

User's Manual

TRACE[®] 700

Building Energy and Economic Analysis

version 6.2



LIMITATIONS OF LIABILITY AND DISCLAIMERS

The Trane Air-Conditioning Economics (TRACE® 700) software is intended as a design-and-analysis tool to help designers optimize the design of the heating, ventilating, and air-conditioning system based on energy utilization and life-cycle cost. Program accuracy is highly dependent on user-supplied data. It is the user's responsibility to understand how the data entered affects program output, and to understand that any predefined libraries are to be used only as guidelines for entering that data. The calculation results and reports from this program are meant to aid the system designer and are not a substitute for design services, judgment, or experience.

TRANE, IN PROVIDING THESE PROGRAMS, ACCEPTS NO RESPONSIBILITY OR LIABILITY FOR THE SUITABILITY OF THE BUILDING AIR-CONDITIONING SYSTEM IN PROVIDING PROPER TEMPERATURE CONTROL, HUMIDITY CONTROL, INFILTRATION, AIR DISTRIBUTION, AND QUIET OPERATION.

TRANE SHALL NOT BE LIABLE FOR ANY CLAIMS, CAUSES OF ACTION, OR DAMAGES ARISING OUT OF OR ALLEGED TO ARISE OUT OF THE USE OR INABILITY TO USE THE TRACE 700 PROGRAM. UNDER NO CIRCUMSTANCES WILL TRANE BE LIABLE FOR ANY INCIDENTAL, CONSEQUENTIAL, OR SPECIAL DAMAGES, REGARDLESS OF THE LEGAL THEORY ADVANCED.

Climatice, Trane, the Trane logo, TRACE, and VariTrac are registered trademarks, and C.D.S. and EarthWise are trademarks, of Trane, which is a wholly owned subsidiary of Ingersoll Rand.

The following are trademarks or registered trademarks of their respective companies: Acrobat Reader from Adobe Systems Incorporated; CALMAC from Calmac Manufacturing Corporation; Pentium from Intel Corporation; Windows and Microsoft from Microsoft Corporation; LEED from the United States Green Building Council.



Contents

Chapter 1 A Brief Introduction

About TRACE 700	1-2
Package contents	1-2
Installing TRACE 700	1-2
Starting TRACE 700	1-2
Learning TRACE 700	1-3
TRACE 700 terminology	1-5

Chapter 2 Program Overview

Calculation phases	2-3
Phase 1: Load-design	2-4
Phase 2: System simulation	2-4
Phase 3: Plant (equipment) simulation	2-5
Phase 4: Economic analysis	2-5
Program layout	2-6
Views	2-6
Other workspace elements	2-9
Color cues	2-10
Performing basic tasks	2-11
Provide weather information	2-11
Create templates	2-12
Create rooms	2-13
Create systems	2-14
Assign rooms to systems	2-15
Create plants	2-15
Assign systems to plants	2-17
Define economics	2-18
Create schedules	2-19
General modeling hints	2-25

Chapter 3 Cooling and Heating Plants

Decoupled chiller arrangement.....	3-3
Parallel chiller arrangement	3-7
Series chiller arrangement.....	3-9
Variable-primary-flow chiller arrangement	3-13
Switchover control for chiller plants.....	3-17
Thermal energy storage	3-21
Cogeneration	3-28
Direct-fired absorption cooling	3-31
Low-flow chilled-water systems	3-33
Purchased chilled water.....	3-37
Purchased district steam and purchased district hot water.....	3-40
Plate-and-frame free cooling	3-43
Refrigerant-migration free cooling.....	3-46
Strainer-cycle free cooling	3-48
Double-bundle condenser heat recovery.....	3-50
Evaporative precooling of condenser air.....	3-54
Cooling tower with VFD	3-57
Chiller-tower optimization	3-59
Domestic hot water assigned to a boiler.....	3-62
Air-to-air heat-pump system	3-64
Water-source heat-pump system	3-68
Ground-source heat-pump system.....	3-72
Central geothermal chillers.....	3-76
Variable refrigerant flow system.....	3-81

Chapter 4 System Design Options

Desiccant dehumidification	4-2
Coil loop for exhaust-air energy recovery	4-8
Total-energy (enthalpy) wheel.....	4-15
Fixed-plate heat exchanger.....	4-21
Heat pipe	4-27
Sensible wheel	4-34
Direct and indirect evaporative cooling.....	4-40
Dedicated outdoor-air systems.....	4-45

Dual-Path Air Handler (Split Dehumidification Unit)	4-67
Systems with 100% outdoor air	4-73
Cold-air distribution	4-76
Chilled beams.....	4-79
Underfloor air distribution.....	4-84
Displacement ventilation.....	4-88
ASHRAE Standard 62.1	4-91

Chapter 5 System Control Strategies

Airside economizers	5-2
Fan cycling	5-4
Optimum start and stop	5-6
Humidification	5-9
Fan-pressure optimization for VAV systems.....	5-12
Ventilation reset for VAV systems	5-14
Unoccupied ventilation (night purge).....	5-17
Morning warm-up for dual-fuel applications	5-20
Chilled-water reset	5-24
Condenser-water reset	5-26
Load-shedding economizer	5-30
Daylighting	5-33
Demand limiting	5-43
Duty cycling.....	5-47
Supply air temperature reset.....	5-50

Chapter 6 Advanced Usage and General Modeling Tips

Common modeling mistakes	6-3
Rooms Tab of Create Rooms.....	6-3
Roofs and Walls tabs of Create Rooms.....	6-5
Internal Loads tab of Create Rooms.....	6-6
Airflows tab of Create Rooms	6-8
Selection tab of Create Systems	6-10
Options tab of Create Systems	6-11
Temp/Humidity tab of Create Systems.....	6-12
Fans tab of Create Systems.	6-13
Coils tab of Create Systems	6-14

Zoning	6-15
Cooling Equipment and Heating Equipment tabs of Create Plants	6-16
Base Utility / Misc. Accessory tab of Create Plants	6-17
Economics and utilities	6-18
Version	6-19
Frequently asked questions	6-20
Comparing input data	6-37
No- or low-heating energy consumption	6-39
Modeling large rooms and zones	6-45
Energy analysis	6-45
Load design	6-46
Zoning of rooms	6-47
Room and zone assignments	6-47
System-level coils	6-47
Zone-level coils	6-48
Room-level coils (fan coils)	6-49
Oversizing and undersizing	6-51
Balancing airflows	6-60
Selecting a DX unit using TRACE 700 output	6-68
Selecting a chilled-water cooling coil using TRACE 700 output	6-74
Modeling for LEED®	6-80
Compressor-only energy rate	6-96
Quick building inputs via the New File Wizard	6-110
Using TRACE 700 Chiller-Plant Analyzer	6-114
Inputting an existing load profile	6-118
Creating spreadsheets and tables from calculation results (TRACE 700 Visualizer)	6-122
Using templates	6-125
Creating alternatives	6-131
Creating schedules	6-137
Creating equipment and unloading curves	6-143

Creating utility rates	6-150
Stepped rate	6-150
Time-of-day rate.....	6-155
Stepped rate with a kWh/kW flag.....	6-162
Adding weather locations and activating the 8760 calculation methodology	6-167
Altering a load design file for energy analysis	6-170
Rooms tab of Create Rooms.....	6-170
Internal Load tab of Create Rooms.....	6-171
Airflows tab of Create Rooms	6-172
Options tab of Create Systems	6-173
Fans tab of Create Systems	6-173
Coils tab of Create Systems	6-173
Archiving and un-archiving instructions (storing library members with project files)	6-175
Printing used library members	6-176
Combining files	6-177
Creating a new file based on an existing file.....	6-179
How to sort output.....	6-180
gbXML import and export	6-181
Exporting gbXML data from Autodesk Building Systems 2005.....	6-182
Importing gbXML data in TRACE 700.....	6-183
Exporting gbXML data from TRACE 700	6-185
Importing gbXML data in Autodesk Building Systems 2005.....	6-186
gbXML results exported from TRACE 700	6-187
Importing a load design Version 3.x or Version 2.x file.....	6-189

1 A Brief Introduction

Welcome to TRACE 700—comprehensive analysis software that helps you compare the energy and economic impact of building-related selections such as architectural features; heating, ventilating, and air-conditioning (HVAC) systems; HVAC equipment; building utilization or scheduling; and financial options. Simplifying these detailed analyses lets you optimize your building-system designs based on energy utilization and life-cycle cost.

In new construction projects, be sure to perform the detailed energy and economic analyses early in the planning process. By doing so, the building owner and project team can productively use the results of these analyses to facilitate design decisions.

The TRACE 700 program can also be invaluable for assessing the energy and economic impact of building renovation or system retrofit projects.

About TRACE 700

Package contents

The TRACE 700 software package includes the following software and documentation:

- TRACE 700 CD-ROM
- Feedback form
- TRACE 700 User's Manual
- Getting Started Manual
- Output Interpretation
- Other PDF manuals

The TRACE 700 CD-ROM contains everything you need to install and run the TRACE 700 application.

For information about the software and hardware needed to use TRACE 700, refer to the ReadMe file on the CD-ROM.

Installing TRACE 700

The TRACE 700 program must be installed on and run from your hard disk or the network hard disk—you cannot run the program from the CD-ROM. Installation instructions are available in the ReadMe file on the CD-ROM.

Uninstalling the program

If you ever need to remove the TRACE 700 application from your PC, use **Add/Remove Programs** in the **Windows Control Panel**. This command removes all TRACE 700 components except for files shared by other applications.


Note: If you customized any of the TRACE 700 libraries, be sure to export them before uninstalling the program. Consult online Help (F1) for instructions.

Starting TRACE 700

Start the TRACE 700 program just as you would any software application. Do one of the following:



Uninstalling the program will *not* remove your project files.

- Double-click  on the desktop.
- From the **Start** menu, select **Program Files > C.D.S. Applications > TRACE 700 > TRACE 700**.

Note: The above sequence is correct only if TRACE 700 is installed to the default folder.

Learning TRACE 700

Trane provides a variety of options to help you learn TRACE 700, including this User's Manual, the Getting Started manual, the Knowledge Base Center, online Help, and easy access to the Trane home page on the World Wide Web (personalized training is also available). Click Help, and from the **Help** menu click Trane on the Web. There you can find technical support, service releases to download, and other forms of user assistance (usage tips and training opportunities, for example), as well as information about other Trane products and services.

This manual

The *TRACE 700 User's Manual* contains step-by-step instructions to help you model common HVAC system options and control strategies. It assumes that you have a working knowledge of your computer and its operating conventions, including how to use a mouse and standard menu commands.

This guide also assumes that you know how to open, save, and close files, and that you can use My Computer and Windows Explorer proficiently. For help with any of these techniques, please refer to your Windows documentation.

Chapter 2 of this guide explains how TRACE 700 is organized, both behind the scenes and on screen.

Electronic manuals

The following references are installed with the program. To view one of these electronic manuals, select it from the TRACE 700 folder under C.D.S. Applications in the **Start** menu.

- TRACE 700 Getting Started Manual, cds-prm002-en.pdf
- TRACE 700 User's Manual, cds-prm001-en.pdf
- Design Output Interpretation

Adobe Acrobat® Reader software is required to view these and other technical documents included on the program CD-ROM. You can download the latest version of Acrobat Reader, free of charge, from the Adobe Web site, www.adobe.com.

Samples

Some example projects in the CDS\TRACE700\PROJECTS subdirectory, COMPLETEDTUTORIAL.TRC and TUTORIALTRC.TRC, will help you get started. Explore each file to acquaint yourself with the entries for modeling loads and systems in the TRACE 700 environment.


The electronic *TRACE 700 Getting Started Manual* provides a tutorial, which demonstrates the steps used to perform various program functions.

Online Help

The online Help for TRACE 700 describes how to perform basic tasks (for example, creating rooms and assigning loads to the HVAC system). It also provides detailed information about each program entry.

To start online Help

Do one of the following:

- On the **Help** menu, click **Contents**.
- Press F1.
- Click  on the toolbar.
- From the **Start** menu, select **Program Files > C.D.S. Applications > TRACE 700 > Help**.

To identify a tool or control

Position the pointer over a tool or control and pause. A ToolTip appears, showing the name of the item. For more details, look up the name of the item in the online Help index.

Internet resources

If your system is connected to the Internet and a Web browser is installed, you can use your computer to access the TRACE 700 home page on the Trane Web site.

The TRACE 700 home page provides links to downloads, support, and on-site training. You can also subscribe to a news service to ensure that you are automatically notified whenever new information is available.

To visit the Trane Web site:

- 1** Go to the Trane home page at www.trane.com and click "Commercial and Industrial."
- 2** Click **Products**.
- 3** Click **Software** on the list to open the C.D.S. Software page.
- 4** Under "Analysis Tools," click **TRACE 700** for information regarding the software. If you have a customer number, click "Knowledge Base Center" to view common questions and answers regarding Trane software products.

Alternatively, either access the Internet and go to www.tranecds.com, or from the TRACE 700 application, click **Help ► Trane on the Web**.

TRACE 700 terminology

Like most software, the TRACE 700 program has a unique vocabulary. Many of the terms will already be familiar. It is, however, important that you understand the fundamentals described here.

Rooms and zones

TRACE 700 defines a *room* as the smallest space for which it can calculate a heating or cooling load. The space may be a large, open-plan office that occupies the entire side of a building, or it may be a conference room separated from adjacent spaces by interior dividers.

Each room is bounded by surfaces that contribute to the heat-transfer characteristics of the room. *Walls* and *roofs* describe surfaces (including windows) that are exposed to the outdoors. *Partitions* are interior dividers that separate spaces with significantly different temperatures.

In addition to walls, roofs, and partitions, a room description includes other factors that affect cooling and heating loads:

internal loads (people, lights, and heat-generating equipment), infiltration, and ventilation requirements.

Zones divide a building into separately controlled areas. Each zone consists of one or more rooms that share similar heating and cooling requirements. In a variable-air-volume (VAV) system, for example, a VAV terminal typically serves several rooms. If you model these rooms as a zone, TRACE 700 will calculate the design capacity of the heating coil in the VAV terminal as well as the design airflow for each room.

Systems and plants

In the TRACE 700 vernacular, *system* describes the distribution of air to and from the conditioned spaces in the building. TRACE 700 can model more than 30 types of systems in five categories: variable volume, constant-volume mixing, constant-volume non-mixing, heating only, and induction.

Each system type in TRACE 700 broadly describes the airside components (coils, fans, and air paths) and the method used to size them. If you choose to do so, you can refine the system description by adding information about options (ventilation, economizing, evaporative cooling, exhaust-air heat recovery).

Note: Block sizing is commonly applied to variable-air-volume (VAV) systems. This method considers the schedules for individual spaces and finds the collective maximum load that will occur at any time. The program then determines fan and coil sizes based on that maximum load. Peak sizing determines fan and coil sizes based on the sum of the maximum load requirements for individual spaces—it is typically used for constant-volume (CV) systems.

Plant refers to the mechanical equipment that conditions the air (heats, cools, humidifies, dehumidifies). Examples include packaged air conditioners, chillers, boilers, and auxiliary equipment such as pumps and cooling towers.

Templates and libraries

Often, several rooms in a building share similar thermostat set points, construction, internal loads, and other design criteria. *Templates* let you enter this information once and then apply it to an unlimited number of rooms. If a design criterion changes, you



Note: The TRACE 700 program includes a separate Library/Template Editors program that lets you view the detailed information found in the standard templates and libraries. You can also use this program to create new global templates and library members.

can either edit the description of the individual room(s) or edit the template to automatically update all affected rooms.

Libraries contain the common design parameters for construction materials, equipment, base utilities, weather, and scheduling—all of which TRACE 700 uses to calculate building and equipment loads. Much of the information in the libraries reflects the design parameters published in the *ASHRAE Handbook—Fundamentals* and similar industry references.

Refer to online Help for more information about these and other TRACE 700 terms.

2 Program Overview

TRACE 700 comprises four distinct calculation phases that, together, provide a comprehensive energy and economic analysis:

- load–design
- system (air distribution) simulation
- plant (air-conditioning equipment) simulation
- economic analysis

Calculations in the load–design phase provide sufficient detail about the heating and cooling loads to evaluate the effect of building orientation, size, shape, and mass, based on hourly climatic data and the resulting heat-transfer characteristics of air and moisture.



All TRACE 700 simulations of systems and equipment are based on data from the manufacturer.

After the load–design phase is complete, subsequent calculations simulate the operation of the building and associated service systems for an entire year (8,760 hours of operation). The results of these calculations can help you assess how annual energy usage is affected by system design, climatic factors, operating strategies, and mechanical equipment characteristics.

All TRACE 700 calculations use techniques recommended by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE), or produce results that are consistent with ASHRAE recommendations. The calculations explicitly describe:

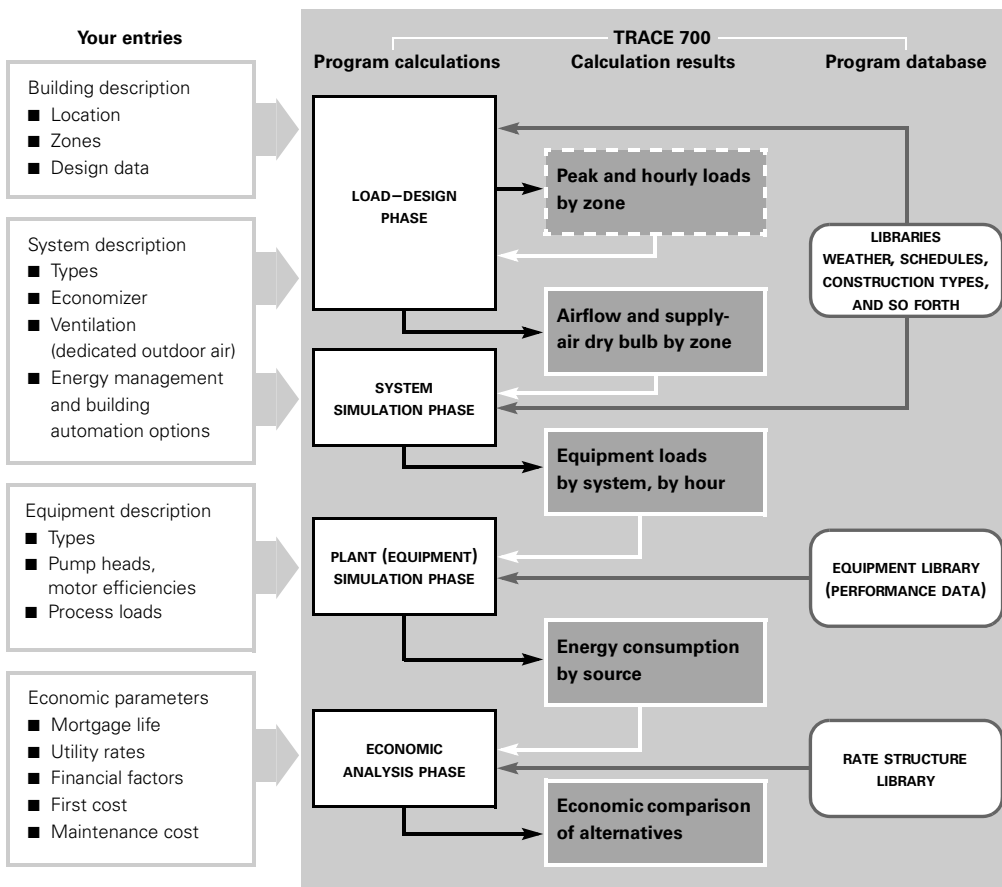
- *Climatic data*, including coincident hourly data for temperature, solar radiation, wind, and humidity, including seasonal variations
- *Structural attributes* of the building, including orientation, size, shape, mass, and heat-transfer characteristics of air and moisture
- *Operational characteristics of the building* and associated service systems, accounting for temperature, humidity, ventilation, illumination, and control modes for occupied and unoccupied hours

- *Operational characteristics of the HVAC system*, accounting for design capacity, part-load performance, and the effects of dry-bulb and wet-bulb temperatures on equipment performance and energy consumption
- *Heat generated inside the building* from illumination, equipment, and the number of people inside the building during and after normal hours of operation

Calculation phases

Figure 2–1 illustrates the relationship between the four calculation phases of the TRACE 700 program. It also summarizes the type of information you must provide at each phase, the kind of results to expect from each phase, and where data from the TRACE 700 libraries is used.

Figure 2–1 Functional organization of TRACE 700





In TRACE 700, *libraries* represent the database that contains common design parameters for load calculations, attributes for common types of HVAC systems, and data provided by the manufacturer, for specific equipment.

A brief description of each calculation phase follows.

Phase 1: Load–design

Calculations performed during the load–design phase define building cooling and heating loads at design conditions, by hour and by system, zone, and space (as well as total for the building), from information found in the **Weather** library for the city you identify. The calculations account for coincident loading by applying the schedules you define for items such as lights, occupancy, and miscellaneous loads.

Beyond this, the program accounts for energy consumed by systems that do not contribute loads to the air-conditioning system. Energy consumption of this type affects both the overall energy demand of the building and the associated energy costs.

For TRACE 700 to perform these calculations, you must first describe the construction, orientation, and location of the building, as well as its utilization profile (schedules for lights, occupancy, and miscellaneous loads).

Other required entries include the type of air-handling system; the percentage of wall, lighting, and miscellaneous loads assigned to the plenum; and the amount of outdoor air needed for proper ventilation at design conditions.

By applying these entries to standard procedures outlined in the *ASHRAE Handbook–Fundamentals*, TRACE 700 determines the quantities of outdoor air and supply air, as well as the supply-air temperature unless already specified by the user. The program also calculates the design cooling load and the design heating load for perimeter and interior spaces.



TRACE 700 can simulate more than 30 different types of air-distribution systems. You can combine these systems in various ways to accommodate the unique application needs of the building you are studying.

Phase 2: System simulation

During the second phase of calculations, TRACE 700 applies all of the building variables that affect system operation—by air-distribution system and by hour—to translate building heat gains and losses into equipment loads.

In effect, TRACE 700 follows the air as it travels throughout each air-distribution system, gaining or losing heat and/or moisture along the way.

Completing the airside system simulation defines the equipment loads for air moving, heating, cooling, and (where applicable) humidification, by system and by hour.

Phase 3: Plant (equipment) simulation

The objective of the calculations in this phase is to translate the equipment loads, by system and by hour, into energy consumption by source. To accomplish that task, the program applies the hourly equipment loads for each system and the relevant weather data. (Weather affects the overall part-load efficiencies of the HVAC equipment whether air- or water-cooled condensing is used.)



For your convenience, the TRACE 700 **Equipment** library already contains the required information about the part-load performance for specific HVAC equipment.

The loads are translated into energy consumption by source. The scope of these calculations includes district hot and/or chilled water and the total amount of makeup water required by a cooling tower—even the energy consumed by the crankcase heaters of a reciprocating compressor.

Required entries are limited to the types of air-moving, heating, and cooling equipment used. For hydronic plants, you will also be asked to enter the total head or maximum energy consumption, and motor efficiency, for each pump.

Armed with this information, the program extracts the appropriate performance information from the **Equipment** library and converts the system loads to energy consumption.

Phase 4: Economic analysis

Put simply, the final phase of calculations determines how much it costs to own and operate a building, including monthly and yearly utility costs over the life of the HVAC system. To aid system comparisons, TRACE 700 also computes various financial measurements such as cash flow effect, profit and loss effects, payback period, present worth of savings, and the incremental return on the additional investment.

To complete these calculations, the program uses the energy consumption calculated during the plant (equipment) simulation and your entries, which describe utility rates, system installation cost, mortgage life, cost of capital, and so on.

Program layout

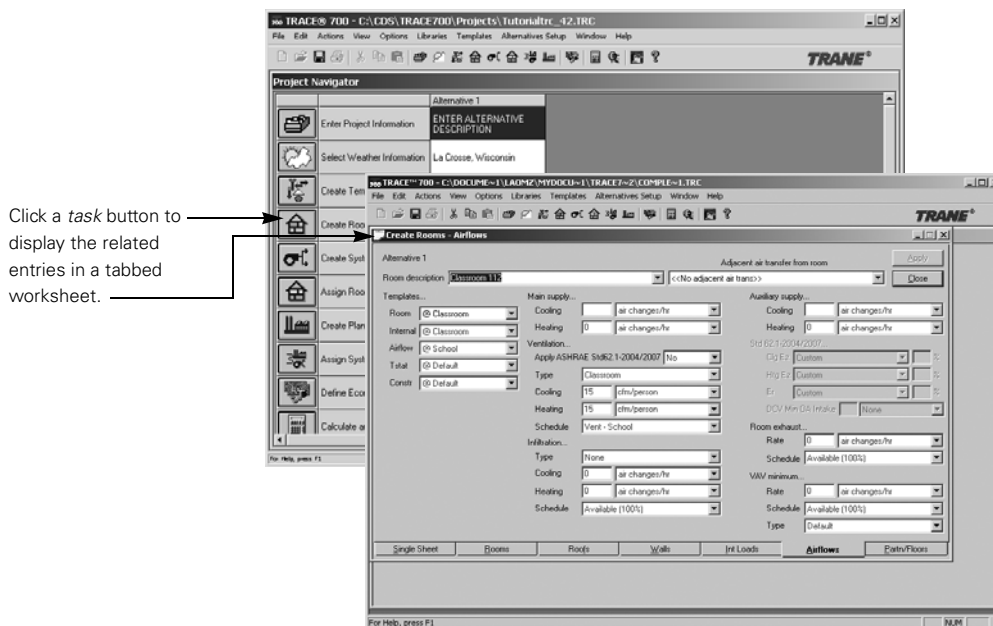
Now that you know how the program is organized *functionally*, this section acquaints you with how the program is organized *physically*.

Views

Performing a complete energy and economic analysis of a building requires details about the building, the system, and the kind of equipment used, as well as information about financing and costs. The TRACE 700 workspace organizes these entries in the following three ways.

Project Navigator view: organizes your entries by *task*. Each task in the analysis process is represented by a button on the floating **Project Navigator** palette. Clicking any of these buttons opens a tabbed worksheet that prompts you for the information needed to complete that step. Refer to Figure 2–2.

Figure 2–2 Project Navigator view

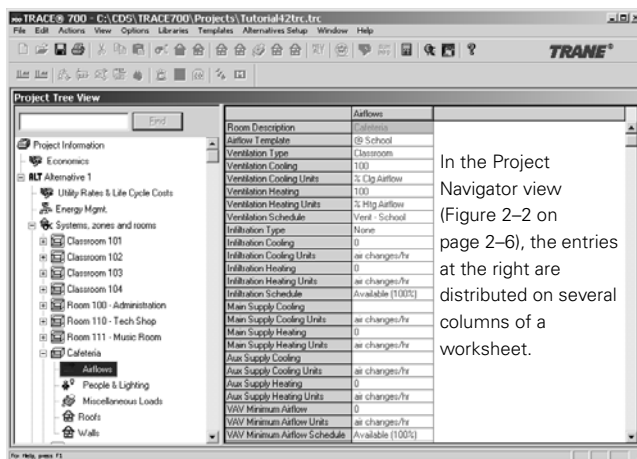


The button arrangement represents the typical sequence of entries, but you can enter information in virtually any order.

Note: The Project Navigator view displays the entries for only one room, system, or plant at a time.

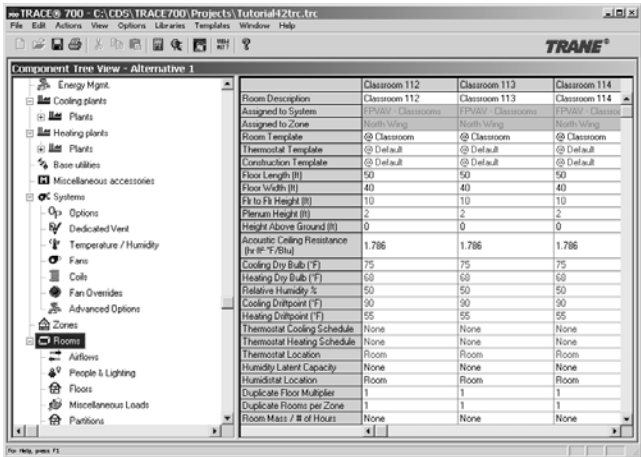
Project Tree view: organizes your entries by *system*, *zone*, and *room*. The left-hand pane displays a hierarchical list of all of the rooms, systems, and plants defined in the current project. Selecting one of these items (a room, for example) displays all of the attributes for the item in the right-hand pane. Refer to Figure 2–3.

Figure 2–3 Project Tree view



Component Tree view: organizes your entries by *attribute*. Selecting an attribute (room airflows, for example) displays all of the airflow-related entries for all of the rooms defined in the current project. Refer to Figure 2–4. After completing the entries in the Project Tree or Project Navigator view, use the Component Tree view to check your work or make changes to a single attribute for multiple rooms.

Figure 2–4 Component Tree view

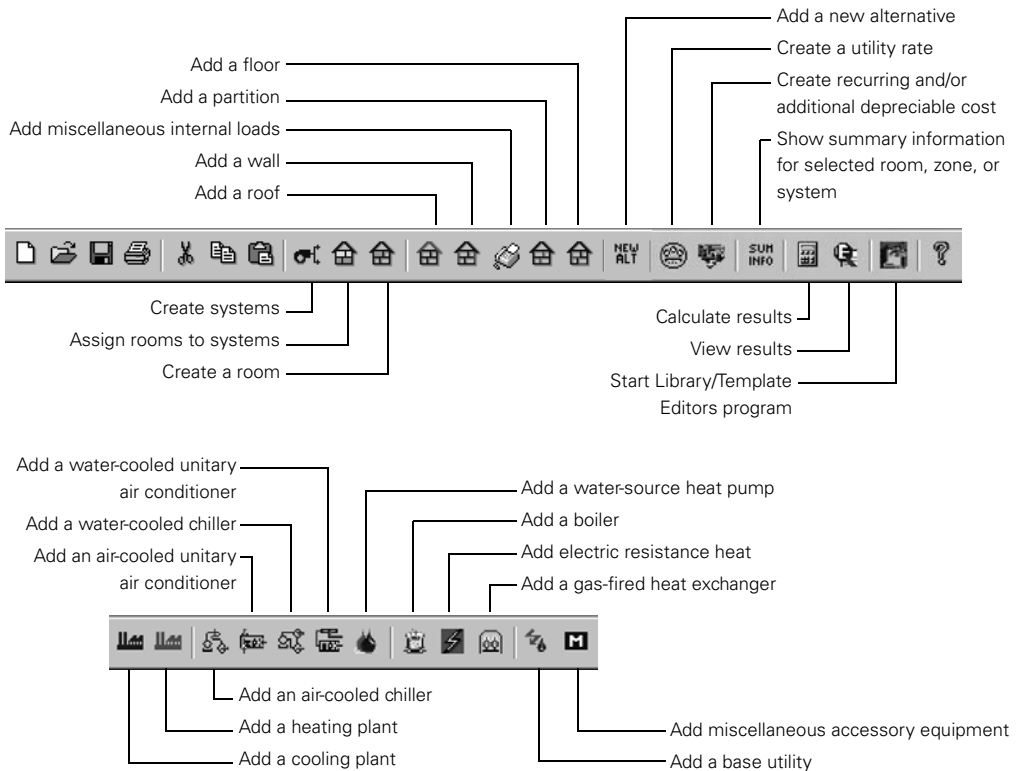


Other workspace elements

Menus across the top of the main TRACE 700 window organize the commands that help you manage and work with the analysis projects. A *toolbar* directly below the menus provides one-click access to many of these commands.

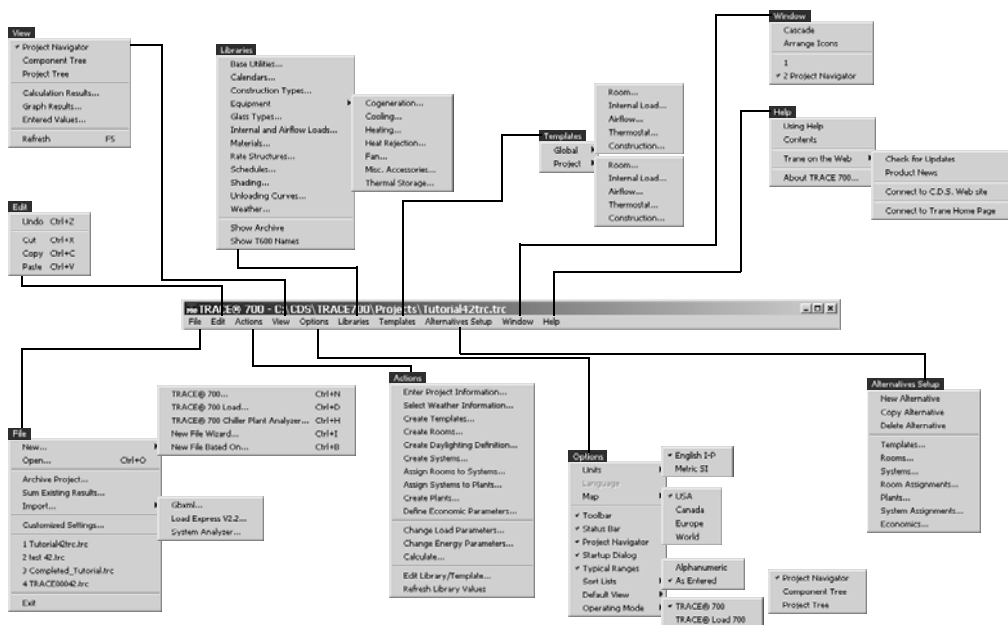
Holding down a toolbar button or highlighting a menu command displays a brief description of its purpose in the *status bar* at the bottom of the TRACE 700 window. For additional information, consult online Help.

Figure 2–5 TRACE 700 toolbar (Project Tree view)*



**Note: The toolbars visible in the Project Navigator and Component Tree views are subsets of the one shown here. The availability of toolbar buttons depends on the item currently selected.*

Figure 2–6 TRACE 700 menus



**Note: Availability of certain menus and commands depends on the current view, whether a project is currently open, and the focus in the current window or dialog box.*

Color cues

As you work with the program, you will see that some of the entry boxes are pale yellow or light gray instead of white, and that some values are red or dark gray instead of black. Color-coding the entries in this fashion lets you distinguish between entries that are:

- changes not advised (red background)
- commonly used (white background)
- seldom used (pale-yellow background)
- unavailable (light-gray background)
- default values from templates (red text)
- non-template or overridden template values (black text)

Performing basic tasks



TRACE 700 Help contains detailed information about each program entry.

The remaining chapters describe how to model common, system-level HVAC options and control strategies. Rather than repeat many of the same steps for each example, this section summarizes each analysis task represented on the Project Navigator palette. For step-by-step instructions and other related information, refer to the tutorial in the electronic TRACE 700 Getting Started Manual and to online Help.

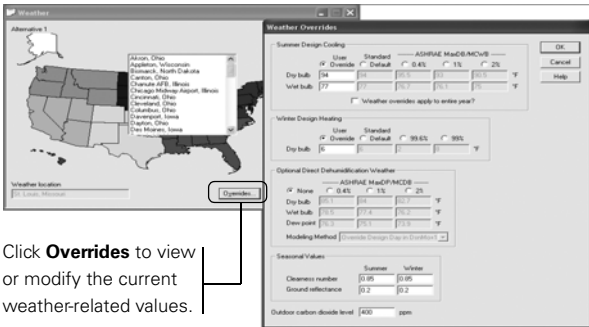


Provide weather information

Local weather conditions, latitude and longitude, and elevation affect the loads in a building. To provide this information, *pick the city that best represents the weather profile that the building will experience.*

The TRACE 700 database includes weather profiles for more than 500 cities around the world. Each profile details the design wet- and dry-bulb temperatures, barometric pressures, wind velocities, ground reflectance, saturation curves, and cloud cover. This information helps the program to determine the conduction, solar, infiltration, and outdoor-air loads in the building.

Figure 2-7 Provide weather information



Click **Overrides** to view or modify the current weather-related values.

Click a region on the map to select the representative city (To change maps, use the **Options** menu.)

Note: Additional weather locations can be imported if necessary. Refer to “Adding weather locations and activating the 8760 calculation methodology” on page 6–167. Additional international weather locations can be downloaded from: <http://www.tranecds.com>

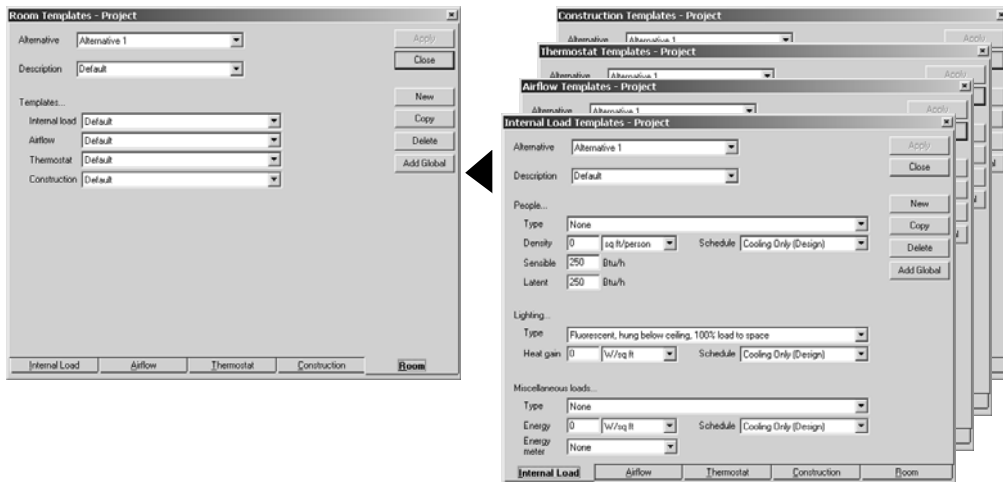


Create templates

Templates establish the default values for four types of room attributes. Each template is defined on a separate tab:

- *Internal load(s)* such as people, lighting, miscellaneous equipment (personal computers, for example), and other sources of heat within the room
- *Airflow(s)*, including ventilation, infiltration, supply (main, auxiliary and VAV minimum), and room exhaust
- *Thermostat* settings for the dry-bulb temperatures and driftpoints during heating and cooling, as well as for relative humidity
- *Construction* of the room—height, the types of windows and skylights, and the materials that compose the heat-transfer surfaces (exterior walls, partitions, roof, floor)

Figure 2–8 Create templates



Note: Global templates are stored in the TRACE 700 database and are available to any project. Project templates become part of the project (.TRC) file. For additional information regarding how to use templates, refer to “Using templates” on page 6–125.



Create rooms

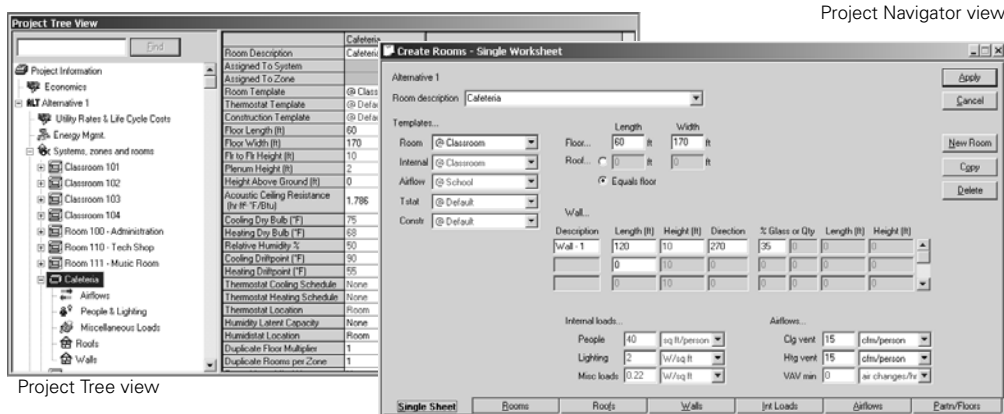
Remember that the TRACE 700 program defines a room as the smallest space for which it can calculate heating and cooling loads. Room attributes include construction, design airflows, thermostat settings, and sources of heat (people, lights, and equipment). If the building contains many similar rooms, use templates to save time.

Before entering information about the rooms, decide how detailed your analysis results should be.

For simple building designs, or when a close estimate of the design loads is sufficient, refer to “Quick building inputs via the New File Wizard” on page 6–110.

For complex building designs, or when accuracy is critical, provide as much information as you can on each tab of the **Create Rooms** window.

Figure 2-9 Create rooms





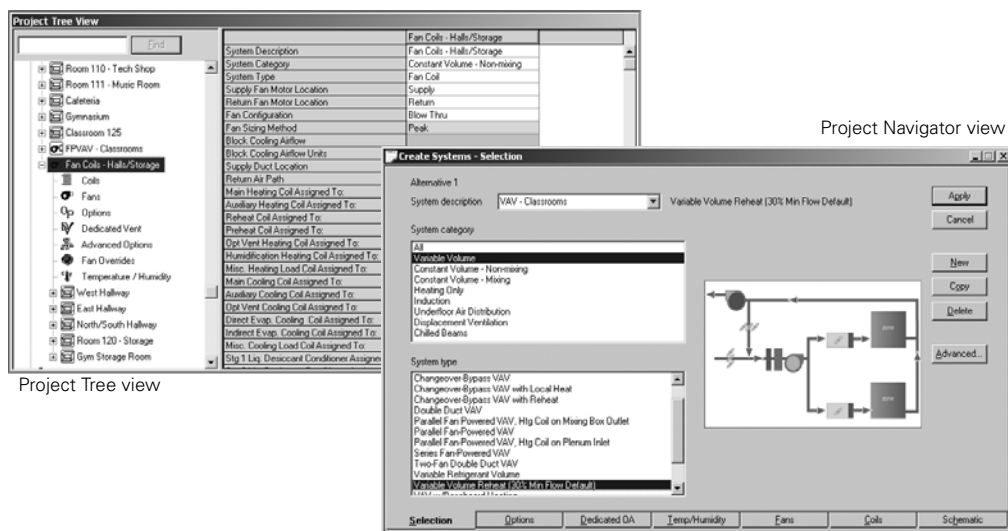
Create systems

Adding an air-distribution system to a project is a matter of choosing a system type. A majority of the information needed to calculate coil loads and airflows is automatically provided, based on the system type you select. However, system and building-specific values such as fan static pressure, fan-motor location, and so forth, should be defined.

If you wish, you can limit the range of design supply-air temperatures or specify a minimum humidity level. You can also add options such as dedicated outdoor-air systems, evaporative cooling, exhaust-air energy recovery, economizing, and dehumidification controls.

Review the system defaults to verify that they are relevant to your specific project analysis. Unless you are modeling an existing air-distribution system, it is seldom necessary to edit the default values for coils.

Figure 2–10 Create systems

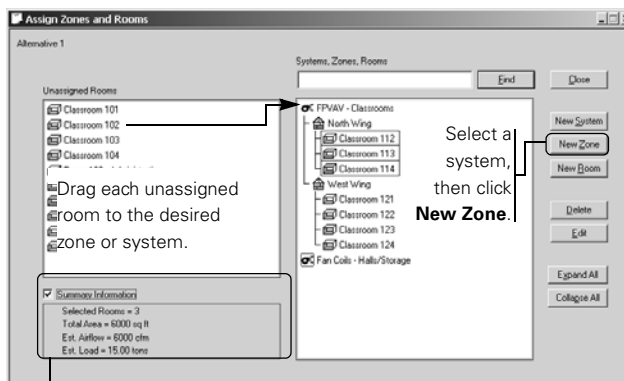




Assign rooms to systems

In order for the program to properly calculate the airflows, coil loads, and fan sizes for each air-distribution system, it must know what rooms and zones each air-distribution system serves.

Figure 2–11 Assign rooms to systems (Project Navigator view)



If you assign individual rooms to a single-zone (SZ) system or to a variable-temperature, constant-volume (VTCV) system, TRACE 700 treats each room as if it has a separate cooling coil. For proper modeling, create a zone for each SZ system, then assign the appropriate rooms to each zone. Refer to “Zoning of rooms” on page 6–47 for details on zoning.

When selected, the **Summary Information** check box displays the estimated airflow and load, as well as the total area, for the selected rooms. Initially, these estimates are based on common industry *rules of thumb*: 1 cfm/ft² and 400 ft²/ton.

You can assign individual rooms to a system. If you are modeling a VAV system, consider grouping the rooms served by the same VAV terminal as a zone. Then assign the zone to a system. This practice permits the program to calculate the design airflow for the heating coil within the VAV terminal, as well as the design airflow for each room in the zone.

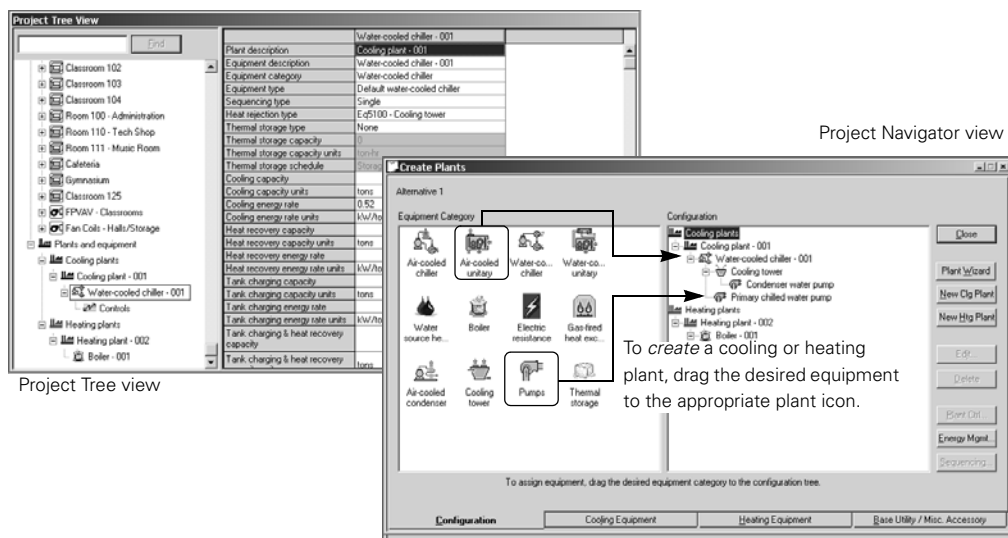
Note: Refer to “Zoning of rooms” on page 6–47 for details on zoning.



Create plants

Cooling and heating **plants** represent mechanical equipment that consumes energy to treat air throughout the building. As shown

Figure 2-12 Create plants



in Figure 2-12, the program models many types of cooling and heating equipment, including:

- air-cooled chiller
- air-cooled unitary air conditioner
- water-cooled chiller
- water-cooled unitary air conditioner
- water-source heat pump
- boiler
- purchased chilled water
- purchased hot water
- air-to-air heat pump
- electric resistance heat
- gas-fired heat exchanger
- air-cooled condenser
- cooling tower
- pump
- thermal storage
- purchased district steam
- cogeneration
- free cooling



When you select an equipment category, the program automatically adds the appropriate auxiliary equipment (pumps, for example).

Adding HVAC equipment to a project is a matter of selecting the desired cooling and heating equipment, as well as auxiliary components such as pumps and cooling towers. *Drag the desired equipment category to the cooling or heating plant on the right-hand side of the Configuration tab.*

If you wish, you can add options such as chilled-water reset, demand limiting, free cooling, evaporative precooling, load-shedding economizing, and chiller sequencing. You can also model the energy consumption of *miscellaneous accessories* attached to the primary HVAC equipment (crankcase heaters, defrost heaters, pilot lights, pumps, parasitic heat losses) and *base utilities*. Like the HVAC system and indoor lights, base utilities (process loads and parking-lot lights, for example) can represent a significant percentage of the energy consumption for the building.

Review the equipment defaults to make sure that the completed entries sufficiently represent equipment and system performance. To account for the energy consumption of a pump, for example, be sure to enter a value for full-load consumption.

*Note: Many of the entries in the **Create Plants** window are blank by default because they only pertain to certain systems. Unless you override the default by entering a value, entries such as capacity will be determined by the results of the load calculations.*



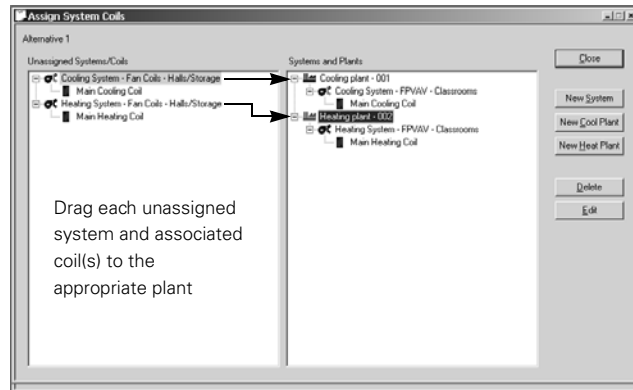
Assign systems to plants

For the program to translate the coil loads, by system and by hour, into energy consumption by source, it must know what systems each cooling plant and heating plant serves.

To assign each system and the associated coil(s), drag it to the appropriate plant—that is, assign cooling coils to cooling plants and heating coils to heating plants, as shown in Figure 2–13 on page 2–18.

Note: In some types of systems, the same coil serves as both the main cooling coil and the main heating coil. Examples include fan coils, unit ventilators, and water-source heat pumps. TRACE 700 represents the cooling and heating functions separately (as purple coils) so that you can assign each coil load to the proper plant.

Figure 2-13 Assign systems to plants (Project Navigator view)



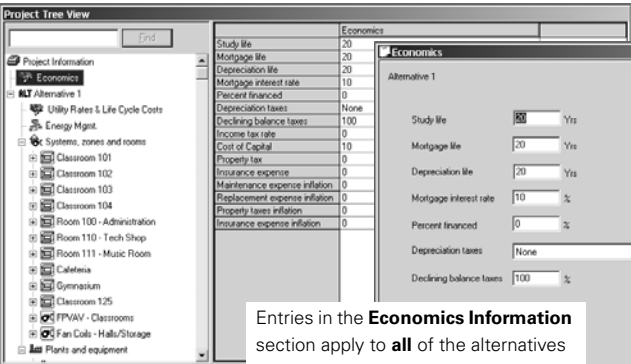
Define economics

The TRACE 700 program calculates financial measures such as the net present value of annual cash flow, internal rate of return, simple payback period, and savings-to-investment ratio. To complete these calculations, the program applies utility rates to the monthly energy consumption of the cooling and heating equipment (determined during the plant simulation). Entries in this section of the program describe various economic factors:

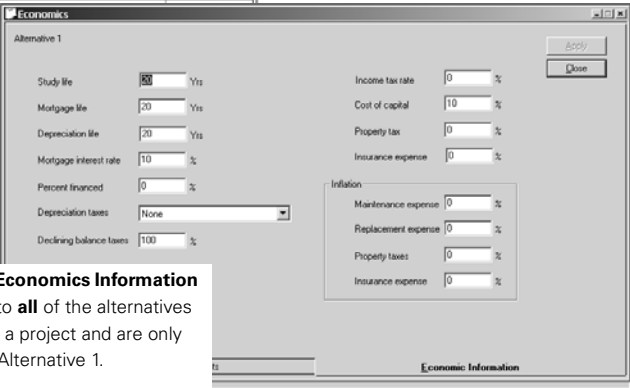
- installed cost
- maintenance cost
- utility rate structures
- cost of capital
- interest rate
- inflation rate
- income-tax rate
- depreciation
- study life
- recurring costs

Figure 2–14 Define economics

Project Tree view

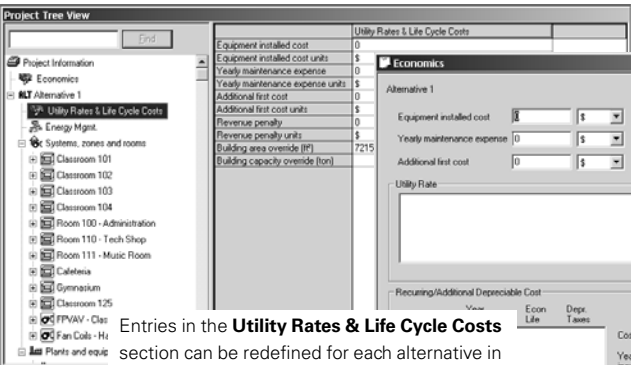


Project Navigator view

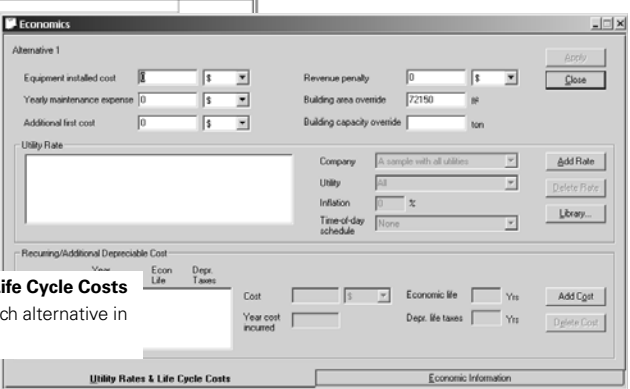


Entries in the **Economics Information** section apply to **all** of the alternatives defined within a project and are only editable from Alternative 1.

Project Tree view



Project Navigator view



Entries in the **Utility Rates & Life Cycle Costs** section can be redefined for each alternative in a project.

Create schedules

Schedules play an important role in load simulations and energy analyses. They define when, and for how long, internal loads and system events occur, both of which affect energy demand and consumption.

Five types of schedules are predefined in the TRACE 700 **Schedules** library:

- **Utilization** schedules define the timetables for internal loads (occupancy, lights, infiltration, miscellaneous) and the air-distribution side of the HVAC system (fans, coils, controls).
- **Thermostat** schedules establish the cooling and heating set points for each hour.
- **Time-of-day** schedules distinguish peak, mid-peak, off-peak, and super-off-peak hours, permitting economic analysis of energy costs.
- **Thermal storage** schedules define when the operating modes for thermal-storage equipment occur.
- **Equipment operation** schedules define the hours of the day that mechanical cooling and heating equipment is available for operation.



The Library/Template Editors program lets you view the attributes of each standard schedule and create new ones of your own. Because schedules are key to developing accurate system models, the procedure to create a schedule is summarized here for your convenience. Although the example specifically describes a **Utilization** schedule, other types of schedules are created in similar fashion.

Table 2-1 Example schedule for year-round building occupancy

Day	Begin	End	Design Occupancy
Monday–Friday	midnight	7:00 a.m.	0% (unoccupied)
	7:00 a.m.	8:00 a.m.	20%
	8:00 a.m.	noon	100%
	noon	1:00 p.m.	50%
	1:00 p.m.	5:00 p.m.	100%
	5:00 p.m.	6:00 p.m.	20%
	6:00 p.m.	midnight	0% (unoccupied)
Saturday–Sunday	midnight	midnight	0% (unoccupied)

Sample scenario

Table 2–1 on page 2–20 describes the year-round schedule for the occupancy of a building. Use this information to create a new **Utilization** schedule in the TRACE 700 **Schedules** library.

Also, keep the following points in mind whenever you apply or customize a schedule:

- When performing a reduced year simulation, each schedule must include individual definitions for each of four day types: **Cooling design**, **Weekday**, **Saturday**, and **Sunday**. (For more information, refer to “Simulation methods” on this page.)

To make the schedule available for calculations of the design cooling load, select **Cooling design** as the starting day type. To identify a separate schedule for weekends, select **Weekday** as the ending day type.

Start	End
Month: January	December
Day type: Cooling design	Weekday
Start time: 6 a.m.	End time: 7 p.m.
	Weekday
	Saturday
	Sunday

To define a 24-hour period, use **Midnight** as the first start and last end times

Start time	End time	Percentage
Midnight	6 a.m.	0
6 a.m.	7 p.m.	100
7 p.m.	Midnight	0

Enter **0** to exclude a scheduled load from energy calculations

Month	Day type
January - May	Cooling design to Weekday
June - August	Cooling design to Sunday
September - December	Cooling design to Weekday
January - May	Saturday to Sunday
September - December	Saturday to Sunday


- **Utilization** schedules require you to define a schedule for the **Heating design** month. The program uses it during the heating load–design calculations of airflow and supply-air dry bulb.

Note: For the heating-design-month schedule, only include loads that contribute significantly to the building heating load—ventilation and infiltration, for example, but not internal loads such as those associated with occupancy and lights. To exclude a load from the schedule, enter 0 as the percentage.

- When creating a **Utilization** schedule, always start with January and end with December.
- For example, to define a **Utilization** schedule for an event that starts in May and ends in September, include January through April and October through December at zero percent.
- When adding start and end times to a schedule definition, use **Midnight** as the first start time *and* the last end time. (The program will prompt you to correct periods that overlap.)

Simulation methods

To arrive at equipment loads and energy consumption, the TRACE 700 program calculations are based on the simulation hours set for the project. You can choose between two methods of calculation: *reduced-year* versus *full-year* analysis (refer to Figure 2–15 on page 2–23).

1 Click  in the toolbar to open the **Schedule** library. Then click **New Sched** to add a new member in that library.

2 Pick **Utilization** as the schedule type. Then give the new schedule a name in the **Description** box. Use the **Comments** box to add a brief explanation (optional).

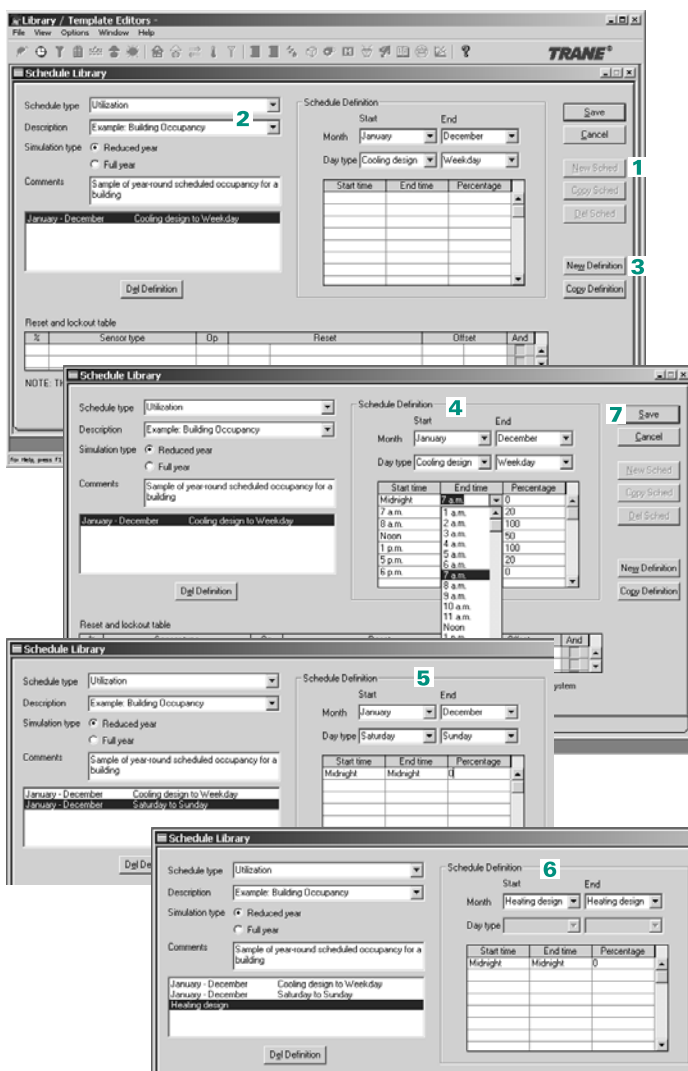
3 Click **New Definition** to begin entering the *cooling design and weekday* definition for the year.

4 Complete the **Schedule Definition** entries using the information in Table 2–1 on page 2–20.

5 Repeat Step 3 and Step 4 to enter the *Saturday and Sunday* definition.

6 Similarly, enter the *heating design* definition as shown. (These entries exclude the effect of occupancy from the calculation of the design heating load.)

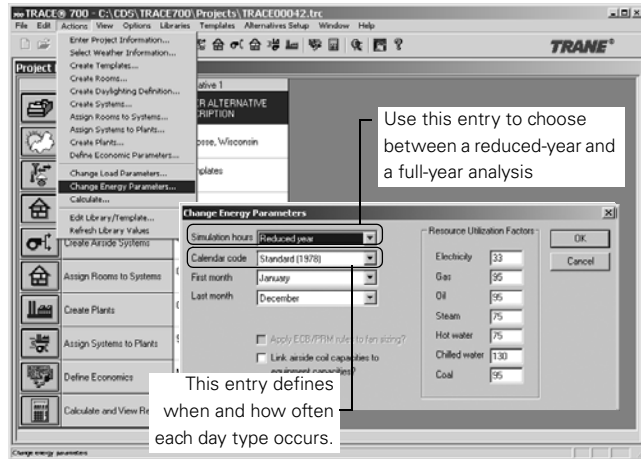
7 Click **Save** to record your entries and make the new **Utilization** schedule available for any TRACE 700 entry that lists **Utilization** schedules. For additional details, refer to “Creating schedules” on page 6–137.



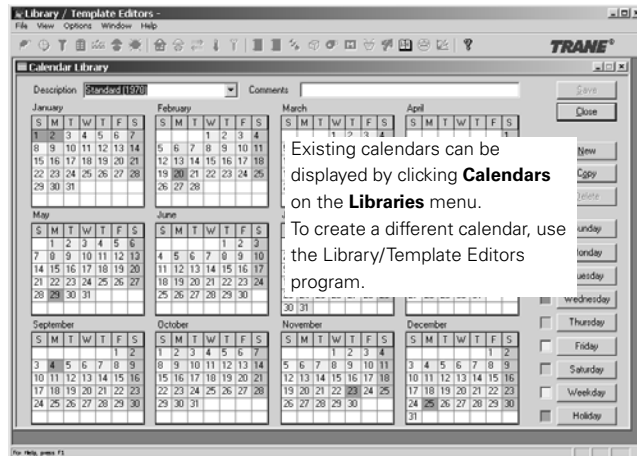
A **reduced-year analysis** calculates coil loads, by month, for a *design* day, a *typical* weekday, a *typical* Saturday, a *typical* Sunday, and a *typical* Monday, using 24 hours of weather that is typical for that month. A calendar code defines the number of occurrences for each day type.

Figure 2-15 Choose a simulation method

TIP
Standardized 8760 weather data for a full-year analysis can be purchased from various U.S. federal government agencies or downloaded at no charge from various Web sites. For example, ASHRAE IWEC (International) weather can be downloaded at no cost from tranecds.com.



Refer to “Adding weather locations and activating the 8760 calculation methodology” on page 6–167 for additional information regarding simulations and adding weather libraries.



By contrast, a *full-year analysis* uses standardized weather data for all 8,760 hours in a year to calculate the actual coil loads for each hour. Sometimes described as an *8760 analysis*, it can have

separate schedules for nine different day types—the seven days of the week *plus* a design day and a holiday. Although the calculation process lasts 5 to 7 times longer than a reduced-year analysis, you can use the additional day types in a full-year analysis to more accurately represent the actual day-to-day operating schedule of the building.

Figure 2-16 TRACE 700 Weather library

Weather Library - General Information

Region: United States Subregion: North Central Location: Appleton, Wisconsin

Latitude: 44 deg Longitude: 88 deg Altitude: 742 ft Time zone: 6 Design month: July Station WMO #: 726455

Station Name: Manitowish Muni Aways Winter Design: 99.6 % 99 % Dry Bulb: -6.4 -0.4

Cooling Maximum DB / Mean Coincident WB: 0.4 % 1 % 2 % Dry Bulb: 84.1 81.3 79 Wet Bulb: 70.4 69 67.4 Dew Point: 64.28 63.32 61.8

Defunct Maximum DB / Mean Coincident DB: 0.4 % 1 % 2 % Dry Bulb: 79.3 76.1 74.2 Wet Bulb: 73.98 71.48 68.71 Dew Point: 71.9 69.6 66.2

Saturation Curve Coefficients: Coef A: -0.32289738 Coef B: 0.94949453 Coef C: -0.013779521 Coef D: 0.0002276629

Comments: Created by C.D.S. Marketing



You can use the following types of weather files in a TRACE 700 analysis:

typical meteorological year, .TMY, .TMY2 ■

test reference year, .TRY ■

California Energy Commission (CEC) energy efficiency standard;

.WY2 (1992–95), .CEC (1988), .CTZ (1978) ■

TRACE 600 weather, .WTR ■

Canadian energy codes, .CWC ■

ASHRAE weather, .IWC ■

Note: Reduced-year schedules can be used for both methods of calculation. Full-year schedules should only be used with full-year simulations. For additional details, refer to “Creating schedules” on page 6–137.

Note: When you import a standardized 8760 weather file into TRACE 700, the program creates a separate set of monthly design 24-hour profiles based on the weather extremes for use with the load–design simulation. For a more accurate analysis, be sure to check the design summer and winter dry-bulb temperature and wet-bulb temperature and adjust them as necessary before completing the import process. Reasonable and accurate design conditions can be obtained from the most recent ASHRAE Handbook of Fundamentals. Importing weather files is discussed in “Adding weather locations and activating the 8760 calculation methodology” on page 6–167.

General modeling hints

The hints this section will help you obtain an accurate analysis of building loads, energy consumption, and the economic impact of various HVAC designs. Use them in conjunction with the specific instructions in Chapter 3 through Chapter 6 to successfully model common, system-level HVAC options and control strategies.

Plants and equipment

- When you create a new project, the program automatically adds the first cooling plant and the first heating plant for you.
- If a plant consists of two or more pieces of equipment, specify the capacity of each piece of cooling or heating equipment. (If you omit this information, the program assigns the entire load to the first piece of equipment that you added to the plant. If you define the capacity of the first piece of equipment but *not* the second, the program will allocate the remaining plant capacity to the second piece of equipment.)
- Specify the full-load energy rate or head pressure for each pump to account for pump energy consumption in your analysis. (Omitting this information tells the program that the pump does not consume energy.)
- To add new pieces of equipment to a TRACE 700 library, copy and modify an existing equipment definition.

*Note: Exercise particular care when creating new pieces of cooling equipment. Modeling accuracy requires that the unloading curves represent performance characteristics at comparable design conditions. The standard unloading curves used in the TRACE 700 **Cooling Equipment** library are typically based on rating conditions defined by the Air-Conditioning and Refrigeration Institute (ARI). Refer to “Creating equipment and unloading curves” on page 6–143 for additional details.*

- Table 2–2 on page 2–26 shows the fuel types and corresponding units of measure that TRACE 700 uses to model various equipment.

