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EXchange



The Next Generation of Hourly Analysis Program (HAP) Software

By James Pegues

In 2017, we proudly celebrate the 30th anniversary of the Hourly Analysis Program's first release. During those 30 years HAP has been updated more than 40 times to keep pace with changes in HVAC technology, ASHRAE¹ Standards, your heating, ventilating and air conditioning (HVAC) system design and energy modeling practices, and software technology. Among those 40 updates were three major updates where the software user interface and calculation capabilities were significantly transformed. Due to recent developments in HVAC technology, industry practice, and software technology, we believe the time is right for a fourth major update to HAP.

There are two primary approaches for an update of this magnitude:

1. A comprehensive overhaul where the program is completely transformed in one large step, with a new user interface, new operating principles, and new capabilities.
2. A staged approach where significant new functionality is incrementally added across a series of releases to steadily transform the software to reach the same end state as in the "comprehensive overhaul" approach.

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After conferring with you, our HAP customers, we've heard loud and clear your concerns about the "comprehensive overhaul" approach. With the relentless pace of business and the demands of project deadlines, you told us you simply cannot accommodate lengthy interruptions in work for retraining your staff to learn and then become proficient with an entirely new tool.

Therefore, we believe the "staged" approach is the right approach to support your business needs. With each successive release of HAP, several significant features will be added or transformed. But the intuitive organization of the software will remain familiar, allowing you to leverage your existing experience and expertise to continue using HAP productively for your projects.

Construction of the first release in this staged sequence, HAP version 6.0, is well along at this point. In HAP 6.0 the major changes will include:

1. Graphically capturing building floor plans and elevations. This will vastly reduce the labor for

manual takeoffs and the large amount of data entry that was required in the past. This will deliver major gains in productivity for your use of the software.

2. Upgrading the calculation engines to use state of the art load calculation and building simulation techniques, to expand the range of application for the program.
3. Other important enhancements to expand modeling features.

While these changes will transform how spaces are created, grouped into zones, and linked to air systems, the remainder of HAP 6.0 will retain its familiar look and feel, helping you stay productive. To become familiar with the new floor plan capture features, we'll provide a variety of training resources to help make this process easy.

In coming issues of the software EXchange newsletter we'll describe in more detail how HAP is being transformed. We will also continue to engage with HAP customers to test concepts and gather feedback on the new features.

James Pegues is Manager of eDesign Software Development for Carrier, based in Syracuse, NY. If you'd like to share thoughts about Carrier's directions for the next generation of HAP, please contact him at software.systems@carrier.utc.com.

¹ASHRAE® is a registered service mark of the [American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc.](http://www.ashrae.org)



Celebrating HAP's 30th Birthday



Celebrating HAP's 30th Birthday is as much a celebration of those who have worked with it over the years as it is about the program itself.

E. W. Bob Boulware, PE, MBA, President of Design-Aire Engineering, Inc. in Indianapolis, Indiana, USA is one such engineer. Bob was eager to share his HAP thoughts and experiences with us in honor of HAP's 30th Birthday.

How long have you been using HAP?

Bob: I purchased the Carrier Load Calculation program in 1983. I recall it was called the Carrier E 20-II program at the time, which was a DOS-based load calculation and bin method load calculator program that also had pipe and duct sizing capability. It was packaged with a brand new 64 k ram IBM computer.

What is it about HAP that allows you to work better/smarter?

Bob: Back in the day, loads were done by hand calculation; Carrier and another manufacturer's design manuals had different equivalent temperature difference values to be used and rarely gave the same answer...which was always a concern to me. Using the computer gave me a sense of precision and assumed accuracy.

One of the first things I learned when using the computer was that the common assumption that peak load occurred at 4pm in July wasn't necessarily true. With south facing glass, on a job we were doing at the time, peak cooling load occurred in September...huge surprise at the time. So it opened our eyes to how a building actually worked based on good data and allowed us to do a better job sizing systems.

What project that you used HAP on are you most proud of? Why?

