

EXchange



HAP v6.0: Enhanced and Expanded Weather Data

This is the third in a series of articles describing key features in the upcoming HAP v6.0 release. In the first article ([Volume 5, Issue 3](#)) we described the rationale for transforming HAP, the "staged" approach designed to help you remain productive as the software evolves, and the key features in the first staged release. In the second article ([Volume 6, Issue 2](#)) we provided an overview of the sketch-over, "visual" take-off process that uses a graphical input of building floor plans to enhance your productivity. From this graphical input process spaces, surface areas and orientations will automatically get created. This includes the ability to graphically place windows and doors in the building envelope, create multiple types of flat or sloped roofs and also create attics and ceiling spaces. This new sketch-over feature will significantly streamline the takeoff process of getting the physical space data defined. This article provides an overview of the new HAP v6.0 Weather Data interface.



The new v6.0 Weather data includes the following enhancements:

- New design weather data for 8,100 sites worldwide, from latest ASHRAE Handbook – Fundamentals.
- Updated simulation weather data for over 8,100 sites worldwide, using TMY3, CWEC, IWEC2 and Climate.OneBuilding data.

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- New Graphical method of choosing site for weather data.
- Automatic loading of paired design and simulation weather data. No longer need to select simulation weather separately.
- Ability to independently choose comfort (design) level or dehumidification design weather for cooling (0.4%, 1%, 2%) and heating (99.6%, 99%, 98%).
- Updated clear sky solar calculation from latest ASHRAE Handbook – Fundamentals.
- Updated Solar tab to show Maximum Solar Fluxes instead of Maximum Solar Heat Gains.
- Added input for site CO₂ concentration (moved from air systems).

- Minor revisions to design weather reports.
- Removed of Atmospheric Clearness Number (obsolete now).

The new v6.0 Weather Design Parameters tab may look similar to the previous v5.11 version at first glance, see Figures 1 & 2 below, however there are lots of new enhancements.

Using Baltimore, Maryland as an example, let's compare HAP v5.11 weather locations with upcoming HAP v6.0. Figure 1 below indicates the existing HAP v5.11 Design Weather Properties, while Figure 2 illustrates the changes and new features in v6.0, as outlined in red.

