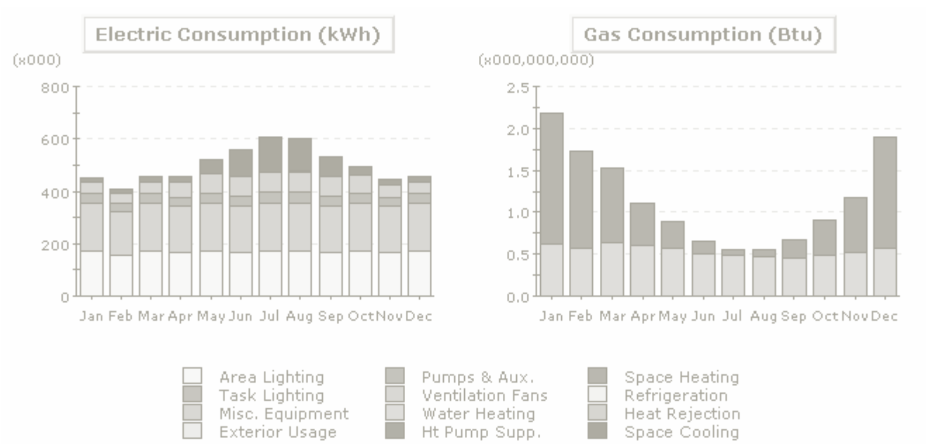
eQUEST Building Energy Modeling Guide for LG Multi V™



Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	17.8	16.1	19.0	21.0	51.4	98.7	131.8	124.6	75.9	35.4	19.7	17.8	629.2
Heat Reject.	-	-	-	0.0	0.5	2.7	4.6	4.3	1.4	0.1	0.1	-	13.7
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	46.2	41.7	47.5	59.0	74.9	72.5	73.2	74.8	75.9	68.6	49.1	46.3	729.7
Pumps & Aux.	33.2	30.0	33.3	32.5	35.4	37.3	40.2	39.8	36.0	34.6	32.3	33.2	417.7
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	183.4	165.7	183.4	177.5	183.4	177.5	183.4	183.4	177.5	183.4	177.5	183.4	2,159.6
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	173.1	156.3	173.1	167.5	173.1	167.5	173.1	173.1	167.5	173.1	167.5	173.1	2,038.0
Total	453.7	409.8	456.3	457.5	518.8	556.1	606.3	600.0	534.2	495.3	446.1	453.8	5,987.8

VRF-TG-BK-001-US 012G03

Table of Contents

Introduction

Overview

The eQUEST Building Energy Modeling Guide for LG Multi V contains step-by-step instructions for modeling LG Multi V system options. This document primarily draws from the DOE-2.2 Building Energy Use and Cost Analysis Program, Volume 1 and Volume 2. To download or learn more about eQUEST, please visit http://www.doe2.com/equest/.

Disclaimer

This Building Energy Modeling Guide should be used as a guideline only. Building load and energy have been approximated for modeling purposes and vary with the input value of equipment (capacity, power input, etc.), and actual results will vary accordingly. The conclusions of this Modeling Guide do not guarantee actual energy costs or savings.

This Modeling Guide and its associated eQUEST library file are intended as design and analysis guides to help designers optimize the design of LG Multi V VRF systems based on energy utilization. Modeling accuracy is highly dependent on user-supplied data. It is the user's responsibility to understand how the data entered affects program output and any predefined libraries are used only as guidelines for entering that data. The calculation results and reports shown in this guide and the eQUEST library file are meant to aid the system designer and are not a substitute for design services, judgment, or experience.

Program Installation

To install eQUEST:

1. Download the latest version of eQUEST from the DOE Website by going to http://www.doe2.com/download/equest/eQUEST_3-64_Setup.exe.
2. Download the eQUEST_3-64_Setup.exe file to a location of your choice.
3. Double click the eQUEST_3-64_Setup.exe file to begin the installation.
4. Follow the program prompts to install the program using the default settings.

Importing Multi V Library File

Importing the Library File

To import the Multi V library file into eQUEST:

1. Obtain the Multi V library file (Bdllib.dat) from your LG Sales Representative.
2. Double click the eQUEST icon on your desktop to launch eQUEST. The eQUEST Startup Options dialog box appears:

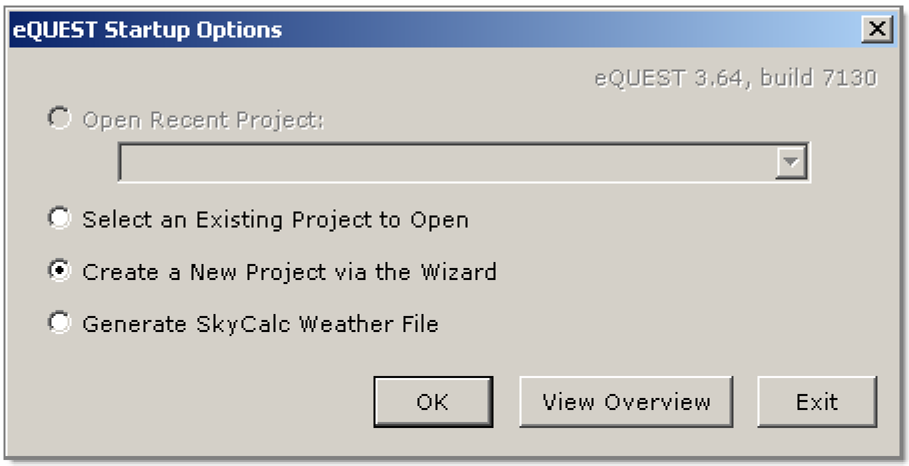


Figure 1: eQUEST startup options dialog box.

Note:	If this is not your first time opening eQUEST, open an existing project instead.

3. Click the **OK** button to create a new project. The Which Wizard dialog box appears:

Figure 2: Which Wizard dialog box.

4. Click the **Schematic Design Wizard** button.
5. When the Wizard appears, click the **Finish** button. The Wizard closes.
6. Click **Tools > View File Locations > View eQUEST Data Directory**. The eQUEST data directory appears in Windows Explorer (often C:\Documents and Settings\Administrator\My Documents\eQUEST 3-64 Data\DOE-2):

