Volume 6, Issue 3

CARRIER® eDESIGN SUITE NEWS

EXchange

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Utilizing HAP Diagnostics Reports to Verify Annual System Simulation Results (Part 1)

This is Part 1 of an article that expands our previous discussion on [Utilizing HAP Diagnostics Reports to Verify System Design Results,] which appeared in the previous Vol 6, Issue 2 EXchange newsletter. In this article we will focus on how to interpret and diagnose annual Building simulation results and demonstrate procedures for identifying any anomalies in the final simulation results. In Part 2, to be included in the next EXchange newsletter (Vol 6, Issue 4), we will demonstrate how to use the air system and plant simulation diagnostic reports to verify annual simulation results.

HAP's simulation capabilities are very robust and allow you to quickly produce summary reports comparing annual energy use and energy costs of multiple, alternate building designs. In addition, detailed reports provide annual, monthly, daily and hourly performance data. HAP's extensive use of graphics allows trends and patterns of equipment performance to be quickly understood. Simulation data may be exported to spreadsheet (.CSV) file format for further analysis, if desired.

Simulation reports may be generated at three different levels within HAP; at the systems level, at the plant level and at the building level. As mentioned previously we will focus only on the building simulation in this article, which includes the

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eDesign Suite

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following: Building simulation (quantifies total building energy consumption, operating costs and emissions utilizing graphics and tabular data), energy budget reports, utility billing details, monthly consumption, peak demand and time of peak demand both for electric energy and fuel usage. In addition, a LEED® Energy Credit report may be generated for Baseline and Proposed buildings.

There is good reason to begin at the end, with the Building Simulation Reports. After all the Building Simulation Reports contain the composite results of the entire project including all HVAC systems, plants and miscellaneous loads. The building simulation reports are available in two categories: Standard Reports and LEED Report, as shown in Figure 1.