Bob: Going back since 1983, energy auditing has been a key component of our engineering practice. We have done numerous schools, hospitals, and other facilities with the projections provided by the HAP Program allowing us to commonly get with 5%-10% of actual costs compared to our projected savings. The project I am most proud of is the former Guide Plant in Anderson, Indiana. It was a 2.4 million square foot facility, consisting of multiple additions that went back to the early 1900's. Our proposed replacement HVAC system of the original central plant was a \$1.4 million project projected to provide a 4 month payback. When completed, the actual operating costs were hitting our projections within 5%.

Which HAP support tools (training seminar or class, help line, EXchange newsletter, web site, software systems email, videos) have you utilized? And have they improved your HAP experience/usage?

Bob: The training seminars were a good start but since then, we have chiefly relied on the engineers manning the telephone help line pretty regularly over the years.



E. W. Bob Boulware, PE, MBA, President Design-Aire Engineering, Inc., Indianapolis

Is there anything you would want to say to the HAP team?

Bob: HAP has been a real godsend to my firm since we started out in 1983. The program allowed a small engineering shop do a better job of sizing HVAC systems which put us way ahead of our competition at the time. Over 35 years later, we still rely on HAP to do operating cost simulations.

Looking forward, I see water conservation replacing energy conservation as the next thing to worry about and would like to see an option that can determine the amount of air conditioning condensate that can be reclaimed.

Dear Bob,

From our team to yours at Design-Aire Engineering, please accept our sincere thank you for your business over the years and for sharing your testimony of the value of HAP to your business, your clients and their buildings.

Cheers!

What's New in HAP 5.10?

We are excited to announce major improvements and feature enhancements for HAP 5.10. These include new modeling capabilities, updated support for ASHRAE Standards and Leadership in Energy and Environmental Design (LEED)² compliance, and productivity enhancements as well as improved reports. A summary list of new features appears below followed by an expanded explanation of each group of enhancements.

1. Support for LEED and ASHRAE Standards

- Support for LEED v4 Compliance
- Support for ASHRAE Standard 90.1-2013 compliance
- Support for ASHRAE Standard 62.1-2016 compliance
- Template archives of prescriptive envelope constructions for ASHRAE 90.1-2013

2. New Modeling Capabilities

- New options for specifying Zone Air Distribution Effectiveness (Ez)
- New options for specifying design heating temperature for reheat terminals

3. Productivity Enhancements

- New VRF Outdoor Unit (ODU) sizing report
- Updated EIA utility prices

1. Support for LEED and ASHRAE Standards

Enhanced features include:

- Support for LEED v4 Minimum Energy Performance prerequisite and Enhanced Energy Performance credit
- A new LEED v4 report replicating the energy consumption and cost portions of the "Minimum Energy Performance Calculator" spreadsheet required by USGBC for LEED v4 submissions. This includes a comprehensive LEED v4 points table
- An updated LEED 2009 report which replicates the energy use and cost portions of the latest "Minimum Energy Performance Calculator" spreadsheet
- Updates supporting ASHRAE 90.1-2013 minimum equipment efficiency calculation, including Packaged RTUs, Split Systems, WSHPs, VPACs and PTACs

- ASHRAE 90.1 minimum efficiency equipment calculations for VRF equipment. This applies both for 90.1-2010 and 90.1-2013, the first two editions which include VRF requirements
- Updated system fan power allowance inputs for 90.1-2013 compliance
- New ASHRAE 90.1-2013 HAP project template (archive file), for all ASHRAE Climate Zones, containing minimally-compliant envelope and Baseline systems
- Updates to the HAP Building Wizard allowing users to specify ASHRAE 90.1-2013 inputs, including updated light power density (LPD) defaults by building type, and prescriptive envelope assemblies

