NEW FEATURES
IN THE
CARRIER
HOURLY ANALYSIS PROGRAM v4.61

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Introduction

This document describes enhancements in the Carrier Hourly Analysis Program (HAP) v4.60 (March 2012) and v4.61 (July 2012). It is intended for new users of HAP and for those upgrading from one of the HAP v4.5 versions to v4.61. Major enhancements in v4.6 relate to two themes, described below. Sections 2 through 8 explain the enhancements in greater detail.

1. **Theme 1 - Expanded Equipment Modeling Capabilities.** Responses to the summer 2011 customer survey indicated a high level of interest in expanding capabilities for modeling HVAC equipment and controls. HAP v4.6 represents a first installment in satisfying these requests by adding models for:

   - Variable Refrigerant Flow (VRF) equipment.
   - Staged air-volume (2-speed fan control) in packaged and split DX equipment.
   - 2-stage compression in single-zone CAV packaged and split DX cooling equipment
   - Multiple boilers, boiler sequencing controls and hot water reset controls for boiler plants.
   - Condensing and non-condensing boilers.
   - Variable speed / variable flow condenser pumps and dry coolers in chiller plants.

   In addition, existing simulation models were upgraded for:

   - All air-cooled DX cooling equipment types.
   - All air source heat pump heating equipment types.

2. **Theme 2 - Expanded Productivity Features.** HAP v4.6 also contains productivity features, including the ability to:

   - Merge multiple projects into one large project, to facilitate more efficient collaboration in project teams
   - Preserve space and zone assignments when changing system type for an existing air system.
   - Import simulation weather data from external file formats such as EnergyPlus EPW, ASHRAE IWEC, ASHRAE IWEC2, NOAA TMY2 and NOAA TMY3.

1. Summary List of Enhancements in v4.60 and v4.61

A complete summary list of enhancements in HAP v4.60 is provided below. More detailed explanations are found in the referenced sections.

1. **Main Window**

   - Expanded "project import" feature to allow full merging of projects.
   - Updated the template project which contains ASHRAE 90.1 default schedules to include elevator and service hot water demand schedules.

   See Section 2 for further details.

2. **Weather**

   - Added feature to import simulation weather data from external sources such as EnergyPlus (EPW), ASHRAE IWEC, ASHRAE IWEC2, NOAA TMY2 and NOAA TMY3 formatted files.

   See Section 3 for further details.

3. **Spaces**

   - Revised limits for lighting ballast multiplier to accept values from 0.1 to 2.0. This change supports three lighting analysis tasks.

   See Section 4 for further details.

4. **Air Systems**

   * Added Variable Refrigerant Flow (VRF) equipment models.
   * Upgraded air-cooled DX cooling models for all applicable equipment types
   * Upgraded air source heat pump (ASHP) models for all applicable equipment types.
   * Added staged air volume (2-speed supply fan control) for single-zone rooftop, split DX AHU, and packaged vertical unit equipment.
   * Added 2-stage compression for single zone CAV rooftop, split DX AHU, and packaged vertical unit cooling equipment.
   * Added feature to specify upper cutoff temperature for ASHP auxiliary heat.
   * Added condenser pump inputs (formerly in cooling towers) for WSHP, GWSHP, GSHP and water-cooled vertical packaged unit equipment.
   * Space and zone assignments are now preserved when system type is changed.
   * Removed "constant temperature, fan cycled", "reset based on greatest zone demand", and "reset based on OAT schedule" capacity control options for single-zone CAV rooftop, split DX AHU and vertical packaged unit equipment.
   * Expanded input formats to allow input power for small wattage fans and compressors to be specified more accurately.

   See Section 5 for further details.

5. **Plants**

   * Added multiple boilers, sequencing control and hot water reset control to boiler plants.
   * Added variable speed / variable flow condenser water pump control and dry coolers for chiller plants.
   * Added condenser pump inputs (formerly in cooling towers) for chiller plants.

   See Section 6 for further details.

6. **Cooling Towers**

   * Added dry cooler model.
   * Moved condenser pump performance inputs to plants and air systems.