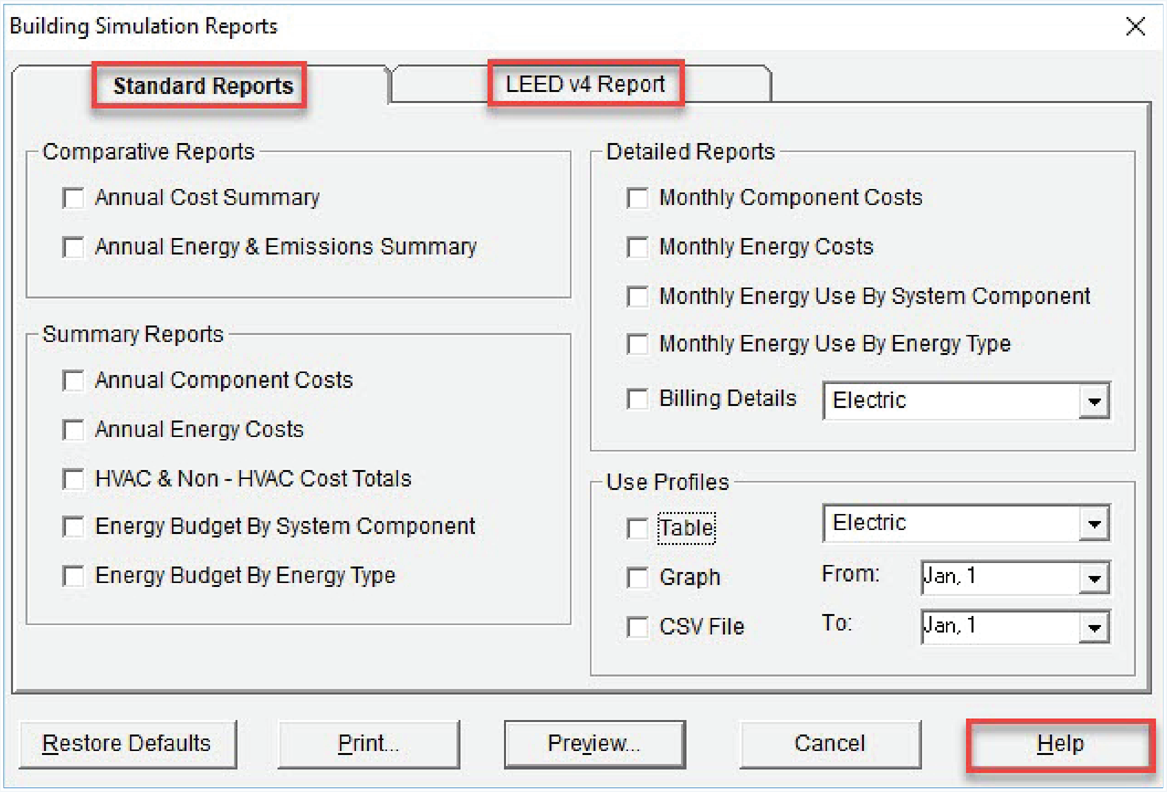

Figure 1. Building Simulation Reports Selection Screen

The Standard Building Simulation Reports are divided into four main categories: Comparative, Summary, Detailed and Use Profile Reports. ***Comparative Reports*** summarize annual component costs and energy use for buildings. Results for as many alternative building designs as desired can be compared side-by-side on these reports. ***Summary Reports*** list annual component costs and energy use for individual buildings, combining graphics with tabular data and includes energy budget reports. ***Detailed Reports*** provide detailed month-by-month cost and energy use data for a building. Many combine graphics and tabular data in a single report and includes a report documenting the calculation of each utility bill, showing monthly consumption, peak demand and time of peak demand data. ***Usage Profiles*** present hourly profiles of electric power or fuel use for any range of days (from 1 to 365) selected by the user. This report is available in both tabular and graphical formats and is useful for studying energy use patterns for the entire building. The Help button in the lower right corner of the screen, see Figure 1 above, opens a detailed explanation of all building simulation reports.

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The LEED Report tab allows you to select the Baseline and Proposed Buildings and generate a LEED Energy Credit report comparing the Baseline design against the Proposed as well as computation of the number of LEED Energy points. This LEED report will not be covered in this article. If interested in more details about how to model a LEED building you should consider attending a [Carrier eDesign Software Training Course]() or click on the Documentation tab at the top of the HAP program menu bar and find the link to the white paper, "Using HAP for LEED EA Credit 1 Analysis", as shown in Figure 2 below:

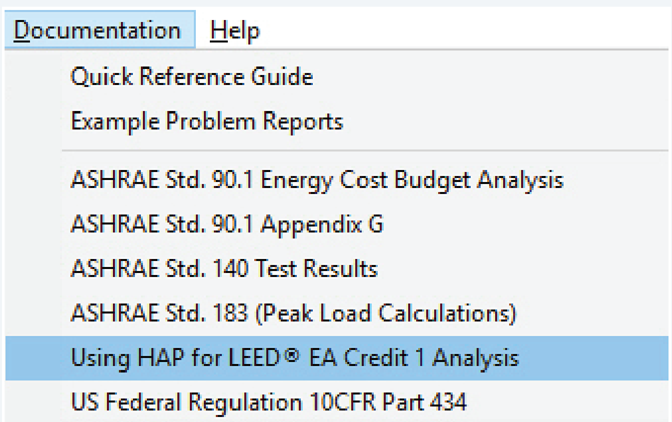

Figure 2. HAP Documentation – Using HAP for LEED EA Credit 1 Analysis White Paper

At the early stage of a preliminary energy analysis there are many unanswered questions such as: *are the total annual building HVAC cooling and heating loads reasonable for this type of building? Is the annual energy consumption reasonable for this type of building in this geographic location? Are the total annual operating costs within the "normal" range for similar buildings of this size and type?*

So how can you ascertain whether or not your building simulation results are reasonable or within acceptable "rules-of-thumb"? One such resource in-use for many years now for comparing building energy usage is the U.S. Department of Energy's (DOE) Buildings Performance Database (BPD), https://www.energy.gov/eere/buildings/building-performance-database, the industry standard for building performance benchmarking. We will not explain how to use the BPD here; you should go to the DOE website and go through the video tutorial, if interested. There are also other building energy benchmarking indexes such as the U.S. Environmental Protection Association's (EPA) Energy Star Rating Program. In addition, many states and municipalities offer programs and databases of existing buildings to facilitate benchmarking of energy usage by building type, location, size, age, etc, which can be most useful.