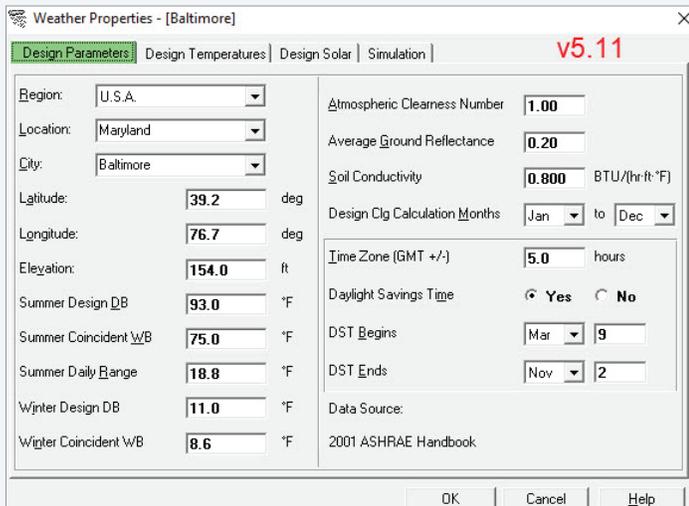


Figure 1. HAP v5.11 Weather Properties - Design Parameters

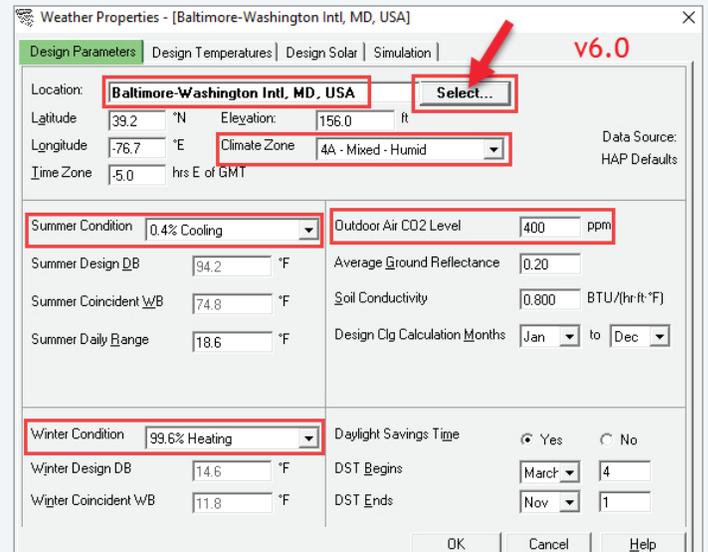


Figure 2. HAP v6.0 Weather Properties - Design Parameters

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As indicated previously, there are some 8,100 new worldwide design weather locations in HAP v6.0 plus approximately the same number of new simulation weather files using TMY3, CWEC, IWE2 and Climate.OneBuilding data. The simulation weather will now automatically be selected for you when you select the design weather location, rather than having to perform this as a separate task. Another major weather enhancement includes the ASHRAE 90.1 Climate Zone as part of the weather data. This greatly improves productivity when modeling LEED® projects requiring specific weather conditions. In addition, we now have the ability to select summer cooling (0.4%, 1%, 2%) and winter heating (99.6%, 99%, 98%) design conditions as well as dehumidification weather. The new dehumidification weather allows us to analyze the site at the design WB (wet bulb) and MCDB (mean coincident dry bulb) conditions; critically important for sizing evaporative cooling systems and components or applications with large ventilation loads. And finally, the outdoor air CO₂ level is now part of the weather data rather than entered in the system under DCV (demand-controlled ventilation) settings. Other enhancements to the weather are described in the bulleted list above.

The first main difference to highlight in the new v6.0 Weather Properties screen is instead of multiple drop-down lists to choose region, location & city you simply click the “Select” button, (see Figure 2). This opens the Step 1 of a four-part Weather Wizard screen. There are two possible methods of selecting the weather location, as shown in Figure 3 below, either by Name of city or town or by Latitude/Longitude.

For this example, we will select by city name. Press “Next” and this brings you to Step 2: Select Location. To select a location simply start typing the name and the program will display all cities that match your text. For example, as you type, “Balti” the list indicates all the cities in the world that begin with that particular text string. At that point you may simply select the city/location you want from the list that appears; in this example Baltimore, Maryland, US, as shown in Figure 4 below.

Select Baltimore MD, US and press “Next”. This opens a map of the area which shows 10 of the closest weather stations in the vicinity of Baltimore, MD, as indicated in Figure 5, on page 4.

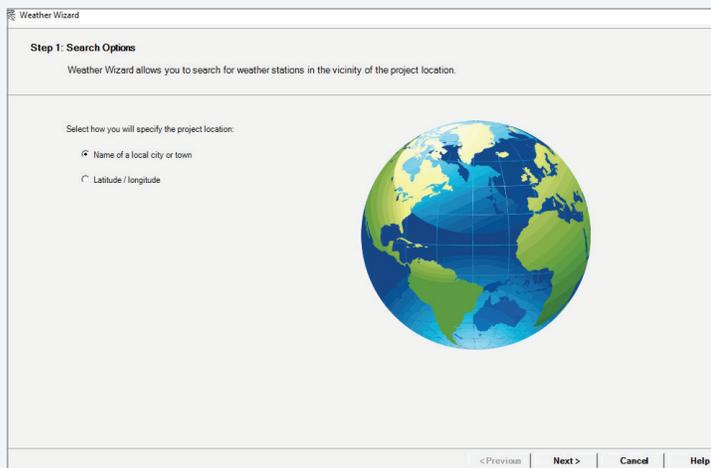


Figure 3. HAP v6.0 Weather Wizard – Step 1: Search Options

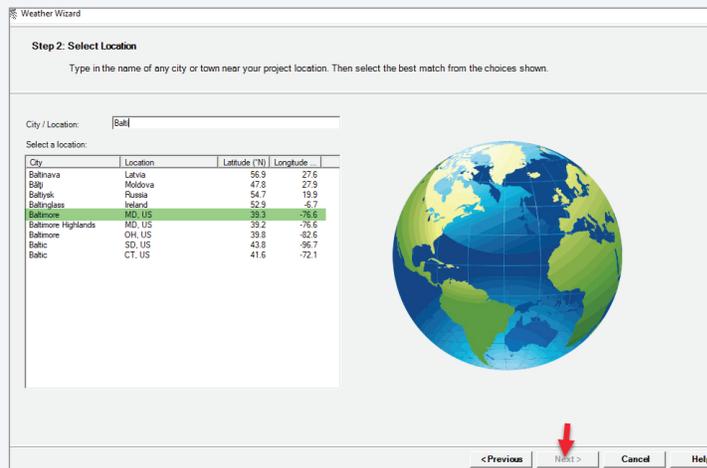


Figure 4. HAP v6.0 Weather Wizard – Location Selection

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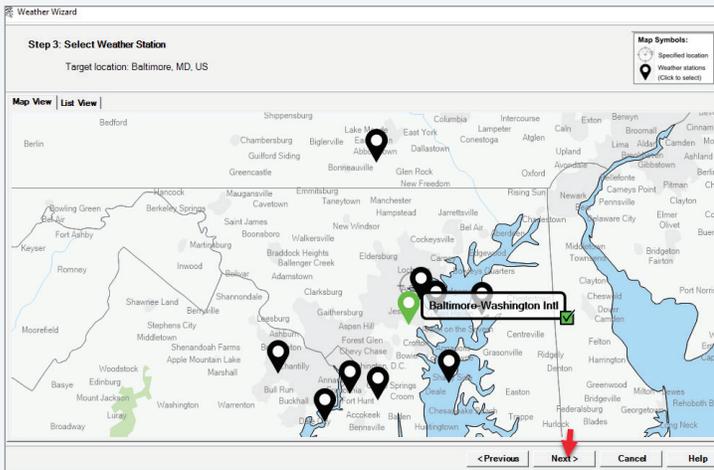