   See Section 7 for further details.

7. **Boilers**

   * Added models for condensing and non-condensing boilers.

   See Section 8 for further details.

8. **Wizards**

   * Added option for Variable Refrigerant Flow (VRF) equipment.
   * Added 2-speed fan control for single-zone CAV rooftop, split DX AHU and vertical packaged unit equipment.
   * Added 2-stage compression for single-zone CAV rooftop, split DX AHU and vertical packaged unit equipment.
   * Added options for variable speed condenser pumps and dry coolers in chiller plants.
   * Added options for multiple boilers, sequencing control and hot water reset control in boiler plants.
   * Added options for condensing and non-condensing boilers in boiler plants.
   * Added options to select Energy Information Administration (EIA) electricity and gas prices for US states in the Utility Rate Wizard.

   See Section 9 for further details.

9. **Documentation**

   * Updated help system and Quick Reference Guide to document new features.

2. New Main Program Window Features

1. **Merging Projects** - The "Import Project Data" option on the Project Menu was expanded to handle space, air system, plant and building data. Previously the option only allowed the lower level project elements - weather, schedules, walls, roofs, windows, doors, external shade geometries, chillers, cooling towers, boilers, electric rates and fuel rates - to be imported from one project into another. By including all sixteen categories of HAP project data in the feature, users can effectively merge complete projects together. This is often useful in large projects where individual team members initially model portions of the building separately and then combine the data for final energy modeling calculations.

   Note that when importing space, air system, plant or building data from one project into another, HAP automatically imports all linked items. For example, if you import 10 spaces, HAP will identify all of the wall, roof, window and door assemblies linked to the spaces, plus the linked schedules and shade geometries and import those automatically with the spaces.

2. **Default Schedules** – The reference project which contains ASHRAE 90.1 default schedules was updated in v4.61 to include elevator and service hot water demand schedules. The archive file for this project is automatically installed with the program. To utilize data from this resource, first select the Project/Retrieve option. From the \E20-II\Archives folder select the archive file named “HAP46_Default_Schedules_and_Utility_Rates.E3A”. After the data is retrieved, save the project. This will serve as a reference project from which data can be imported into other projects . Subsequently as you create new projects, use the Project/Import HAP Project Data option to import schedules and utility rates from the reference project into your new projects. The archive contains ASHRAE default schedules for occupants, lighting, HVAC system, elevators and service hot water for Assembly, Healthcare, Hotel, Light Manufacturing, Office, Parking Garage, Restaurant, Retail, School, and Warehouse space usage types.

3. New Space Features

1. **Lighting Analysis -** Revised the limits for the lighting ballast multiplier to accept values from 0.1 to 2.0. Previously ballast multipliers below 1 could not be entered. This change supports three lighting analysis tasks. The first is modeling of modern fluorescent lighting fixtures having ballast factors less than 1.0. The second is modeling lighting retrofits of the ballast to more efficient (lower) levels. Using the global search and replace feature lighting fixtures in large groups of spaces can be modified to reduce the ballast multiplier to levels below 1.0. Third, the ballast multiplier can be used as a short cut method of modeling lighting fixture wattage reduction, again using the global search and replace feature.

4. New Weather Features

1. **Importing Simulation Weather Files** - An "Import Weather File" option was added to the Simulation tab of the Weather Properties window to allow simulation weather data from an external source to be imported into your project. Previously the only source for simulation weather data was the Carrier library of 500+ city files. In recent years the availability of 8,760-hour simulation weather files has grown dramatically. While Carrier will continue expanding and updating it's library of pre-processed, quality inspected weather files, it is important for users have the ability to access weather from other sources as soon as it is published. This new "Import" option can translate files in commonly used formats: EnergyPlus EPW, ASHRAE IWEC (International Weather for Energy Calculations), ASHRAE IWEC2 (IWEC version 2), NOAA TMY2 and NOAA TMY3. Further formats will be added in the future.