The metric most often used to benchmark a building's annual energy usage is the **Energy Use Intensity (EUI)**, which indicates the building's annual energy use per square foot (kBtu/sq ft/yr). The lower the number the more efficient the building. HAP computes the building's EUI on the Energy Budget by System Component report, as indicated in Figure 3 on page 4.

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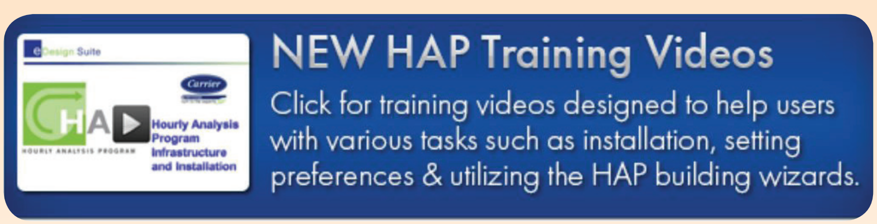

DID YOU KNOW?

There is a series of HAP TRAINING VIDEOS designed to help new users get started and with fundamental tasks such as installation, setting preferences, utilizing the HAP building wizards and more…all are available (free) at [carrier.com/HAP]()!
[Click through to watch.]()

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Energy Budget by System Component - Chiller Comparison

EXchange 6-4 Project 06/21/2018
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1. Annual Coil Loads

Component	Load (kBTU)	(kBTU/ft^2)
Cooling Coil Loads	9,257,988	67.270
Heating Coil Loads	804,785	5.848
Grand Total	**10,062,773**	**73.118**

2. Energy Consumption by System Component

Component	Site Energy (kBTU)	Site Energy (kBTU/ft^2)	Source Energy (kBTU)	Source Energy (kBTU/ft^2)
Air System Fans	476,798	3.465	1,702,851	12.373
Cooling	2,026,174	14.723	7,236,334	52.581
Heating	816,543	5.933	816,543	5.933
Pumps	89,922	0.653	321,149	2.334
Heat Rejection Fans	0	0.000	0	0.000
HVAC Sub-Total	**3,409,437**	**24.774**	**10,076,878**	**73.220**
Lights	1,422,866	10.339	5,081,663	36.924
Electric Equipment	914,560	6.645	3,266,286	23.733
Misc. Electric	0	0.000	0	0.000
Misc. Fuel Use	0	0.000	0	0.000
Non-HVAC Sub-Total	**2,337,426**	**16.984**	**8,347,949**	**60.658**
Grand Total	**5,746,862**	**41.758**	**18,424,827**	**133.878**

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 .... **137624.0** ft^2
   Conditioned Floor Area .... **137624.0** ft^2

Figure 3. Building Simulation Report – Energy Budget by System Component - EUI

Consulting the DOE's Building Performance Database (BPD) for commercial office buildings in all U.S. states most building EUI values range from 40-50 kBtu/sq ft/yr. Figure 3 above indicates an EUI value of 41.8 kBtu/sq ft/yr, so we are within the typical range. Obviously for your specific project you would want to be much more specific and specify your location, building type, age, total floor area, etc, however the example here is just used to illustrate the methodology.

However, what if your calculated results are not reasonable or within the expected values? If the annual operating costs appear to be unrealistic the first thing you should review and double-check is your utility rates for electricity and fuel. If you selected the default EIA utility and fuel rates

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you should be good to go, however if you entered the utility rates manually you should review your rates to make sure they are accurate and reasonable. A wrongly placed decimal point or incorrect energy units for the utility rate can wreak havoc in the final cost results. As a general rule-of-thumb the electric utility rate should be somewhere in the ballpark of $0.06-0.15/kWh and natural gas generally runs in the range of $6.00-12.00/MCF, according to EIA ranges. Once you confirm your utility rates are set correctly the next area to focus on is the component loads and energy usage. The peak cooling and heating loads from the design load calculation portion of HAP should be checked first because **if the loads are not correct the energy and cost data will not be correct either**. There are various sources available for typical rules-of-thumb for cooling load densities for various types of buildings. The old rule-of-thumb has been 300-500 sq ft/ton for commercial buildings including offices, retail, etc. Older buildings tend to fall in the lower range while newer buildings tent to fall in the upper range. Buildings with high occupant densities (such as schools, churches, etc) generally have cooling load densities in the 200-300 sq ft/ton and manufacturing and healthcare facilities can run much lower in the 100 sq ft/ton range or less, while light commercial or residential facilities typically run in the 400-700 sq ft/ton cooling load density range. These are of course very rough guidelines and your results may vary depending on location, building envelope, internal loads, etc.