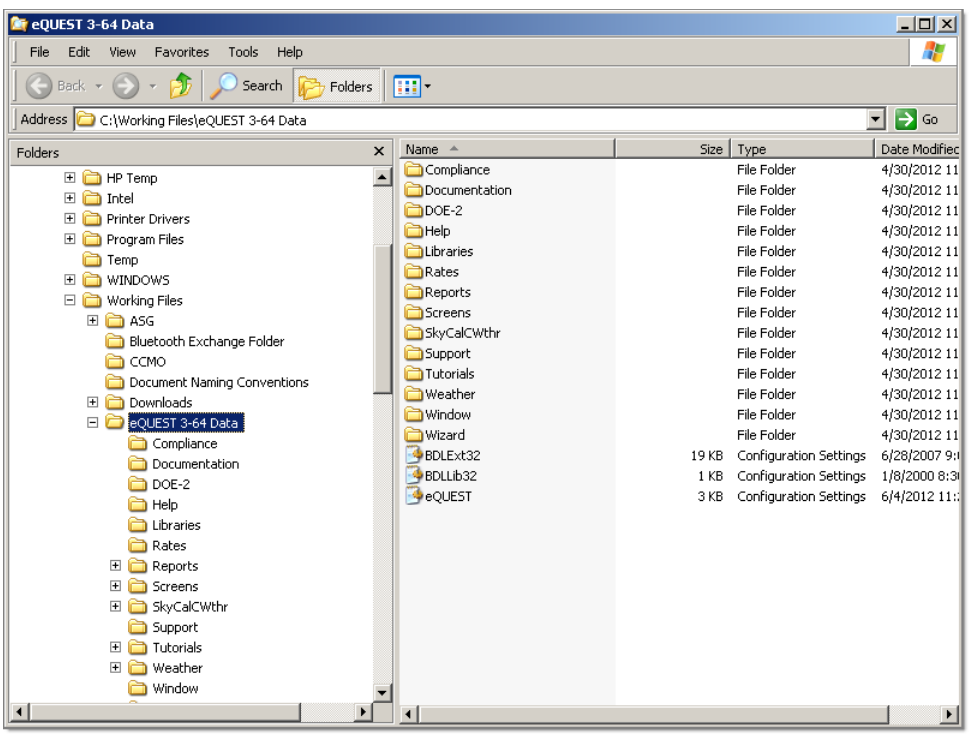


Figure 3: Locating the library file.

7. Double click the DOE-2 subdirectory. A list of files appears:

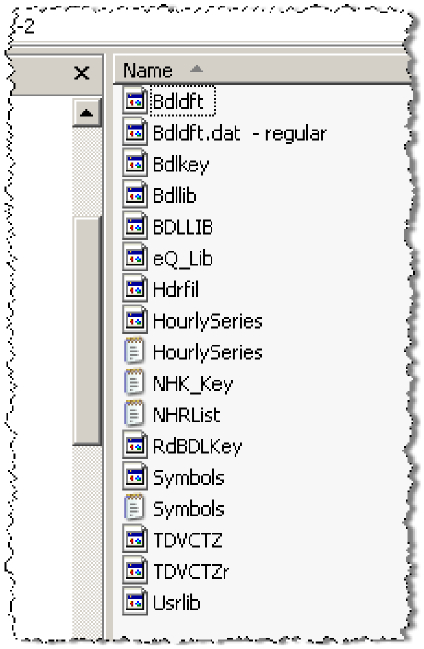


Figure 4: DOE-2 subdirectory.

8. Rename the Bdllib.dat file to original_BDllib.dat. That way you can return to the default file if the need arises.
9. Drag and drop the replacement Bdllib.dat file that you downloader earlier into the Window Explorer dialog box. The file appears in the dialog box.
10. Close the dialog box.
11. In eQUEST click **File > Exit** to close the program.

Testing the Library File

To test the Multi V library file in eQUEST:

1. On your desktop double click the eQUEST icon again. The program appears.
2. Click **Mode > Detailed Data Edit**.
3. Click the **Air-Side HVAC** button. The Air-Side HVAC pane appears.
4. To the left of the pane, locate the **Performance Curves** folder in the tree.
5. Right click the folder and select **Create Curve Fit**. The Create Curve Fit dialog box appears:

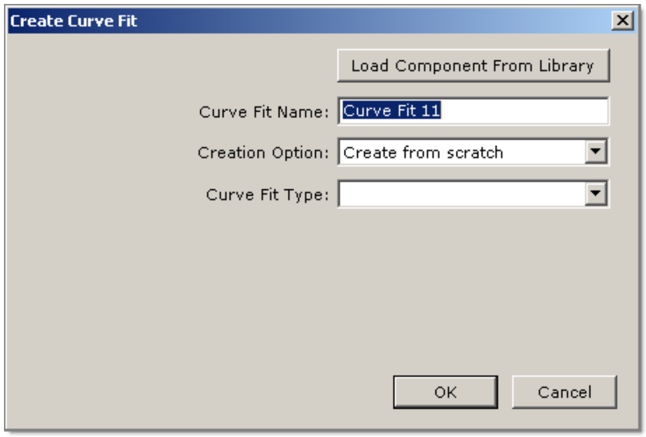


Figure 5: Create Curve Fit dialog box.

6. Click the **Load Component from Library** button. The Curve Fit Library Selection dialog box appears.

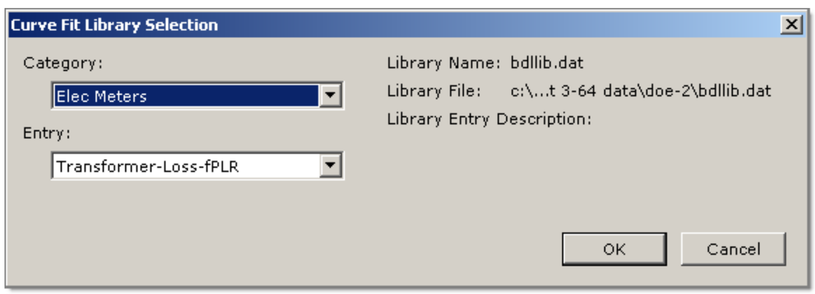


Figure 6: Curve Fit Library Selection dialog box.

7. Select **MultiV 3 (HP)** in the **Category** list. The Entry list populates with Multi V III outdoor units.
8. Click the applicable outdoor unit in the **Entry** list.
9. Click the **OK** button. The dialog box disappears, and the outdoor unit appears in the Curve Fit Name box on the Create Curve Fit dialog box.
10. Click the **OK** button. The dialog box disappears, and the Performance Curve Properties dialog box appears:

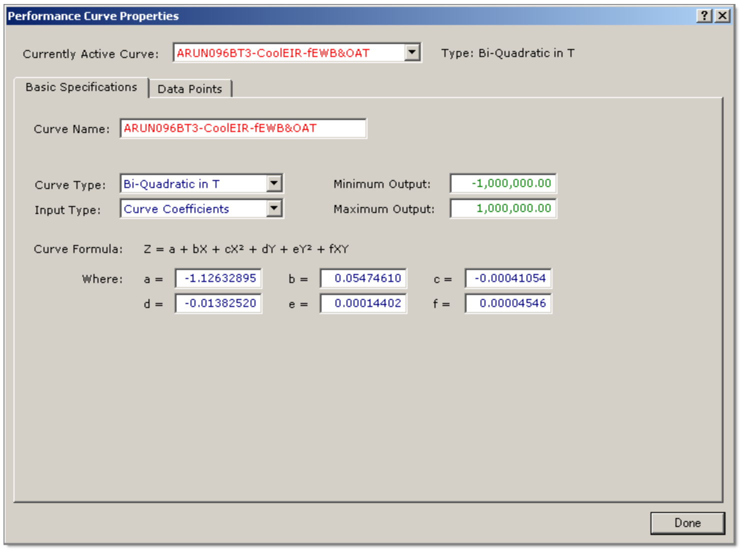


Figure 7: Performance Curve Properties dialog box.

11. Click the **Done** button. The outdoor unit now appears in the Performance Curves folder.

Case Study

This document uses multiple sources of information to streamline the energy modeling process for variable refrigerant flow (VRF) systems. This case study features a building that is served by a VRF system. This study demonstrates how to model the indoor units, piping, and outdoor units.

