built building simulation using the provided information.
2. After initial simulation, if the results will be different from the utility bill data, which often happens in simulation procedure, then the initial simulation should be modified to match with the utility data. This procedure is called “calibration.” This is illustrated in the training material.
3. Finally, generators will be applied to the calibrated building simulation to investigate the feasibility of the system. Iteration will be required to determine the optimum generator sizing, combinations, and operations.

See Figure 1, below, for the general process and sequence of steps in the use of the tool.

¹¹ The computer system requirements are OS: Microsoft Windows XP, Vista, and 7. ORNL has not tried to install the program on the machine with Windows 2000, but is sure it'll work on that OS. HDD: At least 100 MB available space. Except above, CPU speed and RAM capacity would be no problem with most of today's specifications

Figure 1: Sequence of the MF CHP Level 2 Analysis Tool

The nine steps in the Figure above cover the following activities:

(1) The input parameters –building and equipment information—will be put into the pre-developed DoeRayMe (DRM) Template. (2) DRM is the file format of the building description for the tool.

-The DRM Template then will generate the fully functioned DOE-2 Building Description Language (BDL) file (3) (which is the DOE-2 input text file);

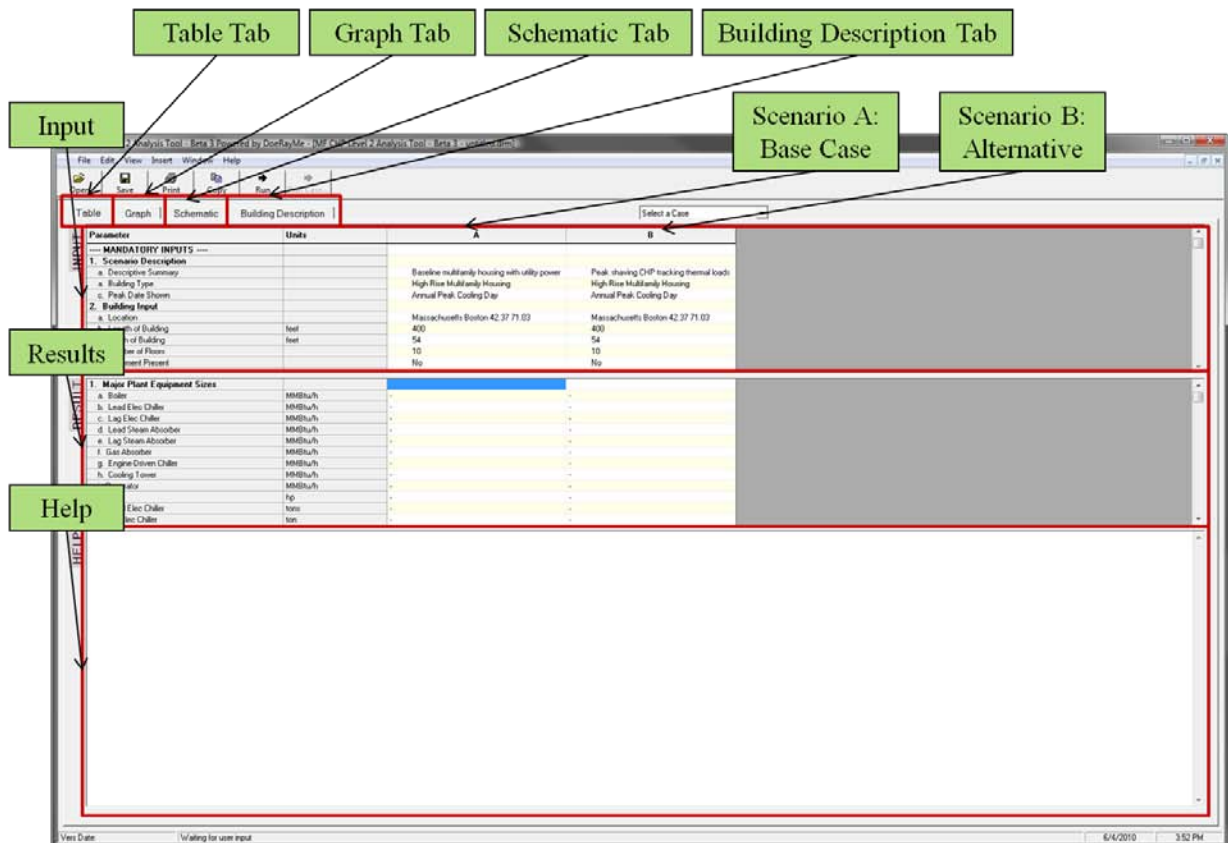
-Then there will be two sets of simulations run, (4) DOE-2 run and (5) output for system sizing (such as chiller, boiler sizing) and then (6) run and (7) output for full 8760 hours of simulation;

-Again, the output from the simulation will be extracted using (8) the DRM template, and be shown on the tool (9), so users can see and use the results.