One common question that often arises is, "why are my heating loads or annual heating costs so low"? This is usually related to the presence of internal heat gains offsetting a large portion of the zone heating losses. This topic is covered in detail in HAP eHelp 005 here: http://dms.hvacpartners.com/docs/1004/public/06/hap_ehelp_005.pdf

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Once you are satisfied that the peak cooling and heating loads are within an acceptable range you should move on to the building reports. If you suspect the annual cooling or heating energy consumption or costs are excessive you should look beyond the annual summary reports and instead review the monthly simulation reports. One such building report is the Monthly Energy Use by Component, as shown in Figure 4 below.

Monthly Energy Use by Component - Chiller Comparison

EXchange 6-4 Project
Carrier

06/23/2018
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1. Monthly Energy Use by System Component

Component	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Air System Fans (kWh)	11126	9653	10403	11440	12399	12486	13804	12591	12652	12114	10004	11069
Cooling												
Electric (kWh)	26929	18115	27503	44189	61278	74472	88779	77959	67406	51997	31360	23850
Natural Gas (Therm)	0	0	0	0	0	0	0	0	0	0	0	0
Fuel Oil (na)	0	0	0	0	0	0	0	0	0	0	0	0
Propane (na)	0	0	0	0	0	0	0	0	0	0	0	0
Remote HW (na)	0	0	0	0	0	0	0	0	0	0	0	0
Remote Steam (na)	0	0	0	0	0	0	0	0	0	0	0	0
Remote CW (na)	0	0	0	0	0	0	0	0	0	0	0	0
Heating												
Electric (kWh)	0	0	0	0	0	0	0	0	0	0	0	0
Natural Gas (Therm)	1670	1583	865	411	220	179	177	173	143	367	620	1758
Fuel Oil (na)	0	0	0	0	0	0	0	0	0	0	0	0
Propane (na)	0	0	0	0	0	0	0	0	0	0	0	0
Remote HW (na)	0	0	0	0	0	0	0	0	0	0	0	0
Remote Steam (na)	0	0	0	0	0	0	0	0	0	0	0	0
Pumps (kWh)	2099	1923	2063	2141	2328	2306	2369	2390	2292	2277	2028	2138
Heat Rej. Fans (kWh)	0	0	0	0	0	0	0	0	0	0	0	0
Lighting (kWh)	36682	31957	33647	35106	35164	33589	36682	33647	35106	36682	32072	36682
Electric Eqpt. (kWh)	23578	20541	21627	22565	22602	21590	23578	21627	22565	23578	20614	23578
Misc. Electric (kWh)	0	0	0	0	0	0	0	0	0	0	0	0
Misc. Fuel												
Natural Gas (Therm)	0	0	0	0	0	0	0	0	0	0	0	0
Propane (na)	0	0	0	0	0	0	0	0	0	0	0	0
Remote HW (na)	0	0	0	0	0	0	0	0	0	0	0	0
Remote Steam (na)	0	0	0	0	0	0	0	0	0	0	0	0

Figure 4. Building Simulation Report – Monthly Energy Use by Component

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Houston, Texas, USA

This report allows you to identify system and plant operation over the entire year. One particularly interesting thing to note about this particular report, shown in Figure 4, is that there are significant cooling loads all months, even in winter. Similarly, there are heating loads in the summer, albeit relatively small ones. The winter coolingloads in January are approximately one-third of the summer peak loads for July (26929/88779). This project happens to be located in Houston, TX, a mild climate in winter, so this likely explains the winter cooling loads. Had this project been located in Boston, Toronto or other cooler climate we would want to dig deeper and find out why we need mechanical cooling in winter. Could it be there are no airside economizers in use or perhaps they are not set properly? Perhaps there is a dehumidification control being used and the air must be subcooled and reheated to maintain building humidity levels.

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What would cause heating in summer, however, in Houston? A closer inspection of the details is necessary. The building simulation report only shows the total heating loads and energy consumption. To dig deeper we need to look at the Monthly System Simulation report, as indicated in Figure 5 below.