Figure 5. HAP v6.0 Weather Wizard – Step 3: Select Weather Station

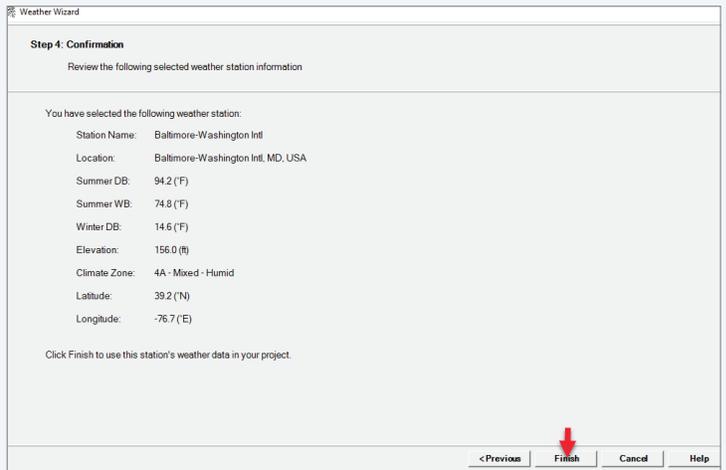


Figure 6. HAP v6.0 Weather Wizard – Step 4: Confirmation

As indicated, there are 10 separate weather locations in the Baltimore vicinity. Hovering your mouse pointer over each place marker (weather station) on the map displays the specific location; in this case Baltimore-Washington Intl Airport is selected. Click on the location you want then press “Next” and it will bring you to Step 4: Confirmation, as shown in Figure 6, above. This allows you an opportunity to confirm the weather station location prior to finishing.

Finally, press “Finish” and this brings you back to the Design Weather Parameters screen, as shown in Figure 2. As noted previously, the simulation weather data for the location is automatically selected for you when you select the design weather.

Expanded weather data is just the “tip of the iceberg” as far as new features coming in HAP 6.0. In the next *EXchange* newsletter we will highlight additional new features of HAP v6.0.



Sizing Cooling Towers & Boilers for Closed-Loop WSHP Systems

The HAP program models all types of water-source terminal heat pump units including closed-loop (water-source), open-loop (ground-water source) and ground-source (geothermal). The closed-loop WSHP system is also sometimes referred to as a “California Loop” WSHP system. The closed-loop WSHP system is applicable to any building that may require multiple control zones, especially those applications where simultaneous cooling and heating loads may occur. The primary advantage of a WSHP system is any zone can have either cooling or heating, as required without having to implement a change-

over sequence on a central plant or air handling unit. Heat is exchanged with a common recirculating loop by rejecting heat (units in cooling mode) or extracting heat (units in heat pump heating mode). The WSHP system airside schematic is shown below in Figure 7. A secondary advantage of this system is in winter when perimeter zones require heat, they may extract heat from the loop that is rejected by the internal (core) zones, which usually require cooling year-round. This allows for heat reclaim to occur, thereby saving significant heating operating costs.

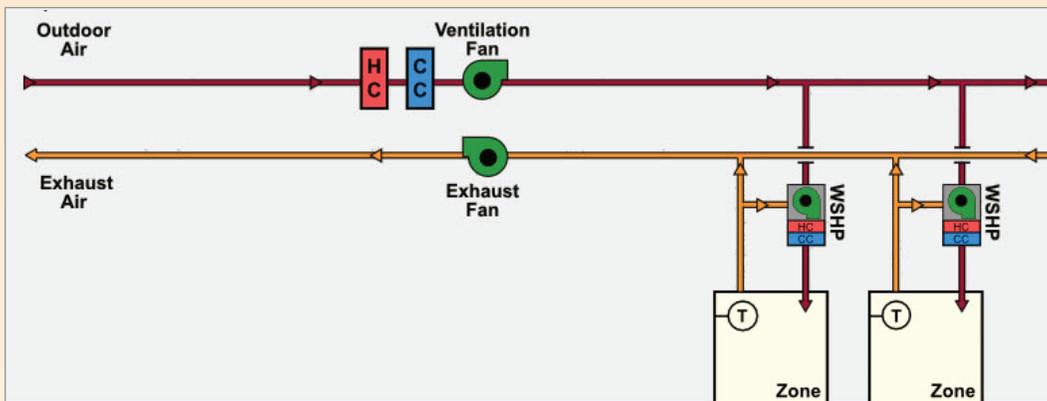


Figure 7. WSHP Airside System Schematic

HAP calculates and reports the zone-by-zone design cooling and heating loads in the *Zone Sizing Summary Report*, as shown in Figure 8.