The procedure for the Level 2 Analysis involves the base case, initial run (as built), calibration of the base case to reconcile with actual data; application and changing generator options, and finding the optimal scenario. At least the Mandatory Inputs should be entered. Use available data/information. Use best guess for unknown data/or leave default values for average multifamily building characteristics, unknown parameters (e.g., window-to-wall ratios, boiler and chiller size, operation schedule) equipment performance data and actual weather versus typical weather file. Following this a calibration will be needed to reconcile guessed entries with known data (e.g. actual utility consumption).

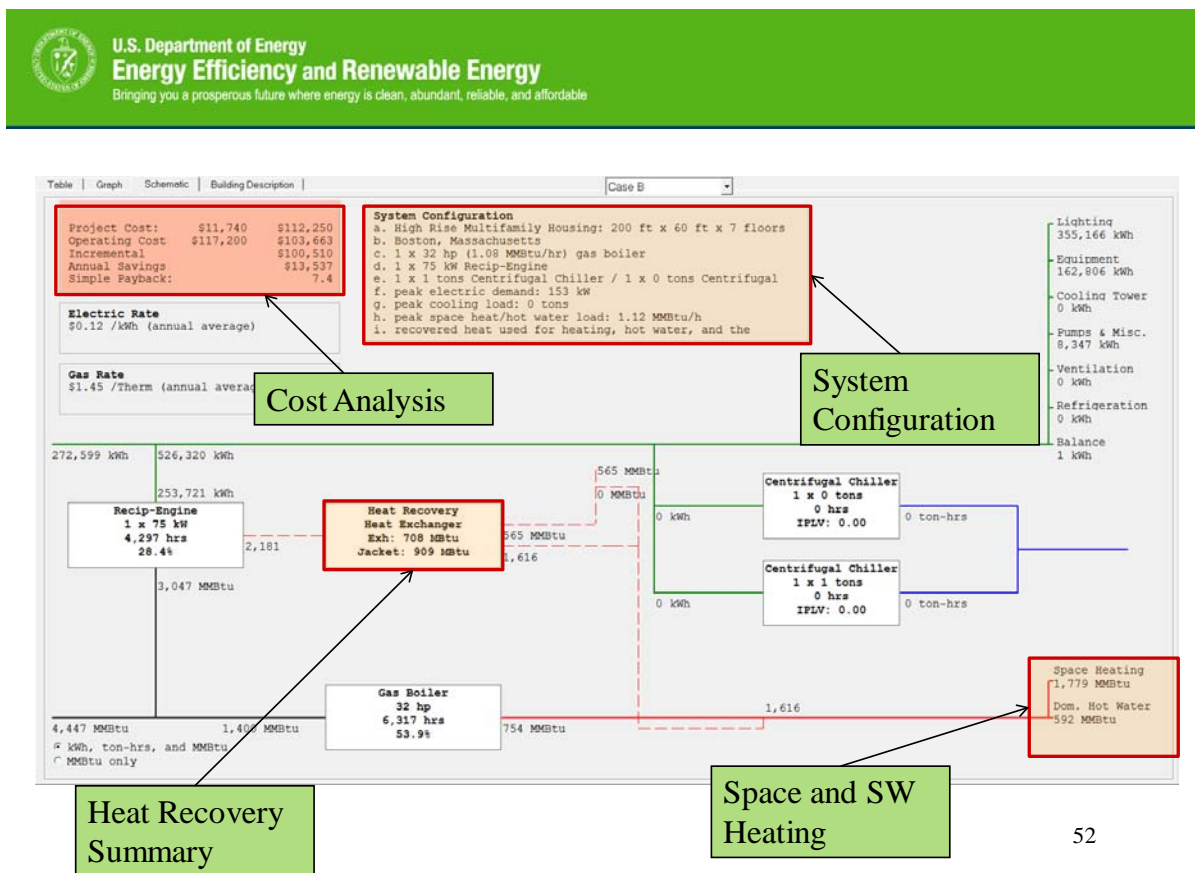
First, when you run the program, you will see the screen like Figure 2 below, with three portions to the screen: Input, Results and Help. Columns A and B provide for two scenarios, e.g. one without and one with a generator to provide some of the heat and power for the building. Columns are added as you choose additional scenarios. Four tabs enable showing Inputs and Outputs as tables, schematics and building description. Inputs can be made directly, chosen from a drop down menu, or selected from a separate window. There are input screens for adding data (Mandatory Input --page 4 above-- with 7 categories for a quick run, and Additional Input with 64 categories for a thorough analysis).

Figure 2. Three basic screens, four tabs and two scenarios.