Table 2–2 Default IP units for equipment energy use		
Description	Consumption	Peak
electricity	kWh	kW
natural gas	therm	therm/hr
fuel oil	(A therm = 100,000 Btu or 100 cu ft of natural gas)	
coal		
wood		
water	1,000 gal	1,000 gal/hr
purchased steam, hot water, or chilled water	therm	therm/hr
process load: steam or hot water	therm	therm/hr
process load: chilled water	ton–hr	ton
other load	therm	therm/hr

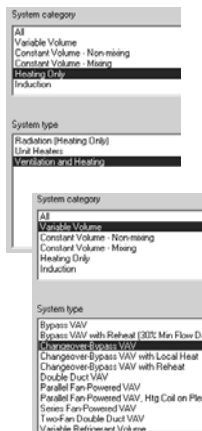
- To model plant-level options such as plate-and-frame free cooling (waterside economizer) or piping arrangements, be sure to identify the option or arrangement for *each chiller* in the plant.
- By default, the order in which you add equipment to a heating or cooling plant becomes the equipment start sequence.

Coil loads

- Coil loads cannot be assigned to individual pieces of equipment; they can only be assigned to plants. Create separate plants to distribute the coil loads across multiple pieces of equipment.

For example, to assign the main cooling load to a chiller and an optional ventilation cooling load to a rooftop air conditioner, create separate cooling plants for the chiller and rooftop air conditioner.

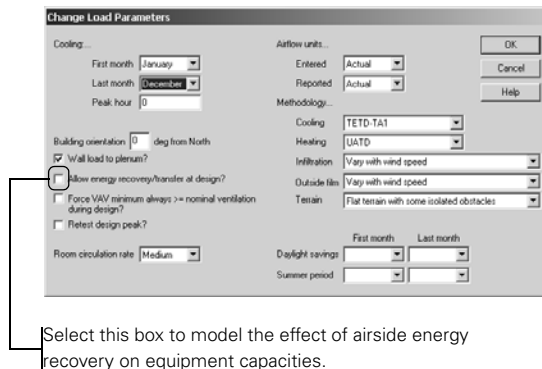
- To properly model the coil loads for a single-zone (SZ) system, create a separate zone for each SZ system in your project. Then assign the appropriate rooms to each zone.
- To model a heating-and-ventilating-only system (that is, an airside system without a cooling coil), select **ventilation and heating** from the **heating only** category of airside systems.
- To model a variable volume, variable temperature (VVT) system such as the VariTrac® changeover–bypass system, select one of the **changeover-bypass VAV** system types from the **variable volume** category of airside systems.



- To model the effect of heat recovery on the sizing of cooling and/or heating equipment:

- Click **Change Load Parameters** in the **Actions** menu.
- Select the check box labeled **Allow energy recovery / transfer at design?** near the left side of the dialog box.

Note: TRACE 700 automatically asks the user whether this box should be checked when a heat-recovery device is selected.



Equipment capacities calculated to reflect airside energy recovery at design may differ significantly from the capacities calculated without this option. Keep this in mind when determining how to size system components.

3 Cooling and Heating Plants

Modeling examples in this chapter

Cooling and heating plant design and control

- Decoupled chiller arrangement, page 3–3
- Parallel chiller arrangement, page 3–7
- Series chiller arrangement, page 3–9
- Variable-primary-flow chiller arrangement, page 3–13
- Switchover control for chiller plants, page 3–17
- Thermal energy storage, page 3–21
- Cogeneration, page 3–28
- Direct-fired absorption cooling, page 3–31
- Low-flow chilled-water systems, page 3–33
- Purchased chilled water, page 3–37
- Purchased district steam and purchased district hot water, page 3–40

Free cooling and heat rejection

- Plate-and-frame free cooling, page 3–43
- Refrigerant-migration free cooling, page 3–46
- Strainer-cycle free cooling, page 3–48
- Double-bundle condenser heat recovery, page 3–50
- Evaporative precooling of condenser air, page 3–54
- Cooling tower with VFD, page 3–57
- Chiller–tower optimization, page 3–59

Domestic hot water

- Domestic hot water assigned to a boiler, page 3–62

Heat pump systems

- Air-to-air heat-pump system, page 3–64
- Water-source heat-pump system, page 3–68

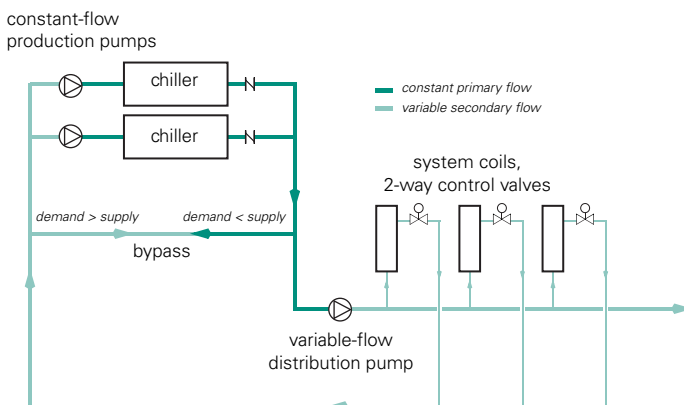
- Ground-source heat-pump system, page 3–72
- Central geothermal chillers, page 3–76
- Variable refrigerant flow system, page 3–81

Note: This (and each succeeding) chapter provides basic how-to instructions to help you model common, system-level HVAC options and control strategies. Each example begins with a brief description of the system option or strategy, followed by a sample scenario that illustrates the entries needed to model it. Typical values are suggested where appropriate.

Decoupled chiller arrangement

The basic, decoupled chilled-water system shown in Figure 3–1 is sometimes described as a *primary–secondary* pumping arrangement. Although separate pumps are dedicated to the production and distribution sides of the system—meaning that both pumps transport the same water—there is no duplication of pumping energy. That is because the production pumps only overcome the production-side pressure drop (production piping, chillers, and check valves), while the distribution pump only overcomes the pressure drop on the delivery side of the system (distribution piping and coils).

Figure 3–1 Decoupled chiller arrangement



A bypass line hydraulically decouples the production and distribution pumps, preventing them from operating in a series-coupled pumping arrangement. In effect, it creates a supply/demand relationship at the tee that connects the production (supply) and distribution (demand) sides of the system. The direction and amount of flow through the bypass line determines the number of chillers operating at any one time.

This arrangement provides constant water flow through the chillers while they operate. It also permits two-way valves at the coils, with the valves varying the flow based on the cooling

demand. Equipping the distribution pump for variable flow—by adding a variable-frequency drive, for example—can limit the dynamic pumping head, which reduces energy consumption significantly.

Application considerations

- Not all chilled-water loads peak simultaneously, resulting in the quantity of water flowing at any one time being less than the *sum-of-the-peaks* load. Varying the flow through the distribution loop may permit you to select smaller chillers, pumps, and piping.
- Only the water that the loads actually use is pumped. This usually results in a significantly reduced flow rate, accompanied by an even more significant reduction in pumping energy.
- None of the unused chilled water bypasses the cooling coils—the return water is therefore always at least as warm as it is at full load. Warm return water permits *preferential* loading of chillers and accommodates energy-saving options such as free cooling and heat recovery.


Related reading

- *Chilled-Water Systems* Air Conditioning Clinic, one of the systems series (Trane literature number TRG-TRC016-EN)
- *Multiple-Chiller-System Design and Control* Applications Engineering Manual (Trane literature number SYS-APM001-EN)

Sample scenario

Three 500-ton, three-stage, centrifugal chillers are piped in parallel with each other and with a bypass line. Each chiller has a pair of constant-volume pumps, one for chilled water and one for condenser water. An 85-kW, variable-volume pump circulates the chilled water through the coils to satisfy the building load.

The illustrations that follow demonstrate how to define the cooling plant (Steps 1–5) and add a secondary distribution pump (Steps 6–9).

 Define the **cooling plant** by selecting **Create Plants** in the **Project Navigator** window.

- 1 Drag three water-cooled chillers to the cooling plant and click the **Cooling Equipment** tab.

For *each* chiller:

- 2 Select the appropriate **equipment type**.
- 3 Pick **parallel-decoupled** as the sequencing type.
- 4 Enter the **cooling capacity** (500 tons). (If left blank, the program calculates this value and assigns the entire capacity to the first chiller.)

- 5 Specify the **full-load energy consumption** for each pump.

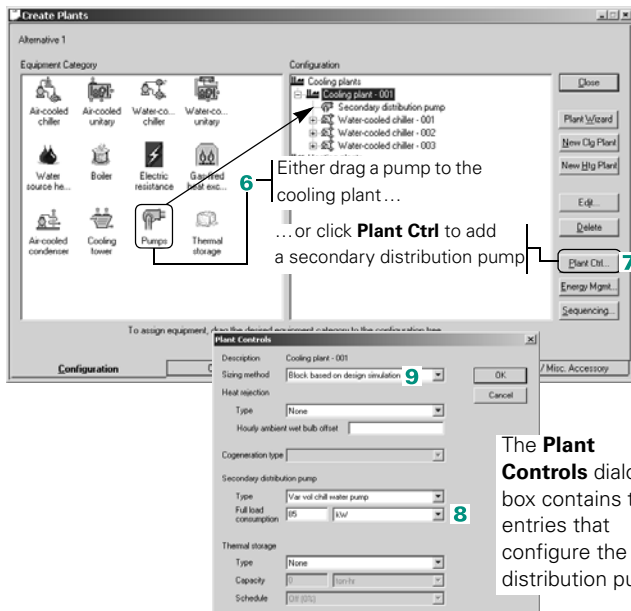
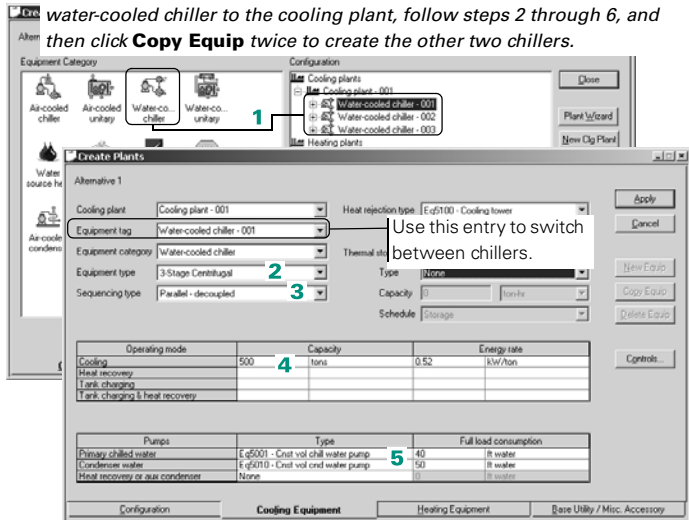
- 6 On the **Configuration** tab, add a secondary distribution pump to the cooling plant.

- 7 To open the **Plant Controls** dialog box, select the *cooling plant* and click **Plant Ctrl**.

- 8 Choose a variable-flow chilled-water pump, and then enter the **full-load energy consumption** for the pump (85 kW).

- 9 Change the plant sizing method to **block plant** because the cooling capacity produced by the decoupled chillers will equal the largest simultaneous load of the coils.

*Note: The three chillers are identical. As an alternative, drag only one water-cooled chiller to the cooling plant, follow steps 2 through 6, and then click **Copy Equip** twice to create the other two chillers.*

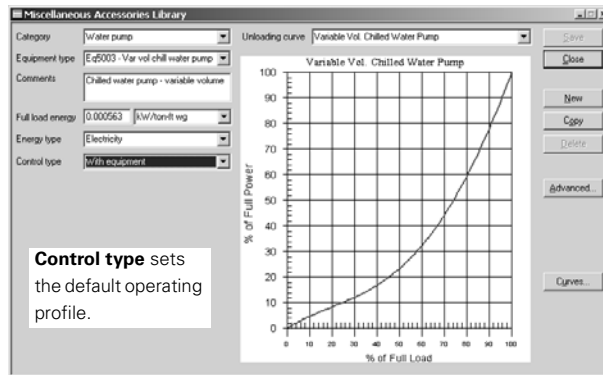


The **Plant Controls** dialog box contains the entries that configure the distribution pump.

*Note: In a decoupled piping arrangement, the secondary distribution pump runs whenever one or more of the chillers is operating. To model this control characteristic, library definitions for pumps use **with equipment** as the control type.*



Use the *Library/Template Editors* program to view the predefined pumps in the Miscellaneous Accessories library or create custom pumps. On the **Libraries** menu, select **Equipment** and then **Misc. Accessories**.



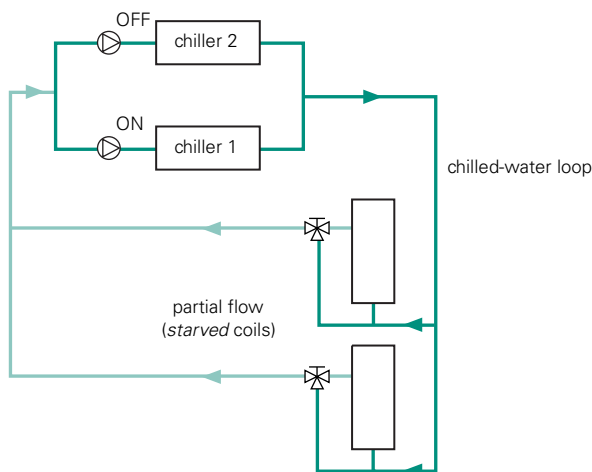
Parallel chiller arrangement

To ensure uninterrupted cooling, many chilled-water plants are designed with at least two chillers even though a single chiller can often satisfy the system load. Typically, either of two pumping arrangements is used when the chillers are piped in parallel. One arrangement uses a single pump to circulate chilled water through the system. The other (shown in Figure 3–2) dedicates a separate chilled-water pump to each chiller.

The parallel arrangement in Figure 3–2 represents a *swing-chiller* control strategy that *unequally* divides the total cooling capacity between the chillers—one third and two thirds, for example. When a cooling load exists, the smaller chiller starts first. When the load exceeds the capacity of the smaller chiller, it stops and the larger chiller starts. If the cooling load exceeds the capacity of the larger chiller, both chillers operate and share the load proportionally according to their capacity.

Note: To operate as described for the unequal division, chiller sequencing with a switchover point must be defined. Refer to “Switchover control for chiller plants” on page 3–17.

Figure 3–2 Parallel chillers with separate, dedicated pumps



Application considerations

- Using a single pump to circulate water through the chilled-water loop does not provide standby capability.
- Providing a separate, dedicated, chilled-water pump for each chiller helps maintain the proper *mixed* chilled-water temperature. Cycling each chiller–pump pair can significantly reduce the total system flow, and may cause insufficient cooling in some areas of the building.
- The load profile for a *plant* with multiple chillers differs from the load profile of each chiller due to thermal inertia. Judiciously sizing the chillers can improve the overall efficiency of the plant.

Related reading

- *Chilled-Water Systems* Air Conditioning Clinic, one of the systems series (Trane literature number TRG-TRC016-EN)
- *Multiple-Chiller-System Design and Control* Applications Engineering Manual (Trane literature number SYS-APM001-EN)
- “Chilled-Water Plants and Asymmetry as a Basis of Design,” *Engineers Newsletter* (volume 28, number 4)

Modeling instructions

The procedure for modeling a cooling plant with chillers piped in parallel is similar to the procedure for a decoupled chiller arrangement (refer to “Decoupled chiller arrangement” on page 3–3). When defining the cooling plant, however, choose **Parallel** as the sequencing type for each chiller and do not include a secondary distribution pump.

For *each chiller*, choose the **sequencing type** that describes the hydraulic arrangement of the plant.

Enter the **full-load energy consumption** for each pump to include them in the energy analysis.
Unlike primary-secondary systems, do not input a secondary distribution pump.

Alternative 1

Cooling plant: Cooling plant - 001

Equipment tag: Water-cooled chiller - 001

Equipment category: Water-cooled chiller

Equipment type: Helical Rotary (≥ 130 tons)

Sequencing type: Parallel

Heat rejection type: E-q5100 - Cooling tower

Thermal storage: [Empty]

Type: [Empty]

Capacity: 0 tons-hr

Schedule: Storage

Operating mode	Capacity	Energy rate
Cooling	300 tons	0.61 kW/ton
Heat recovery		

Type	Full load consumption
C-q5001 - Crst vol chl water pump	90 ft water
C-q5010 - Crst vol chl water pump	90 ft water
None	0 ft water

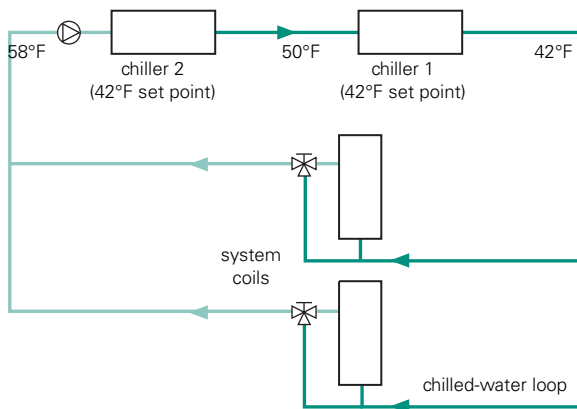
Configuration Cooling Equipment Heating Equipment Base Utility / Misc. Accessory

Series chiller arrangement

Piping chillers in series means that the entire system flow becomes the flow rate through each chiller. Accommodating this amount of water typically requires an evaporator with fewer passes, which compromises individual chiller efficiency. The loss in efficiency, however, can be offset by increased *system* efficiency. The upstream chiller operates at warmer temperatures, and a lower system flow rate yields a higher temperature differential.

Temperature control can be accomplished in several ways. The strategy represented in Figure 3–3 uses the design chilled-water temperature as the set point for each chiller. Either chiller can satisfy up to 50 percent of the total cooling load for the building. When the cooling demand exceeds 50 percent of the total load, the upstream chiller is preferentially loaded because it will attempt to produce the design chilled-water temperature. The downstream chiller operates as needed to satisfy the remaining load.

Figure 3–3 Chillers arranged in series



Application considerations

- Reducing the chilled-water flow rate for chillers piped in series lowers the pressure drop through each chiller, which saves pump energy.
- Flow and pressure-drop limitations make it difficult to apply more than two chillers in series.
- The difference between the entering- and leaving-chilled-water temperatures (ΔT) is larger for series arrangements than for other plant configurations. Account for the larger ΔT when selecting cooling coils.


Related reading

- *Chilled-Water Systems* Air Conditioning Clinic, one of the systems series (Trane literature number TRG-TRC016-EN)
- *Multiple-Chiller-System Design and Control* Applications Engineering Manual (Trane literature number SYS-APM001-EN)
- "Don't Overlook Optimization Opportunities in 'Small' Chilled Water Plants," *Engineers Newsletter* (volume 32, number 4)

Sample scenario

An absorption chiller (upstream) and a centrifugal chiller (downstream) are piped in a series arrangement. Each of these water-cooled chillers has a nominal cooling capacity of 500 tons and a dedicated condenser-water pump. The absorption chiller is *preferentially loaded*, that is, it starts first and handles most of the cooling load. If the cooling demand exceeds the capacity of the absorption chiller, the centrifugal chiller cycles on the minimum step of unloading (for the centrifugal chiller).

The following illustrations demonstrate how to define the chillers (Steps 1–6) and the loading strategy (Steps 7–8).

 After creating a **cooling plant** that consists of two water-cooled chillers, define each chiller.

1 Define the first chiller as an **absorption** machine.

2 Pick **Series** as the sequencing type.

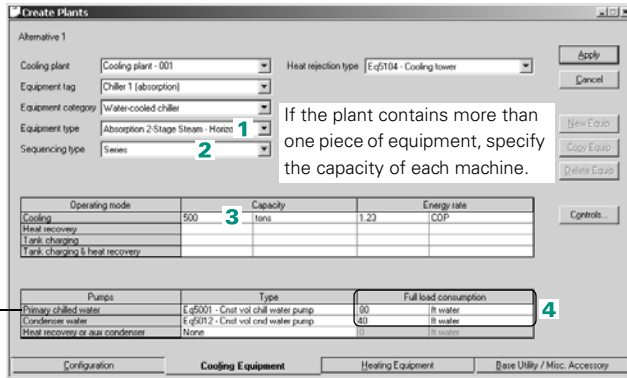
3 Enter the **capacity** of the chiller.

4 Specify the **full-load consumption** of the dedicated condenser-water pump and the shared chilled-water pump.

5 Switch to the second chiller and repeat Steps 2–4 to define it as a **centrifugal** chiller.

6 Pick **None** as the type of primary chilled-water pump.

Note: If a user has chillers in series (with a $10^{\circ}\Delta T$), the program will automatically adjust it to $5^{\circ}\Delta T$. However, if it is anything other than 10° , the program will use that entered value. For example, if chillers each have $12^{\circ}\Delta T$, the final leaving temperature will be 24° colder than the entering temperature.



Alternative 1

Cooling plant: Cooling plant - 001 Heat rejection type: Eqf104 - Cooling tower

Equipment tag: Chiller 1 (absorption)

Equipment category: Water-cooled chiller

Equipment type: Absorption 2 Stage Steam - Hotex

Sequencing type: Series

Operating mode table:

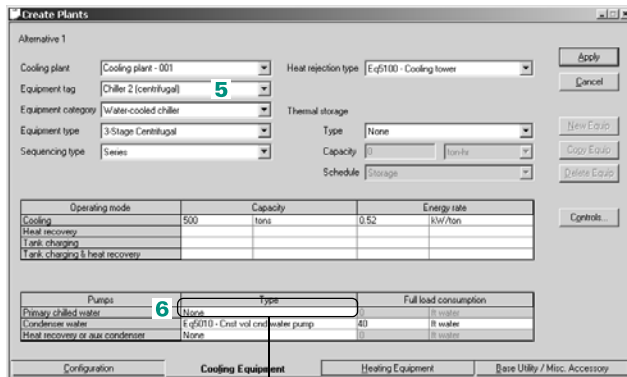
Operating mode	Capacity	Energy rate
Cooling	500 tons	1.23 COP
Heat recovery		
Tank charging		
Tank charging & heat recovery		

Pumps table:

Pumps	Type	Full load consumption
Primary chilled water	Eqf001 - Crst vol chl water pump	100 ft water
Condenser water	Eqf012 - Crst vol cond water pump	40 ft water
Heat recovery or aux condenser	None	0 ft water

Buttons: Apply, Cancel, New Equip, Copy Equip, Delete Equip, Controls...

For chillers piped in series, define only one primary chilled-water pump. For the other chiller, pick **None**.



Alternative 1

Cooling plant: Cooling plant - 001 Heat rejection type: Eqf100 - Cooling tower

Equipment tag: Chiller 2 (centrifugal)

Equipment category: Water-cooled chiller

Equipment type: 3-Stage Centrifugal

Sequencing type: Series

Operating mode table:

Operating mode	Capacity	Energy rate
Cooling	500 tons	0.52 kW/ton
Heat recovery		
Tank charging		
Tank charging & heat recovery		

Pumps table:

Pumps	Type	Full load consumption
Primary chilled water	None	0 ft water
Condenser water	Eqf010 - Crst vol cond water pump	40 ft water
Heat recovery or aux condenser	None	0 ft water

Buttons: Apply, Cancel, New Equip, Copy Equip, Delete Equip, Controls...

Choosing **None** indicates that the chiller shares a pump already defined for this cooling plant.

The sequencing strategy for the chillers is defined at the plant level.

7 Select **Cooling plant 001** and click **Sequencing**.

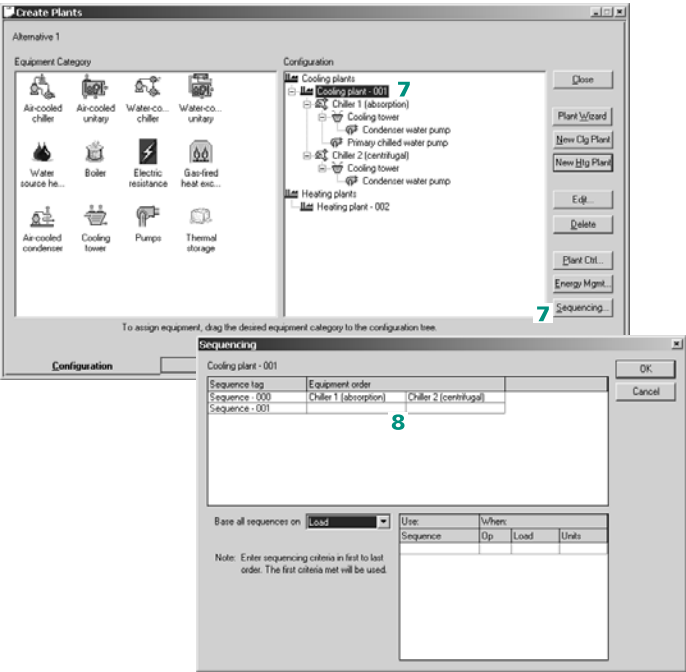
8 Reading left to right, the equipment order shows which chiller starts first, second, and so on, when a cooling load exists. By default, *the program sequences the chillers in the order that you created them.*

To change the displayed sequence, delete each entry and pick the desired equipment tag from the list.

When the desired sequences, operators, and so on, have been defined, click **OK** to exit.

No further entries are needed unless you define two or more equipment sequences. Click **Cancel** to exit if no entries have been made.

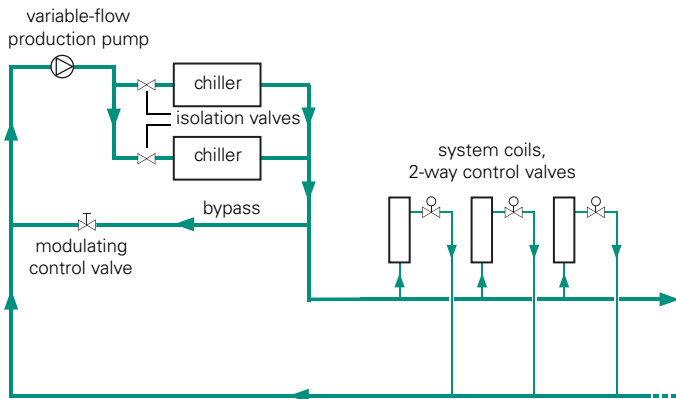
For examples, refer to “Switchover control for chiller plants” on page 3–17.



Variable-primary-flow chiller arrangement

A variable-primary-flow design displaces the small, inefficient, low-head primary pumps used in primary–secondary systems. The pressure drops previously satisfied by the primary pumps are instead satisfied by the distribution pump(s), permitting selection of larger, more-efficient pumps (with efficiencies similar to those of the *secondary* pumps in a primary–secondary system). Variable primary flow can be used with chillers in a parallel- or series-type arrangement. The inputs required to model a VPF system in TRACE 700 are very similar to the methods used to model a standard parallel or series chiller arrangement.

Figure 3–4 Variable-primary-flow chiller arrangement



Application considerations

- Varying the water-flow rate through the chiller evaporator poses two control challenges for those who design and operate VPF systems:
 - a Maintain the chiller flow rate between the minimum and maximum limits of the evaporator.
 - b Manage transient flows without compromising stable operation, especially in multi-chiller plants.

- Be sure to verify that the selected chilled-water pump(s) accurately reflect the actual pump(s) selected for the building. Click **Equipment** on the **Libraries** menu, then click **Misc. Accessories**. The unloading curve, full-load energy rate, and so forth, of the simulated pump can be viewed. If the actual and simulated pumps are not similar, then a custom pump will need to be created.
- If multiple pumps are going to be used to distribute the chilled water, then either a single pump with a combined unloading curve assigned directly to the cooling plant, or multiple pumps assigned to the cooling plant as miscellaneous accessories (via the **Misc. Accessory** tab), should be used.

Related reading

- *Multiple-Chiller-System Design and Control Applications Engineering Manual* (Trane literature number SYS-APM001-EN)
- "An idea for chilled-water plants whose time has come: Variable-primary-flow systems," *Engineers Newsletter* (volume 28, number 3)
- "Variable-primary-flow systems revisited," *Engineers Newsletter* (volume 31, number 4)

Sample scenario

In this example, two chillers in a parallel arrangement with a single VPF pump will be modeled.

Note: There are actually two types of variable primary flow arrangements, dedicated and manifold. This scenario is manifold. A dedicated arrangement would have a variable pump for each chiller rather than one variable pump for all chillers.

 In **Create Plants**, define the **cooling plant**.

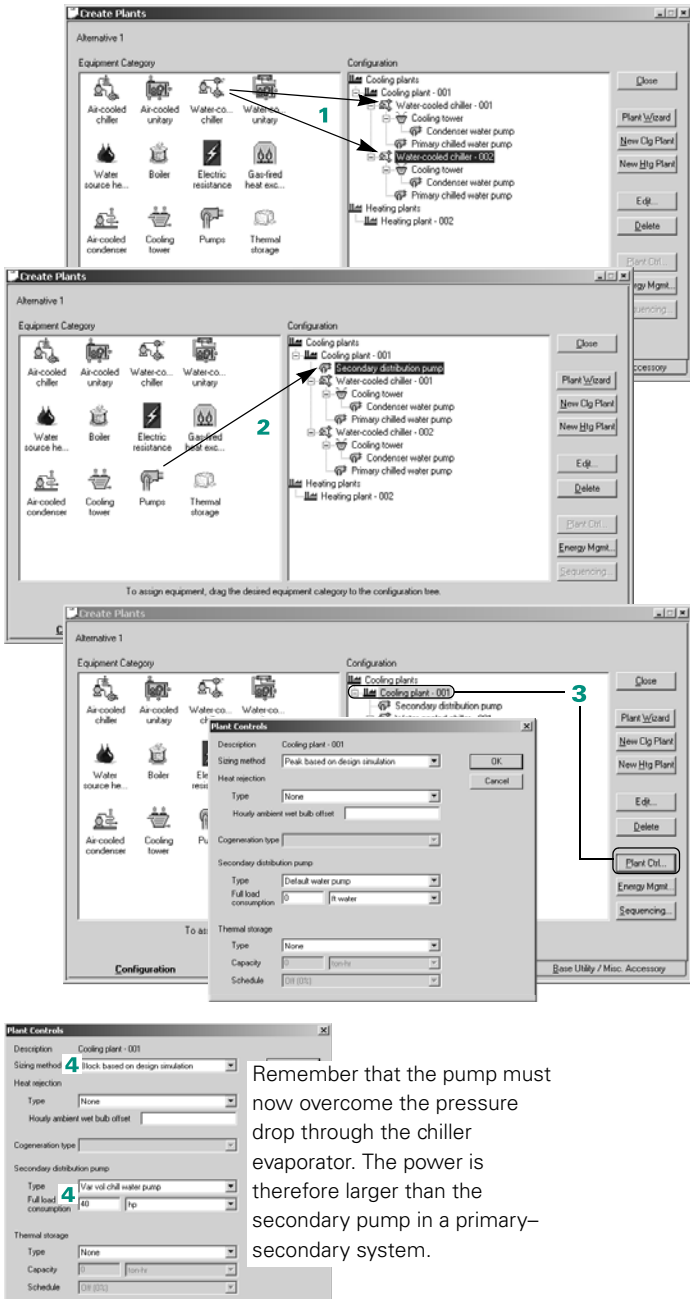
- 1 Drag and drop two water-cooled chillers from the **Equipment Category** section to the cooling plant.

- 2 Drag and drop a pump from the **Equipment Category** section to the cooling plant.

- 3 Click the cooling plant and click **Plant Ctrl** (only active when the Cooling Plant is selected) to activate the **Plant Controls**.

- 4 On the **Plant Controls** screen, select the **Pump Type**, input the **full load consumption**, change the plant sizing method to **block plant**, and click **OK**.

*Note: To model dedicated VPF, similar inputs would be required. However, rather than assigning one large pump at the **Plant** level, the chilled-water pumps would be entered with each piece of equipment on the **Cooling Equipment** tab.*



Remember that the pump must now overcome the pressure drop through the chiller evaporator. The power is therefore larger than the secondary pump in a primary–secondary system.

- 5 Click the **Cooling Equipment** tab to access the chiller information.
- 6 Input the specifics of the first chiller by:
 - a Renaming the chiller plant
 - b Naming the chiller
 - c Selecting the specific type of chiller
 - d Selecting the correct sequencing (**Parallel** for this example)
 - e Inputting the chiller capacity
 - f Inputting a full-load efficiency at design conditions
 - g Inputting the condenser-water pump full-load consumption
 - h Eliminating the primary chilled-water pump (change the Primary chilled-water pump type to **None**).
- 7 Click **Apply** and then repeat the same process for the second chiller. Select the second chiller from the **Equipment Tag** list on the **Cooling Equipment** tab.

Alternative 1

Cooling plant: Cooling plant - 003
 Equipment tag: Water-cooled chiller - 001
 Equipment category: Water-cooled chiller
 Equipment type: Default water-cooled chiller
 Sequencing type: Single

Heat rejection: Type: Cooling tower for Cent. Chillers
 Hourly ambient wet bulb offset:
 Thermal storage: Type: None
 Capacity: 0 ton-hr
 Schedule: Storage

Operating mode	Capacity	Energy rate
Cooling	tons	0.52 kW/ton
Heat recovery	tons	kW/ton
Tank charging	tons	kW/ton
Tank charging & heat recovery	tons	kW/ton

Pumps	Type	Full load consumption
Primary chilled water	Cnst vol chl water pump	0 ft water
Condensate water	Cnst vol cond water pump - Low Eff	0 ft water
Heat recovery or aux condensate	None	0 ft water

Configuration **5 Cooling Equipment** Heating Equipment Base Utility / Misc. Accessory

Alternative 1

Cooling plant: Chiller Plant
 Equipment tag: wCC 1
 Equipment category: Water-cooled chiller
 Equipment type: 3-Stage Centrifugal w/ VFD Tower
 Sequencing type: Parallel

Heat rejection: Type: Cooling tower with VFD 15F
 Hourly ambient wet bulb offset:
 Thermal storage: Type: None
 Capacity: 0 ton-hr
 Schedule: Storage

Operating mode	Capacity	Energy rate
Cooling	500 tons	0.52 kW/ton
Heat recovery		
Tank charging		
Tank charging & heat recovery		

Pumps	Type	Full load consumption
Primary chilled water	None	0 ft water
Condensate water	Cnst vol cond water pump	15 hp
Heat recovery or aux condensate	None	0 ft water

Configuration **Cooling Equipment** Heating Equipment Base Utility / Misc. Accessory

Alternative 1

Cooling plant: Chiller Plant
 Equipment tag: wCC 1
 Equipment category: Water-cooled chiller
 Equipment type: 3-Stage Centrifugal w/ VFD Tower
 Sequencing type: Parallel

Heat rejection: Type: Cooling tower with VFD 15F
 Hourly ambient wet bulb offset:
 Thermal storage: Type: None
 Capacity: 0 ton-hr
 Schedule: Storage

Operating mode	Capacity	Energy rate
Cooling	500 tons	0.52 kW/ton
Heat recovery		
Tank charging		
Tank charging & heat recovery		

Pumps	Type	Full load consumption
Primary chilled water	None	0 ft water
Condensate water	Cnst vol cond water pump	15 hp
Heat recovery or aux condensate	None	0 ft water

Configuration **Cooling Equipment** Heating Equipment Base Utility / Misc. Accessory

Switchover control for chiller plants



Equipment schedules take precedence over switchover sequences.

For example, if the second chiller in the current start sequence is scheduled off, the program skips it and starts the next *available* chiller.

Switchover control is a common control strategy in HVAC systems that consist of two or more cooling-and/or-heating chillers piped in a decoupled, variable primary, parallel, or series arrangement. (Refer to “Decoupled chiller arrangement” on page 3–3, “Variable-primary-flow chiller arrangement” on page 3–13, “Parallel chiller arrangement” on page 3–7, and “Series chiller arrangement” on page 3–9 for examples.) TRACE 700 lets you model switchover control based on the cooling or heating load, the air temperature outside, or a schedule that you define.

Related reading

- *Chilled-Water Systems* Air Conditioning Clinic, one of the systems series (Trane literature number TRG-TRC016-EN)
- *Multiple-Chiller-System Design and Control Applications* Engineering Manual (Trane literature number SYS-APM001-EN)
- “Chilled Water Plants and Asymmetry as a Basis of Design,” *Engineers Newsletter* (volume 28, number 4)

Sample scenario

A hybrid plant consists of two chillers (and related auxiliaries) piped in a parallel, decoupled arrangement using a 300-ton, three-stage centrifugal chiller (electric) and a 500-ton, direct-fired absorption chiller (natural gas). The electric centrifugal chiller is started first. Operation can be switched to the direct-fired absorption chiller in *one* of three ways:

- The building cooling load exceeds 300 tons.
- The temperature outside exceeds 85°F.
- The on-peak period is in effect (8:00 a.m. until 8:00 p.m. for this example).




Switchover control sequences are defined for **plants**, not equipment, from the **Configuration** tab.

“Decoupled chiller arrangement” on page 3–3 describes the procedure for modeling chillers that are piped in a decoupled arrangement. The examples that follow demonstrate how to model the equipment start sequence for each condition described above.

Switchover sequence based on load

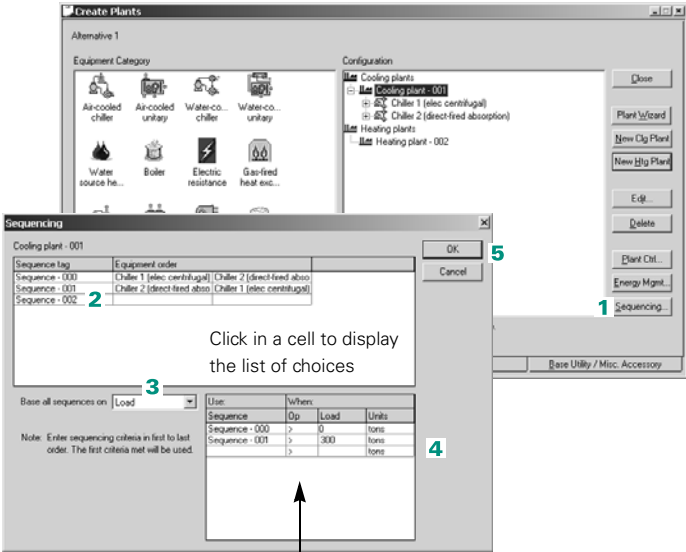
For this example, the cooling load determines which chiller starts first. The centrifugal chiller handles loads up to 300 tons. For loads greater than 300 tons, the absorption chiller starts first. If the current load is greater than the capacity of the first chiller in the sequence, the second chiller restarts and both chillers share the load in proportion to their design capacities.

 To create a switchover sequence based on load:

- 1 Select the cooling plant and open the **Sequencing** dialog box.
- 2 Create two start sequences, one that starts the centrifugal chiller first, and one that starts the absorption chiller first.
- 3 Pick **Load** as the basis for switching between sequences.
- 4 Using the **operator (op)**, **load**, and **units** entries, define the load condition that determines when each sequence will be used.

The program *locks in* the first operator you choose (>, <, >=, or <=) for the remaining entries. This helps prevent gaps and overlaps in the switchover conditions.

- 5 When satisfied with your entries, click **OK** to save them.




Use	Op	Load	Units
Sequence - 001	<	1000	tons
Sequence - 000	<	300	tons

If you choose > (or >=) as the operator, define the *smallest* load-based control point first. Make each successive control point larger than (or greater than, equal to) the one that preceded it.

If you choose < (or <=) as the operator, define the *largest* load-based control point first. Make each successive control point smaller (or less than, equal to) the one that preceded it.

Switchover sequence based on outside air temperature

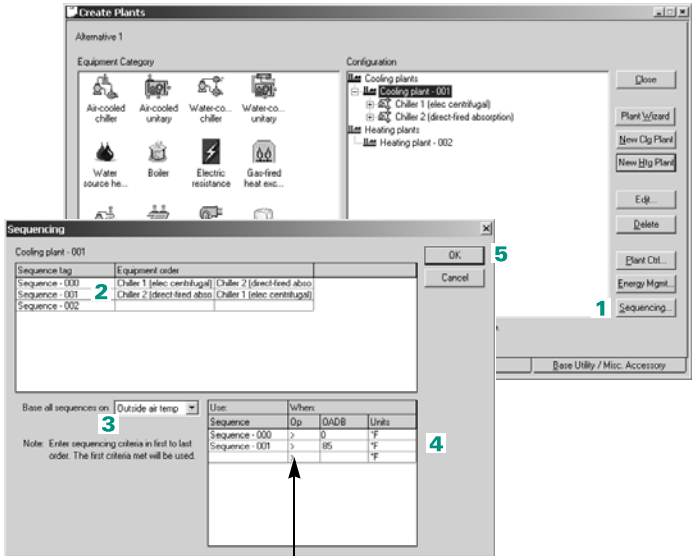
The dry-bulb temperature outside determines which chiller starts first in this example. At outside temperatures up to 85°F, the centrifugal chiller starts first. If it is hotter than 85°F, the absorption chiller starts first. Both chillers share the load proportionately if the chiller that started first is unable to satisfy the cooling demand.

 To create a switchover sequence based on the dry-bulb temperature of outside air (OADB):

- 1 Select the cooling plant and open the **Sequencing** dialog box.
- 2 Create two start sequences, one that starts the centrifugal chiller first, and one that starts the absorption chiller first.
- 3 Pick **outdoor air temp** as the basis for switching between sequences.
- 4 Using the **operator (op)**, **OADB**, and **units** entries, define the temperature that determines when each sequence will be used.

The program *locks in* the first operator you choose (>, <, >=, or <=) for the remaining entries. This helps prevent gaps and overlaps in the switchover conditions.

- 5 When satisfied with your entries, click **OK** to save them.



If you choose > (or >=) as the operator, define the control point with the *coldest* outside-air temperature first. Make each successive control point warmer than (or greater than, equal to) the one that preceded it.


Use	Op	OADB	Units
Sequence - 001	<	150	F
Sequence - 000	<	85	F

If you choose < (or <=) as the operator, define the control point with the *hottest* outside-air temperature first. Make each successive control point cooler (or less than, equal to) the one that preceded it.

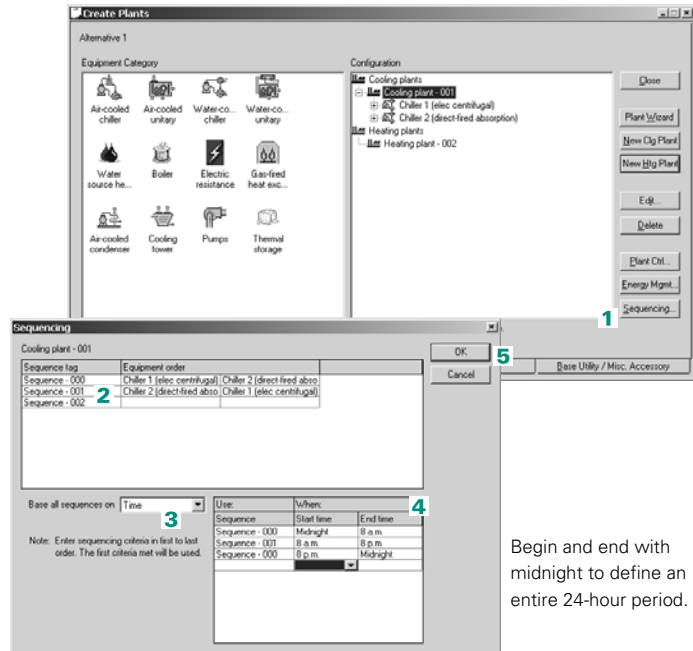
Switchover sequence based on time

For this example, the time of day determines which chiller starts first. The absorption chiller starts first during the on-peak period (from 8 a.m. until 8 p.m.). If it is unable to satisfy the cooling demand, the centrifugal chiller starts and both chillers share the load proportionately. From 8 p.m. until 8 a.m., the centrifugal chiller starts first to take advantage of off-peak electrical rates.

Note: To model time-based sequences that vary by the day of the week or with holidays, use the Library/Template Editors program to create the desired operating schedules. Then assign the appropriate operating schedule to each piece of equipment. For an example, refer to "Morning warm-up for dual-fuel applications" on page 5–20.

 To create a switchover sequence based on the time of day:

- 1 Select the cooling plant and open the **Sequencing** dialog box.
- 2 Create two start sequences, one that starts the centrifugal chiller first, and one that starts the absorption chiller first.
- 3 Pick **time** as the basis for switching between sequences.
- 4 Use the **start time** and **end time** entries to define when each sequence will be used.
- 5 When satisfied with your entries, click **OK** to save them.



Begin and end with midnight to define an entire 24-hour period.

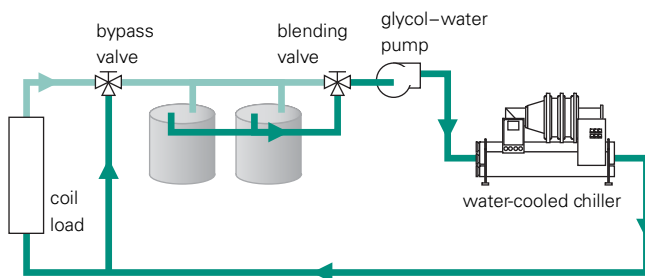
Thermal energy storage

Adding thermal energy storage to an HVAC system can reduce energy costs associated with comfort cooling by shifting equipment operation from high- to low-cost times of day. Typically, this practice is only economically feasible where the local utility company offers incentives in the form of rate structures or rebates.

Many utility companies face a capacity shortage for a relatively short period each day—typically during normal working hours. To encourage users to reduce their energy consumption, the local utility often imposes time-of-day rates that are highest during peak demand periods. One way to curtail the energy costs incurred at these higher rates is to operate the cooling equipment when utility rates are low (usually during the evening) and store the thermal energy potential until it is needed.

Ice tanks like those shown in Figure 3–5 are often used as a means of thermal storage because of their compact size and pre-engineered design. During off-peak periods (when utility rates are low), the chiller cools a glycol–water mixture to a temperature of 23°F. This mixture then circulates through tubes within the ice tank, where it freezes the surrounding water. When cooling is needed during an on-peak period (when utility rates are high), the glycol–water mixture—heated by the building load—circulates through the storage tanks to melt the ice.

Figure 3–5 Example of a chilled-water loop with thermal energy storage



Application considerations

- The tanks required for thermal energy storage incur additional installation costs. However, such systems often require less chiller capacity. The savings that result from selecting a smaller chiller may partially offset the additional first cost of thermal energy storage.
- Many utilities offer negotiable rebates for thermal storage. Contact your local utility representative to maximize the potential economic benefits.

Related reading

- *Thermal Storage* Engineered Systems Clinics (Trane literature numbers ISS-CLC-1, ISS-CLC-2, ISS-CLC-3, and ISS-CLC-4)
- *Control of Ice Storage Systems* Applications Engineering Manual (Trane literature number ICS-AM-4)
- *Ice Storage Systems* Applications Engineering Manual (Trane literature number SYS-AM-10)

Sample scenario

There are various ways to design a chilled-water plant with thermal energy storage. This section demonstrates how to model two variations:

- Thermal energy storage with one chiller (page 3–22)
- Thermal energy storage with multiple chillers (page 3–25)


Note: TRACE 700 generates a special report, Thermal Storage, for HVAC designs that include thermal storage. The report provides an hourly profile of ambient conditions and plant-level cooling loads, as well as chiller loads, chiller energy consumption, and available storage capacities available for cold storage applications (ice and chilled water).

Thermal energy storage with one chiller

A 500-ton centrifugal chiller makes chilled water and ice (335 tons) at energy rates of 0.65 kW/ton and 0.78 kW/ton, respectively. The ice-storage tanks, which have a useful capacity of 2,000 ton-hours, discharge between 11 a.m. and 5 p.m. and charge between 11 p.m. and 7 a.m. (Assume that the tanks are virtually empty at the end of each discharge period.) At all other

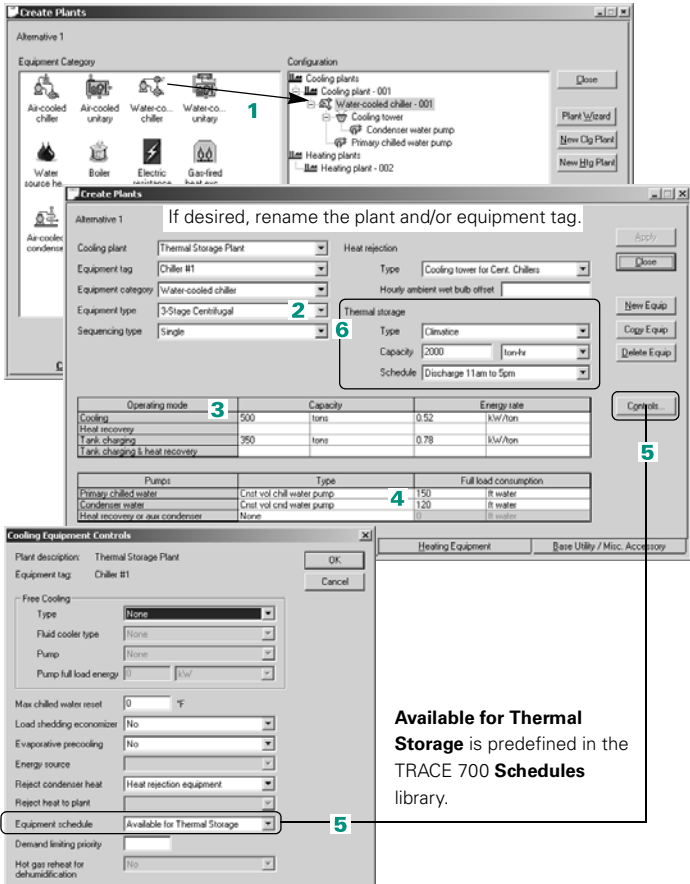
times, the chiller runs in standard cooling mode to satisfy the cooling demand.

Note: To properly model this scenario, be sure to enter the capacity and energy consumption of the chiller during both standard cooling and ice-making modes.

 When a single chiller charges the tanks in a thermal-storage application, storage characteristics are defined at the chiller level.

- 1 Add a chiller to the cooling plant.
- 2 Describe the chiller type.
- 3 Define the **capacity** and **full-load energy rate** of the chiller when cooling (500 tons at 0.65 kW/ton) *and* when charging the storage tanks (335 tons at 0.78 kW/ton).
- 4 Specify the **full-load consumption** for each pump.
- 5 Choose an **equipment operation schedule** that makes the chiller available for thermal storage.
- 6 Describe the parameters for thermal storage by entering the **type**, **capacity**, and **schedule**.

Note: If the user does not specify capacity or energy rate in tank charge mode, or select a schedule allowing thermal storage, the tanks will discharge but never recharge.



Create Plants

Alternative 1

Equipment Category: Air-cooled chiller, Air-cooled unitary, Water-co. chiller, Water-co. unitary, Water source heat, Boiler, Electric resistance, Gas-fired, Heat recovery

Configuration: Cooling plants - 001, Cooling plant - 001, Water-cooled chiller - 001, Cooling tower, Condenser water pump, Primary chilled water pump, Heating plants, Heating plant - 002

Create Plants

Alternative 1

If desired, rename the plant and/or equipment tag.

Cooling plant: Thermal Storage Plant, Heat rejection: Cooling tower for Cent. Chillers

Equipment tag: Chiller #1, Type: Cooling tower for Cent. Chillers

Equipment category: Water-cooled chiller, Hourly ambient wet bulb offset: []

Equipment type: 3-Stage Centrifugal, Sequencing type: Single

Thermal storage: Type: Climatic, Capacity: 2000 tons/hr, Schedule: Discharge 11am to 5pm

Operating mode	Capacity	Energy rate
Cooling	500 tons	0.65 kW/ton
Heat recovery		
Tank charging	335 tons	0.78 kW/ton
Tank charging & heat recovery		

Pumps	Type	Full load consumption
Primary chilled water	Cent vol chill water pump	150 ft water
Condenser water	Cent vol cond water pump	120 ft water
Heat recovery or aux condens	None	0 ft water

Cooling Equipment Controls

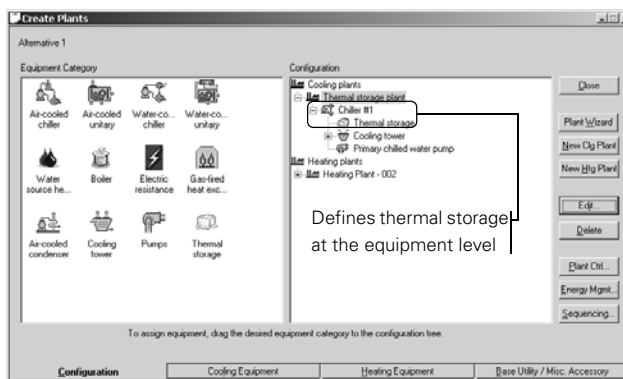
Plant description: Thermal Storage Plant, Equipment tag: Chiller #1


Free Cooling: Type: None, Fluid cooler type: None, Pump: None, Pump full load energy: 0 kW


Max chilled water reset: 0 °F, Load shedding economizer: No, Evaporative precooling: No, Energy source: [], Reject condenser heat: Heat rejection equipment, Reject heat to plant: [], Equipment schedule: Available for Thermal Storage, Demand limiting priority: [], Hot gas reheat for dehumidification: No

Available for Thermal Storage is predefined in the TRACE 700 Schedules library.

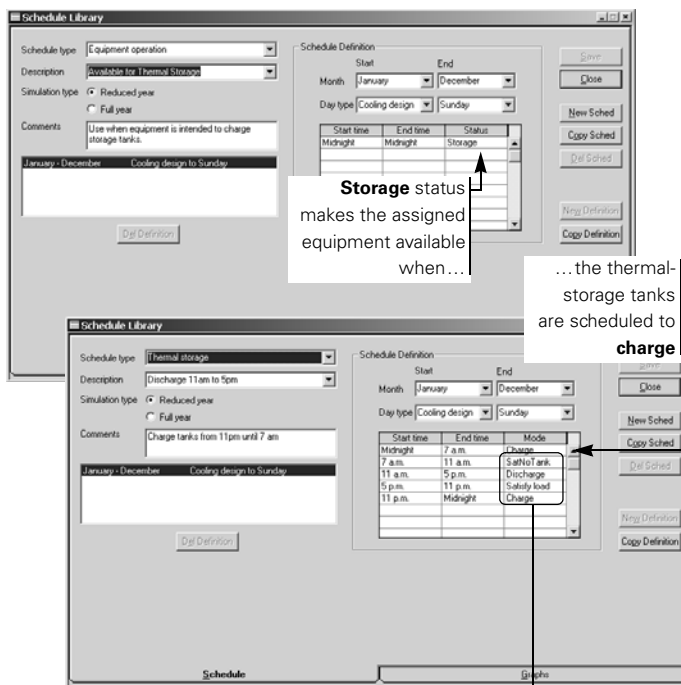
Specifying thermal storage at the equipment level automatically results in a plant configuration that looks similar to the one shown here.



 Use the Library/Template Editors program to view or customize existing schedules.

The  **Schedule** library contains both of the schedules used in this scenario:

- **Available for Thermal Storage** is an **Equipment operation** schedule. With *storage* status, it forces the ice-making chiller to follow the schedule selected for thermal storage.
- **Discharge 11 a.m. to 5 p.m.** is a **Thermal storage** schedule that defines when each tank operating mode occurs.




Here is what each operating **mode** represents:

- Charge**—Chiller makes ice after satisfying the assigned cooling loads
- Discharge**—Ice melts to satisfy the assigned loads: storage-equipment type determines the control strategy
- SatLoad**—Chiller satisfies the cooling load: tanks supplement capacity, if needed, but do not recharge until the next charging period
- SatNoTank**—Chiller satisfies the cooling load: excess load passes either to the next piece of cooling equipment in the start sequence or to the next hour

Thermal energy storage with multiple chillers

A chilled-water plant consists of ice-storage tanks and two 500-ton chillers that are piped in parallel. *During off-peak periods*, a dedicated ice-making chiller recharges the tanks while the *cooling-only* chiller satisfies the off-peak cooling load.

During on-peak periods (10 a.m. to 6 p.m., weekdays only), the tanks satisfy the cooling demand: both chillers are off. If the tanks cannot handle the on-peak cooling load (all of the ice melts), the *cooling-only* chiller satisfies the remaining load.

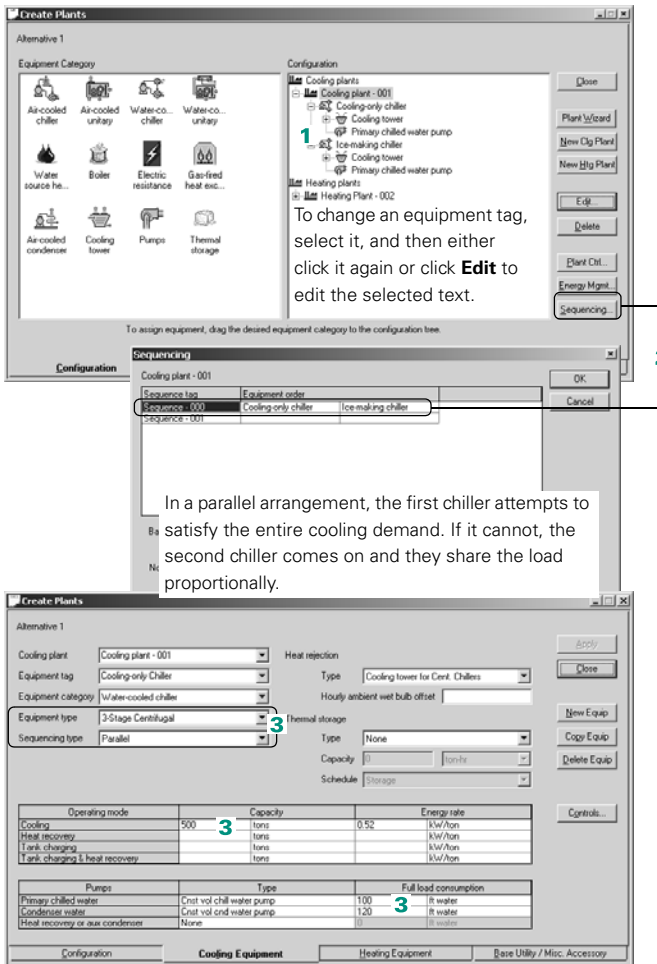
 This thermal-storage application uses two chillers, but only one chiller makes ice. To model the plant:

1 Add two water-cooled chillers to the cooling plant. Replace the generic tags: use **Cooling-only chiller** for the *first* machine and **Ice-making chiller** for the other.

2 The order in which you add equipment to a plant establishes the default start sequence. (Refer to “Switchover control for chiller plants” on page 3–17).

Verify that the cooling-only chiller is the first (farthest left) chiller in the start sequence.

3 Define the cooling-only chiller using the entries shown for **equipment type**, **sequencing type**, and **cooling capacity**. Also enter the **full-load consumption** for each pump.



To change an equipment tag, select it, and then either click it again or click **Edit** to edit the selected text.


In a parallel arrangement, the first chiller attempts to satisfy the entire cooling demand. If it cannot, the second chiller comes on and they share the load proportionally.


Equipment

Operating mode			Capacity	Energy rate
Cooling	500	3	tons	0.52 kW/ton
Heat recovery			tons	kW/ton
Peak charging			tons	kW/ton
Peak charging & heat recovery			tons	kW/ton

Pumps			Type	Full load consumption
Primary chilled water			Cnst vol chill water pump	100 ft water
Condenser water			Cnst vol cond water pump	120 ft water
Heat recovery or aux condenser			None	0 ft water


3

 The on-peak control strategy in this scenario calls for the tanks to satisfy the cooling load. Use the Library/Template Editors program to modify an existing piece of thermal-storage equipment.

4  In the **Thermal Storage** library, copy the **Climatice** equipment type and rename it.

5 Pick an appropriate schedule and specify the **storage capacity**.

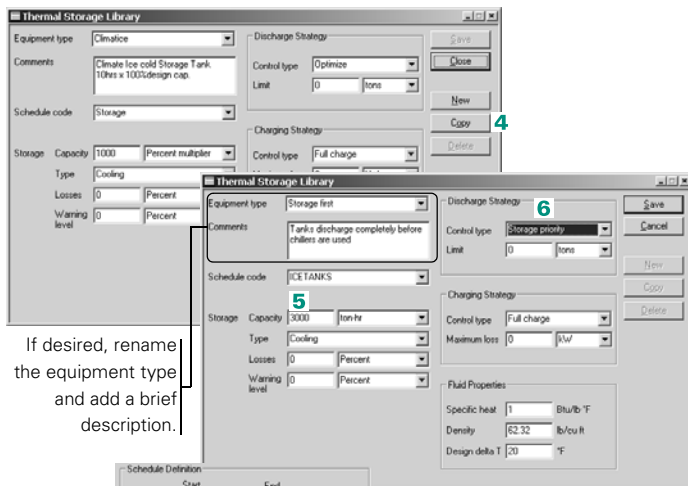
6 Choose **storage priority** as the discharge-strategy **control type**. When scheduled to discharge, the tanks attempt to satisfy the entire cooling load. If there is not enough stored cooling, the tanks discharge completely—then mechanical cooling satisfies the load.

 Return to the **Create Plants** window of the TRACE 700 project.

7 Define the attributes of the **ice-making chiller** (type, sequencing, capacities, and pumps).

8 Choose a schedule that makes the chiller available for thermal storage.

9 Pick the new **thermal storage type** created in Steps 4–6 to define the storage parameters.



Thermal Storage Library

Equipment type: Climatice

Comments: Climate ice cold Storage Tank. 1000's a 100's design cap.

Schedule code: Storage

Storage Capacity: 1000 Percent multiplier: 1

Type: Cooling

Losses: 0 Percent

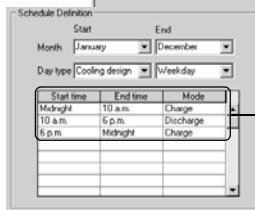
Warning level: 0 Percent

Discharge Strategy: Control type: Optimize Limit: 0 tons

Charging Strategy: Control type: Full charge

Fluid Properties: Specific heat: 1 Btu/lb·°F Density: 62.52 lb/cu ft Design delta T: 20 °F

If desired, rename the equipment type and add a brief description.



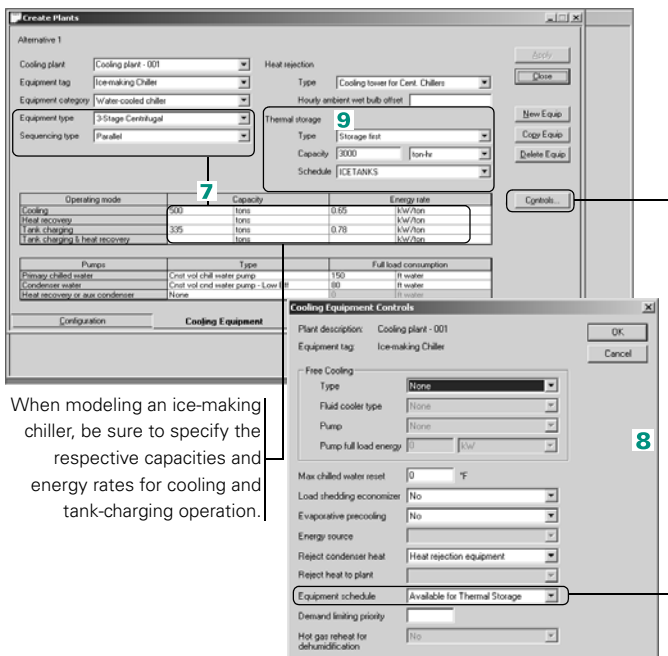
Schedule Definition

Start: January End: December

Day type: Cooling design Week-day: Week-day

Start time	End time	Mode
Midnight	10 a.m.	Charge
10 a.m.	6 p.m.	Discharge
6 p.m.	Midnight	Charge

The **ICETANKS** schedule melts ice (discharges the tanks) from 10 a.m. to 6 p.m. and makes ice (charges the tanks) from 6 p.m. to 10 a.m.



Create Plants

Alternative 1

Cooling plant: Cooling plant - 001

Equipment tag: Ice-making Chiller

Equipment category: Water-cooled chiller

Equipment type: 3-Stage Centrifugal

Sequencing type: Parallel

Operating mode: Cooling

Capacity: 500 tons

Energy rate: 0.65 kW/ton

Heat rejection: Cooling tower for Cent. Chiller

Hourly ambient wet bulb offset: 0

Thermal storage: Type: Storage tank Capacity: 3000 tons Schedule: ICE TANKS

Pumps: Primary chilled water, Condensate water

Cooling Equipment Controls

Plant description: Cooling plant - 001

Equipment tag: Ice-making Chiller

Free Cooling: Type: None

Fluid cooler type: None

Pump: None

Pump full load energy: 0 kW

Max chilled water reset: 0 °F

Load shedding economizer: No

Evaporative precooling: No

Energy source: Heat rejection equipment

Reject condenser heat: Heat rejection equipment

Reject heat to plant: No

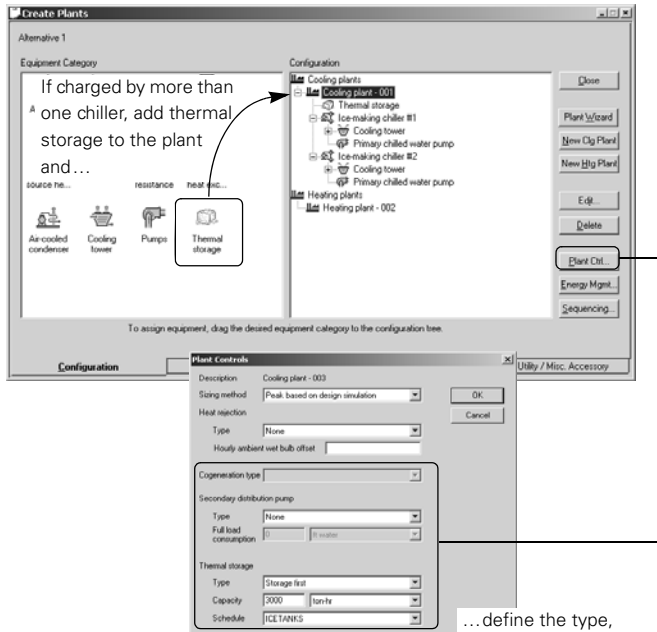
Equipment schedule: Available for Thermal Storage

Demand limiting priority: No

Hot gas reheat for dehumidification: No

When modeling an ice-making chiller, be sure to specify the respective capacities and energy rates for cooling and tank-charging operation.

Note: If two or more chillers charge the storage tanks, define the thermal-storage parameters at the plant level using the Plant Controls dialog box, as shown below. When defining each of the ice-making chillers, remember to specify the capacity and energy rate when charging the tanks, and to choose a schedule that makes the chiller available for storage.