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 Coil Load	Zone CFM/ft²
Core-Z05	140.9	106.3	75.3 / 65.1	58.0 / 57.1	-	Jul 0600	0.69
East-Z02	39.7	34.1	75.6 / 64.2	58.0 / 56.9	-	Jul 1000	1.44
North-Z01	46.0	38.0	75.2 / 64.8	58.8 / 57.8	-	Jul 1800	1.08
South-Z03	62.6	54.2	75.6 / 64.5	58.7 / 57.7	-	Oct 1500	1.50
West-Z04	43.7	38.5	75.7 / 64.6	59.0 / 57.9	-	Jul 1800	1.70

Terminal Unit Sizing Data - Heating, Fan, Ventilation							
Zone Name	Heating Coil Load (MBH)	Heating Coil Ent/Lvg DB (°F)	Htg Coil Water Flow @20.0 °F (gpm)	Fan Design Airflow (CFM)	Fan Motor (BHP)	Fan Motor (kW)	OA Vent Design Airflow (CFM)
Core-Z05	51.3	68.1 / 76.5	-	5806	0.859	0.681	819
East-Z02	19.6	69.3 / 79.4	-	1834	0.271	0.215	124
North-Z01	29.7	68.7 / 81.5	-	2191	0.324	0.257	197
South-Z03	29.2	69.1 / 78.3	-	3030	0.448	0.355	197
West-Z04	17.6	68.9 / 76.6	-	2173	0.321	0.255	124

Figure 8. Zone Sizing Summary Report – Terminal Unit Sizing Data

(Continued from page 5)

Each separate WSHP terminal unit is then sized to meet its respective peak cooling and heating loads. Generally, some type of electronic equipment selection software is used, such as *Carrier's Electronic Catalog* (E-CAT) Program. This allows a fast selection to be performed and provides all capacity and performance values as well as critical sizing data for the waterside (pump) pressure loss and airside (fan) pressure and fan power as well as electrical service requirements. As an example, a typical E-CAT equipment schedule is shown in Figure 9 right, for the Z05 – Core zone only. The core area zone will be divided into two equally-sized WSHP terminal units. As you can see the unit selection below meets or exceeds the design load requirements, as indicated in Figure 8 for the Z05 Core zone.

Now that we have the air terminal sizing and equipment selection completed, we may move on to the water-side of the system. The WSHP plant schematic is shown below in Figure 10 and includes the WSHP terminals, a common water loop, loop pumps, cooling tower and auxiliary boiler.

	Z-05 Core
Unit Model	50HQP
Unit Size	072 (6 tons)
Voltage	208/230-1-60
Quantity	1
Total Cooling (MBH)	73.0
Sensible Cooling (MBH)	54.4
Total Heating (MBH)	94.9
Cooling kW	4.7
Heating kW	5.3
Cooling EER	13.4
Heating COP	5.2
Heat of Extraction (MBH)	79.3
Heat of Rejection (MBH)	86.9
Actual Air Flow (CFM)	2,900
Actual ESP (in wg)	0.250
Cool EAT DB (F)	75.3
Cool EAT WB (F)	65.1
Heat EAT DB (F)	68.1
Water Loop Flow (gpm)	18.0
Water Pres. Drop (ft wg)	17.4
Max Fuse (amps)	60
Min Circuit Amps	45

Figure 9. Equipment Schedule from E-CAT Selection Software

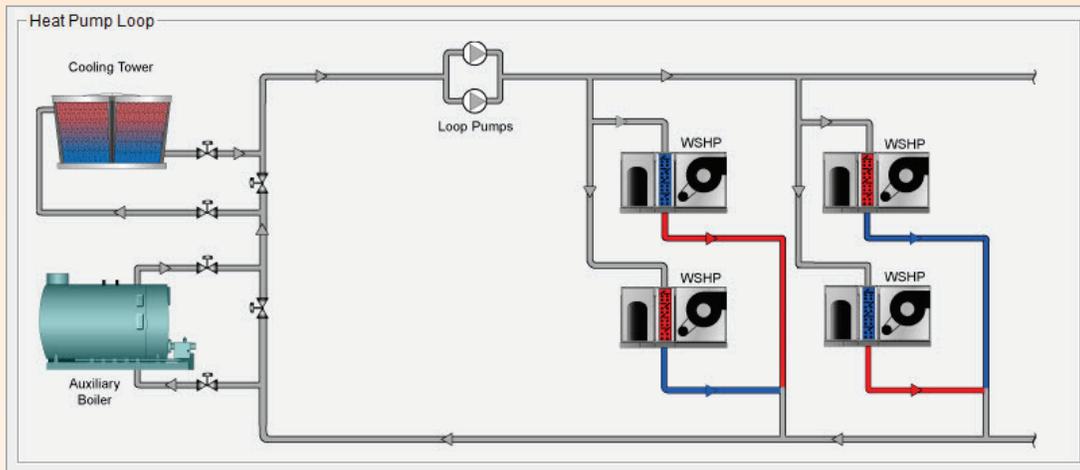


Figure 10. Water-Source Heat Pump Hydronic Plant Schematic

The common water loop is generally maintained between an upper and lower loop setpoint temperature. A typical loop temperature control range is 86° F for the upper setpoint and 68° F for the lower setpoint. As long as the loop temperature remains between the upper and lower setpoints the WSHP terminals simply reject and extract heat to and from the loop, respectively. Should the loop temperature rise above the upper setpoint (86° F) the cooling tower is energized to maintain the loop at or below the maximum setpoint. Likewise, should the loop temperature drop below the lower setpoint (68° F) the supplemental boiler is energized to keep the loop at the minimum loop setpoint.