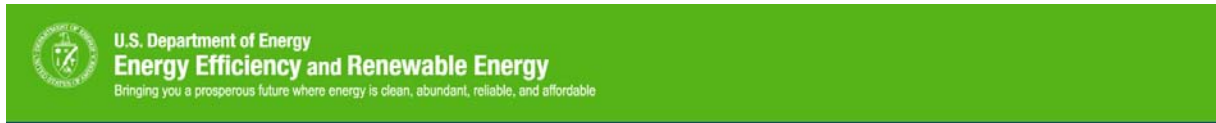
Output screens can be in the form of graphs or a schematic summary of energy (gas and electric) flow, summary of calculated project cost, operating cost, annual savings and simple payback

Figure 3. Output Screen



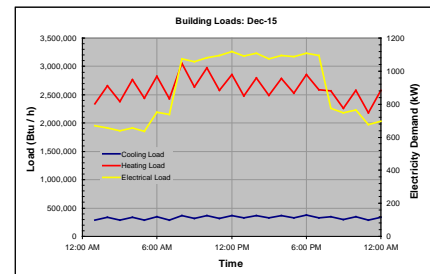
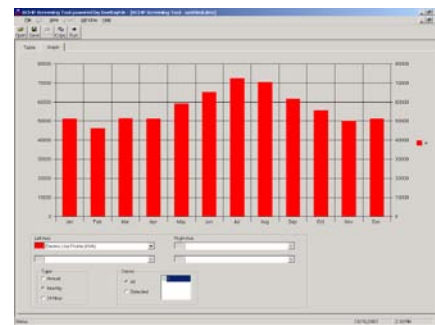
The most useful summary array of results may be the following:

Figure 4. Results Displays



- **Results**

- Annual Gas and Electricity Consumption & Costs
- Equipment Sizes & Costs
- System Life Cycle Costs
- Parametric Analysis of Up to 26 Systems
- Simple Payback Relative To Baseline System
- Hourly Load Profiles for Selected Dates



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There are some 17 other screens that deal with calibration, changes to input, output (annual consumption), adding generators, checking outputs and “next steps” (analyzing and finding the optimal generator and schedule for the building). The 107 page User’s Manual provides detailed guidance.

V. ADVICE FOR USERS

In addition to the cautionary advice provided on pages 3 and 4, ORNL has identified some limitations and issues in Beta 3. Some key items are:

- Complicated utility rate structures may be simulated with simpler transforms.
- 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.
- Desiccant systems do not appear to allow use of recovered heat from CHP systems, and changes appear necessary to correct the algorithms.

Other issues identified by reviewers of the Tool and this Guide include:

- Some graphs don't properly display electric cost savings.
- The detailed utility structure is too complicated in this level of analysis; only the blended standard rate (\$/kWh and \$/therm) will be enough, and possibly peak demand can be added. One another option is adding the website address in the tool for users to find the utility rate in their region in real time. The 2008 average utility rate is shown in the tool as a reference, but users need to be able to put in their own utility rate, which can be easily identified from their utility bills. The big utility rate data base is not adequate since it'll change overtime.
- The results on the main screen are pretty detailed, and they could be divided first into *Key outputs* and then *Additional outputs* in a similar fashion with the input screen (i.e., mandatory inputs then additional inputs).
- It would be useful to identify a website for the real time utility cost.

HUD is exploring with ORNL the possibilities for another agreement to deal with these limitations and the provision of data on additional multifamily building types and locations.

Use of MF CHP for other Energy Conservation Measure (ECM) Analyses. The MF CHP tool can control most of the detailed input parameters for the DOE-2 building energy simulation. *Therefore, the tool surely can be used for other ECM analysis such as better insulation, better windows, changing the lighting system, replacement of chiller, boiler, and much more.* This feature may be of use to those considering combining a CHP project with other building upgrades. In such cases, the interactive effects of multiple ECMs and a CHP project will likely affect generator selection and economics.

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 Level 2 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 BCHP 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/>

Providing access to DOE-2 gives multifamily housing owners and managers a powerful tool for analyzing a wide range of potential energy conservation measures in addition to combined heat and power. These are typically considered in energy audits and for energy performance contracts involving public housing agencies. These measures are important to establish a proper base for calculating the size and operating time for CHP systems.

Feedback/questions/comments on MF CHP should be sent to:

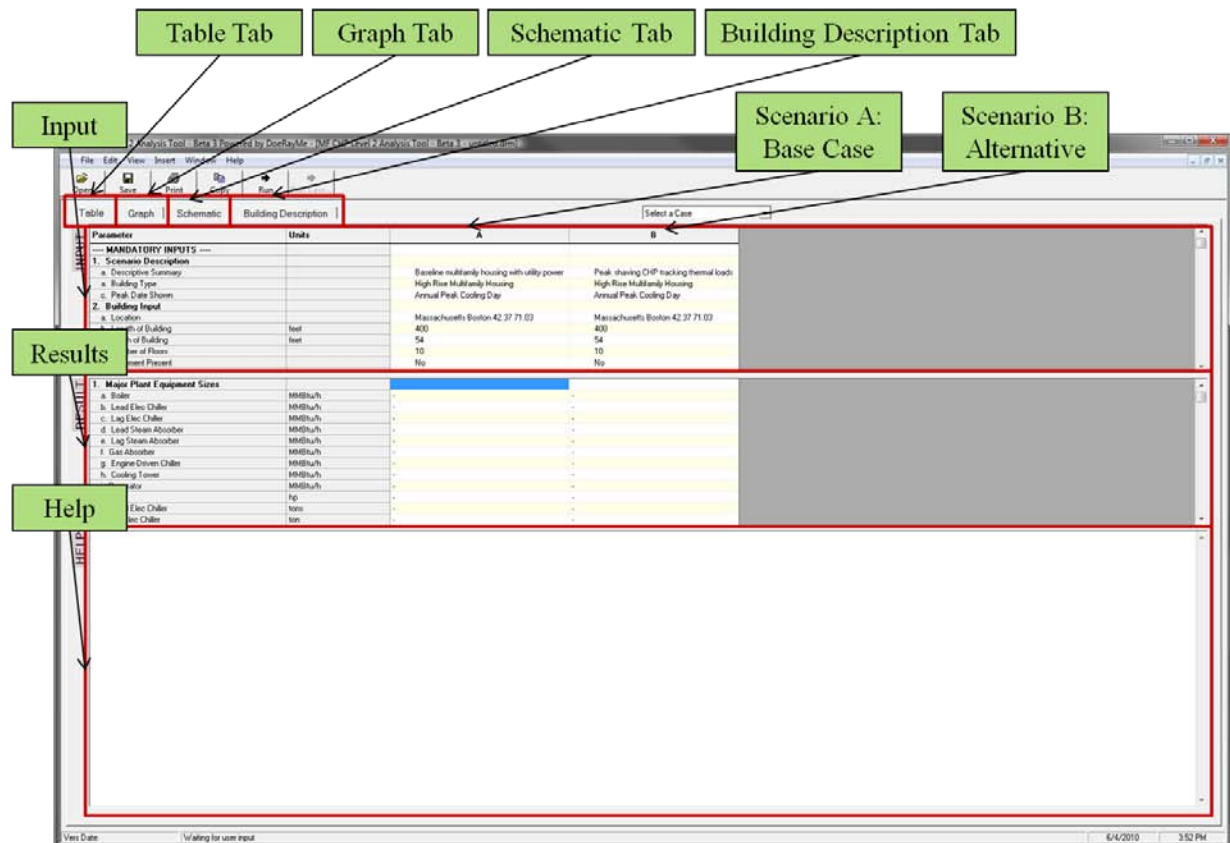
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APPENDIX

A BRIEF EXERCISE TO INTRODUCE THE USER TO THE MF CHP LEVEL 2 ANALYSIS BETA VERSION

The MF CHP Level 2 Analysis Tool was designed to be simple to use but making it *easy for you* to use is what really matters. Here is a brief introduction to understanding how the Tool works [prepared by GARD Analytics for BCHPsc].

When you first *start MF CHP Level 2 Analysis Tool* the main screen below (also Figure 2 above) consists of four tabs labeled **Table**, **Graph**, **Schematic**, and **Building Description**. The **Table** tab shows you a grid with a list of parameters, their units and the values for two alternatives labeled A and B. The **Table** tab is divided into three portions, **Input**, **Result** and **Help**. The **Input** area contains parameters that you change depending on the building and its systems. [There are the seven “Mandatory” categories followed by the “Additional Inputs” with 64 categories] **Result** shows the results of a simulation and Help shows you some information about each row in the Input and Result areas. The lines separating the **Input**, **Result** and **Help** areas can be moved up and down to allow you to see the area that you are most interested in.



Try clicking on different lighter colored boxes in the **Input** grid under columns A or B. The **Help** area on the bottom should change for each row to show you some information about that row. Depending on the row, you can pull down a list of choices, enter a value, or click a button that takes you to a selection screen. Although there are many input rows, for a quick simulation, you need to complete only Mandatory Inputs.

The screenshot displays the MF CHP Level 2 Analysis Tool interface. The window title is "MF CHP Level 2 Analysis Tool - Beta 3 Powered by DoeRayMe - [MF CHP Level 2 Analysis Tool - Beta 3 - untitled.drm]". The menu bar includes File, Edit, View, Insert, Window, and Help. The toolbar contains icons for Open, Save, Print, Copy, Run, and Run Case... The main interface is divided into three sections: INPUT, RESULT, and HELP.

