Designing/Simulating WSHP (California Loop) Systems

This document explains how to design and simulate a California Loop type water source heat pump (WSHP) systems using Carrier HAP software. A simple three-zone system will be used to demonstrate how to design and simulate a WSHP system using HAP. The user should refer to the HAP Help Systems for additional information. Additionally, Carrier's *WSHP System Design Guide* (catalog# 795-202) addresses further details associated with this system.

A California Loop WSHP system consists of a number of heat pump units connected to a common recirculating water loop. WSHP units on this loop exchange heat with the loop by rejecting heat to the loop (for those units in the cooling mode) and extracting heat from the loop (for those units in the heating mode), as shown in Figure 1.

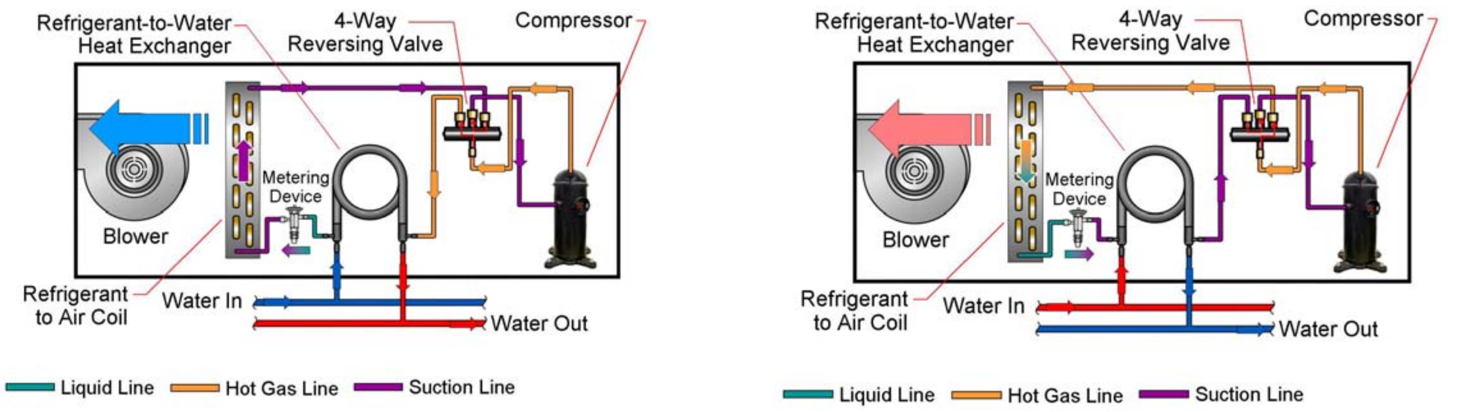

Figure 1 – WSHP Cooling & Heating Operation

In a closed-loop WSHP system, heat is rejected from the loop through a cooling tower and heat is added through a hot water boiler. An upper and lower loop temperature setpoint establishes the sequence of operation of the cooling tower and boiler. A common loop temperature range is 50 °F to 85 °F, for example. If the loop temperature rises above the upper loop setpoint due to many WSHP units operating in the cooling mode, the cooling tower is energized to maintain the loop at a temperature no greater than the upper setpoint. If the loop temperature drops below the minimum loop setpoint due to many WSHP units operating in the heating mode, a hot water boiler is energized to maintain the loop temperature at a temperature no less than the lower setpoint. During the intermediate season, various WSHP units simply exchange heat to and from the loop to meet the individual zone load requirements and the boiler and cooling tower remain off. This allows for heat-reclaim to occur in the building since heat generated in the core of the building may be rejected to the loop where the perimeter units can redistribute this heat efficiently without using *new* energy for heating. This process is called heat rejection and is the primary benefit of a California Loop WSHP system.

By code, ventilation air must be provided to the building. With a WSHP system, there are essentially two methods to achieve this:

1) Direct Ventilation - untreated outside air is directly introduced to the return air side of the WSHP unit where it mixes with the return air, then becomes conditioned by the heating and cooling coils in the WSHP unit. This is often undesirable because the WSHP unit coils are not typically capable of removing the high latent heat in summer, nor are they capable of heating extremely cold ambient air in the winter. HAP refers to this type of ventilation system as a *Direct Ventilation* unit.

2) Common Ventilation System - a dedicated outside air unit is often used to pre-condition or temper the ventilation air prior to introduction to the return air side of the WSHP units. This reduces the loads imposed on the WSHP coils and allows them to condition the zone loads by "decoupling" the ventilation load from the WSHP units. Heat reclaim type devices are often used, such as heat wheels, and are incorporated inside these ventilation units to recover some of the waste heat that is

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normally rejected along with the building exhaust air. HAP refers to this means of ventilation as a *Common Ventilation System* as illustrated in Figure 2.

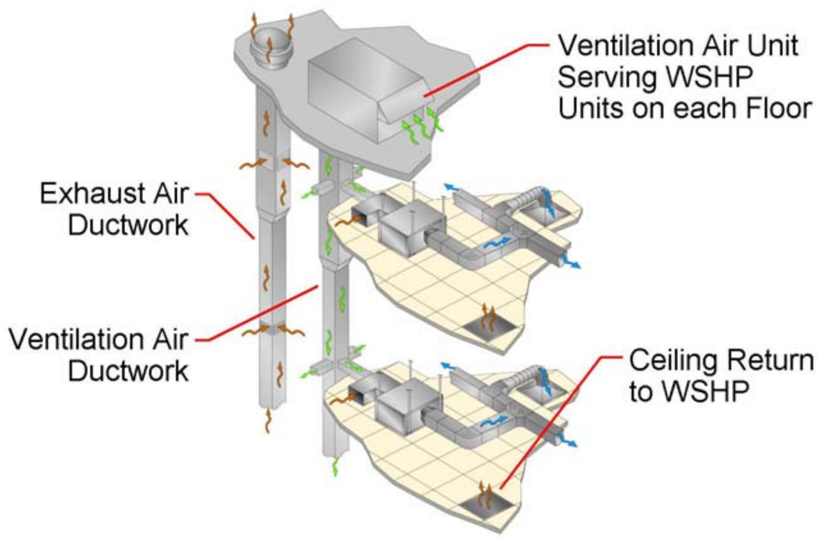

Figure 2 – Common Ventilation System for WSHP

The HAP modeling procedures are described as follows:

Air System Properties: Define one air system for the entire collection of WSHP units and the Common Ventilation System. HAP limits the number of WSHP units (zones) per air system to 100. Multiple air systems must be used if there are more than 100 WSHP units, each with a separate boiler and tower.

HAP will model each zone in the system as a separate WSHP unit. Loads for each zone will be calculated and the performance of each WSHP will be performed separately. Interaction of the WSHP units via the common water loop will also be analyzed. Loads and energy use for the individual WSHP units are then summed to obtain system totals that are displayed on the simulation reports. Modeling tips are shown starting with Figure 3:

- Specify the Equipment Type as "Terminal Units"

- Specify the Air System Type as "Water Source Heat Pump" and proceed to enter the remaining air system properties.

