Volume 2, Issue 3

CARRIER eDESIGN SUITE NEWS

EXchange

Modeling Variable Refrigerant Flow Systems in HAP

Variable Refrigerant Flow (VRF) systems have become a common choice in recent years in commercial building HVAC design. As use of VRF becomes more common, the need arises to evaluate its energy performance versus other HVAC equipment options. Carrier's Hourly Analysis Program (HAP) offers energy modeling features for VRF systems, including cooling-only, heat pump (non-heat recovery) and heat pump (with heat recovery) variations. Below is a brief introduction to modeling VRF systems in HAP.

1. **Getting started** - Preparation for modeling VRF is the same as any other HVAC scenario in HAP. Select the site weather data and define characteristics of all spaces in the building including wall, roof, window and door assemblies, as well as surfaces, internal heat gains and schedules.

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(Continued from page 1)

2. **Create a new air system** - The air system data will describe the complete system, including the zones, thermostat controls, indoor DX fan coil units, refrigerant piping and the outdoor condensing unit. A dedicated outdoor air system (DOAS) can also be included as part of the system definition.

3. **Air System Properties - General Tab** - Select equipment type as terminal units and select system type as variable refrigerant flow (VRF). If the application uses a DOAS unit for air ventilation, select the common ventilation unit option.

4. **Ventilation System Components Tab** - If the application uses a DOAS unit, define components and controls for the DOAS system on the ventilation system components tab. This includes cooling and heating coils, fans and, if applicable, air-to-air heat recovery equipment. Note that the DOAS unit is an air-cooled DX type of unit, such as a rooftop, which operates separately from the VRF equipment.

5. **Zone Components Tab** - On this tab, configure spaces into zones, define thermostat setpoints and schedule, and define the design and operating characteristics of the indoor fan coil units.

6. **Equipment Tab** - This tab contains equipment performance inputs for the VRF system. This includes design capacities and efficiencies, information about refrigerant piping length, compressor type, and whether heat recovery is available. If the system includes a DOAS unit, this tab is also where the cooling and heating equipment performance is specified for that unit.

Performance Calculation Model. There is a common misperception that because HAP only requires you to enter VRF equipment performance in terms of design EER and COP, these inputs represent the entire performance model. That is, condensing unit cooling input kW for each hour is calculated simply as load / EER. This is false. Instead, HAP uses a complex algorithm to estimate how the efficiency of the condensing unit changes hour by hour as operating and environmental conditions change:

- For cooling, condensing unit input power is calculated as a function of outdoor air dry-bulb temperature, indoor unit entering wet-bulb temperature, part-load ratio, refrigerant line length, refrigerant line maximum vertical distance, compressor type, and, if applicable, heat recovery operation.

- For heating, condensing unit input power is calculated as a function of outdoor air dry-bulb temperature, indoor unit entering dry-bulb temperature, part-load ratio, refrigerant line length, refrigerant line maximum vertical distance, compressor type, defrost operation and, if applicable, heat recovery operation.

The design EER and COP entered in the program are used to determine condensing unit input kW at the design rating point. Input kW is then corrected for hour-by-hour operating factors mentioned above to determine hourly operating efficiency.