INPUT Section:

Parameter	Units	A	B
MANDATORY INPUTS			
1. Scenario Description			
a. Descriptive Summary		Baseline multifamily housing with utility power	Peak shaving CHP tracking thermal loads
a. Building Type		High Rise Multifamily Housing	High Rise Multifamily Housing
c. Peak Date Shown		Annual Peak Cooling Day	Annual Peak Cooling Day
2. Building Input			
a. Location		Massachusetts Boston 42.37 71.03	Massachusetts Boston 42.37 71.03
b. Length of Building	feet	400	400
c. Width of Building	feet	54	54
d. Number of Floors		10	10
e. Basement Present		No	No
RESULT Section:			
1. Major Plant Equipment Sizes			
a. Boiler	MMBtu/h	-	-
b. Lead Elec Chiller	MMBtu/h	-	-
c. Lag Elec Chiller	MMBtu/h	-	-
d. Lead Steam Absorber	MMBtu/h	-	-
e. Lag Steam Absorber	MMBtu/h	-	-
f. Gas Absorber	MMBtu/h	-	-
g. Engine-Driven Chiller	MMBtu/h	-	-
h. Cooling Tower	MMBtu/h	-	-
i. Generator	MMBtu/h	-	-
j. Boiler	hp	-	-
k. Lead Elec Chiller	tons	-	-
l. Lag Elec Chiller	ton	-	-

HELP Section:

Select the location of the building. If none of the locations on the list exactly match the building location than 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.

Status Bar: Vers Date: | Waiting for user input | 7/29/2010 | 4:19 PM

You can add more alternatives by using the **Insert** menu. Each new alternative is shown by a new column in the grid. For the parameters that show a list of values, try selecting different choices.

MF CHP Level 2 Analysis Tool - Beta 3 Powered by DoeRayMe - [MF CHP Level 2 Analysis Tool - Beta 3 - untitled.drm]

File Edit View Insert Window Help

Open Save

Copy of Current Column
Column Linked to Current Column
Column of Default Values

Table | Graph | Select a Case

Parameter	Units	A	B
MANDATORY INPUTS ----			
1. Scenario Description			
a. Descriptive Summary		Baseline multifamily housing with utility power	Peak shaving CHP tracking thermal loads
a. Building Type		High Rise Multifamily Housing	High Rise Multifamily Housing
c. Peak Date Shown		Annual Peak Cooling Day	Annual Peak Cooling Day
2. Building Input			
a. Location		Massachusetts Boston 42.37 71.03	Massachusetts Boston 42.37 71.03
b. Length of Building	feet	400	400
c. Width of Building	feet	54	54
d. Number of Floors		10	10
e. Basement Present		No	No
RESULT			
1. Major Plant Equipment Sizes			
a. Boiler	MMBtu/h	-	-
b. Lead Elec Chiller	MMBtu/h	-	-
c. Lag Elec Chiller	MMBtu/h	-	-
d. Lead Steam Absorber	MMBtu/h	-	-
e. Lag Steam Absorber	MMBtu/h	-	-
f. Gas Absorber	MMBtu/h	-	-
g. Engine-Driven Chiller	MMBtu/h	-	-
h. Cooling Tower	MMBtu/h	-	-
i. Generator	MMBtu/h	-	-
j. Boiler	hp	-	-
k. Lead Elec Chiller	tons	-	-
l. Lag Elec Chiller	ton	-	-