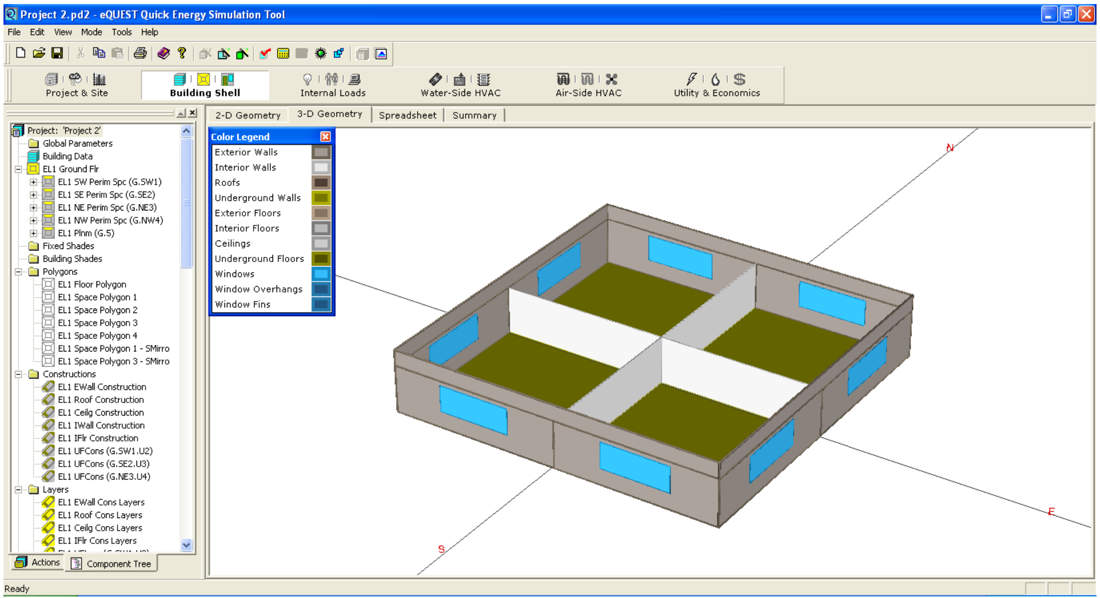


Figure 8: eQUEST main window.

To model the building's energy use:

1. We determine systems loads by space or zone, using the load calculation results from eQUEST. For example, if four arbitrary zones are created, the peak loads of the might appear as follows:

   Zone 1 = 24,000 Btu/hr

   Zone 2 = 24,000 Btu/hr

   Zone 3 = 24,000 Btu/hr

   Zone 4 = 24,000 Btu/hr

2. Our building's location is Atlanta, so the design temperature is 94°F.
3. We select an indoor unit (IDU) for each zone or space using the LG Multi V III product line. We decide on four Four-Way Ceiling Cassettes.
4. We inspect the indoor unit capacity tables for those units, considering the indoor and outdoor temperatures. Select units whose capacity is the nearest to or greater than the anticipated load. Are choices were as follows:

Note:	Individual indoor unit capacity is subject to change depending on what outdoor units are used. Actual capacity has to be calculated according to the combination by using the outdoor unit capacity table.

- Zone 1 = 24,000 Btu/hr: ARUN243TMC2. 24,000 Btu/hr load: one 2.0 ton unit, 24,000 Btu/h. Capacity index (CI) = 24
- Zone 2 = 24,000 Btu/hr: ARUN243TMC2. 24,000 Btu/hr load: one 2.0 ton unit, 24,000 Btu/h. CI = 24
- Zone 3 = 24,000 Btu/hr: ARUN243TMC2. 24,000 Btu/hr load: one 2.0 ton unit, 24,000 Btu/h. CI = 24
- Zone 4 = 24,000 Btu/hr: ARUN243TMC2. 24,000 Btu/hr load: one 2.0 ton unit, 24,000 Btu/h. CI = 24

5. We select an outdoor unit for the loads from our LG Multi V III product line. We view allowable unit combinations in the Indoor Unit Combination Total Capacity Index Table in the appropriate LG Engineering Product Data Book (EPDB). In general, we choose outdoor units based on the location of the unit, zoning, and purpose of the rooms. The indoor and outdoor unit combination is determined by their combination ratios, which is the ratio of the indoor unit capacity to the outdoor unit capacity, expressed as a percentage. Optimally we shoot for a 100% ratio or slightly under. Based on the following:

    Total Load = 8 tons = 96,000 Btu/h = 96, CI = 96

    IDU Capacity = 8 tons = 96,000 Btu/h, CI = 96

    We chose an LG Multi V III ARUN096DT3 (8 tons = 96,000 Btu/h, CI = 96).

Figure 9 LG Multi V III ARUN096DT3

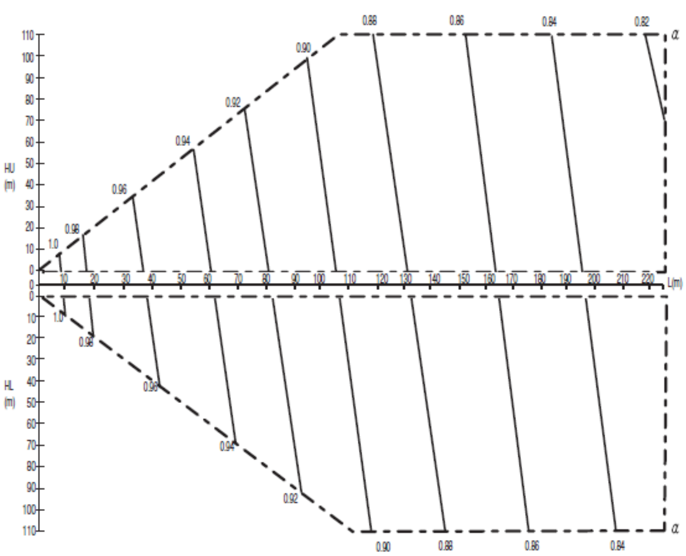
6. We know the combination ratio is good because 96/96 = 1 = 100%.
7. Next, we modify the indoor unit capacity index based on an indoor temperature of 67°F WB, once again using the appropriate EPDB. We arrive at the following results:
   - Zone 1: Initial CI = 24. Adjusted CI = 24.2 MBH (20.3 MBH sensible).
   - Zone 2: Initial CI = 24. Adjusted CI = 24.2 MBH (20.3 MBH sensible).
   - Zone 3: Initial CI = 24. Adjusted CI = 24.2 MBH (20.3 MBH sensible).
   - Zone 4: Initial CI = 24. Adjusted CI = 24.2 MBH (20.3 MBH sensible).