We must also size a cooling tower to reject the heat from the circulating loop as well as a supplemental boiler to heat the loop in winter. To size the tower and boiler we need the maximum simultaneous peak cooling and heating loads for all WSHP terminal units. This is sometimes referred to as the "block load" on the building. The Zone Sizing Summary Report (see Figure 8) lists the individual terminal unit peak cooling loads. However, if you notice the times of the peak zone cooling coil loads are not coincident, in other words they do not all peak at the same time of day or month. The east (Z02) zone peaks in the morning at 10 am in July while the west (Z04) and north (Z01) zones peak at 6 pm in July and

(Continued from page 6)

the south zone (Z03) peaks at 3 pm in October. This October peak is due to the low solar angle of incidence, which results in the largest peak solar gain at that time of the year for south facing exposures.

So, because of the non-coincident zone peak load times we cannot simply add together all the WSHP peak zone cooling

loads to arrive at the block loads. We need a way to determine the simultaneous peak. Fortunately, there is an easy way. HAP has a report called the *Air System Design Load Summary*.

This report is shown below in Figure 11.

Air System Design Load Summary for WSHP						
Project Name: WSHP Prepared by: Carrier						
	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Jul 1800 COOLING OA DB / WB 98.0 °F / 73.5 °F			HEATING DATA AT DES HTG HEATING OA DB / WB 17.0 °F / 13.9 °F		
ZONE LOADS	Details	Sensible (BTU/hr)	Latent (BTU/hr)	Details	Sensible (BTU/hr)	Latent (BTU/hr)
Window & Skylight Solar Loads	1200 ft²	44980	-	1200 ft²	-	-
Wall Transmission	4800 ft²	8789	-	4800 ft²	11957	-
Roof Transmission	15000 ft²	65343	-	15000 ft²	72345	-
Window Transmission	1200 ft²	13484	-	1200 ft²	34980	-
Skylight Transmission	0 ft²	0	-	0 ft²	0	-
Door Loads	0 ft²	0	-	0 ft²	0	-
Floor Transmission	15000 ft²	0	-	15000 ft²	11366	-
Partitions	0 ft²	0	-	0 ft²	0	-
Ceiling	0 ft²	0	-	0 ft²	0	-
Overhead Lighting	12300 W	41967	-	0	0	-
Task Lighting	0 W	0	-	0	0	-
Electric Equipment	11250 W	38385	-	0	0	-
People	75	39375	69375	0	0	0
Infiltration	-	0	0	-	0	0
Miscellaneous	-	0	0	-	0	0
Safety Factor	0% / 0%	0	0	0%	0	0
>> Total Zone Loads	-	252323	69375	-	130648	0
Zone Conditioning	-	263192	69375	-	130720	0
Plenum Wall Load	0%	0	-	0	0	-
Plenum Roof Load	0%	0	-	0	0	-
Plenum Lighting Load	0%	0	-	0	0	-
Exhaust Fan Load	1463 CFM	1084	-	1463 CFM	-1084	-
Ventilation Load	1463 CFM	32173	5258	1463 CFM	82667	0
Ventilation Fan Load	1463 CFM	1626	-	1463 CFM	-1626	-
Space Fan Coil Fans	-	6018	-	-	-6018	-
Duct Heat Gain / Loss	0%	0	-	0%	0	-
>> Total System Loads	-	304093	74633	-	204659	0
Cooling Coil	-	60317	19458	-	0	0
Heating Coil	-	0	-	-	57111	-
Terminal Unit Cooling	-	243818	55693	-	0	0
Terminal Unit Heating	-	0	-	-	147502	-
>> Total Conditioning	-	304135	75151	-	204614	0
Key:	Positive values are clg loads Negative values are htg loads			Positive values are htg loads Negative values are clg loads		
	Cooling Tower Load:			Boiler Load:		
	304,135			204,614 Btu/hr * 1.25		
	+ 75,151			255,768 Btu/hr		
	379,286 Btu/hr * 1.25					
	474,108 Btu/hr					

Figure 11. Air System Design Load Summary – Cooling Tower & Boiler Sizing

(Continued from page 7)

There are two separate cooling and heating coil loads indicated. The "Cooling Coil" and "Heating Coil" loads are for the DOAS system, which is preconditioning the ventilation air for delivery to the WSHP terminal units. The "Terminal Unit" cooling and heating loads are the "block" loads on the overall system at the design summer and winter conditions. The rule-of-thumb for computing cooling tower and boiler sizes is to use a 1.25 multiplier to the peak loads to account for the heat of compression (cooling) and for the morning warm-up period (heating) after night setback. Cooling tower and boiler sizing calculations are indicated in Figure 11.