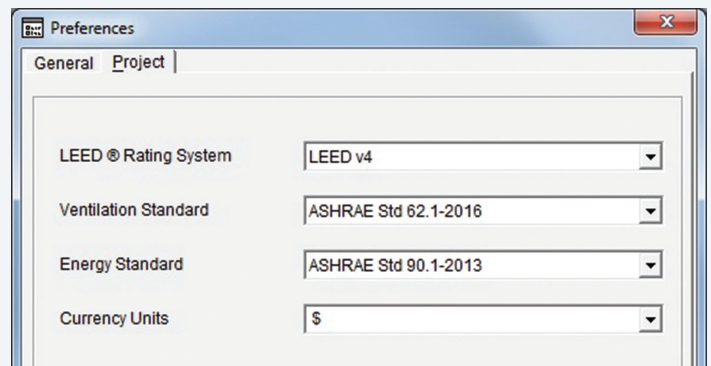


Figure 1. HAP 5.10 Project Preferences Settings Screen

- Addition of Project Preferences settings for LEED v4, ASHRAE 62.1-2016, and ASHRAE 90.1-2013, as shown in Figure 1

The LEED Rating System input field has been moved from the bottom of the list to the top such that when selecting it first it will automatically populate the applicable Ventilation Standard and Energy Standard versions required for that version of LEED. Note: you may always override these default Ventilation and Energy Standards versions later, if required, since some local state and municipal energy codes are more stringent than LEED with regards to ASHRAE Standards requirements.

²LEED® is a registered trademark of the [U.S. Green Building Council](http://www.usgbc.org)

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In addition, the status bar located at the bottom of the HAP main screen now indicates the versions of LEED, ASHRAE 62.1 & 90.1 that are currently set in Project Preferences, allowing for easy verification of versions used without having to go and check Preference settings.

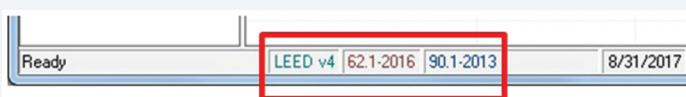


Figure 2. HAP 5.10 Project Preferences – Main Screen Status Bar

2. New Modeling Capabilities

New options were added for determining the Zone Air Distribution Effectiveness, E_z , in Standard 62.1 Ventilation Rate Procedure calculations. In previous versions of HAP the E_z was automatically determined for you based on an assumption of ceiling supply and return locations, and the heating supply-air-to-space temperature difference.

First, a new input was added to allow you to directly specify supply and return locations to support applications where supply and/or return are not ceiling-located (Figure 4). The new location input covers all configurations as described in ASHRAE Std 62.1 Table 6.2.2.2.

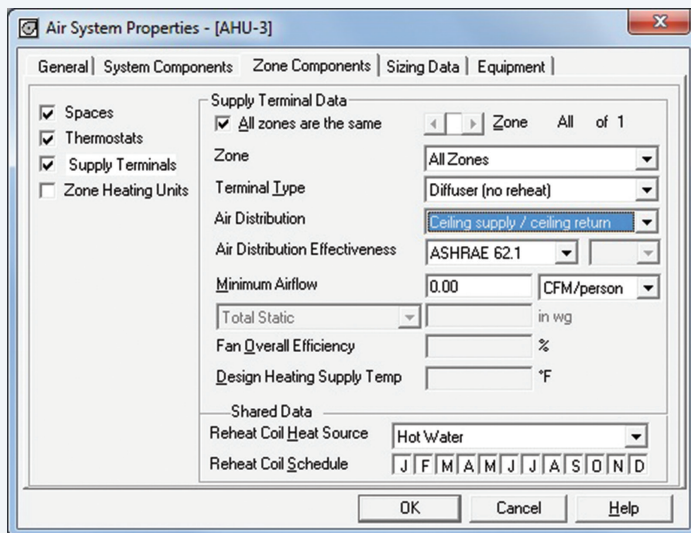


Figure 3. HAP 5.10 Air System Zone Components Terminal Location Settings Screen

Note in Figure 3, the Air Distribution terminal locations are now user-specified. Possible choices of supply and return locations include:

- Ceiling Supply / Ceiling Return
- Ceiling Supply / Ceiling Return (Low velocity)
- Ceiling Supply / Floor Return
- Floor Supply / Floor Return
- Floor Supply / Ceiling Return
- Floor Supply / Ceiling Return (Low velocity)

Second, a new input for specifying heating supply air temperature (SAT) for reheat coils in air terminals was added (Figure 4). In prior versions of HAP, a heating SAT was assumed for VAV reheat, CAV reheat, and CAV mixing box reheat terminals. That assumed heating SAT affected the selection of air distribution effectiveness. Having explicit SAT inputs for all terminal types removes this assumption and gives a user more control over accurate selection of the air distribution effectiveness. This heating SAT input also gives a designer greater control over the calculation of reheat coil capacity. Reheat coil sizing calculations have been updated to use the new heating SAT value.

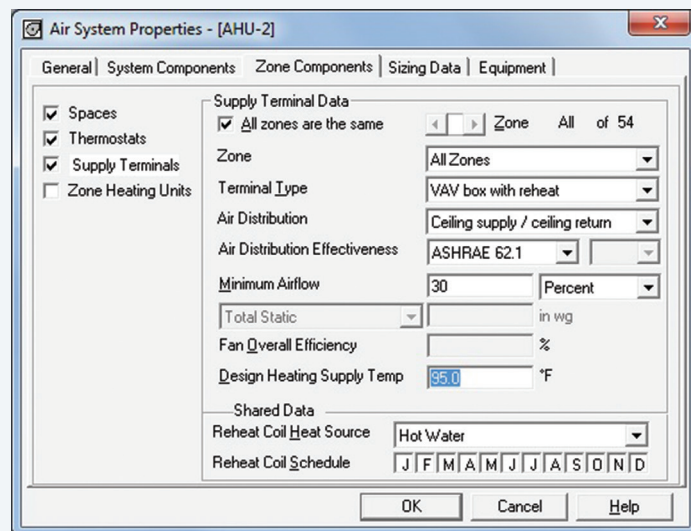


Figure 4. Heating Supply Temperature for Reheat Terminals

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Finally, for those instances when the user wants to enter the Ez value directly, one of the available options for Air Distribution Effectiveness will be, "User-specified," as shown in Figure 5 below. The rationale for including the user-specified option is to allow modeling of special situations which might not be covered by the available options for automatic calculation of Ez.

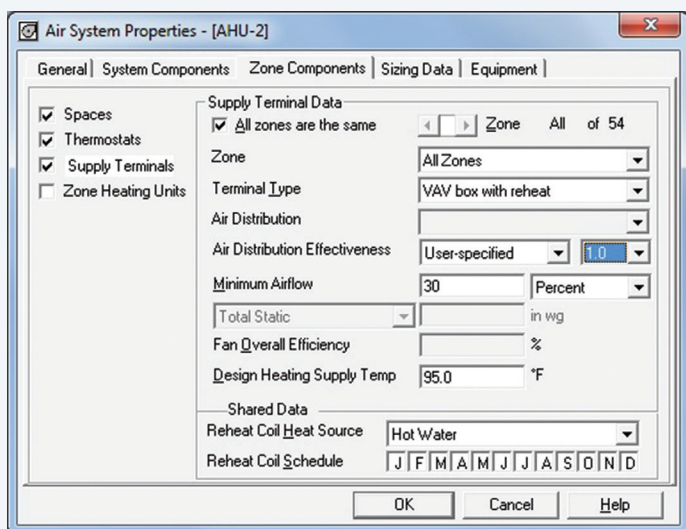


Figure 5. HAP 5.10 Air Distribution Effectiveness, Ez – User-specified

3. Productivity Enhancements

Features added in HAP v5.10 include:

- New VRF Outdoor Unit Sizing Data. The Zone Sizing Summary Report now includes a new sizing data table for a VRF outdoor unit (ODU) including any refrigerant line losses as defined (see the FAQ that follows for an expanded explanation of this new feature, including an example of the report data).
- New Energy Information Agency (EIA) Utility Price Data for 2015, which is the latest data available. These are state-wide average electricity and natural gas prices for all 50 U.S. states. These rates may be used in lieu of actual utility rate structures for LEED project submissions.