   For a sum of IDU outputs of 96.8 MBH.
8. Next, we modify ODU capacity for any piping losses. For this calculation we assume that we have 65 feet of pipe from the ODU to farthest IDU, where the main pipe is 30 feet long and there is 40 feet of branch pipe. Our farthest IDU is 9.8 feet below the ODU, which is placed on the roof. Our overall equivalent pipe length, L, is as follows:

   $L = (L_{main} \times Cf) + L_{branch}$

   $L = 30 \text{ ft} \times 1.0 + 130 \text{ ft.} = 160.0 \text{ ft.}$

   Cf represents the correction factor, which also comes for the EPDB. We then correct for the elevation change, Hp. Using Cf and Hp, we determine our overall capacity correction factor using the following chart:



HU (m) 110	-	-	-	-	-	-	-	-	-	-	-	0.89	0.88	0.88	0.87	0.86	0.86	0.85	0.84	0.84	0.83	0.83	0.82
100	-	-	-	-	-	-	-	-	-	-	0.90	0.89	0.88	0.88	0.87	0.86	0.86	0.85	0.84	0.84	0.83	0.83	0.82
90	-	-	-	-	-	-	-	-	-	0.91	0.90	0.89	0.88	0.88	0.87	0.86	0.86	0.85	0.84	0.84	0.83	0.83	0.82
80	-	-	-	-	-	-	-	-	0.92	0.91	0.90	0.89	0.88	0.88	0.87	0.86	0.86	0.85	0.84	0.84	0.83	0.83	0.82
70	-	-	-	-	-	-	-	0.92	0.92	0.91	0.90	0.89	0.89	0.88	0.87	0.86	0.86	0.85	0.85	0.84	0.83	0.83	0.82
60	-	-	-	-	-	-	0.93	0.93	0.92	0.91	0.90	0.89	0.89	0.88	0.87	0.87	0.86	0.85	0.85	0.84	0.83	0.83	0.82
50	-	-	-	-	-	0.94	0.93	0.93	0.92	0.91	0.90	0.89	0.89	0.88	0.87	0.87	0.86	0.85	0.85	0.84	0.83	0.83	0.82
40	-	-	-	-	0.95	0.94	0.94	0.93	0.92	0.91	0.90	0.89	0.89	0.88	0.87	0.87	0.86	0.85	0.85	0.84	0.84	0.83	0.82
30	-	-	-	0.96	0.95	0.95	0.94	0.93	0.92	0.91	0.90	0.90	0.89	0.88	0.87	0.87	0.86	0.85	0.85	0.84	0.84	0.83	0.82
20	-	-	0.98	0.97	0.96	0.95	0.94	0.93	0.92	0.91	0.90	0.90	0.89	0.88	0.87	0.87	0.86	0.85	0.85	0.84	0.84	0.83	0.82
10	-	0.99	0.98	0.97	0.96	0.95	0.94	0.93	0.92	0.91	0.90	0.90	0.89	0.88	0.88	0.87	0.86	0.86	0.85	0.84	0.84	0.83	0.82
7.5	0.99	0.99	0.98	0.97	0.96	0.95	0.94	0.93	0.92	0.91	0.90	0.90	0.89	0.88	0.88	0.87	0.86	0.86	0.85	0.84	0.84	0.83	0.82
0	1.0	0.99	0.98	0.97	0.96	0.95	0.94	0.93	0.92	0.91	0.91	0.90	0.89	0.88	0.88	0.87	0.86	0.86	0.85	0.84	0.84	0.83	0.82
0	7.5	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	225 L(m)
HL (m) 0	1.0	0.99	0.98	0.97	0.96	0.95	0.94	0.93	0.92	0.91	0.91	0.90	0.89	0.88	0.88	0.87	0.86	0.86	0.85	0.84	0.84	0.83	0.82
7.5	1.0	0.99	0.98	0.97	0.96	0.95	0.94	0.93	0.92	0.91	0.91	0.90	0.89	0.88	0.88	0.87	0.86	0.86	0.85	0.84	0.84	0.83	0.82
10	-	0.99	0.98	0.97	0.96	0.95	0.94	0.93	0.92	0.91	0.91	0.90	0.89	0.88	0.88	0.87	0.86	0.86	0.85	0.84	0.84	0.83	0.82
20	-	-	0.98	0.97	0.96	0.95	0.94	0.93	0.92	0.91	0.91	0.90	0.89	0.88	0.88	0.87	0.86	0.86	0.85	0.84	0.84	0.83	0.82
30	-	-	-	0.97	0.96	0.95	0.94	0.93	0.92	0.92	0.91	0.90	0.89	0.88	0.88	0.87	0.86	0.86	0.85	0.85	0.84	0.83	0.83
40	-	-	-	-	0.96	0.95	0.94	0.93	0.92	0.92	0.91	0.90	0.89	0.89	0.88	0.87	0.86	0.86	0.85	0.85	0.84	0.83	0.83
50	-	-	-	-	-	0.95	0.94	0.93	0.93	0.92	0.91	0.90	0.89	0.89	0.88	0.87	0.87	0.86	0.85	0.85	0.84	0.83	0.83
60	-	-	-	-	-	-	0.94	0.94	0.93	0.92	0.91	0.90	0.89	0.89	0.88	0.87	0.87	0.86	0.85	0.85	0.84	0.84	0.83
70	-	-	-	-	-	-	-	0.94	0.93	0.92	0.91	0.90	0.90	0.89	0.88	0.87	0.87	0.86	0.85	0.85	0.84	0.84	0.83
80	-	-	-	-	-	-	-	-	0.93	0.92	0.91	0.90	0.90	0.89	0.88	0.87	0.87	0.86	0.85	0.85	0.84	0.84	0.83
90	-	-	-	-	-	-	-	-	-	0.92	0.91	0.90	0.90	0.89	0.88	0.87	0.87	0.86	0.86	0.85	0.84	0.84	0.83
100	-	-	-	-	-	-	-	-	-	-	0.91	0.91	0.90	0.89	0.88	0.88	0.87	0.86	0.86	0.85	0.84	0.84	0.83
110	-	-	-	-	-	-	-	-	-	-	-	0.91	0.90	0.89	0.88	0.88	0.87	0.86	0.86	0.85	0.84	0.84	0.83

Figure 10 Capacity Correction Factor

The result is a cooling capacity of α = 0.98 based on the overall equivalent pipe length, L, and the level difference, Hp.

Note:	If you are interested in learning more about piping losses and Multi V III system design, download the EPDB from LG-VRF.com.
Note:	The LG Air-Conditioner Technical Solution software automates much of the piping loss calculation. You can download it at LG-VRF.com.

9. Next, we correct for temperature effects on outdoor unit capacity using the following input data:
   - CR = 100%
   - Tout_db = 94°F
   - Tin_wb = 67°F

   We arrive at a new total cooling capacity of 95.79 MBH with an electrical power input of 6.64 kW for the compressors and the outdoor unit's fan motor.
10. Next, we correct with a safety factor. A 100% safety factor is assumed to be sufficient with a 100% CR, so there is zero net change.