Alternatively, on the cooling tower sizing, if you have actual E-CAT equipment selections for the WSHP terminal

units (see Figure 9) the "Heat of Rejection" is indicated. Again, this includes the heat-of-compression, which is 86.9 MBH. Simply sum all of the heat-of-rejection values for all the terminal units to arrive at the value needed for the cooling tower size.

One last thing... if you plan to run an energy simulation on your building, you should go back into the HAP WSHP system inputs and adjust your assumed equipment cooling and heating capacities and kW values, supply fan static as well as the water loop flow and pump heads, if necessary to reflect the actual equipment performance rather than using default values. If you used "auto-sizing" you may now change this to user-defined sizing and instead input the actual sizes of the equipment selected.



Frequently Asked Questions

FAQ #1: I am modeling a packaged, air-cooled DX unit in HAP and am curious about the difference between “Conventional Cutoff OAT” and “Low Temperature Cutoff OAT” in the Cooling Equipment Data settings? In other words, if I set conventional cutoff to 0° F is that the same as setting low temperature cutoff to 0° F?

Answer: No, those inputs are not the same, each will yield a different result. A full explanation of each option is below. The Cooling Equipment Data input screen is shown in Figure 1.

Before we discuss how to configure the cutoff temperatures in HAP let’s first explain what low-temperature operation is. Many buildings have internal heat gains all year such that the building, especially interior spaces or spaces with high internal load density, require cooling year-round. Specific applications that meet this requirement of year-round cooling include: computer server rooms, electrical equipment rooms, process cooling areas and conference rooms with a large people density.

On a DX refrigerant system, the condensing temperature (and corresponding refrigerant pressure) drops as the outdoor air temperature drops. The “lift” or work the compressor must do to compress the refrigerant gas also decreases as ambient conditions drop. However, at some particular outdoor air temperature the condensing pressure drops to a point where the refrigerant metering device is no longer capable of properly metering the refrigerant, resulting in short-cycling of the compressor and during cold weather will prevent the cooling compressor from starting. A low-pressure (aka low-ambient) control consists of a refrigerant pressure sensor on the condenser coil which detects low condensing pressure. This sensor connects to a fan controller that controls the condenser fan operation either by cycling the fan(s) or modulating their speed. Less air across the condenser coil allows the condensing pressure to remain at a higher level, which keeps the mechanical cooling on-line.

Under the Cooling Equipment Data tab in HAP (see Figure 1 above) there are three separate operational inputs for an air-cooled DX unit, each of which are described below:

Conventional Cutoff OAT is the outdoor air temperature above which the air-cooled DX equipment operates in a conventional fashion. Above the cutoff the system efficiency changes as a function of OADB, EWB and airflow through

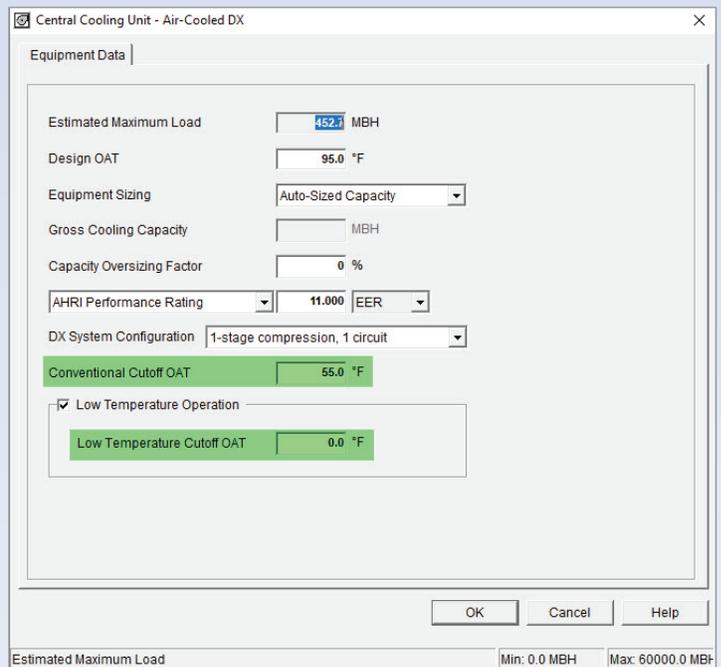


Figure 1. Central Cooling Unit – Air-Cooled DX Equipment Data Input Screen

the condenser coil. For equipment with special low-ambient (head pressure) controls, the unit operates normally above this cutoff temperature and cycles or modulates the outdoor (condenser) fans to maintain a constant head pressure below this temperature. For equipment without special low-ambient controls, the unit operates normally above this temperature and is off for temperatures colder than this value. NOTE: since mechanical cooling is disabled below this cutoff temperature this may result in unmet cooling load hours unless an airside economizer is employed.

Low Temperature Operation checkbox specifies whether special controls are used to allow a DX cooling unit to operate at low-ambient temperatures. When this control is used, the program assumes head pressure is maintained at a constant level below the “Conventional Cutoff OAT”. This is achieved by cycling or modulating condenser fan operation.

(Continued from page 9)

On the other hand, if low temperature control is not used, the program assumes the unit will not operate below the Conventional Cutoff OAT.