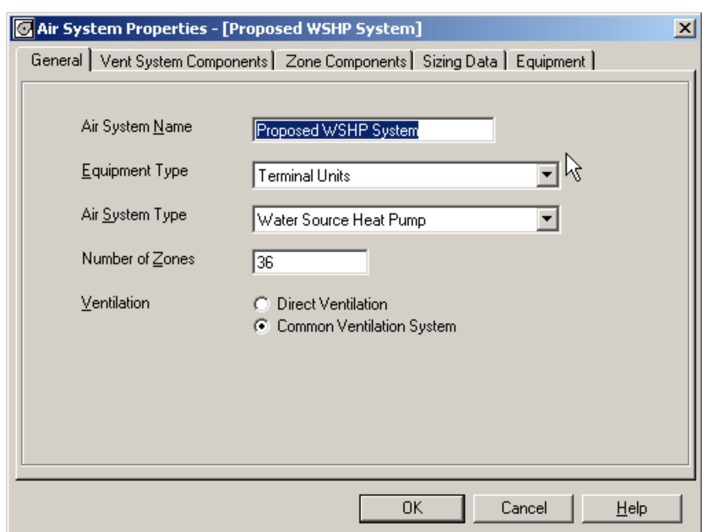

Figure 3 - WSHP Terminal Units

Designing/Simulating WSHP (California Loop) Systems

- Define the *Common Ventilation System* under the Vent System Components tab as shown in Figure 4. The Common Ventilation System is also known as a Make-up Air System. This system provides conditioned ventilation air to each zone.

- In this example, HAP will determine the minimum ventilation requirements for the Common Ventilation System based on ASHRAE 62-2001.

- The ventilation reclaim device provides sensible and latent heat recovery between the exhaust and ventilation air streams.

- Define the Cooling and Heating Coil for the Common Ventilation System. The Cooling Coil can be designated as a WSHP unit by selecting "Water-Cooled DX". Select "Air-Cooled DX" if it is a rooftop or other type DX unit. This example uses a packaged rooftop unit with DX cooling as the cooling coil for the Common Ventilation System.

- Additional input is necessary to define any humidification, dehumidification, and ventilation fan, duct system, and exhaust fan size if these components exist.

- Define the WSHP units serving each zone. Click on Common Data under the Zone Components tab as shown in Figure 5. These units are defined under the "Common Terminal Unit Data". Cooling and heating coil data must be entered.

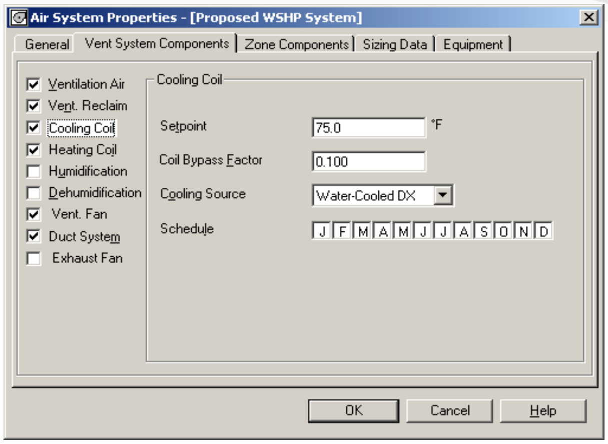

Figure 4 – Common Ventilation System Properties

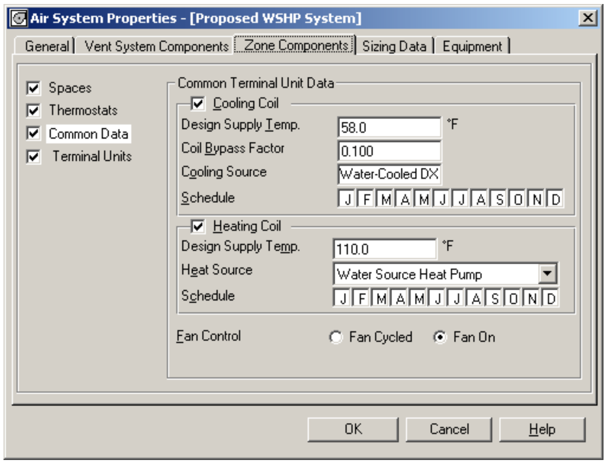

Figure 5 – Common Data for WSHP

At this point, the cooling and heating load calculations must be performed to determine the required size of the Common Ventilation System and each WSHP unit. Figure 6 shows how to initiate the System Sizing and Zone Sizing Summary reports that must be generated to determine the ventilation, cooling, and heating loads.

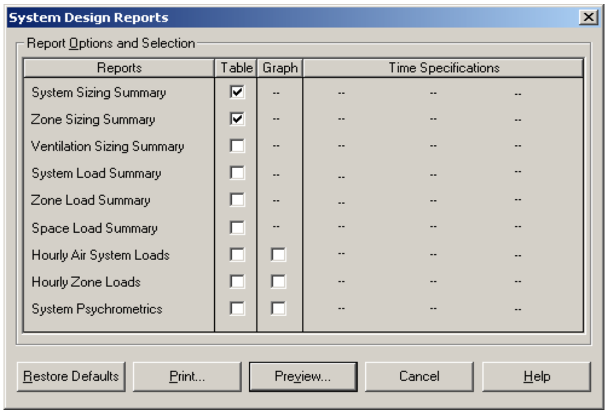

Figure 6 – Print/View Design Data

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- The Air System Sizing Summary shown in Figure 7 describes the loads associated with the Common Ventilation System. This information is used to select the equipment needed for this system.

Air System Sizing Summary for Proposed WSHP System

Project Name: LEED Analysis Using HAP (Proposed WSHP) 10/06/2005
Prepared by: Carrier Software Systems 04:28PM

Air System Information

Air System Name	**Proposed WSHP System**	Number of zones	**36**
Equipment Class	**TERM**	Floor Area	**24000.0** ft²
Air System Type	**WSHP**	Location	**Harrisburg, Pennsylvania**

Sizing Calculation Information

Zone and Space Sizing Method:

Zone CFM	**Sum of space airflow rates**	Calculation Months	**Jan to Dec**
Space CFM	**Individual peak space loads**	Sizing Data	**Calculated**

Cooling Coil Sizing Data

Total coil load	**2.2** Tons	Load occurs at	**Aug 1500**
Total coil load	**26.3** MBH	OA DB / WB	**92.0 / 74.0** °F
Sensible coil load	**26.3** MBH	Entering DB / WB	**81.5 / 68.2** °F
Coil CFM at Aug 1500	**1920** CFM	Leaving DB / WB	**68.7 / 64.1** °F
Max coil CFM	**1920** CFM	Bypass Factor	**0.100**
Sensible heat ratio	**1.000**		
Water flow @ 10.0 °F rise	**N/A**		

Heating Coil Sizing Data

Max coil load	**22.8** MBH	Load occurs at	**Des Htg**
Coil CFM at Des Htg	**1920** CFM	Ent. DB / Lvg DB	**52.6 / 63.7** °F
Max coil CFM	**1920** CFM		
Water flow @ 20.0 °F drop	**N/A**		

Ventilation Fan Sizing Data

Actual max CFM	**1920** CFM	Fan motor BHP	**5.10** BHP
Standard CFM	**1899** CFM	Fan motor kW	**3.80** kW
Actual max CFM/ft²	**0.08** CFM/ft²		

Outdoor Ventilation Air Data

Design airflow CFM	**1920** CFM	CFM/person	**21.05** CFM/person
CFM/ft²	**0.08** CFM/ft²		

Figure 7 – Common Ventilation System Size Requirements

- The Zone Sizing Summary shown in Figure 8 describes the WSHP capacity requirements for each zone.

- HAP considers the ventilation air temperature and it's impact on the coil entering temperature. The coil entering conditions is a result of mixed air from the common ventilation unit and room return air. The result is shown as the Coil Entering DB/WB (°F) on Figure 8.