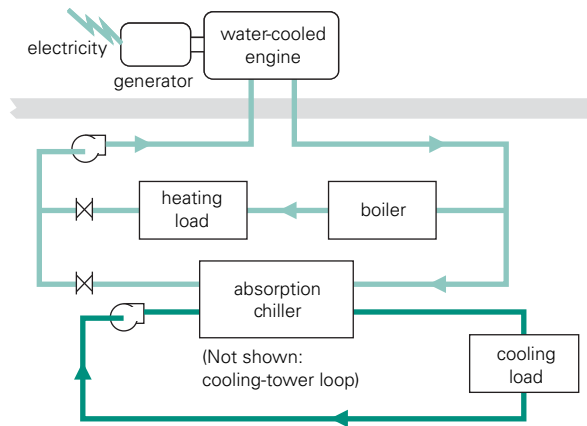


...define the type, capacity, and operating schedule at the plant level.

Cogeneration

Cogeneration systems can reduce the overall energy costs for a building by generating electricity on-site and capturing the waste heat produced by the engine. The cost of locally generated electricity often exceeds the cost of energy from the utility, and the economic advantage of cogeneration systems is therefore derived from appropriate use of the waste heat. One common application is hot water for domestic or process loads. Waste heat from cogeneration can also serve as an energy source for comfort heating.

Figure 3-6 Cogeneration system



Application considerations

- When compared with conventional HVAC systems, cogeneration systems are more expensive to install and require additional maintenance. Consider these characteristics when determining whether cogeneration is feasible for a particular application.
- An absorption chiller that provides chilled water for comfort or process cooling can magnify the economic potential of waste heat from cogeneration. If the cogenerator cannot produce water that is hot enough to drive the absorption cycle, it may be necessary to add another heat source to raise the water temperature and serve as a backup system.



TRACE 700 generates a special **Cogeneration** report that provides an hourly profile of the electrical and heating loads before and after cogeneration, as well as the rejected heating load and the consumption of fuel for cogeneration.

Related reading

- 2004 ASHRAE Handbook – HVAC Systems and Equipment, Chapter 7

Sample scenario

A boiler provides the hot water necessary to satisfy all of the heating loads in a building. The same boiler also furnishes the hot water needed to fire a two-stage absorption chiller. The building generator satisfies electrical loads up to 175 kW. The heat it produces is applied to either the building heating load or the absorption chiller. The illustrations below and on page 3–30 demonstrate how to model an HVAC design that includes cogeneration.



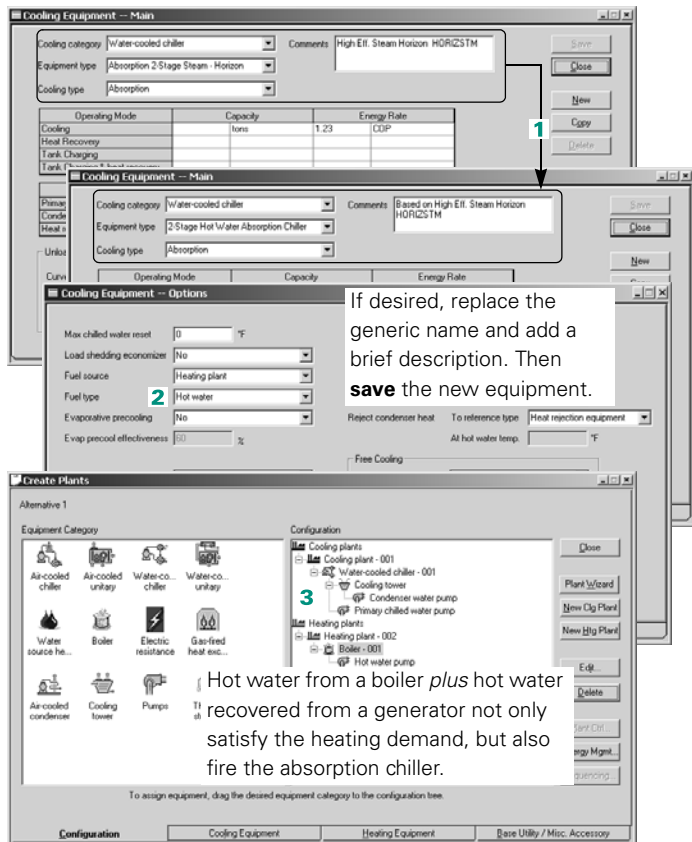
To model this cogeneration example, use the Library/Template Editors program to add a hot-water absorption chiller to the **Cooling Equipment** library.

- 1 **Copy** one of the existing, water-cooled absorption chillers in the **Cooling Equipment** library.
- 2 On the **Options** tab, change the **fuel type** from steam to **hot water**. (Return to the **Main** tab to save this entry.)



To model the cooling and heating plants.

- 3 Add a water-cooled chiller to the cooling plant and a boiler to the heating plant. The boiler is the energy source for the chiller. For convenience, define it first.



- 4 Describe the boiler on the **Heating Equipment** tab. Choose the appropriate **equipment type** and specify the **full-load consumption** of the hot-water pump.

For this example, pick a gas-fired boiler and enter 50 feet of water as the pump head.

- 5 Next, describe the chiller. For the **equipment type**, choose the hot-water absorption chiller created in Steps 1–2.

Also specify the **full-load consumption** of each pump.

- 6 Identify the heating plant that contains the boiler as the **energy source** for the chiller.

- 7 The generator, which is used to satisfy electrical loads, uses the boiler loop for heat rejection.

To model it, select the appropriate **cogeneration type**. The generator selected for this example is a gas engine that generates up to 175 kW.

Create Plants

Alternative 1

Heating plant: Heating plant - 002

Equipment tag: Hot-water boiler

Equipment category: Boiler

Equipment type: Gas Fired Hot Water Boiler

Capacity: 1000 MWh

Energy rate: 63.3 Percent efficient

Thermal storage: Type: None, Capacity: 0 ton-hr, Schedule: Storage

Hot water pump: Type: Eq020 - Heating water circ pump, Full load consumption: 50 ft water

Equipment schedule: Available (100%)

Demand limiting: priority

Create Plants

Alternative 1

Cooling plant: Cooling Cogen Plant

Equipment tag: Absorption Chiller

Equipment category: Water-cooled chiller

Equipment type: 2-Stage Hot Water Absorption (Cogen)

Sequencing type: Single

Heat rejection: Type: Eq0104 - Cooling tower, Hourly ambient wet bulb offset: 0

Thermal storage: Type: None, Capacity: 0 ton-hr, Schedule: Storage

Operating mode	Capacity	Energy rate
Cooling	tons	1.23 COP
Heat recovery	tons	kW/ton
Tank charging	tons	kW/ton
Tank charging & heat recovery	tons	kW/ton

Pumps	Type	Full load consumption
Primary chilled water	Eq001 - Cntrl vol chill water pump	80 ft water
Condensate water	Eq012 - Cntrl vol cond water pump	80 ft water
Heat recovery or aux condenser	None	

Cooling Equipment Controls

Plant description: Cooling plant - 001

Equipment tag: Absorption Chiller

Free Cooling: Type: None, Fluid cooler type: None, Pump: None, Pump full load energy: 0 kW

Max chilled water reset: 0 °F

Load shedding economizer: No

Evaporative precooling: No

Energy source: Heating plant - 002

Reject condensate heat: Heat rejection equipment

Reject heat to plant: None

Plant Controls

Alternative 1

Description: Heating plant - 002

Sizing method: Peak plant

Heat rejection: Type: None, Hourly ambient wet bulb offset: 0

Cogeneration type: Cogen gas 175 kW

Secondary distribution pump: Type: None, Full load consumption: 0 ft water

Thermal storage: Type: None, Capacity: 0 ton-hr, Schedule: Storage

Configuration

Cooling plants

- Cooling plant - 001
 - Absorption chiller
 - Cooling tower
 - Condensate water pump
 - Primary chilled water pump
- Heating plants
 - Heating plant - 002
 - Hot-water boiler

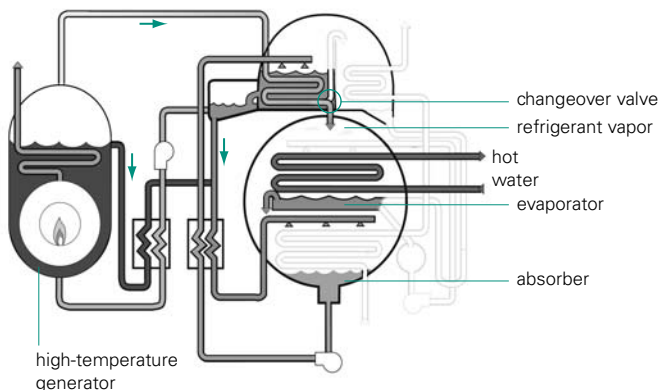
If desired, open the **Cogeneration** library to view the equipment defined there. Custom cogeneration can be created in the library.

Direct-fired absorption cooling

As the name implies, a direct-fired absorption chiller relies on natural gas or other fuels to drive an absorption refrigeration cycle. The highly efficient performance of the chiller—which typically results in a Coefficient of Performance that exceeds 1.0, including burner losses—enables it to compete favorably with electric chillers in many regions where electricity rates are high.

What sets direct-fired absorption chillers apart from other machines is their ability to serve either a cooling load or a heating load. This flexibility can be particularly appealing for applications that need chilled water for comfort cooling during the summer and hot water for comfort heating during the winter. In these applications, the direct-fired absorption chiller can replace the traditional chiller-and-boiler combination while occupying significantly less floor space.

Figure 3-7 Direct-fired absorption chiller as a *chiller-heater*



Application considerations

- Manufacturers of direct-fired absorption chillers often provide both standard and high-efficiency models in sizes that commonly range from 100 to 1,100 nominal tons.
- Consider using a direct-fired absorption chiller as the primary component of a hybrid cooling plant or in other applications

where electricity is expensive or in short supply. For example, use the direct-fired absorption chiller to satisfy the peak load and an electric chiller to handle the base load.

Related reading

- *Absorption Chiller System Design Applications* Engineering Manual (Trane literature number SYS-AM-13)
- *Absorption Water Chillers* Air Conditioning Clinic, one of the equipment series (Trane literature number TRG-TRC011-EN)

Sample scenario

A 650-ton, direct-fired absorption chiller satisfies the cooling demand for a building, but does not handle the heating load—a gas-fired boiler provides hot water for this purpose.

To define the cooling plant:

- 1 Choose a direct-fired absorption chiller from the **water-cooled chiller** category as the **equipment type**.
- 2 Specify the **cooling capacity** (in this case, 650 tons).
- 3 Enter the **full-load consumption** for each pump.
- 4 Assign the excess heat from the direct-fired generator to the heat-rejection equipment.

To define the heating plant:

- 5 Choose a hot-water boiler as the **equipment type**.
- 6 Enter the **full-load consumption** for the hot-water pump.

The screenshot displays the 'Create Plants' dialog box in the TRACE 700 software. The 'Cooling Equipment' tab is selected, showing the configuration for 'Cooling plant - 001'. The 'Equipment tag' is 'Chiller 1', and the 'Equipment category' is 'Water-cooled chiller'. The 'Equipment type' is 'Direct Fired Absorption - Std. Eff.'. The 'Operating mode' is 'Cooling' with a capacity of 650 tons. The 'Energy rate' is 0.0117. The 'Pumps' section shows 'Primary chilled water' and 'Condenser water' pumps with full load consumption of 90 and 40 ft water respectively. The 'Heat rejection type' is 'Eq0104 - Cooling tower'. The 'Cooling Equipment Controls' dialog box is also visible, showing 'Plant description: Cooling plant - 001' and 'Equipment tag: Chiller 1'. The 'Reject condenser heat' is set to 'Heat rejection equipment'.

Low-flow chilled-water systems



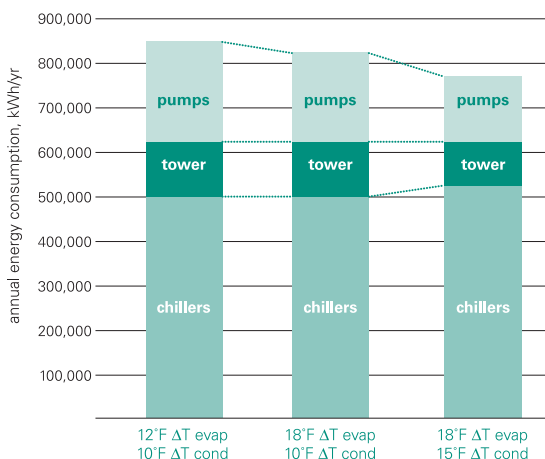
The condenser-water flow rate for absorption chillers is slightly higher—3.6 gpm/ton for single-effect machines, and 4.0 gpm/ton and 4.50 gpm/ton, respectively, for double-effect steam, hot water, and direct-fired machines.

The standard rating conditions established by ARI 550/590–1998 set flow rates of 2.4 gpm/ton and 3.0 gpm/ton for the evaporator and condenser, respectively. This evaporator flow rate corresponds to a 10°F temperature difference (ΔT). The condenser flow rate yields a 9.1°F to 10°F ΔT , depending on compressor efficiency.

For a given load, reducing the flow rate through the condenser or evaporator increases the difference between the entering- and leaving-water temperatures—colder water leaves the evaporator and warmer water leaves the condenser.

Figure 3–8 illustrates how this phenomenon affects power consumption. Although the compressor works harder to provide additional lift, the cost savings that accrue from smaller pumps and more-efficient tower operation more than offset the drop in chiller performance.

Figure 3–8 Effect of lower flow rates in chilled-water plants



Application considerations

- Evaluate the effect of low flow rates and large temperature differentials on the *entire* chilled-water plant. The design that

most benefits the chiller may not yield the lowest overall energy consumption for the plant.

- Some climates may preclude cooler leaving-tower water temperatures. In such cases, raising the condenser ΔT to 15°F requires a 5°F increase for the water leaving the condenser. Although this will degrade the efficiency of the chiller, supplying warmer water to the tower will reduce the horsepower requirements of the cooling-tower fans and increase the capacity of the tower.
- Increasing the evaporator ΔT can make a series chiller-piping arrangement appealing, particularly for applications with helical-rotary compressors or absorption chillers.

Related reading

- *Multiple-Chiller-System Design and Control Applications Engineering Manual* (Trane literature number SYS-APM001-EN)
- "How Low-Flow Systems Can Help You Give Your Customers What They Want," *Engineers Newsletter* (volume 26, number 2)

Sample scenario

A central cooling plant includes a 500-ton centrifugal chiller. The temperature differentials across the evaporator and condenser are 10°F and 15°F, respectively. Constant-volume pumps serve the chilled-water and condenser-water loops.

Modeling this scenario requires you to customize three existing pieces of equipment, as illustrated on pages 3–35 and 3–36: a cooling tower, a chiller, and a constant-volume pump.

Note: Lowering the condenser flow rate decreases the full-load energy rate of the cooling tower. Use this equation to calculate the new energy rate:


$$\frac{LWT_d - WBT}{LWT_x - WBT}$$


where,

LWT_d = leaving-condenser-water temperature that provides a 10°F ΔT (for example, 85°F to 95°F)


WBT = design wet-bulb temperature

LWT_x = new design leaving-condenser-water temperature that provides the desired ΔT (a 20°F ΔT in this example)

 Use the Library/Template Editors program to modify *existing* definitions for a chilled-water pump, cooling tower, and chiller.

1  In the **Miscellaneous Accessories** library, copy an existing pump. (Use *Var vol cond water pump* for this example.) Rename the new pump and add comments if desired.

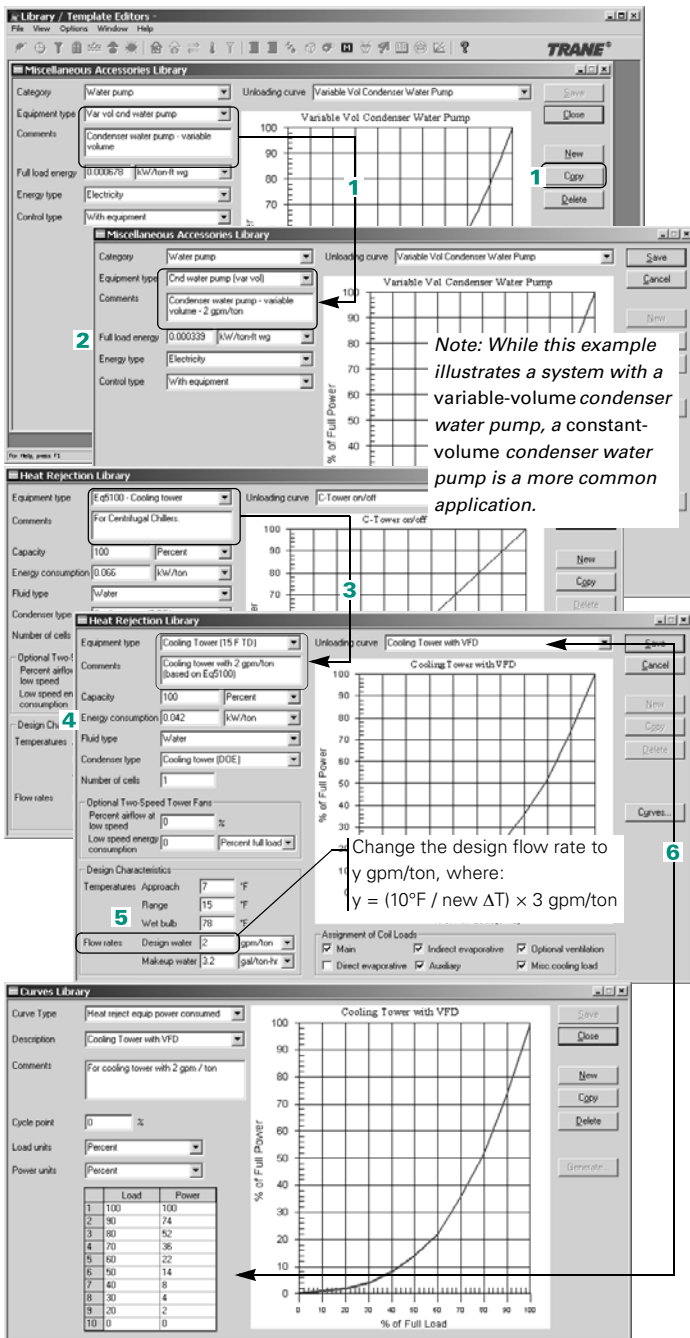
2 Reduce the **full-load energy rate** by $10/x$, where x is the temperature difference across the evaporator (in this case, 20). **Save** your entries.

3  In the **Heat Rejection** library, copy an existing tower (for example, Eqs100). Rename the new tower and add comments if desired.

4 Decrease the **full-load energy rate** by $95^{\circ}\text{F} - 78^{\circ}\text{F} / \text{LWT}_x - 78^{\circ}\text{F}$ (This formula is explained on page 3–34.)

5 Modify the design characteristics of the tower to reflect the new **range** (15°F) and **flow rate** (2 gpm/ton).

6 Cooling towers in low-flow applications often use variable-frequency drives. If desired, define (continued on page 36)



The screenshot displays the TRANE Library/Template Editors interface, showing the process of modifying a Variable Volume Condenser Water Pump and a Cooling Tower. The interface is divided into several panes: Miscellaneous Accessories Library, Heat Rejection Library, and Curves Library.

Miscellaneous Accessories Library: The 'Variable Vol Condenser Water Pump' is selected. The 'Unloading curve' is shown as a graph of '% of Full Power' vs. '% of Full Load'. The 'Full load energy' is set to 0.000339 kW/ton-hr. The 'Control type' is 'With equipment'.

Heat Rejection Library: The 'Cooling Tower (DOE)' is selected. The 'Unloading curve' is shown as a graph of '% of Full Power' vs. '% of Full Load'. The 'Full load energy' is set to 0.042 kW/ton-hr. The 'Control type' is 'With equipment'.

Curves Library: The 'Cooling Tower with VFD' curve is selected. The 'Unloading curve' is shown as a graph of '% of Full Power' vs. '% of Full Load'. The 'Full load energy' is set to 0.042 kW/ton-hr. The 'Control type' is 'With equipment'.

Notes:

- Note:** While this example illustrates a system with a variable-volume condenser water pump, a constant-volume condenser water pump is a more common application.
- Change the design flow rate to y gpm/ton, where:

$$y = (10^{\circ}\text{F} / \text{new } \Delta T) \times 3 \text{ gpm/ton}$$


Flow rates table:

Load	Power
1	100
2	90
3	80
4	70
5	60
6	50
7	40
8	30
9	20
10	10

(continued from page 35)

a new unloading curve and assign it to the cooling tower. Refer to “Creating equipment and unloading curves” on page 6–143.

Be sure to **save** the cooling tower before proceeding.

- 7  In the **Cooling Equipment** library, copy an existing chiller. (Use **3-stage centrifugal** for this example.)


Rename the new chiller and add comments if desired.

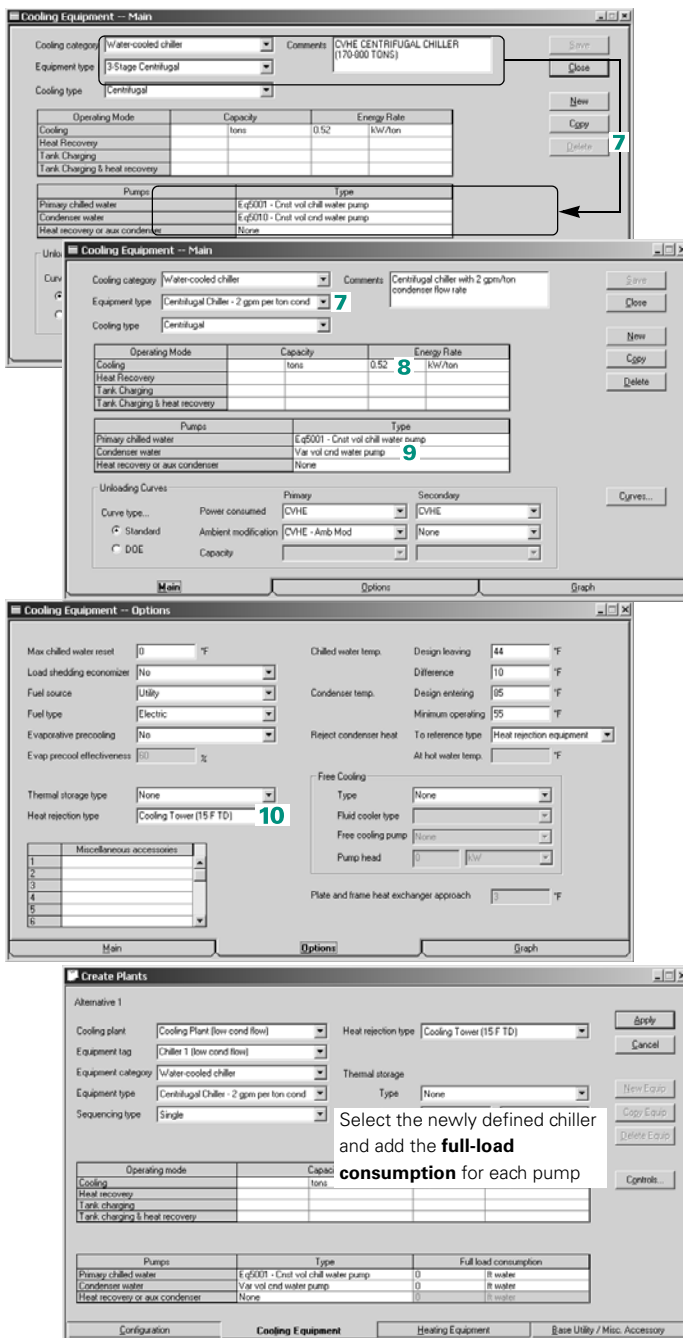
- 8 Increase the full-load **energy rate** of the chiller to reflect the additional lift required from the compressor. (Obtain the new energy rate from a chiller selection.)

- 9 Select the variable-volume pump created in Steps 1–2 for the condenser-water loop.

Note: To model a low-flow design that uses a variable-volume condenser pump, disable ambient relief. Refer to “Condenser-water reset” on page 5–26.

- 10 Choose the cooling tower created in Steps 3–6 as the **heat rejection type**. Then save the chiller definition.

 When finished, return to the TRACE 700 project and use the newly created chiller to define the cooling plant.



The image displays three screenshots of the TRACE 700 software interface, specifically the 'Cooling Equipment' and 'Create Plants' dialog boxes.

Cooling Equipment - Main (Top): This dialog box shows the configuration for a 'Water-cooled chiller'. The 'Equipment type' is set to '3-Stage Centrifugal'. The 'Operating Mode' table shows 'Cooling' with a capacity of 0.52 tons and an energy rate of 0.52 kW/ton. The 'Pumps' table shows 'Primary chilled water' with a type of 'E.g. 5001 - Cent vol chll water pump'. The 'Heat rejection type' is set to 'None'.

Cooling Equipment - Main (Middle): This dialog box shows the configuration for a 'Water-cooled chiller'. The 'Equipment type' is set to 'Centrifugal Chiller - 2 gpm per ton cond'. The 'Operating Mode' table shows 'Cooling' with a capacity of 0.52 tons and an energy rate of 0.52 kW/ton. The 'Pumps' table shows 'Primary chilled water' with a type of 'E.g. 5001 - Cent vol chll water pump'. The 'Heat rejection type' is set to 'None'.

Cooling Equipment - Options (Bottom): This dialog box shows the configuration for a 'Water-cooled chiller'. The 'Max chilled water reset' is set to 0 °F. The 'Load shedding economizer' is set to 'No'. The 'Fuel source' is set to 'Utility'. The 'Evaporative precooling' is set to 'No'. The 'Thermal storage type' is set to 'None'. The 'Heat rejection type' is set to 'Cooling Tower (15 F TD)'. The 'Free Cooling' section shows 'Type' set to 'None'.

Create Plants (Bottom): This dialog box shows the configuration for a 'Cooling Plant (low cond flow)'. The 'Cooling plant' is set to 'Cooling Plant (low cond flow)'. The 'Equipment tag' is set to 'Chiller 1 (low cond flow)'. The 'Equipment category' is set to 'Water-cooled chiller'. The 'Equipment type' is set to 'Centrifugal Chiller - 2 gpm per ton cond'. The 'Sequencing type' is set to 'Single'. The 'Heat rejection type' is set to 'Cooling Tower (15 F TD)'. The 'Thermal storage' is set to 'None'. The 'Full load consumption' table shows 'Primary chilled water' with a consumption of 0 ft water, 'Condenser water' with a consumption of 0 ft water, and 'Heat recovery or aux condenser' with a consumption of 0 ft water.

Purchased chilled water

Purchased chilled water is water that is typically chilled in a remote location and piped to individual buildings as a source of cooling. A utility company will generally create the chilled water in a central plant and charge the building owner and/or occupants for the water. There are several advantages to this type of operation: low first cost for the building owner, increased floor space (because the chillers are not located in the building), possible lower environmental impacts due to the high efficiency of large chillers, and so on. In addition, thermal storage can be used by the utility to allow generation of the chilled water at night, when off-peak energy rates may be available, and distribute it during the day, when needed by the customers.

Application consideration


- Purchased chilled water can offer lower first costs, but life cycle costs may be higher.

Related reading

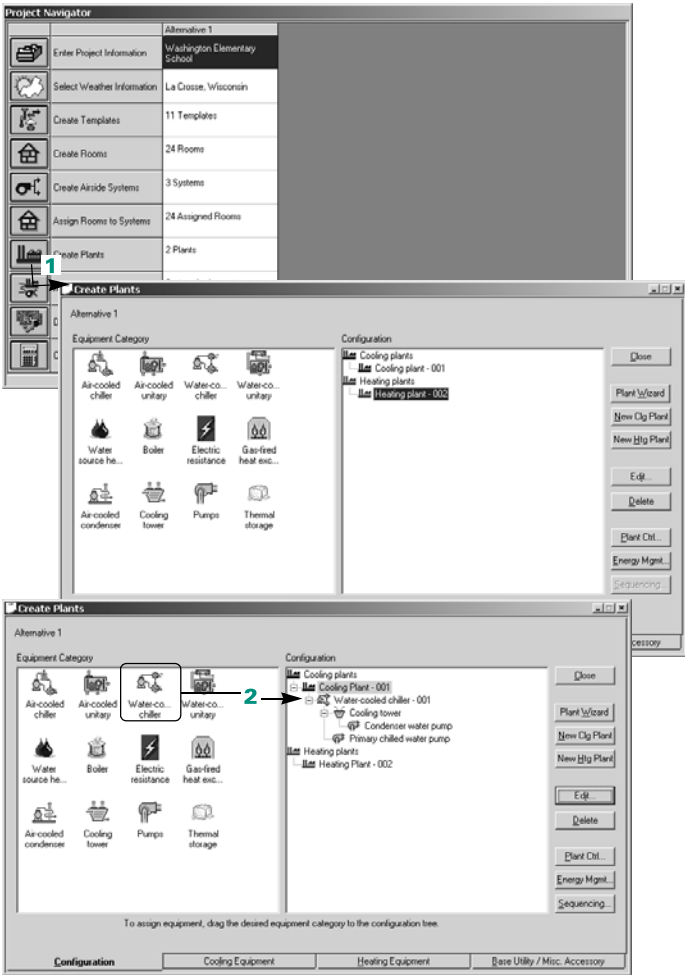
- Purchased chilled water, purchased district steam, and purchased district hot water are all modeled similarly in TRACE 700. Refer to “Purchased district steam and purchased district hot water” on page 3–40.

Sample scenario

In this example, the building being modeled purchases chilled water from a central chilled-water plant owned by the local utility. The building owner pays only for the chilled water and the electrical use of the chilled-water pump.

1  Start by clicking **Create Plants**.

2 From the **Equipment Category** section on the left side of the screen, click a **Water-Cooled Chiller** and drag it over to the cooling plant.



3 Click the cooling plant, click **Edit**, and rename the plant.

4 Click the **Cooling Equipment** tab.

5 In the **Equipment Type** list, click **Purchased Chilled Water**. It is also recommended to change the Equipment Tag to a more appropriate name.

6 Because pumping energy is required in this scenario, input the pump type and the full-load energy rate.

Configuration

- Cooling plants
 - Water-cooled chiller - 001
 - Cooling tower
 - Condenser water pump
 - Primary chilled water pump
 - Heating plants
 - Heating Plant - 002

Cooling Equipment

Alternative 1

Cooling plant: Purchased Chilled Water
 Equipment tag: Water-cooled chiller - 001
 Equipment category: Water-cooled chiller
 Equipment type: Default water-cooled chiller
 Sequencing type: Single

Heat rejection: Type: Cooling tower for Cent. Chillers
 Hourly ambient wet bulb offset:
 Thermal storage: Type: None
 Capacity: 0 tons
 Schedule: Storage

Operating mode	Capacity	Energy rate
Cooling	tons	kW/ton
Heat recovery	tons	kW/ton
Tank charging	tons	kW/ton
Tank charging & heat recovery	tons	kW/ton

Pumps	Type	Full load consumption
Primary chilled water	Cnst vol chl water pump	0 ft water
Condenser water	Cnst vol cond water pump - Low Eff	0 ft water
Heat recovery or aux condenser	None	0 ft water

Cooling Equipment

Alternative 1

Cooling plant: Purchased Chilled Water
 Equipment tag: PCW
 Equipment category: Water-cooled chiller
 Equipment type: Purchased Chilled Water
 Sequencing type: Single

Heat rejection: Type: None
 Hourly ambient wet bulb offset:
 Thermal storage: Type: None
 Capacity: 0 tons
 Schedule: Storage

Operating mode	Capacity	Energy rate
Cooling	tons	COP
Heat recovery		
Tank charging		
Tank charging & heat recovery		

Pumps	Type	Full load consumption
Primary chilled water	Cnst vol chl water pump	75 ft water
Condenser water	None	0 ft water
Heat recovery or aux condenser	None	0 ft water

Cooling Equipment

Note: The COP of purchased chilled water should be 1.0 or less. A COP of 1 indicates that for every Btu of cooling load, 1 Btu of purchased chilled water should be consumed. Refer to "Frequently asked questions," which begins on page 6-20, for additional details.

Purchased district steam and purchased district hot water

Purchased district hot water and purchased district steam are typically heated in a remote location and piped to individual buildings as a source of heating. A utility company will generally create the hot water (or steam) in a central plant and charge the building owner and/or occupants for it. There are several advantages to this type of operation: low first cost for the building owner, increased floor space (because boilers are not located in the building), possible lower environmental impacts due to high efficiency of large boilers, and so on.

Application consideration

- Purchased district hot water and purchased district steam can offer lower first costs, but life cycle costs may be higher.


Related reading

- Purchased chilled water, purchased district steam, and purchased district hot water are all modeled similarly in TRACE 700. Refer to “Purchased chilled water” on page 3–37.

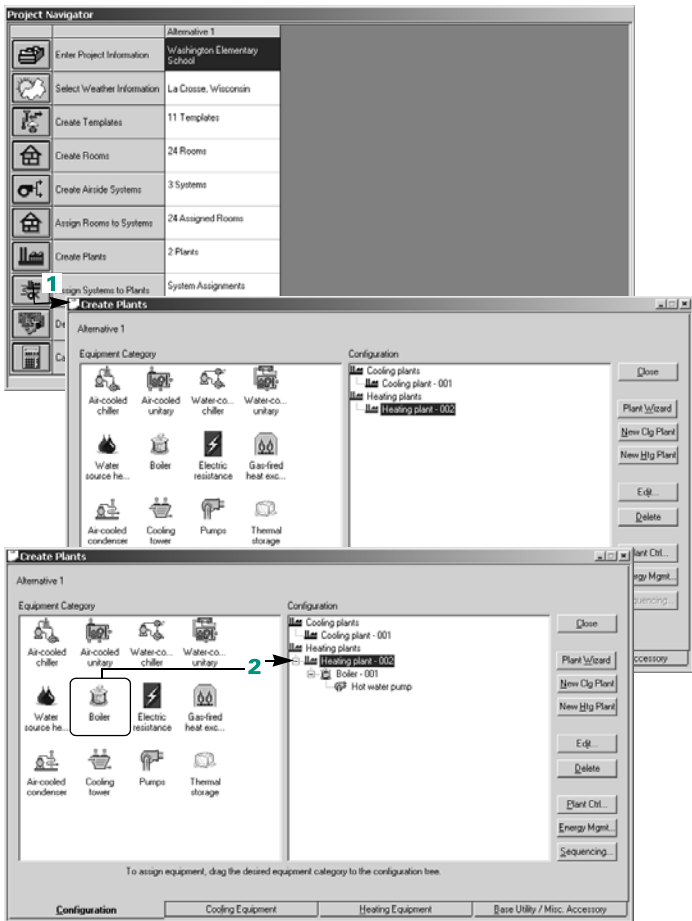
Sample scenario

In this example, the building being modeled purchases hot water from a central hot-water plant owned by the local utility. The building owner pays only for the hot water and the electrical use of the hot-water pump.

Note: Steps are also shown for modeling purchased district steam.

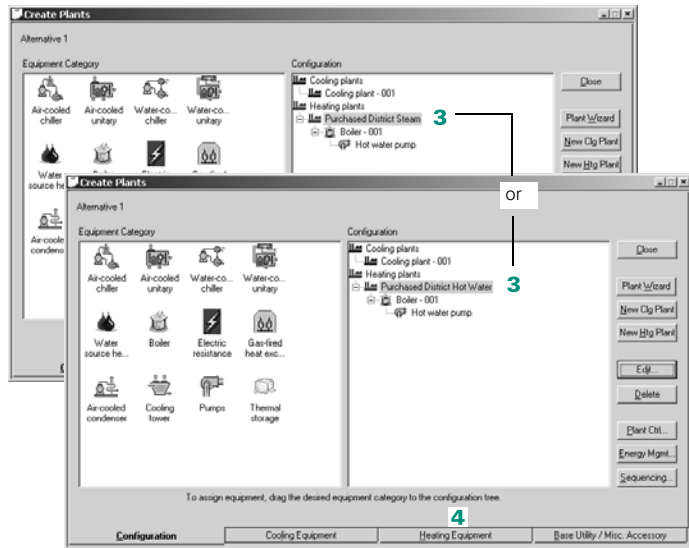
- 1  Start by clicking **Create Plants**.

- 2 From the **Equipment Category** section on the left side of the screen, click a **Boiler** and drag it over to the heating plant.



- 3 Click the heating plant, click **Edit**, and rename the plant.

- 4 Click the **Heating Equipment** tab.



- 5 In the **Equipment Type** list, select the appropriate equipment type to be modeled (Purchased district steam or Purchased district hot water). It is also recommended to change the **Equipment Tag** to a more appropriate name.
- 6 Input the appropriate pump type and the full-load consumption for the pump (Purchased district hot water only).

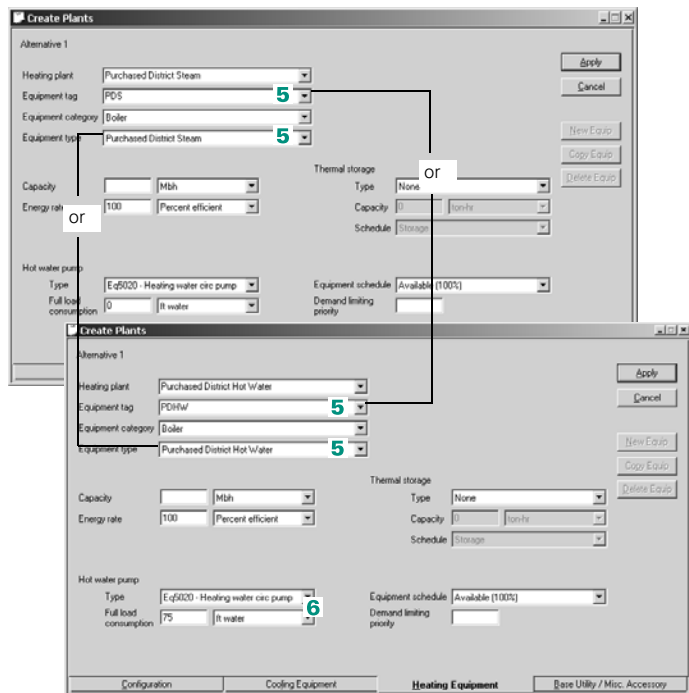


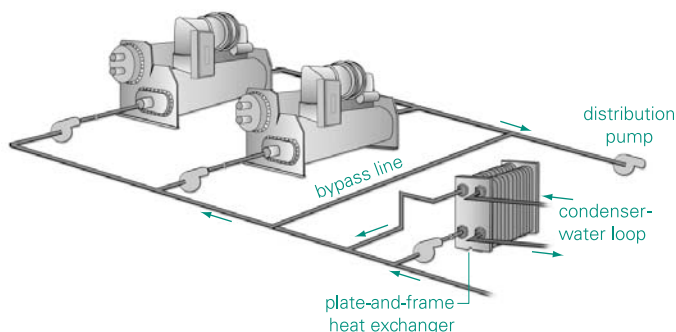
Plate-and-frame free cooling



Plate-and-frame heat exchangers are sometimes referred to as **waterside economizers**.

One way to reduce the energy consumption of a chilled-water plant is to precool the water in the chilled-water loop before it enters the evaporator. This can be accomplished by piping a plate-and-frame heat exchanger into the chilled-water and condenser-water loops. Using the piping arrangement shown in Figure 3–9, free cooling and mechanical cooling occur simultaneously. (Plate-and-frame free cooling can be achieved with other piping arrangements, depending on the operating characteristics desired.)

Figure 3–9 Chilled-water plant with plate-and-frame free cooling



When the ambient wet-bulb temperature is low enough, the heat exchanger transfers heat *from* the chilled water returning to the evaporator *to* the condenser water returning from the cooling tower. Precooling the chilled water before it enters the evaporator lessens the cooling burden, reducing the energy that the chiller uses.

Application considerations

- Adding a heat exchanger to provide free cooling increases the initial cost of the system. The additional pressure loss also raises pumping costs.
- The ambient wet-bulb temperature determines the free-cooling capacity of the heat exchanger—cooling capacity diminishes as the ambient wet-bulb temperature rises. Free cooling is only

available when the ambient wet-bulb (AWB) temperature is less than the design return chilled-water (DRCW) temperature *plus* the heat exchanger approach (HEA) temperature, that is,

$$AWB < (DRCW + HEA)$$

- The cooling tower must be designed for winter operation.
- Water entering the condenser must be maintained within the temperature limits specified by the chiller manufacturer.


Related reading

- *Multiple-Chiller-System Design and Control Applications* Engineering Manual (Trane literature number SYS-APM001-EN)
- *Chilled Water Systems* Air Conditioning Clinic, one of the systems series (Trane literature number TRG-TRC016-EN)
- "A New Era of Free Cooling," *Engineers Newsletter* (volume 20, number 3)

Sample scenario

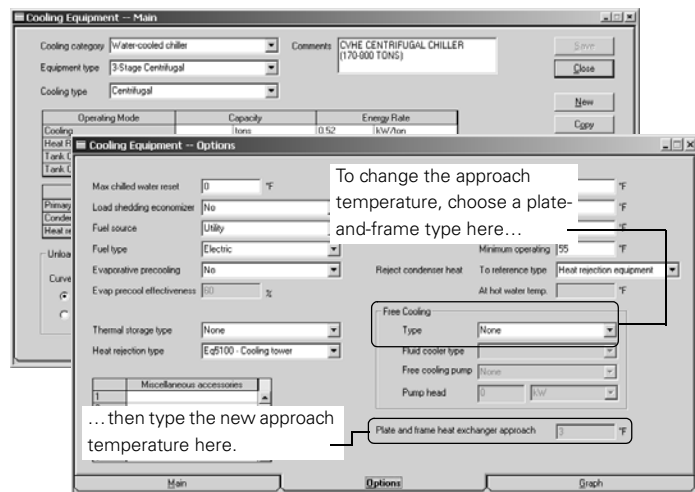
A chilled-water plant includes a three-stage centrifugal chiller and a plate-and-frame heat exchanger that has a 3°F approach.


The following illustrations demonstrate how to model this plant.

 Cooling-equipment definitions in the TRACE 700 library include an approach temperature for a plate-and-frame heat exchanger—the default is 3°F.

To model a different approach temperature, use the Library/Template Editors program to *copy and modify* an existing piece of cooling equipment.

Note: TRACE 700 assumes that the capacity of the heat exchanger equals the cooling capacity of the chiller to which it is assigned.



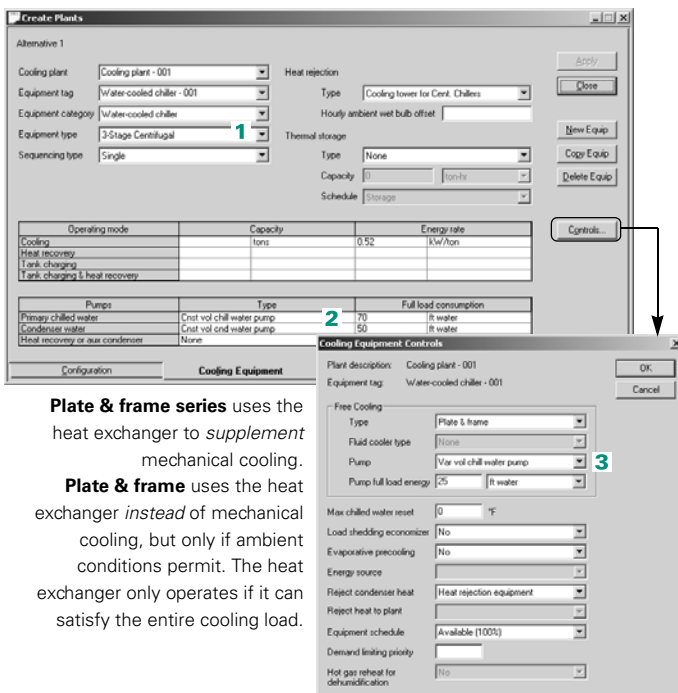
 To model a cooling plant that includes a plate-and-frame heat exchanger:

1 Select the desired **equipment type**. For this example, pick one of the centrifugal chillers from the **water-cooled chiller** category.

2 Enter the **full-load consumption** for each pump.

3 Click **Controls** and choose one of the plate-and-frame options as the **free cooling type**.

For a cooling plant with multiple chillers, be sure to specify the free-cooling option for each chiller.



Create Plants

Alternative 1

Cooling plant: Cooling plant - 001

Equipment tag: Water-cooled chiller - 001

Equipment category: Water-cooled chiller

Equipment type: 3-Stage Centrifugal

Sequencing type: Single

Heat rejection: Cooling tower for Cent. Chiller

Type: Cooling tower for Cent. Chiller

Hourly ambient wet bulb offset:

Thermal storage: None

Type: None

Capacity: 0.52 ton/hr

Schedule: Storage

Operating mode	Capacity	Energy rate
Cooling	ton	0.52 kW/ton
Heat recovery		
Tank charging		
Tank charging & heat recovery		

Pumps	Type	Full load consumption
Primary chilled water	Cent vol chill water pump	70 ft water
Condenser water	Cent vol cond water pump	50 ft water
Heat recovery or aux condenser	None	

Cooling Equipment Controls

Plant description: Cooling plant - 001

Equipment tag: Water-cooled chiller - 001

Free Cooling:

Type: Plate & frame

Fluid cooler type: None

Pump: Var vol chill water pump

Pump full load energy: 25 ft water

Max chilled water reset: 0 °F

Load shedding economizer: No

Evaporative precooling: No

Energy source: Heat rejection equipment

Reject condenser heat: Heat rejection equipment

Reject heat to plant: None

Equipment schedule: Available (100%)

Demand linking priority: None

Hot gas reheat for defrostification: No

Plate & frame series uses the heat exchanger to *supplement* mechanical cooling.

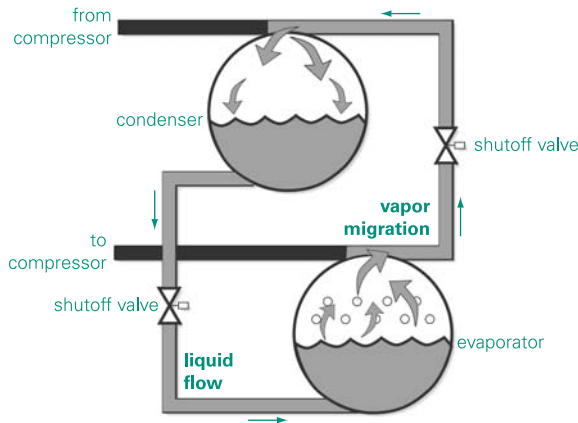
Plate & frame uses the heat exchanger *instead* of mechanical cooling, but only if ambient conditions permit. The heat exchanger only operates if it can satisfy the entire cooling load.

Refrigerant-migration free cooling

As the name implies, refrigerant-migration free cooling is based on the principle that refrigerant migrates to the coldest point in a refrigeration circuit. Under favorable conditions, this energy-saving option for centrifugal chillers can provide up to 40 percent of the design cooling capacity of the chiller.

When condenser water returning from the cooling tower is colder than the water in the chilled-water loop, as depicted in Figure 3–10, the refrigerant pressure in the condenser is less than that in the evaporator. This difference in pressure drives refrigerant vapor from the evaporator to the condenser, where it liquefies. With the help of gravity, the liquid refrigerant flows back to the evaporator. The non-mechanical refrigeration cycle is sustained, providing free cooling, as long as the differential refrigerant pressure is sufficient to drive vapor from the evaporator to the condenser.

Figure 3–10 Refrigerant-migration free cooling



Application considerations

- Mechanical cooling and refrigerant-migration free cooling cannot occur simultaneously. This type of free cooling can only be used if the cooling capacity of the tower water is sufficient to meet the entire building load.


- Little, if any, free-cooling capacity is available when the ambient wet-bulb temperature exceeds 50°F.
- Unlike the compressor (which is off), accessories such as pumps and cooling-tower fans continue to operate in the conventional manner during the free-cooling mode.
- The cooling tower must be designed for winter operation.

Related reading

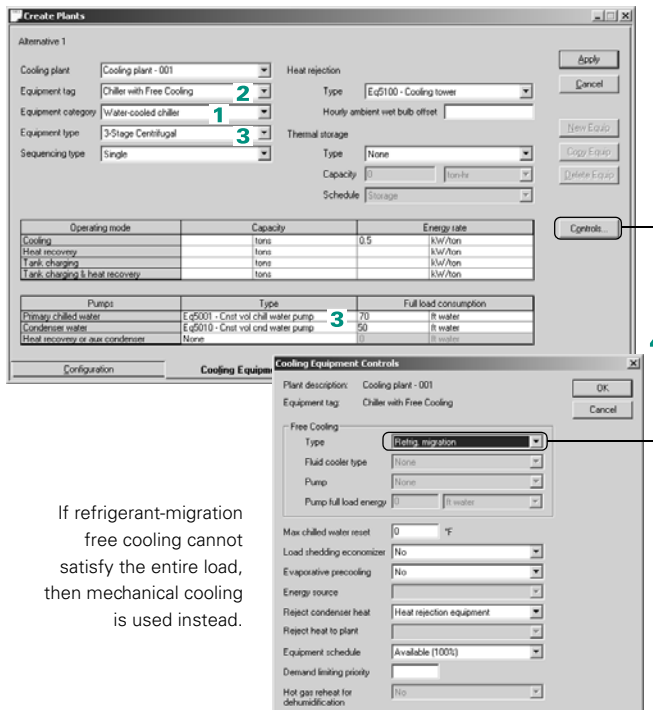
- *Chilled Water Systems* Air Conditioning Clinic, one of the systems series (Trane literature number TRG-TRC016-EN)

Sample scenario

A water-cooled centrifugal chiller is equipped for refrigerant-migration free cooling. When ambient conditions permit, free cooling satisfies up to 40 percent of the design capacity of the chiller.

 To model a chiller with refrigerant-migration free cooling:

- 1 Add the appropriate **equipment category** to the cooling plant. For this example, select **water-cooled chiller**. (This is equivalent to dragging an equipment icon to a plant on the **Configuration** tab.)
- 2 Replace the default **equipment tag** with a more descriptive name, if desired.
- 3 Select the desired **equipment type** and **full-load consumption** for each pump.
- 4 Click **Controls** and choose the appropriate option from the list of free cooling types (in this case, refrigerant migration).



Create Plants

Alternative 1

Cooling plant: Cooling plant - 001

Equipment tag: Chiller with Free Cooling

Equipment category: Water-cooled chiller

Equipment type: 3-Stage Centrifugal

Sequencing type: Single

Heat rejection: Type: Eq5100 - Cooling tower

Hourly ambient wet bulb offset:

Thermal storage: Type: None

Capacity: 0

Schedule: Storage

Operating mode	Capacity	Energy rate
Cooling	tons	0.5
Heat recovery	tons	kW/ton
Tank charging	tons	kW/ton
Tank charging & heat recovery	tons	kW/ton

Pumps	Type	Full load consumption
Primary chilled water	Eq5001 - Crst vol chd water pump	70
Condenser water	Eq5010 - Crst vol cond water pump	50
Heat recovery or aux condenser	None	0

Cooling Equipment Controls

Plant description: Cooling plant - 001

Equipment tag: Chiller with Free Cooling

Free Cooling: Type: Refrigerant migration

Fluid cooler type: None

Pump: None

Pump full load energy: 0

Max chilled water reset: 0 °F

Load shedding economizer: No

Evaporative precooling: No

Energy source:

Reject condenser heat: Heat rejection equipment

Reject heat to plant:

Equipment schedule: Available (100%)

Demand limiting priority:

Hot gas reheat for dehumidification: No

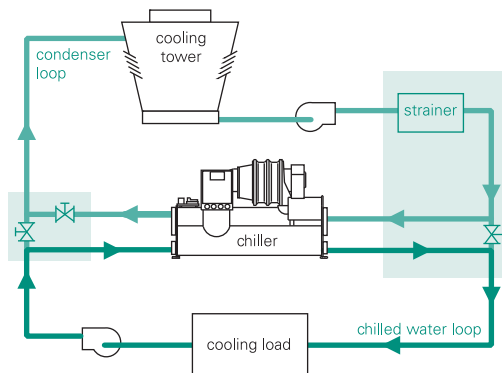
If refrigerant-migration free cooling cannot satisfy the entire load, then mechanical cooling is used instead.

Strainer-cycle free cooling

Like other methods of free cooling for chillers, strainer-cycle free cooling acts as a *waterside economizer* that reduces the amount of energy consumed to produce chilled water. In this case, the source of cooling is condenser water returning from the cooling tower.

Figure 3–11 illustrates a typical strainer-cycle piping arrangement that provides free cooling. When the ambient wet-bulb temperature is cold enough, the tower water is *valved* around the chiller and directly into the chilled-water loop. A filter is positioned upstream of the valve to strain the condenser water *before* it enters the chilled-water loop, resulting in the name given to this method of free cooling.

Figure 3–11 Piping arrangement for strainer-cycle free cooling




Application considerations

- Pumping cooling-tower water throughout the entire chilled-water loop increases the risk of corrosion and fouling. Water treatment, though costly, can help mitigate this risk.
- Free cooling is only available if the leaving-tower water can satisfy the entire cooling load, limiting the effectiveness of this option. Ambient wet-bulb temperature determines the amount of free-cooling capacity available from the *strainer cycle*—cooling capacity diminishes as the ambient wet-bulb temperature rises.

- The cooling tower must be designed for winter operation.

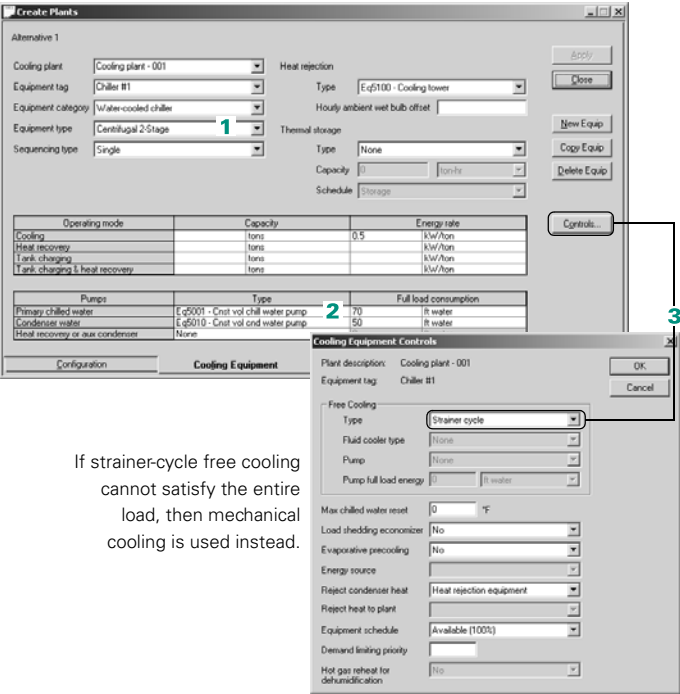
Sample scenario

A chilled-water plant, which includes a water-cooled centrifugal chiller, is piped to provide strainer-cycle free cooling.

 After adding a water-cooled chiller to the cooling plant:

- 1 Choose the appropriate **equipment type** (a centrifugal chiller for this example).
- 2 Specify the **full-load consumption** for each pump.
- 3 Click **Controls** and choose **strainer cycle** from the list of free cooling types.

Strainer-cycle free cooling occurs at the plant level. If the cooling plant includes multiple chillers, repeat this step for each chiller.



Create Plants

Alternative 1

Cooling plant: Cooling plant - 001

Equipment tag: Chiller #1

Equipment category: Water-cooled chiller

Equipment type: Centrifugal 2-Stage

Sequencing type: Single

Heat rejection

Type: E-q100 - Cooling towers

Hourly ambient wet bulb offset:

Thermal storage

Type: None

Capacity: 0 tons/hr

Schedule: Storage

Operating mode	Capacity	Energy rate
Cooling	tons	0.5 kW/ton
Heat recovery	tons	kW/ton
Tank charging	tons	kW/ton
Tank charging & heat recovery	tons	kW/ton

Pumps

	Type	Full load consumption
Primary chilled water	E-q5001 - Cent vol chd water pump	70 ft water
Condenser water	E-q5010 - Cent vol cond water pump	50 ft water
Heat recovery or aux condensers	None	

Cooling Equipment Controls

Plant description: Cooling plant - 001

Equipment tag: Chiller #1

Free Cooling

Type: Strainer cycle

Fluid cooler type: None

Pump: None

Pump full load energy: 0 ft water

Max chilled water reset: 0 °F

Load shedding economizer: No

Evaporative precooling: No

Energy source:

Reject condenser heat: Heat rejection equipment

Reject heat to plant:

Equipment schedule: Available (100%)

Demand limiting priority:

Hot gas reheat for dehumidification: No

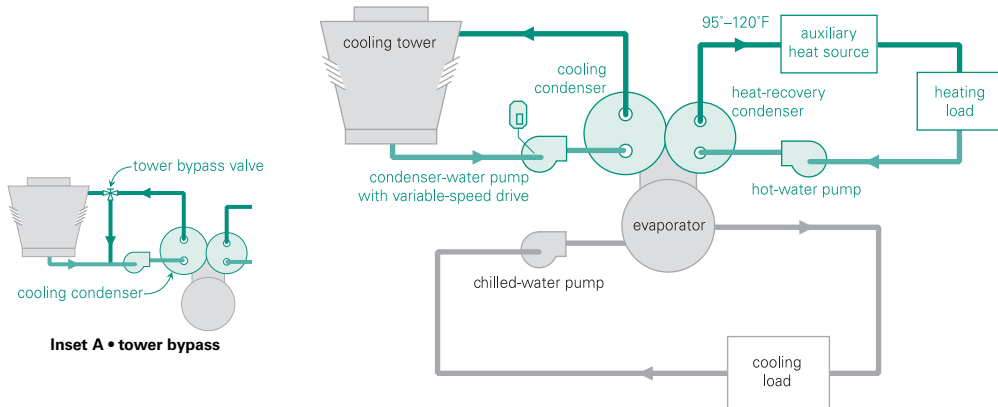
If strainer-cycle free cooling cannot satisfy the entire load, then mechanical cooling is used instead.

Double-bundle condenser heat recovery

The *double-bundle* method of condenser heat recovery can reduce the amount of energy consumed for heating in chilled-water applications. It adds a second, *heat-recovery* condenser to collect heat that normally would be rejected to the cooling tower by the cooling condenser. The collected heat is then used to (pre)heat water for domestic use, comfort heating, or a process application.

Figure 3–12 illustrates a typical chilled-water plant equipped to satisfy concurrent cooling and heating loads. When a heating load exists, water flow through the cooling condenser is adjusted so that the chiller rejects less heat to the cooling tower. Flow modulation can be accomplished with a variable-frequency drive on the condenser pump or, alternatively, could be accomplished by varying the temperature of the water entering the condenser by installing a cooling-tower bypass (Inset A).

Figure 3–12 Heat recovery with a double-bundle condenser



As the water temperature returning from the heating load falls, the variable-frequency drive modulates the condenser-water pump to decrease the flow of water through the cooling condenser and tower. (If a cooling-tower bypass is used, the bypass valve modulates to divert a greater amount of water directly back to the cooling condenser.)

With less heat rejected outdoors, more heat can be collected by the heat-recovery condenser. The amount of heat recovered depends on the extent to which condenser-water flow is reduced. Given the characteristics of the application and of the chiller selected, the heat-recovery condenser can produce hot water ranging from 95°F to 120°F.

Application considerations

- A backup source of heat is required if the heat recovered from the cooling process is not sufficient to satisfy the entire heating load.
- Double-bundle condenser heat recovery is an equipment option that must be specified when ordering the chiller.
- The chiller consumes more energy per cooling ton when it operates in the heat-recovery mode.


Related reading

- *Multiple-Chiller-System Design and Control Applications* Engineering Manual (Trane literature number SYS-APM001-EN)

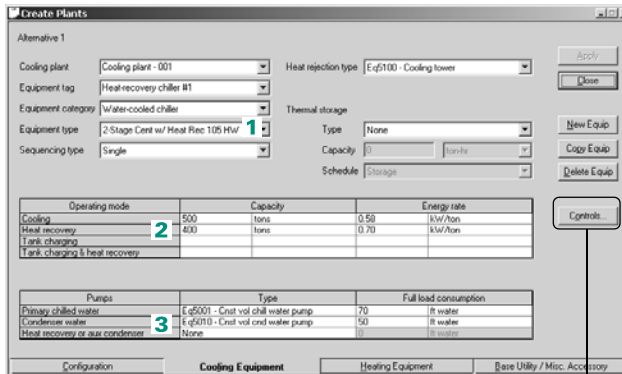
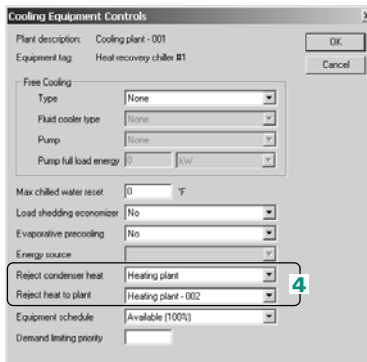
Sample scenario

A water-cooled, centrifugal chiller has a nominal cooling capacity of 500 tons, and is equipped with a heat-recovery condenser to satisfy the comfort-heating load. The pumps that serve the chilled-water and condenser-water loops are rated for 70 feet and 50 feet of static head, respectively. A gas-fired boiler provides backup heat, if needed, using a hot-water pump rated for 60 feet of static head. Any excess heat is rejected from the system via the cooling tower.

If the entering condenser water is 85°F, then the chiller consumes 0.58 kW/ton to make chilled water. When no heating load exists, the tower attempts to make 65°F water. During the heat-recovery mode, the chiller can produce 400 tons of cooling at 0.70 kW/ton.

 To model the cooling plant in this example:

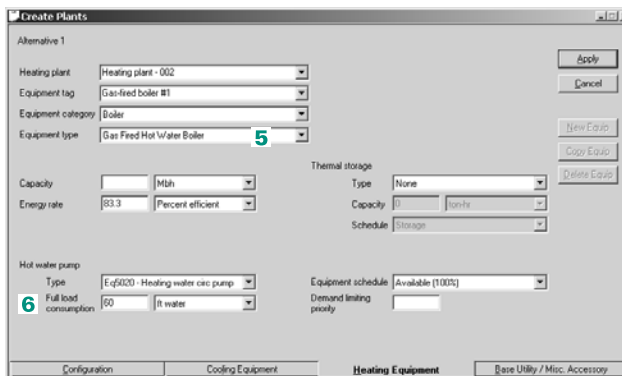
- 1 Pick a water-cooled centrifugal chiller with heat recovery as the **equipment type**.
- 2 Specify the **capacity** and **energy rate** for each operating mode (cooling and heat recovery).
- 3 Enter the **full-load consumption** for each pump.
- 4 Reject the heat recovered by the chiller to the heating plant when a heating load exists.





To accomplish condenser-water reset by varying flow (rather than temperature), choose a variable-volume pump. Refer to “Flow-based condenser-water reset” on page 5–29.

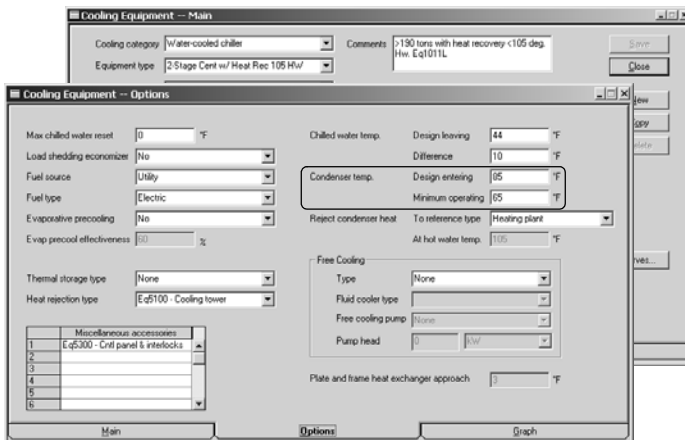
To model the heating plant in this example:

- 5 Choose a hot-water boiler as the **equipment type**.
- 6 Enter the static head of the hot-water pump as the **full-load consumption** for the pump.



 Definitions for water-cooled chillers in the **Cooling Equipment** library include design entering and minimum operating temperatures for condenser water.

Use the Library/Template Editors program to display the values for a particular chiller.



Cooling Equipment - Main

Cooling category: Water-cooled chiller
 Equipment type: 2 Stage Cent w/ Heat Rec 106 Hw/
 Comments: >190 tons with heat recovery <105 deg. Hw. Eq1011L

Cooling Equipment - Options

Max chilled water reset: 0 °F
 Load shedding economizer: No
 Fuel source: Utility
 Fuel type: Electric
 Evaporative precooling: No
 Evap precool effectiveness: 50 %
 Thermal storage type: None
 Heat rejection type: Eq100 - Cooling tower

Chilled water temp. Design leaving: 44 °F
 Difference: 10 °F
 Condenser temp. Design entering: 05 °F
 Minimum operating: 05 °F
 Reject condenser heat: To reference type: Heating plant
 At hot water temp: 100 °F

Free Cooling
 Type: None
 Fluid cooler type:
 Free cooling pump: None
 Pump head: 0 ftw
 Plate and frame heat exchanger approach: 1 °F

Miscellaneous accessories
 1: Eq5300 - Ctrl panel & interlocks
 2:
 3:
 4:
 5:
 6:

Main Options Graph

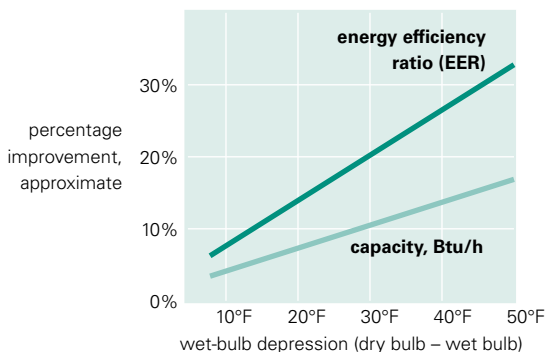
Evaporative precooling of condenser air

Precooling the condenser air stream can increase the efficiency and capacity of mechanical cooling equipment. The cost-effectiveness of this option is directly related to the ambient conditions in which it is used. Generally, the drier and hotter the climate, the greater the potential savings.

Evaporative precoolers primarily consist of porous, absorbent material continuously saturated with water. Commonly used with air-cooled equipment such as rooftop air conditioners, the precooler is mounted on the entering-air side of the condenser coil.

As the condenser fans draw air through the precooler, water contained in the wetted media evaporates, cooling the air stream before it enters the condenser coil. The temperature drop resulting from the evaporative process increases condenser capacity and improves the overall efficiency of the machine. The extent to which efficiency is improved is determined by the difference between the wet- and dry-bulb temperatures and also by the effectiveness of the precooling coil (refer to Figure 3–13).