   Note that simulation weather files from external sources sometimes contain bad data points. Bad data points are temperature, humidity or solar values far larger or smaller than should occur for a given location at a given time, and are usually due to weather station equipment malfunctions or data processing errors. After using the "Import Weather File" option we recommend reviewing the simulation weather reports to determine if the data is reliable for use in your simulations. HAP displays a message after the data is imported with recommended procedures for verifying the quality of the data.

5. New Air System Features

1. **Variable Refrigerant Flow (VRF) Equipment Models** - Added air-side and equipment models for VRF equipment. Cooling-only, cooling with electric heat, and heat pump system configurations are offered, with digital scroll or variable speed scroll condensing unit options.
2. **Upgraded Air-Cooled DX Cooling, ASHP Equipment Models** - Equipment simulation models which calculate the off-design and part-load performance of air-cooled DX equipment and air source heat pump equipment were upgraded. Previous versions of HAP use 2-dimensional models which calculate changes in equipment capacity and efficiency as a function of outdoor air dry-bulb temperature and part-load ratio. These algorithms were upgraded with a 4-dimensional model based on correlations of performance data for current DX equipment. For cooling equipment, the new model considers changes in capacity and efficiency as a function of outdoor air dry-bulb temperature, entering coil wet-bulb temperature, airflow and part-load ratio. For heat pump heating equipment the model considers performance as a function of outdoor air dry-bulb temperature, entering coil dry-bulb temperature, airflow and part-load ratio. Both old and new models include considerations for defrost cycles below 40 F (4.4 C) OADB.
3. **Staged Air Volume** - A model for staged air volume (2-speed indoor fan control) was added to single zone rooftop, split DX AHU and vertical packaged unit systems. Indoor fan speed control is specified in the supply fan section of air system inputs. Three options are offered:

"1-speed fan, cooling and heating", "2-speed fan cooling, 1-speed fan heating", "2-speed fan, cooling and heating".

4. **2-Stage Compression Model** - A model for 2-stage compression was added for single-zone CAV rooftop, split DX AHU and vertical packaged unit cooling equipment. In the cooling equipment performance inputs users can now choose between "1-stage compression, single circuit" and "2-stage compression, separate circuits" options. The 1-stage option models single stage on/off cycling of the compressor. The 2-stage option models two stages of capacity, and cycles between high stage, low stage and off.

5. **ASHP Auxiliary Heat Cutoff Temperature** - Added an input for the upper cutoff temperature for air source heat pump auxiliary heat. This was primarily added to help users comply with LEED® project requirements - that in a baseline ASHP system auxiliary heat shall not operate above 40 F (4.4 C) OADB. While it is rare for auxiliary heat to run above 40 F OADB in a LEED baseline simulation due to the 25% heating capacity oversizing rule, it was time consuming for engineers to prove this in LEED submissions. This new input provides a simple way for users to document that HAP explicitly prevents auxiliary heat running above a specified cutoff point.

6. **Condenser Pump Performance Inputs** - Condenser pump performance inputs were moved from Cooling Tower Properties to the Air System Properties. These inputs only appear for WSHP, GWSHP, GSHP and water-cooled vertical packaged unit equipment, on the Miscellaneous Components window under the Equipment tab.

7. **Preserving Space and Zone Assignments** - HAP was revised to preserve space and zone assignments when system type is changed. This feature is useful when copying and editing systems, an especially frequent task in LEED projects. Previously, changing the system type in an existing system reset all of the space and zone assignments and required the user to re-specify this data. In HAP v4.60 this is no longer necessary. Note that when changing from a multiple zone system to a "CAV - Single-Zone" or to a "Tempering Ventilation" system, only space assignments for the first zone can be preserved since both system types are limited to having only one zone.

8. **Obsolete Capacity Control Options** - The following three capacity control options were removed for single-zone CAV rooftop, split DX AHU and vertical packaged unit equipment: "constant temperature, fan cycled", "reset based on greatest zone demand", "reset based on OAT schedule". "Constant temperature, fan cycled" was removed because modern equipment typically runs fan-on during occupied hours to comply with ventilation requirements. The latter two control options apply to single-zone CAV chilled water AHU equipment and are not used for DX equipment. When converting existing v4.5 projects to v4.6 format, the converter automatically changes capacity control to "cycled or staged compressor, fan on" if any of these obsolete options were used for these equipment types.