- Cooling and heating sizing data is presented on this HAP report. This shows that 1.5 to 5 ton WSHP units are needed to meet the design cooling loads. In this example, combinations of 1.5 to 3 ton units will be selected for higher efficiency performance. The design airflow rate, total and sensible cooling loads, along with the heating coil loads and entering coil conditions, are then used to size the WSHP units using manufacturer's selection software or catalog information.

Zone Sizing Summary for Proposed WSHP System

Project Name: LEED Analysis Using HAP (Proposed WSHP) 10/07/2005
Prepared by: Carrier Software Systems 03:56PM

Terminal Unit Sizing Data - Cooling

Zone Name	Total Coil Load (MBH)	Sens Coil Load (MBH)	Coil Entering DB / WB (°F)	Coil Leaving DB / WB (°F)	Water Flow @ 10.0 °F (gpm)	Time of Peak Load
Zone 1	15.2	14.8	77.9 / 65.6	60.7 / 59.5	-	Jun 1700
Zone 2	27.2	25.6	77.8 / 64.7	58.8 / 57.5	-	Jul 1600
Zone 3	14.1	13.8	77.6 / 64.5	59.1 / 57.9	-	Jul 1100
Zone 4	22.9	22.2	78.2 / 64.5	58.6 / 57.3	-	Jul 1000
Zone 5	18.6	18.3	77.6 / 64.8	59.6 / 58.4	-	Sep 1400
Zone 6	60.2	58.8	77.7 / 64.9	59.6 / 58.4	-	Oct 1400
Zone 7	19.6	19.3	77.9 / 65.4	60.5 / 59.3	-	Sep 1600
Zone 8	23.1	22.4	78.1 / 65.5	60.5 / 59.3	-	Jul 1700
Zone 9	17.0	13.2	77.5 / 65.8	58.0 / 56.9	-	Sep 0900
Zone 10	15.2	14.8	77.9 / 65.6	60.7 / 59.5	-	Jun 1700
Zone 11	27.2	25.6	77.8 / 64.7	58.8 / 57.5	-	Jul 1600
Zone 12	14.1	13.8	77.6 / 64.5	59.1 / 57.9	-	Jul 1100
Zone 13	22.9	22.2	78.2 / 64.5	58.6 / 57.3	-	Jul 1000
Zone 14	18.6	18.3	77.6 / 64.8	59.6 / 58.4	-	Sep 1400
Zone 15	60.2	58.8	77.7 / 64.9	59.6 / 58.4	-	Oct 1400
Zone 16	19.6	19.3	77.9 / 65.4	60.5 / 59.3	-	Sep 1600
Zone 17	23.1	22.4	78.1 / 65.5	60.5 / 59.3	-	Jul 1700
Zone 18	17.0	13.2	77.5 / 65.8	58.0 / 56.9	-	Sep 0900

Figure 8 - WSHP Sizing Requirements

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HAP is both a load estimating and an energy simulation program. If the goal is to calculate design loads and size WSHP units to meet the design conditions, the detailed equipment data for the WSHP system components are not necessary. However, if the goal is to simulate annual energy costs, additional time is necessary to obtain and enter detailed equipment data for actual and realistic WSHP system components. The manufacturer's catalog or selection software should be used to ensure the accurate results.

Now it's time to select equipment to satisfy the system & zone loads. The following summarizes the selection and input of the Common Ventilation System, Water Source Heat Pumps, Cooling Tower, and Boiler. Figure 8 shows the Air System Properties under the Equipment tab. Clicking on the "Edit Equipment Data…" button will allow entry of the Common Ventilation System, WSHP, Cooling Tower, and Boiler equipment performance data.

Common Ventilation System

- The Common Ventilation System performance data must be entered as the "Vent. Cooling Unit" and "Vent. Heating Unit" as shown on Figure 9.
- An air-cooled DX rooftop unit with gas heat was selected for the make-up air unit in this example. Refer to the manufacturer's equipment selection software or product data to obtain the necessary performance data.
- Define the Common Ventilation System performance by clicking on the Edit Equipment Data… tab for the "Vent. Cooling Unit" and "Vent. Heating Unit" as shown in Figure 9.
- Since the cooling and heating load calculations have been performed, HAP will present the "Estimated Maximum Load" for the Vent. Cooling Unit as shown in Figure 10. This will be the basis for the equipment selection.
- Select the equipment and enter its performance data as shown in Figure 10.

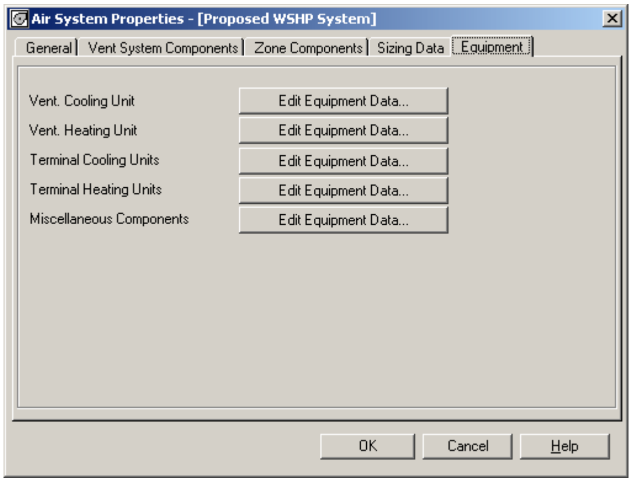

Figure 9 – Equipment Performance Data

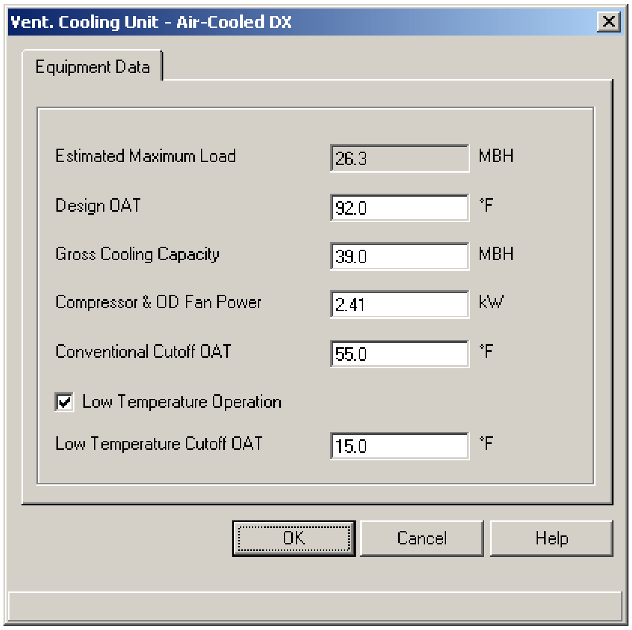

Figure 10 – Common Ventilation Equipment Performance

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Designing/Simulating WSHP (California Loop) Systems

Water Source Heat Pump Units

The WSHP units can now be selected. These selections are based on the "Zone Sizing Summary" report shown in Figure 8 above. This report provides the total and sensible coil load, heating load, and design airflow for each zone.

- Carrier's WSHP Builder program was used to select each of the units and generate an equipment schedule as shown in Figure 11.

- The WSHP equipment selection indicates the total and sensible cooling performance, heating performance, cooling and heating unit input energy (kW) plus the heat of extraction and heat of rejection rates. The total equipment capacity should be slightly greater than the estimated load to ensure the sensible cooling capacities may be met. In this example, the WSHP units will be selected from those shown in Figure 11.