Monthly Simulation Results for VAV AREA A (CHW)

Project Name: EXchange 6-4 Project
Prepared by: Carrier

Air System Simulation Results (Table 1):

Month	Precool Coil Load (kBTU)	Preheat Coil Load (kBTU)	Preheat Eqpt Load (kBTU)	Preheat Coil Input (kBTU)	Preheat Heating Misc. Electric (kWh)	Central Cooling Coil Load (kBTU)	Terminal Heating Coil Load (kBTU)
January	29589	19963	19836	20662	0	11130	2209
February	21040	18836	18835	19619	0	8509	2069
March	27211	11288	11288	11759	0	11120	105
April	42042	5289	5289	5509	0	15959	286
May	60101	2055	2055	2141	0	21586	1361
June	76998	430	430	448	0	25487	2672
July	96676	235	235	245	0	29095	2570
August	82824	413	413	430	0	25831	2268
September	69205	908	908	946	0	22506	1496
October	50509	4706	4706	4902	0	17929	279
November	30351	8072	8072	8409	0	11777	74
December	27508	21776	21697	22601	0	10476	1638
Total	**614054**	**93971**	**93762**	**97669**	**0**	**211406**	**17029**

Figure 5. System Simulation Report – Monthly Simulation Results

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This example happens to be a VAV system with series fan-powered mixing box terminals, however, there are significant precool and preheat coil loads all year long. What might cause this? Inspecting the system inputs for preheat and precool coil confirms that they have been set incorrectly, which is a common error many users make, as shown in Figure 6 below.

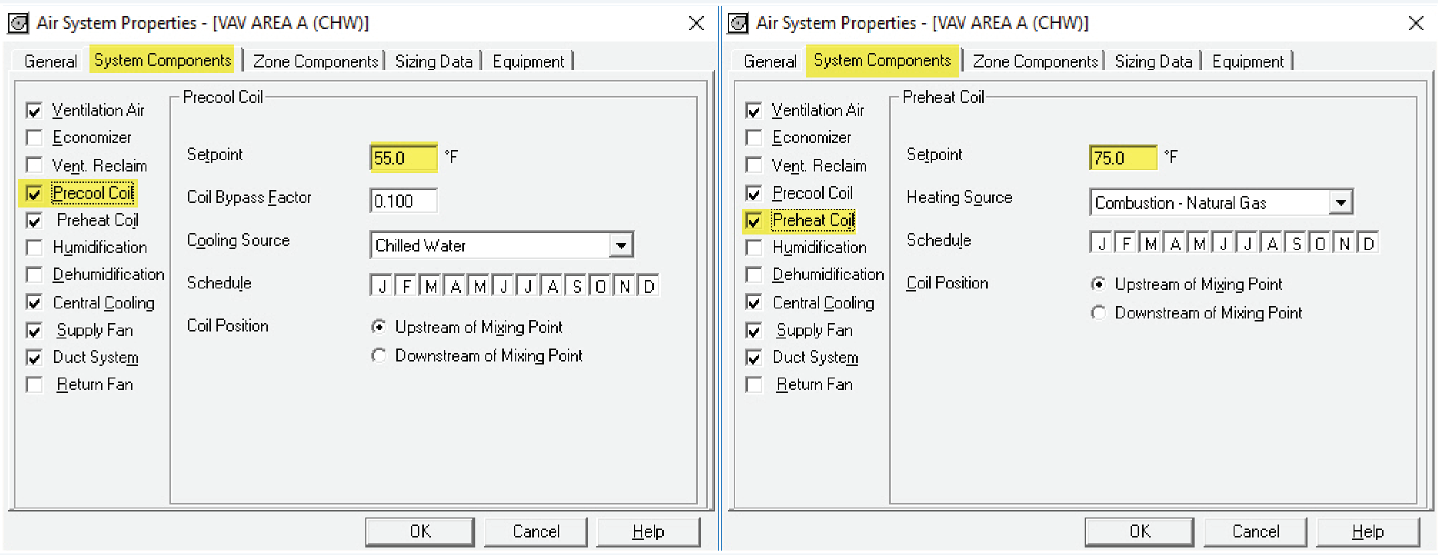

Figure 6. Air System Inputs - System Components – Preconditioning Coil Settings

It is important to understand how preconditioning coils function. They are not primary cooling and heating coils to heat and cool the zones, rather they are "tempering" coils to precondition the ventilation air such that the central cooling (CC) and terminal reheat (RH) coils may operate to condition the zones and the ventilation load can be decoupled from the zone loads. The other critical thing to understand is the relative placement of the precool (PC) and preheat (PH) coils, as indicated in Figure 7 below.