9. **Expanded Input Formats for Small Wattage Equipment** - Input data formats for fan motor and compressor motor power inputs were expanded to allow more complete specification of power for smaller wattage equipment. For example, fan motor input kW for a fan powered mixing box terminal was formerly limited to one decimal place. A 245 watt motor would have to be defined as 0.2 or 0.3 kW, leaving a margin of error versus the actual motor power. In HAP v4.60, the motor can be specified as 0.245 kW to eliminate this margin of error.

6. New Plant Features

1. **Expanded Boiler Plant Models** - Boiler plant models were expanded to allow multiple boilers, sequencing control and hot water reset controls. Hot water and steam boiler plants can now contain up to 12 boilers connected in parallel. Boilers can be equally unloaded or sequenced on load. For hot water boiler plants, hot water supply temperature can be controlled as a fixed temperature, reset according to return water temperature or reset according to an outdoor air temperature schedule.
2. **Expanded Chiller Plant Models** - Chiller plant models were expanded to allow variable speed / variable flow condenser water systems and to allow use of dry coolers for heat rejection.
3. **Condenser Pump Performance Inputs** - Because of the addition of variable speed / variable flow condenser water systems (above), condenser pump performance inputs were moved from Cooling Tower Properties to Plant Properties. These inputs appear on a new Condenser Water tab in the Plant Properties window.

7. New Cooling Tower Features

1. **Dry Coolers.** Features for modeling dry cooler equipment were added. This equipment uses a water-to-air heat exchanger to reject heat by sensible heat transfer.
2. **Condenser Pump Performance Inputs.** Condenser pump performance inputs were removed from the Cooling Tower Properties window. For heat rejection equipment used with chiller plants, condenser pump performance inputs were moved to the plant input data. For heat rejection equipment used with water source heat pump systems or water-cooled vertical packaged unit systems, the condenser pump performance inputs were moved to the air system input data. When converting existing v4.5 projects to v4.6 format, the converter automatically moves condenser pump performance data to the proper new location.

8. New Boiler Features

1. **Expanded Boiler Models.** Two new modeling options were added for condensing and non-condensing boiler equipment. The names of the modeling options were also changed to better communicate the differences between the models. The full set of four model options offered in HAP v4.60 is:

    * Constant Efficiency - A simple model in which a single efficiency value is used for all operating conditions.
    * User Defined Curve - A simple 1-dimensional model in which the user defines boiler efficiency as a function of part-load ratio.
    * (NEW) Condensing Boiler - A 2-dimensional model in which a correlation of condensing boiler equipment performance calculates boiler efficiency as a function of part-load ratio and hot water supply temperature.
    * (NEW) Non-Condensing Boiler - A 2-dimensional model in which a correlation of non-condensing boiler equipment performance calculates boiler efficiency as a function of part-load ratio and hot water supply temperature.

9. New Wizard Features

1. **Equipment Wizard Upgrades** - The equipment wizard was updated to offer the new modeling features added in the main HAP input screens:

   * Variable Refrigerant Flow (VRF) equipment.
   * 2-speed fan control for single-zone CAV rooftop, split DX AHU and vertical packaged unit equipment.
   * 2-stage compression for single-zone CAV rooftop, split DX AHU and vertical packaged unit cooling equipment
   * Variable speed condenser pumps and dry coolers in chiller plants.
   * Multiple boilers, sequencing control and hot water reset control in boiler plants.
   * Condensing and non-condensing boilers.

2. **Utility Rate Wizard Upgrades** - Added options to select Energy Information Administration (EIA) electricity and gas prices for US states. The EIA is an agency of the US government which compiles and publishes average utility prices by state. EIA state average prices are often used for LEED energy modeling projects. Previously a user had to look these prices up in the HAP help system and manually enter them in the utility rate wizard screen. In HAP v4.60, a user can now select the rates from a drop down list, to automatically insert the prices in the input screen. This feature uses the latest EIA published data which is for 2009. For projects outside the US, electric and gas prices can still be directly defined.

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