Frequently Asked Questions

FAQ #1: I modeled a Variable Refrigerant Flow (VRF) system in HAP and see the indoor fan coil unit sizing data displayed on the Zone Sizing Summary Report which allows me to size the indoor terminals, however these are connected to a single VRF outdoor unit (ODU). Where do I find the sizing data for the ODU?

Answer: With HAP 5.10 we have included a new table on the Zone Sizing Summary Report that includes the ODU sizing information, as shown in Figure 1 below.

In this table:

1. **Peak Coincident Indoor Unit Loads.** This row lists the largest combined indoor unit (IDU) load imposed on the outdoor unit (ODU). The outdoor unit serves multiple indoor units whose loads vary independently. Typically the outdoor unit is sized on the peak coincident, or largest combined load, imposed by the indoor units at one point in time, rather than being sized on the sum of individual peak IDU loads. Therefore, the peak coincident load accounts for load diversity among the indoor units.
2. **Estimated Piping / Line Losses.** The ODU must also be sized to overcome refrigerant piping losses that occur between the outdoor unit and the indoor units. When long lines exist, the VRF outdoor unit will have to generate extra cooling or heating output to overcome refrigerant pressure drop in the lines to satisfy loads at the indoor unit. Refrigerant line length and vertical distance were specified on the Equipment tab of the Air System Properties and are used to calculate capacity correction factors to determine the line losses shown in this table. For example if the capacity correction factor for a given pipe length is 0.9, the outdoor unit will have to provide 100/0.9 or 111 MBH of cooling output in order to meet a load of 100 MBH at the indoor units. Separate correction factors are calculated for cooling duty and heating duty based on the piping length and vertical distance.

If the estimated line loss is shown as zero, it either means that you did not specify line length and vertical distance, or the line length and vertical distances are very small resulting in negligible losses.

Note: Refrigerant line losses vary with each particular VRF outdoor unit product line and model size. HAP uses capacity correction factors that are an average of many manufacturer's products and models in order to represent "typical" losses. Therefore, when selecting equipment it is critical to consult actual product data to determine the capacity correction factors for the specific product you are selecting, and then apply these correction factors to determine your actual losses and the actual total required ODU capacity.

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3. Total Required ODU Capacity. This is the sum of the peak coincident IDU load and the estimated line loss. As noted in the previous item, the line loss included in this total is an estimated “typical” value. Therefore, when selecting equipment you should

always determine the actual line losses for your product, recalculate the line loss that applies to your specific product, and calculate a new total required capacity using that line loss.

VRF Outdoor Unit Sizing Data

| | Cooling [MBH] | Cooling [Tons] | Heating [MBH] |
|------------------------------------|---------------|----------------|---------------|
| Peak Coincident Indoor Unit Loads | 110.4 | 9.2 | 74.7 |
| Estimated Piping / Line Losses | 4.6 | 0.4 | 1.0 |
| Total Required ODU Capacity | 115.0 | 9.6 | 75.7 |

Note: VRF piping / line losses are based on typical loss factors for this class of equipment. Actual line loss varies widely from one product to another. Therefore, when selecting equipment it is critical to consult manufacturer's guidance to utilize actual line loss data.