Figure 3–13 Effect of evaporative precooling



Application considerations


- Adding an evaporative precooling increases water usage, which may be a significant cost consideration in dry climates.
- Condenser fans must sustain higher static pressures when an evaporative precooling media is used to lower the temperature of the condenser air stream. Consult the manufacturer to determine fan capabilities.
- Like condensate drain pans, evaporative precooling systems require additional care to ensure proper cleanliness and operation.

Sample scenario

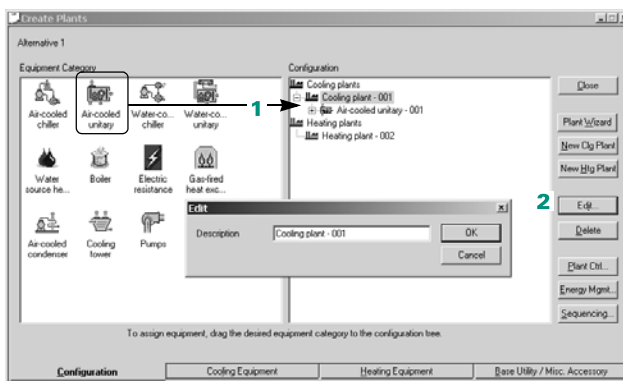
A 60-ton rooftop air conditioner cools a building. To reduce the energy consumption of the air conditioner, an evaporative precooling media is used to lower the temperature of the condenser air stream. The effectiveness of the evaporative precooling is rated at 60 percent.

The illustrations below and on page 56 demonstrate how to add a rooftop air conditioner to the current project (Steps 1–3) and equip it with evaporative precooling (Steps 4–5).

*Note: Evaporative precooling effectiveness defaults to 60 percent for all air-cooled equipment in the **Cooling Equipment** library. To change this default value, copy an existing piece of cooling equipment and modify it using the Library/Template Editors program.*

 First, define the **cooling plant** as a rooftop air conditioner.

- 1 Drag the **air-cooled unitary** icon to the cooling plant.
- 2 If desired, rename the plant icon as **Rooftop Unit**. (If you prefer, you can rename the equipment tag from the **Cooling Equipment** tab.)



Next, define the capacity of the rooftop unit.

- Enter **60 tons** as the cooling capacity.

Finally, add the evaporative precooling option to the unit.

- Click **Controls**.

- Choose **Yes** in the **Evaporative precooling** box and click **OK**.

To save your entries, click **Apply** on the **Cooling Equipment** tab.

The 'Create Plants' dialog box shows the configuration for a cooling plant. The 'Cooling plant - 001' is selected. The 'Equipment tag' is 'Rooftop Unit' and the 'Equipment category' is 'Air-cooled unitary'. The 'Capacity' is set to 60 tons. The 'Controls' tab is active, showing 'Evaporative precooling' set to 'Yes'. The 'Cooling Equipment Controls' sub-dialog is also shown, with 'Evaporative precooling' set to 'Yes'.

To create a piece of custom cooling equipment, open the **Cooling Equipment** library:

- On the **Main** tab, choose **Air-cooled unitary** as the **cooling category**.
- Choose an equipment type that is similar to the one you want to create.
- Click **Copy**.
- Rename the **equipment type** with a meaningful identifier and add comments if desired.
- On the **Options** tab, choose **Yes** for the entry in **evaporative precooling**.

- Use **evap precool effectiveness** to specify the efficiency value of the evaporative precooling function.

Be sure to save your new custom cooling equipment when finished.

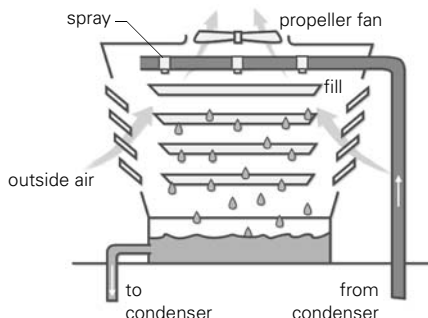
The 'Cooling Equipment - Main' dialog box shows the configuration for a cooling equipment type. The 'Cooling category' is 'Air-cooled unitary' and the 'Equipment type' is 'Large Rooftop - Recip Compressor'. The 'Cooling type' is 'Direct expansion (DX)'. The 'Options' tab is active, showing 'Evaporative precooling' set to 'Yes' and 'Evap precool effectiveness' set to 62%.

Cooling tower with VFD

A cooling tower rejects the heat from a water-cooled condenser by spraying water over a fill while drawing outside air through it. As the heat-rejection load and ambient wet bulb change, the cooling-tower fans must move either more or less air to produce the desired water temperature. One popular method for controlling the speed of the cooling-tower fans is to use variable-frequency drives (VFDs). This approach offers several benefits:

- Tight control of tower-water temperature.
- Fan power varies with the cube of the speed, resulting in great potential for energy savings.
- In addition to avoiding gearbox or motor wear, fans operate more quietly at low speeds when equipped with variable-frequency drives than with other methods of modulation.

Figure 3-14 Cooling tower with VFD



Application consideration

- Balancing chiller and cooling-tower energy is an important aspect of controlling condenser-water temperature. Studies indicate that during many points of operation, the optimal condition is *not* the lowest water temperature that the cooling tower can produce. To reduce the *combined* energy consumption of the chiller and tower, consider using automated, system-level controls to establish the target water temperature for the tower sump.

Related reading

- *Multiple-Chiller-System Design and Control Applications* Engineering Manual (Trane literature number SYS-APM001-EN)
- “Tower Water Temperature...Control it How?,” *Engineers Newsletter* (volume 24, number 1)

Sample scenario

A chiller plant consists of a three-stage, electric centrifugal chiller that rejects condenser heat to a cooling tower. The capacity of the cooling-tower fans is regulated by a variable-frequency drive. The illustrations that follow demonstrate how to add a centrifugal chiller (Steps 1–2), related pumps (Step 3), and a cooling tower with variable-frequency drive (Step 4).

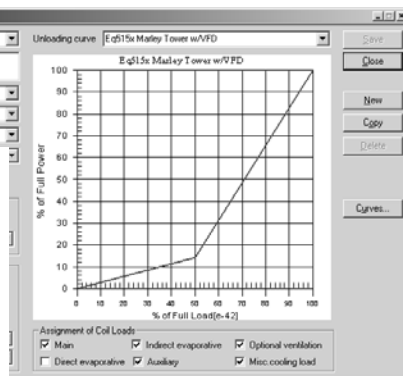
Create a **cooling plant** consisting of a water-cooled chiller, cooling tower, and pumps.

- 1 Describe the chiller as a three-stage centrifugal.
- 2 If desired, specify the cooling capacity (required if the plant contains more than one piece of cooling equipment.)
- 3 To include the pumps in the calculation of plant energy consumption, complete the entries for full-load consumption.
- 4 Pick a cooling tower equipped with a VFD. To view the unloading characteristics of the cooling tower, or to create a tower with a different unloading curve and add it to the TRACE 700 library of heat-rejection equipment, use the Library/Template Editors program.

Operating mode	Capacity	Energy rate
Cooling	500 tons	0.52 kW/ton
Heat recovery	tons	kW/ton
Tank charging	tons	kW/ton
Tank charging & heat recovery	tons	kW/ton

Pumps	Type	Full load consumption
Primary chilled water	E45001 - Crst vol chill water pump	80 ft water
Condenser water	E45010 - Crst vol cond water pump	40 ft water
Heat recovery or aux condenser	None	0 ft water

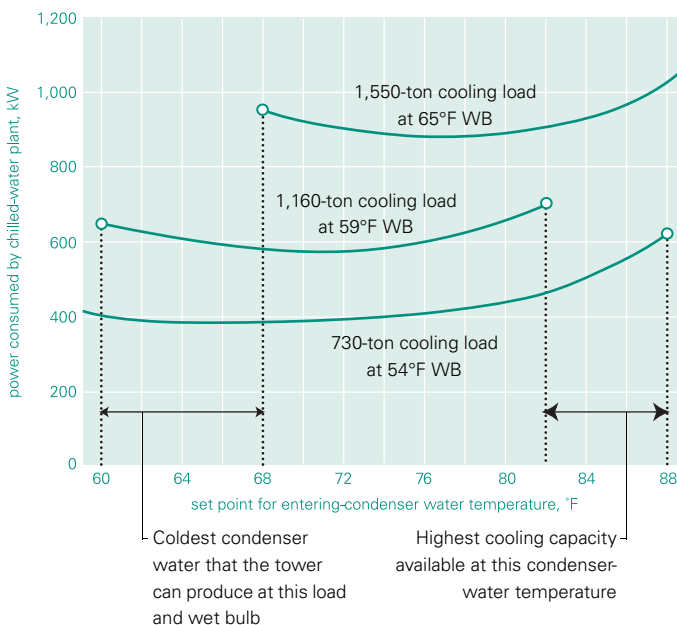
Note: Use the *Library/Template Editors* program to view the characteristics of predefined equipment or to add custom equipment. Refer to online Help for additional information about individual fields associated with the equipment.



Chiller–tower optimization

Independent studies of the relationship between the cooling tower and chiller demonstrate the importance of balancing chiller and cooling-tower energy. As Figure 3–15 illustrates, the optimal condenser-water temperature for a specific chilled-water plant depends on both chiller load and ambient conditions.

Figure 3–15 Chiller–tower energy consumption



During many points of operation, the optimal condition is *not* the lowest water temperature that the cooling tower can produce. To reduce the overall energy consumption of the chiller–tower combination, it is important for the system designer and plant operator to evaluate the use of system-level controls that establish a set-point temperature for the tower sump based on ambient and load conditions.

Application considerations

- Load, ambient conditions, and the part-load operating characteristics of the chiller and tower ultimately determine the optimum tower control temperatures for a given installation. Information-sharing controls are key to successful optimization.
- Energy consumption of helical-rotary (screw) compressors drops quickly with reduced head pressure (condenser-water temperature). The optimal tower-sump set point for these compressors is therefore lower than for centrifugal compressors.
- Chiller operation at elevated tower-water temperatures, though efficient, may cause adverse effects over time. Operating with a *higher-than-normal* pressure differential between the evaporator and condenser places a greater burden on the compressor.

Related reading


- *Multiple-Chiller-System Design and Control Applications Engineering Manual* (Trane literature number SYS-APM001-EN)
- "Tower Water Temperature—Control It How?" *Engineers Newsletter* (volume 24, number 1)

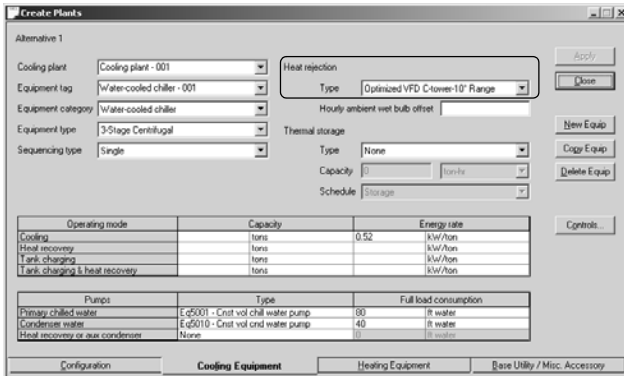
Sample scenario

Condenser heat from a water-cooled chiller is rejected to a cooling tower. A building automation system governs plant operation, optimizing the water temperature leaving the cooling tower to minimize the combined energy consumption of the chiller and tower.

The following illustrations represent the entries used to model the control strategy for chiller–tower optimization.

Note: Of the cooling towers predefined in the TRACE 700 library of heat rejection equipment, two include optimized control of condenser-water temperature as well as variable-frequency drives: Optimized VFD C-tower – 10°F represents a 10°F design range, and Optimized VFD C-tower – 15°F represents a 15°F design range.

 After creating a cooling plant that consists of a water-cooled chiller, cooling tower, and related pumps, pick one of the *optimized* cooling towers as the **heat rejection type**.



Create Plants

Alternative 1


Cooling plant: Cooling plant - 001
 Equipment tag: Water-cooled chiller - 001
 Equipment category: Water-cooled chiller
 Equipment type: 3-Stage Centrifugal
 Sequencing type: Single


Heat rejection: Type: Optimized VFD C-tower-10" Range
 Hourly ambient wet bulb offset:
 Thermal storage: Type: None
 Capacity: 0 tons
 Schedule: Storage

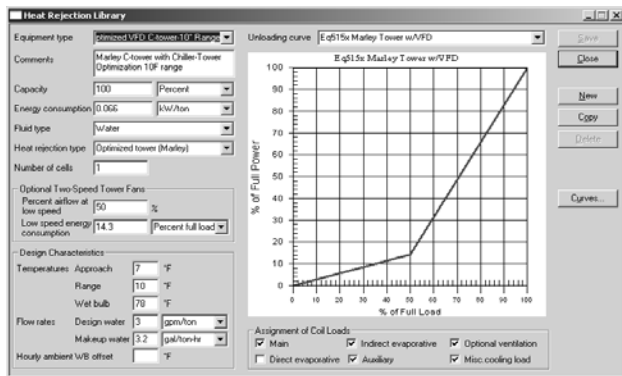
Operating mode	Capacity	Energy rate
Cooling	tons	0.52 kW/ton
Heat recovery	tons	kW/ton
Tank charging	tons	kW/ton
Tank charging & heat recovery	tons	kW/ton

Pumps	Type	Full load consumption
Primary chilled water	Eq5001 - Crst vol chl water pump	80 ft water
Condenser water	Eq5010 - Crst vol cond water pump	40 ft water
Heat recovery or aux condensate	None	ft water

Configuration **Cooling Equipment** Heating Equipment Base Utility / Misc. Accessory

 Use the Library/Template Editors program to view the attributes of the predefined cooling towers with optimized control.

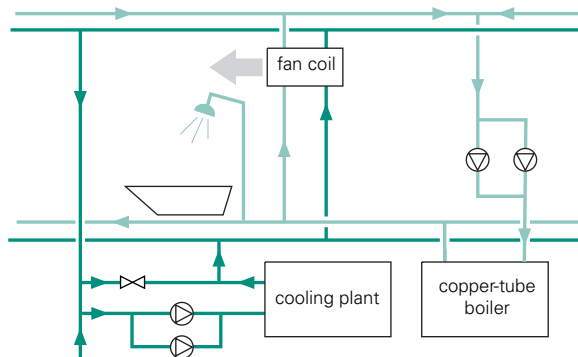
 Copy and modify one of these towers to add your own cooling-tower definitions to the library of **Heat Rejection** equipment.



Domestic hot water assigned to a boiler

Current construction practices yield well-insulated, tightly constructed buildings that lose less heat and experience less infiltration than their predecessors. The reduced heating burden permits the use of domestic hot water for comfort heating. A central boiler not only provides potable hot water for washing and cooking, but also for comfort heating (that is, by supplying hot water to fan coils distributed throughout the building).

Figure 3-16 Integrated HVAC and domestic hot-water systems



Application considerations


- All components connected to the domestic water system must be compatible with, and rated for use with, potable water. For example, use bronze pumps, copper-tube boilers, and fan coils with lead-free fittings and solder.
- Eliminate air from the potable-water loop, at the expansion tank as well as at the fan coils.
- Provide appropriate water treatment.

Sample scenario

A gas-fired boiler provides hot water to satisfy the heating load for the building. The same boiler also supplies 105°F water at a rate of 200 gpm to satisfy the hourly demand for domestic hot water. The illustrations below demonstrate how to model a boiler

that serves two purposes: comfort heating and domestic hot water.

Note: Gallons should not be used with domestic hot water. Gallons should only be used for water consumption, i.e., makeup water.

 To represent the domestic hot water for this example, create a new base utility using the Library/Template Editors program.


1 Copy the **domestic hot water** member of the **Base Utility** library.

2 Rename the copy and add comments if desired.

3 Replace the existing hourly demand with **200 gpm**.

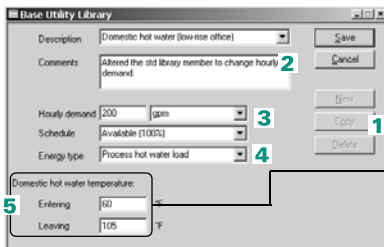
4 Change energy type to **Process hot water load**.

5 Provide the water temperatures entering and leaving the boiler (**60** and **105**, respectively) and save the new utility.

6 Using , add a boiler to the heating plant.

7 Define the domestic hot water load as a base utility using the new library member created in Steps 1 through 4. Assign it to the heating plant and click **Apply**.

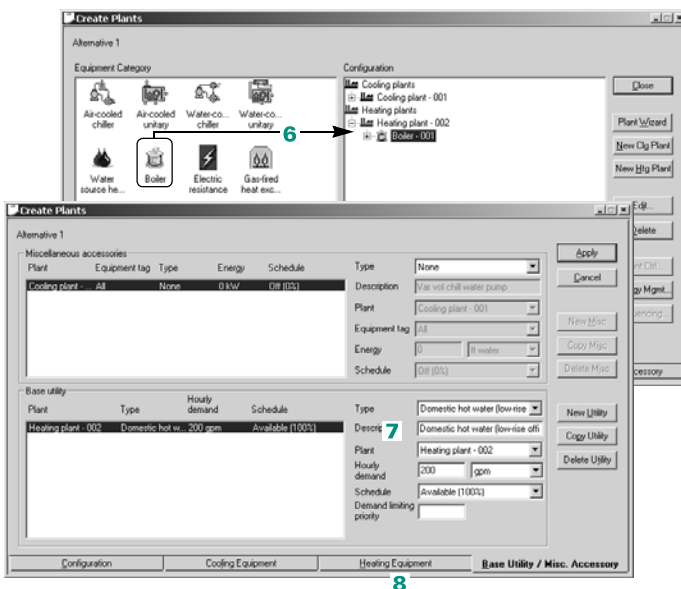
8 Specify the **equipment type** and **full load consumption** of the hot water pump on the **Heating Equipment** tab.



The 'Base Utility Library' dialog box is shown. It has a 'Description' field with 'Domestic hot water (low-rise office)' and a 'Comments' field with 'Altered the std library member to change hourly demand'. The 'Hourly demand' is set to '200 gpm', 'Schedule' is 'Available (100%)', and 'Energy type' is 'Process hot water load'. The 'Domestic hot water temperature' section shows 'Entering' as '60' and 'Leaving' as '105'. Buttons for 'Save', 'Cancel', 'New', 'Copy', and 'Delete' are on the right. Numbered callouts 1 through 5 point to the 'Copy' button, the 'Comments' field, the 'Hourly demand' field, the 'Energy type' dropdown, and the 'Entering' temperature field respectively.

To include domestic hot water in the heating energy calculations, provide temperatures when the hourly demand is a flow rate.

Note: Entering and leaving temperatures are only available when using units of gpm or lps.



Two dialog boxes are shown. The top one is 'Create Plants' for 'Alternative 1', showing a 'Configuration' tab with a list of plants including 'Cooling plant - 001', 'Heating plant - 002', and 'Boiler - 001'. A numbered callout 6 points to the 'Boiler - 001' entry. The bottom dialog box is 'Create Plants' for 'Alternative 1' with the 'Base Utility' tab selected. It shows a table of base utilities with columns for Plant, Equipment tag, Type, Energy, and Schedule. A new entry 'Heating plant - 002' is added with 'Domestic hot w.' as the equipment tag, '200 gpm' as the hourly demand, and 'Available (100%)' as the schedule. On the right, the 'Domestic hot water (low-rise office)' utility is selected, and its details are shown: Description, Plant ('Heating plant - 002'), Hourly demand ('200 gpm'), Schedule ('Available (100%)'), and Demand limiting priority. Numbered callouts 7 and 8 point to the 'Domestic hot water (low-rise office)' dropdown and the 'Hourly demand' field respectively.

Air-to-air heat-pump system

To provide comfort cooling and heating, air-to-air heat pumps rely on two refrigerant-to-air heat exchangers, one located inside the building and the other outside. During cooling operation, the heat pump operates as a conventional air conditioner—refrigerant passing through the *indoor* coil picks up heat from the space (cooling it), and then rejects that heat outdoors when it passes through the *outdoor* coil.

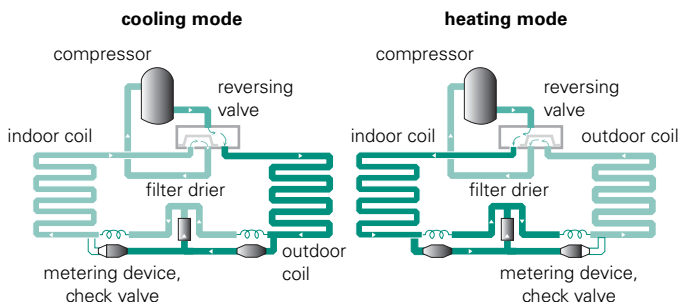
The refrigeration cycle operates in reverse during heating operation. Ambient heat transfers to the refrigerant passing through the *outdoor* coil, and is then released to the space when the refrigerant passes through the *indoor* coil.



Oversizing the cooling capacity of the heat pump lessens the use of electric heat, but it can also cause excessive cycling and discomfort.

Supplementary electric-resistance heat typically serves as a backup during defrost cycles and when the heat pump is unable to satisfy the heating load. Backup heating is especially important in cold climates because the capacity of the heat pump decreases as the temperature outside falls.

Figure 3-17 Operating modes of air-to-air heat pumps



Application considerations


- Most air-to-air heat pumps can provide cooling at ambient temperatures as cold as 35°F. Adding an optional head-pressure control can extend operation to 0°F, and may be required to enable low-ambient cooling in applications that use changeover-bypass VAV controls.

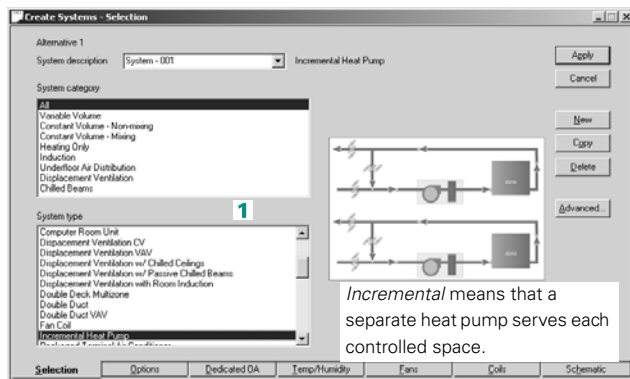
- To reduce drafts during heating operation, use diffusers that control air velocity and throw. (The heating supply-air temperature is usually lower for heat pumps than for other types of HVAC systems.)
- Some air-to-air heat pumps include barometric-relief, gravity-actuated dampers that open as the building pressure rises. Whether barometric relief is sufficient during economizer operation depends on the characteristics of the air-distribution system. When making this determination, be sure to account for the return-air pressure drop.

Sample scenario

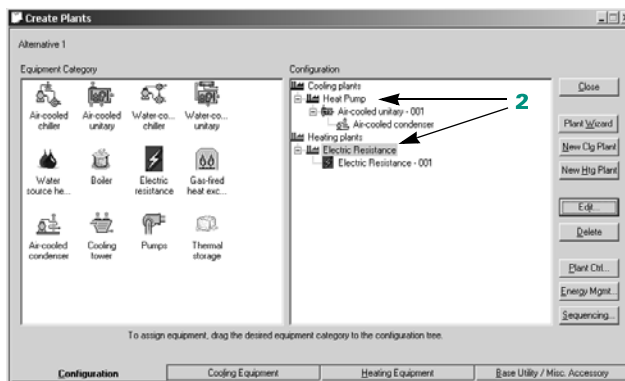
A dedicated, air-to-air heat pump satisfies the air-conditioning needs of each retail store in a strip mall. Electric resistance heat serves as a backup when the heat pump is unable to satisfy the entire heating load for the store.

To model each air-to-air heat pump:

- 1  Create an airside system and define it as an **incremental heat pump**.

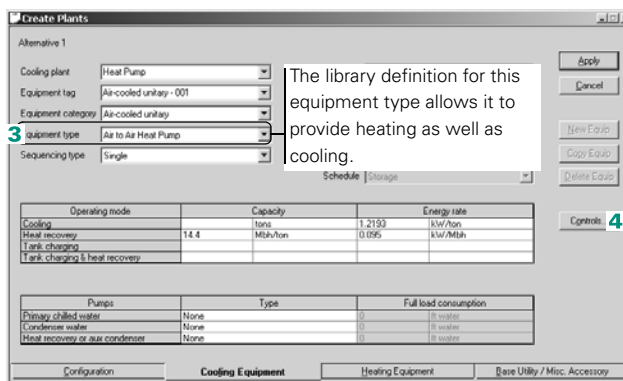


2 Use **air-cooled unitary** and **electric resistance** to begin defining the cooling and heating plants. Rename the cooling plant to **Heat pump** and the heating plant to **Electric resistance**.



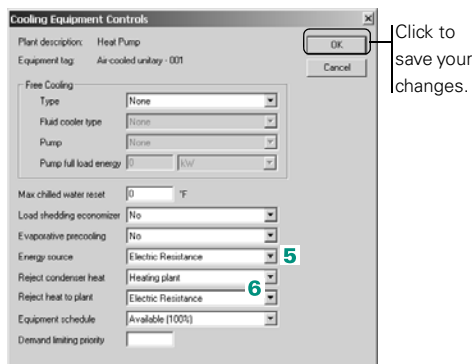
3 With the cooling plant displayed on the **Cooling Equipment** tab, pick **air-to-air heat pump** as the equipment type.


4 Open the **Cooling Equipment Controls** dialog box.



5 Use the **energy source** entry to identify which heating plant (if more than one) will serve as a backup if the heat pump cannot satisfy the load.


6 Assign excess heat from the condenser loop to loads served by the selected heating plant.

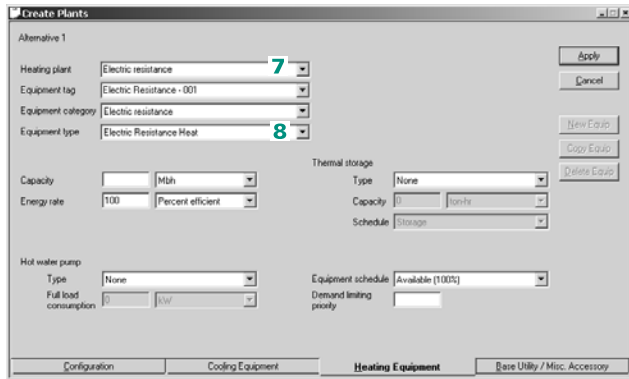


 The **Cooling Equipment** library provides performance characteristics for each library member, including the air-to-air heat pump selected in Step 3.

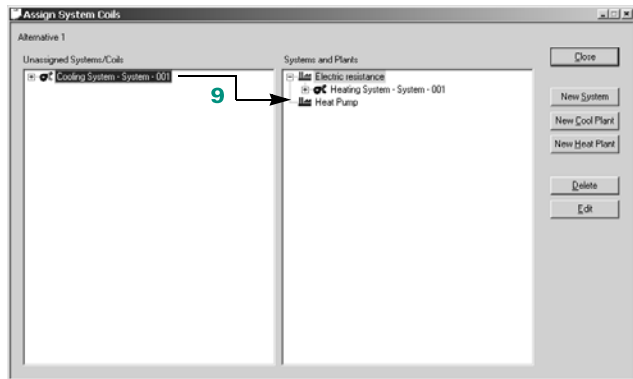
7 To finish defining the electric resistance heat that will serve as a backup for the heat pumps, select the heating plant on the **Heating Equipment** tab.

8 Pick one of the electric resistance heat entries as the **equipment type**.

9  Finally, assign each coil load to the appropriate plant.



The **Create Plants** dialog box shows the configuration for Alternative 1. The **Heating plant** is set to **Electric resistance** (marked with a green 7). The **Equipment tag** is **Electric Resistance - 001**. The **Equipment category** is **Electric resistance**. The **Equipment type** is **Electric Resistance Heat** (marked with a green 8). The **Capacity** is **100** MWh. The **Energy rate** is **100** Percent efficient. The **Thermal storage** is set to **None**. The **Capacity** is **0** ton/hr. The **Schedule** is **Storage**. The **Hot water pump** is set to **None**. The **Equipment schedule** is **Available (100%)**. The **Demand limiting priority** is **None**. The tabs at the bottom are **Configuration**, **Cooling Equipment**, **Heating Equipment**, and **Base Utility / Misc. Accessory**.

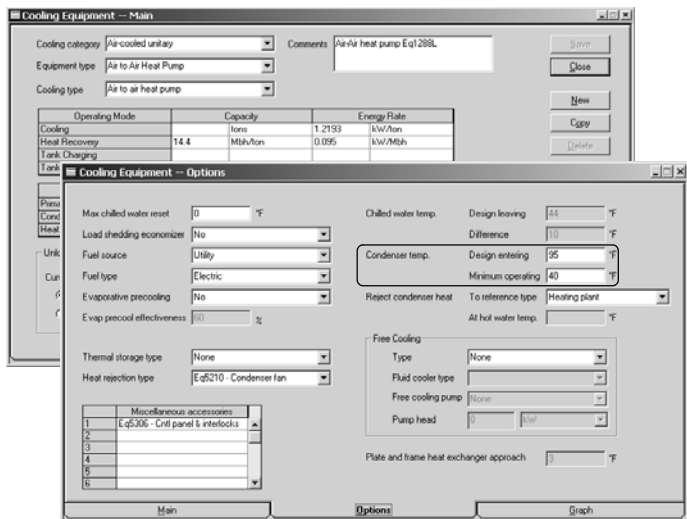


The **Assign System Coils** dialog box shows the assignment of coils to systems. The **Unassigned Systems/Coils** list contains **Cooling System - System - 001** (marked with a green 9). The **Systems and Plants** list contains **Electric resistance**, **Heating System - System - 001**, and **Heat Pump**. The buttons on the right are **Close**, **New System**, **New Cool Plant**, **New Heat Plant**, **Delete**, and **Edit**.

*Note: Electric resistance heat not only supplements the heat pump, but also operates in lieu of the heat pump if the temperature outside is colder than the **minimum condenser operating limit**.*

In this example, the heat pump does not operate when it is colder than 40°F outside.

*Use the Library/Template Editors program to view or modify this entry in the **Cooling Equipment** library.*



The **Cooling Equipment - Main** dialog box shows the configuration for Alternative 1. The **Cooling category** is **Air-cooled unitary**. The **Equipment type** is **Air to Air Heat Pump**. The **Cooling type** is **Air to air heat pump**. The **Comments** are **Air-Air heat pump Eq1288L**. The **Operating Mode** table shows the following data:

Operating Mode	Capacity	Energy Rate
Cooling	14.4	1.2193
Heat Recovery	None	0.085
Evap. precooling	None	0.085

The **Cooling Equipment - Options** dialog box shows the configuration for Alternative 1. The **Max chilled water reset** is **0** °F. The **Load shedding economizer** is **No**. The **Fuel source** is **Utility**. The **Fuel type** is **Electric**. The **Evaporative precooling** is **No**. The **Evap precool effectiveness** is **0** %.

The **Thermal storage type** is **None**. The **Heat rejection type** is **Eq5210 - Condenser fan**.

The **Chilled water temp.** is **44** °F. The **Design leaving** is **44** °F. The **Difference** is **10** °F. The **Condenser temp.** is **95** °F. The **Design entering** is **95** °F. The **Minimum operating** is **40** °F. The **Reject condenser heat** is **To reference type**. The **To reference type** is **Heating plant**. The **At hot water temp.** is **None**.

The **Free Cooling** section shows the **Type** is **None**. The **Fluid cooler type** is **None**. The **Free cooling pump** is **None**. The **Pump head** is **0** ft. The **Plate and frame heat exchanger approach** is **0** °F.

Water-source heat-pump system

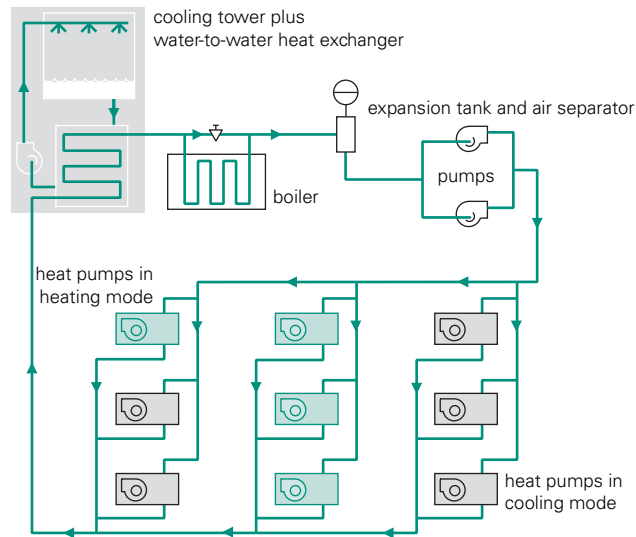


TRACE 700 generates a special report for HVAC designs that include water-source heat pumps. The **Thermal Storage** report provides an hourly profile of ambient conditions, plant-level cooling loads, heat-pump loads and energy consumption, and condenser-loop temperatures.

Water-source heat pumps (WSHPs) transfer heat from air to water and vice versa. Piping the heat pumps together in a common water loop creates a heat-recovery system that can redistribute heat where it is needed—for example, from interior zones to perimeter spaces. This capability saves energy by reducing the operating time of the cooling tower and boiler. It also makes applied WSHP systems popular in commercial buildings that have many spaces with dissimilar cooling and heating needs. In such applications, each space is served by one or more heat pumps and is controlled independently.

WSHP systems readily adapt to the special requirements of speculative jobs, because only the heat pumps required for the initial phase of occupancy must be procured. Additional heat pumps can be purchased, installed, and connected to the loop as needed. This offers the opportunity to meter individual spaces so that the tenants pay the individual operating costs of the spaces they occupy.

Figure 3-18 Applied water-source heat-pump system



Application considerations

- Design the air-distribution system to provide proper ventilation, either locally at each heat pump or centrally using a dedicated ventilation system.
- Heat pumps are situated in or near occupied spaces. Provide appropriate acoustical treatments to ensure that the noise from the compressors and fans is unobtrusive.
- For proper maintenance, heat pumps must be located in accessible areas. In new buildings, this requires coordination with the architect.

Related reading

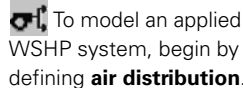
- *Water-Source Heat-Pump Systems* Air Conditioning Clinic, one of the systems series (Trane literature number TRG-TRC015-EN)
- *Water Source Heat-Pump System Design* Applications Engineering Manual (Trane literature number SYS-AM-7)

Sample scenario

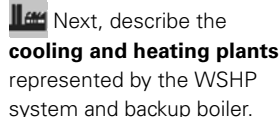
An applied, water-source heat-pump system (one heat pump per room) provides comfort cooling and heating for a multistory commercial building. The pump that circulates water through the common condenser loop is rated for 50 feet of static head. A gas-fired boiler and an auxiliary pump rated for 20 feet of static head serve as a backup if the condenser loop is unable to satisfy the entire heating load.

Note: TRACE 700 generates a special report, Thermal Storage, for HVAC designs that include thermal storage. The report provides an hourly profile of ambient conditions and plant-level cooling loads, as well as heat-pump loads, heat-pump energy consumption, and condenser-loop temperatures for hot and cold storage applications

The illustrations on pages 3–70 and 3–71 demonstrate how to model the air-distribution, cooling, and heating functions of the WSHP system and then assign the coil loads.

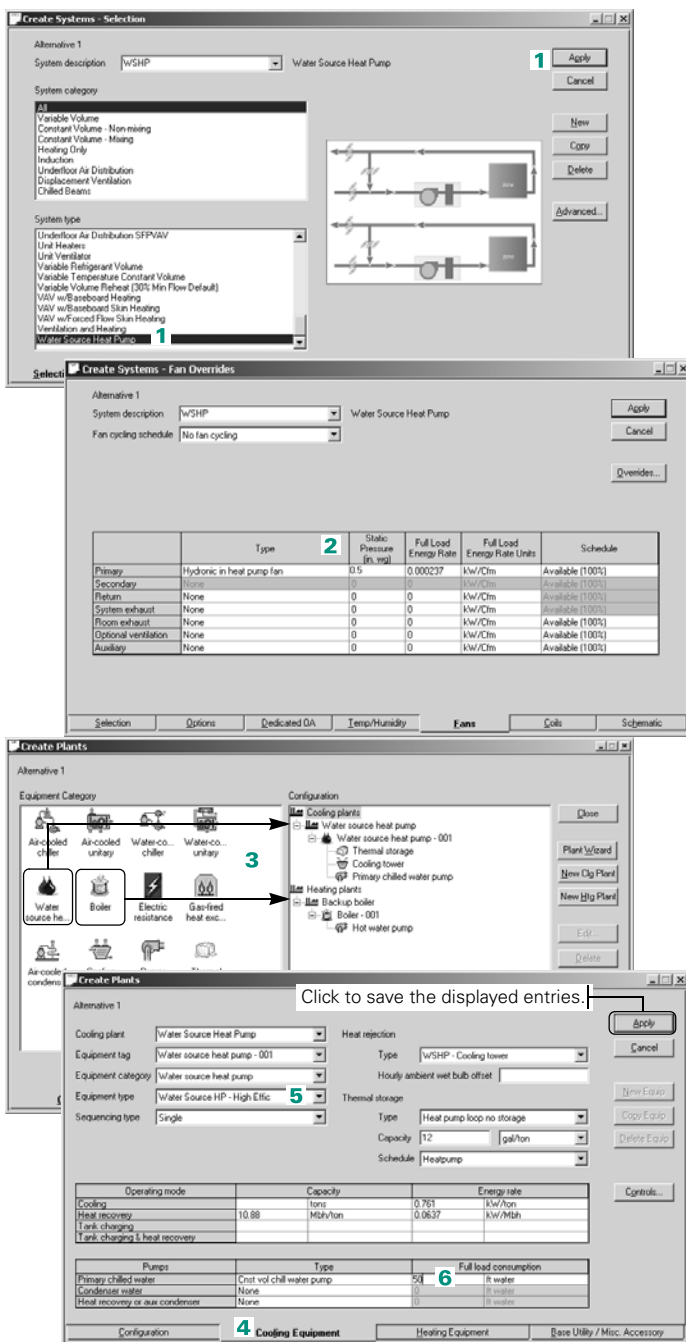


- 1 Pick **Water Source Heat Pump** as the system type. Then click **Apply** to save your entries.
- 2 On the **Fans** tab, select **Hydronic in heat pump fan** and enter 0.5 for the static pressure.



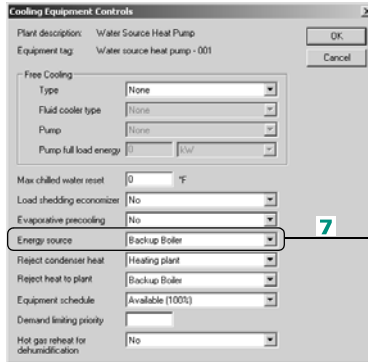
- 3** Drag the appropriate icons from the **Equipment Category** section to define each plant. Rename the cooling plant as **WSHP** and the heating plant as **Backup boiler**.

- 4 Select the cooling plant and click the **Cooling Equipment** tab.
- 5 Choose the water-source heat pump that best matches the target performance.
- 6 Enter the **full-load consumption** of the pump that serves the common water loop—the **primary chilled-water pump**, in this case.



- 7 Click **Controls** to assign the excess heat from the common water loop to loads served by the heating plant identified as the **energy source**.

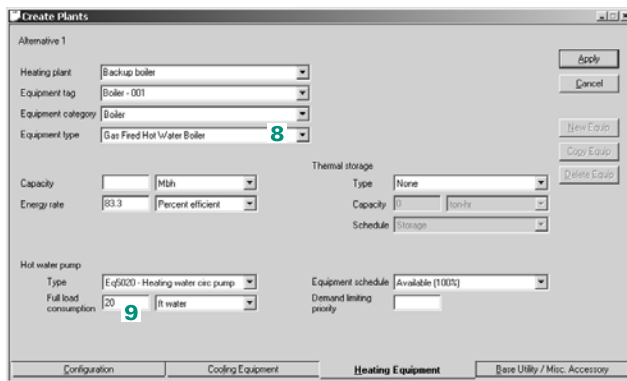
Note: Do not remove thermal storage. The water loop is modeled as a special thermal storage type in TRACE 700. Removing the thermal storage eliminates the water loop from the simulation.



The 'Cooling Equipment Controls' dialog box is shown. It contains several tabs: 'Plant description', 'Equipment tag', 'Free Cooling', 'Max chilled water reset', 'Load shedding economizer', 'Evaporative precooling', 'Energy source', 'Reject condenser heat', 'Reject heat to plant', 'Equipment schedule', 'Demand limiting priority', and 'Hot gas reheat for dehumidification'. The 'Energy source' dropdown menu is highlighted with a green box and the number 7. The selected value is 'Backup boiler'.

This entry identifies the heating plant that will serve as a backup if the heat pumps cannot satisfy the load.

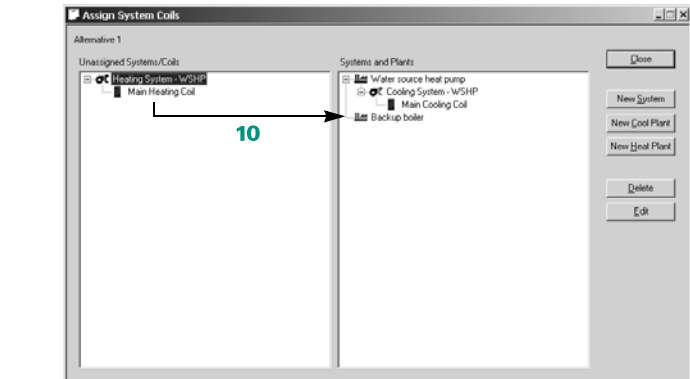
- 8 Be sure to apply your changes. On the **Heating Equipment** tab, pick the boiler that most closely matches the anticipated performance.



The 'Create Plants' dialog box is shown. It contains several tabs: 'Configuration', 'Cooling Equipment', 'Heating Equipment', and 'Base Utility / Misc. Accessory'. The 'Heating Equipment' tab is selected. The 'Heating plant' dropdown menu is highlighted with a green box and the number 8. The selected value is 'Backup boiler'.

- 9 Enter the **full-load consumption** of the pump that circulates hot water from the boiler.

*Note: The **minimum operating condenser temperature** of the selected heat pump (refer to page 3–67) determines when the boiler turns on to maintain the condenser water temperature. To view or alter this entry, use the Library/Template Editors program.*



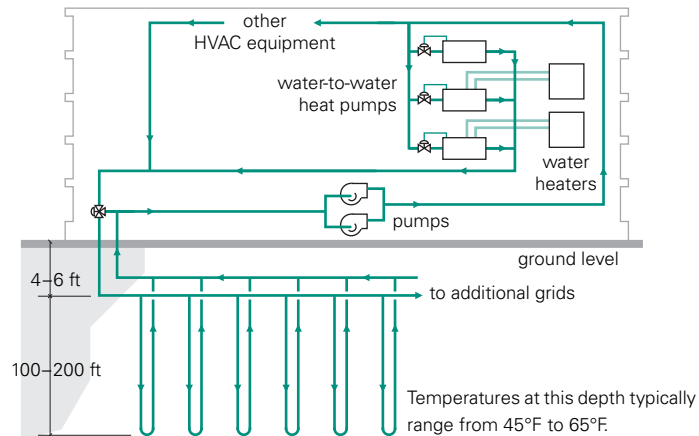
The 'Assign System Coils' dialog box is shown. It contains two main sections: 'Unassigned Systems/Coils' and 'Systems and Plants'. The 'Unassigned Systems/Coils' section lists 'Main Heating Coil' and 'Main Cooling Coil'. The 'Systems and Plants' section lists 'Water source heat pump', 'Cooling System - WSHIP', 'Main Cooling Coil', and 'Backup boiler'. A green arrow points from 'Main Heating Coil' to 'Backup boiler' with the number 10 next to it.

- 10 Finally, assign each coil load to the appropriate plant.

Ground-source heat-pump system

A common variation of the water-source heat-pump system uses the earth as both a heat source and a heat sink. Known as a ground-source (GSHP) system, this variation takes advantage of the relatively constant 45°F to 65°F temperatures that exist 20 to 30 feet below the surface. When buried in the ground, the high-density thermal plastic pipe acts as a heat exchanger. During the cooling season, it transfers the heat absorbed by the heat pumps to the ground for *storage*. When heating is needed, the heat exchanger *recaptures* the heat from the ground and returns it to the building.

Figure 3-19 Applied ground-source heat-pump system



If properly designed, an applied GSHP system does not require a cooling tower. Aesthetically, this means that all of the heat from the building can be rejected without any visible sign of a cooling system. A boiler is also unnecessary if the heat pumps can satisfy the entire heating load, which saves initial cost and floor space.

Application considerations

- GSHP systems are more expensive to install, but less expensive to operate, than conventional water-source heat-pump systems. Perform a life-cycle cost analysis to determine the economic viability for a particular application.
- Installation requires excavation, trenching, or boring by a qualified contractor.
- Ground-coupled loops can be installed in a horizontal, vertical, or spiral configuration. Available land, soil conditions, and excavation costs will determine the appropriate choice for a given application.

Note: A boiler will still need to be input for a GSHP model in TRACE 700. However, if the water loop is properly sized (input as the thermal storage capacity), the minimum and maximum condenser operating temperatures are correct, and the load profile is realistic, the boiler may not activate.

Related reading


- *Water-Source Heat-Pump Systems* Air Conditioning Clinic, one of the systems series (Trane literature number TRG-TRC015-EN)

Sample scenario

An applied, ground-source heat-pump system (one heat pump per room) provides comfort cooling and heating for a multistory commercial building. The pump that circulates water through the common condenser loop is rated for 50 feet of static head. A gas-fired boiler and an auxiliary pump rated for 20 feet of static head serve as a backup if the condenser loop is unable to satisfy the entire heating load.


Note: TRACE 700 generates a special report, Thermal Storage, for HVAC designs that include thermal storage. The report provides an hourly profile of ambient conditions and plant-level cooling loads, as well as heat-pump loads, heat-pump energy consumption, and condenser-loop temperatures for hot and cold storage applications.

The following procedure demonstrates how to model the air-distribution, cooling, and heating functions of the GSHP system and assign the coil loads.

 To model an applied GSHP system, begin by defining **air distribution**.

1 Pick **Water Source Heat Pump** as the system type. Then click **Apply** to save your entries.

2 On the **Fans** tab, select **Hydronic in heat pump fan** and enter 0.5 for the static pressure.

 Next, describe the **cooling and heating plants** represented by the GSHP system and backup boiler.

3 Drag the appropriate icons from the **Equipment Category** section to define each plant. Rename the cooling plant as **Ground source heat pump** and the heating plant as **Backup boiler**.

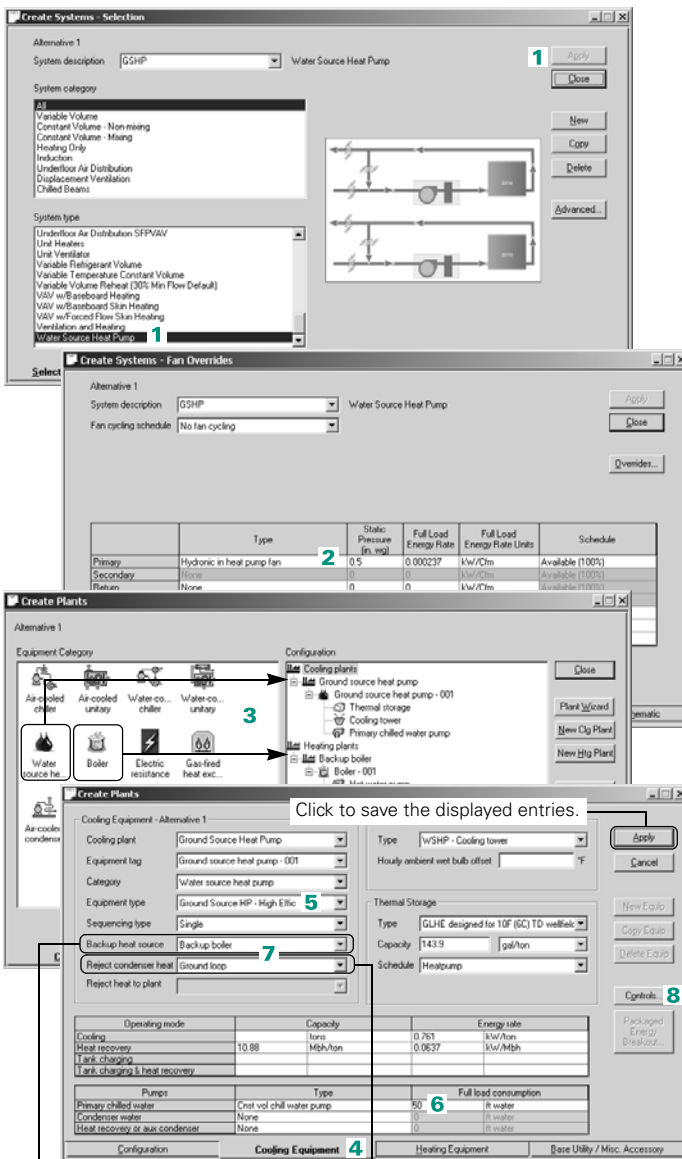
4 Select the cooling plant and click the **Cooling Equipment** tab.

5 Choose the ground-source heat pump that best matches the target performance.

6 Enter the **full-load consumption** of the pump that serves the common water loop—the **primary chilled-water pump**, in this case.

7 Select the **backup heat source** and select the ground loop for **reject condenser heat**.

8 Click **Controls**.



Create Systems - Selection

Alternative 1
System description: GSHP Water Source Heat Pump
System category: All
System type: Underfloor Air Distribution SFP/AV

Create Systems - Fan Overrides

Alternative 1
System description: GSHP Water Source Heat Pump
Fan cycling schedule: No fan cycling

	Type	Static Pressure (in. w.g.)	Full Load Energy Rate	Full Load Energy Rate Units	Schedule
Primary	Hydronic in heat pump fan	0.5	0.000237	kW/Chm	Available (100%)
Secondary	None	0	0	kW/Chm	Available (100%)
Return	None	0	0	kW/Chm	Available (100%)

Create Plants

Alternative 1
Equipment Category: Air-cooled chiller, Air-cooled unitary, Water-cooled unitary, Water-cooled unitary, Water source heat pump, Boiler, Electric resistance, Gas-fired heat exc...

Cooling plants
Ground source heat pump
Ground source heat pump - 001
Thermal storage
Cooling tower
Primary chilled water pump

Heating plants
Backup boiler
Backup boiler - 001

Create Plants - Cooling Equipment - Alternative 1

Cooling plant: Ground Source Heat Pump
Equipment tag: Ground source heat pump - 001
Category: Water source heat pump
Equipment type: Ground Source HSP - High Effici
Sequencing type: Single
Backup heat source: Backup boiler
Reject condenser heat: Ground loop
Reject heat to plant: Ground loop

Thermal Storage
Type: GLUE designed for 10F (5C) TD wetbulk
Capacity: 143.9 gal/ton
Schedule: Heatpump

Operating mode	Capacity	Energy rate
Cooling	10.88 tons	0.761 kW/ton
Heat recovery		0.0637 kW/ton
Tank charging		
Tank charging & heat recovery		

Pumps	Type	Full load consumption
Primary chilled water	Cent vol chill water pump	50 ft water
Condenser water	None	0 ft water
Heat recovery or aux condenser	None	0 ft water

Controls

This entry identifies the heating plant that will serve as a backup if the heat pumps cannot satisfy the load.

This entry defaults to Ground loop so that any excess heat from the heat pump is rejected to the ground loop.

9 Click Cooling Plant and Geothermal Controls.

10 Choose the geothermal loop type by specifying the temperature of the loop entering the building in the **TLoop Ent Bldg** field.

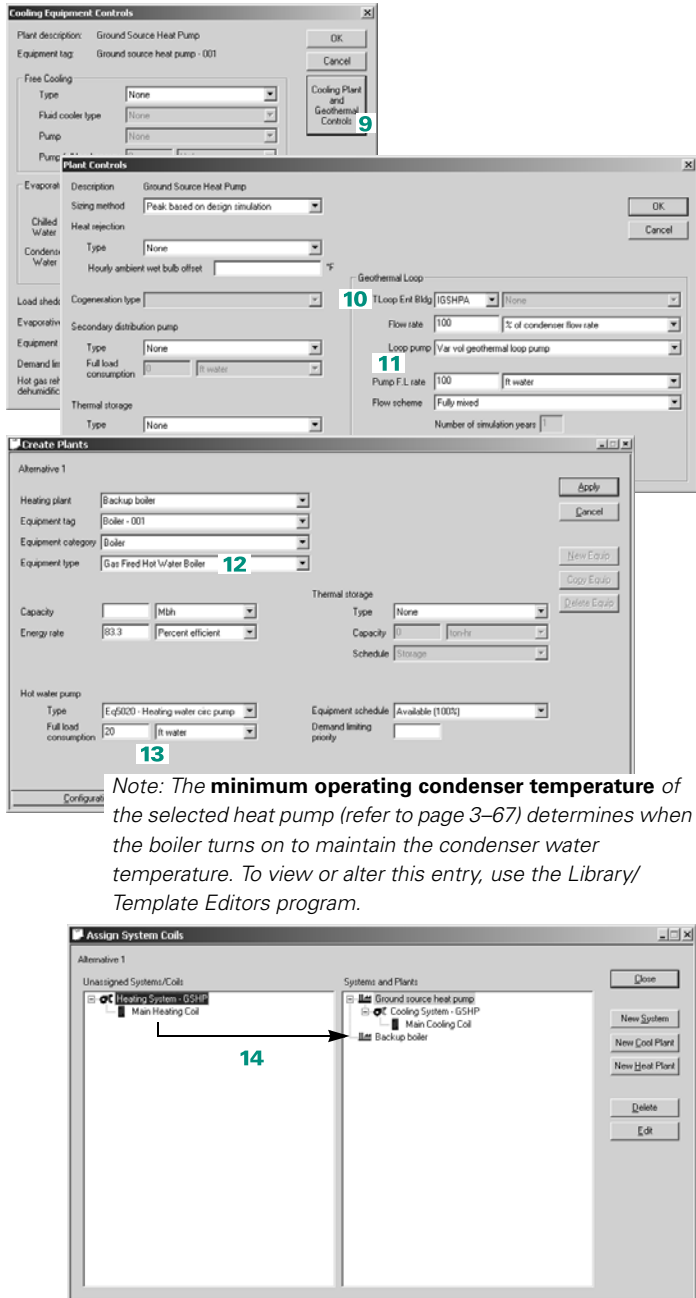
*Note: IGSHPA should only be used for horizontal borefields. Vertical bore requires a separate IDF file to be used in conjunction with the project. The Custom selection in this field requires a separate Geothermal schedule defined in the **Schedules Library**. When using either IGSHPA or Custom geothermal loop types, plant- or equipment-level thermal storage should be defined to reflect the capacity of the borefield loop.*

11 Enter the geothermal loop **flow rate**, geothermal loop **pump** type and associated **full-load energy rate**. Enter **fully mixed** as the flow scheme.

12 On the **Heating Equipment** tab, pick the boiler that most closely matches the anticipated performance.

13 Enter the **full-load consumption** of the pump that circulates hot water from the boiler.

14 Finally, assign each coil load to the appropriate plant.

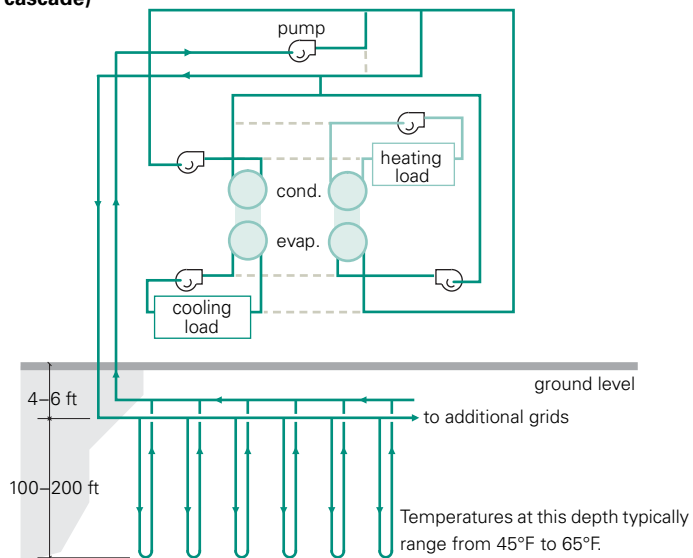


Note: The minimum operating condenser temperature of the selected heat pump (refer to page 3–67) determines when the boiler turns on to maintain the condenser water temperature. To view or alter this entry, use the Library/Template Editors program.

Central geothermal chillers

A central geothermal system uses the earth as a heat sink and energy source to provide cooling and heating. Unlike a distributed ground-source heat pump system, a central geothermal system uses centrally located chillers instead of small unitary heat pumps distributed throughout the building. This system allows greater freedom of airside system selection as heated and chilled water can be distributed to system coils throughout the building.

Figure 3–20 Central geothermal chiller system (Trane bidirectional cascade)



Application considerations

- Inputting the entire cooling and heating load is critical for chiller selection and modeling. Include all end-use components such as domestic hot water (refer to “Domestic hot water assigned to a boiler” on page 3–62), dedicated outside air systems (refer to “Dedicated outdoor-air systems” on page 4–45), etc.
- The Building Cool/Heat Demand report shows airside coil loads from the System simulation. The Plant Load Summary report

shows all loads assigned to the central geothermal chiller system including all end-use components.

- Central geothermal systems may have additional pumps. Be sure to include all pumps within Create Plants. If additional pumps are needed, they may be modeled as accessory pumps within Miscellaneous Accessories. The bidirectional cascade system employs condenser and evaporator energy transfer pumps, which are modeled as Miscellaneous Accessories in this example.

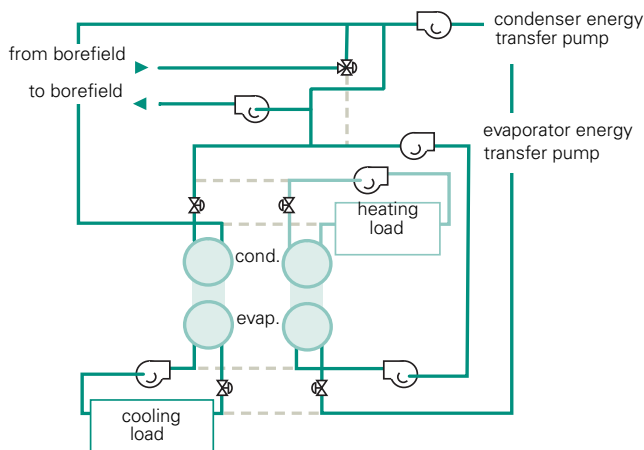
Related reading

- *Central Geothermal Systems* Application Manual (Trane literature number SYS-APM009-EN)

Sample scenario

A central geothermal system uses two RTWD chillers in parallel, each capable of providing 200 tons of cooling and 1870 Mbh of heating. This system is set up as a bidirectional cascade and uses two energy transfer loops with pumps to transfer energy between the chillers during simultaneous cooling and heating.

Figure 3-21 Two-chiller bidirectional cascade central geothermal system



The following procedure demonstrates how to implement the cooling plants, pumps, geothermal loop, and heating equipment.

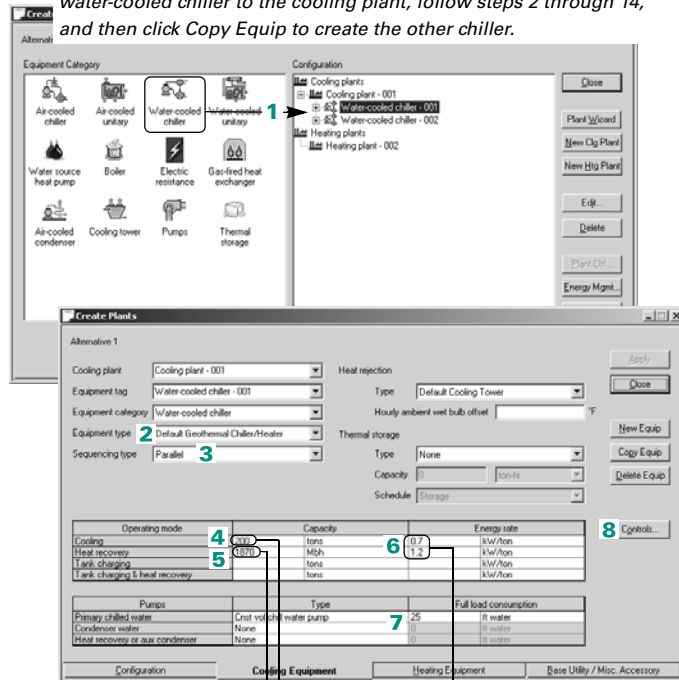
Define the **cooling plant** by selecting **Create Plants** in the **Project Navigator** window.

- 1 Drag two water-cooled chillers to the cooling plant and click the **Cooling Equipment** tab.

For each chiller:

- 2 Select the appropriate **equipment type**.
- 3 Pick **Parallel** as the sequencing type.
- 4 Enter the **cooling capacity** (200 tons).
- 5 Enter the **cooling capacity** for the chiller when it is in heat recovery mode (1870 Mbh).
- 6 Specify the full-load **energy consumption** for the chiller in the cooling mode and in the heat recovery mode.
- 7 Enter the pump **types** and **full-load energy consumption** rates for the chilled water pump and condenser water pump. (If there is no heat rejection device, there would be no condenser water pump.) The bidirectional cascade pumps for the evaporator and condenser energy transfer loops will be entered as miscellaneous accessories in a later step, as will a secondary distribution pump and a borefield pump.
- 8 Click **Controls**.

Note: The two chillers are identical. As an alternative, drag only one water-cooled chiller to the cooling plant, follow steps 2 through 14, and then click Copy Equip to create the other chiller.



TRACE will automatically add heat-of-compression to the entered value to account for compressor heat.

If this entry is left blank, TRACE calculates this value and sizes the first chiller for the entire cooling capacity.

These energy consumption rates are at design chiller conditions for the cooling and heating mode.

9 Select the back-up heating plant for **Reject heat to plant**.

10 Select **Ground loop** for **Reject condenser heat**.

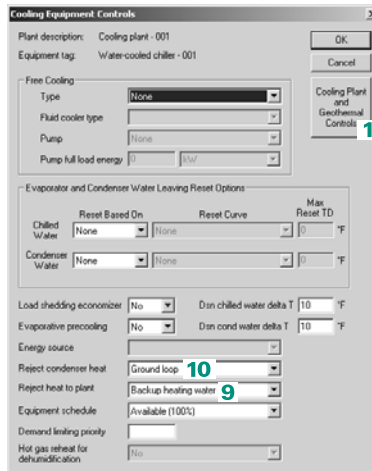
11 Click **Cooling Plant and Geothermal Controls** to open the **Plant Controls** dialog box.

12 Choose the geothermal loop type by specifying the temperature of the loop entering the building in the **TLoop Ent Bldg** field.

*Note: IGSHPA should only be used for horizontal borefields. Vertical bore requires a separate IDF file to be used in conjunction with the project. The Custom selection in this field requires a separate Geothermal schedule defined in the **Schedules Library**. When using either IGSHPA or Custom geothermal loop types, plant- or equipment-level thermal storage should be defined to reflect the capacity of the borefield loop.*

13 Enter the geothermal loop **flow rate**, geothermal loop **pump** type and associated **full-load energy rate**. Enter **Bidirectional cascade** as the **flow scheme**.

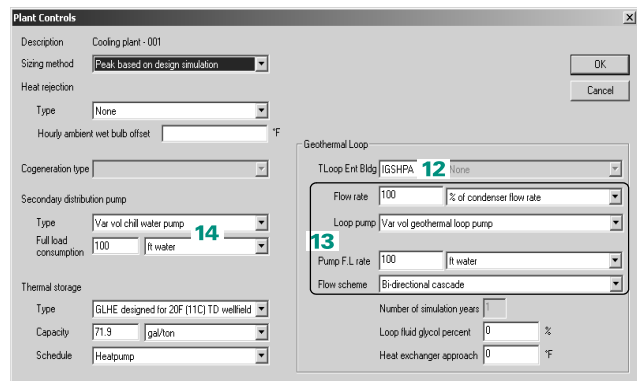
14 If a primary-secondary distribution system will be used, enter the **secondary distribution pump** type and **full load consumption** rate.



The **Cooling Equipment Controls** dialog box is shown. It contains the following fields and values:

- Plant description: Cooling plant - 001
- Equipment tag: Water-cooled chiller - 001
- Free Cooling: Type: None, Fluid cooler type: , Pump: None, Pump full load energy: 0 Btu/h
- Evaporator and Condenser Water Leaving Reset Options:

	Reset Based On	Reset Curve	Max Reset TD
Chilled Water	None	None	0 °F
Condenser Water	None	None	0 °F
- Load shedding economizer: No
- Evaporative precooling: No
- Energy source:
- Reject condenser heat: Ground loop (10)
- Reject heat to plant: Backup heating water (9)
- Equipment schedule: Available (100%)
- Demand limiting priority:
- Hot gas reheat for dehumidification: No

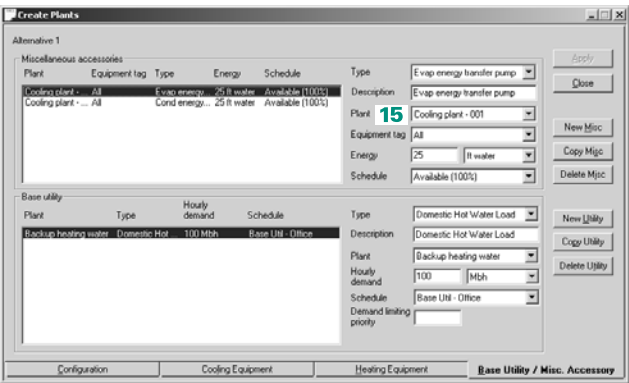


The **Plant Controls** dialog box is shown. It contains the following fields and values:

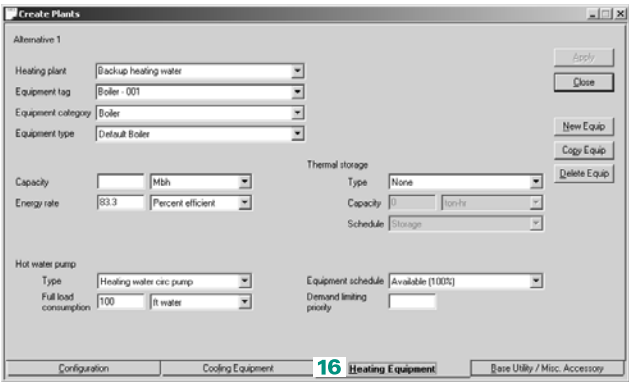
- Description: Cooling plant - 001
- Sizing method: Peak based on design simulation
- Heat rejection: Type: None, Hourly ambient wet bulb offset: °F
- Cogeneration type:
- Secondary distribution pump: Type: Var vol chill water pump (14), Full load consumption: 100 ft water
- Thermal storage: Type: GLHE designed for 20F (11C) TD wellfield, Capacity: 71.9 gal/ton, Schedule: Heatpump
- Geothermal Loop:

TLoop Ent Bldg	IGSHPA (12)
Flow rate	100 % of condenser flow rate
Loop pump	Var vol geothermal loop pump
Pump F.L. rate	100 ft water
Flow scheme	Bi-directional cascade
- Number of simulation years:
- Loop fluid glycol percent: 0 %
- Heat exchanger approach: 0 °F

15Enter the evaporator and condenser energy transfer pumps within the **Base Utility / Misc. Accessory screen**. The evaporator energy transfer pump will be activated when the chiller(s) are in cooling mode, and the condenser energy transfer pump will be activated when the chiller(s) are in heating mode. In simultaneous mode, both pumps will be active. The pumps only need to be assigned to the Cooling Plant using the **Plant** field. To ensure proper bidirectional cascade pump modeling, it is critical to use the standard library members already created for this system (**Evap energy transfer pump** and **Cond energy transfer pump**).