    95,790[Btu/hr] × 100% = 95,790Btu/hr
11. We then ensure that the indoor unit capacity divided by the modified outdoor unit capacity is greater than the peak cooling or heating load. Otherwise the indoor unit capacity must be increased.
12. Next, we input the air-side HVAC system parameters in eQUEST:

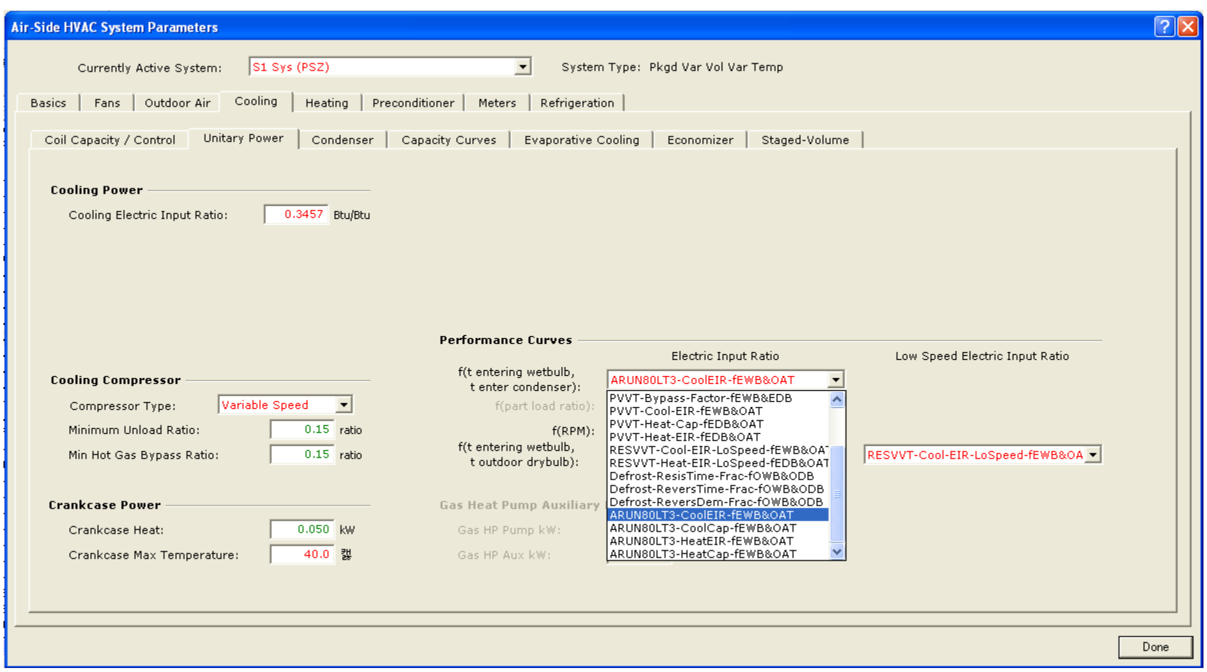


Figure 11: Unitary Power (Cooling) Tab.

Cooling data:

- COOLING-CAPACITY : *95,790*
- Cooling EIR = *0.2399*
- (Cooling Capacity: 96.0 Mbh, Power Input: 6.75kW, EER =14.2)
- Compressor type: *Variable Speed*
- Minimum Unload ratio: *0.15*
- Min hot gas bypass ratio: *0.15*
- Crankcase heat: *0.060*kW
- Crankcase Max Temperature: *40*°F
- Performance Curves:
  - COOL-EIR-FT : *ARUN096DT3*
  - COOL-EIR-FPLR : *ARUN096DT3*
  - COOL-EIR-LS-FT : RESVVT cool Lo speed EIR-FRPM
  - COOL-CAP-FT : *ARUN096DT3*
  - COOL-SH-FT : *ARUN096DT3*

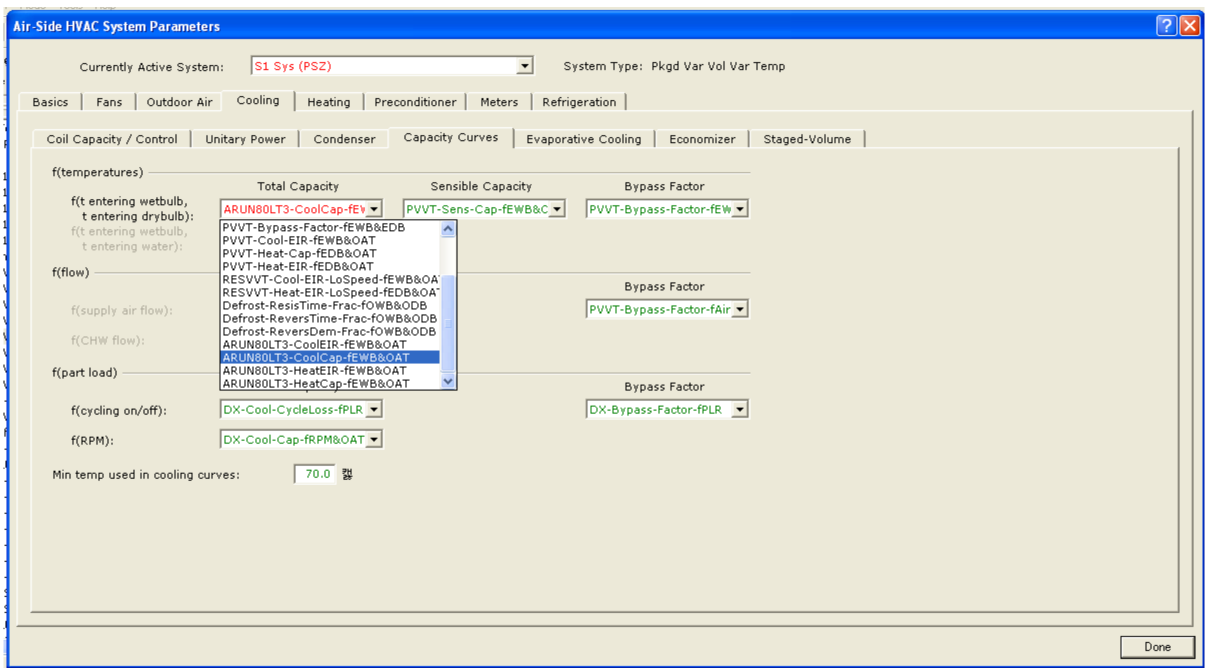


Figure 12: Capacity Curves (Cooling) Tab.