Low Temperature Cutoff OAT defines the outdoor air temperature when head pressure (low temperature operation) control is used. For temperatures between the "Conventional Cutoff OAT" and the "Low Temperature Cutoff OAT", the DX unit operates with the special head pressure controls. Below the "Low Temperature Cutoff OAT" the unit is off.

The DX unit refrigerant system will operate differently above and below Conventional Cutoff OAT. Below the cutoff you basically operate at the efficiency you had at the Conventional Cutoff OAT because the refrigeration system is trying to falsely maintain the same condensing

pressure so your lift doesn't get smaller. Compressor power stays relatively constant. There are small changes in condenser fan power since as it gets colder you need less airflow over the condenser coil to maintain steady condenser pressure so you can modulate the condenser fans. That's a bit of an oversimplification, but it's a decent oversimplification to understand what's going on. If you set Conventional Cutoff OAT = 0° F, HAP will interpret that as saying the equipment operates normally all the way down to 0° F and never goes into head pressure control. But if you say YES to Low Temperature Operation and set Low Temperature Cutoff of 0° F, then HAP models head pressure control down to 0° F, and that will give you much higher compressor and OD fan kW over that range.

FAQ #2: I have a building with 29,000 CFM of ventilation air and am attempting to model a heat reclaim (H/R) device in HAP to capture heat from the exhaust (return) air taken from various zones in the building. 13,000 CFM of this ventilation air is being directly exhausted from restrooms, kitchen and chemical storage rooms, resulting in 16,000 CFM of return/exhaust air returning to the H/R device, as indicated in Figure 2 below.

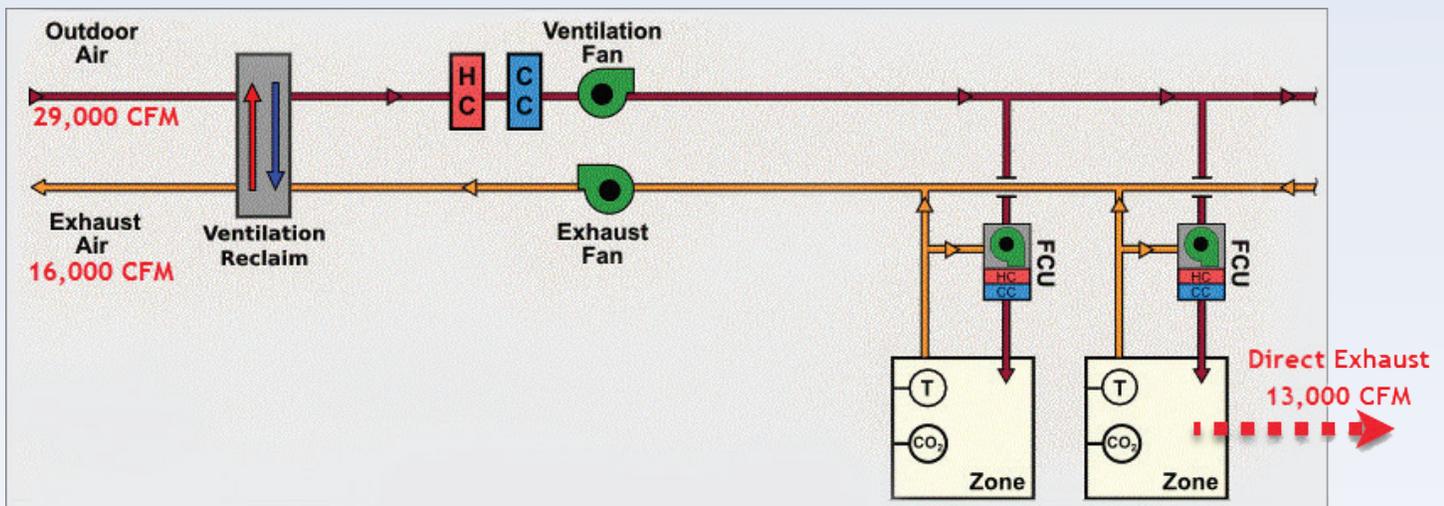


Figure 2. Terminal Unit System with Heat Reclaim Device & Unbalanced Ventilation/Exhaust Airflows

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I am using a terminal fan coil system and under the Zone Components tab under the System for Thermostat the “Direct Exhaust Airflow” input field is grayed-out and unavailable (see Figure 3 right). When I model the H/R in the DOAS unit serving the fan coil units HAP assumes all the exhaust air is flowing back through the return duct to the central DOAS unit. How do I account for this unbalanced airflow across the return (exhaust) side of the H/R device?

Answer: You cannot directly input CFM on the exhaust side of the H/R device; however, you can get around this limitation by determining an “equivalent” thermal efficiency of the H/R device. So, if you have 29,000 CFM of ventilation air and 16,000 CFM on the exhaust-side a simple ratio of the two airflows may be applied to the balanced airflow **actual** thermal efficiency of the device to arrive at an **equivalent** thermal efficiency as follows:

Equivalent Thermal Efficiency = Actual Thermal Efficiency with balanced airflows * 16000 / 29000

For example, assuming your actual thermal efficiency with balanced airflows is 75%, the equivalent thermal efficiency would be: $75\% (16/29) = 41.4\%$

This equivalent thermal efficiency is then entered in HAP for the H/R device thermal efficiency, see Figure 4.