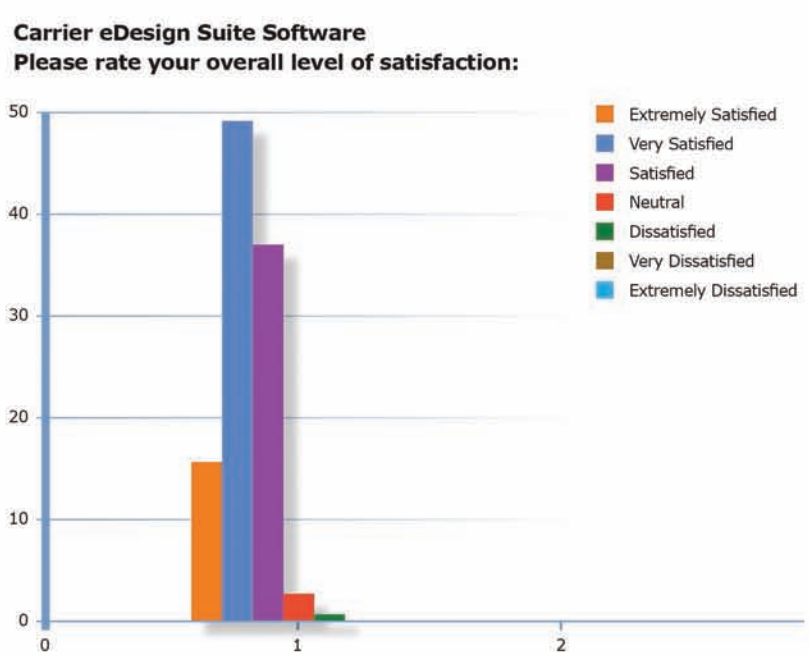

Figure 1 Software

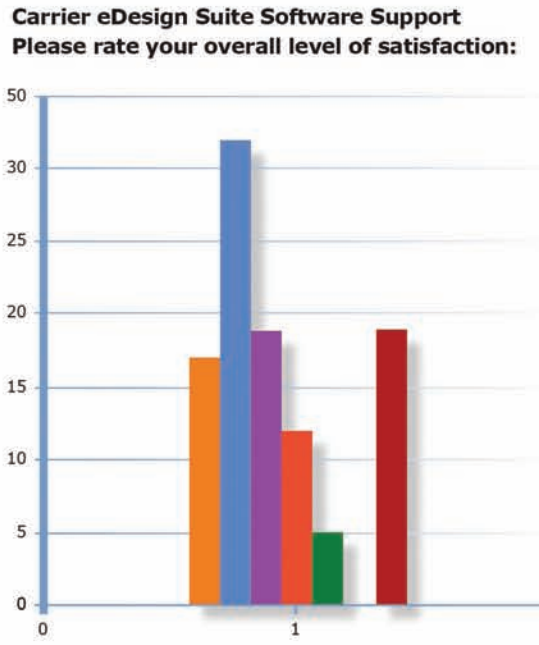

Figure 2 Support

Surveys can be surprising!

In order to stay in touch with the needs and concerns of our current software users, we conducted a short eDesign software survey during July. The survey contained 12 questions, addressing topics such as overall satisfaction with the functionality of software, level of administrative support, technical support and training. We were surprised by some of the feedback and wanted to share it with you along with the improvements we are making based on the responses.

Overall satisfaction with the software was high with 97 percent of respondents being "satisfied" or better (Figure 1). Administrative and technical support was also rated on a satisfaction scale and the result was also very positive (Figure 2). Movement toward an email-based inquiry/response support approach has allowed us to efficiently address the largest number of user questions in a rapid manner. As always, if a

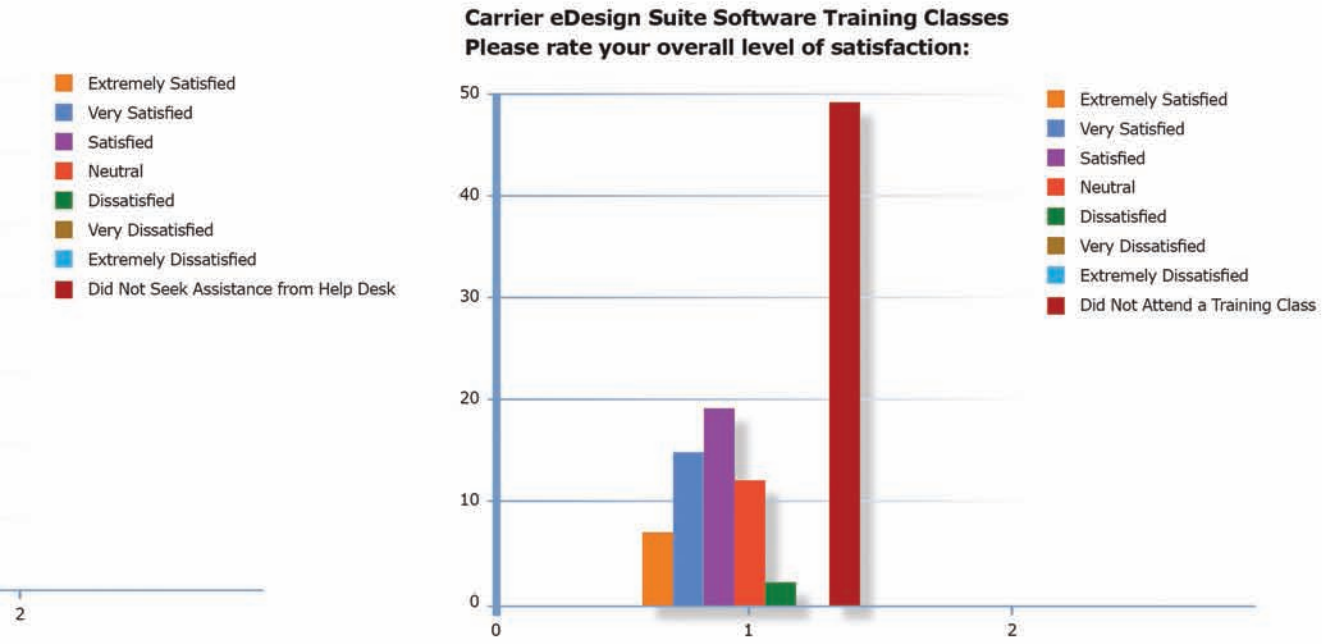

Figure 3 Training

phone call is necessary or requested, we respond accordingly to maintain high customer satisfaction.

Along with these ratings, comments were requested to identify opportunities for software improvement. Suggestions included adding new system or equipment modeling capabilities, additional graphical user interface features, data management improvements, customizable reports and greater data interoperability between programs. Other comments referred to features recently added and others currently planned for near-term software releases. A companion article in this newsletter describes feature additions in recent and upcoming software releases.