HELP

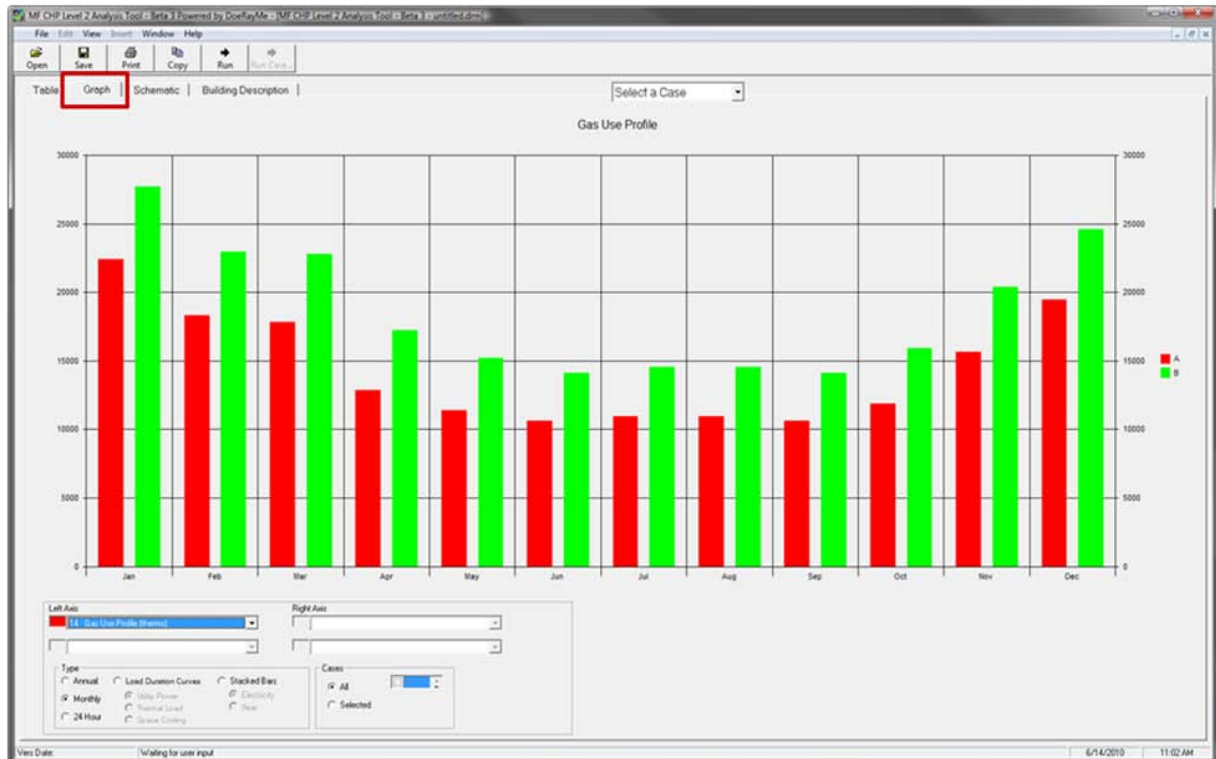
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Parameter	Units	A	B	C
MANDATORY INPUTS				
1. Scenario Description				
a. Descriptive Summary		Baseline multifamily housing with utility power	Peak shaving CHP tracking thermal loads	Peak shaving CHP tracking thermal loads
a. Building Type		High Rise Multifamily Housing	High Rise Multifamily Housing	High Rise Multifamily Housing
c. Peak Date Shown		Annual Peak Cooling Day	Annual Peak Cooling Day	Annual Peak Cooling Day
2. Building Input				
a. Location		Massachusetts Boston 42.37 71.03	Massachusetts Boston 42.37 71.03	Massachusetts Boston 42.37 71.03
b. Length of Building	feet	400	400	400
c. Width of Building	feet	54	54	54
d. Number of Floors		10	10	10
e. Basement Present		No	No	No
RESULT				
1. Major Plant Equipment Sizes				
a. Boiler	MMBtu/h	-	-	-
b. Lead Elec Chiller	MMBtu/h	-	-	-
c. Lag Elec Chiller	MMBtu/h	-	-	-
d. Lead Steam Absorber	MMBtu/h	-	-	-
e. Lag Steam Absorber	MMBtu/h	-	-	-
f. Gas Absorber	MMBtu/h	-	-	-
g. Engine-Driven Chiller	MMBtu/h	-	-	-
h. Cooling Tower	MMBtu/h	-	-	-
i. Generator	MMBtu/h	-	-	-
j. Boiler	hp	-	-	-
k. Lead Elec Chiller	tons	-	-	-
l. Lag Elec Chiller	ton	-	-	-

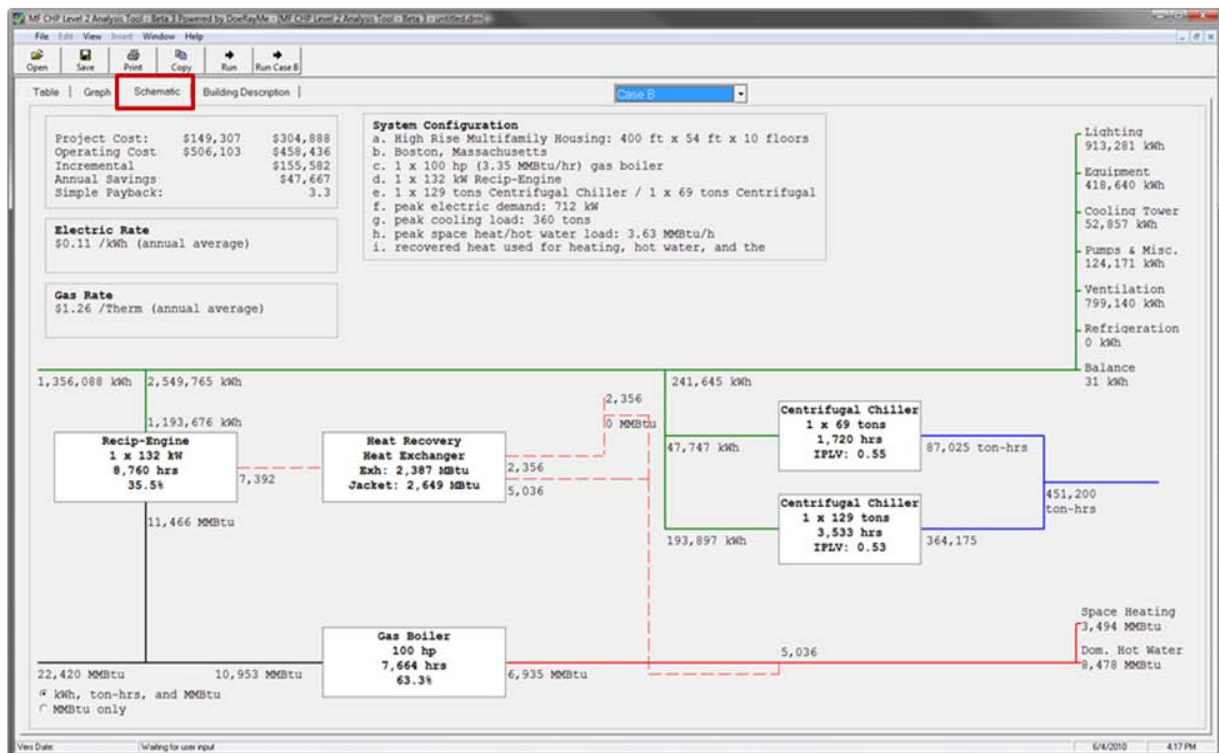
Now press the **Run** button at the top of the window. You will notice another window on your screen will open showing the activities of DOE2 (another program that actually performs the simulation of the energy use in the building). Each alternative needs two simulations, first a short simulation for sizing equipment and then a longer hour-by-hour annual simulation. When this is done, check the simulation results in the results section — are they different?