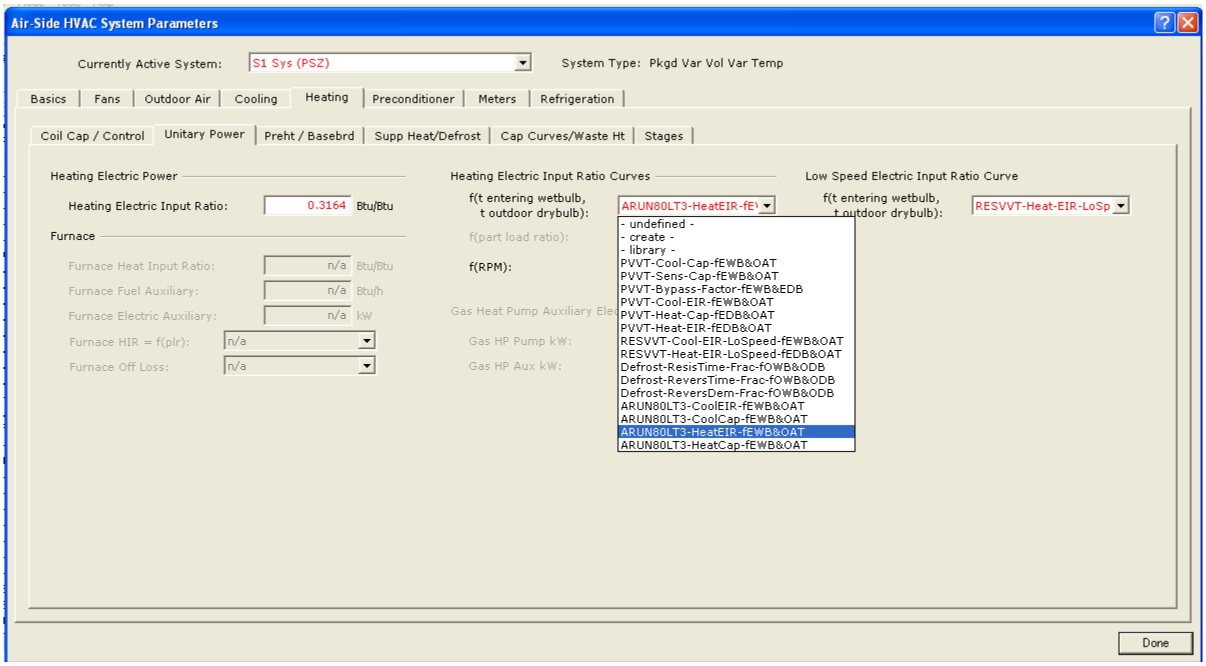


Figure 13: Unitary Power (Heating) Tab.

Heating data:

- HEAT-SOURCE : *HEAT-PUMP*
- HEATING-CAPACITY : *-101,370*
- HEATING EIR = *0.2167*
- (HEATING Capacity: 108.0 Mbh, Power Input: 6.86kW, COP =4.61)
- MAX-SUPPLY-T : *105*
- Performance Curves:
  - HEAT-EIR-FT : *ARUN096DT3*
  - HEAT-EIR-FPLR: *ARUN096DT3*
  - HEAT-EIR-LS-FT : RESVVT heat Lo speed EIR-FRPM

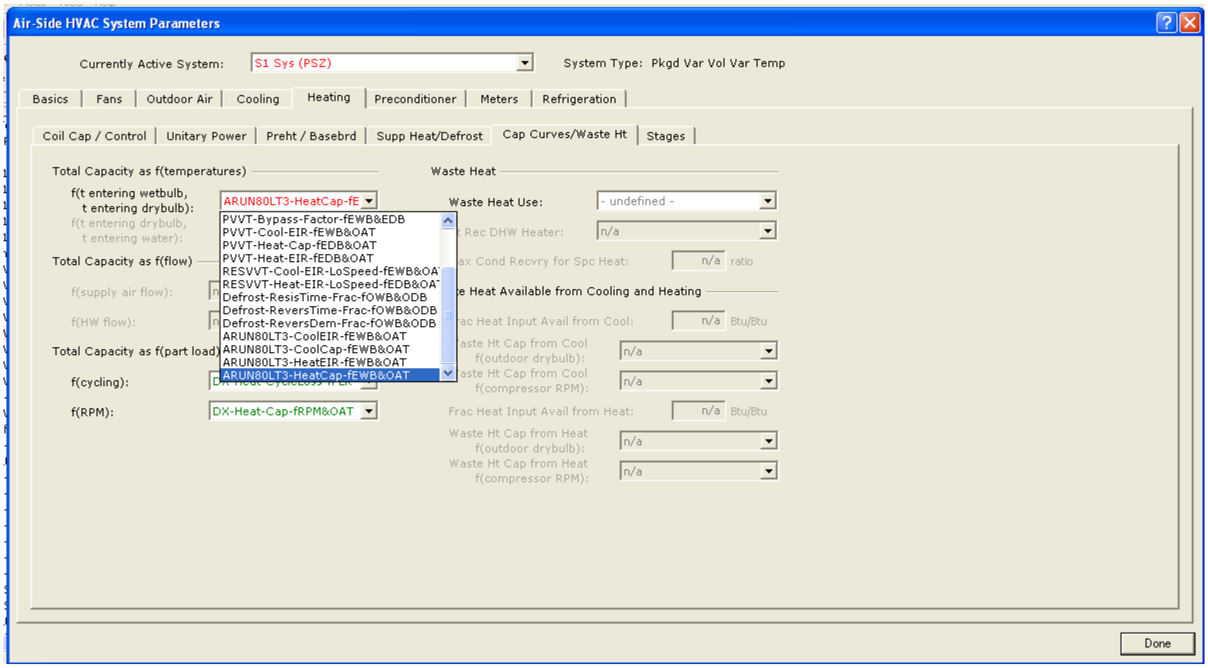


Figure 14: Cap Curves/Waste Ht (Heating) Tab.

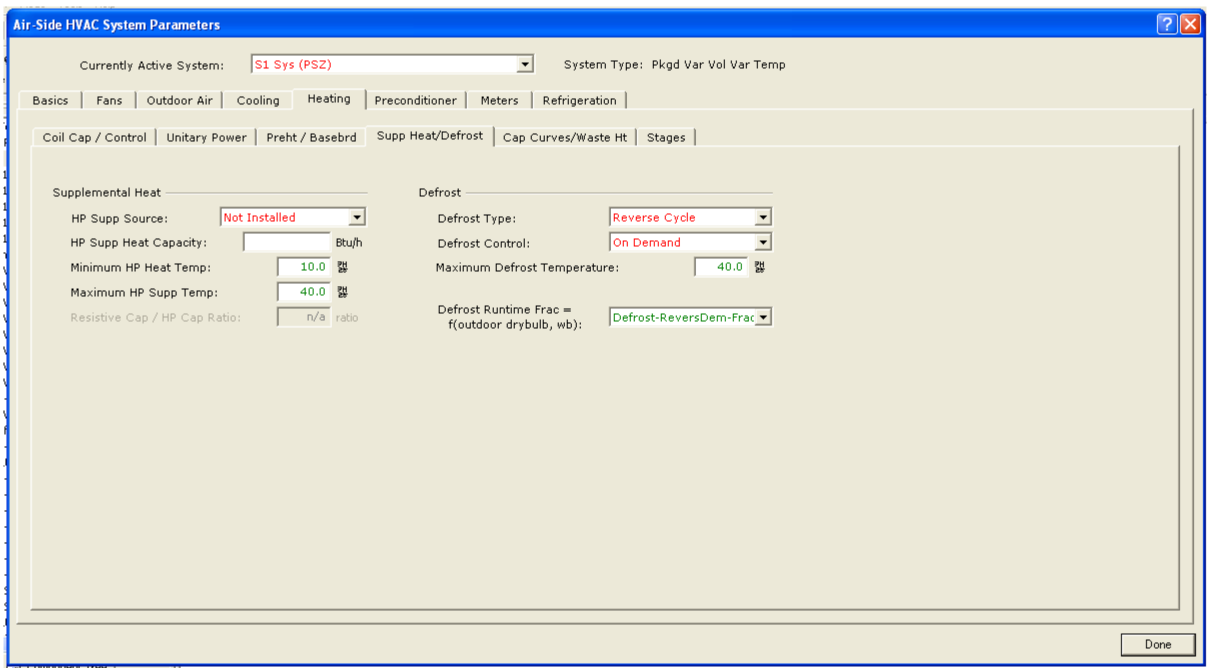


Figure 15: Supp Heat/Defrost (Heating) Tab.