When it comes to training (Figure 3), about half the respondents indicated they have never taken an eDesign Software Suite training class. Although these classes are scheduled around the country, some indicated that class location was still an issue. The ability to leave work and attend was also highlighted as a problem. We are addressing these concerns by providing additional locations for classes as well as online training options. Stay tuned for more on this topic in future EXchange issues.

As your feedback is valuable to us, we intend to conduct short surveys each January. Look for the first of these annual surveys in 2014, with a focus on technical issues. Moving forward, we plan to rotate focus between support and training topics. In the meantime, questions and comments can always be submitted to software.systems@carrier.utc.com.

Recent Feature Enhancements in HAP

Carrier's software help desk fields questions every day from engineers using a wide range of Hourly Analysis Program (HAP) versions, from HAP v4.80 (releasing late October 2013) through HAP v4.50 (2010) and sometimes as far back as HAP v4.1 (2002). Among the 114 technical feature requests received in the July 2013 software survey were many requests for features already offered in the latest versions of HAP. In an effort to more widely publicize recently released features, the table below lists the key feature updates in HAP v4.50 through v4.80. Feature enhancements for all HAP versions from v4.00 forward can be found on the What's New in HAP web page.

HAP v4.80 [releasing late October 2013]

Active chilled beam air system models

Induction beam air system models

HAP v4.70 [May 2013]

Reversible chiller (aka heat pump chiller) central plants with changeover controls

Air-to-water, water-to-water heat pump central plants

Service hot water (SHW) plants for tankless and storage hot water applications

Combined heating plants serving space and SHW loads

ASHRAE 62.1-2010 data and calculations

ASHRAE 90.1-2010 calculations

HAP v4.61 [July 2012]

Primarily problem corrections

HAP v4.60 [March 2012]

Variable Refrigerant Flow (VRF) equipment models - cooling, heat pump, heat pump with heat recovery

2-speed indoor fan control for single-zone DX equipment

2-stage compression for DX cooling equipment

Multiple boiler plants with boiler sequencing and hot water temperature reset controls

Detailed condensing boiler and non-condensing boiler equipment models

Variable speed condenser water pumps

Ability to merge data from multiple projects

Ability to import simulation weather data from external sources

HAP v4.51 [May 2011]

Bundled reports (package of reports generates as a single print job or Word document)

Updates to LEED Energy and Atmosphere Credit 1 reporting format

HAP v4.50 [March 2010]

LEED Energy and Atmosphere Credit 1 template report

Auto calculation of ASHRAE 90.1 minimum equipment efficiencies

Auto calculation of ASHRAE 90.1 Appendix G fan power allowance for baseline buildings

Automated duplication and rotation of building and HVAC equipment for baseline buildings

Wizard features for rapid creation of energy analysis inputs

Frequently Asked Questions

Q. Can Carrier's Hourly Analysis program model VRF systems and if so, what system options are available to choose from?

A. Yes HAP can model VRF systems for both design loads and energy simulations. System options available for modeling VRF systems include:

- Two ventilation options including Direct Ventilation or a Common (DOAS) Ventilation System
- Multiple compressor types including variable speed scroll (VSD), and digital scroll (DS)
- Heat recovery system
- Multiple heating options including air-source heat pump (using auxiliary electric resistance heat) or primary electrical resistance heat only.

Q. Does the VRF model in HAP take into account the effect of the refrigerant piping length between the indoor and outdoor components?

A. Yes HAP accounts for the effect of refrigerant piping in both total equivalent length and the vertical separation:

1. Refrigerant Piping Equivalent Length. 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. These corrections are included in the software. Capacity correction factors for line loss are reported in charts or tables in manufacturer's literature. For example if the reported capacity correction factor for a given 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.

2. Refrigerant Piping Vertical Distance. HAP requires the user to specify if the outdoor unit(s) are above the indoor unit(s) (for example a roof-mounted outdoor unit) or vice-versa, (for example a ground-level outdoor unit serving indoor units on upper floors). This distance is used for a purpose similar to the refrigerant piping equivalent length above. The greater the vertical distance between outdoor unit and indoor units, the larger the cooling or heating output required to meet loads at the indoor units.

2013 Training Class Schedule

Location	Load Calculation for Commercial Buildings	Energy Simulation for Commercial Buildings	Energy Modeling for LEED® Energy & Atmosphere Credit 1	Advanced Modeling Techniques for HVAC Systems
Philadelphia, PA	Oct 21	N/A	Oct 22	Oct 23
New Jersey/New York	Dec 9	Dec 10	N/A	Dec 11

Additional classes are being added.

eDesign Suite Software Current Versions (North America)

Program Name	Current Version	Functionality
Hourly Analysis Program (HAP)	v4.70	Peak load calculation, system design, whole building energy modeling, LEED® analysis.
Building System Optimizer	v1.10	Whole building energy modeling for schematic design.
Block Load	v4.15	Peak load calculation, system design.
Engineering Economic Analysis	v3.01	Lifecycle cost analysis.
Refrigerant Piping Design	v4.00	Refrigerant line sizing.
System Design Load	v4.70	Peak load calculation, system design.

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