16Configure the back-up heating water system on the **Heating Equipment** tab by choosing a boiler type, capacity, full-load energy rate, hot water pump type, and pump full-load consumption rate.



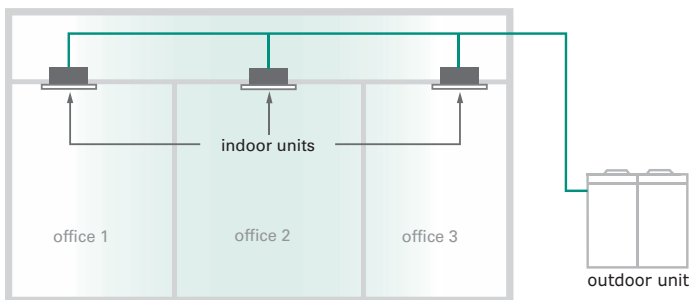
Variable refrigerant flow system

Variable refrigerant flow (VRF) systems use a combination of indoor and outdoor units to provide cooling and heating to conditioned spaces within a building. In a typical VRF system, each room is served by an indoor unit located in or near that room. Indoor units may be unducted (attached to the ceiling or wall of the room) or ducted (located in the ceiling plenum or closet). Each indoor unit contains a refrigerant-to-air heat exchanger and a fan (typically multi-speed). All of the indoor units are connected to an air-cooled condensing unit located outdoors using a common set of refrigerant pipes. Outdoor units contain one or more compressors and an air-cooled condenser.

In some applications, the indoor units may be able to handle a portion of the outdoor air load; however, a dedicated outdoor-air system is typically used with a VRF system.

Multiple configurations are available for the indoor and outdoor units. Using a heat pump outdoor unit allows the system to operate in either the cooling mode *or* heating mode. Using a heat recovery system allows some zones to operate in the cooling mode *at the same time* other zones operate in the heating mode.

Figure 3–22 Variable refrigerant flow system



Application considerations

- The indoor units are modeled with multi-speed fans. The **VAV Minimum** controls on the **Airflows** template or **Airflows** tab of **Create Systems** can be used to define the supply airflow when

the space temperature is within the thermostat deadband. The default is 10% of design supply airflow.

- If a **VRF Heat Pump** outdoor unit is selected, the zones served by that unit will either all operate in the cooling mode or all operate in the heating mode. If a **VRF Heat Recovery** outdoor unit is selected, some zones served by that unit can operate in the cooling mode while others operate in the heating mode.
- In some applications, the indoor units may be able to handle a portion of the outdoor air load; however, a separate dedicated outdoor-air system is often required. See “Dedicated outdoor-air systems” on page 4–45 for more information.

Related reading

- “ASHRAE Standard 15 Applied to Packaged, Split, and VRF Systems,” *Engineers Newsletter* (volume 37, number 1)

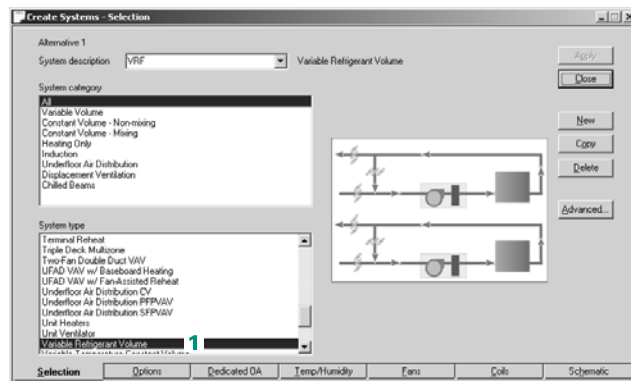
Sample scenario

A VRF system is used to condition multiple spaces within a multistory building. Electric resistance heat is employed as a backup heating source, and the ventilation is handled by a dedicated outdoor-air system. Both a VRF heat pump and heat recovery system will be illustrated.

The following procedure demonstrates how to model the VRF airside system, cooling and heating equipment, as well as assigning the coil loads.

To model the VRF system, begin by defining the **air distribution** system.

- 1 Pick **Variable Refrigerant Volume** as the system type. Click **Apply** to save your entries.



- On the **Fans** tab, select **VRV Indoor Fan** and enter 0.5 for the static pressure.

Note: If a ducted indoor VRF unit is used, the static pressure on the indoor fan will be higher.

Next, describe the **cooling and heating plants** represented by the VRF system and backup electric resistance heat.

- VRF plants are considered **Air-Cooled Unitary** plants. Drag the appropriate icons from the **Equipment Category** section to define each plant. Rename the cooling plant as **VRF** and the heating plant as **Backup electric resistance** by selecting the plant and clicking the **Edit** button.

- Select the cooling plant and click on the **Cooling Equipment** tab.

- Choose the VRF plant that best matches the target performance and operation. There are two categories of plant available: **VRF Heat Pump** and **VRF Heat Recovery**.

- Specify **Backup electric resistance** as the backup heat source.

Create Systems - Fan Overrides

Alternative 1
System description: VRV
Fan cycling schedule: Cycle with occupancy

	Type	Static Pressure (in. w.g.)	Full Load Energy Rate	Full Load Energy Rate Units	Schedule
Primary	VRV Indoor Fan	0.5	0.001	kW/Chin w.g.	Available (100%)
Secondary	None	0	0	kW	Available (100%)
Return	None	0	0	kW	Available (100%)
System exhaust	None	0	0	kW	Available (100%)
Room exhaust	None	0	0	kW	Available (100%)
Optional ventilation	None	0	0	kW	Available (100%)
Auxiliary	None	0	0	kW	Available (100%)

90.1 Primary Fan Power Adjustment

Create Plants

Alternative 1

Equipment Category: Air-cooled unitary, Electric resistance

Configuration: Cooling plants: VRV, Air-cooled unitary - 001; Heating plants: Backup electric resistance - 001

Create Plants - Alternative 1

Cooling plant: VRV
Equipment tag: Air-cooled unitary - 001
Category: Air-cooled unitary
Equipment type: VRF Heat Pump / Variable Speed Compressor
Sequencing type: Single
Backup heat source: Backup electric resistance
Reject condenser heat: Heat rejection equipment
Reject heat to plant:

Heat Rejection: Type: VRV Condensing Unit
Hourly ambient wet bulb offset: °F

Thermal Storage: Type: None
Capacity: tons
Schedule: Storage

Operating mode	Capacity	Energy rate
Cooling	13.5 tons	0.975 kW/ton
Heat recovery	13.5 tons	0.881 kW/ton
Tank charging	tons	kW/ton
Tank charging & heat recovery	tons	kW/ton

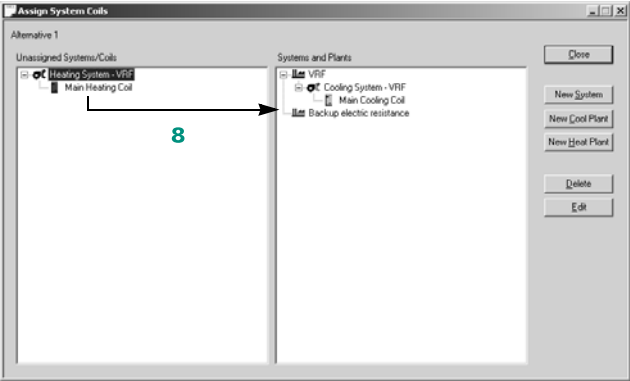
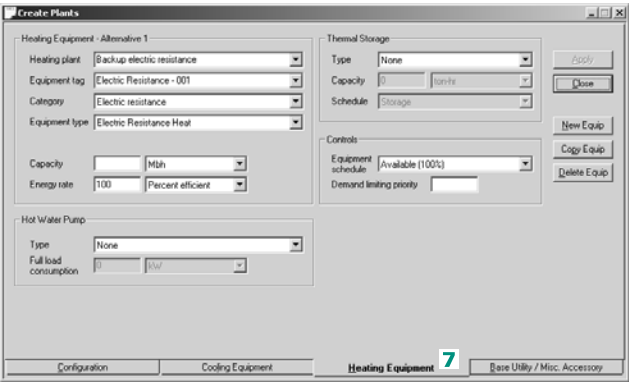
Pumps	Type	Full load consumption
Primary chilled water	None	0 water
Condenser water	None	0 water
Heat recovery & aux condenser	None	0 water

Configuration: Cooling Equipment, Heating Equipment, Base Utility / Misc. Accessory

Note: The VRF Heat Recovery option is able to recover heat from one VRF indoor unit and share it with other indoor units that are connected to the same refrigerant circuit. TRACE assumes that heat can be recovered between all zones that are assigned to the system. However, heat recovery outdoor units are available only up to a certain capacity (20 tons, as of this writing). To accurately model VRF heat recovery, the design capacity of all the indoor units (zones) assigned to the system should be no larger than the available capacity of the VRF Heat Recovery outdoor unit. This might require the creation of several systems and several cooling plants.

7 On the **Heating Equipment** tab, refine your backup heating plant if necessary.

8 Finally, assign each coil load to the appropriate plant.



4 System Design Options

Modeling examples in this chapter

Energy recovery and dehumidification

- Desiccant dehumidification, page 4–2
- Coil loop for exhaust-air energy recovery, page 4–8
- Total-energy (enthalpy) wheel, page 4–15
- Fixed-plate heat exchanger, page 4–21
- Heat pipe, page 4–27
- Sensible wheel, page 4–34

System options

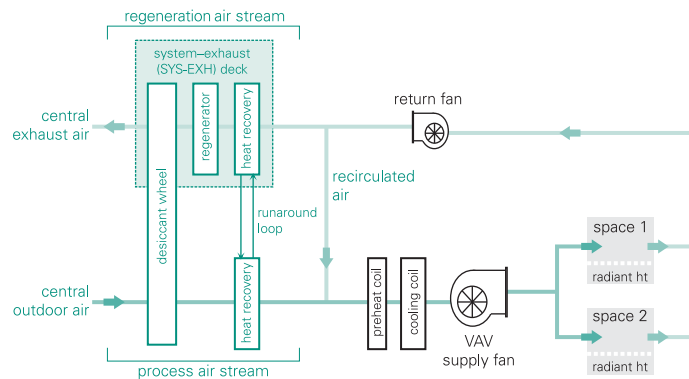
- Direct and indirect evaporative cooling, page 4–40
- Dedicated outdoor-air systems, page 4–45
- Dual-path air handler (split dehumidification unit), page 4–67
- Systems with 100% outdoor air, page 4–73
- Cold-air distribution, page 4–76
- Chilled beams, page 4–79
- Underfloor air distribution, page 4–84
- Displacement ventilation, page 4–88
- ASHRAE Standard 62.1, page 4–91

This chapter provides basic how-to instructions to help you model system-level options such as energy recovery. Each example begins with a brief description of the option, followed by a sample scenario that illustrates how to model it. Typical values are suggested where appropriate.

Desiccant dehumidification

Desiccant dehumidification describes the use of a *moisture-attracting* material (solid or liquid) in the air stream. As Figure 4–1 suggests, desiccant dehumidification requires a *process* air stream and a *regeneration* air stream. In this example, the moisture in the *process* (outdoor) air stream is absorbed by the desiccant wheel, which then releases the collected moisture in the *regeneration* (exhaust) air stream.

Figure 4–1 Air-distribution system with desiccant dehumidification



Continued operation of the desiccant requires a regeneration process. Regeneration is usually accomplished by applying heat to the regeneration air stream before it reaches the desiccant.

Consideration of desiccant dehumidification is warranted whenever one or more of the following conditions is true of a prospective application:

- The latent load is significantly larger than the sensible load
- The cost to regenerate the desiccant is low when compared to the cost associated with overcooling the space
- The humidity-control level in the space would require chilling the supply air to subfreezing dew points when vapor-compression refrigeration alone is used

Typical applications for desiccant dehumidification include ice rinks, supermarkets, retail clothing stores, and clean rooms, as well as installations in humid southern climates. In each instance, desiccant dehumidification provides independent control of sensible and latent heat without the need for reheat. It also dehumidifies the supply air stream without lowering the dry-bulb temperature.

Application considerations


- Desiccant regeneration commonly requires high temperatures, which incurs a significant energy cost.
- Exposure to contaminants, clogging, and thermal stress causes desiccants to degrade over time.
- One should consider space requirements, cost, and added pressure drop when evaluating whether desiccant dehumidification is practical for a particular application.

Related reading

- *Dehumidification in HVAC Systems Applications Engineering Manual* (Trane literature number SYS-APM004-EN)

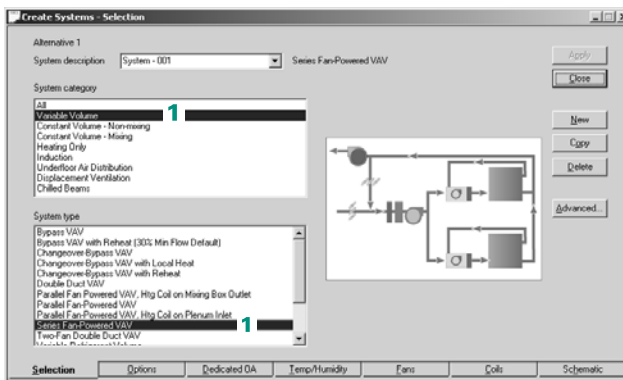
Sample scenario

The ventilation deck of the air-distribution system for a building includes a solid-desiccant wheel with an integral run-around coil loop. The wheel only operates from 6 a.m. until 6 p.m.

 To model desiccant dehumidification, which is a means of removing latent heat from an air stream, begin by modeling the air-distribution system.

- 1 Choose the desired system type from the categories listed.

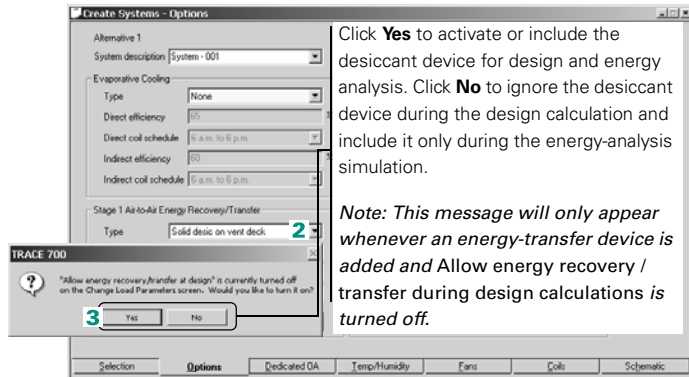
For this example, select **Series Fan-Powered VAV** from the **Variable Volume** category.



2 Specify the **type** of air-to-air energy recovery / transfer and the location of the *process* air stream. This example uses a solid desiccant located on the ventilation deck.

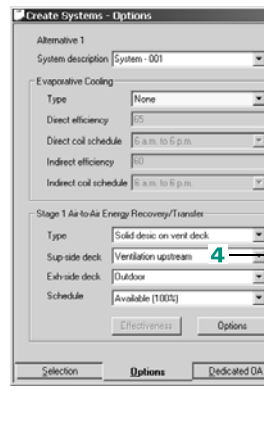
3 A message will appear that asks whether the user wants to account for energy recovery / transfer during the design and energy analysis simulations or only during the energy analysis simulation. Select **Yes** for this example.

4 Select the appropriate supply-side deck for the device. For this example, **Ventilation upstream** will be selected as the supply-side deck. The desiccant device will be used to dehumidify the outdoor air stream.



Click **Yes** to activate or include the desiccant device for design and energy analysis. Click **No** to ignore the desiccant device during the design calculation and include it only during the energy-analysis simulation.

Note: This message will only appear whenever an energy-transfer device is added and Allow energy recovery / transfer during design calculations is turned off.



- Select **Ventilation upstream** if the device is located in the outdoor air stream and upstream of the optional ventilation coil.
- Select **Ventilation downstream** if the device is located in the outdoor air stream and downstream of the optional ventilation cooling coil.
- Select **Return / outdoor air downstream** if the device is located after the mixed air stream, downstream of the main cooling coil.
- Select **Return / outdoor air upstream** if the device is located after the mixed air stream, upstream of the main cooling coil.

*Note: If no optional ventilation system has been input, then **Ventilation upstream** and **Ventilation downstream** will function identically. If the main cooling coil has been deleted, or if the ventilation-deck location on the **Advanced** window in **Create Systems** is not **Return/Outdoor deck**, then **Return / outdoor air upstream** and **Return / outdoor air downstream** will function identically.*

- 5 Select the exhaust-side deck for the device. This will determine which airflow will be used as the *regeneration* air stream. The airstreams typically used are building exhaust air, outdoor air, or a mixture of the two.

*Note: In this case, the airflow that is being exhausted from the building at the system level will be used as the regeneration airstream for the desiccant device. Because of this, **System Exhaust** will be used.*

- Select **Outdoor & room exhaust mix** if the regenerator will first try to use room exhaust as the sole source of regeneration airflow. If the room exhaust airflow is insufficient, the rest of the regeneration airflow will be made up of outdoor air.
- Select **Outdoor & system exhaust mix** if the regenerator will first try to use system exhaust as the sole source of regeneration airflow. If the system exhaust airflow is insufficient, the rest of the regeneration airflow will be made up of outdoor air.
- Select **Outdoor** if outdoor air is used exclusively as the regeneration airstream.
- Select **System Exhaust** if main system exhaust is used exclusively as the regeneration airstream. If a liquid desiccant is used and the system exhaust varies in volume (due to varying ventilation rates), do not use this input for the exhaust-side deck—use **Outdoor & system exhaust mix** to get the required constant regeneration airflow.
- Select **Room Exhaust** if the room exhaust airflow is used exclusively as the regeneration airstream. Room exhaust airflows are input on the **Airflows** tab of **Create Rooms**. If no room exhaust is input, then all exhaust air will be at the system level. Also, if a liquid desiccant is used and the room exhaust varies in volume (due to varying ventilation rates or room exhaust schedules), do not use this input for the exhaust-side deck—use **Outdoor & room exhaust mix** to get the required constant regeneration airflow.

*Note: If the proper airstreams are not selected for the energy recovery / transfer device, then the device will not function correctly or may not function at all. The **Airflows** section of the **System Checksums** report can be used to verify that sufficient airflow is available to be used for energy recovery / transfer. Room Exhaust = Rm Exh on the **System Checksums** report and System Exhaust = Exhaust on the **System Checksums** report.*


6 Choose the schedule that describes when the desiccant device is permitted to operate. For this example, a custom schedule was created that allows the desiccant device to operate only from 6 a.m. to 6 p.m.

7 Now that the desiccant subsystem has been input, the coil loop needs to be added as the second stage of energy recovery. The coil loop will preheat the *regeneration* airstream, reducing the amount of energy required to regenerate the desiccant and cool the outdoor air after it leaves the desiccant device, therefore reducing the amount of cooling energy required. Refer to “Coil loop for exhaust-air energy recovery” on page 4–8 for step-by-step instructions on how to input a coil loop.

Note: If both stage 1 and stage 2 energy recovery/transfer devices are given the same exhaust-side deck, then stage 1 will be upstream of stage 2.

The default schedule **Available 100%** will allow the energy recovery / transfer device to operate year-round. Liquid-desiccant systems should typically only be made available to operate during occupied hours, because the liquid-desiccant system will try to maintain the ERD (energy-recovery device) leaving-air humidity ratio at its design value. (This is auto-calculated, based on the design conditions, unless overridden by the user on the **Desiccant Dehumidification Options** screen that appears when the **Options** button is clicked.)


Note: For instructions on how to create custom schedules, refer to “Creating schedules” on page 6–137. Within the custom schedule, 0 percent would indicate that the desiccant device is deactivated, and 100 percent would indicate that it is available to operate.

 Next, define the heating plant that serves the main airside heating loads.

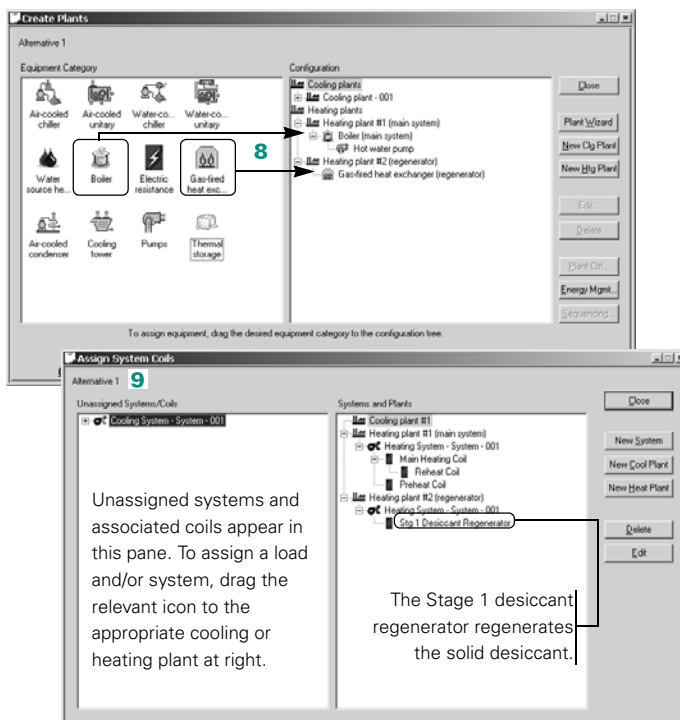
- 8 Add a gas-fired, hot-water **boiler** to serve the main heating load.

To provide the heat needed to regenerate the desiccant, add a **gas-fired heat exchanger**.

Not shown: Specify **equipment types, capacities, schedules, and the full-load consumption** of the hot-water pump on the **Heating Equipment** tab.

- 9  Assign the heating coil loads to the heating plants.

*Note: To further refine the model of the desiccant dehumidification device, the **Options** button on the **Options** tab of **Create Systems** can be used to define such items as parasitic energy consumers, supply-side design air conditions, coolant types, approach temperatures, heat-source temperatures, economizer lockout, and so on.*



Additional item

- 1 When adding a desiccant subsystem to an airside system, it is recommended that the minimum and maximum cooling supply-air dry bulbs be set equal to each other to fix the value for the cooling supply-air dry bulb. This is suggested because TRACE 700 cannot psychrometrically solve for the cooling supply-air dry bulb when an energy recovery / transfer device is attached to the Return/Outdoor deck. Refer to “Frequently asked questions” on page 6–20 for the ramifications of inputting a cooling supply-air dry bulb.

Coil loop for exhaust-air energy recovery



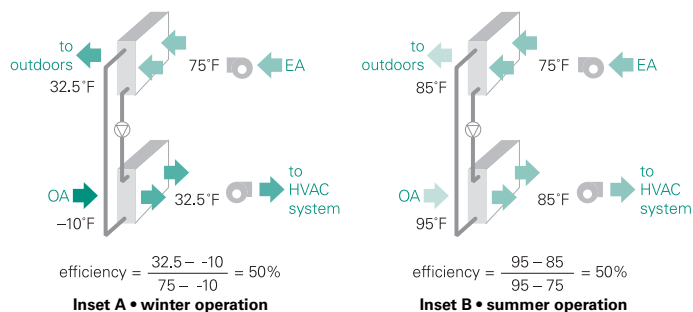
Devices (including total-energy wheels and heat pipes) other than the coil loop described here can exchange sensible and/or latent heat for energy recovery.

An exhaust-air energy-recovery system can reduce utility costs by capturing and using energy that would normally be lost to the exhaust air stream.

A coil loop can be applied either to the primary supply-air system or to independent systems such as the dedicated ventilation system that serves a laboratory. The effectiveness of the coil loop typically ranges from 45 percent to 60 percent for recovering sensible heat.

Figure 4–2 illustrates how the coil loop works. During the heating season (Inset A), heat extracted from the exhaust air stream (EA) warms the air brought into the building. Operation of the coil loop is limited to prevent the supply-air temperature from exceeding the cooling set point. (This condition is most likely to occur on mild days during the spring and fall.) Preconditioning the outdoor air (OA) in this manner reduces the heating load, which in turn reduces the energy consumption of the HVAC system.

Figure 4–2 Operating modes for coil-loop energy recovery

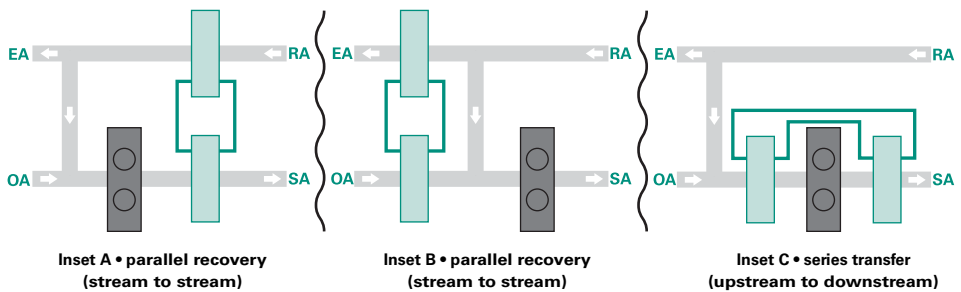


Coil-loop operation reverses during the cooling season (Inset B). Sensible heat is extracted from the air brought into the building and is rejected to the cooler and drier exhaust air stream. This time, preconditioning by the coil loop reduces the cooling load and, in turn, the energy consumption of the HVAC system.

A coil loop—also called a *coil runaround loop*—consists of two or more finned-tube coils that are piped together in a closed loop. A small pump circulates the working fluid (usually a solution of inhibited glycol and water) through the two coils. An expansion tank and a means for modulating capacity, either a three-way mixing valve or a variable-frequency drive on the pump, complete this energy-recovery device.

Figure 4–3, and Figure 4–4 on page 4–10, show the typical arrangements for sensible-heat recovery in mixed-air and dedicated ventilation systems. In Figure 4–3, which shows mixed-air systems, sensible-heat recovery can be used to reheat the dehumidified supply air for independent control of both temperature and humidity (Insets A and C), or to precondition the outdoor air (Insets B and C).

Figure 4–3 Mixed-air arrangements



In Figure 4–4 on page 4–10, which shows dedicated ventilation systems, sensible-heat recovery is often used to reheat the dehumidified outdoor air (Insets A and C), or to precondition the outdoor air (Insets B and C). Insets A and C are typically used with systems that deliver dehumidified outdoor air at a *neutral* dry-bulb temperature.

Each of the arrangements in Figure 4–3 and Figure 4–4 can be modeled using TRACE 700. However, only the arrangement shown in Figure 4–4, Inset C, will be covered in this discussion of coil-loop energy recovery. For arrangements other than this one, select the appropriate energy-recovery configuration (similar to step 2 in this example) and refer to the following:

Figure 4–4 Dedicated ventilation arrangements

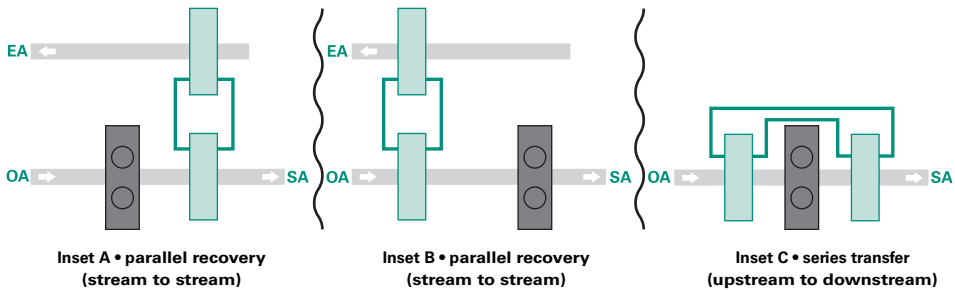


Figure 4–3:

- for *Inset A*, refer to steps 1 through 6 in “Fixed-plate heat exchanger” on page 4–21
- for *Inset B*, refer to steps 1 through 6 in “Total-energy (enthalpy) wheel” on page 4–15
- for *Inset C*, refer to steps 1 through 6 in “Heat pipe” on page 4–27

Figure 4–4:

- for *Inset A*, refer to steps 1 through 6 in “Sensible wheel” on page 4–34
- for *Inset B*, refer to steps 1 through 6 in “Total-energy (enthalpy) wheel” on page 4–15

Application considerations

- Coil-loop energy recovery increases the static pressure on both sides of the air-distribution system—supply and exhaust. Contact the manufacturers of the heat-exchange devices for estimated pressure drops.
- Unlike other types of exhaust-air energy recovery, a coil-loop recovery system does *not* require close proximity of the exhaust, supply, or makeup air streams. It can recover heat from diverse exhaust locations scattered throughout the building.

Related reading

- “Air-to-Air Energy Recovery,” *Engineers Newsletter* (volume 29, number 5)
- *Air-to-Air Energy Recovery in HVAC Systems Applications* Engineering Manual (Trane literature number SYS-APM003-EN)

Sample scenario

To input the type of heat recovery in Figure 4–4, Inset C, we will model an office building with a dedicated ventilation unit (makeup-air unit) that dehumidifies the outdoor air, and then reheats the air to a room *neutral* dry-bulb temperature before the air is delivered directly to the space. Water-source heat-pump (WSHP) units are installed in the ceiling plenum above each room and handle the cooling and heating needs for the rooms. To reduce the amount of reheat energy needed, and to increase the dehumidification capacity of the cooling coil in the dedicated ventilation unit, a coil loop is used to precool the outdoor air stream *before* it enters the optional ventilation-unit cooling coil, and then reheat the dehumidified outdoor air *after* it leaves the optional ventilation-unit cooling coil.

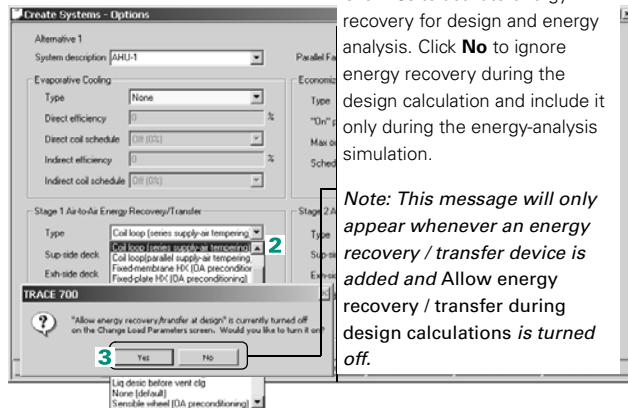
Note: For details on modeling the WSHP portion of the system, refer to “Water-source heat-pump system” on page 3–68. For details on modeling the Dedicated Ventilation Unit portion of the system, refer to “Dedicated outdoor-air systems” on page 4–45.

To model the coil-loop scenario:

- 1 On the **Actions** list, select **Change Load Parameters** and define the **first month** and **last month** of the summer (cooling) season. These entries help determine when the energy recovery / transfer device provides cooling rather than heating.

2 After defining the system, click the **Options** tab and select the desired air-to-air energy recovery / transfer type, which determines the type of energy recovery / transfer and the basic configuration. In this case, **Coil loop (series supply-air tempering)**.

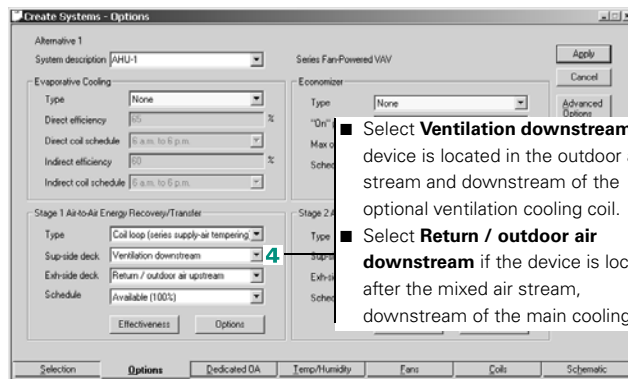
3 A message will appear that asks whether the user wants to account for energy recovery / transfer during the design and energy analysis simulations or only during the energy analysis simulation. Select **Yes** for this example.



Click **Yes** to activate energy recovery for design and energy analysis. Click **No** to ignore energy recovery during the design calculation and include it only during the energy-analysis simulation.

Note: This message will only appear whenever an energy recovery / transfer device is added and Allow energy recovery / transfer during design calculations is turned off.

4 Select the appropriate supply-side deck for the device. For this example, **Ventilation downstream** will be selected as the supply-side deck. The coil loop will be used to reheat the ventilation air downstream of the optional ventilation cooling coil.



■ Select **Ventilation downstream** if the device is located in the outdoor air stream and downstream of the optional ventilation cooling coil.
 ■ Select **Return / outdoor air downstream** if the device is located after the mixed air stream, downstream of the main cooling coil.

5 Select the exhaust-side deck for the device. In this case, **Ventilation upstream** will be selected as the exhaust-side deck. The coil loop will be used to precool the ventilation air upstream of the optional ventilation cooling coil.

- Select **Return / outdoor air upstream** if the mixed air stream (recirculated return air—after room exhaust and system exhaust—plus the ventilation) is used as the exhaust side.
- Select **Ventilation upstream** if the outdoor air, before it enters the make-up air (dedicated ventilation) unit, is going to be used as the exhaust side. This selection should only be used in combination with a make-up air unit. In this case, **Ventilation upstream** will be selected as the exhaust-side deck. The coil loop will be used to precool the ventilation air upstream of the optional ventilation cooling coil.

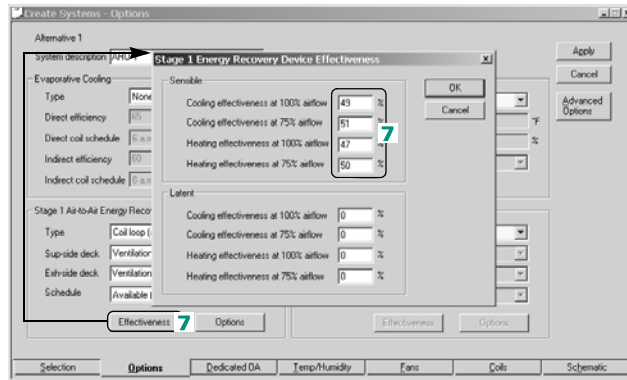
Note: If the proper airstreams are not selected for supply-side and exhaust-side decks of the energy recovery/transfer device, then the unit will not function correctly or may not function at all.

Note: If both stage 1 and stage 2 energy recovery/transfer devices are given the same exhaust-side deck, then stage 1 will be upstream of stage 2.

6 Choose the schedule that describes when the coil loop is permitted to operate. The schedule **Available 100%** will allow the device to operate year-round.

- 7 Input the coil-loop effectiveness (essentially how efficiently the coil loop recovers energy) by clicking **Effectiveness** and entering the sensible percentages at different airflows. Click **OK** and then click **Apply** when finished.

*Note: To further refine the model of the energy-recovery device, the **Options** button on the **Options** tab can be used to define such items as parasitic energy consumers (such as the pump in this example), static pressure drop, bypass dampers, part load controls, economizer lockout, and frost prevention.*



Note: Cooling Effectiveness refers to supply-side ARI entering conditions at 95°F dry bulb / 78°F wet bulb and exhaust-side air entering at 75°F dry bulb / 63°F wet bulb. Heating Effectiveness refers to supply-side ARI entering conditions at 35°F dry bulb / 33°F wet bulb and exhaust-side air entering at 70°F dry bulb / 58°F wet bulb.

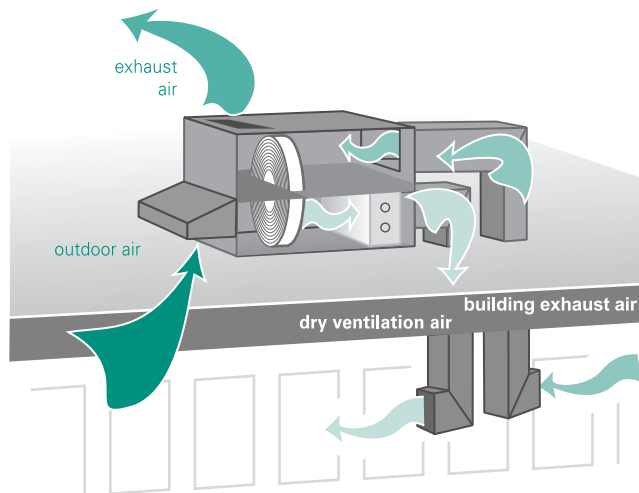
Additional Item

- 1 When adding a coil loop to an airside system, it is recommended that the minimum and maximum cooling supply-air dry bulbs be set equal to each other to fix the value for the cooling supply-air dry bulb. This is suggested because TRACE 700 cannot psychrometrically solve for the cooling supply-air dry bulb when an energy recovery / transfer device is attached to the Return/ Outdoor deck. Please read the **FAQ** and **Oversizing and Undersizing** sections of the manual for the ramifications of fixing a cooling supply-air dry bulb.

Total-energy (enthalpy) wheel

A total-energy wheel is a revolving cylinder filled with a desiccant-treated medium that is suited for transferring sensible and latent heat. Heat transfer occurs when adjacent air streams (usually supply and exhaust) pass through the wheel in a counterflow arrangement. The exchange medium inside the wheel collects sensible heat from the warmer of the two air streams and releases it in the cooler air stream. Latent heat transfer occurs as the medium collects moisture from the more-humid air stream and releases it in the drier air stream.

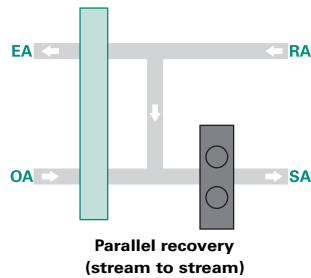
Figure 4-5 Total-energy wheel



Like other energy-recovery devices, total-energy wheels can yield significant energy savings in systems that exhaust large amounts of air.

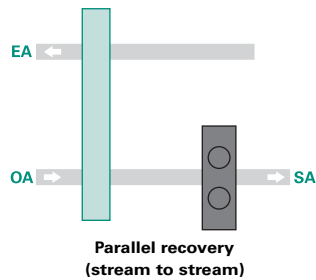
Figure 4-6 and Figure 4-7 on page 4-16 show the typical arrangements for total-energy recovery in mixed-air and dedicated ventilation systems. In Figure 4-6, which shows a mixed-air system, total-energy recovery can be used to precondition the outdoor air.

Figure 4–6 Mixed-air arrangement



In Figure 4–7, which shows a dedicated ventilation system, total-energy recovery is often used to precondition the outdoor air.

Figure 4–7 Dedicated ventilation arrangement



The arrangements in Figure 4–6 and Figure 4–7 can be modeled using TRACE 700.

Figure 4–6 and Figure 4–7 are input identically, however, a dedicated ventilation unit must be input to accurately simulate Figure 4–7. Refer to “Dedicated outdoor-air systems” on page 4–45 for information related to modeling a dedicated ventilation/ makeup air unit.

Application considerations

- The air streams targeted for energy transfer (usually exhaust air and ventilation air) must be situated near each other.

- Total-energy wheels can recover both latent heat and sensible heat with an effectiveness that typically ranges from 65 percent to 80 percent. Adding a wheel usually increases the system static pressure by 0.7 in. wg to 1.2 in. wg.
- Cross contamination between air streams is possible. To minimize air carryover in critical applications, add an effective purge arrangement. Placement of the fan in relation to the wheel should *promote leakage from the outdoor (ventilation) air stream to the exhaust air stream*, rather than the reverse.
- The relatively compact size of a total-energy wheel can permit factory installation in air handlers, rooftop air conditioners, and some terminal devices such as unit ventilators.
- Climates that economically favor heat pumps are good candidates for successful total-energy wheel applications. When applied in very cold climates, it may be necessary to add preheat to prevent frosting of the wheel.

Related reading

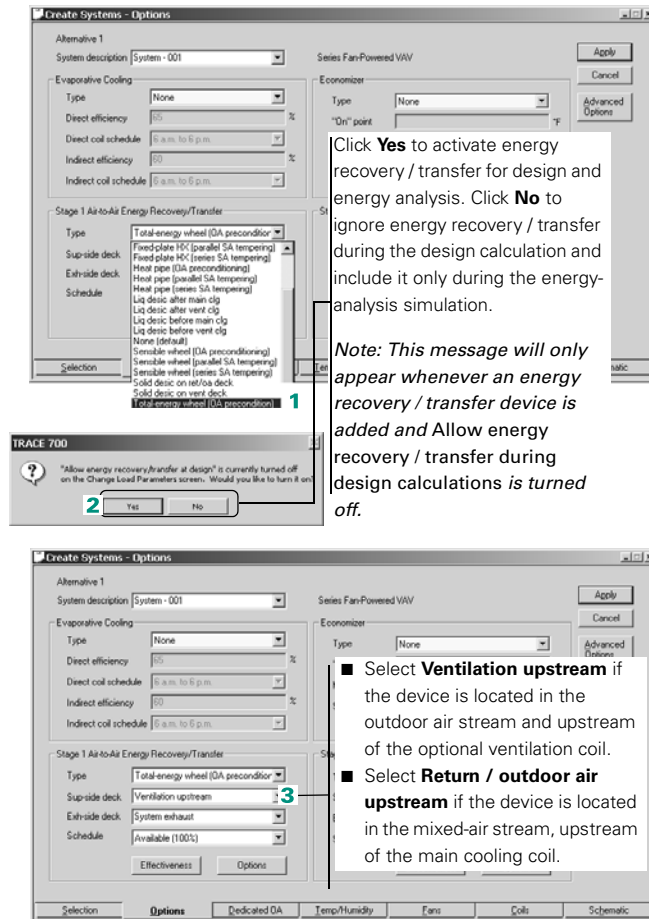
- "Air-to-Air Energy Recovery," *Engineers Newsletter* (volume 29, number 5)
- *Air-to-Air Energy Recovery in HVAC Systems Applications* Engineering Manual (Trane literature number SYS-APM003-EN)

Sample scenario

The air-distribution system for a building includes a total-energy wheel (also commonly referred to as an enthalpy wheel). The wheel preconditions the outdoor air entering the building by exchanging both sensible and latent heat with the main exhaust air stream. When operating in the heating mode, the wheel warms and humidifies the outdoor air. During the cooling mode, it cools and dehumidifies.

To model the total-energy wheel scenario:

- 1 After defining the airside system, select the desired air-to-air energy recovery / transfer type, which determines the type of energy recovery / transfer and the basic configuration. In this case, **Total-energy wheel (OA preconditioner)**.
- 2 A message will appear that asks whether the user wants to account for energy recovery / transfer during the design and energy analysis simulations or only during the energy analysis simulation. Select **Yes** in this example.
- 3 Select the appropriate supply-side deck for the device. For this example, **Ventilation upstream** will be selected as the supply-side deck. The total-energy wheel will be used to condition the ventilation air upstream of the optional ventilation coil.



- 4 Select the exhaust-side deck for the device. In this case, the energy from the system exhaust air stream will be used to precool and dehumidify the ventilation air. As a result, **System Exhaust** will be selected.

*Note: If the proper airstreams are not selected for supply-side and exhaust-side decks of the energy recovery/transfer device, then the unit will not function correctly or may not function at all. The **Airflows** section of the **System Checksums** report can be used to verify that a specific airflow is available for energy recovery. On the **System Checksums** reports, **Room Exhaust** = Rm Exh, **System Exhaust** = Exhaust, and **Return Air** = Return Air.*

- 5 Choose the schedule that describes when the total-energy wheel is permitted to operate. The schedule **Available 100%** will allow the device to operate whenever it is advantageous.

- 6 Input the effectiveness of the wheel (essentially how efficiently the wheel recovers energy) by clicking **Effectiveness** and entering the sensible and latent effectiveness percentages at different airflows. Click **OK** and then click **Apply** when finished.

- Select **System Exhaust** if main system exhaust is used exclusively as the exhaust side.
- Select **Room Exhaust** if the room exhaust airflow is used exclusively as the exhaust side. Room exhaust airflows are input on the **Airflows** tab of **Create Rooms**. If no room exhaust is input, then all exhaust air will be at system level.

*Note: To further refine the model of the energy-recovery device, the **Options** button on the **Create Systems - Options** tab can be used to define such items as parasitic energy consumers, static pressure drop, bypass dampers, part load controls, economizer lockout, and frost prevention.*

Additional Items

- 1 When adding an energy wheel to an airside system, it is recommended that the minimum and maximum cooling supply-air dry bulbs be set equal to each other to fix the value for the cooling supply-air dry bulb. This is suggested because TRACE 700 cannot psychrometrically solve for the cooling supply-air dry bulb when an energy-recovery device is attached to the Return/Outdoor deck. Please read the **FAQ** and **Oversizing and Undersizing** sections of the manual for the ramifications of fixing a cooling supply-air dry bulb.
- 2 Energy recovery / transfer devices are generally applied at higher airflows (higher face velocities) than what the manufacturer submits for ARI certification. For example, if a wheel is rated at 400 fpm, a typical sensible-heating effectiveness is around 74 percent. However, it is likely that this wheel will be applied at a much higher airflow (600-700 fpm), which will decrease its effectiveness. The user should work with the manufacturer's representative to determine the effectiveness of the device at the desired airflow (and at 75 percent of the desired airflow), and then input these values for the 100 percent and 75 percent airflow points for accurate modeling.
- 3 Refer to Table 4–1 for recommendations on energy-recovery applications in different scenarios.

Table 4–1 Applications for Air-to-Air Energy recovery

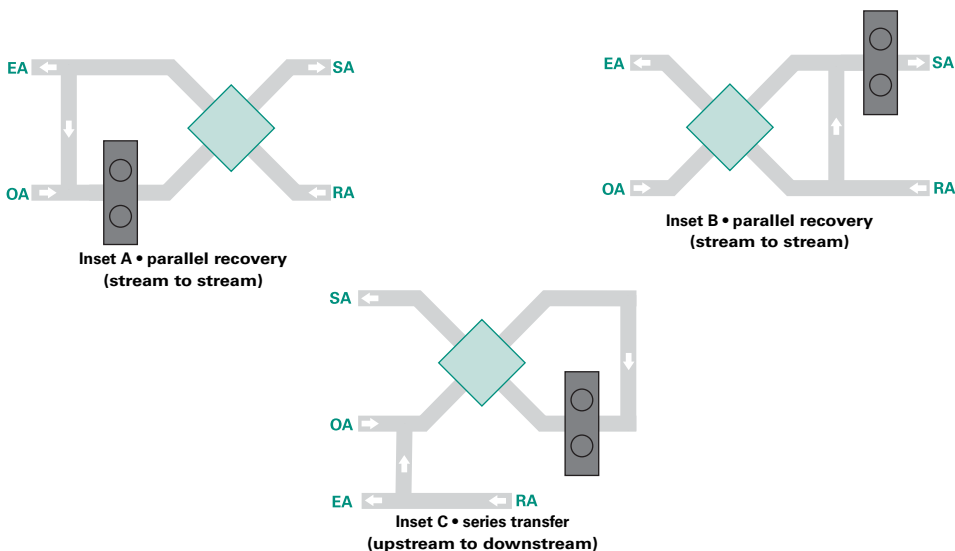
Ventilation System		Energy-Recovery Technology	
Source	Supply-air Temperature	Supply-air Tempering	Outdoor-air Preconditioning
Dedicated outdoor air	Cold	Not applicable	Sensible or total
	Neutral	Sensible (parallel or series)	Sensible or total
Mixed air (outdoor air plus recirculated return air)	Modulated (constant volume)	Sensible (parallel or series)	Sensible or total
	Cold (variable volume)	Not applicable	Sensible or total

Fixed-plate heat exchanger

A fixed-plate heat exchanger consists of alternate layers of thermally conductive plates that are sealed to form separate passages for two air streams. The plates are constructed from aluminum or other materials with a similarly high thermal conductivity. Fixed-plate heat exchangers exist in various configurations, materials, and capacities—of the available flow patterns, cross-flow is the most common. The plates in most of these devices transfer only *sensible* heat between the two air streams.

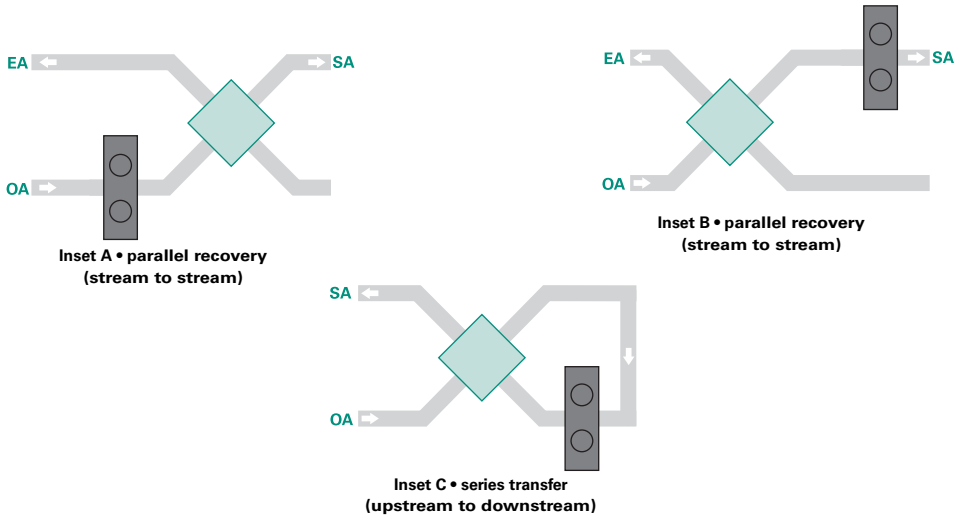
Figure 4–8, and Figure 4–9 on page 4–22, show the typical arrangements for sensible-heat recovery in mixed-air and dedicated ventilation systems. In Figure 4–8, which shows mixed-air systems, sensible-heat recovery can be used to reheat the dehumidified supply air (Insets A and C) or to precondition the outdoor air (Insets B and C).

Figure 4–8 Mixed-air arrangements



In Figure 4–9, which shows dedicated ventilation systems, sensible-heat recovery is often used to reheat the dehumidified outdoor air (Insets A and C), or to precondition the outdoor air (Insets B and C). Insets A and C are typically used with systems that deliver dehumidified outdoor air at a *neutral* dry-bulb temperature.

Figure 4–9 Dedicated ventilation arrangements



Each of the arrangements in Figure 4–8 and Figure 4–9 can be modeled using TRACE 700. However, only the arrangement shown in Figure 4–8, Inset A, will be covered in this discussion of fixed-plate heat-exchanger energy recovery. For arrangements other than this one, select the appropriate energy-recovery configuration (similar to step 1 in this example) and refer to the following:

Figure 4–8:

- for *Inset B*, refer to steps 1 through 6 in “Total-energy (enthalpy) wheel” on page 4–15
- for *Inset C*, refer to steps 1 through 6 in “Heat pipe” on page 4–27

for *Inset A*, refer to steps 1 through 6 in “Sensible wheel” on page 4–34

for *Inset B*, refer to steps 1 through 6 in “Total-energy (enthalpy) wheel” on page 4–15

for *Inset C*, refer to steps 2 through 7 in “Coil loop for exhaust-air energy recovery” on page 4–8

"Air-to-Air Energy Recovery," *Engineers Newsletter* (volume 29, number 5)

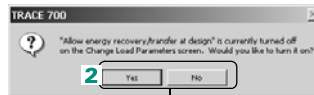
Air-to-Air Energy Recovery in HVAC Systems Applications
Engineering Manual (Trane literature number SYS-APM003-EN)

To input the type of heat recovery in Figure 4–8, Inset A, we will model a laboratory that is conditioned by a variable-volume reheat system. To reduce the amount of reheat energy required, a fixed-plate heat exchanger will transfer sensible heat from the return air stream to reheat the supply air stream after it leaves the main cooling coil.

1 After defining the system, select the desired air-to-air energy recovery / transfer type, which determines the type of energy recovery / transfer and the basic configuration. In this case, **Fixed-plate HX (parallel SA tempering)**.



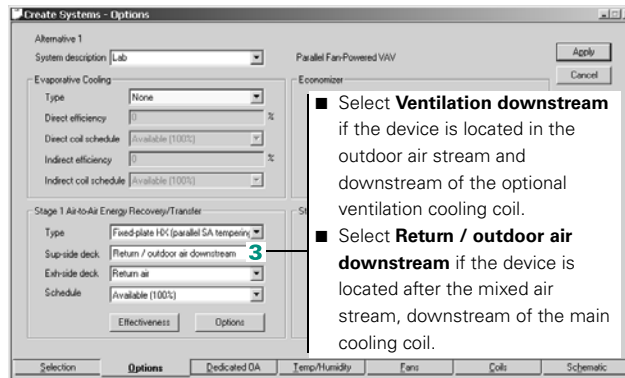
2 A message will appear that asks whether the user wants to account for energy recovery / transfer during the design and energy analysis simulations or only during the energy analysis simulation. Select **Yes** for this example.



Click **Yes** to activate energy recovery / transfer for design and energy analysis. Click **No** to ignore energy recovery / transfer during the design calculation and include it only during the energy-analysis simulation.

Note: This message will only appear whenever an energy recovery / transfer device is added and Allow energy recovery / transfer during design calculations is turned off.

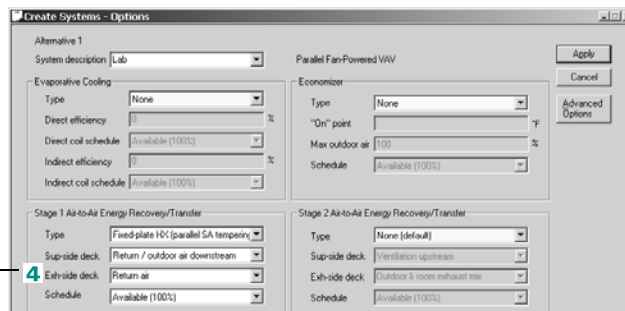
3 Select the appropriate supply-side deck for the device. For this example, **Return / outdoor air downstream** will be selected as the supply-side deck. This will allow the heat exchanger to reheat the supply air after it has left the cooling coil.



- Select **Ventilation downstream** if the device is located in the outdoor air stream and downstream of the optional ventilation cooling coil.
- Select **Return / outdoor air downstream** if the device is located after the mixed air stream, downstream of the main cooling coil.

4 Select the exhaust-side deck for the device. In this case, **Return air** will be selected as the exhaust-side deck. This will allow the heat exchanger to use energy from the return air stream to provide reheat.

Note: If the proper airstreams are not selected for supply-side and exhaust-side decks of the energy recovery/transfer device, then the unit will not function correctly or may not function at all.



- Select **System Exhaust** if main system exhaust is used exclusively as the exhaust side.
- Select **Room Exhaust** if the room exhaust airflow is used exclusively as the exhaust side. Room exhaust airflows are input on the **Airflows** tab of **Create Rooms**. If no room exhaust is input, then all exhaust air will be at system level.
- Select **Return air** if airflow returning back through the plenum or return duct (pre system exhaust and post room exhaust) is used as the exhaust side.

Note: If two energy recovery/transfer devices are input, and both stage 1 and stage 2 devices are given the same exhaust-side deck, then stage 1 will be upstream of stage 2.

5 Choose the schedule that describes when the heat exchanger is permitted to operate. The schedule **Available 100%** will allow the device to operate year-round.

6 Input the effectiveness of the fixed-plate heat exchanger (essentially how efficiently the heat exchanger recovers energy) by clicking **Effectiveness** and entering the sensible effectiveness percentages at different airflows. Click **OK** and then click **Apply** when finished.

Note: To further refine the model of the energy-recovery device, the Options button can be used to define such items as parasitic energy consumers, static pressure drop, bypass dampers, part load controls, economizer lockout, and frost prevention.

Additional Items

- 1 When adding a fixed-plate heat exchanger to an airside system, it is recommended that the minimum and maximum cooling supply-air dry bulbs be set equal to each other to fix the value for the cooling supply-air dry bulb. This is suggested because TRACE 700 cannot psychrometrically solve for the cooling supply-air dry bulb when an energy-recovery device is attached to the Return/Outdoor deck. Please read the **FAQ** and **Oversizing and Undersizing** sections of the manual for the ramifications of fixing a cooling supply-air dry bulb.

- 2 Energy recovery / transfer devices are generally applied at higher airflows (higher face velocities) than what the manufacturer submits for ARI certification. For example, if a fixed-plate heat exchanger is rated at 400 fpm, a typical sensible-heating effectiveness is around 65 percent. However, it is likely that this device will be applied at a much higher airflow (600-700 fpm), which will decrease its effectiveness. The user should work with the manufacturer's representative to determine the effectiveness of the device at the desired airflow (and at 75 percent of the desired airflow), and then input these values for the 100 percent and 75 percent airflow points for accurate modeling.
- 3 Refer to Table 4–2 for recommendations on energy-recovery applications in different scenarios.

Table 4–2 Applications for Air-to-Air Energy recovery

Ventilation System		Energy-Recovery Technology	
Source	Supply-air Temperature	Supply-air Tempering	Outdoor-air Preconditioning
Dedicated outdoor air	Cold	Not applicable	Sensible or total
	Neutral	Sensible (parallel or series)	Sensible or total
Mixed air (outdoor air plus recirculated return air)	Modulated (constant volume)	Sensible (parallel or series)	Sensible or total
	Cold (variable volume)	Not applicable	Sensible or total

Heat pipe

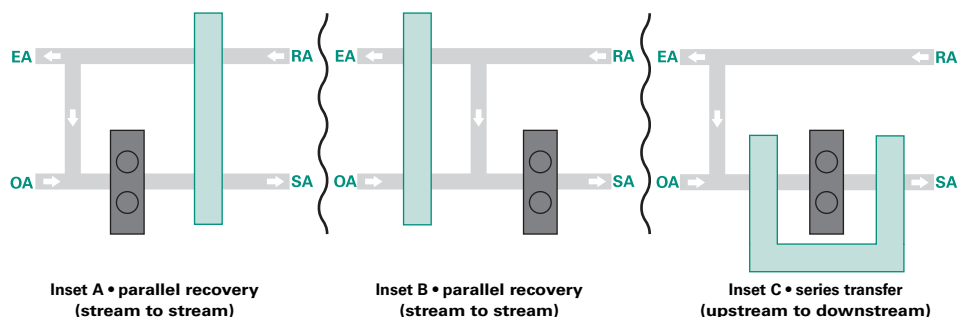
A heat pipe resembles a finned-tube coil. Each of its large tubes is an independent, sealed container that is filled with a heat-transfer fluid (typically a chemical refrigerant). A partition divides the *air side* of the heat pipe into separate *evaporator* and *condenser* sections. The capillary wick structure within the pipe walls induces refrigerant flow between the *evaporator* and *condenser* without the help of a compressor or pump.

Two air streams flow across each heat pipe. Warm air flows across the *evaporator* and cool air flows across the *condenser*. The refrigerant inside the *evaporator* evaporates as it absorbs heat from the warm air. Given the comparative coolness of the air flowing over the *condenser*, the refrigerant vapor pressure is lower in that section of the heat pipe than in the *evaporator*. The difference in vapor pressures causes the refrigerant vapor to migrate from the *evaporator* to the *condenser*. Cool air flowing over the *condenser* absorbs heat from the refrigerant vapor, causing the refrigerant to condense. The liquid refrigerant then *wicks* back to the *evaporator* section of the heat pipe and the cycle repeats.

The direction of heat transfer reverses when the relative temperatures of the two air streams are reversed. In an outdoor-air preconditioning application, for example, when the outdoor air is *warmer* than the exhaust air, the *evaporator* is in the outdoor air stream and the *condenser* is in the exhaust air stream. When the outdoor air is *cooler* than the exhaust air, the *evaporator* is in the exhaust air stream and the *condenser* is in the outdoor air stream.

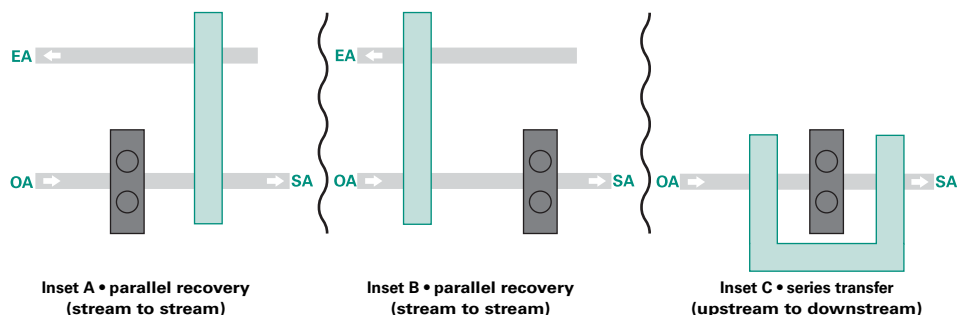
Figure 4–10 and Figure 4–11 on page 4–28 show the typical arrangements for sensible-heat recovery in mixed-air and dedicated ventilation systems. In Figure 4–10, which shows mixed-air systems, sensible-heat recovery can be used to reheat the dehumidified supply air (Insets A and C) or to precondition the outdoor air (Insets B and C).

Figure 4–10 Mixed-air arrangements



In Figure 4–11, which shows dedicated ventilation systems, sensible-heat recovery is often used to reheat the dehumidified outdoor air (Insets A and C), or to precondition the outdoor air (Inset B). Insets A and C are typically used with systems that deliver dehumidified outdoor air at a *neutral* dry-bulb temperature.

Figure 4–11 Dedicated ventilation arrangements



Each of the arrangements in Figure 4–10 and Figure 4–11 can be modeled using TRACE 700. However, only the arrangement shown in Figure 4–10, Inset C, will be covered in this discussion of heat-pipe energy recovery. For arrangements other than this one, select the appropriate energy-recovery configuration (similar to step 1 in this example) and refer to the following:

Figure 4–10:

- for *Inset A*, refer to steps 1 through 6 in “Fixed-plate heat exchanger” on page 4–21
- for *Inset B*, refer to steps 1 through 6 in “Total-energy (enthalpy) wheel” on page 4–15

Figure 4–11:

- for *Inset A*, refer to steps 1 through 6 in “Sensible wheel” on page 4–34
- for *Inset B*, refer to steps 1 through 6 in “Total-energy (enthalpy) wheel” on page 4–15
- for *Inset C*, refer to steps 2 through 7 in “Coil loop for exhaust-air energy recovery” on page 4–8

Related reading

- “Air-to-Air Energy Recovery,” *Engineers Newsletter* (volume 29, number 5)
- *Air-to-Air Energy Recovery in HVAC Systems Applications* Engineering Manual (Trane literature number SYS-APM003-EN)

Sample scenario

To input the type of heat recovery in Figure 4–10, Inset C, we will model a restaurant that is cooled by a constant-volume rooftop. A heat pipe will be used to precool the mixed air before it enters the main cooling coil and reheat the air after it leaves the main cooling coil. This arrangement is sometimes referred to as *series* energy recovery. The series arrangement will reduce both the cooling energy and the reheat energy required by the system (if it is a system with reheat), while increasing dehumidification capabilities.

To model the heat pipe scenario:

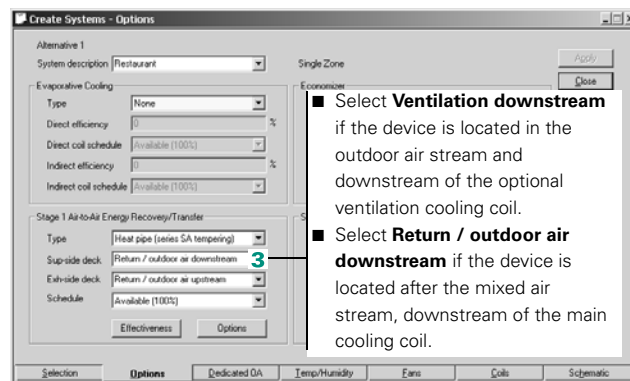
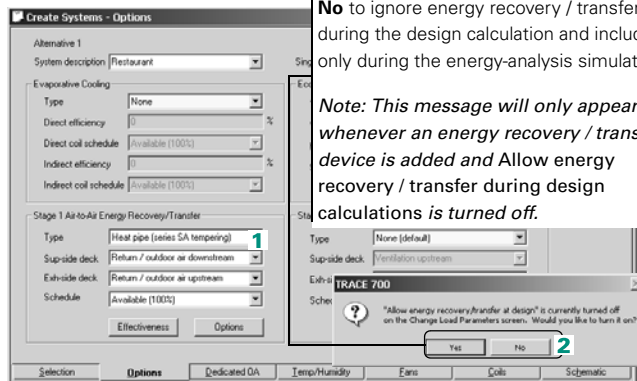
- 1 After defining the system, select the desired air-to-air energy recovery / transfer type, which determines the type of energy recovery / transfer and the basic configuration. In this case, **Heat pipe (series SA tempering)**.
- 2 A message will appear that asks whether the user wants to account for energy recovery / transfer during the design and energy analysis simulations or only during the energy analysis simulation. Select **Yes** for this example.

Note: Series energy transfer in mixed-air systems typically does not reduce cooling-equipment capacity, because no energy transfer occurs at the design cooling conditions.

- 3 Select the appropriate supply-side deck for the device. For this example, **Return / outdoor air downstream** will be selected as the supply-side deck. The heat pipe will be used to reheat the mixed air stream downstream of the main cooling coil.

Click **Yes** to activate energy recovery / transfer for design and energy analysis. Click **No** to ignore energy recovery / transfer during the design calculation and include it only during the energy-analysis simulation.