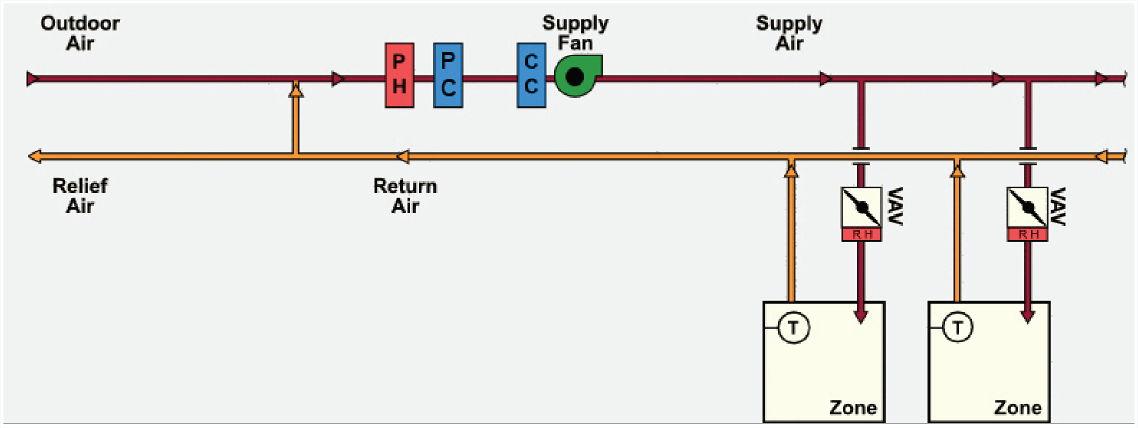

Figure 7. System Schematic - VAV System with Series Fan-Powered Mixing Box Terminals

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The precool coil is downstream of the preheat coil, therefore if the preheat coil setting (75F) is greater than the precool coil (55F) it will simply impose a false load on the precool coil, which is what is happening in this instance. However, the other problem in this example is the precool coil is set to 55F at all times. This means the supply air will always be cooled to 55F regardless of the zone cooling or heating loads. A supply air reset control strategy might be prudent in this case to minimize reheat requirements or setting the preconditioning coils to something more reasonable like 53F heat, 60F cool to prevent the coils from fighting.

Once you have inspected all the air system component settings and controls you should re-simulate the building and review the same monthly simulation report to see if cooling in winter and heating in summer is still occurring.

This concludes Part 1 of this article covering Building Simulation reports. In Part 2, in the next issue of the *EXchange* newsletter (Vol 6, Issue 4), we will explore in-depth how to interpret the Plant and Air System Simulation reports.

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Frequently Asked Questions

FAQ #1: How is a Ventilation Reclaim device controlled in HAP? In other words, how does it know when to recover energy such that it does not operate when it is going to recover heat that is not needed?