Figure 1. Zone Sizing Summary Report - VRF ODU Sizing Data

FAQ #2: I notice on the Systems Psychrometrics Report that an air constant 1.054 BTU/(hr-CFM-F) is reported, as shown here in Figure 2:

This air constant is shown at the site's altitude but not at any particular temperature. Since the density of air changes significantly at different temperatures why doesn't HAP compute

the air density at each point in the system? Specifically, if I am heating say 4200 CFM of -3F ventilation air up to 53F, and since using the 1.054 air constant in the heat loss equation is applicable to air at an inlet temp of 70 degF, won't this severely undersize the heating coil due to the much higher density of air at the design temperature of -3 degF?

| WINTER DESIGN HEATING | | | | | | | |
|-----------------------|----------|--------------------|---------------------------|---------------|-----------------|------------------------|----------------------|
| TABLE 1: SYSTEM DATA | | | | | | | |
| Component | Location | Dry-Bulb Temp (°F) | Specific Humidity (lb/lb) | Airflow (CFM) | CO2 Level (ppm) | Sensible Heat (BTU/hr) | Latent Heat (BTU/hr) |
| Ventilation Air | Inlet | -3.0 | 0.00018 | 4200 | 400 | -319342 | 0 |
| Vent - Return Mixing | Outlet | -3.0 | 0.00018 | 4200 | 400 | - | - |
| Preheat Coil | Outlet | 53.0 | 0.00018 | 4200 | 400 | 247899 | - |
| Central Cooling Coil | Outlet | 53.0 | 0.00018 | 4200 | 400 | 0 | 0 |
| Supply Fan | Outlet | 55.4 | 0.00018 | 4200 | 400 | 10508 | - |
| Cold Supply Duct | Outlet | 55.4 | 0.00018 | 4200 | 400 | - | - |
| Zone Air | - | 69.1 | 0.00018 | 4200 | 400 | -76052 | 0 |
| Return Plenum | Outlet | 69.1 | 0.00018 | 4200 | 400 | 0 | - |

Air Density x Heat Capacity x Conversion Factor: At sea level = 1.080; At site altitude = 1.054 BTU/(hr-CFM-F)
Air Density x Heat of Vaporization x Conversion Factor: At sea level = 4746.6; At site altitude = 4632.3 BTU/(hr-CFM)
Site Altitude = 673.0 ft

Figure 2. System Psychrometrics Report – Winter Design Conditions

Answer: HAP corrects for air density at site elevation but does not correct density as air temperature changes. This is common HVAC design practice that has been used for decades.

Consider the following example:

1. 4200 CFM of air at -3 F dry-bulb enters a heating coil. At a density of 0.0869 lb/ft³ this represents a mass flow of 365 lb/min.
2. Due to conservation of mass, the mass flow entering and leaving the coil must be the same. So 365 lb/min exits the coil. But because the leaving coil temperature is 53 F, the density has changed to 0.07735 lb/ft³. So the leaving volumetric flow is 4719 CFM.
3. Therefore, 4200 CFM enters the coil and 4719 CFM leaves the coil.

4. Heating and air conditioning equipment rating tables specify volumetric flow rate rather than mass flow rate. So when selecting the heating coil, do you use 4200 CFM or 4719 CFM as the coil airflow?

True physical behavior is that the CFM leaving the coil is larger than the CFM entering the coil, but that makes equipment selection difficult. As a result, the industry standardized practice is to use a simplifying assumption that density is constant at an average temperature at standard atmospheric conditions at the given site elevation. This is an engineering approximation that facilitates equipment selection. HAP adheres to that standard industry practice and therefore corrects air density for elevation but not temperature.

2017 eDesign Suite Training Class Schedule







| 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> |
|-----------------|--|--|--|---|---|---------------------------------------|
| Raleigh NC* | Sep 11 | Sep 12 | Sep 13 | Sep 14 | — | — |
| Melrose Park IL | Sep 20 | Sep 21 | — | — | — | — |
| Baltimore MD | Oct 31 | Nov 01 | — | Nov 2 | Nov 03 (AM) | — |
| Atlanta GA | Nov 14 | Nov 15 | — | Nov 16 | — | — |

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Additional classes are being scheduled now, please check back again.

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eDesign Suite Software Current Versions (North America)

| Program Name | Current Version | Functionality |
|---|-----------------|--|
|  Hourly Analysis Program (HAP) | v5.10 | 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 | v4.00 | Refrigerant line sizing |
|  System Design Load | v5.10 | Peak load calculation, system design |

**Late 2017



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