Note: This message will only appear whenever an energy recovery / transfer device is added and Allow energy recovery / transfer during design calculations is turned off.



- Select **Ventilation downstream** if the device is located in the outdoor air stream and downstream of the optional ventilation cooling coil.
- Select **Return / outdoor air downstream** if the device is located after the mixed air stream, downstream of the main cooling coil.

- 4 Select the exhaust-side deck for the device. In this case, **Return / outdoor air upstream** will be selected as the exhaust-side deck. The heat pipe will be used to precool the mixed air stream before it enters the main cooling coil.

Note: If the proper airstreams are not selected for supply-side and exhaust-side decks of the energy recovery/transfer device, then the unit will not function correctly or may not function at all.

- Select **Return / outdoor air upstream** if the mixed air stream (recirculated return air—after room exhaust and system exhaust—plus the ventilation) is used as the exhaust side.
- Select **Ventilation upstream** if the outdoor air, before it enters the dedicated ventilation unit, is going to be used as the exhaust side. This selection should only be used in combination with a dedicated ventilation unit.

- 5 Choose the schedule that describes when the heat pipe is permitted to operate. The schedule **Available 100%** will allow the device to operate year-round.

- 6 Input the heat pipe effectiveness (essentially how efficiently the heat pipe recovers energy) by clicking **Effectiveness** and entering the sensible effectiveness percentages at different airflows. Click **OK** and then click **Apply** when finished.

- 7 On the **Temp/Humidity** tab of **Create Systems**, input the maximum room relative humidity that the system should try to maintain. In this case, input 60 percent. Click **Apply** when finished.

*Note: To further refine the model of the energy-recovery device, the **Options** button on the **Options** tab can be used to define such items as parasitic energy consumers, static pressure drop, bypass dampers, part load controls, economizer lockout, and frost prevention.*

Additional Items

- 1 When adding a heat pipe to an airside system, it is recommended that the minimum and maximum cooling supply-air dry bulbs be set equal to each other to fix the value for the cooling supply-air dry bulb. This is suggested because TRACE 700 cannot psychrometrically solve for the cooling supply-air dry bulb when an energy-recovery device is attached to the Return/Outdoor deck. For the ramifications of fixing a cooling supply-air dry bulb, please refer to "Frequently asked questions" on page 6–20 and "Oversizing and undersizing" on page 6–51.
- 2 Energy recovery / transfer devices are generally applied at higher airflows (higher face velocities) than what the manufacturer submits for ARI certification. For example, if a heat pipe is rated at 400 fpm, a typical sensible-heating effectiveness is around 50 percent. However, it is likely that this device will be applied at a much higher airflow (600-700 fpm), which will decrease its effectiveness. The user should work with the manufacturer's representative to determine the effectiveness of the device at the desired airflow (and at 75 percent of the desired airflow), and

then input these values for the 100 percent and 75 percent airflow points for accurate modeling.

- 3 Refer to Table 4–3 for recommendations on energy-recovery applications in different scenarios.

Table 4–3 Applications for Air-to-Air Energy recovery

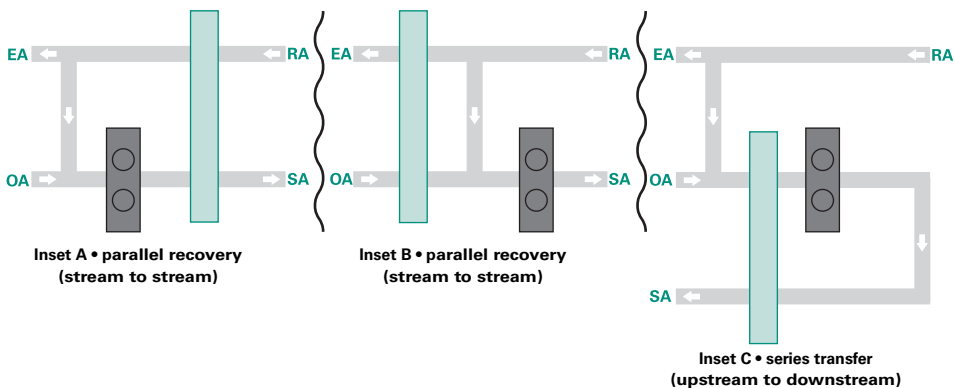
Ventilation System		Energy-Recovery Technology	
Source	Supply-air Temperature	Supply-air Tempering	Outdoor-air Preconditioning
Dedicated outdoor air	Cold	Not applicable	Sensible or total
	Neutral	Sensible (parallel or series)	Sensible or total
Mixed air (outdoor air plus recirculated return air)	Modulated (constant volume)	Sensible (parallel or series)	Sensible or total
	Cold (variable volume)	Not applicable	Sensible or total

Sensible wheel

Sensible-energy rotary heat exchangers (sensible-energy wheels) are similar to total-energy wheels in both price and appearance. The main difference between the two types of energy wheels is a coating that is applied to the total energy wheel that allows it to transfer moisture in addition to sensible heat. Sensible energy wheels are typically applied in scenarios where the addition of moisture would be detrimental to the system.

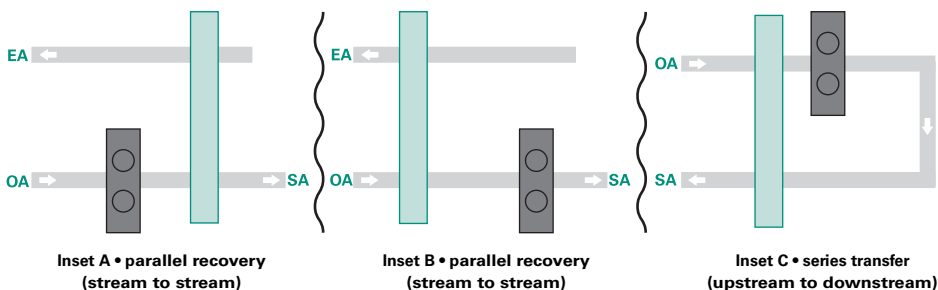
Figure 4–12, and Figure 4–13 on page 4–35, show the typical arrangements for sensible-heat recovery in mixed-air and dedicated ventilation systems. In Figure 4–12, which shows mixed-air systems, sensible-heat recovery can be used to reheat the dehumidified supply air (Insets A and C) or to precondition the outdoor air (Inset B).

Figure 4–12 Mixed-air arrangements



In Figure 4–13 on page 4–35, which shows dedicated ventilation systems, sensible-heat recovery is often used to reheat the dehumidified outdoor air (Insets A and C), or to precondition the outdoor air (Insets B and C). Insets A and C are typically used with systems that deliver dehumidified outdoor air at a *neutral* dry-bulb temperature.

Figure 4–13 Dedicated ventilation arrangements



Each of the arrangements in Figure 4–12 and Figure 4–13 can be modeled using TRACE 700. However, only the arrangement shown in Figure 4–13, Inset A, will be covered in this discussion of sensible-wheel energy recovery. For arrangements other than this one, select the appropriate energy-recovery configuration (similar to step 1 in this example) and refer to the following:

Figure 4–12:

- for *Inset A*, refer to steps 1 through 6 in “Fixed-plate heat exchanger” on page 4–21
- for *Inset B*, refer to steps 1 through 6 in “Total-energy (enthalpy) wheel” on page 4–15
- for *Inset C*, refer to steps 1 through 6 in “Heat pipe” on page 4–27

Figure 4–13:

- for *Inset B*, refer to steps 1 through 6 in “Total-energy (enthalpy) wheel” on page 4–15
- for *Inset C*, refer to steps 2 through 7 in “Coil loop for exhaust-air energy recovery” on page 4–8

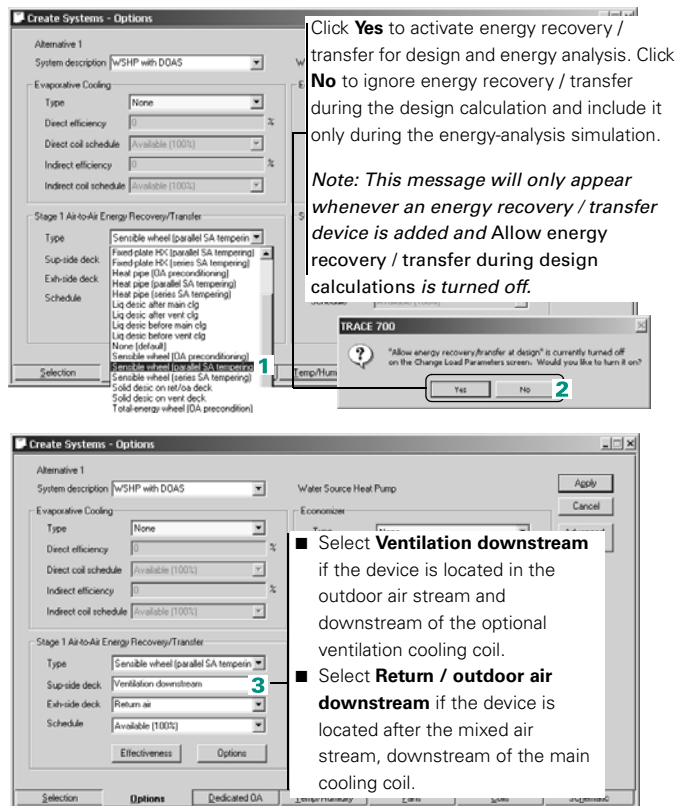
Related reading

- “Air-to-Air Energy Recovery,” *Engineers Newsletter* (volume 29, number 5)
- *Air-to-Air Energy Recovery in HVAC Systems Applications* Engineering Manual (Trane literature number SYS-APM003-EN)

Sample scenario

To input the type of heat recovery in Figure 4–13, Inset A, we will model an office building with a dedicated ventilation unit (make-up air unit) that dehumidifies the outdoor air and then reheats the air to a room *neutral* dry-bulb temperature, before the air is delivered directly to the space. Water-source heat-pump (WSHP) units are installed in the ceiling plenum above each room and handle the cooling and heating needs for the rooms. To reduce the amount of reheat energy needed, a sensible-energy wheel will be used to remove heat from the exhaust air stream and reheat the dehumidified outdoor air.

- 1 After defining the WSHP system and the dedicated ventilation system, select the desired air-to-air energy recovery / transfer type, which determines the type of energy recovery / transfer and the basic configuration. In this case, **Sensible wheel (parallel SA tempering)**.
- 2 A message will appear that asks whether the user wants to account for energy recovery / transfer during the design and energy analysis simulations or only during the energy analysis simulation. Select **Yes** for this example.
- 3 Select the appropriate supply-side deck for the device. For this example, **Ventilation downstream** will be selected as the supply-side deck. The sensible-energy wheel will be used to reheat the ventilation air downstream of the optional ventilation cooling coil.



- 4 Select the exhaust-side deck for the device. In this case, the energy from the system exhaust air stream will be used to reheat the ventilation air. As a result, **System Exhaust** will be selected.

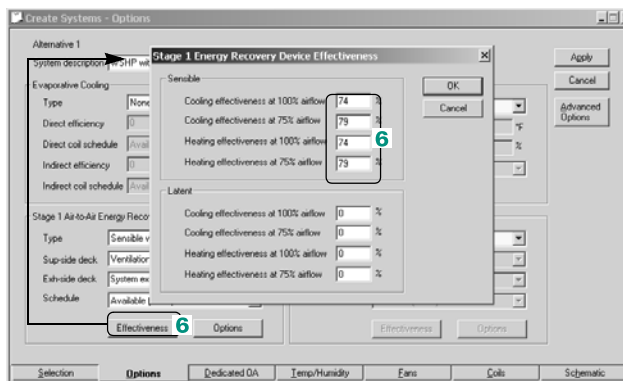
*Note: If the proper airstreams are not selected for supply-side and exhaust-side decks of the energy recovery/transfer device, then the unit will not function correctly or may not function at all. The **Airflows** section of the **System Checksums** report can be used to verify that a specific airflow is available for energy recovery. On the **System Checksums** reports, **Room Exhaust** = Rm Exh, **System Exhaust** = Exhaust, and **Return air** = Return Air.*

- Select **System Exhaust** if main system exhaust is used exclusively as the exhaust side.
- Select **Room Exhaust** if the room exhaust airflow is used exclusively as the exhaust side. Room exhaust airflows are input on the **Airflows** tab of **Create Rooms**. If no room exhaust is input, then all exhaust air will be at system level.
- Select **Return air** if airflow returning back through the plenum or return duct (pre system exhaust and post room exhaust) is used as the exhaust side.

- 5 Choose the schedule that describes when the sensible-energy wheel is permitted to operate. The schedule **Available 100%** will allow the device to operate year-round.

- 6 Input the effectiveness of the sensible-energy wheel (essentially how efficiently the wheel recovers energy) by clicking **Effectiveness** and entering the sensible effectiveness percentages at different airflows. Click **OK** and then click **Apply** when finished.

Note: To further refine the model of the energy-recovery device, the Options button can be used to define such items as parasitic energy consumers, static pressure drop, bypass dampers, part load controls, economizer lockout, and frost prevention.



Additional Items

- 1 When adding an energy wheel to an airside system, it is recommended that the minimum and maximum cooling supply-air dry bulbs be set equal to each other to fix the value for the cooling supply-air dry bulb. This is suggested because TRACE 700 cannot psychrometrically solve for the cooling supply-air dry bulb when an energy-recovery device is attached to the Return/Outdoor deck. For the ramifications of fixing a cooling supply-air dry bulb, please refer to "Frequently asked questions" on page 6–20 and "Oversizing and undersizing" on page 6–51.
- 2 Energy recovery / transfer devices are generally applied at higher airflows (higher face velocities) than what the manufacturer submits for ARI certification. For example, if a wheel is rated at 400 fpm, a typical sensible-heating effectiveness is around 74 percent. However, it is likely that this wheel will be applied at a much higher airflow (600-700 fpm), which will decrease its effectiveness. The user should work with the manufacturer's representative to determine the effectiveness of the device at the desired airflow (and at 75 percent of the desired airflow), and

then input these values for the 100 percent and 75 percent airflow points for accurate modeling.

- 3 Refer to Table 4–4 for recommendations on energy-recovery applications in different scenarios.

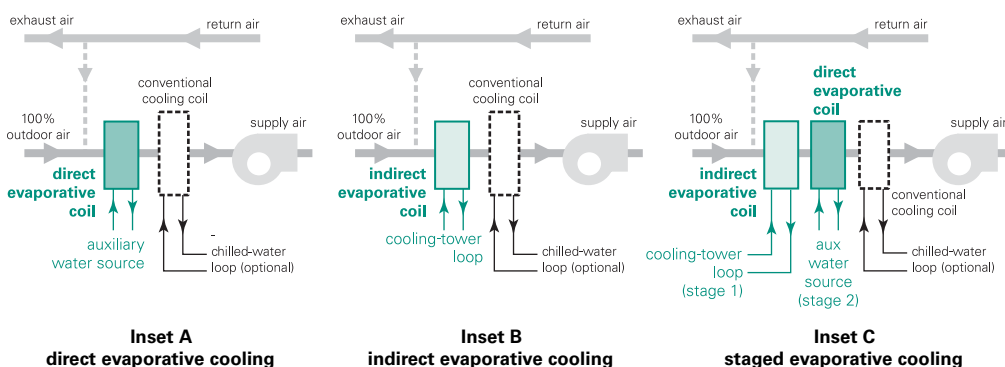
Table 4–4 Applications for Air-to-Air Energy recovery

Ventilation System		Energy-Recovery Technology	
Source	Supply-air Temperature	Supply-air Tempering	Outdoor-air Preconditioning
Dedicated outdoor air	Cold	Not applicable	Sensible or total
	Neutral	Sensible (parallel or series)	Sensible or total
Mixed air (outdoor air plus recirculated return air)	Modulated (constant volume)	Sensible (parallel or series)	Sensible or total
	Cold (variable volume)	Not applicable	Sensible or total

Direct and indirect evaporative cooling

Using the evaporative process to precool the supply air stream can reduce the energy consumption of mechanical cooling equipment. Two methods of evaporative cooling exist: direct and indirect. The effectiveness of each method depends on the extent to which the dry-bulb temperature of the supply air exceeds the wet-bulb temperature of the supply air.

Figure 4–14 Examples of evaporative cooling arrangements



Direct evaporative cooling (Figure 4–14, Inset A) introduces water directly into the supply air stream, usually with a spray or wetted media. The water evaporates as it absorbs heat from the passing air, which lowers the dry-bulb temperature of the air. However, it also increases the moisture content of the air, which raises the dew point.

By contrast, *indirect evaporative cooling* (Inset B) uses an additional waterside coil to cool the supply air. Positioned upstream of the conventional cooling coil, the *indirect* coil is piped to a cooling tower where the evaporative process occurs. This method of precooling does not increase the moisture content (dew point) of the supply air because evaporation occurs at the tower. It is, however, not as effective as the direct evaporative cooling process.

A third option blends both direct and indirect evaporative processes. *Staged evaporative cooling systems* (Inset C) are arranged so that the indirect coil activates first, precooling the supply air without increasing the moisture content. The supply air then passes through the direct evaporative coil, where it is cooled further with only a slight increase in humidity. A conventional cooling coil, if used, provides the additional cooling needed to satisfy any remaining load.

Application considerations

- Although evaporative cooling can effectively reduce the amount of mechanical cooling an application requires, it seldom eliminates the need for a conventional cooling coil altogether.
- Using evaporative coils in conjunction with a conventional cooling coil typically adds from 0.2 in. wg to 0.4 in. wg to the static pressure of the air-distribution system.
- Direct evaporative cooling systems require additional care to ensure proper cleanliness and operation.


Sample scenario

The air-handling system for a building includes three cooling coils (illustrated in Figure 4–14 on page 4–40, Inset C) and an economizer that modulates based on the ambient dry-bulb temperature. If the economizer is unable to satisfy the cooling load—or if ambient conditions preclude economizer operation—then the indirect evaporative-cooling coil (60 percent effective) activates. If the cooling demand still is not satisfied, a direct evaporative-cooling coil (65 percent effective) activates. Any remaining load is handled by the conventional cooling coil. The added pressure drop imposed by the evaporative cooling coils increases the static-pressure requirement for the supply fan to 4 in. wg.

At the chilled-water plant, a water-cooled centrifugal chiller supplies cold water to the conventional cooling coil. The cooling tower furnishes water to the indirect evaporative-cooling coil. A pump, rated for 40 ft of static head, provides water from an auxiliary source to the direct evaporative-cooling coil.

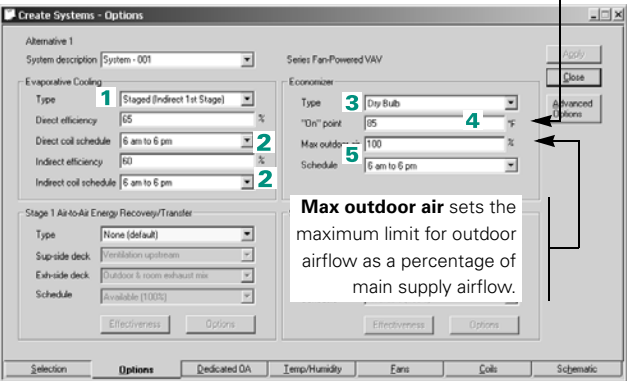
Note: Do not confuse evaporative cooling (modeled here) with evaporative precooling, (refer to “Evaporative precooling of condenser air” on page 3–54). Evaporative cooling reduces the

amount of mechanical cooling required, while evaporative precooling provides ambient relief for cooling equipment with air-cooled condensers.

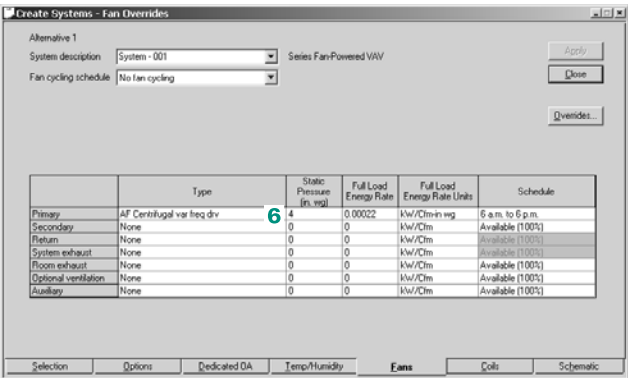
 Evaporative cooling and airside economizing are modeled as options of the air distribution system. After selecting an airside system (in this case, **Series Fan-Powered VAV**):

- 1 Describe the type of evaporative cooling desired. For this scenario, pick **Staged Evaporative Cooling** with the indirect coil activating first.
- 2 Specify the efficiency of each coil and when it can operate (schedule).
- 3 Choose an economizer type that describes the type of control desired (dry-bulb temperature, in this case.)
- 4 Set an on point to describe when the economizer should be enabled.
- 5 Specify how much outdoor air can be brought into the building (max outdoor air) and when the economizer can operate (schedule), weather permitting.
- 6 Enter the static pressure that the primary (supply) fan must overcome.


Evaporative cooling extends the operating range of the economizer. The outdoor condition at which the dampers are fully open is therefore higher than normal.



Note: Refer to “Creating schedules” on page 6–137 for information related to creating schedules.



	Type	Static Pressure (in. w.g.)	Full Load Energy Rate	Full Load Energy Rate Units	Schedule
Primary	AF Centrifugal var freq drv	4	0.00022	kW/Cfm in w.g.	6 a.m. to 6 p.m.
Secondary	None	0	0	kW/Cfm	Available (100%)
Return	None	0	0	kW/Cfm	Available (100%)
System exhaust	None	0	0	kW/Cfm	Available (100%)
Floor exhaust	None	0	0	kW/Cfm	Available (100%)
Optional ventilation	None	0	0	kW/Cfm	Available (100%)
Auxiliary	None	0	0	kW/Cfm	Available (100%)

 Next, define the cooling and heating plants that satisfy the coil loads.


- 7 Add a water-cooled chiller and a boiler to the main cooling and heating plants, respectively.

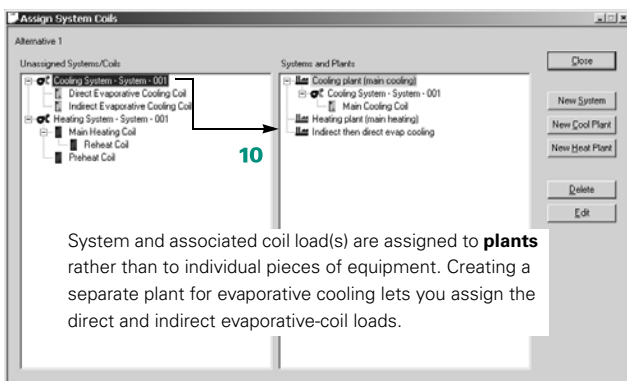
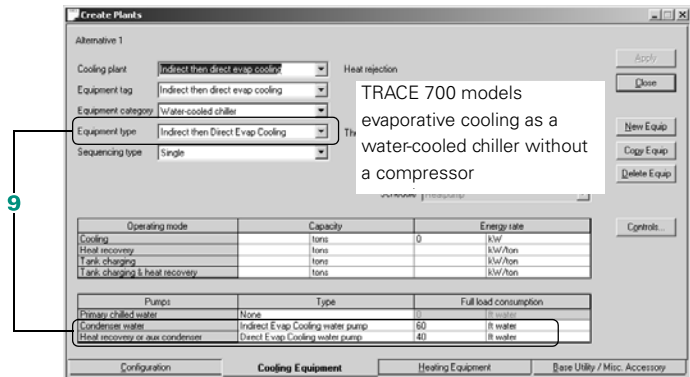
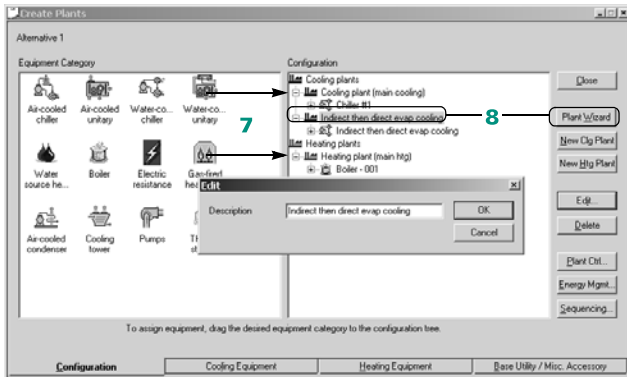
Not shown: On the appropriate tabs, define the **equipment type** and **full-load consumption** for the pumps.

- 8 Create a new cooling plant to represent the cooling provided by the evaporative coils (and permit proper coil assignment in Step 10).

Replace the generic identifier with a more-descriptive name for easy identification.

- 9 Define the evaporative cooling plant by choosing the appropriate **equipment type** and entering the **full-load consumption** for the pumps.

- 10  Assign the system and associated coil load(s) to the proper plant.



System and associated coil load(s) are assigned to **plants** rather than to individual pieces of equipment. Creating a separate plant for evaporative cooling lets you assign the direct and indirect evaporative-coil loads.



These illustrations from the Library/Template Editors program show how TRACE 700 models staged evaporative cooling.

The definition for the **Indirect then Direct Evap Cooling** equipment type resides in the **Cooling Equipment** library. It sets the compressor energy rate at 0 kW and assigns pumps that only operate when a load exists on the direct or indirect evaporative coil.

Library / Template Editors -

File View Options Window Help

TRANE®

Cooling Equipment -- Main

Cooling category: Water-cooled chiller
Equipment type: Indirect then Direct Evap Cooling
Cooling type: Centrifugal

Comments: Model of Indirect then Direct evaporative cooling equipment

Buttons: Save, Close, New, Copy, Delete, Curves...

Operating Mode	Capacity	Energy Rate
Cooling	tons	0 kW
Heat Recovery	tons	kW/ton
Tank Charging	tons	kW/ton
Tank Charging & heat recovery	tons	kW/ton

Pumps	Type
Primary chilled water	None
Condenser water	Indirect Evap Cooling water pump
Heat recovery or aux condensers	Direct Evap Cooling water pump

Unloading Curves

Curve type... Power consumed

Primary: E vap cooling
Secondary: E vap cooling

Standard DOE Ambient modification: E vap cooling amb
Capacity: None

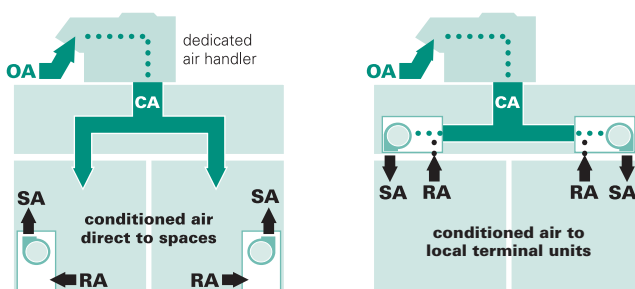
Buttons: Main, Options, Graph

For Help, press F1

Dedicated outdoor-air systems

A dedicated outdoor-air system (DOAS) (dedicated ventilation unit) uses a separate air handler to dehumidify, cool, heat, and sometimes humidify the incoming outdoor air before delivering it to other HVAC units or directly to the occupied zones. In either case, the local HVAC units handle the zone cooling and heating loads. Treating the outdoor air separately from recirculated return air makes it easy to verify sufficient ventilation airflow and enables enforcement of a maximum humidity limit in occupied zones.

Figure 4-15 Dedicated outdoor-air systems



Application considerations

- Always provide conditioned air that is drier than the air in the space. This practice minimizes the cooling capacity required from the local HVAC terminals and adequately controls the indoor relative humidity without additional, zone-level dehumidification enhancements.
- Deliver “cold” conditioned air whenever possible, and use recovered energy to reheat during mild weather. Providing “cold” conditioned air from the DOAS minimizes the cooling loads at the local HVAC terminals. During mild weather (spring and fall), modulate the amount of recovered energy used by the DOAS for reheat; only warm the conditioned air enough to minimize inefficient reheat at the local HVAC terminals. “Neutral”-temperature conditioned air (which has a dry-bulb temperature approximating that of the air in the space) increases the cooling

capacity required from the local HVAC terminals and requires more reheat at the dedicated outdoor-air unit.

- Select equipment to limit indoor relative humidity to 60–65 percent. Targeting a drier condition in the space will require larger equipment and consume more energy.
- Employ communicating controls to optimize energy use. Dynamically resetting the dew point or dry-bulb temperature delivered by the DOAS can minimize the energy use by the overall system.

Related reading

- “Dedicated Ventilation Systems,” *Engineers Newsletter* (volume 30, number 3)
- *Dehumidification in HVAC Systems* Applications Engineering Manual (Trane literature number SYS-APM004-EN)
- *Designing Dedicated Outdoor-Air Systems* Application Guide (Trane literature number SYS-APG001-EN).

Sample scenarios

Table 4–5 Sample Scenarios

Topic	
Scenario 1 (page 46)	Cool/Heat (Fixed Setpoints)
Scenario 2 (page 51)	Dehumidify and Reheat/Heat (Fixed Setpoints)
Scenario 3 (page 56)	Dehumidify (Priority) or Cool/Heat (Optimized SADP)
Scenario 4 (page 62)	Dehumidify and Reheat/Heat (Optimized SADB))

Scenario 1. A building is served by a fan-coil system and a dedicated outdoor-air unit that cools the outdoor air to 70°F dry bulb during the cooling season, or heats the outdoor air to 68°F dry bulb during the heating season, before delivering the conditioned outdoor air directly to the individual spaces. (Note: In non-arid climates, this approach may not adequately dehumidify the outdoor air.)

- When the outdoor dry-bulb temperature is greater than the cooling supply-air dry-bulb setpoint, the dedicated outdoor-air unit will cool the entering outdoor air to the cooling supply-air dry-bulb setpoint.

- When the outdoor dry-bulb temperature is less than the cooling supply-air dry-bulb setpoint, the dedicated outdoor-air unit will heat the entering outdoor air to the heating supply-air dry-bulb setpoint.

This example will cover how to model the air-distribution system (steps 1–8), model the cooling and heating equipment (steps 9–11), and assign the loads from the coils to the equipment (step 12).

- 1 Start by selecting **Fan Coil** as the system type.

- 2 On the **Dedicated OA** tab, select the type of dedicated ventilation unit to be modeled. In this example, the dedicated ventilation unit will supply air to spaces at a specific dry bulb. Therefore, **Cool / Heat** will be selected.

The top screenshot shows the 'Create Systems - Selection' dialog box. Under 'System type', 'Fan Coil' is selected and highlighted with a red '1'. The bottom screenshot shows the 'Create Systems - Dedicated Ventilation' dialog box. Under 'Configuration', 'Cool / Heat' is selected and highlighted with a red '2'. The 'Dedicated OA' tab is active, showing various setpoint and schedule options.

None – no dedicated ventilation unit

Cool / heat – a dedicated ventilation unit is used to cool the outdoor air to the user-input cooling dry bulb during the cooling season or heat the outdoor air to the user-input heating dry bulb during the heating season.

Dehumidify (priority) or Cool / Heat – a dedicated ventilation unit is used to dehumidify the outdoor air to the user-input cooling dew point (not reheated) during the cooling season or heat the outdoor air to the user-input heating dry bulb during the heating season.

Dehumidify and Reheat / Heat – a dedicated ventilation unit is used to dehumidify the outdoor air to the user-input cooling dew point (then reheat it to the user-input cooling dry bulb) during the cooling season or heat the outdoor air to the user-input heating dry bulb during the heating season.

3 Select the control method for the unit. Because the dedicated ventilation cooling coil cools the outdoor air to the cooling supply-air dry bulb, or the dedicated ventilation heating coil heats the outdoor air to the heating supply-air dry bulb, **Fixed Setpoints** will be used.

4 Input the Cooling and Heating Design Setpoints. In this scenario, 70°F should be input for the cooling supply-air dry bulb, and 68°F for the heating supply-air dry bulb.

5 Select the schedule for the coils and fan in the dedicated outdoor-air unit.

If the ventilation air is to be precooled, the **Dedicated Ventilation Cooling Coil** schedule defines the hours of available operation of the ventilation cooling coil. The optional ventilation cooling coil is available for any hour that this schedule reads 1 percent or greater.

If the ventilation air is to be preheated, the **Dedicated Ventilation Heating Coil** schedule defines the hours of available operation of the ventilation heating coil. The optional ventilation heating coil is available for any hour that this schedule reads 1 percent or greater.

The **Optional ventilation fan** schedule defines the hours that the ventilation unit can operate. If the **Optional ventilation fan** schedule reads 1 percent or greater, the fan is available that hour.

Note: If a custom schedule is created for the fan or coils, it is recommended to use values of 0 percent for hours off and 100 percent for hours available to run to avoid confusion.

- 6 Select the dedicated ventilation-deck location. This tells TRACE 700 where to supply the preconditioned outdoor air. For this scenario, the outdoor air will be delivered directly to the spaces. As a result, **Room Direct** will be selected.

Create Systems - Dedicated Ventilation

Alternative 1
System description: Fan Coils and DOAU

Configuration: Cool / Heat

Cooling/Heating Design Setpoints:
Cooling supply air dry bulb: 70 °F
Heating supply air dry bulb: 68 °F
Cooling supply air dew point: °F

Cooling SA dew point low limit: °F

Dedicated Ventilation Schedules:
Cooling coil: Available (100%)
Heating coil: Available (100%)
Optional ventilation fan: Available (100%)

Dedicated Ventilation Locations:
Deck: Room Direct
Level: System

Selection Options **Dedicated OA** Temp/Humidity Fans Coils Schematic

Return/Outdoor Deck – conditioned outdoor air is mixed with the return air in the main unit(s).

Plenum – conditioned outdoor air is delivered to the plenum above the spaces.

Room Direct – conditioned outdoor air is delivered directly to the spaces. This can also be used to model the delivery of conditioned outdoor air to dual-duct VAV boxes where it mixes locally with recirculated return air.

- 7 Select the level of the ventilation-deck location. For this scenario, one large dedicated ventilation unit will condition the outdoor air for all of the rooms assigned to the fan-coil system, so the coils should be set at the **System** level.

Create Systems - Dedicated Ventilation

Alternative 1
System description: Fan Coils and DOAU

Configuration: Cool / Heat

Cooling/Heating Design Setpoints:
Cooling supply air dry bulb: 70 °F
Heating supply air dry bulb: 68 °F
Cooling supply air dew point: °F

Cooling/Heating Setpoint Limits:
Supply air dry bulb high limit: °F
Supply air dry bulb low limit: °F
Cooling SA dew point high limit: °F
Cooling SA dew point low limit: °F

Dedicated Ventilation Schedules:
Cooling coil: Available (100%)
Heating coil: Available (100%)
Optional ventilation fan: Available (100%)

Dedicated Ventilation Locations:
Deck: Room Direct
Level: System

Apply Cancel

System – The dedicated ventilation unit will be placed at the system level. It will pretreat the outdoor air for all of the rooms and zones assigned to the airside system. This is the most common choice for dedicated ventilation systems. The **System Checksums** or **System Component Selection** reports should be used to size the dedicated ventilation unit.


Zone – Each zone (or room assigned directly to the system) will get a separate dedicated ventilation system. The **Zone Checksums** or **System Component Selection** reports should be used to size the dedicated ventilation unit.

Room – Each room will get a separate dedicated ventilation system. The **Room Checksums** or **System Component Selection** reports should be used to size the dedicated ventilation unit.

Same level as main cooling coil – The dedicated ventilation unit will be placed at the same level as the main cooling coil. The **System Component Selection** report should be used to size the dedicated ventilation unit.

Same level as main heating coil – The dedicated ventilation unit will be placed at the same level as the main heating coil. The **System Component Selection** report should be used to size the dedicated ventilation unit.


- 8 On the **Fans** tab, input the fan type and the total static pressure for the primary fan (the fans in the fan-coil units) and the optional ventilation fan (the fan in the dedicated ventilation unit).

 Next, define the **cooling and heating plants** represented by the fan-coil system and the rooftop air conditioner:

- 9 Add two new cooling plants and two new heating plants to the **Configuration** pane.

- 10 Drag the appropriate icons from the **Equipment Category** section to define each plant.

- 11 To finish defining this equipment, enter the information from Table 4–6 on page 4–51 on the appropriate equipment tab.

 Finally, assign the coil loads of the air-distribution system to the proper cooling and heating plants:

- 12 Drag each coil in the **Unassigned Systems/Coils** pane to the appropriate plant in the **Systems and Plants** pane.

The illustration labeled *After* shows the completed assignments.

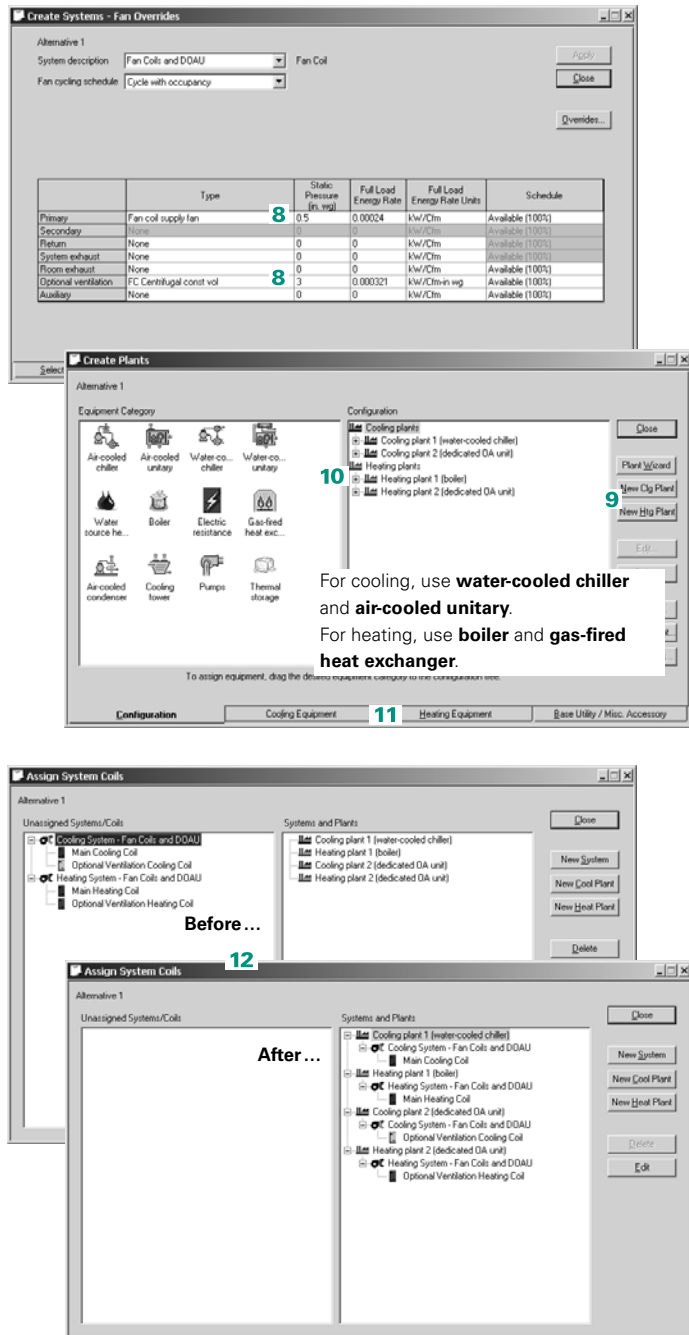


Table 4–6 Equipment types

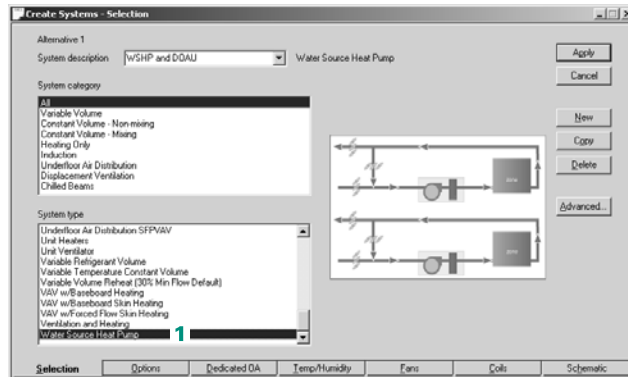
	Cooling Equipment tab	Heating Equipment tab
Water-cooled chiller	2-stage centrifugal	gas-fired hot water boiler
Air-cooled unitary	split system RAUC-20+ ton scroll	rooftop gas heat

Scenario 2. A building is served by a water-source heat pump (WSHP) system and a dedicated outdoor-air unit that delivers conditioned outdoor air to the individual heat pumps. During the cooling season, the dedicated outdoor-air unit dehumidifies the outdoor air to 55°F dew point and then reheats it to a “neutral” 70°F dry bulb. During the heating season, the dedicated unit heats the outdoor air to 68°F dry bulb.

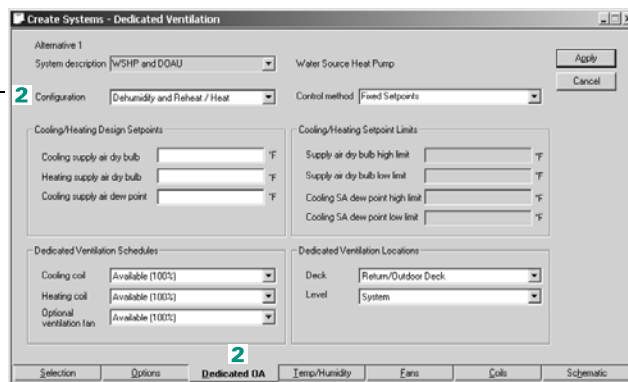
- When the outdoor dew point is greater than the cooling supply-air dew point setpoint, the dedicated outdoor-air unit will dehumidify the entering outdoor air to the cooling supply-air dew point setpoint, then reheat it to the cooling supply-air dry-bulb setpoint.
- When the outdoor dew point is less than the cooling supply-air dew point setpoint and the outdoor dry-bulb temperature is greater than the cooling supply-air dry-bulb setpoint, the dedicated outdoor-air unit will cool the entering outdoor air to the cooling supply-air dry-bulb setpoint.
- When the outdoor dew point is less than the cooling supply-air dew point setpoint and the outdoor dry-bulb temperature is less than the cooling supply-air dry-bulb setpoint, the dedicated outdoor-air unit will heat the entering outdoor air to the heating supply-air dry-bulb setpoint.

This example will cover how to model the air-distribution system (steps 1–8), model the cooling and heating equipment (steps 9–11), and assign the loads from the coils to the equipment (step 12).

- 1 Start by selecting **Water source heat pump** as the system type.



- 2 On the **Dedicated OA** tab, select the type of dedicated ventilation unit to be modeled. In this example, the dedicated ventilation unit will supply low dew-point air reheated to a room-neutral dry bulb in cooling mode, and air at a specific dry bulb in heating mode. Therefore, **Dehumidify and Reheat / Heat** will be selected.



None – no dedicated ventilation unit

Cool / heat – a dedicated ventilation unit is used to cool the outdoor air to the user-input cooling dry bulb during the cooling season, or heat the outdoor air to the user-input heating dry bulb during the heating season.

Dehumidify (priority) or Cool / Heat – a dedicated ventilation unit is used to dehumidify the outdoor air to the user-input cooling dew point (not reheated) during the cooling season, or heat the outdoor air to the user-input heating dry bulb during the heating season.

Dehumidify and Reheat / Heat – a dedicated ventilation unit is used to dehumidify the outdoor air to the user-input cooling dew point (then reheat it to the user-input cooling dry bulb) during the cooling season, or heat the outdoor air to the user-input heating dry bulb during the heating season.

3 Select the control method for the unit. Because the dedicated ventilation cooling coil dehumidifies the outdoor air to cooling supply-air dew point and reheats it to room neutral, or the dedicated ventilation heating coil heats the outdoor air to heating supply-air dry bulb, **Fixed Setpoints** will be used.

4 Input the Cooling and Heating Design Setpoints. In this scenario, 55°F should be input for the cooling supply-air dew point, 70°F for the cooling supply-air dry bulb, and 68°F for the heating supply-air dry bulb.

5 Select the schedule for the coils and fan in the dedicated outdoor-air unit.

Note: If a custom schedule is created for the fan or coils, it is recommended to use values of 0 percent for hours off and 100 percent for hours available to run to avoid confusion.

Create Systems - Dedicated Ventilation

Alternative 1
System description: [wSHP and DOAU]
Configuration: [Dehumidify and Reheat / Heat]
Cooling/Heating Design Setpoints:
Cooling supply air dry bulb: [] °F
Heating supply air dry bulb: [] °F
Cooling supply air dew point: [] °F
Dedicated Ventilation Schedules:
Cooling coil: [Available (100%)]
Heating coil: [Available (100%)]
Optional ventilation fan: [Available (100%)]
Dedicated Ventilation Locations:
Deck: [Return/Outdoor Deck]
Level: [System]

Create Systems - Dedicated Ventilation

Alternative 1
System description: [wSHP and DOAU]
Configuration: [Dehumidify and Reheat / Heat]
Cooling/Heating Design Setpoints:
Cooling supply air dry bulb: [70] °F
Heating supply air dry bulb: [68] °F
Cooling supply air dew point: [55] °F
Dedicated Ventilation Schedules:
Cooling coil: [Available (100%)]
Heating coil: [Available (100%)]
Optional ventilation fan: [Available (100%)]
Dedicated Ventilation Locations:
Deck: [Return/Outdoor Deck]
Level: [System]

Selection Options **Dedicated OA** Temp/Humidity Fans Coils Schematic

If the ventilation air is to be precooled, the **Dedicated Ventilation Cooling Coil** schedule defines the hours of available operation of the ventilation cooling coil. The optional ventilation cooling coil is available for any hour that this schedule reads 1 percent or greater.

If the ventilation air is to be preheated, the **Dedicated Ventilation Heating Coil** schedule defines the hours of available operation of the ventilation heating coil. The optional ventilation heating coil is available for any hour that this schedule reads 1 percent or greater.

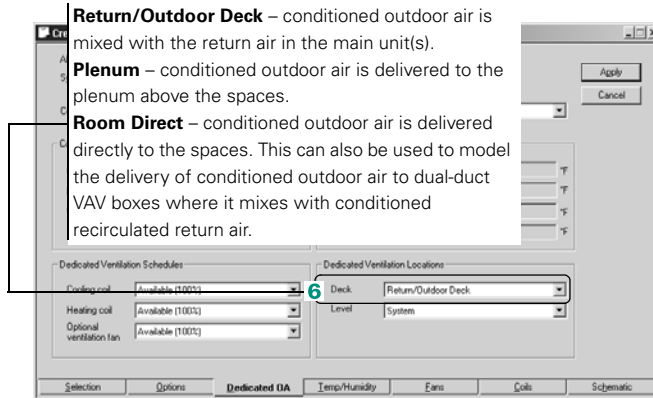
The **Optional ventilation fan** schedule defines the hours that the ventilation unit can operate. If the **Optional ventilation fan** schedule reads 1 percent or greater, the fan is available that hour.

Create Systems - Dedicated Ventilation

Alternative 1
System description: [wSHP and DOAU]
Configuration: [Dehumidify and Reheat / Heat]
Cooling/Heating Design Setpoints:
Cooling supply air dry bulb: [70] °F
Heating supply air dry bulb: [68] °F
Cooling supply air dew point: [55] °F
Dedicated Ventilation Schedules:
Cooling coil: [Available (100%)]
Heating coil: [Available (100%)]
Optional ventilation fan: [Available (100%)]
Dedicated Ventilation Locations:
Deck: [Return/Outdoor Deck]
Level: [System]

Selection Options **Dedicated OA**

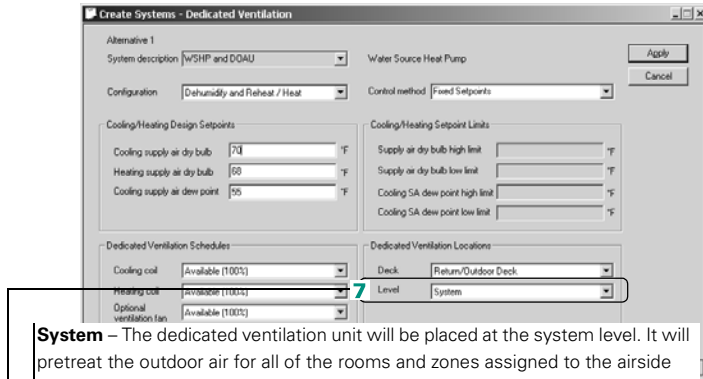
- 6 Select the dedicated ventilation deck location. This tells TRACE 700 where to supply the preconditioned outdoor air. For this scenario, the outdoor air will be delivered to the heat pumps. As a result, **Return/Outdoor Deck** will be selected.



Return/Outdoor Deck – conditioned outdoor air is mixed with the return air in the main unit(s).
Plenum – conditioned outdoor air is delivered to the plenum above the spaces.
Room Direct – conditioned outdoor air is delivered directly to the spaces. This can also be used to model the delivery of conditioned outdoor air to dual-duct VAV boxes where it mixes with conditioned recirculated return air.

- 7 Select the level of the ventilation deck location. For this scenario, one large dedicated ventilation unit will condition the outdoor air for all of the rooms assigned to the WSHP airside system, so the coils should be set at the **System** level.

*Note: For additional details on **Systems**, refer to the **System Type: Characteristics** in online Help.*



System – The dedicated ventilation unit will be placed at the system level. It will pretreat the outdoor air for all of the rooms and zones assigned to the airside system. This is the most common choice for dedicated ventilation systems. The **System Checksums** or **System Component Selection** reports should be used to size the dedicated ventilation unit.


Zone – Each zone (or room assigned directly to the system) will get a separate dedicated ventilation system. The **Zone Checksums** or **System Component Selection** reports should be used to size the dedicated ventilation unit.

Room – Each room will get a separate dedicated ventilation system. The **Room Checksums** or **System Component Selection** reports should be used to size the dedicated ventilation unit.

Same level as main cooling coil – The dedicated ventilation unit will be placed at the same level as the main cooling coil. The **System Component Selection** report should be used to size the dedicated ventilation unit.

Same level as main heating coil – The dedicated ventilation unit will be placed at the same level as the main heating coil. The **System Component Selection** report should be used to size the dedicated ventilation unit.


- 8 On the **Fans** tab, input the fan type and the total static pressure for the primary fan (the fans in the WSHP units) and the optional ventilation fan (the fan in the dedicated ventilation unit).

 Next, define the **cooling and heating plants** represented by the WSHP system and the rooftop air conditioner.

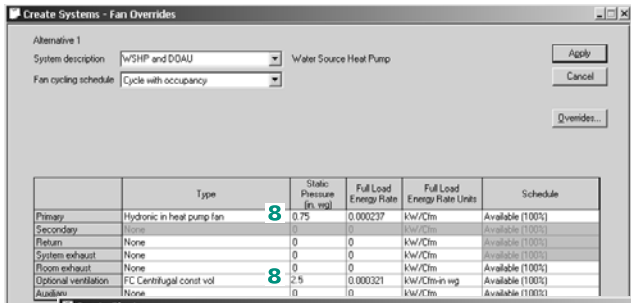
- 9 Add two new cooling plants and two new heating plants to the **Configuration** pane.

- 10 Drag the appropriate icons from the **Equipment Category** section to define each plant.

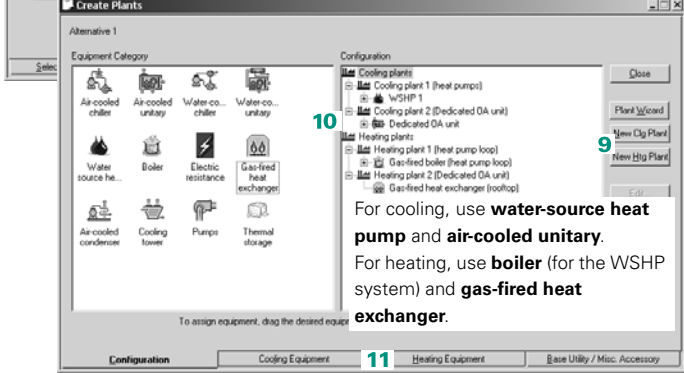
- 11 To finish defining this equipment, enter the information from Table 4–7 on page 4–56 on the appropriate equipment tab.

 Finally, assign the coil loads of the air distribution system to the proper cooling and heating plants.

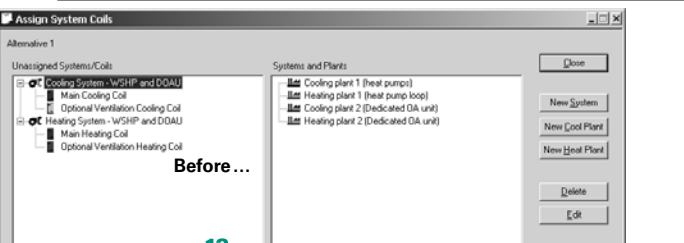
- 12 Drag each coil in the Unassigned Systems/ Coils pane to the appropriate plant in the Systems and Plants pane. The illustration labeled “After” shows the completed assignments.



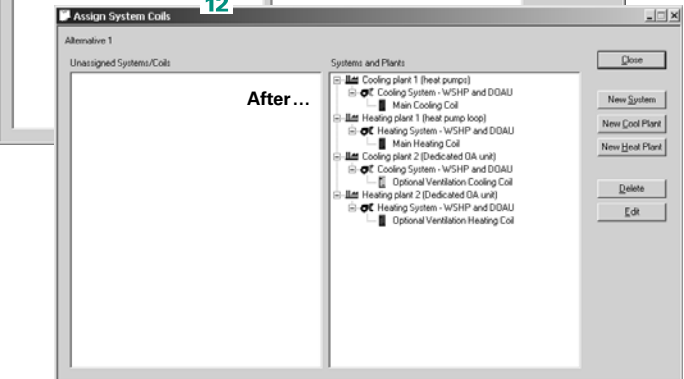
	Type	Static Pressure (in. wg)	Full Load Energy Rate	Full Load Energy Rate Units	Schedule
Primary	Hydronic in heat pump fan	0.75	0.000237	kW/Cfm	Available (100%)
Secondary	None	0	0	kW/Cfm	Available (100%)
Return	None	0	0	kW/Cfm	Available (100%)
System exhaust	None	0	0	kW/Cfm	Available (100%)
Floor exhaust	None	0	0	kW/Cfm	Available (100%)
Optional ventilation	FC Centrifugal const vol	2.5	0.000321	kW/Cfm-in wg	Available (100%)
Auxiliary	None	0	0	kW/Cfm	Available (100%)



For cooling, use **water-source heat pump** and **air-cooled unitary**.
For heating, use **boiler** (for the WSHP system) and **gas-fired heat exchanger**.



Before ...



After ...

Table 4–7 Equipment types

	Cooling Equipment tab	Heating Equipment tab
Water-source heat pump	water source HP–high efficiency	gas-fired hot water boiler
Air-cooled unitary	split system RAUC-20+ ton scroll	rooftop gas heat

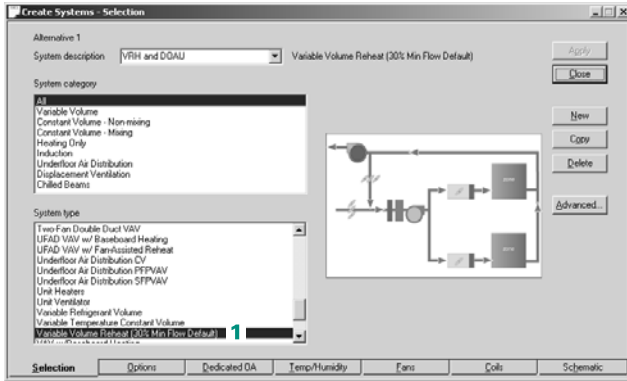
Scenario 3. A building is served by a VAV air-handling system on each floor. A dedicated outdoor-air unit delivers conditioned outdoor air to the intake of each air handler. During the cooling season, the dedicated outdoor-air unit dehumidifies the outdoor air to 55°F dew point, but does not reheat it. During the heating season, the dedicated unit heats the outdoor air to 68°F dry bulb.

In addition, the system-level controller polls the humidity sensors located in each room and resets the dew point leaving the dedicated outdoor-air unit, to prevent the relative humidity in the worst-case room from rising above 60% while minimizing energy use.

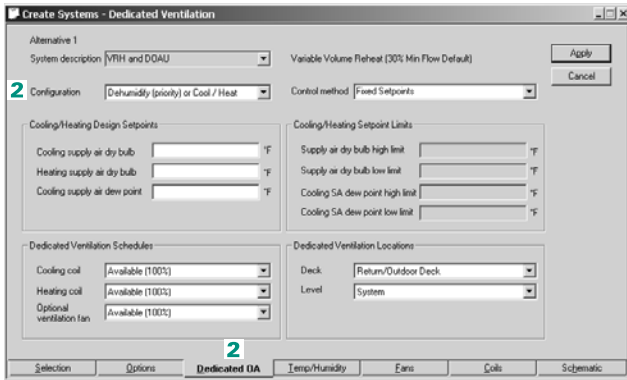
- The system controller determines the highest possible cooling supply-air dew point setpoint that still avoids the relative humidity from rising above the maximum upper limit (60%, in our example) in any room.
- When the outdoor dew point is greater than the current cooling supply-air dew point setpoint, the dedicated outdoor-air unit will dehumidify the entering outdoor air to the cooling supply-air dew point setpoint.
- When the outdoor dew point is less than the current supply-air dew point setpoint and the outdoor dry-bulb temperature is greater than the cooling supply-air dry-bulb setpoint, the dedicated outdoor-air unit will cool the entering outdoor air to the cooling supply-air dry-bulb setpoint.
- When the outdoor dew point is less than the current cooling supply-air dew point setpoint and the outdoor dry-bulb temperature is less than the cooling supply-air dry-bulb setpoint, the dedicated outdoor-air unit will heat the entering outdoor air to the heating supply-air dry-bulb setpoint.

This example will cover how to model the air-distribution system (steps 1–8), model the cooling and heating equipment (steps 9–11), and assign the loads from the coils to the equipment (step 12).

- 1 Start by selecting **Variable Volume Reheat** as the system type.



- 2 On the **Dedicated OA** tab, select the type of dedicated ventilation unit to be modeled. In this example, the dedicated ventilation unit will supply low dew-point air (not reheated) in cooling mode, and air at a specific dry bulb in heating mode. Therefore, **Dehumidify (priority) or Cool / Heat** will be selected.



None – no dedicated ventilation unit

Cool / heat – a dedicated ventilation unit is used to cool the outdoor air to the user-input cooling dry bulb during the cooling season, or heat the outdoor air to the user-input heating dry bulb during the heating season.

Dehumidify (priority) or Cool / Heat – a dedicated ventilation unit is used to dehumidify the outdoor air to the user-input cooling dew point (not reheated) during the cooling season, or heat the outdoor air to the user-input heating dry bulb during the heating season.

Dehumidify and Reheat / Heat – a dedicated ventilation unit is used to dehumidify the outdoor air to the user-input cooling dew point (then reheat it to the user-input cooling dry bulb) during the cooling season, or heat the outdoor air to the user-input heating dry bulb during the heating season.

- 3 Select the control method for the unit. Because the dew point delivered by the dedicated ventilation cooling coil is reset based on the worst-case room, **Optimize Supply Air Dew Point** will be used.

- 4 Input the **Cooling and Heating Design Setpoints**. In this scenario, 65°F should be input for the cooling supply-air dry bulb, 68°F for the heating supply-air dry bulb, 65°F for the cooling supply-air dew point high limit, and 55°F for the cooling supply-air dew point low limit.

If the ventilation air is to be precooled, the **Dedicated Ventilation Cooling Coil** schedule defines the hours of available operation of the ventilation cooling coil. The optional ventilation cooling coil is available for any hour that this schedule reads 1 percent or greater.

- 5 Select the schedule for the coils and fan in the dedicated outdoor-air unit.

Note: If a custom schedule is created for the fan or coils, it is recommended to use values of 0 percent for hours off and 100 percent for hours available to run to avoid confusion.

If the ventilation air is to be preheated, the **Dedicated Ventilation Heating Coil** schedule defines the hours of available operation of the ventilation heating coil. The optional ventilation heating coil is available for any hour that this schedule reads 1 percent or greater.

The **Optional ventilation fan** schedule defines the hours that the ventilation unit can operate. If the **Optional ventilation fan** schedule reads 1 percent or greater, the fan is available that hour.

- 6 Select the dedicated ventilation deck location. This tells TRACE 700 where to supply the preconditioned outdoor air. For this scenario, the outdoor air will be delivered to the mixing box of the VAV air handler. As a result, **Return / Outdoor Deck** will be selected.

Return/Outdoor Deck – conditioned outdoor air is mixed with the return air in the main unit(s).

Plenum – conditioned outdoor air is delivered to the plenum above the spaces.

Room Direct – conditioned outdoor air is delivered directly to the spaces. This can also be used to model the delivery of conditioned outdoor air to dual-duct VAV boxes where it mixes with conditioned recirculated return air.

- 7 Select the level of the ventilation deck location. For this scenario, one large dedicated ventilation unit will condition the outdoor air for all of the rooms assigned to the VAV airside system, so the coils should be set at the **System** level.

*Note: For additional details on **Systems**, refer to the **System Type: Characteristics** in online Help.*

System – The dedicated ventilation unit will be placed at the system level. It will pretreat the outdoor air for all of the rooms and zones assigned to the airside system. This is the most common choice for dedicated ventilation systems. The **System Checksums** or **System Component Selection** reports should be used to size the dedicated ventilation unit.

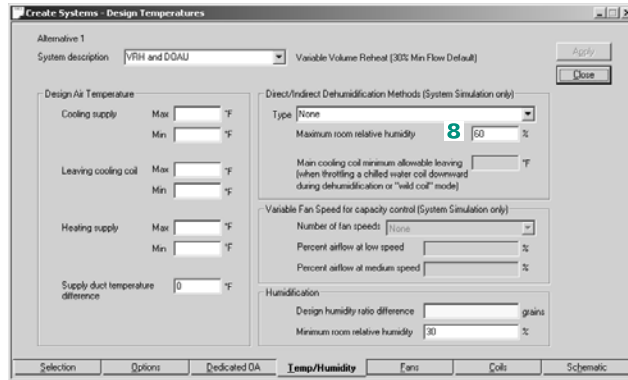
Zone – Each zone (or room assigned directly to the system) will get a separate dedicated ventilation system. The **Zone Checksums** or **System Component Selection** reports should be used to size the dedicated ventilation unit.

Room – Each room will get a separate dedicated ventilation system. The **Room Checksums** or **System Component Selection** reports should be used to size the dedicated ventilation unit.

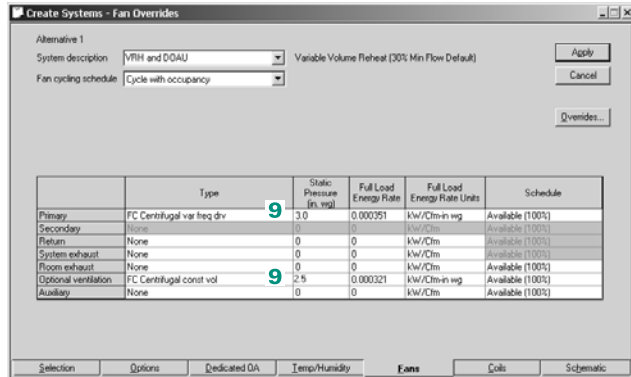
Same level as main cooling coil – The dedicated ventilation unit will be placed at the same level as the main cooling coil. The **System Component Selection** report should be used to size the dedicated ventilation unit.

Same level as main heating coil – The dedicated ventilation unit will be placed at the same level as the main heating coil. The **System Component Selection** report should be used to size the dedicated ventilation unit.

8 On the **Temp/Humidity** tab, specify a **Maximum room relative humidity of 60%**.



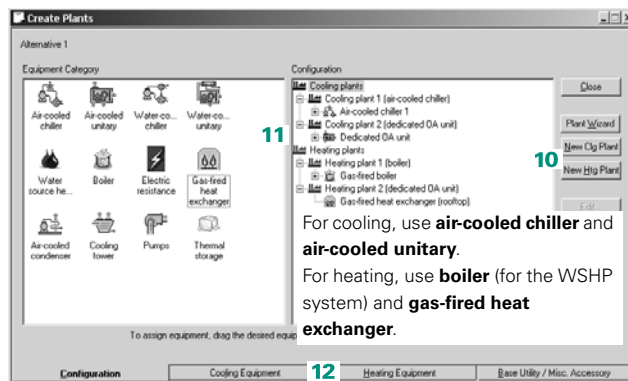
9 On the **Fans** tab, input the fan type and the total static pressure for the primary fan (the fans in the VAV air handler) and the optional ventilation fan (the fan in the dedicated ventilation unit).



Next, define the **cooling and heating plants** represented by the VAV system and the rooftop air conditioner.

10 Add two new cooling plants and two new heating plants to the **Configuration** pane.


11 Drag the appropriate icons from the **Equipment Category** section to define each plant.



For cooling, use **air-cooled chiller** and **air-cooled unitary**.

For heating, use **boiler** (for the WSHW system) and **gas-fired heat exchanger**.

12 To finish defining this equipment, enter the information from Table 4-8 on page 4-61 on the appropriate equipment tab.

 Finally, assign the coil loads of the air distribution system to the proper cooling and heating plants.

13 Drag each coil in the Unassigned Systems/Coils pane to the appropriate plant in the Systems and Plants pane.

The illustration labeled “After” shows the completed assignments.

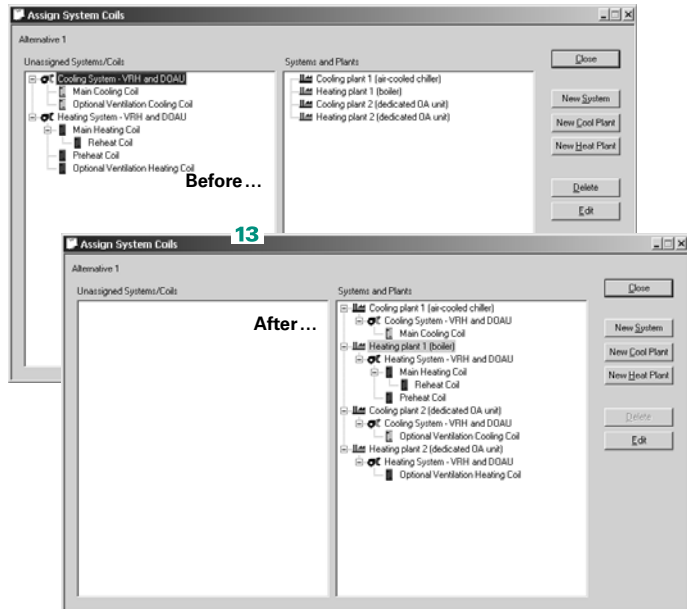


Table 4–8 Equipment types

	Cooling Equipment tab	Heating Equipment tab
Air-cooled chiller	air-cooled helical-rotary chiller	gas-fired hot water boiler
Air-cooled unitary	split system RAUC-20+ ton scroll	rooftop gas heat

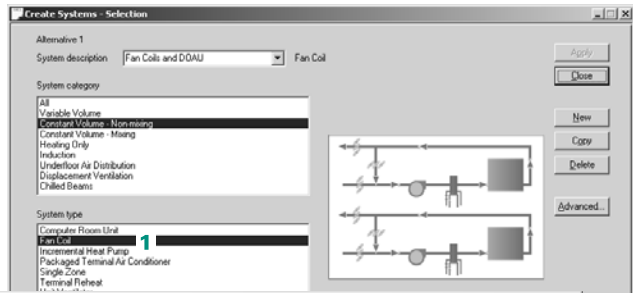
Scenario 4. A building is served by a fan-coil system and a dedicated outdoor-air unit that delivers conditioned outdoor air directly to the individual spaces. The system-level controller polls the fan-coils and resets the dry-bulb temperature leaving the dedicated outdoor-air unit to avoid overcooling or overheating any room.