- HP-SUPP-SOURCE: *Not installed*
- DEFROST-TYPE : *REVERSE-CYCLE*
- DEFROST-CTRL : *ON-DEMAND*
- DEFROST-T : Set to *40*°F.

13. We then add fan parameters. We enter the total static pressure (TSP) or fan power (kW/cfm) of the system supply fan.

Note:	TSP includes also includes pressure drops across filters and other internal air handler components.

Depending on the system type, you can set fans to cycle at night. Select "no OA at night" if there is no economizer or "no OA at night + economizer" plus the economizer type if your system has an economizer.

Note:	You may need to remove the economizer low limit in detail mode.

For our system, we have four 4-Way Ceiling cassettes (ARUN243TMC2), each with a 30W fan motor moving air at 600 cfm.

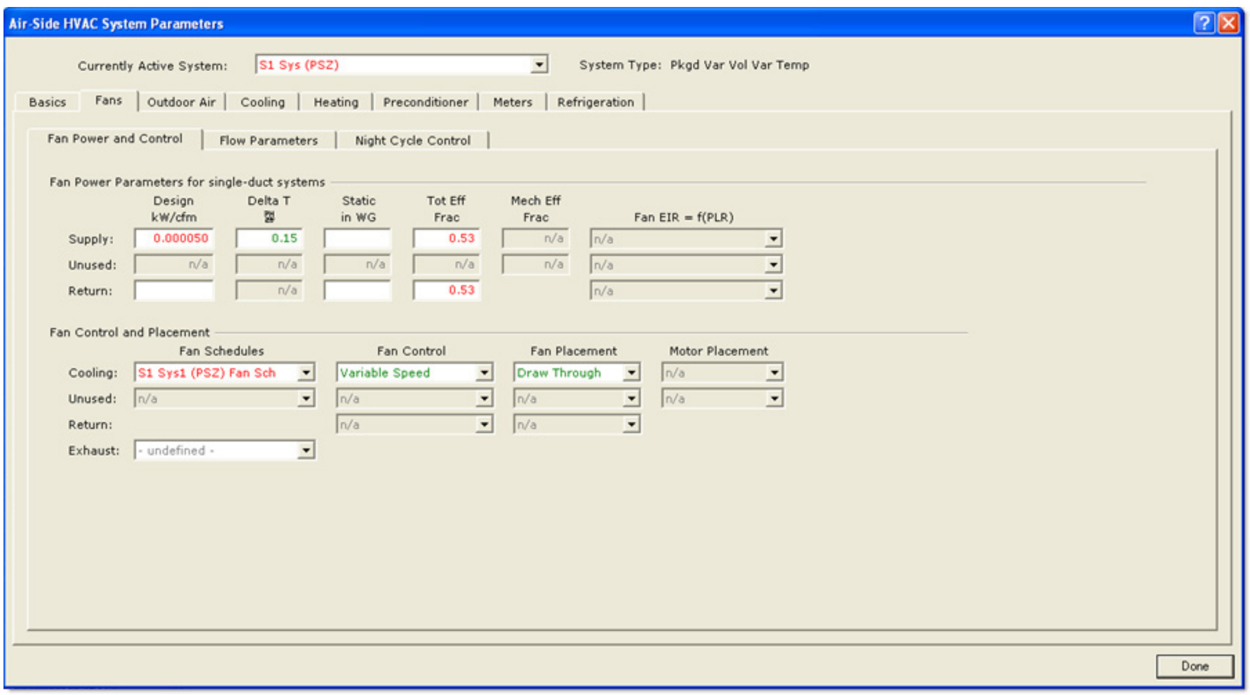


Figure 16: Fan Power and Control (Fans) Tab.

Refer to the EPDB for the indoor units you intend to model to find the TSP and other data. Pressure losses should include filters, coils, and the distribution system. You should use the full-load power of the supply fan per unit of supply air flow rate at sea level, using either SUPPLY-STATIC or SUPPLY-KW/FLOW. eQUEST calculates the part-load power consumption of the supply fan versus the part-load characteristics corresponding to the control mode selected. You should choose the variable speed option, specify the supply fan placement, and specify the design air flow capacity of the indoor units' supply fans.

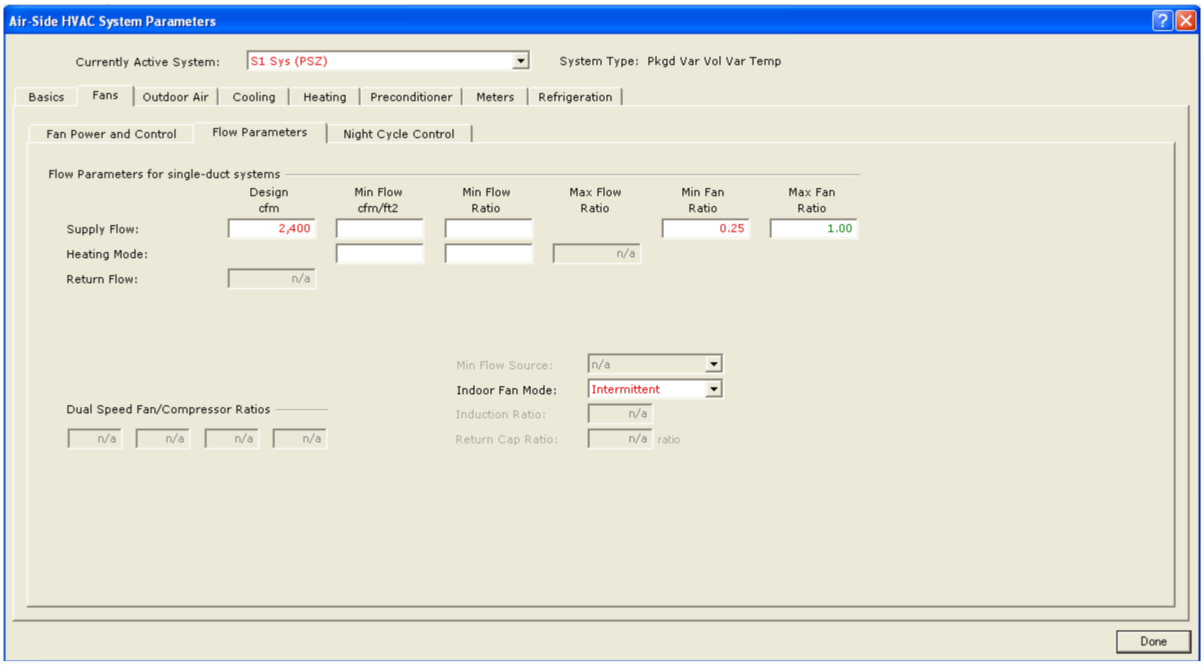


Figure 17: Flow Parameters (Fan) Tab.

Both the minimum and maximum air flow rates through a supply fan are expressed as a fraction of the design flow rate. We chose to set the rate to INTERMITTENT where the indoor unit fan operates as with the CONTINIOUS setting but only for a fraction of an hour required for space heating or cooling.