- The cooling and heating kW values listed in Figure 11 represent the total unit values. This includes both the compressor and supply fan kW. Since HAP analyzes supply fan kW separately from compressor energy, the supply fan kW must be subtracted from the cooling and heating kW values prior to entering into HAP.

- Figure 12 represents an EXCEL spreadsheet used to manually calculate the compressor kW. Consult the Carrier product data or WSHP Builder program to obtain the indoor fan electric data. Figure 12 shows the fan FLA (amps) for each of the WSHP units. The FLA must be converted to kW by applying the following formula for single-phase direct-drive motors:

Fan kW = Fan FLA x Volts ÷1000
= 1.0 x 230 ÷1000
= 0.23 kW

Schedule Manager

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	1.5 ton unit	2 ton unit	2.5 ton unit	3 ton unit
Unit Model	50RHS	50RHS	50RHS	50RHS
Unit Size	1.5 Tons	2 Tons	2.5 Tons	3 Tons
Voltage	208/230-1-60	208/230-1-60	208/230-1-60	208/230-1-60
Quantity	1	1	1	1
Total Cooling (MBH)	18.2	24.7	29.1	34.8
Sensible Cooling (MBH)	15.3	19.7	25.1	22.7
Total Heating (MBH)	23.1	31.6	36.5	40.2
Cooling kW	1.3	1.7	2.0	2.5
Heating kW	1.2	1.8	2.0	2.5
Cooling EER	14.1	14.3	14.5	14.0
Heating COP	5.5	5.1	5.2	4.7
Heat of Extraction (MBH)	18.9	25.4	29.5	31.7
Heat of Rejection (MBH)	22.6	30.5	35.9	43.3
Design Air Flow (CFM)	1,100.0	1,100.0	1,100.0	1,100.0
Design ESP (in wg)	0.05	0.05	0.05	0.05
Actual Air Flow (CFM)	760	940	1,150	1,240
Actual ESP (in wg)	0.100	0.100	0.100	0.100
Cool EAT DB (F)	78.0	77.0	78.0	80.0
Cool EAT WB (F)	65.0	65.0	65.0	70.0
Heat EAT DB (F)	68.0	68.0	68.0	68.0
Water Loop Flow (gpm)	4.5	6.0	7.5	6.0
Water Pres. Drop (ft wg)	4.2	4.0	6.2	6.0
Max Fuse (amps)	15	20	25	30
Min Circuit Amps	11	14	17	19

Figure 11 - WSHP Equipment Selection

- For three-phase belt-drive electric motors, the formula is:

$$kW = \frac{Bhp \times 0.746}{\eta_m}$$

where:

Bhp = fan motor brake horsepower
0.746 = conversion factor
η_m = fan motor/drive efficiency (if unknown, use 0.85)

	1.5 ton unit	2 ton unit	2.5 ton unit	3 ton unit
Unit Model	50RHS	50RHS	50RHS	50RHS
Unit Size	1.5 Tons	2 Tons	2.5 Tons	3 Tons
Voltage	208/230-1-60	208/230-1-60	208/230-1-60	208/230-1-60
Total Cooling (MBH)	18.2	24.7	29.1	34.8
Sensible Cooling (MBH)	15.3	19.7	25.1	29.7
Total Heating (MBH)	23.1	31.6	36.5	40.2
Cooling kW	1.3	1.7	2.0	2.5
Heating kW	1.2	1.8	2.0	2.5
Cooling EER	14.1	14.3	14.5	14.0
Heating COP	5.5	5.1	5.2	4.7
Fan FLA (amps)	1.0	1.1	1.3	1.8
Fan (kW)	0.23	0.25	0.30	0.41
Compressor Cooling (kW)	1.07	1.45	1.70	2.09
Compressor Heating (kW)	0.97	1.55	1.70	2.09

Figure 12 – Compressor kW Calculation

Designing/Simulating WSHP (California Loop) Systems

- The compressor kW can now be determined by subtracting the fan kW from the cooling and heating kW for each WSHP unit. A simple spreadsheet calculation can be used as shown in Figure 12.

  Compressor kW = Cooling kW - Fan kW
  = 1.30 – 0.23
  = 1.07 kW

- The WSHP equipment performance data can now be entered into HAP. From the Air System Properties input screen, go to the Equipment tab, and then click on the "Edit Equipment Data…" button for the Terminal Cooling Units. Enter the WSHP equipment cooling performance data as shown on Figure 13.

- WSHP heating performance data should then be entered under Terminal Heating Units as shown in Figure 14.

- Be sure to define cooling and heating performance data for all WSHP units by clicking on the Zone Name for each WSHP.

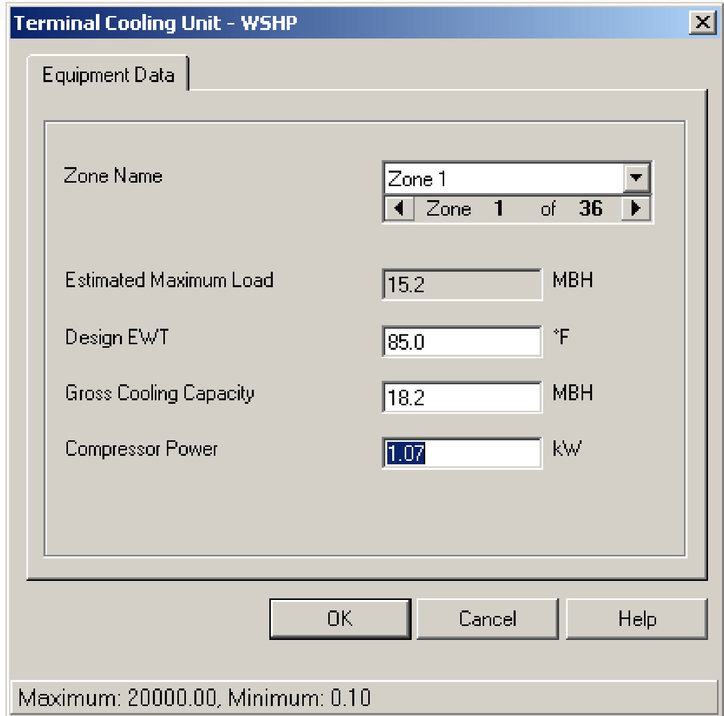

Figure 13 – WSHP Cooling Performance Data Entry

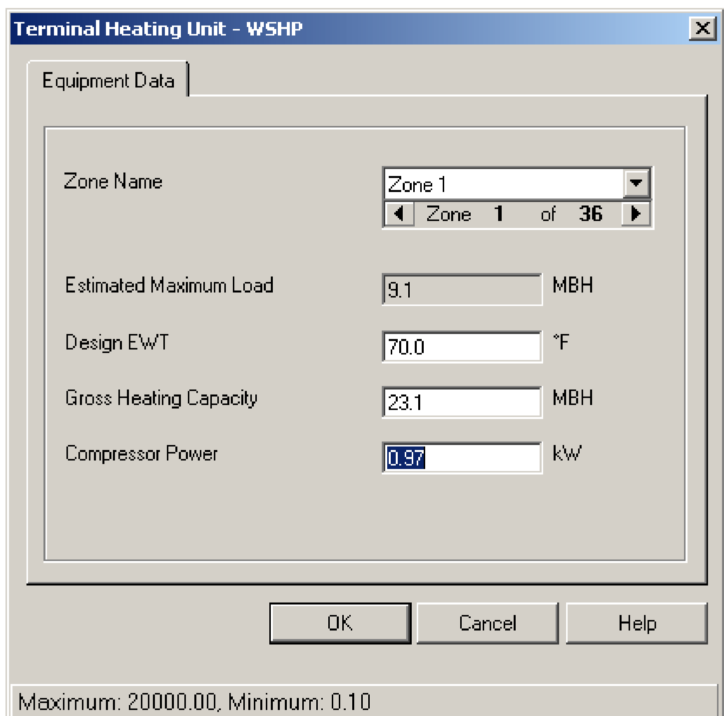

Figure 14 – WSHP Heating Performance Data Entry

Designing/Simulating WSHP (California Loop) Systems

Cooling Tower

The type of WSHP system must be defined so HAP can allow the configuration of a cooling tower and boiler. HAP recognizes that a "Closed Loop/WSHP" system configuration will require a cooling tower and boiler.