During the cooling season, the dedicated outdoor-air unit dehumidifies the outdoor air to 55°F dew point and then, if necessary, reheats it just enough to avoid overcooling the room with the lowest sensible cooling load. During the heating season, the dedicated unit heats the outdoor air as much as possible, without overheating the room with the lowest sensible heating load.

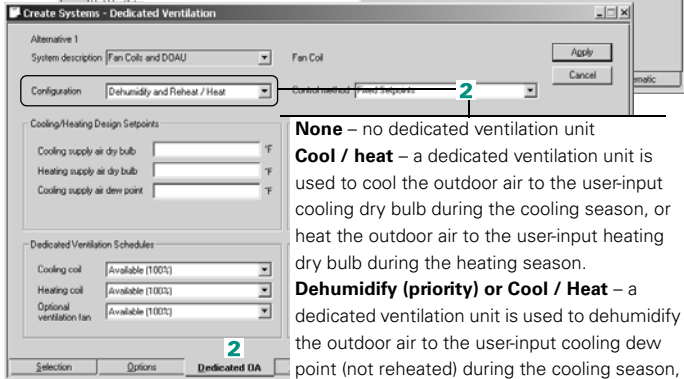
- The system controller determines the current supply-air dry-bulb setpoint needed to avoid overcooling or overheating any room.
- When the outdoor dew point is greater than the cooling supply-air dew point setpoint, the dedicated outdoor-air unit will dehumidify the entering outdoor air to the cooling supply-air dew point setpoint, then reheat it to the current supply-air dry-bulb setpoint.
- When the outdoor dew point is less than the cooling supply-air dew point setpoint and the outdoor dry-bulb temperature is greater than the current supply-air dry-bulb setpoint, the dedicated outdoor-air unit will cool the entering outdoor air to the current supply-air dry-bulb setpoint.
- When the outdoor dew point is less than the cooling supply-air dew point setpoint and the outdoor dry-bulb temperature is less than the current supply-air dry-bulb setpoint, the dedicated outdoor-air unit will heat the entering outdoor air to the current supply-air dry-bulb setpoint.

This example will cover how to model the air-distribution system (steps 1–8), model the cooling and heating equipment (steps 9–11), and assign the loads from the coils to the equipment (step 12).

- 1 Start by selecting **Fan Coil** as the system type.

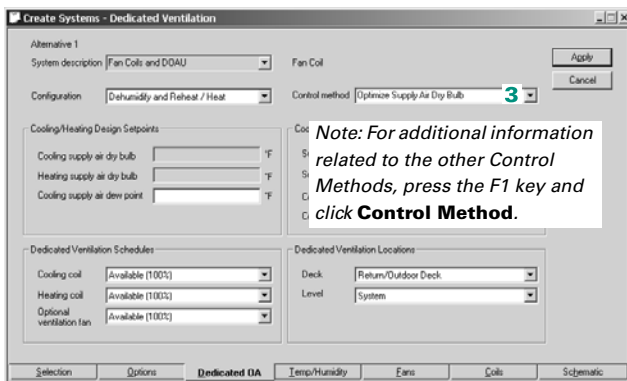


- 2 On the **Dedicated OA** tab, select the type of dedicated ventilation unit to be modeled. In this example, the dedicated ventilation unit will supply low dew-point air (and possibly reheated) in cooling mode, and air at a specific dry bulb in heating mode. Therefore, **Dehumidify and Reheat / Heat** will be selected.



None – no dedicated ventilation unit
Cool / heat – a dedicated ventilation unit is used to cool the outdoor air to the user-input cooling dry bulb during the cooling season, or heat the outdoor air to the user-input heating dry bulb during the heating season.
Dehumidify (priority) or Cool / Heat – a dedicated ventilation unit is used to dehumidify the outdoor air to the user-input cooling dew point (not reheated) during the cooling season, or heat the outdoor air to the user-input heating dry bulb during the heating season.
Dehumidify and Reheat / Heat – a dedicated ventilation unit is used to dehumidify the outdoor air to the user-input cooling dew point (then reheat it to the user-input cooling dry bulb) during the cooling season, or heat the outdoor air to the user-input heating dry bulb during the heating season.

- 3 Select the control method for the unit. Because the dedicated ventilation cooling coil dehumidifies the outdoor air to cooling supply-air dew point and reheats it based on the worst-case room, or the dedicated ventilation heating coil heats the outdoor air to heating supply-air dry bulb, **Optimize SADB** will be used.



- 4 Input the Cooling and Heating Design Setpoints. In this scenario, 55°F should be input for the cooling supply-air dew point, 55°F for the supply-air dry bulb low limit, and 70°F for the supply-air dry bulb high limit.

If the ventilation air is to be precooled, the **Dedicated Ventilation Cooling Coil** schedule defines the hours of available operation of the ventilation cooling coil. The optional ventilation cooling coil is available for any hour that this schedule reads 1 percent or greater.

- 5 Select the schedule for the coils and fan in the dedicated outdoor-air unit.

Note: If a custom schedule is created for the fan or coils, it is recommended to use values of 0 percent for hours off and 100 percent for hours available to run to avoid confusion.

If the ventilation air is to be preheated, the **Dedicated Ventilation Heating Coil** schedule defines the hours of available operation of the ventilation heating coil. The optional ventilation heating coil is available for any hour that this schedule reads 1 percent or greater.

The **Optional ventilation fan** schedule defines the hours that the ventilation unit can operate.

If the **Optional ventilation fan** schedule reads 1 percent or greater, the fan is available that hour.

- 6 Select the dedicated ventilation deck location. This tells TRACE 700 where to supply the preconditioned outdoor air. For this scenario, the outdoor air will be delivered directly to the spaces. As a result, **Room Direct** will be selected.

Return/Outdoor Deck – conditioned outdoor air is mixed with the return air in the main unit(s).

Plenum – conditioned outdoor air is delivered to the plenum above the spaces.

Room Direct – conditioned outdoor air is delivered directly to the spaces. This can also be used to model the delivery of conditioned outdoor air to dual-duct VAV boxes where it mixes with conditioned recirculated return air.

- 7 Select the level of the ventilation deck location. For this scenario, one large dedicated ventilation unit will condition the outdoor air for all of the rooms assigned to the Fan Coil system, so the coils should be set at the **System** level.

*Note: For additional details on **Systems**, refer to the **System Type: Characteristics** in online Help.*

System – The dedicated ventilation unit will be placed at the system level. It will pretreat the outdoor air for all of the rooms and zones assigned to the airside system. This is the most common choice for dedicated ventilation systems. The **System Checksums** or **System Component Selection** reports should be used to size the dedicated ventilation unit.

Zone – Each zone (or room assigned directly to the system) will get a separate dedicated ventilation system. The **Zone Checksums** or **System Component Selection** reports should be used to size the dedicated ventilation unit.


Room – Each room will get a separate dedicated ventilation system. The **Room Checksums** or **System Component Selection** reports should be used to size the dedicated ventilation unit.

Same level as main cooling coil – The dedicated ventilation unit will be placed at the same level as the main cooling coil. The **System Component Selection** report should be used to size the dedicated ventilation unit.

Same level as main heating coil – The dedicated ventilation unit will be placed at the same level as the main heating coil. The **System Component Selection** report should be used to size the dedicated ventilation unit.

- 8 On the **Fans** tab, input the fan type and the total static pressure for the primary fan (the fans in the Fan Coil units) and the optional ventilation fan (the fan in the dedicated ventilation unit).


	Type	Static Pressure (in. w.g.)	Full Load Energy Rate	Full Load Energy Rate Units	Schedule
Primary	Fan coil supply fan	0.5	0.00024	kW/Cfm	Available (100%)
Secondary	None	0	0	kW/Cfm	Available (100%)
Return	None	0	0	kW/Cfm	Available (100%)
System exhaust	None	0	0	kW/Cfm	Available (100%)
Room exhaust	None	0	0	kW/Cfm	Available (100%)
Optional ventilation	FC Centrifugal const vol	3.0	0.000321	kW/Cfm-in w/g	Available (100%)
Auxiliary	None	0	0	kW/Cfm	Available (100%)

 Next, define the **cooling and heating plants** represented by the fan coil system and the rooftop air conditioner.

9 Add two new cooling plants and two new heating plants to the **Configuration** pane.

10 Drag the appropriate icons from the **Equipment Category** section to define each plant.

11To finish defining this equipment, enter the information from Table 4–9 on page 4–66 on the appropriate equipment tab.

 Finally, assign the coil loads of the air distribution system to the proper cooling and heating plants.

12Drag each coil in the Unassigned Systems/ Coils pane to the appropriate plant in the Systems and Plants pane.

The illustration labeled “After” shows the completed assignments.

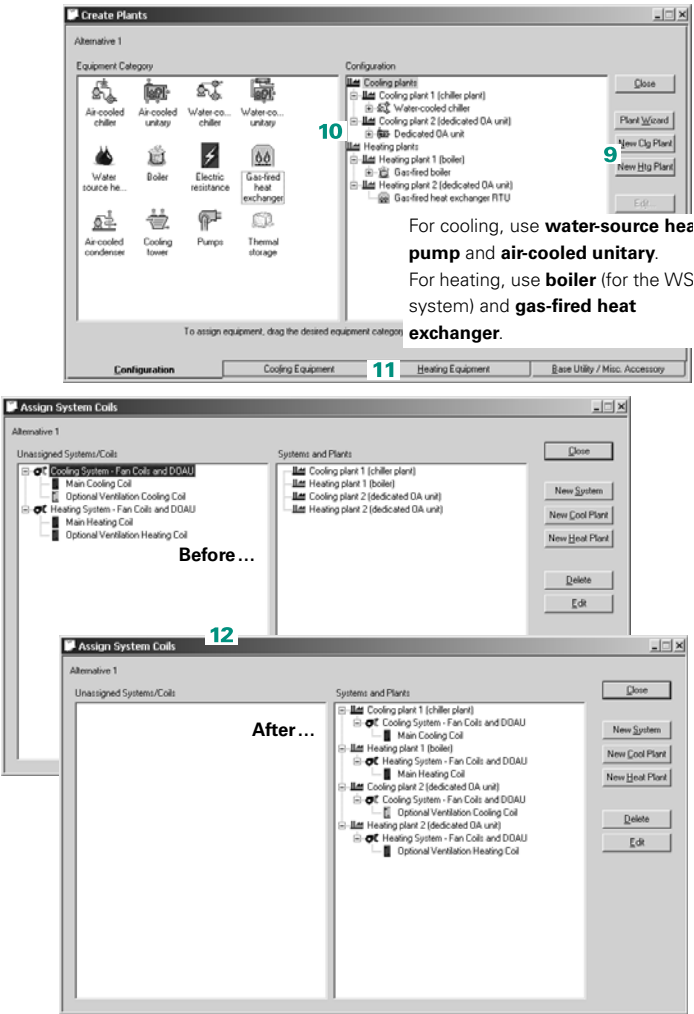


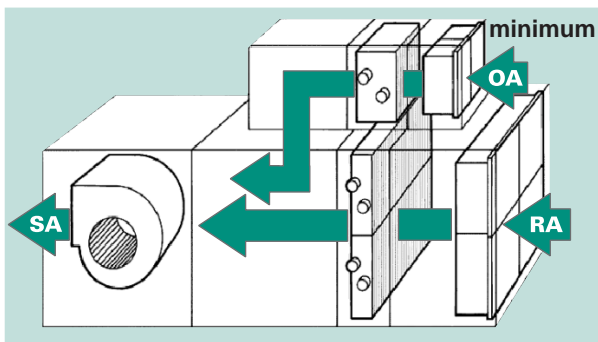
Table 4–9 Equipment types

	Cooling Equipment tab	Heating Equipment tab
Water-source heat pump	3-stage centrifugal chiller	gas-fired hot water boiler
Air-cooled unitary	split system RAUC-20+ ton scroll	rooftop gas heat

Dual-Path Air Handler (Split Dehumidification Unit)

A dual-path air handler (split dehumidification unit) separately conditions the outdoor and recirculated airstreams within the same unit. Each airstream has its own cooling coil, but a single constant-volume fan serves both paths.

Figure 4-16 Split dehumidification unit



Sample scenario

A large meeting room is served by a dual-path air handler (split dehumidification unit). During the cooling season, the dew point of the air leaving the outdoor-air cooling coil is adjusted to prevent the relative humidity in the room from rising above 60%. The return-air cooling coil is then modulated to maintain the space dry-bulb temperature at setpoint. During the heating season, the outdoor-air heating coil heats the entering outdoor air to 55°F dry bulb.

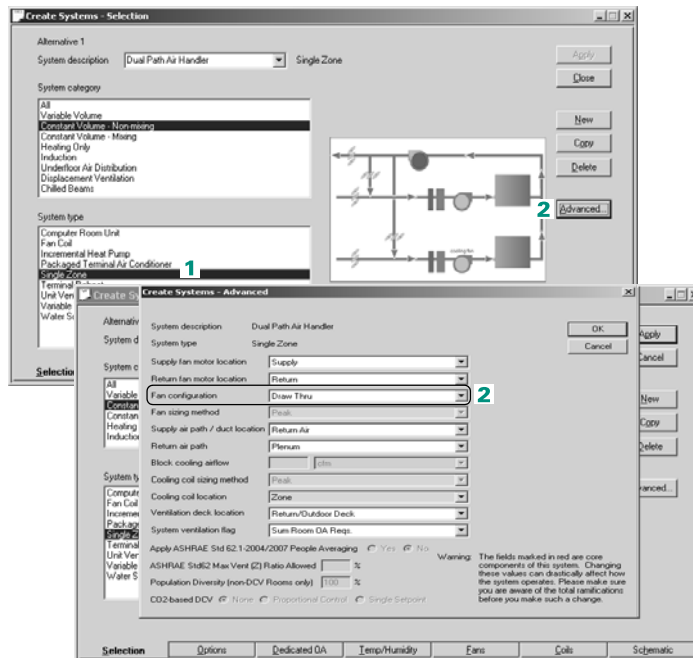
- The system controller determines the highest possible dew point leaving the outdoor-air cooling coil that avoids the room relative humidity from rising above the maximum upper limit (60%, in this example).
- When the outdoor dew point is greater than the current cooling supply-air dew point setpoint, the outdoor-air cooling coil will dehumidify the entering outdoor air to the cooling supply-air dew point setpoint. The return-air cooling or heating coil modulates to maintain the space temperature at setpoint.

- When the outdoor dew point is less than the current supply-air dew point setpoint and the outdoor dry-bulb temperature is greater than the cooling supply-air dry-bulb setpoint, the outdoor-air cooling coil will cool the entering outdoor air to the cooling supply-air dry-bulb setpoint. The return-air cooling or heating coil modulates to maintain the space temperature at setpoint.
- When the outdoor dew point is less than the current cooling supply-air dew point setpoint and the outdoor dry-bulb temperature is less than the cooling supply-air dry-bulb setpoint, the outdoor-air heating coil will heat the entering outdoor air to the heating supply-air dry-bulb setpoint. (If no heating coil exists in the outdoor-air path, input the heating supply-air dry bulb colder than the winter outdoor design temperature.) The return-air cooling or heating coil modulates to maintain the space temperature at setpoint.

This example will cover how to model the air-distribution system (steps 1–8), model the cooling and heating equipment (steps 9–11), and assign the loads from the coils to the equipment (step 12).

1 Start by selecting **Single Zone** as the system type.

2 Click **Advanced** and select (or verify) **Draw Thru** fan configuration.



- 3 On the **Dedicated OA** tab, select **Split Dehumidification Unit**.

Split Dehumidification Unit – a dual-path air handler brings outdoor air through a dedicated coil to cool the outdoor air to the user-input cooling dew point (not reheated) during the cooling season, or heat the outdoor air to the user-input heating dry bulb during the heating season, before it is mixed with recirculated return air and delivered through a common supply fan.

- 4 Select the control method for the unit. Because the ventilation cooling coil dehumidifies the outdoor air to the cooling supply-air dew point that is reset based on room relative humidity, **Optimize Supply Air Dew Point** will be used.

*Note: For additional information related to the other Control Methods, press F1 and click **Control Method**.*

- 5 Input the Cooling and Heating Design Setpoints. In this scenario, 65°F should be input for the cooling supply-air dry bulb, 55°F for the heating supply-air dry bulb, 65°F for the cooling supply-air dew point high limit, and 55°F for the cooling supply-air dew point low limit.

- 6 Select the schedule for the coils and fan in the split dehumidification unit.

If the ventilation air is to be precooled, the **Dedicated Ventilation Cooling Coil** schedule defines the hours of available operation of the ventilation cooling coil. The optional ventilation cooling coil is available for any hour that this schedule reads 1 percent or greater.

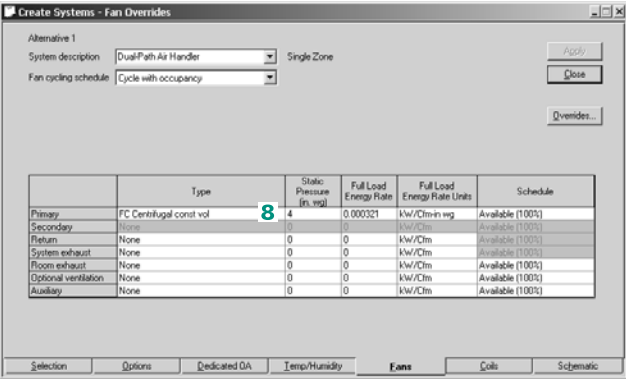
If the ventilation air is to be preheated, the **Dedicated Ventilation Heating Coil** schedule defines the hours of available operation of the ventilation heating coil. The optional ventilation heating coil is available for any hour that this schedule reads 1 percent or greater.

The **Optional ventilation fan** schedule defines the hours that the ventilation unit can operate. If the **Optional ventilation fan** schedule reads 1 percent or greater, the fan is available that hour.

Note: If a custom schedule is created for the fan or coils, it is recommended to use values of 0 percent for hours off and 100 percent for hours available to run to avoid confusion.

- 7 On the **Temp/Humidity** tab, select **Direct Dehumidification...** as the **Dehumidification Method** and specify a **Maximum room relative humidity** of 60%.

8 On the **Fans** tab, input the fan type and the total static pressure for the primary fan in the dual-path air handler.

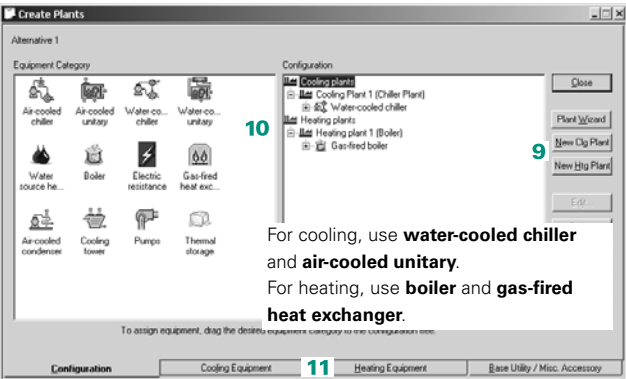



Next, define the **cooling and heating plants** represented by the dual-path air handler system and the rooftop air conditioner:

9 Add a new cooling plant and a new heating plant to the **Configuration** pane.

10 Drag the appropriate icons from the **Equipment Category** section to define each plant.

11 To finish defining this equipment, enter the information from Table 4–10 on page 4–72 on the appropriate equipment tab.



 Finally, assign the coil loads of the air-distribution system to the proper cooling and heating plants:

12 Drag each coil in the **Unassigned Systems/Coils** pane to the appropriate plant in the **Systems and Plants** pane.

The illustration labeled *After* shows the completed assignments.

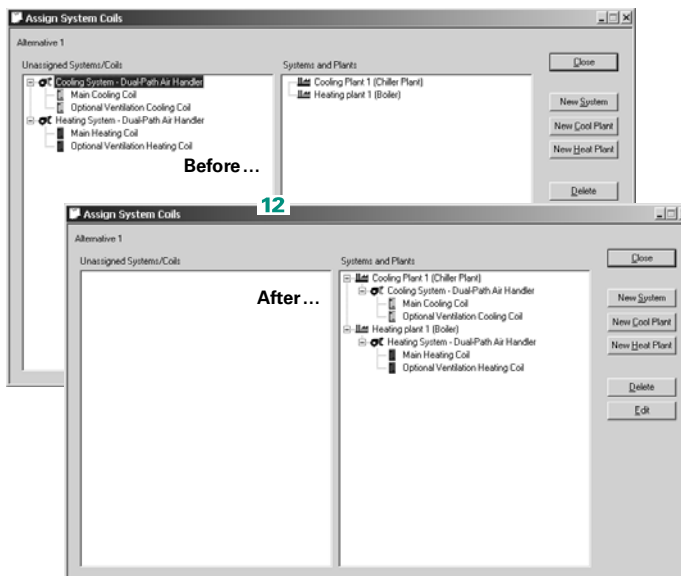


Table 4–10 Equipment types

	Cooling Equipment tab	Heating Equipment tab
Water-cooled chiller	3-stage centrifugal chiller	gas-fired hot water boiler

Systems with 100% outdoor air

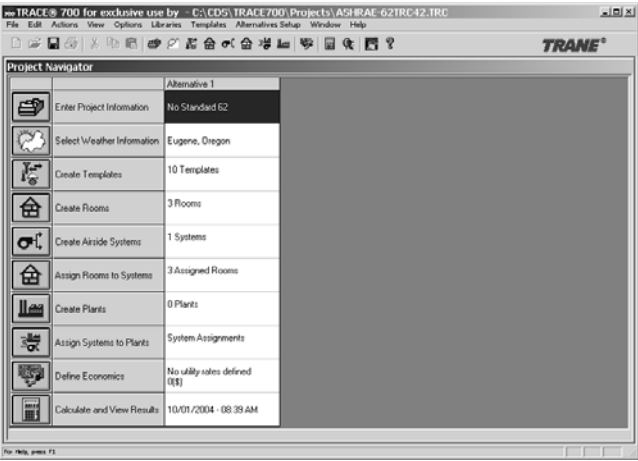
Systems that use 100 percent outdoor air are common in laboratories and hospitals. This system is the only equipment serving the assigned zones.

Note: This system should not be confused with a dedicated outdoor air system or dedicated ventilation unit. A dedicated outdoor air system uses a separate air handler to condition the outdoor air before delivering it to the outdoor- and/or mixed-air intakes of other HVAC units, or directly to the occupied spaces. Terminal units handle only the local space loads associated with the building.

Sample scenario

A hospital has a laboratory area that requires 100 percent outdoor air. The air handler will be used to treat the outdoor air and deliver it to the laboratory area. This same air handler will also provide all cooling and heating to the laboratory area.

- 1 Select a weather file and input the room information (room areas, thermostat setpoints, internal loads, and so on) as would be done in a typical file.



- The cooling ventilation rate should be input as **100** and the units should be selected as **% Cooling Airflow**. The heating ventilation rate should be input as **100** and the units should be selected as **% Heating Airflow**. This can be done on a room-by-room basis on the **Airflows** tab of **Create Rooms**, or for the rooms in general on the **Airflow** template in **Create Templates**

Note: For additional details on templates, please refer to "Using templates" on page 6–125.

- If a minimum airflow must be supplied to the space, then input the minimum airflow rate under the main supply airflow, using the units of air changes/hour, cfm/sq ft, L/s/sq m, cfm/person, or L/s/person. By default, TRACE 700 will calculate the supply airflow based on the loads for the space.
- If a VAV system is being modeled, the heating minimum airflow should also be input for the VAV minimum airflow rate.

The screenshot shows the 'Create Rooms - Airflows' dialog box. The 'Ventilation' section is highlighted with a green box and a red '2'. The 'Cooling' field is set to '100' and the 'Heating' field is set to '100'. The 'Units' dropdown for both is set to '% Cg Airflow'.

*Note: Ventilation can also be input at the system level. On the **Options** tab of **Create Systems**, click **Advanced Options** to override system level ventilation. Refer to online Help for additional information related to system-level ventilation input and how it will affect the simulation.*

The screenshot shows the 'Create Rooms - Airflows' dialog box. The 'Main supply' section is highlighted with a green box and a red '3'. The 'Cooling' field is set to '5' and the 'Heating' field is set to '5'. The 'Units' dropdown for both is set to 'air changes/hr'. The 'VAV minimum' section is also highlighted with a green box and a red '4'.

- 5 Select the appropriate airside system, associated fans, static pressures, and supply-air temperature ranges for the system in **Create Systems**.
- 6 Assign the rooms to the airside system and calculate the design results for the air handler.

	Type	Static Pressure (in. w.g.)	Full Load Energy Rate	Full Load Energy Rate Units	Schedule
Primary	FC Centrifugal const vol	4	0.000321	kW/Cfm-in wg	Available (100%)
Secondary	None	0	0	kW/Cfm	Available (100%)
Return	FC Centrifugal const vol	1.5	0.000321	kW/Cfm-in wg	Available (100%)
System exhaust	None	0	0	kW/Cfm	Available (100%)
Room exhaust	None	0	0	kW/Cfm	Available (100%)
Optional ventilation	None	0	0	kW/Cfm	Available (100%)
Auxiliary	None	0	0	kW/Cfm	Available (100%)

Additional Items

- For a system to be 100 percent outdoor air, all rooms assigned to the system must be specified as 100 percent outdoor air.
- Ventilation load (shown on the *output reports*) will only reflect the cooling required to cool the air from ambient conditions to room neutral. The cooling coil will be sized based on the total load—cooling the air from ambient conditions to the leaving cooling-coil conditions in a 100 percent outdoor-air system. Ventilation load is calculated based on equations 26 and 27 found on page 26.9 in the 2001 ASHRAE Handbook of Fundamentals.

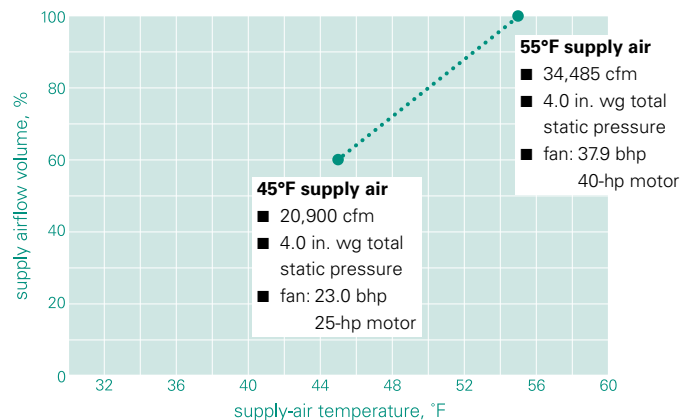
Cold-air distribution

Cold-air distribution describes comfort-cooling applications that deliver supply air of 48°F or less to the occupied spaces in a building. Supply-air temperatures of 45°F to 48°F are most common, but applications with temperatures as cold as 42°F also exist. Successful installations throughout this range demonstrate how readily cold-air distribution can be adapted to individual job requirements.

The appeal of cold supply air lies in the dramatic impact on the amount of air required for sensible cooling. Lowering the supply-air temperature from 55°F to 45°F reduces the supply-air *volume* by 30 to 40 percent.

Reducing the amount of supply air needed in an application lowers the first cost of the HVAC system (smaller fans and ductwork, smaller overall ampacity). Cold supply air also lowers the relative humidity in the occupied space, improving indoor-air quality.

Figure 4-17 Effect of cold-air distribution



Application considerations

- Use a vapor retarder on the warm side of perimeter walls to minimize vapor-pressure diffusion.


- Maintain a slightly positive pressure inside the building to prevent infiltration.
- Ideally, use linear slot diffusers with a high aspiration ratio to provide proper air movement.
- Implement a control strategy that resets the supply-air-temperature set point to minimize reheat.

Related reading

- “Cold Air Makes Good \$ense,” *Engineers Newsletter* (volume 29, number 2)

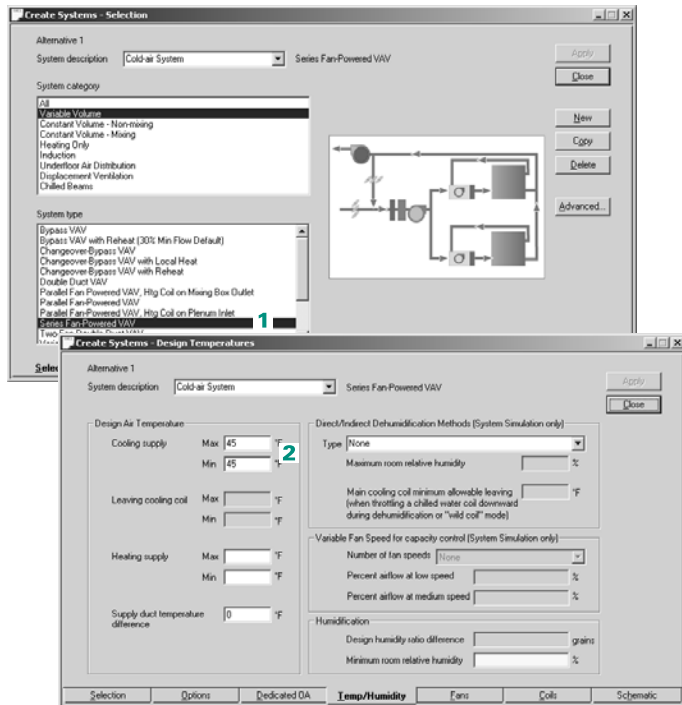
Sample scenario

The air-distribution system for a building consists of series-fan-powered VAV terminals rated for 0.5 in. wg static pressure, and a variable-volume, forward-curved (FC) fan sized for the system static pressure of 3 in. wg. Chilled water, produced by a three-stage centrifugal chiller that consumes 0.7 kW/ton at full load, cools the supply air to 45°F.

 Begin by defining the air-distribution system.


1 From the **variable volume** category, choose **series fan-powered VAV** as the system type.

2 Lock in the design supply-air temperature for cooling by entering the same value for minimum and maximum (in this case, 45°F).

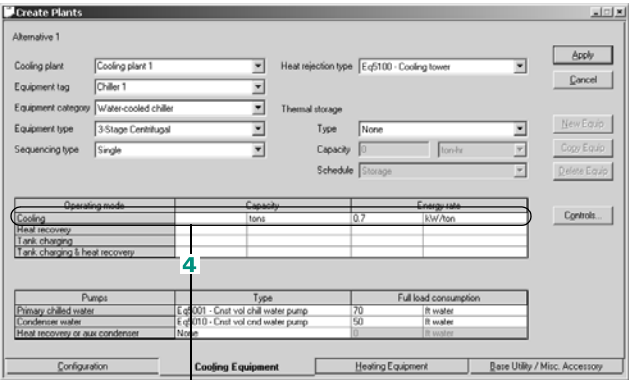


3 Specify the **type**, **static pressure**, and **schedule** for each fan in the system—in this case, the primary, secondary, and exhaust fans.

Typically, the secondary fan is a central *heating* fan. However, in a fan-powered VAV system, it represents the fans in the VAV terminals.

 When defining the cooling plant:

4 Increase the **full-load energy rate** of the chiller to reflect the additional lift required from the compressor. (Use a computerized selection program to determine the new energy rate.)



If left blank in a single-chiller plant, TRACE 700 sets the capacity of the chiller equal to the design load of the airside systems and/or coils assigned to it. The capacity should not be left blank in a multiple-chiller plant.

Note: Some cold air systems deliver 45°F air to fan-powered VAV terminals, where it is warmed to 55°F by mixing it with plenum air. This technique increases the energy consumed by the secondary fans in the VAV terminals.

*To model the effect on the secondary fans, either enter the new full-load energy rate for the secondary fans on the **Fans** tab in your TRACE 700 project or use the Library/Template Editors program to customize an existing fan type. The new full-load energy rate can be determined from the ratio of airflows.*

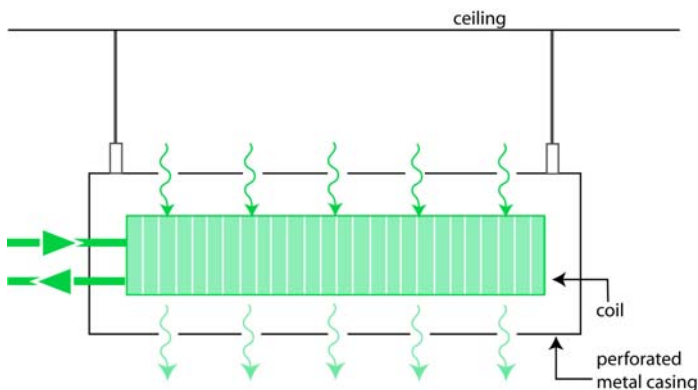
Chilled beams

TRACE 700 incorporates two chilled beam strategies: passive and active.

Passive chilled beams consist of a fin-and-tube cooling coil, contained in a housing (or casing), suspended from the ceiling. Chilled water passes through the tubes. Warm air from the space rises toward the ceiling, and the air around the chilled beam is cooled, causing it to descend back toward the floor. It essentially cools the space through convection. Passive chilled beams are used for sensible cooling only (no latent cooling, no dehumidification).

A building with passive chilled beams requires a separate mechanical ventilation system to deliver the required amount of ventilation air to each space and deliver that air dry enough (at a low dew point) to offset the space latent loads and maintain the indoor dew point low enough to avoid condensation on the chilled beams.

Figure 4–18 Passive chilled beam



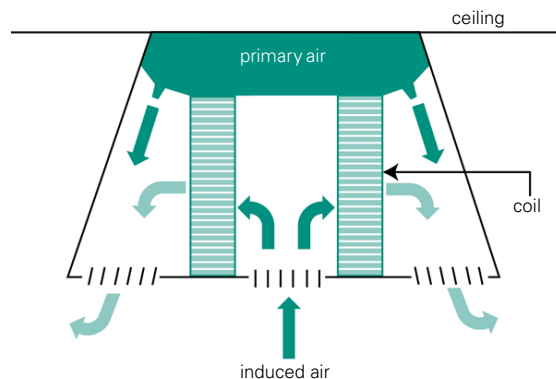
Active chilled beams also consist of a fin-and-tube cooling coil, contained in a housing, suspended from or recessed into the ceiling. Active chilled beams are also used for sensible cooling only (no latent cooling, no dehumidification). Active chilled beams

differ from passive chilled beams because they have an integral air supply. This “primary air” passes through nozzles at a high velocity. As a result, air is induced from the space through the cooling coil. Because of the induction process, active chilled beams provide more cooling capacity than a same-sized passive chilled beam.

By definition, active chilled beams are combined with a separate primary air system that 1) delivers the required amount of ventilation air to each space, 2) delivers the air dry enough (at a low dew point) to offset the space latent loads and maintain the indoor dew point low enough to avoid condensation on the chilled beams, and 3) delivers enough primary air to induce sufficient room airflow to offset the space sensible cooling loads.

Although active chilled beam systems include the ability to provide some heating, cooler climates may necessitate additional heating systems (e.g., baseboard heating).

Figure 4-19 Active chilled beam



Application considerations

- Chilled beam systems require smaller ductwork, air handlers, and fans than a comparable VAV system. However, energy use depends on climate, operating hours, and building use.
- Chiller plant arrangement may also play a role in energy use. To avoid condensation, chilled beams must be supplied with warmer-than-normal chilled water temperatures. When coupling chilled beams with a traditional air handler for the primary air

system, designers may choose a dedicated chiller arrangement (one plant delivering very cold water to the primary air handlers and a separate plant delivering warmer chilled water to the chilled beams) or a shared plant serving both chilled beams and air handlers. Consider the advantages and disadvantages of both options when determining your plant configuration.

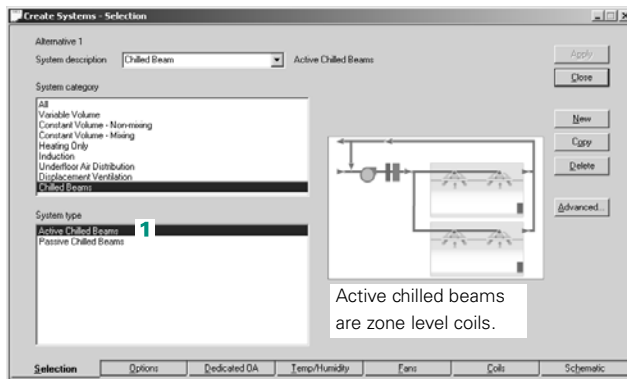
- Due to the potential for condensation, special consideration should be given to the geographic region where chilled beams are employed.

Sample scenario

An active chilled beam system satisfies the ventilation and cooling requirements for an office building. Supplemental heating in the form of radiant floor heating will be included to satisfy any heating requirement the primary air system is unable to handle.

To model each active chilled beam:

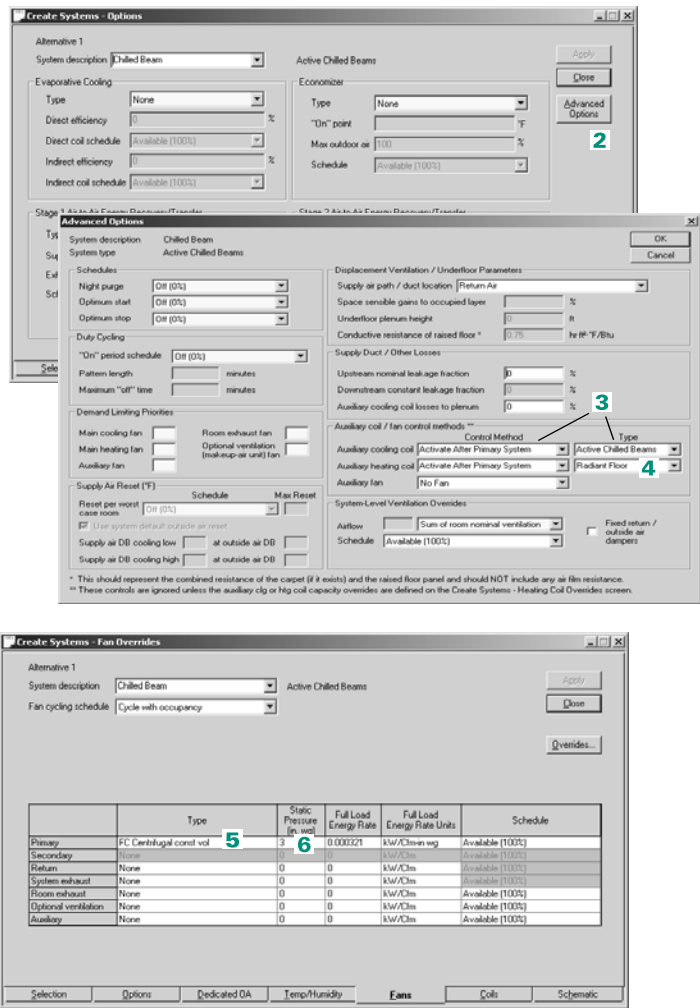
- 1 Create an airside system and define it as **Active Chilled Beam**.



- Click the **Options** tab and click **Advanced Options**.
- Select the control method. Also, ensure the **Type** reads **Active Chilled Beams**.
- Select the **Auxiliary heating coil type**.

*Note: Unlike other systems, **Cooling supply** and **Leaving cooling coil** temperatures (found under the **Temp/Humidity** tab) entered by the user will be ignored for both passive and active chilled beam systems. TRACE 700 calculates the supply temperature based on the upper limit of the room dew point plus a safety margin.*

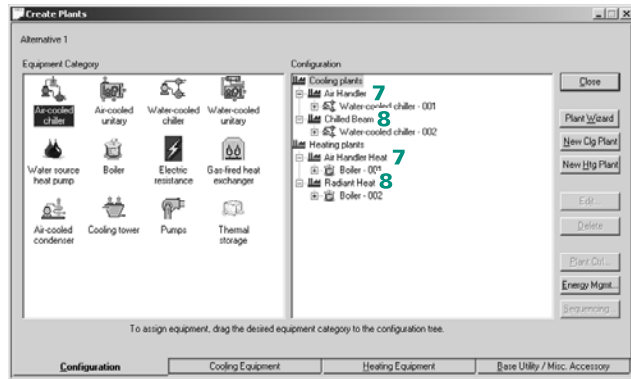
- On the **Fans** tab, choose a fan type for the primary air handler fan.
- Enter a static pressure for the primary air handler.



7 Use **water-cooled chiller** and **boiler** to begin defining the cooling and heating plants for the air handler. Rename the cooling plant to **Air Handler** and heating plant to **Air Handler Heat**.

8 Use the **water-cooled chiller** and **boiler** to begin defining the cooling and heating plants for the air handler. Rename the cooling plant to **Chilled Beam** and heating plant to **Radiant Floor**.

Note: Two chiller plants and two heating plants were created. This models a dedicated chiller arrangement. One chiller provides chilled water to the chilled beams, while the other chiller provides chilled water to the main cooling coil in the primary air handler. One boiler provides water to the main and pre-heat coils found in the primary air handler. The other boiler provides water for the radiant floor.

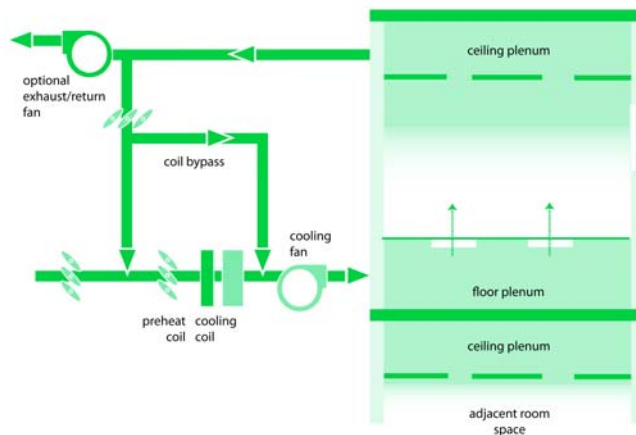


Underfloor air distribution

An underfloor air distribution (UFAD) system delivers supply air via an underfloor plenum, and a return-air bypass arrangement around the cooling coil is implemented in order to provide sufficient dehumidification without the need for reheat.

In traditional systems, complete mixing results in equally distributed temperatures and heat gains. In contrast, UFAD systems result in a temperature gradient. Since the air moves vertically, temperature increases as the air rises. The air movement also distributes a fraction of the heat gains directly to the return air plenum.

Figure 4-20 Underfloor air distribution system



Application considerations

- The cool temperatures in the underfloor plenum increase conduction and radiation in the space. As a result, the conductive resistance of the floor must be considered.
- When modeling multiple floors, an adjacent floor should be modeled as the surface separating the return air plenum of the lower space and the supply air plenum of the adjacent upper space.

- Because the supply air is introduced from the pressurized floor plenum, a warmer supply-air temperature is necessary to avoid an uncomfortable temperature difference between ankle and head heights. As the room sensible cooling load decreases, the capacity of the main cooling coil will be reduced, resulting in a warmer supply-air temperature.
- While the supply air is delivered at warmer dry bulb temperatures, it still must be delivered dry enough to provide sufficient dehumidification. Thus, air leaving the cooling coil should be about the same temperature as in a traditional system, which drives the need for the return air bypass.

Related reading

- “Underfloor Air Distribution: Turning Air Distribution Upside Down,” *Engineers Newsletter* (volume 30, number 4)

Sample scenario

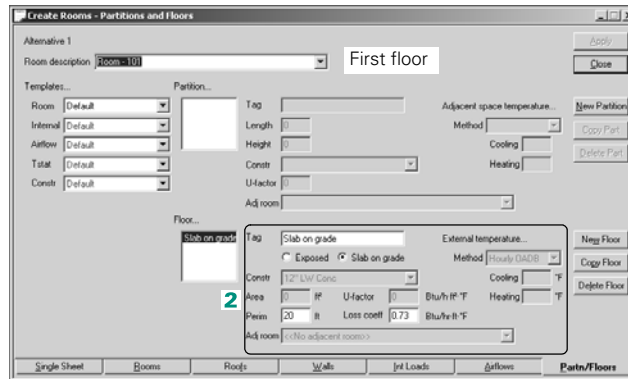
A UFAD system is to be installed in a two-story office building. To model this system, each floor requires a floor plenum and a ceiling plenum. Calculations will have to be completed to determine the portion of wall conduction into the floor plenum. This will be the fraction of the wall exposed to the floor plenum. TRACE 700 also accounts for heat transfer between floor plenum and the corresponding adjacent space.

- 1 Enter the percent of the wall area that is exposed to the underfloor plenum.

Note: This must be done for all spaces that have underfloor plenums.

The screenshot shows the 'Create Rooms - Walls' dialog box in TRACE 700. The 'Alternative 1' dropdown is set to 'Room - 101'. The 'Room' dropdown is set to 'Default'. The 'Wall' dropdown is set to 'South'. The 'Tag' dropdown is set to 'South'. The 'Construct' dropdown is set to 'Face back, Face back, 2" Ins'. The 'Length' is 20 ft, 'Height' is 14 ft, and 'U-factor' is 0.11432 Btu/h·ft²·°F. The 'Pct wall area to underfloor plenum' is 10.7%. The 'Glass' section shows 'Wall area' as 25 % and 'Type' as 'Double Coated 1/4"'. The 'Shading' section shows 'Internal' as 'None' and 'External' as 'Overhang - None'. The 'Single Sheet' button is highlighted at the bottom.

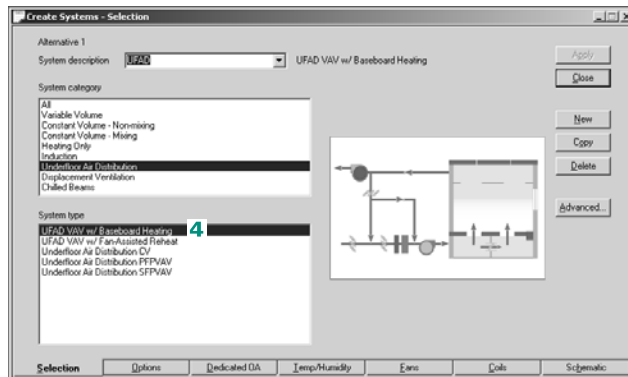
- 2 Room-101 is exposed to the ground. On the **Floors** tab of **Create Rooms**, create a **New Floor** to account for the heat transfer.



- 3 Room-201 is directly above Room-101. To model the heat transfer between the rooms, create an exposed floor with an **Adjacent Room** external temperature method. Select Room-101 as the **Adjacent Room**.



- 4 In **Create Systems**, select **UFAD VAV w/ Baseboard Heating**.



5 On the **Options** tab, click **Advanced Options**.

6 Define the **Supply air path/duct location**, **Space sensible gains to occupied layer**, **Underfloor plenum height**, and **Conductive resistance of raised floor**.

*Note: If **Space sensible gains to occupied layer** is left blank, it will be calculated automatically.*

Alternative 1
System description: UFAD
UFAD VAV w/ Baseboard Heating

Evaporative Cooling
Type: None
Direct efficiency: 0 %
Direct coil schedule: Available (100%)

Economizer
Type: None
"On" point: °F
Max outdoor air: 100 %

Indirect: **Advanced Options**

Stage 1 A
Type: Night purge
Optimum start: 0H (0%)
Optimum stop: 0H (0%)

Duty Cycling
"On" period schedule: 0H (0%)
Pattern length: minutes
Maximum "off" time: minutes

Demand Limiting Priorities
Main cooling fan: Room exhaust fan
Main heating fan: Optional ventilation (makeup air unit) fan
Auxiliary fan:

Supply Air Reset (°F)
Reset per worst case room: 0H (0%)
Use system default outside air reset: ☒
Supply air DB cooling low: at outside air DB
Supply air DB cooling high: at outside air DB

Displacement Ventilation / Underfloor Parameters
Supply air path / duct location: No duct, Supply via Underfloor Plenum
Space sensible gains to occupied layer: %
Underfloor plenum height: 1.5 ft
Conductive resistance of raised floor: 0.75 hr ft² F/Btu

Supply Duct / Duct Losses
Upstream nominal leakage fraction: 0 %
Downstream constant leakage fraction: 0 %
Auxiliary cooling coil losses to plenum: 0 %

Auxiliary coil / fan control methods
Auxiliary cooling coil: Activate After Primary System
Auxiliary heating coil: Activate After Primary System
Auxiliary fan: No Fan

System-Level Ventilation Overrides
Airflow: Sum of room nominal ventilation
Schedule: Available (100%)
Fixed return / outside air dampers: ☐

* This should represent the combined resistance of the carpet (if it exists) and the raised floor panel and should NOT include any air film resistance.
** These controls are ignored unless the auxiliary coil or fan capacity overrides are defined on the Create Systems - Heating Coil Overrides screen.

7 Define **Fans**, **Static Pressure**, and **Full Load Energy Rate**.

Alternative 1
System description: UFAD
UFAD VAV w/ Baseboard Heating

Fan cycling schedule: Cycle with occupancy

	Type	Static Pressure (in. w.g.)	Full Load Energy Rate	Full Load Energy Rate Units	Schedule
Primary	FC Centrifugal var freq drv	1.5	0.00055	kW/Cfm	Available (100%)
Secondary	None	0	0	kW/Cfm	Available (100%)
Return	None	0	0	kW/Cfm	Available (100%)
System exhaust	None	0	0	kW/Cfm	Available (100%)
Room exhaust	None	0	0	kW/Cfm	Available (100%)
Optional ventilation	None	0	0	kW/Cfm	Available (100%)
Auxiliary	None	0	0	kW/Cfm	Available (100%)

Selection Options Dedicated OA Temp/Humidity Fans Coils Schematic

Displacement ventilation

A displacement ventilation system supplies very low velocity air to the space via a raised floor system or through low sidewall air outlets.

As this cool air nears heat sources in the room (people, equipment, etc.), thermal plumes cause the air to rise, taking heat and contaminants out of the breathing zone.

One of the advantages of a displacement ventilation system is that only the lower portion of the room is actually conditioned (typically six feet from the floor), while the air in the upper portion is much warmer.

In addition to supplying air at low velocities, displacement ventilation systems must also supply conditioned air at temperatures typically between 65°F and 68°F to avoid drafts and cold feet.

Displacement ventilation systems can be paired with radiant ceiling or chilled beam systems that handle some of the sensible cooling loads of the space.

Application considerations

- When 100 percent outdoor air is used, good air quality conditions can be achieved because the contaminants are continually exhausted from the space.
- The use of warmer supply air allows extended use of economizers, especially in drier climates. In addition, climates with low humidity may also operate with chilled water at higher temperatures, which improves chiller efficiency.
- In humid climates, the supply air typically must be dehumidified before being reheated or mixed with return air, to reach the desired warmer supply temperatures (typically 65°F or greater).

Sample scenario

A displacement ventilation system is being installed in a new school and will supply air via sidewall diffusers. The displacement system will be sized to meet the ventilation load as well as the latent load in the occupied space. A chilled ceiling system will meet the sensible loads of the occupied space. Since both the displacement ventilation and the chilled beam system use chilled water coils, a water-cooled chiller will deliver cold water to each.

To model a displacement ventilation system, begin by specifying the ventilation for each room.

- 1 On the **Airflows** tab of **Create Rooms**, specify the ventilation for each room.

Note: TRACE defaults to 100% Outdoor Air for the Displacement Ventilation w/ Chilled Ceilings, Displacement Ventilation w/ Passive Chilled Beams, and Displacement Ventilation with Room Induction systems (i.e., supply airflow always equals ventilation airflow). Do not use the % Cfg Airflow or % Htg Airflow as the ventilation types.

Next, define air distribution.

- 2 In **Create Systems**, select **Displacement Ventilation w/Chilled Ceilings** as the **System Type**.

- 3** On the **Options** tab, click **Advanced Options**.
Choose **Supply via Sidewall Displacement Ventilation**.

- 4** On the **Temp/Humidity** tab, enter the appropriate **Cooling supply** temperature for the system.

Note: TRACE 700 defaults to 65°F supply air for all displacement ventilation systems. It is not recommended to set the supply temperature below 65°F.

ASHRAE Standard 62.1

ASHRAE Standard 62.1 prescribes minimum breathing zone ventilation rates and a calculation procedure to find the minimum intake airflow needed for different ventilation systems. These rates and procedures must be used to find the design outdoor air intake flow, which establishes the required capacity of the mechanical system equipment.

The first step is to determine the minimum ventilation that is required for each different space type. This is also known as the *zone level procedure*. The ventilation requirements for individual space types can be found in Table 6-1 of Standard 62.1.

Once the minimum ventilation requirement for each space type has been determined, equation 6-1 of the standard is used to calculate the required amount of airflow for the breathing zone. The effectiveness of the air mixture within the space, called the Zone Effectiveness, is determined based on the position of the supply diffusers and return air grilles in each zone. This factor also accounts for any ventilation that would not be used within the breathing zone that could be recirculated into the space.

The zone level procedure concludes with the solving of equation 6-2 to determine the required outdoor air for each zone. This is determined by dividing the Breathing Zone Outdoor Airflow by the Zone Effectiveness. This process must be completed for each zone that will comply with Standard 62.1.

Now that each zone level ventilation requirement has been determined, the *system level* ventilation can be calculated, which is also known as the Outdoor Air Intake for the system. This procedure varies for different system types. For single zone systems, equation 6-3 indicates that the ventilation requirement will be identical for both the zone and the system because they are one and the same. For 100% Outdoor Air systems (also known as Dedicated Outdoor Air systems within TRACE), equation 6-4 is used, which sums the zone level outdoor airflow to derive the system level. For multiple zone, recirculating systems (i.e., variable-air-volume reheat systems), sections

6.2.5.1 through 6.2.5.4 are used to determine the required system level ventilation. Once the system level ventilation has been determined, the procedure is complete.

Application considerations

- ASHRAE Standard 62.1 may not be as stringent as local codes. You can create new airflow requirements using the **Internal Loads** and **Airflows** library.
- The minimum discharge airflow for each space is critical in determining the system level ventilation requirements when using ASHRAE Standard 62.1 calculation methods. The ASHRAE Standard 62.1 calculations in TRACE assume that each VAV box is at the minimum reheat setting when determining the critical fraction of outside air for the system. This can be conservative if all VAV reheat minimums are set to the same value or when utilizing the default reheat minimum that comes with each TRACE system selection.

In reality, the expected minimum airflow at the worst case outside air condition analyzed will likely be greater than the reheat minimum for most VAV boxes when in cooling mode. Adjusting the reheat minimums in each VAV box to the expected minimum values can reduce required outside air intake; however, in most cases, this will increase reheat energy when performing an energy simulation.

- Designers should account for occupant diversity in cases where the design population is significantly larger than what the actual population will be in the building.
- To ensure that each space receives its specified ventilation airflow by automatically increasing VAV reheat minimum settings when they are set lower than the ventilation requirement, check the **Force VAV minimum always \geq nominal ventilation during design** check box on the **Change Load Parameters** screen.

Related reading

- “Addendum 62N Breathes New Life into ASHRAE 62,” *Engineers Newsletter* (volume 33, number 1)
- “CO₂-Based Demand-Controlled Ventilation with ASHRAE 62.1-2004,” *Engineers Newsletter* (volume 34, number 5)
- “Potential ASHRAE Standard Conflicts—Indoor Air Quality and Energy Standards,” *Engineers Newsletter* (volume 37, number 4)

Sample scenario

ASHRAE Standard 62.1 ventilation requirements will be applied to an elementary school to ensure proper space ventilation for the occupants.

*Note: Ventilation requirements can be applied either in the **Airflows** tab of **Create Rooms** or in the **Ventilation** templates. For a discussion of templates, see “Using templates” on page 6–125.*

- 1 In the **Apply ASHRAE Std 62.1-2004/2007** field, select **Yes** to set the zone-level outside air requirement per the standard.
- 2 Select the appropriate space type. These values are from Table 6.1 of Standard 62.1.

- 3 Select the appropriate cooling and heating effectiveness numbers. Be sure to specify a recirculation rate.

*Note: If the recirculation effectiveness is unknown, select **Default based on system type**. TRACE has a default value for each available airside system.*

- 4 Click **Advanced** for each system that will have outside air calculations based on Standard 62.1.
- 5 Select the appropriate Standard 62.1 calculation.

Note: The ventilation reset option allows system outdoor intake dampers to dynamically reset ventilation airflow for hourly changing system loads and airflows.

Additional items

Create Systems - Advanced

System description: VAV-Reheat (Classrooms)

System type: Variable Volume Reheat (30% Min Flow Default)

Supply fan motor location: Supply

Return fan motor location: Return

Fan configuration: Draw Thru

Fan sizing method: Block

Supply air path / duct location: Return Air

Return air path: Plenum

Block cooling airflow: cfm

Cooling coil sizing method: Block

Cooling coil location: System

Ventilation deck location: Return/Outdoor Deck

System ventilation flag: **2** ASHRAE Std 62.1-2004/2007 w/ Vent Reset

Apply ASHRAE Std 62.1-2004/2007 People Averaging: ☐ Yes ☒ No

ASHRAE Std62 Max Vent (Z) Ratio Allowed: **1** %

Population Diversity (non-DCV Rooms only): 100 %

CO2-based DCV: **2** ☒ None ☐ Proportional Control ☐ Single Setpoint

Warning: The fields marked in red are core components of this system. Changing these values can drastically affect how the system operates. Please make sure you are aware of the total ramifications before you make such a change.

- 1** The **ASHRAE Std62 Max Vent (Z) Ratio Allowed** field can be used to optimize the trade-off between reheat and outside air intake. Spaces that have lesser loads and airflows may have outside air requirements that force them to become a critical factor in the Standard 62.1 ventilation calculations. By examining the Z fractions in the ASHRAE Std 62.1 report, users can set the maximum outside air fraction for the system such that the program automatically adjusts the reheat minimum for those spaces to match the maximum outside air fraction (Z). In doing so, zones that have their reheat minimum adjusted based on this constraint will see larger minimum airflows and an increase in reheat energy necessary to maintain space conditions. However, the resultant system outside air intake can be reduced and therefore may result in overall energy savings. An iterative process may be required to determine the optimal ratio.
- 2** There is an additional option that is available when **ASHRAE Std 62.1-2004/2007 w/ Vent Reset** is selected. The **CO2-based Demand Controlled Ventilation (DCV)** is enabled and can be set to **None**, **Proportional Control**, or **Single Setpoint**.

Proportional Control is detailed in Appendix A of Standard 62.1-2004.

- a When **Proportional Control** is selected, the outdoor air controller will adjust the outdoor air intake flow proportionally between the minimum ventilation flow and the design ventilation flow.
- b When **Single Setpoint** is selected, the intake airflow is adjusted to maintain the indoor CO2 concentration at the minimum CO2 concentration in the space for any population. If the OA damper reaches the minimum outdoor air intake flow and the population in the zone continues to drop, the OA damper remains at the minimum outdoor air intake flow as specified in the **DCV Minimum OA Intake** field on the **Create Rooms – Airflows** screen.

The **Outdoor Carbon Dioxide Level**, which defaults to 400 ppm for each weather location, is located on the **Weather Overrides** screen. This value can be changed if desired.

CO2 sensor locations must be specified within **Create Rooms** or the **Rooms** template.

5 System Control Strategies

Modeling examples in this chapter

Airside controls

- Airside economizers, page 5–2
- Fan cycling, page 5–4
- Optimum start and stop, page 5–6
- Humidification, page 5–9
- Fan-pressure optimization for VAV systems, page 5–12
- Ventilation reset for VAV systems, page 5–14
- Unoccupied ventilation (night purge), page 5–17
- Morning warm-up for dual-fuel applications, page 5–20

Waterside controls

- Chilled-water reset, page 5–24
- Condenser-water reset, page 5–26
- Load-shedding economizer, page 5–30

Miscellaneous controls

- Daylighting, page 5–33
- Demand limiting, page 5–43
- Duty cycling, page 5–47
- Supply air temperature reset, page 5–50

Note: Use the basic how-to instructions in this chapter to help you model typical, system-level control strategies. Each example begins with a brief description of the control strategy, followed by a sample scenario that illustrates the entries needed to model it. Typical values are suggested where appropriate.

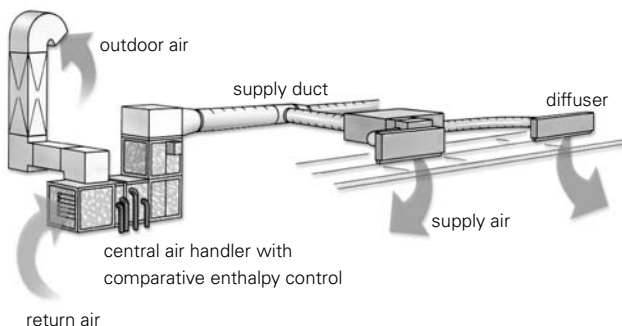
Airside economizers

When ambient conditions permit, an airside economizer cycle brings outdoor air into the building to provide natural, non-mechanical cooling. Operating the mechanical cooling system less reduces utility costs.

One way to control the economizer cycle is to monitor the enthalpy of the outdoor air and compare it with a predefined limit. As the ambient enthalpy drops below this limit, the position of the outdoor–return air dampers modulates to maintain the desired supply-air temperature.

Designers often set a conservative limit for economizer cycles based on outdoor enthalpy. If improperly adjusted, the economizer cycle may actually *increase* the mechanical cooling load. *Comparative enthalpy control* takes better advantage of natural cooling by monitoring both the outdoor-air stream and the return-air stream. The outdoor–return air dampers are then positioned to use the air stream with the lowest enthalpy.


Figure 5–1 Airside economizer



Application considerations

- The control system must monitor the outdoor-air and return-air enthalpies, and control the outdoor–return air dampers and fans accordingly.

- Select a high-quality enthalpy sensor (*low cost* sensors are often short-lived and require frequent replacement). Avoid placing the sensor in direct sunlight or near heat sources.
- Consider the climate when assessing the appropriateness of airside economizing and setting an economizer control point. Bringing air that is too moist or too dry into the building can degrade indoor-air quality.
- To avoid overpressurization, provide a means of exhausting large amounts of air from the building during the economizer mode.
- Position intakes to avoid bringing contaminated air into the building.

 To model an airside economizer with enthalpy-based control, complete the following entries for the selected airside system.

- 1 Choose an **Economizer Type** to define the basis of operation. (For this example, pick **Enthalpy**.)
- 2 Ensure that **“On” point** is blank.

*Note: If comparative enthalpy control is not available, input the desired **“On point”** — 30 Btu/lb is typical for enthalpy-based economizers. (Notice that Btu/lb is used instead of °F, as is used with dry bulb economizers.)*

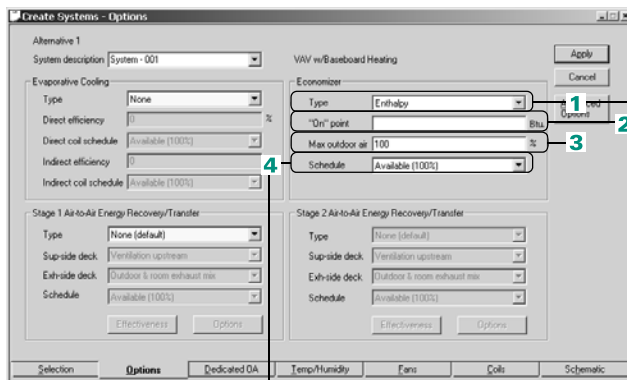
- 3 Define the **maximum percentage of outdoor air**. (A value of 100 lets the outdoor-air dampers provide up to 100 percent of the supply airflow for cooling design.)

- 4 Select a **schedule** to define when the economizer can operate, provided that outdoor-air conditions are suitable.

Sample scenario

An enthalpy-controlled economizer is available to provide natural cooling whenever the enthalpy of the outdoor air is less than that of the return air. The outdoor–return air dampers can be opened to supply 100 percent of design airflow.

TRACE 700 can model three types of airside economizers: **Enthalpy**, **Dry Bulb**, and **Wet Bulb**.



Available (100%) means that the economizer is available, but not necessarily on, every hour of the year.

If **“On” point** is not blank, then whenever the enthalpy of the outdoor air is below the **“On”** point, the outdoor air dampers are fully open.

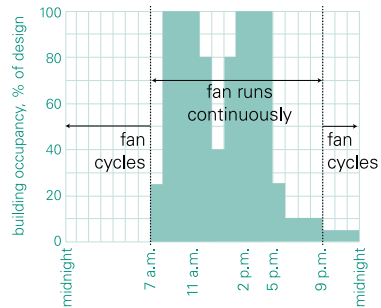
Fan cycling

In terms of energy consumption, constant-volume (CV) systems are costly. Comfort is maintained by modulating temperature rather than the amount of air delivered. Consequently, the fans run continuously, delivering design (full-load) airflow even at part-load conditions.

For CV systems that use many small fans rather than a few large ones, fan cycling can provide one of the economic benefits normally attributed to variable-volume systems—reducing energy consumption by moving less air.

Figure 5–2 Fan cycling

This chart represents the **cycle with occupancy** fan-cycling schedule. The fan cycles on and off with loads during unoccupied hours (defined in TRACE 700 as less than or equal to 5 percent of design occupancy).




Application considerations

- A building automation system (BAS) is required to implement fan cycling. To ensure occupant comfort, the BAS should automatically override fan cycling if the temperature in the space is outside the accepted range.
- Cycling increases the number of fan starts, which accelerates wear and increases maintenance costs. Avoid cycling fans with motors larger than 20 hp.
- Fan cycling is only an option for *CV systems* and for *VAV systems with minimum stops*.