Try changing the building location or another parameter and pressing the **Run** button again. Does the cooling and heating energy change?

Try out the **Graph** tab. The graphs, also called charts, can be monthly results or annual results from the simulation. The controls to select what is shown on the graph are in the lower part of the window. The numbers shown on the graph are taken from the grid on the **Table** tab, but are now being shown graphically. This is a quick way to see the impact of changing some parameters.



The **Schematic** tab provides a good summary of the energy (elec. and gas) flow based on the selected case. It also shows the summary of calculated project cost, operating cost, annual savings and simple payback.



Select **Building Description** tab when you want to see the building/zone characteristics such as floor space, window area, internal load and building schedule by zone.

Table | Graph | Schematic | **Building Description** | Case A

A. High Rise Multifamily Housing
 Boston, Massachusetts
 84,000 sq ft (200 x 60 ft; 7 Stories)
 rotated 0 degrees from cardinal direction

Wall & Roof Construction

Wall Construction
 a. 3/4 inch Gypsum
 b. 8 inch HW concrete
 c. 11 sq ft-F-Hr/Btu (inside)
 d. 4 inch Face brick

Roof Construction
 a. 8 inch HW concrete
 b. 17 sq ft-F-Hr/Btu (outside)

Ceiling, Windows, Schedule

Ceiling: Acoustic Tile and airspace
 Windows
 a. Single Pane Gl 3mm
 b. 0 inch overhang

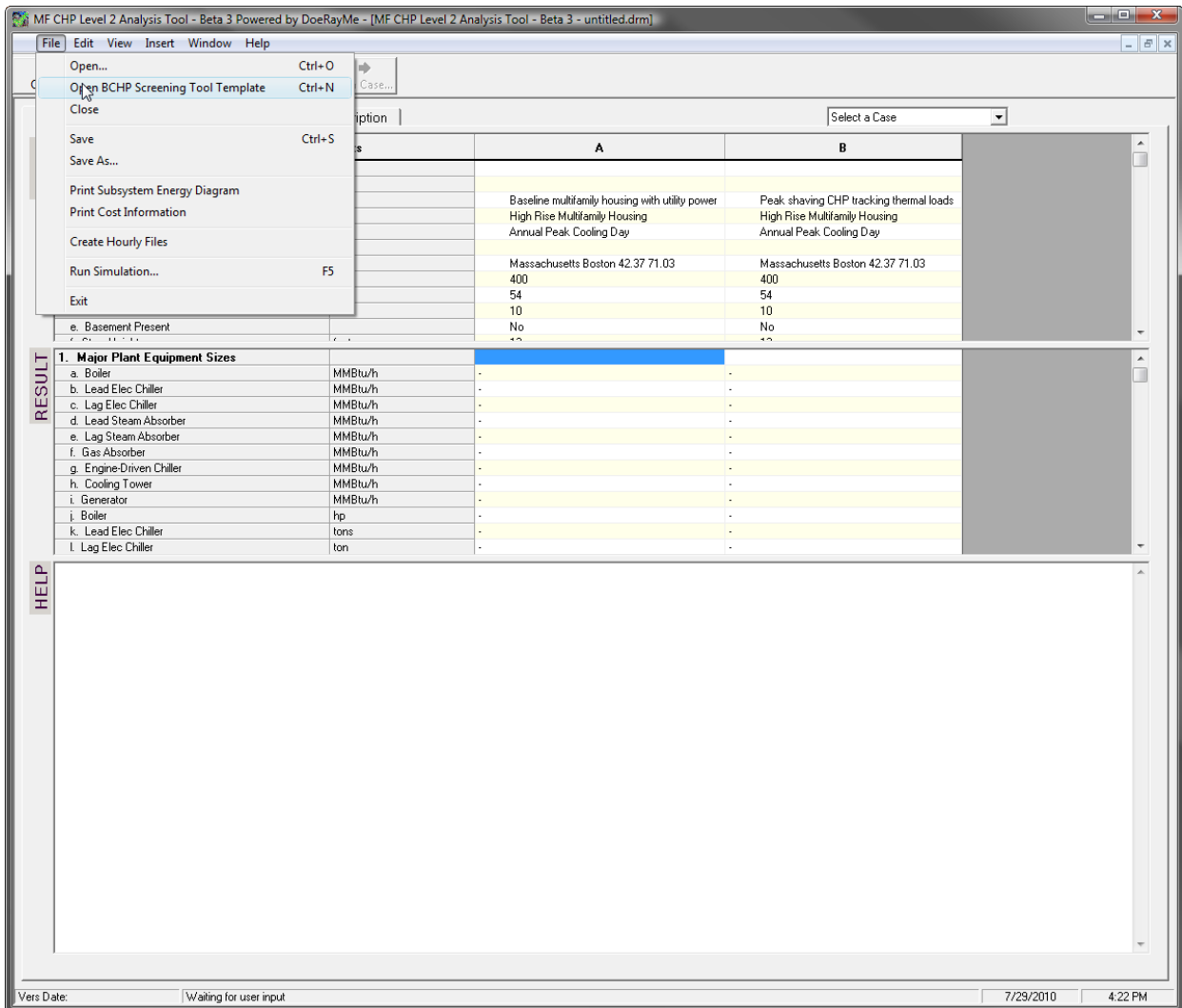
Building Occupancy Schedule
 a. weekdays: 24 hrs
 b. Saturdays: 24 hrs
 c. Sundays: 24 hrs