- Choose "Closed Loop/WSHP" as the system configuration as shown on Figure 15. This input screen comes from the Miscellaneous Components "Edit Equipment Data…" button shown in Figure 9.
- Next, the cooling tower size, total loop flow, and estimated loop pressure drop must be determined.
- The cooling tower should be sized based on the heat of rejection of the block cooling load or the total heat of rejection of all WSHP units connected to the WSHP loop. In this example, the total heat of rejection of all WSHP will be used to determine the cooling tower size. Carrier's WSHP Builder program provided this information for this example.

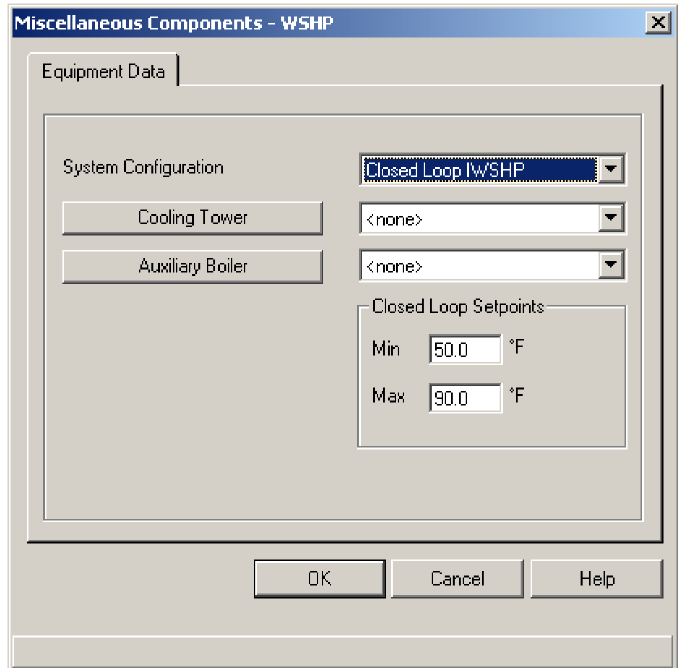

Figure 15 – Closed Loop WSHP System Configuration

- A simple spreadsheet calculation has been used to account for the total heat of rejection (THR), total loop flow, and estimated loop pressure drop for all WSHP units as shown in Figure 16.
- As a result, the tower should provide a minimum of 1310 MBH of heat rejection at design conditions.
- The loop pump must provide at least 297 gpm flow with sufficient head to overcome the loop pressure drop, including the pressure drop through the WSHP units, cooling tower and boiler.

	1.5 ton unit	2 ton unit	2.5 ton unit	3 ton unit	
Unit Model	50RHS	50RHS	50RHS	50RHS	
Unit Size	1.5 Tons	2 Tons	2.5 Tons	3 Tons	
Voltage	208/230-1-60	208/230-1-60	208/230-1-60	208/230-1-60	Grand Total
Total Cooling (MBH)	18.2	24.7	29.1	34.8	
Sensible Cooling (MBH)	15.3	19.7	25.1	29.7	
Total Heating (MBH)	23.1	31.6	36.5	40.2	
Cooling kW	1.3	1.7	2.0	2.5	
Heating kW	1.2	1.8	2.0	2.5	
Cooling EER	14.1	14.3	14.5	14.0	
Heating COP	5.5	5.1	5.2	4.7	
Heat of Extraction (MBH)	18.9	25.4	29.5	31.7	
Heat of Rejection (MBH)	22.6	30.5	35.9	43.3	
Water Loop Flow (gpm)	4.5	6.0	7.5	9.0	
Water Pres. Drop (ft wg)	4.2	4.0	6.2	6.0	
No. of Units	**11**	**10**	**9**	**11**	
Total Heat Rejection (Tower MBH)	**249**	**305**	**323**	**433**	**1310**
Total Heat Extraction (Boiler MBH)	**208**	**254**	**266**	**317**	**1044**
Total Loop Flow (gpm)	**49.5**	**66**	**82.5**	**99.0**	**297**

Figure 16 – Cooling Tower & Loop Pump Size Calculations

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Refer to the cooling tower manufacturer's data. In this example, a closed circuit cooling tower from Baltimore Air Coil was selected as shown in Figure 17.

The following information is typically needed to select the tower:

Fluid Type - In this example, water was used.
Loop Flow – Based on the sum of loop water flow (gpm) for all WSHP units
Entering Fluid Temperature to the Tower – Based on the following formula:

EWT = Leaving Fluid Temperature (°F) + [(THR)/(gpm * 500)]
= 85 °F + [(1,310,000 Btu/hr)/(300 gpm * 500)]
EWT = 93.8 °F

Leaving Fluid Temperature from the Tower – In this example, 85 °F was used.
Entering Wet Bulb Temperature – Based on outdoor weather data at peak design conditions. Refer to HAP Weather Properties for this information.

- Note the total fan motor power from the tower select is 5.0 Hp. Converting this to kW = 4.39.

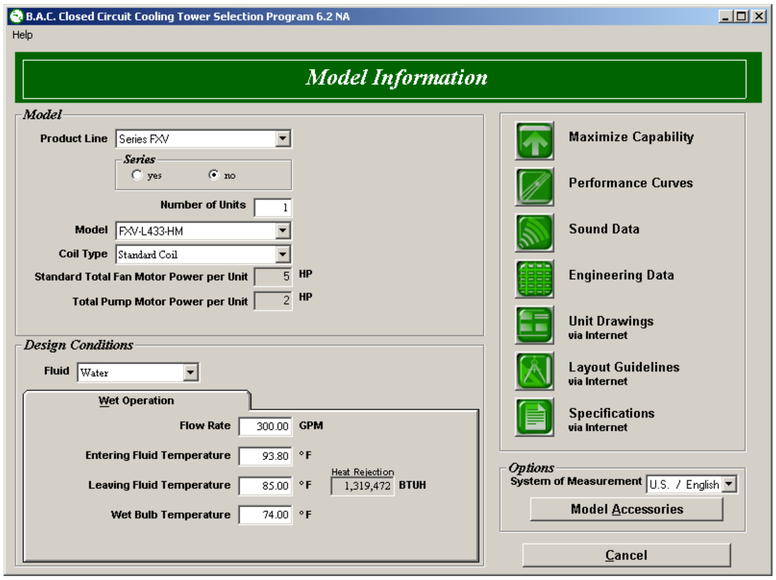

Figure 17 – Cooling Tower Selection
Photo Courtesy of Baltimore Air Coil

Now it's time to enter the cooling tower performance into HAP under the Cooling Tower Properties.