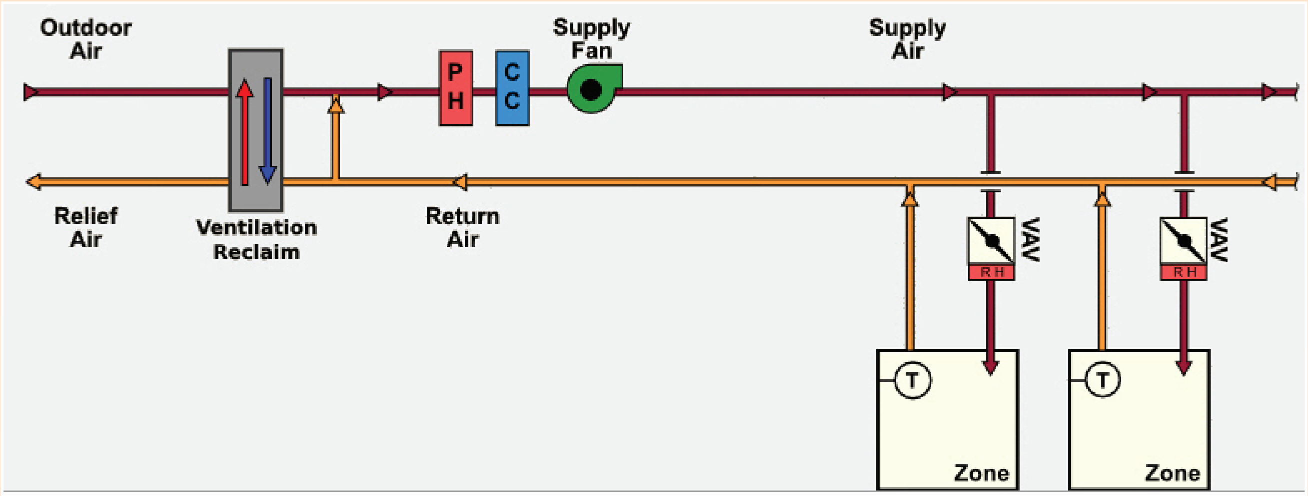

Figure 1. Air System Schematic

Answer: A vent reclaim device transfers heat between the outdoor ventilation and exhaust air streams in order to reduce loads on air system cooling and heating coils. A simple performance model is used to simulate ventilation reclaim device operation. This model determines the sensible or total (sensible + latent) heat transferred and the electrical power consumed by the device. The vent reclaim device transfers heat between the outgoing exhaust air stream and the incoming outdoor ventilation air stream in direct proportion to the thermal efficiency specified. The reclaim coil in the outdoor ventilation air stream is located upstream of the point where outdoor air mixes with return air and is upstream of any precool or preheat coils, as indicated in Figure 1 above.

The vent reclaim device is available to operate for all months it is scheduled on and when operating selectively transfers heat between air streams for all system operating hours when outdoor ventilation and exhaust airflow exists. For example, if the system is performing cooling, the ventilation reclaim system will cool the outdoor ventilation airstream if possible but will not turn on if operation would heat the ventilation airstream. If an airside economizer is also specified the vent reclaim device remains off during times when the ambient conditions permit economizer operation. When the air system is performing heating, the vent reclaim system will warm the ventilation air stream if possible but will not turn on if operation would cool the ventilation airstream. The vent reclaim device control modulates its operation as necessary to prevent overheating or overcooling the ventilation air stream. Chapter 31.8 in the HAP Help system has a detailed explanation with examples of operation in both cooling and heating modes.

Note: if "direct" exhaust is specified in the zones this exhaust airflow does not flow back through the return air duct and does not pass through the exhaust side of the vent reclaim device, thus heat is not reclaimed from this zone direct exhaust. This is explained in detail in a previous *EXchange* FAQ here.

2018 eDesign Suite Training Class Schedule

Location	**Load Calculation for Commercial Buildings** *System Design Load HAP*	**Energy Simulation for Commercial Buildings** *HAP*	**Energy Modeling for LEED® Energy & Atmosphere Credit 1** *HAP*	**Advanced Modeling Techniques for HVAC Systems** *HAP*	**Engineering Economic Analysis** *EEA*	**Block Load Basic** *Block Load*
Montreal, QC	Sep 25	Sep 26	—	Sep 27	—	—
Boston, MA	Oct 16	Oct 17	—	Oct 18	—	—
Kapolei, HI	Oct 23	Oct 24	—	Oct 25	Oct 26	—
Lafayette, LA	Oct 30	Oct 31	—	—	—	—
New Orleans, LA	—	Nov 1	—	—	—	—
Syracuse, NY†	Nov 12	Nov 13	—	—	—	—
Toronto, ON	Dec 4	Dec 5	—	Dec 6	—	—
Denver, CO	Dec 4	Dec 5	—	Dec 6	—	—
New York City, NY	Dec 11	Dec 12	—	Dec 13	—	—

This schedule is current as of Septmeber 10, 2018. Additional classes are being scheduled now. Please click here to check for updated schedules.
Click here to **REGISTER FOR UPCOMING CLASSES.**

†Tuition-free.

eDesign Suite Software Current Versions (North America)

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

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