North East Zone	North Central Zone	North West Zone
1. Use: UD1	1. Use: UD1	1. Use: UD1
2. Floor Space a. percent: 5% bldg area b. absolute: 4,200 sq ft	2. Floor Space a. percent: 40% bldg area b. absolute: 33,600 sq ft	2. Floor Space a. percent: 5% bldg area b. absolute: 4,200 sq ft
3. Window Area: 21% of wall area	3. Window Area: 23% of wall area	3. Window Area: 21% of wall area
4. Peak Occupancy: 9 people	4. Peak Occupancy: 75 people	4. Peak Occupancy: 9 people
5. Internal Loads a. total heat: 4,500 Btu/h b. sensible heat: 2,250 Btu/h c. lighting: 14.1 kW d. plug loads: 17.6 kW	5. Internal Loads a. total heat: 37,500 Btu/h b. sensible heat: 18,750 Btu/h c. lighting: 903.2 kW d. plug loads: 1,129.0 kW	5. Internal Loads a. total heat: 4,500 Btu/h b. sensible heat: 2,250 Btu/h c. lighting: 14.1 kW d. plug loads: 17.6 kW
6. Outside Air: 135 cfm	6. Outside Air: 1,125 cfm	6. Outside Air: 135 cfm

South East Zone	South Central Zone	South West Zone
1. Use: UD1	1. Use: UD1	1. Use: UD1
2. Floor Space a. percent: 5% bldg area b. absolute: 4,200 sq ft	2. Floor Space a. percent: 40% bldg area b. absolute: 33,600 sq ft	2. Floor Space a. percent: 5% bldg area b. absolute: 4,200 sq ft
3. Window Area: 21% of wall area	3. Window Area: 23% of wall area	3. Window Area: 21% of wall area
4. Peak Occupancy: 9 people	4. Peak Occupancy: 75 people	4. Peak Occupancy: 9 people
5. Internal Loads a. total heat: 4,500 Btu/h b. sensible heat: 2,250 Btu/h c. lighting: 14.1 kW d. plug loads: 17.6 kW	5. Internal Loads a. total heat: 37,500 Btu/h b. sensible heat: 18,750 Btu/h c. lighting: 903.2 kW d. plug loads: 1,129.0 kW	5. Internal Loads a. total heat: 4,500 Btu/h b. sensible heat: 2,250 Btu/h c. lighting: 14.1 kW d. plug loads: 17.6 kW
6. Outside Air: 135 cfm	6. Outside Air: 1,125 cfm	6. Outside Air: 135 cfm

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Now to save your work press the **Save** button and give the file a name. You can even have multiple files open at once. To have another blank template with default values open, select **File** and then **open BCHP Screening Tool Template**.



Try experimenting with other features on the menus and with changing parameter values and running the simulation. Believe it or not, you have already learned about 75% of the features in the MF CHP Level 2 Analysis Tool. Experiment some more with different parameters until you become comfortable with these features.

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September 1, 2010