- Under Miscellaneous Components, click on the "Cooling Tower" button (refer to Figure 14 above) to launch the Cooling Tower Properties as shown in Figure 18.
- Enter the total loop flow as the Condenser Water Flow Rate.
- The Cooling Tower Model information should be determined from the cooling tower selection information.

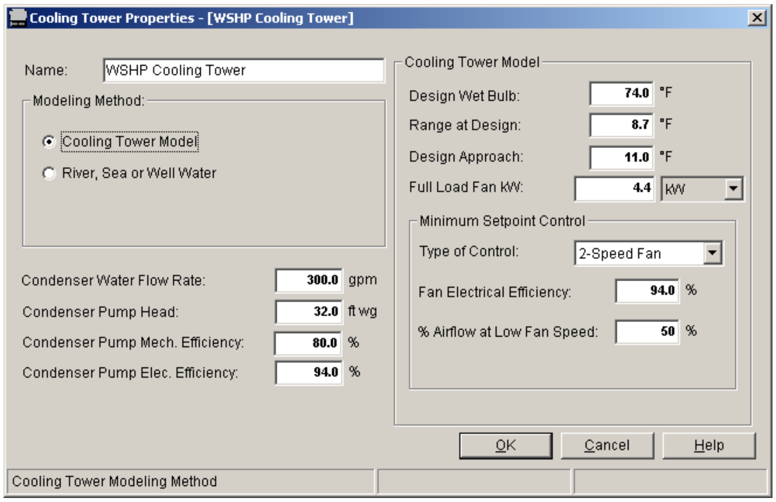

Figure 18 – Cooling Tower Properties Input

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Boiler

The boiler size for WSHP systems with night set back should be the sum of heat of extraction for all WSHP units. The spreadsheet calculation shown as Figure 16 shows the total heat of extraction of 1044 MBH. Refer to the boiler manufacturer's product data to select an appropriate boiler.

In this example, (4) ultra high efficiency condensing gas fired boilers with 20 to 100% modulation, low temperature operation capability each with 289 MBH net capacity where selected.

- Under Miscellaneous Components, click on the "Auxiliary Boiler" button (refer to Figure 15 above) to launch the Boiler Properties as shown in Figure 19.
- Enter the total loop flow as the Hot Water Flow Rate and other boiler performance data as shown in Figure 19.
- Click OK to save the boiler properties.

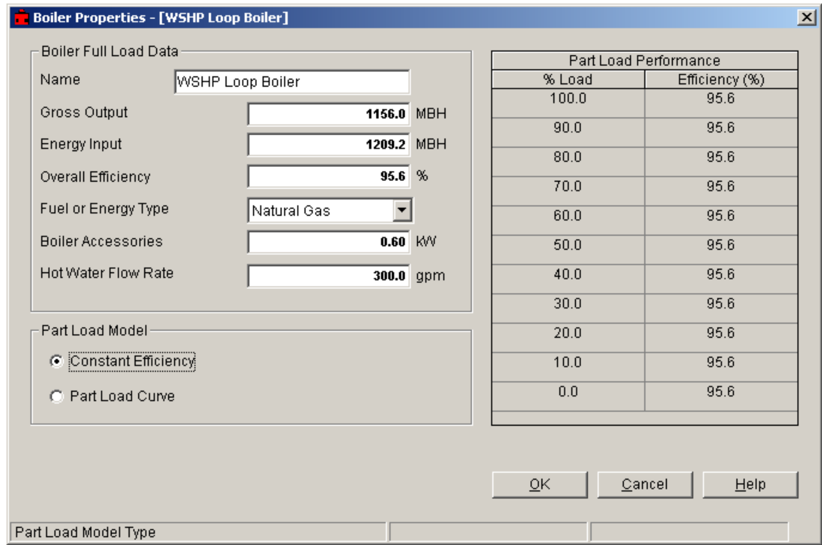


Figure 19 – Boiler Performance Data

This will conclude the Miscellaneous Components equipment data input. Once complete, the properties in Figure 20 will be shown. Notice the Closed Loop Setpoints were established at 50°F minimum and 85°F maximum.

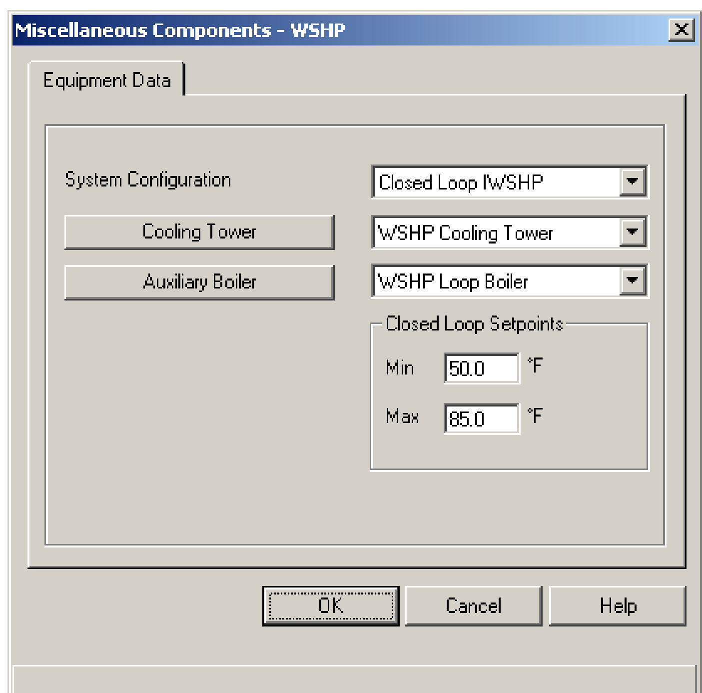


Figure 20 – Completed Miscellaneous Components Equipment Data

Designing/Simulating WSHP (California Loop) Systems

We can now continue with the plant and building definition.

Plants:

Plant inputs are not necessary for WSHP systems. All HVAC equipment energy is accounted for in air system calculations.

Buildings:

A building must be created to allow HAP to simulate all building systems and to calculate the annual energy costs.

- Add the Proposed WSHP System to the Building as shown in Figure 21.

- Miscellaneous energy consuming systems can be accounted for under the "Misc. Energy" tab. This tab defines other systems that can be simulated by HAP. Typical systems include, swimming pool heaters, domestic hot water heaters, parking lot lights, elevators, etc. In this example, no miscellaneous energy systems are included.

- Electric and natural gas meters must be added to the building as shown in Figure 22. The meters are based on actual site utility costs and rate structures.

- Refer to the utility company's web site or commercial customer representative for actual rate structures. Interpretation of the utility rate structure relative to HAP's electric and fuel rate properties input requirements could be a tedious task. Focused attention should be given to the definition of the rate structures.

- Further guidance can be found in the HAP Help system by pressing F1 or referencing HAP Quick Reference Guide, Chapter 6.13, "Modeling Utility Rate Structures" available on the HAP installation CD or by ordering catalog number 811-262 from your local Carrier representative.