14. Next, we run the simulation.

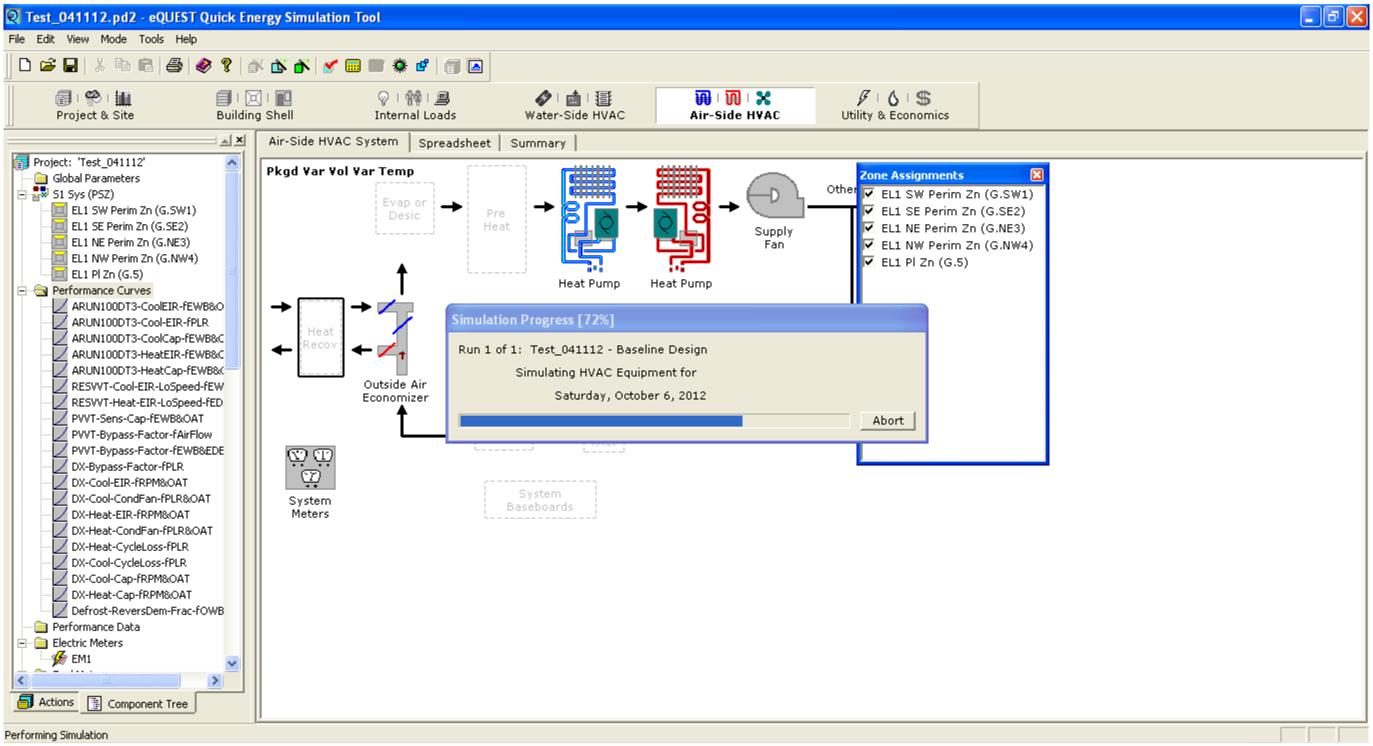


Figure 18: Simulation calculation in progress.

15. Finally, we inspect the results:

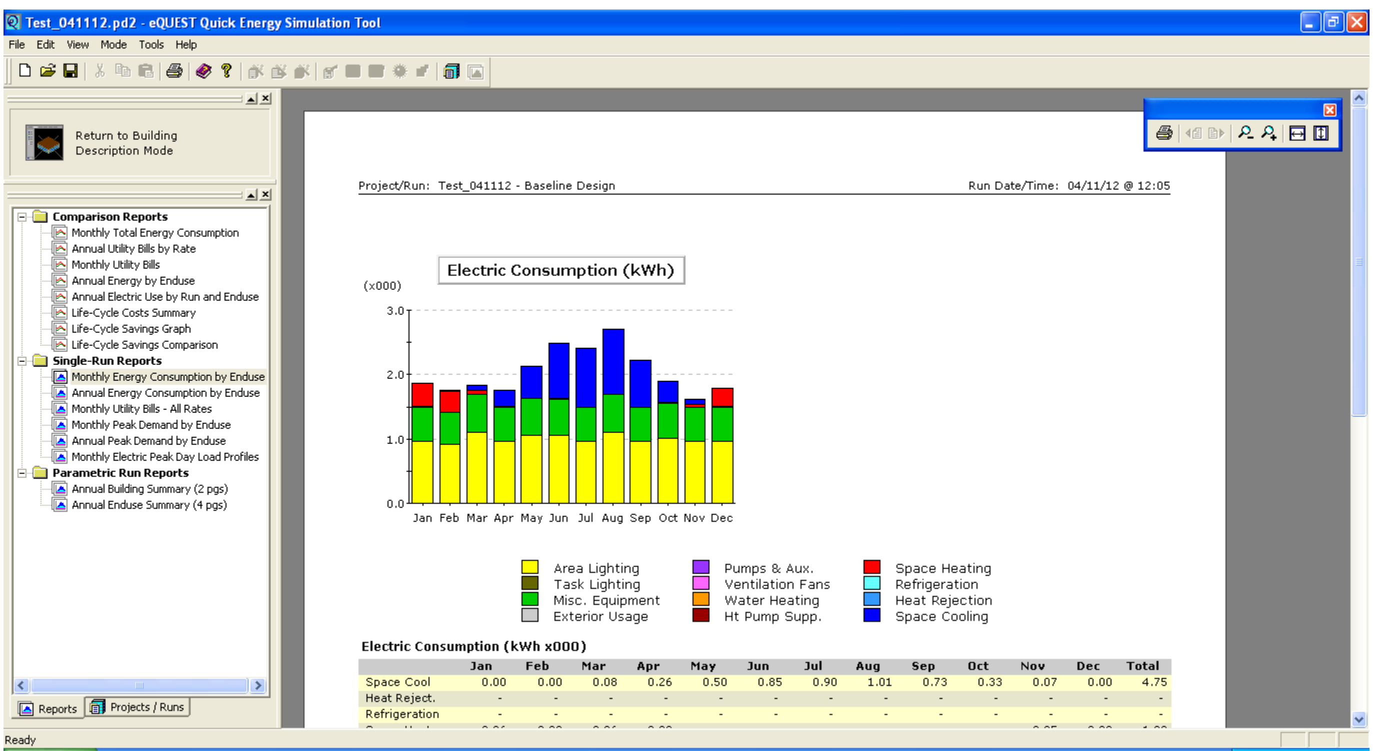


Figure 19: Simulation results.

The results consist of reports in three main categories:

- Verification reports that summarize the model input, as well as design values calculated by the program.
- Summary reports that present the results of the program simulation.
- Hourly reports that tabulate the hourly values of a user-selected set of simulation variables.

References

- DOE-2.2 Building Energy Use and Cost Analysis Program, Volume 1 Basic, Lawrence Berkeley National Laboratory and James J. Hirsch & Associates (JJH).
- DOE-2.2 Building Energy Use and Cost Analysis Program, Volume 2 Dictionary, Lawrence Berkeley National Laboratory and James J. Hirsch & Associates (JJH).
- ASHRAE/IESNA Standard 90.1-2007 : http://www.ashrae.org.