This adjustment is required so the BTUs transferred to or from the OA stream will reflect real performance of having 16,000 CFM instead of the 29,000 CFM the program thinks is going thru the exhaust side. This way you can keep the DOAS system configuration in-place and get the reclaim heat quantities correct at the same time.

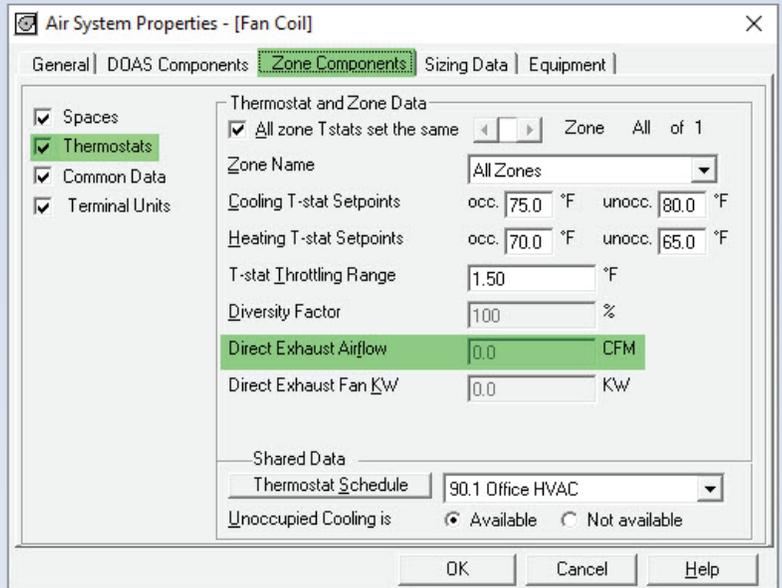


Figure 3. Terminal Unit System – HAP Zone Components Input for Direct Exhaust (grayed-out)

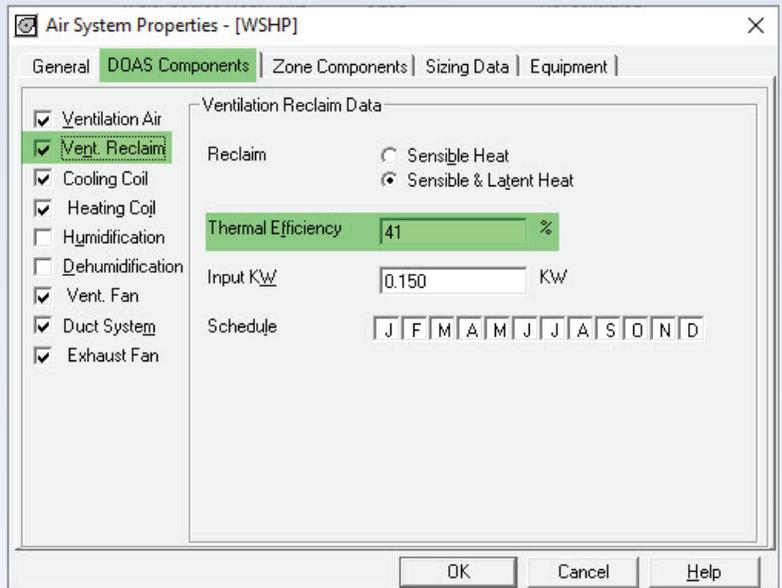


Figure 4. Terminal Unit System – DOAS Components Input for Vent Reclaim Thermal Efficiency

Upcoming eDesign Suite Training Classes

Location	Load Calculation for Commercial Buildings <i>System Design Load HAP</i>	Energy Simulation for Commercial Buildings <i>HAP</i>	Energy Modeling for LEED® Energy & Atmosphere Credit 1 <i>HAP</i>	Advanced Modeling Techniques for HVAC Systems <i>HAP</i>	Engineering Economic Analysis <i>EEA</i>	Block Load Basic <i>Block Load</i>
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New York, NY	Sneak Peek: HAP v6.0 Dec 10				—	—

This schedule is current as of December 5, 2019. Classes for 2020 are currently being planned and announced soon. Additional classes are being scheduled now. Please [click here](#) to check for updated schedules.

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eDesign Suite Software Current Versions (North America)

Program Name	Current Version	Functionality
 Hourly Analysis Program (HAP)	v5.11	Peak load calculation, system design, whole building energy modeling, LEED® analysis
 Building System Optimizer	v1.60	Rapid building energy modeling for schematic design
 Block Load	v4.16	Peak load calculation, system design
 Engineering Economic Analysis	v3.06	Lifecycle cost analysis
 Refrigerant Piping Design	v5.00	Refrigerant line sizing
 System Design Load	v5.11	Peak load calculation, system design



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