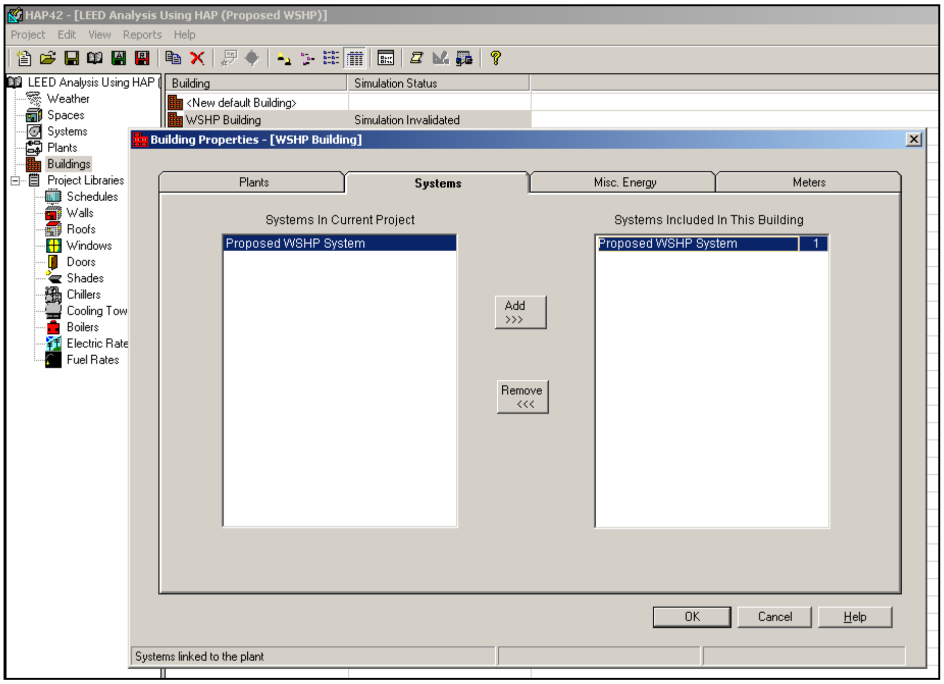


Figure 21 – Building Properties Input

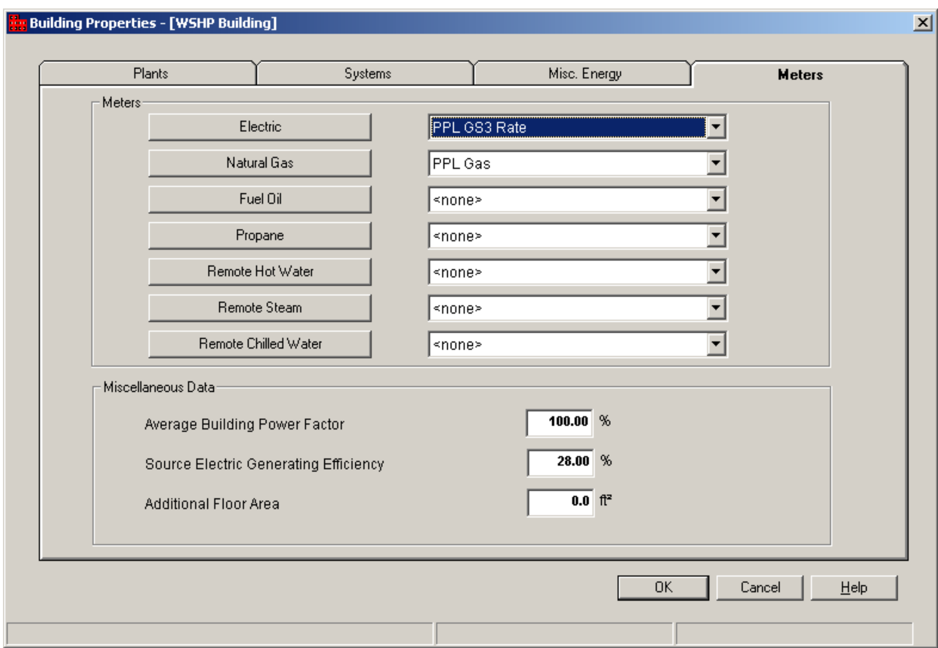


Figure 22 – Utility Meter Selection

Software Systems Technical Support:
software.systems@carrier.utc.com
1-800-253-1794

Designing/Simulating WSHP (California Loop) Systems

Energy Simulation:

Note: WSHP systems take longer to simulate than other HVAC systems because many iterations must be done between the performance of the WSHP units and the interaction with the loop. These iterations must occur before the calculations can converge on a balance point. Because all WSHP units in a single system are connected to a common loop, it is suggested that whenever possible, reduce the number of WSHP units modeled by "lumping" similar thermal zones together rather than modeling single "typical" units for every single space. Be sure to only combine zones with similar thermal loads, such as those common to a particular area, exposure, or occupancy. As an example, (10) 1.5 ton units serving the north exposure could be combined together to model (1) 15-ton zone.

- To initiate the building energy simulation, right mouse click on the WSHP Building and select the “Print/View Simulation Data”.
- HAP can generate many simulation reports as shown in Figure 23.
- Click on the “Preview” button to initiate the simulation calculation.
- A sample of the simulation reports is shown in Figure 24.

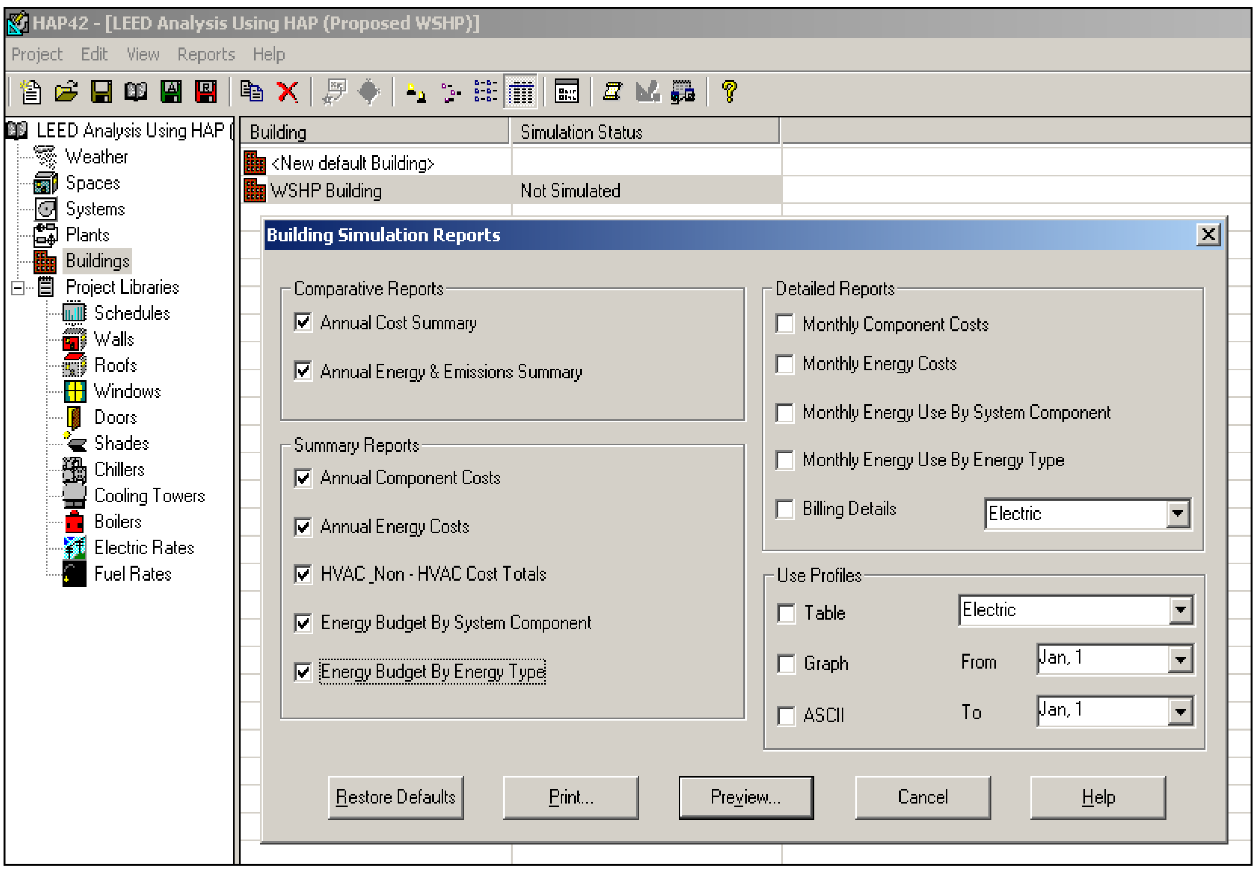
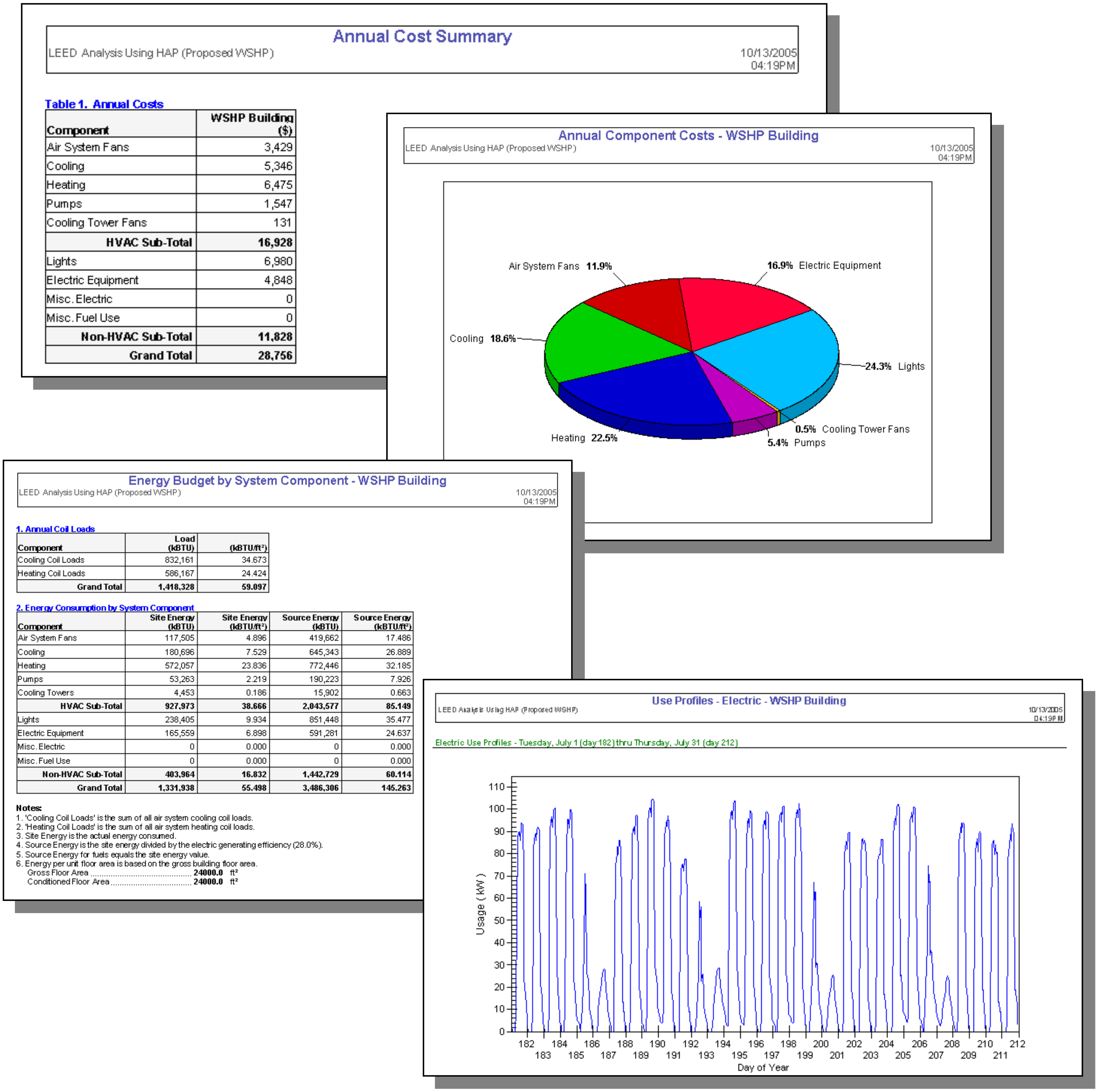


Figure 23 – Building Energy Simulation Report Selection

Designing/Simulating WSHP (California Loop) Systems

Simulation Results:



Annual Cost Summary

LEED Analysis Using HAP (Proposed WSHP) 10/13/2005 04:19PM

Table 1. Annual Costs

Component	WSHP Building ($)
Air System Fans	3,429
Cooling	5,346
Heating	6,475
Pumps	1,547
Cooling Tower Fans	131
HVAC Sub-Total	**16,928**
Lights	6,980
Electric Equipment	4,848
Misc. Electric	0
Misc. Fuel Use	0
Non-HVAC Sub-Total	**11,828**
Grand Total	**28,756**

Energy Budget by System Component - WSHP Building

LEED Analysis Using HAP (Proposed WSHP) 10/13/2005 04:19PM

1. Annual Coil Loads

Component	Load (kBTU)	(kBTU/ft²)
Cooling Coil Loads	832,161	34.673
Heating Coil Loads	586,167	24.424
Grand Total	**1,418,328**	**59.097**

2. Energy Consumption by System Component

Component	Site Energy (kBTU)	Site Energy (kBTU/ft²)	Source Energy (kBTU)	Source Energy (kBTU/ft²)
Air System Fans	117,505	4.896	419,662	17.486
Cooling	180,696	7.529	645,343	26.889
Heating	572,057	23.836	772,446	32.185
Pumps	53,263	2.219	190,223	7.926
Cooling Towers	4,453	0.186	15,902	0.663
HVAC Sub-Total	**927,973**	**38.666**	**2,043,577**	**85.149**
Lights	238,405	9.934	851,448	35.477
Electric Equipment	165,559	6.898	591,281	24.637
Misc. Electric	0	0.000	0	0.000
Misc. Fuel Use	0	0.000	0	0.000
Non-HVAC Sub-Total	**403,964**	**16.832**	**1,442,729**	**60.114**
Grand Total	**1,331,938**	**55.498**	**3,486,306**	**145.263**

Notes:
1. 'Cooling Coil Loads' is the sum of all air system cooling coil loads.
2. 'Heating Coil Loads' is the sum of all air system heating coil loads.
3. Site Energy is the actual energy consumed.
4. Source Energy is the site energy divided by the electric generating efficiency (28.0%).
5. Source Energy for fuels equals the site energy value.
6. Energy per unit floor area is based on the gross building floor area.
   Gross Floor Area .... **24000.0** ft²
   Conditioned Floor Area .... **24000.0** ft²

Figure 24 – Building Energy Simulation Results