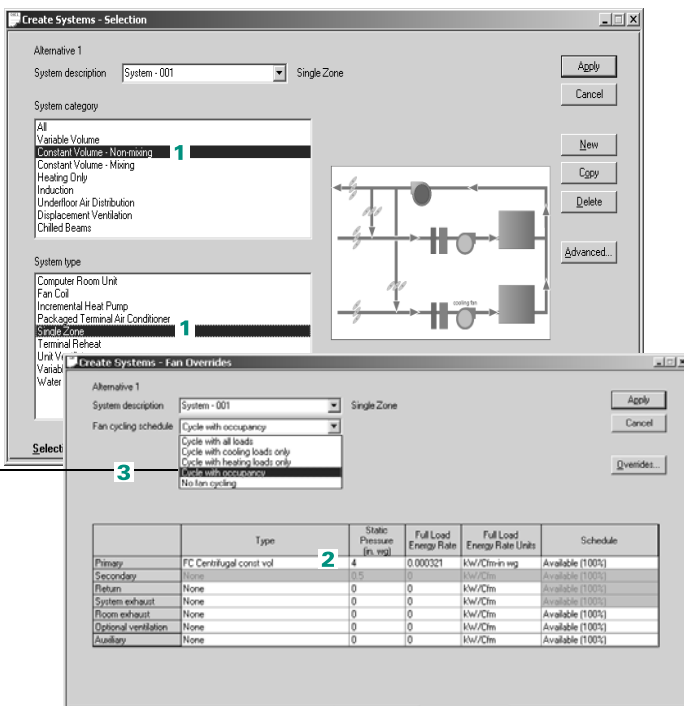
Sample scenario

A constant-volume fan is scheduled to operate continuously when the building is occupied. During unoccupied hours, the fan

cycles on/off when the thermostat set point/driftpoint temperature is exceeded. (Figure 5–2 on page 5–4 illustrates this control strategy.)

 To model a fan-cycling strategy:

- 1 Select the desired type of airside system (in this case, a single-zone, constant-volume system).
- 2 Enter the **type** and **static pressure** of the supply fan to describe it.
- 3 Choose the appropriate fan-cycling schedule. For this scenario, pick **cycle with occupancy**.
- 4 For additional information related to how the fan-cycling schedule and the fan schedule interact, refer to “Frequently asked questions” on page 6–20.



Fan cycling schedule defines whether fan cycling is permitted and, if so, how it is implemented:

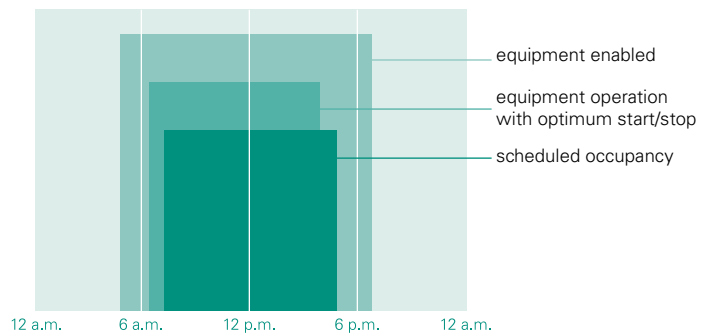
- **Cycle with all loads.** Fan operates continuously when any building load exists, regardless of occupancy: fan stops when the load is satisfied.
- **Cycle with cooling loads only.** Fan operates continuously when a cooling load exists, regardless of occupancy: fan stops when the cooling load is satisfied. When a heating load exists, the fan runs continuously.
- **Cycle with heating loads only.** Fan operates continuously when a heating load exists, regardless of occupancy: fan stops when the heating load is satisfied. When a cooling load exists, the fan runs continuously.
- **Cycle with occupancy.** Fan operates continuously during occupied hours. Fan is off during unoccupied hours (occupancy is less than 5 percent), but starts if cooling or heating is needed and then stops when the load is satisfied.
- **No fan cycling.** Fan operates continuously whenever the utilization percentage in the fan (not *fan cycling*) schedule is greater than 0 percent: fan is off when utilization is 0 percent.

Optimum start and stop

Optimum start and stop is a control strategy that leverages the thermal capacity of the building to reduce the hours of equipment operation. For example, *lightly* constructed, wood-frame buildings respond more quickly to the operation of the HVAC system than buildings constructed of denser materials such as brick. Knowing how quickly the target temperature in the space can be achieved lets you minimize the length of time that the HVAC system operates before the occupied period begins.

Starting equipment as late (and stopping it as early) as possible, based on scheduled occupancy, ambient conditions, and the thermal characteristics of the building, can yield significant energy savings without sacrificing comfort.

Figure 5–3 Comparison of occupancy and operating schedules



Application consideration


- Use a building automation system (BAS) to monitor and control the entire HVAC system. Ideally, the BAS should be capable of learning from previous experience so that it can optimally start and stop equipment daily.


Sample scenario

The building supply fan is scheduled to operate from 6 a.m. until 6 p.m. each day. An optimal start/stop strategy turns on the fan as late as possible between 6 a.m. and 7 a.m., then turns it off as early as possible between 5 p.m. and 6 p.m.

An override will restore normal operation while the optimal start/stop strategy is in effect, if the space temperature drifts more than 3°F from the set point, or if the relative humidity in the space exceeds design by more than 10 percent.

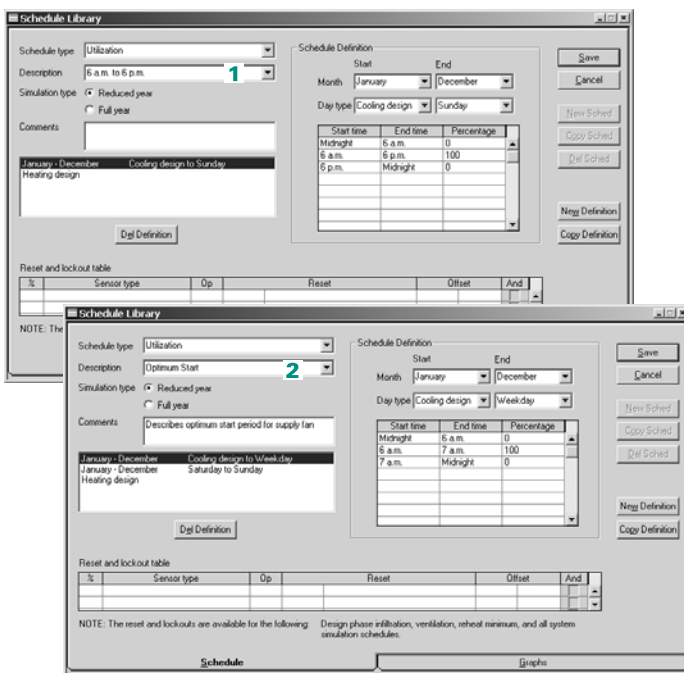
Note: For additional information related to creating utilization schedules and reset lockouts, refer to “Creating schedules” on page 6–137.

 In the Library/Template Editors program:

- 1  Create a new **Utilization** schedule to define when the supply fan operates (from 6 a.m. to 6 p.m. daily for this example).

Make the *Heating design* schedule 100 percent midnight to midnight.

- 2 Create a second schedule that tells the program when to search for an *Optimum start* time for the supply fan—in this case, from 6 a.m. to 7 a.m. on weekdays only.



Schedule Library

Schedule type: Utilization
 Description: 6 a.m. to 6 p.m.
 Simulation type: ☒ Reduced year ☐ Full year
 Comments: January - December: Cooling design to Sunday; Heating design
 Del Definition

Schedule Definition

Start: Month: January End: December
 Day type: Cooling design Sunday

Start time	End time	Percentage
Midnight	6 a.m.	0
6 a.m.	6 p.m.	100
6 p.m.	Midnight	0

 Save Cancel New Sched Copy Sched Del Sched New Definition Copy Definition

Reset and lockout table

%	Sensor type	Op	Reset	Offset	And

NOTE: The reset and lockouts are available for the following: Design phase initialization, ventilation, reheat minimum, and all system simulation schedules.

Schedule Library

Schedule type: Utilization
 Description: Optimum Start
 Simulation type: ☒ Reduced year ☐ Full year
 Comments: Describes optimum start period for supply fan
 January - December: Cooling design to weekday; Heating design: Saturday to Sunday
 Del Definition

Schedule Definition

Start: Month: January End: December
 Day type: Cooling design Week-day

Start time	End time	Percentage
Midnight	6 a.m.	0
6 a.m.	7 a.m.	100
7 a.m.	Midnight	0

 Save Cancel New Sched Copy Sched Del Sched New Definition Copy Definition

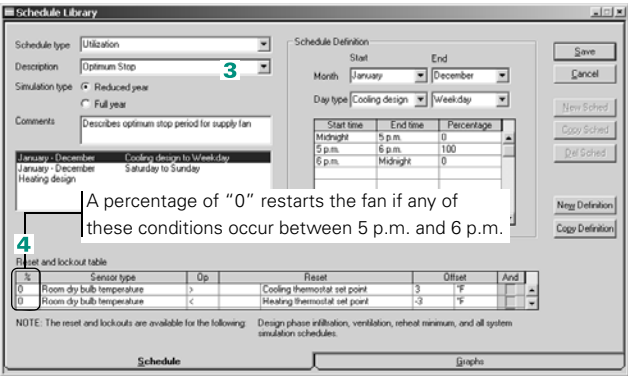
Reset and lockout table

%	Sensor type	Op	Reset	Offset	And

NOTE: The reset and lockouts are available for the following: Design phase initialization, ventilation, reheat minimum, and all system simulation schedules.

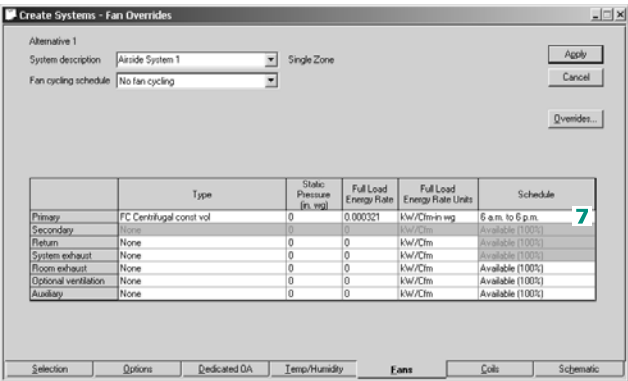
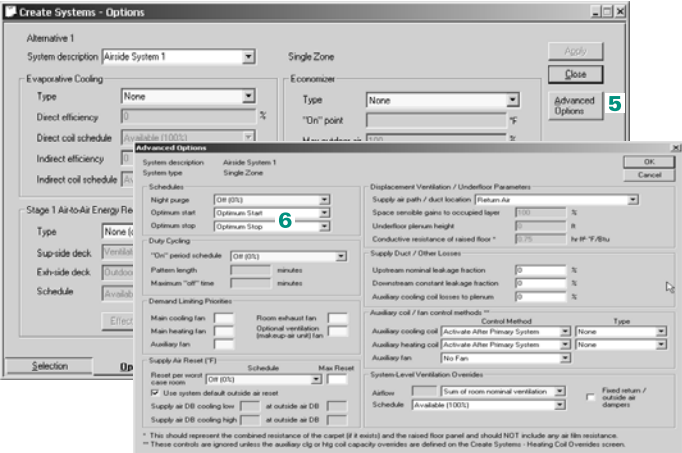
Schedule Graphs

- 3 Create a third **Utilization** schedule that tells the program when to search for an *Optimum stop* time for the fan (that is, between 5 p.m. and 6 p.m. on weekdays only).
- 4 Use the *Reset and lockout* table to describe the conditions that determine whether the fan remains on throughout this period.



The optimum start/stop strategy for the central fan would be implemented by a building automation system (BAS). In the **Create Systems** window of your TRACE 700 project:

- 5 Click the **Options** tab and click **Advanced Options** to display the optional, airside control strategies.
- 6 Enable **optimum start** and **optimum stop** by selecting a schedule for each control strategy.
- 7 While still in the **Create Systems** window, switch to the **Fans** tab and select the desired operating **schedule** for the supply (primary) fan.



Humidification

Some buildings require humidification to provide a comfortable, healthy environment and help protect computing equipment and furnishings.

Depending on the climate, maintaining a relative humidity of at least 30 percent may require the addition of moisture. In commercial applications with central air-handling systems, this can be accomplished by adding a humidifier to the air handler. Of the types available, ASHRAE encourages the use of steam rather than wetted media or atomized water. Using low-pressure, low-temperature water vapor simplifies the humidification process. It is also effective—complete absorption occurs in a short distance and the sensible air temperature remains constant, so higher relative humidities can be achieved without condensate forming in the air handler or ductwork.

Application considerations


- It is important to introduce no more moisture into the air stream than can be absorbed *without* condensation.
- Condensate is most likely to form first on windows, because the surface temperature on them is usually the coldest in the building during cold weather. If the humidity required for a particular application causes condensation on windows, add insulative films or extra panes of glass to increase the thermal resistance.
- A humidifier that is factory-installed, and controlled as an integral part of a central-station air handler, is typically more cost-effective and less prone to misapplication than an equivalent field-built system.

Relating reading. *Designing an “IAQ-Ready” Air Handler System* Applications Engineering Manual (Trane literature number SYS-AM-14)

Sample scenario

The variable-volume air-distribution system for the building consists of series-fan-powered VAV terminals that are equipped with electric heat coils. To maintain a minimum relative humidity

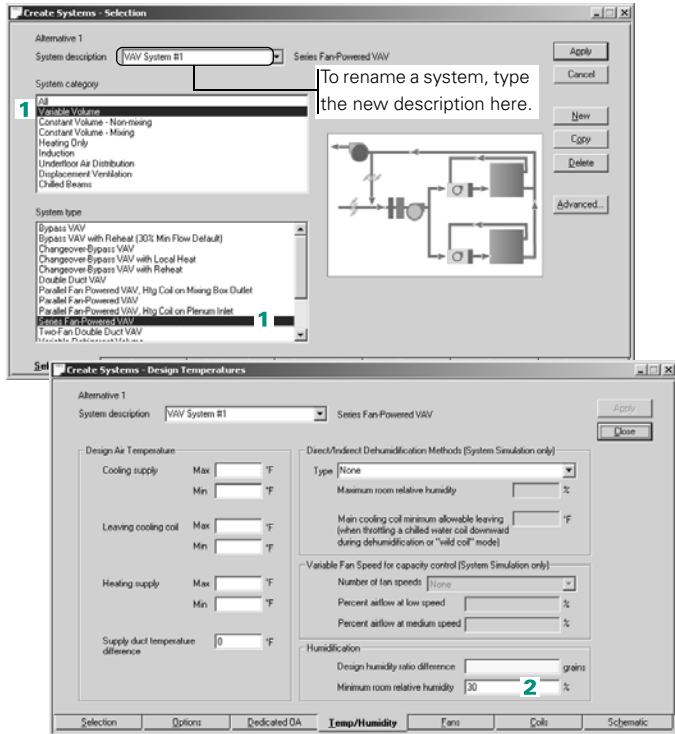
of 30 percent during the heating season, the air-distribution system includes a steam humidifier that is fed by a gas-fired boiler.

 Begin by defining the air-distribution system.

- 1 Choose **Variable Volume** as the system category and **Series Fan-Powered VAV** as the system type.


- 2 Add a humidification coil to the system by specifying the **minimum room relative humidity**. For this example, use the minimum room relative humidity recommended by ASHRAE, which is 30 percent.

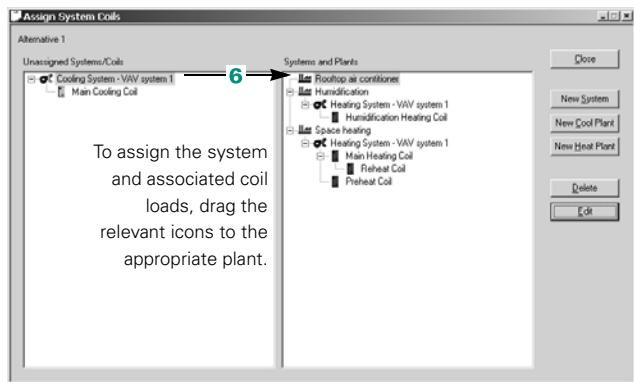
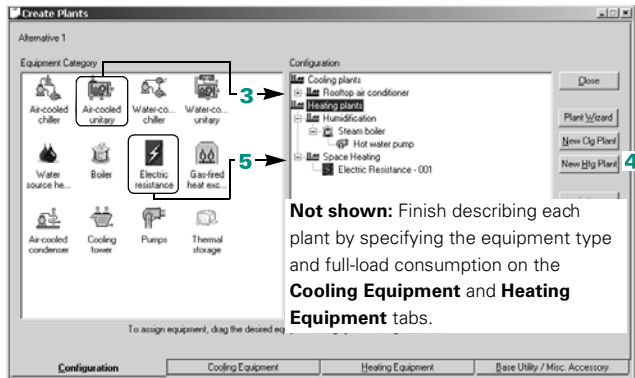
The humidification coil will activate whenever the relative humidity falls below this value.





Next, describe the cooling and heating plants that will satisfy the coil loads.

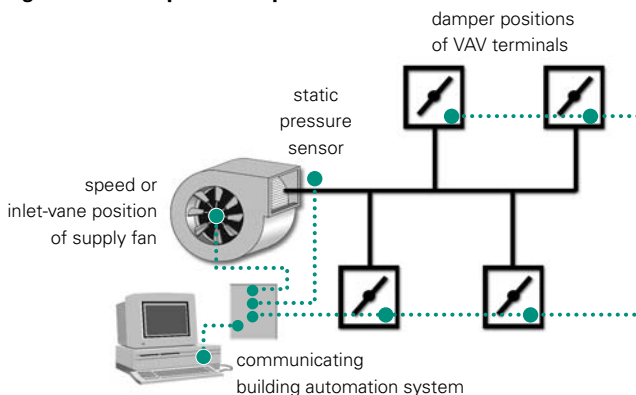
- 1 To represent the rooftop air conditioner, drag the **air-cooled unitary** icon to the cooling plant.
- 2 On the **Cooling Equipment** tab, select a specific equipment type.
- 3 Drag the **Electric resistance** icon to the heating plant to represent the electric heat coils in the VAV terminals.
- 4 Create a new heating plant to represent the boiler that serves the humidification coil.
- 5 On the **Heating Equipment** tab, select the **Gas Fired Steam Boiler**.
- 6  Assign each coil load to the appropriate plant.



Fan-pressure optimization for VAV systems

Fan-pressure optimization is a control strategy that reduces the energy use of the supply fan at part-load conditions. In applications with variable airflow, the control system monitors the operation of each VAV terminal to identify the zone with the highest load. It then unloads the supply fan just enough to keep the VAV damper in the *critical* zone fully open.

Figure 5-4 Fan-pressure optimization



Unloading the fan in this fashion decreases the static pressure in the duct, reducing the energy consumption and noise level of the fan.

Application consideration


- Effective implementation of fan-pressure optimization requires a control system capable of monitoring the damper positions in all the VAV terminal units.

Relating reading

- *Ventilation and Fan Pressure Optimization for VAV Systems* Engineering Bulletin (Trane literature number SYS-EB-2)
- "VAV System Optimization," *Engineers Newsletter* (volume 20, number 2)

Sample scenario

Parallel-fan-powered VAV terminals deliver supply air to the occupied spaces in a building. Fan-pressure optimization is one of the control strategies implemented by the building automation system. The BAS polls the individual VAV terminals to verify that each is receiving the airflow needed to satisfy the space load. It then modulates the supply fan, which is equipped with a variable-frequency drive, to satisfy the VAV terminal with the largest load.

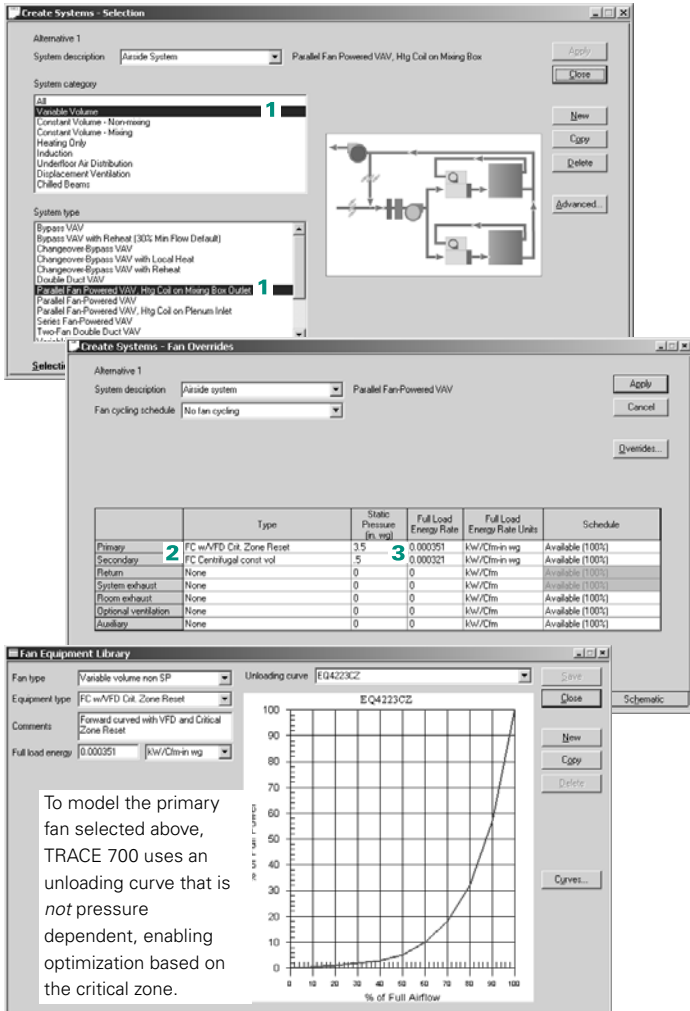
 To model fan-pressure optimization, define the air-distribution system.

1 Choose the desired system type from the **Variable Volume** category. For this example, use **Parallel Fan-Powered VAV**.

2 For the primary (central supply) fan, pick one of the predefined fan types with **critical zone reset**. This example uses a forward-curved fan with a variable-frequency drive.

Then choose an appropriate fan type to represent the secondary fans in the fan-powered VAV terminals.

3 Enter the static pressure required for each fan type.



Create Systems - Selection

Alternative 1
System description: Airside System
Parallel Fan Powered VAV, Htg Coil on Mixing Box

System category: **Variable Volume**

System type: **Parallel Fan-Powered VAV, Htg Coil on Mixing Box**

Create Systems - Fan Overrides

Alternative 1
System description: Airside system
Parallel Fan-Powered VAV
Fan cycling schedule: No fan cycling

	Type	Static Pressure (in. w.g.)	Full Load Energy Rate	Full Load Energy Rate Units	Schedule
Primary	FC w/VFD Crit. Zone Reset	3.5	0.000351	kW/Cfm-in w.g.	Available (100%)
Secondary	FC Centrifugal const vol	5	0.000321	kW/Cfm-in w.g.	Available (100%)
Return	None	0	0	kW/Cfm	Available (100%)
System exhaust	None	0	0	kW/Cfm	Available (100%)
Room exhaust	None	0	0	kW/Cfm	Available (100%)
Optional ventilation	None	0	0	kW/Cfm	Available (100%)
Auxiliary	None	0	0	kW/Cfm	Available (100%)

Fan Equipment Library

Fan type: Variable volume non SP
Equipment type: FC w/VFD Crit. Zone Reset
Comments: Forward curved with VFD and Critical Zone Reset
Full load energy: 0.000351 kW/Cfm-in w.g.

Unloading curve: EQ4223CZ

EQ4223CZ

100
90
80
70
60
50
40
30
20
10
0

0 10 20 30 40 50 60 70 80 90 100

% of Full Airflow

0.000351 kW/Cfm-in w.g.

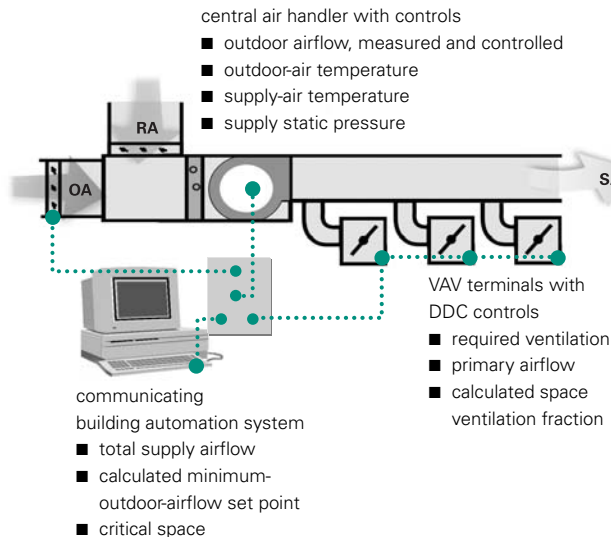
To model the primary fan selected above, TRACE 700 uses an unloading curve that is *not* pressure dependent, enabling optimization based on the critical zone.

Ventilation reset for VAV systems

ANSI/ASHRAE 62, *Ventilation for Acceptable Indoor Air Quality*, is considered the standard of care for designing ventilation systems in commercial buildings. That document details a prescriptive Ventilation Rate Procedure for compliance, which relies on adequate dilution of space contaminants to achieve acceptable indoor-air quality.

Two ventilation rates must be considered to successfully apply the Ventilation Rate Procedure in a multiple-space system: the *minimum required ventilation rate for each space*, which can be determined from the type of occupancy and design population; and the *total system ventilation rate* needed at the air handler, which is defined by Equation 6–1 from ANSI/ASHRAE 62–2001. Equation 6–1 takes credit for *unused* ventilation air returning from overventilated spaces, reducing the total amount of outdoor airflow for the system.

Figure 5–5 Ventilation reset for VAV systems



A ventilation-reset strategy that dynamically solves Equation 6–1, and regulates outdoor airflow accordingly, helps ensure that

every zone is properly ventilated at all load conditions. Implementing such a strategy requires:

- DDC–VAV terminals that continuously measure the volume of supply air and the ventilation fraction for each space
- A building automation system (BAS) that continuously monitors this information and dynamically solves Equation 6–1 to determine the amount of outdoor air needed at the air handler
- An air handler that continuously monitors the amount of outdoor air entering the system and resets the position of the outdoor–return air damper accordingly to maintain the set point calculated by the BAS

When effectively applied, ventilation reset can also prevent costly overventilation.

Application considerations

- Ventilation reset is most effective if each VAV terminal senses and controls supply airflow independently from fluctuations in duct pressure.
- A building automation system that monitors and logs the operation of the ventilation system can provide a useful record of compliance with ANSI/ASHRAE 62.


Related reading

- *Ventilation and Fan Pressure Optimization for VAV Systems* Engineering Bulletin (Trane literature number SYS-EB-2)
- “Ventilating Single-Duct VAV Systems,” *Engineers Newsletter* (volume 27, number 1)


Sample scenario

The variable-volume (VAV) airside system for a building is designed for compliance with ANSI/ASHRAE 62–2001, *Ventilation for Acceptable Indoor Quality*. It is controlled by a building automation system that iteratively solves Equation 6–1 to dynamically regulate the amount of outdoor air brought into the system.

To model ventilation reset in a VAV system:

- 1  Specify the **ventilation airflows** (cooling and heating), as well as the **minimum primary airflow (VAV min)**, for each room.

VAV min sets the minimum stop on the VAV terminals. It is required to model ventilation reset in a VAV, bypass, or terminal mixing system.

- 2  Choose the desired system type from the **Variable Volume** category.
- 3 Open the **Advanced** dialog box and change the system ventilation flag (control method) to **ASHRAE Std 62 w/Vent Reset**.

This entry directs the program to calculate the system-level ventilation airflow required for design by solving Equation 6–1 of ASHRAE Standard 62–2001.

During simulation, TRACE 700 calculates the individual room ventilation fractions for each hour, to arrive at the hourly ventilation airflow required at the system level.

Note: For an optimally designed system, several iterations of calculations may be required to find optimal minimum-stop positions when using ASHRAE STD 62 as the ventilation methodology. Refer to “ASHRAE Standard 62” in the online Help for additional information related to ASHRAE STD 62 calculations.

Other methods of controlling system-level ventilation include:

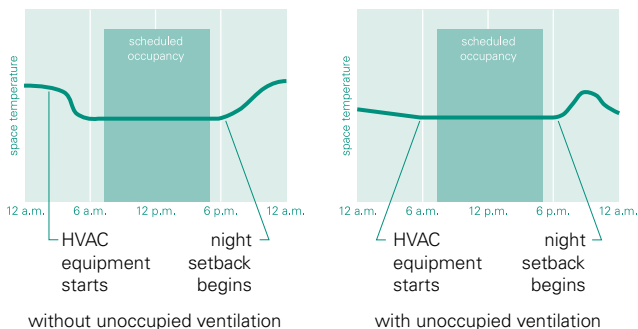
- **ASHRAE Std 62**, which directs TRACE 700 to use Equation 6–1 to calculate the system-level ventilation airflow required for design. During simulation, the system will attempt to introduce this amount of air whenever ventilation is needed.
- **Sum Room OA Reqs.**, which defines the system-level ventilation requirement for design, and for each hour of simulation, as the sum of the hourly room requirements for outdoor air. This control method does *not* satisfy the ventilation requirement for multiple-space systems that is defined in ASHRAE Standard 62–2001.

Unoccupied ventilation (night purge)

Unoccupied ventilation can serve as an effective tool to improve indoor-air quality by flushing many indoor contaminants from the building. This practice introduces large quantities of outdoor air to purge stale air from the building without increasing the cooling load.

In climates with cool nighttime temperatures, this control strategy can also reduce utility costs by taking advantage of the thermal capacity of the building. When the nighttime temperature outside reaches a predefined value, the control system activates the supply fan and opens the outdoor-air damper to introduce outdoor air directly into the building. The fans remain on until the space temperature falls to a specified level. In effect, the cool air brought into the building at night reduces or eliminates the morning *pull-down* load that often develops in a building during the cooling season.

Figure 5–6 Effect of unoccupied ventilation on space temperature





Application considerations

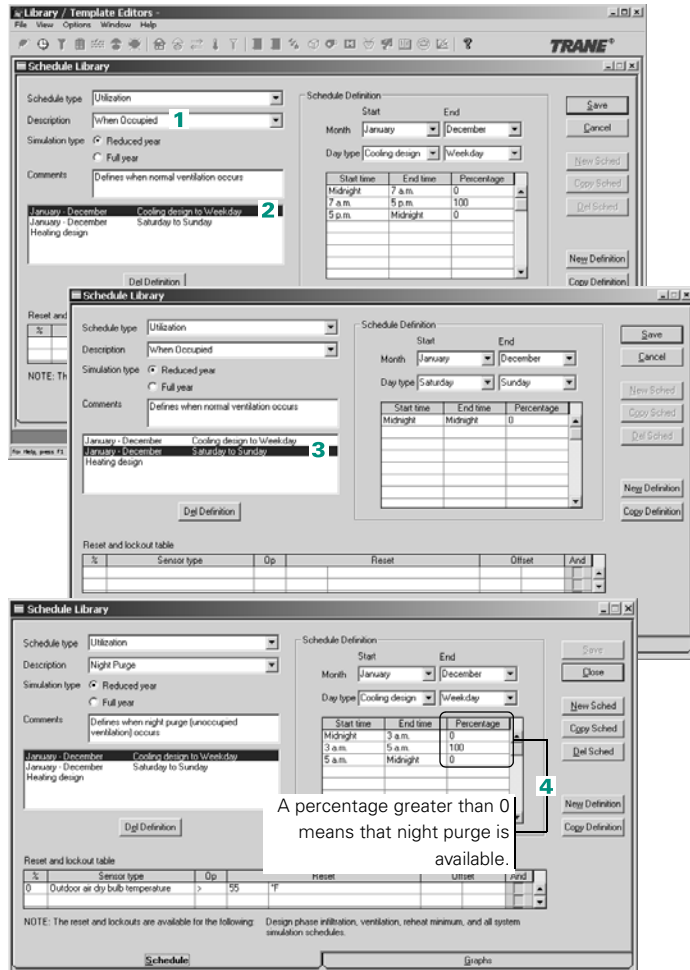
- The control system must monitor both inside and outside temperatures (and/or enthalpies).
- In humid climates, avoid bringing moisture-laden outdoor air into the building.
- Position the outdoor-air intakes to avoid introducing contaminated air into the space.

Sample scenario


Normal quantities of outdoor air are brought into the building for ventilation during occupancy, which occurs weekdays from 7 a.m. until 5 p.m. The night-purge cycle is enabled between 3 a.m. and 5 a.m. whenever the outdoor-air temperature is cooler than 55°F, Monday through Friday.

 In the **Schedule** library of the Library/Template Editors program:

-  Create a new **Utilization** schedule to define when normal ventilation occurs.
- Define the **cooling design schedule** to establish occupancy as 7 a.m. to 5 p.m. on weekdays. Then define a **heating design schedule** that is 100 percent from midnight to midnight.
- Set the midnight-to-midnight percentage to 0 for **Saturday and Sunday**, indicating that the building is not supplied ventilation during that time.
- Create a new **Utilization** schedule that defines when the night-purge cycle occurs—that is, on from 3 a.m. to 5 a.m. Cooling design to Weekday.
- Set the Midnight to Midnight percentage to 0 for Saturday and Sunday, indicating the night purge is not active on weekends (not shown).




- 6 Establish a lockout that will disable the night-purge cycle if the outdoor-air temperature is greater than 55°F.

 In either the **Create Rooms** or the **Create Templates** section of your TRACE 700 project:

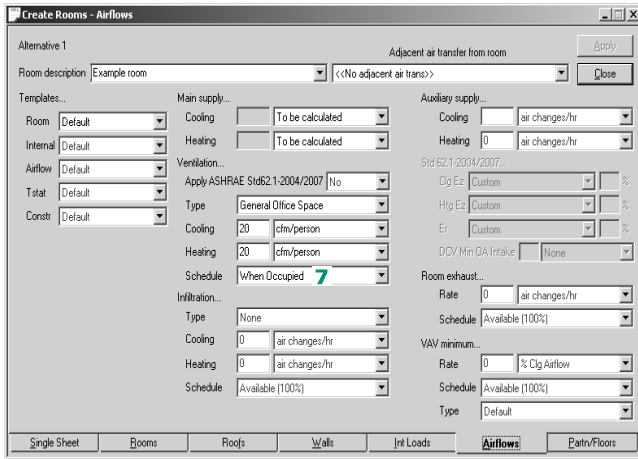
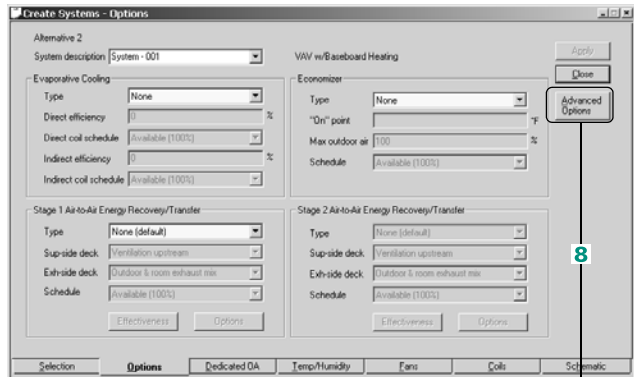
- 7 Switch to the **Airflows** tab and select the **ventilation schedule** defined in Steps 1–3 for normal occupancy.

In this example, the **When Occupied** schedule introduces 100 percent of the design outdoor-airflow requirement between 7 a.m. and 5 p.m. on weekdays.

At all other times, the outdoor-air dampers are closed, unless the night-purge cycle is active.

- 8  The night-purge cycle is an option for the airside system. Click the **Options** tab of the **Create Systems** window and click **Advanced Options**.

- 9 To make the night-purge cycle available, choose the custom schedule just created.

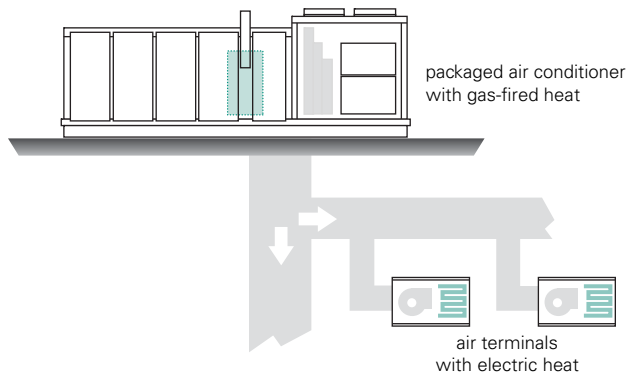

Morning warm-up for dual-fuel applications

The interior zones in many buildings require year-round cooling during the day, even when the temperature outside is 20°F or less. Such conditions also require heating—at night, and in perimeter zones during the day.

Depending on the load profile of the building, it may be cost-effective to design an HVAC system that uses two sources of heating energy. For example, if relatively little heat is required during the day, the terminal units may be equipped with small electric heat coils. An inexpensive heat source such as natural gas can then be used to handle the increased heating load that exists at night and during morning warm-up.

Note: To conserve heating energy, it is common practice to set back the thermostat during unoccupied periods. Morning warm-up describes the control strategy that restores the desired space temperature in time for occupancy.

Figure 5–7 HVAC system with two energy sources for heating




Application considerations


- Controls must be provided to switch from one heat source to the other.
- A dual-fuel system design may be ineligible for the special rates that some utilities offer for all-electric systems.

Sample scenario

A gas-fired, rooftop air conditioner and VAV terminals with electric heating coils serve a small building. Either heat source can handle the design heating load of 200 MBh. However, the electric heating coils only operate during scheduled occupancy, that is, from 7 a.m. until 8 p.m. on weekdays. The gas-fired furnace in the rooftop air conditioner provides heating at night, during morning warm-up (which begins at 5 a.m. on weekdays), and on weekends.

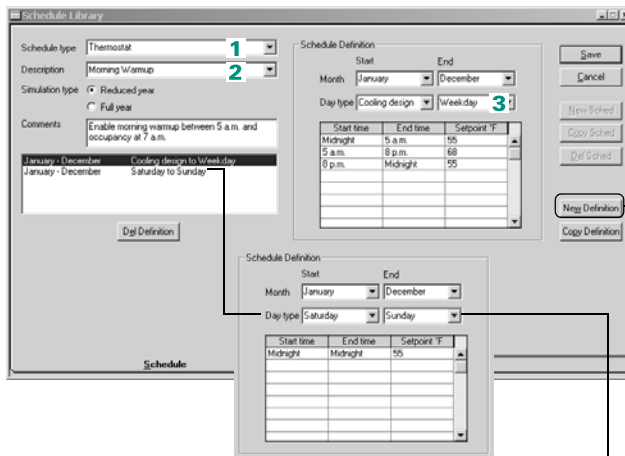
The illustrations that follow demonstrate how to create schedules that simulate morning warm-up (Steps 1–3), determine equipment availability (Steps 4–5), and assign the schedules to the appropriate rooms and equipment (Steps 6–9).

 Use the Library/Template Editors program to create a schedule for the thermostat set points.

- 1  Open the **Schedule** library and pick **Thermostat** as the schedule type.
- 2 Create a new schedule and name it *Morning Warmup*. Add comments, if desired, to further describe the schedule.
- 3 Define a **Weekday** schedule with an after-hours set point of 55°F and an occupied set point of 68°F that is also in effect during the morning warm-up period (from 5 a.m. to 7 a.m.).

To maintain the 55°F set point throughout the *weekend*, define a separate schedule for Saturday and Sunday.

Click **New Definition** to define a new timetable for a different day type or month within the current schedule.



Start time	End time	Setpoint °F
Midnight	5 a.m.	55
5 a.m.	8 p.m.	68
8 p.m.	Midnight	55

Start time	End time	Setpoint °F
Midnight	Midnight	55

TRACE 700 schedules define timetables for four **day types**: **Cooling design**, **Weekday**, **Saturday**, and **Sunday**. The definitions within each schedule must account for all four day types. Refer to “Create schedules” on page 2–19. For more information, refer to online Help.

With the **Schedule** library still open, select **Equipment operation** from the **Schedule type** list to create schedules that describe when each heat source is available.

- 4 Create a new schedule with *two definitions* to describe when the **gas-fired furnace** in the rooftop air conditioner can operate.

- On **weekdays** during morning warm-up (5 a.m. to 7 a.m.) and at night after occupancy ends (8 p.m.).

- On **weekends** throughout the day.

- 5 Create a new schedule that describes when the **electric heating coils** can operate.

- On **weekdays** during occupancy (7 a.m. to 8 p.m.), but not on **weekends**.



Return to the TRACE 700 project to assign the new **Thermostat** and **Equipment operation** schedules.

- 6 In either the **Create Rooms** or the **Create Templates** section: for each room, choose the **Morning Warm-up** schedule as the **Thermostat** heating schedule.

Schedule Library

Schedule type: Equipment operation
 Description: Gas-fired rooftop
 Simulation type: Reduced year
 Comments: Operates at night and on weekends

Schedule Definition

Start	End	Status
Midnight	7 a.m.	Normal
7 a.m.	8 p.m.	Off
8 p.m.	Midnight	Normal

Day type: Cooling design Week-day

Schedule Library

Schedule type: Equipment operation
 Description: Electric heat sched
 Simulation type: Reduced year
 Comments: Operates only on weekdays during the day

Schedule Definition

Start	End	Status
Midnight	7 a.m.	Off
7 a.m.	8 p.m.	Normal
8 p.m.	Midnight	Off

Day type: Cooling design Week-day

Create Rooms - Rooms

Alternative 1

Room description: Room 100 - Administration

Templates...

Room: Classrooms
 Internal: Office
 Airflow: School
 Total: Default
 Constr: Default

Size...

Length: 50 ft
 Width: 60 ft
 Height: 10 ft
 Floor to floor: 10 ft
 Plenum: 2 ft
 Above ground: 0 ft

Design...

Cooling dry bulb: 75 °F
 Heating dry bulb: 58 °F
 Relative humidity: 50 %

Thermostat...

Cooling setpoint: 30 °F
 Heating setpoint: 75 °F
 Cooling schedule: None
 Heating schedule: Morning Warmup
 Location: Room

Humidity...

Latent capacity: None
 Humidistat locn: Room

Room mass/avg time lag: None
 Slab construction type: 4" LWF Concrete
 Acoustic ceiling resistance: 1.796 hr ft²-S/btu

Finally, create a **heating plant** that consists of the gas-fired furnace in the rooftop air conditioner and the electric heating coils in the VAV terminals.

- 7 Add a **gas-fired heat exchanger** and **electric resistance heat** to the heating plant.

Then use the entries on the **Heating Equipment** tab to finish defining each piece of equipment.

- 8 With the gas-fired heat exchanger displayed:

- Choose the appropriate **equipment type**.

- Enter the **heating capacity**.

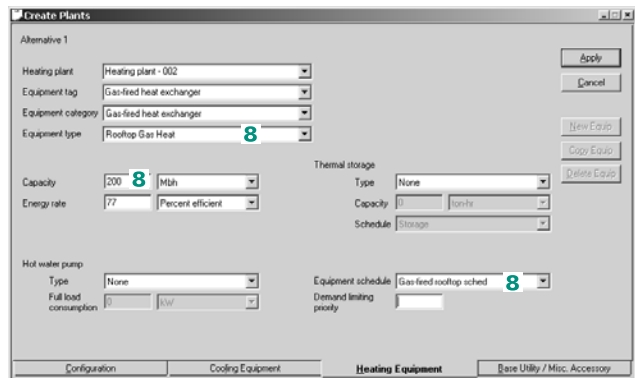
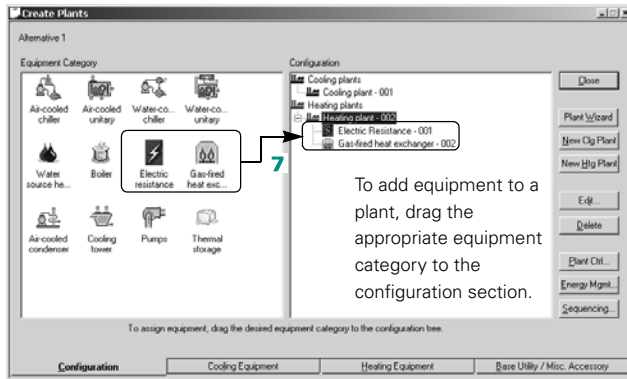
- Select the **Equipment operation** schedule that determines when the gas-fired furnace can operate.

- 9 Switch to the electric resistance heat and:

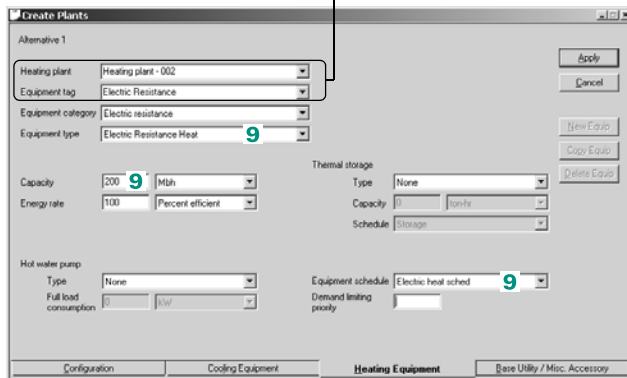
- Choose the appropriate **equipment type**.

- Enter the **heating capacity**.

- Select the **Equipment operation** schedule that determines when the electric heating coils can operate.



Use these entries to move between plants and equipment, respectively.



Chilled-water reset

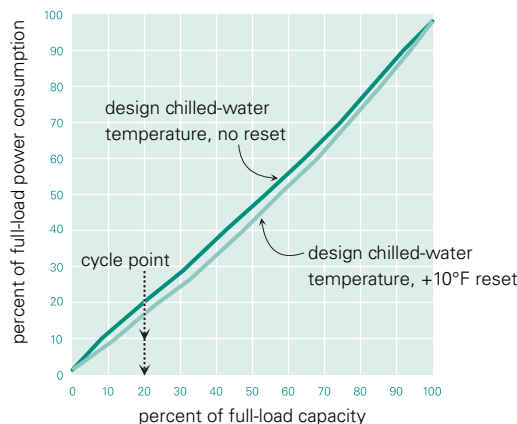
Chilled-water reset adjusts the chilled-water set point to improve the efficiency of the chiller, reducing the energy consumption of the chiller.

Usually, a chilled-water-reset strategy raises the set-point temperature when the building load is at less-than-design conditions. Producing warmer chilled water lessens the burden on the compressor, which means that the chiller consumes less energy.

Consider a centrifugal chiller with entering- and leaving-water temperatures of 54°F and 44°F, respectively, at design conditions, and a maximum reset of 4°F. When the building load falls to 80 percent of design, the water temperature leaving the evaporator is reset upward, by 2°F, to 46°F. If the building load continues to drop, the set point is adjusted upward until the maximum reset set point of 48°F is reached (44°F design set point + 4°F maximum reset).

As a *rule-of-thumb*, each 1°F increase in the chilled-water temperature reduces the energy consumption of the chiller by an amount from 1 percent to 1.5 percent.

Figure 5–8 Example of chiller unloading characteristics



Application considerations


- Raising the chilled-water temperature in variable-volume systems increases the energy consumption of pumps, and may more than offset the savings in chiller efficiency.
- If humidity control is critical, take particular care to ensure that the warmer chilled water does not cause the loss of space temperature or humidity control.
- To ensure adequate refrigerant flow and maintain proper oil movement within the chiller, maintain the minimum pressure differential (specified by the manufacturer) between the condenser and evaporator.

Related reading

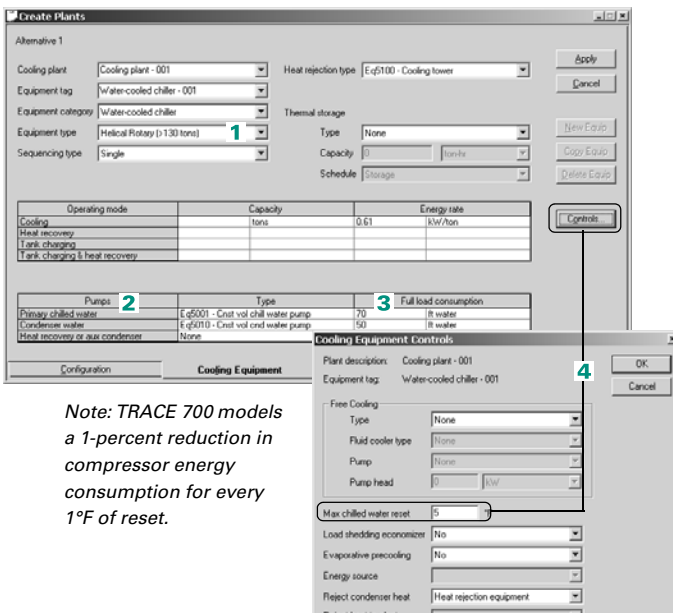
- *Multiple-Chiller-System Design and Control Applications* Engineering Manual (Trane literature number SYS-APM001-EN)

Sample scenario

The chilled-water plant for a building consists of a water-cooled chiller, a cooling tower, and related pumps. At part-load conditions, the chilled-water set point is reset upward. The maximum amount of reset is 5°F.

 After adding a water-cooled chiller to the cooling plant:

- 1 Describe the chiller type.
- 2 Review the default pumps and choose a different type, if appropriate.
- 3 Specify the **full-load consumption** for each pump.
- 4 Click **Controls** on the **Cooling Equipment** tab. On the **Cooling Equipment Controls** screen, enter the maximum amount of reset that can be applied to the chilled-water set point—in this case, 5°F.



Create Plants

Alternative 1

Cooling plant: Cooling plant - 001 Heat rejection type: Eq100 - Cooling tower

Equipment tag: Water-cooled chiller - 001

Equipment category: Water-cooled chiller

Equipment type: Helical Rotary (1-130 tons) **1**

Sequencing type: Single

Thermal storage: None

Type: None

Capacity: 0

Schedule: Storage

Operating mode

Operating mode	Capacity	Energy rate
Cooling	tons	0.61
Heat recovery		
Tank charging		
Tank charging & heat recovery		

Pumps **2**

Pumps	Type	Full load consumption
Primary chilled water	Eq0001 - Cent vol chl water pump	70
Condenser water	Eq0010 - Cent vol cond water pump	50
Heat recovery or aux condenser	None	

Cooling Equipment Controls

Plant description: Cooling plant - 001

Equipment tag: Water-cooled chiller - 001

Fire Cooling: Type: None

Fluid cooler type: None

Pump: None

Pump head: 0

Max chilled water reset: 5

Load shedding economizer: No

Evaporative precooling: No

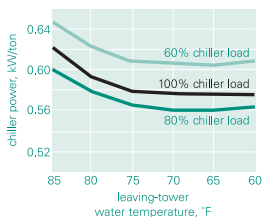
Energy source:

Reject condenser heat: Heat rejection equipment

Note: TRACE 700 models a 1-percent reduction in compressor energy consumption for every 1°F of reset.

Condenser-water reset

As long as the evaporator temperature remains constant, lowering the entering-condenser-water temperature increases the efficiency of a chiller. That is because the colder condensing temperature reduces the pressure difference between the evaporator and the condenser, easing the burden on the compressor. Gains in efficiency are limited, however.

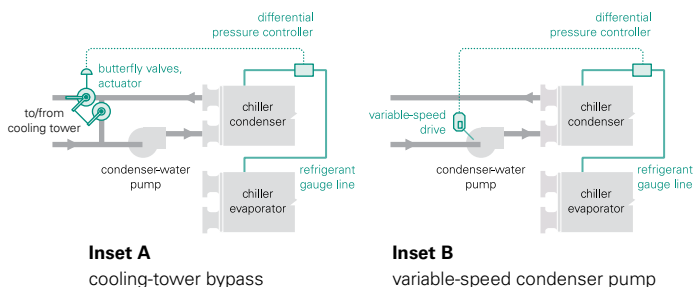


At the system level, the energy savings that accrue from improved chiller efficiency may be offset by increased operating costs for fans and pumps. Note, also, that *chiller efficiency will not continue to improve with every reduction in condenser temperature*. Power used per cooling ton bottoms out and actually begins to increase as condensing pressure falls. Consequently, the best way to improve chiller efficiency is by actively controlling condenser pressure.

There are several ways to control condenser pressure. The most versatile of these automatically accounts for changing loads. It regulates the *difference* in refrigerant pressure between the condenser and the evaporator by:

- Modulating the speed of the cooling-tower fans—or adjusting a tower bypass valve, as shown in Inset A of Figure 5—9—to control the entering-condenser-water temperature
- Adjusting the condenser-water flow rate using a pump equipped with an inverter and a variable-frequency drive (Inset B)

Figure 5-9 Methods for controlling condenser pressure



Application considerations

- Chiller efficiency represents only part of the total operating cost for a chilled-water plant. Use a building automation system capable of controlling *all* plant components.
- Contact the chiller manufacturer to determine the differential refrigerant pressure that will maximize efficiency while ensuring adequate refrigerant flow and lubrication.
- Although the butterfly valves associated with the cooling-tower bypass provide excellent control, they also increase the first cost of the system.
- Be sure to maintain the condenser-water flow rate above the minimum limit recommended by the chiller manufacturer. Monitor the condenser approach temperature to check for fouled tubes.

Related reading

- *Multiple-Chiller-System Design and Control Applications* Engineering Manual (Trane literature number SYS-APM001-EN)

Sample scenario

A 500-ton, three-stage, centrifugal chiller is designed for a condensing temperature of 85°F. The leaving-tower set point is reset downward to 55°F when ambient and operating conditions permit (usually when a 20°F to 22°F differential exists between the water temperatures entering and leaving the condenser).




You can model either temperature-based reset or flow-based reset, but not both.

The following examples demonstrate two ways to model condenser-water reset: by regulating the condenser-water *temperature* (page 5–28) and by varying condenser-water *flow* (page 5–29). Both methods require you to copy and modify an existing piece of cooling equipment.

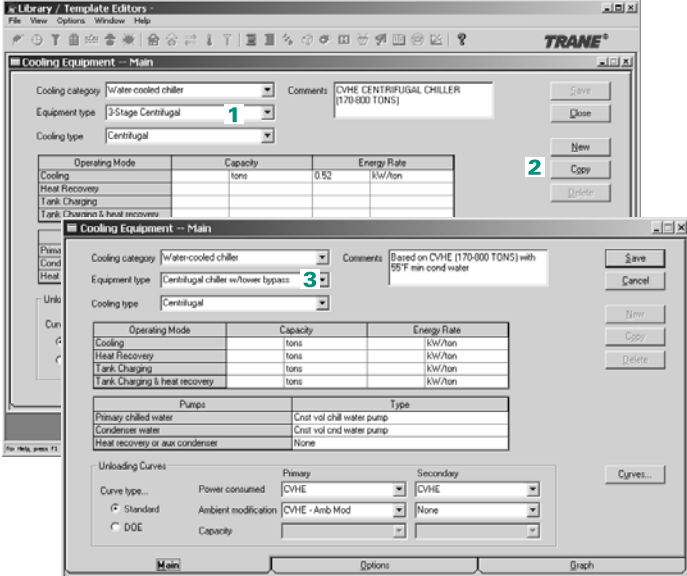
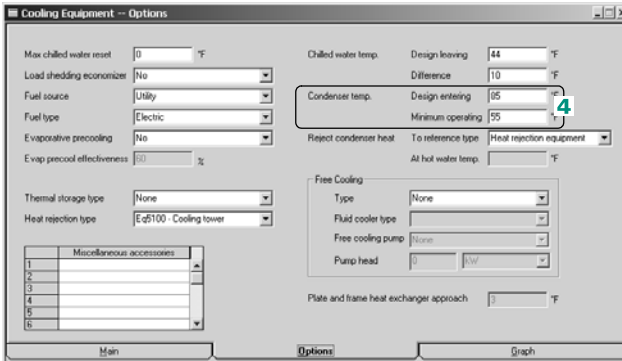
Temperature-based condenser-water reset

Use the procedure illustrated below when the speed of the tower fans, or the position of a tower bypass valve, controls the entering condenser-water temperature.

Use the Library/Template Editors program to customize an existing piece of cooling equipment.


- 1  Open the **Cooling Equipment** library and choose the **Equipment type** that best matches what you want to model.
- 2 Click **Copy**.
- 3 Replace the generic name for the equipment type with something more descriptive, and add comments if desired.
- 4 Specify the lowest permissible condenser-water temperature for the chiller. (The default for most water-cooled chillers in the TRACE 700 library is either 55°F or 65°F.)


When finished, return to the TRACE 700 project to add the newly created equipment to the cooling plant.





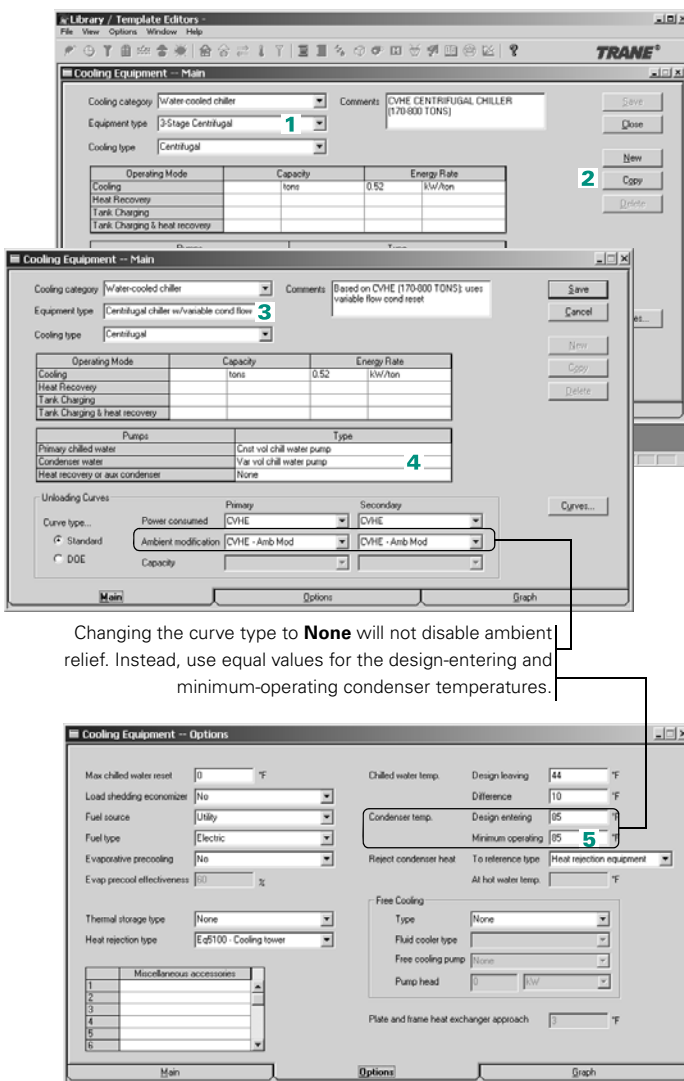
Flow-based condenser-water reset

Most of the water-cooled chillers in the **Cooling Equipment** library are defined with constant-flow condenser pumps. The following example demonstrates how to model condenser-water reset that is controlled by varying the flow of water through the condenser.

 Use the Library/Template Editors program to customize an existing piece of cooling equipment:

- 1  Open the **Cooling Equipment** library and choose the **Equipment type** that best matches what you want to model.
- 2 Click **Copy**.
- 3 Replace the generic name for the equipment type with something more descriptive, and add comments if desired.
- 4 Choose a **variable-flow pump** for the condenser-water loop.
- 5 To eliminate the effect of ambient relief for the condenser, specify a minimum-operating temperature that *equals* the design-entering temperature.

 When finished, return to the TRACE 700 project to add the newly created equipment to the cooling plant.



The screenshots show the TRANE Library/Template Editors interface. The top window shows the 'Cooling Equipment - Main' tab with the following settings:

- Cooling category: Water-cooled chiller
- Equipment type: 3-Stage Centrifugal (labeled 1)
- Cooling type: Centrifugal
- Comments: CVHE CENTRIFUGAL CHILLER (170-800 TONS)
- Buttons: Save, Close, New, Copy (labeled 2), Delete

The bottom window shows the 'Cooling Equipment - Main' tab with the following settings:

- Cooling category: Water-cooled chiller
- Equipment type: Centrifugal chiller w/variable cond flow (labeled 3)
- Cooling type: Centrifugal
- Comments: Based on CVHE (170-800 TONS) uses variable flow cond reset
- Buttons: Save, Cancel, New, Copy, Delete

The 'Pumps' section in the bottom window shows:

	Type
Primary chilled water	Cent vol chill water pump
Condenser water	Var vol chill water pump (labeled 4)
Heat recovery or aux condenser	None

The 'Unloading Curves' section shows:

- Curve type: Power consumed
- Primary: CVHE
- Secondary: CVHE
- Ambient modification: CVHE - Amb Mod
- Capacity: CVHE - Amb Mod

A callout box points to the 'Ambient modification' dropdown, stating: "Changing the curve type to **None** will not disable ambient relief. Instead, use equal values for the design-entering and minimum-operating condenser temperatures."

The bottom window shows the 'Cooling Equipment - Options' tab with the following settings:

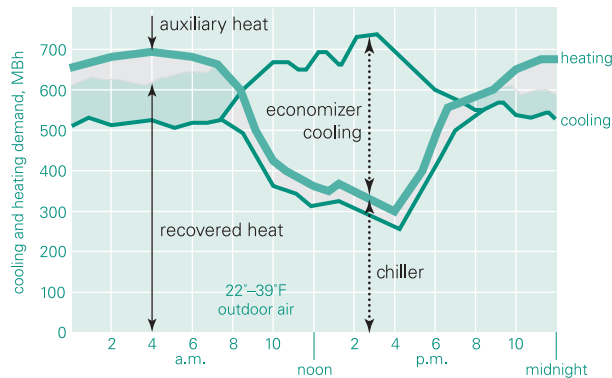
- Max chilled water reset: 0 °F
- Load shedding economizer: No
- Fuel source: Utility
- Fuel type: Electric
- Evaporative precooling: No
- Evap precool effectiveness: 0.0 %
- Thermal storage type: None
- Heat rejection type: Eqs100 - Cooling tower
- Miscellaneous accessories: 1, 2, 3, 4, 5, 6
- Chilled water temp. Design leaving: 44 °F
- Difference: 10 °F
- Condenser temp. Design entering: 65 °F
- Minimum operating: 65 °F (labeled 5)
- Reject condenser heat: To reference type
- Heat rejection equipment: Heat rejection equipment
- Air hot water temp: °F
- Free Cooling: Type: None, Fluid cooler type: , Free cooling pump: None, Pump head: 0 kW
- Plate and frame heat exchanger approach: °F

Load-shedding economizer

Conventional practice uses an airside economizer to satisfy internal loads when ambient conditions permit, and thereby minimize operation of the mechanical cooling equipment. Similarly, recovered condenser heat can be used to supplement an auxiliary source of heat to offset thermal heat losses in perimeter zones.

A load-shedding economizer saves energy by combining these concepts to minimize the operation of both the chiller *and* the auxiliary heating equipment. The chiller satisfies the *heating* load and virtually eliminates the need for auxiliary heat during occupied hours. Meanwhile, natural cooling—that is, outdoor air introduced by an airside economizer—satisfies only the portion of the cooling load that is not already handled by the chiller. In this way, the economizer balances the operation of the chiller with the perimeter heating loads. That is, the economizer only trims the excess cooling load that is not needed for heating purposes. Refer to Figure 5–10.

Figure 5–10 Effect of operating a load-shedding economizer



For coordinated operation, the same controller governs the economizer and the heat-recovery equipment. An initial decrease in the heating demand prompts the controller to turn off the auxiliary heat and rely on recovered heat to satisfy the perimeter loads. Further decreases in heating demand indicate that less

heat is needed, so the controller modulates the economizer dampers open. The chiller responds by unloading to reduce the amount of recovered heat available.

If the economizer is fully open (shedding as much chiller capacity as ambient conditions permit) and the heating demand drops further, the cooling condenser rejects the unneeded heat to the cooling tower.


The control sequence just described operates in reverse when the heating demand increases.

Application considerations

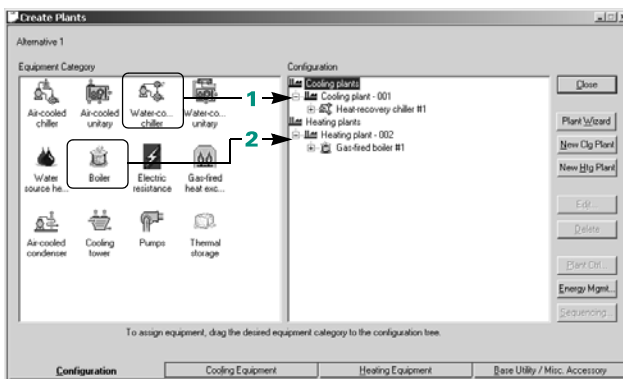
- For a load-shedding economizer to operate as intended, the temperature and humidity outdoors must be low enough to provide effective cooling.
- When specifying equipment for the chilled-water plant, the chiller must be equipped for condenser heat recovery, and the control system must be capable of balancing cooling and heating demands, to optimize the operation of the economizer.

Sample scenario

A chilled-water plant includes a three-stage, centrifugal chiller, equipped for heat recovery, and a load-shedding economizer. During the standard cooling mode, the chiller can produce 500 tons of cooling while consuming 0.58 kW/ton. When operating in the heat-recovery mode, the chiller can produce 400 tons of cooling and consumes 0.70 kW/ton.

 To model the cooling and heating plants in this example:

- 1 Add a water-cooled chiller to the cooling plant. If desired, replace the generic equipment tag with a more descriptive name.
- 2 Waterside heat-recovery applications typically include a backup source of heat. For this example, add a boiler to the heating plant.



- 3 Choose a boiler type.
- 4 Enter the static head to represent the **full-load consumption** of the hot-water pump.
- 5 Select a heat-recovery chiller as the **equipment type**.
- 6 Specify the **capacity** and **energy rate** for each operating mode (cooling and heat recovery).
- 7 Enter the **full-load consumption** for each pump.
- 8 Assign the heat recovered by the chiller to the heating plant.
- 9 Add a load-shedding economizer to balance the heating demand.

Operating mode	Capacity	Energy rate
Cooling	500 tons	0.58 kW/ton
Heat recovery	400 tons	0.7 kW/ton
Tank charging	tons	kW/ton
Tank charging & heat recovery	tons	kW/ton

Pumps	Type	Full load consumption
Primary chilled water	Eq5001 - Crst vol chl water pump	70 ft water
Condensate water	Eq5010 - Crst vol cond water pump	150 ft water
Heat recovery or aux condensate	None	

Daylighting

Daylighting systems can significantly reduce both lighting consumption and cooling-energy consumption by reducing the electric-lighting heat gain in the building. However, daylighting can also cause increased heating-energy consumption, something that must be considered when evaluating adding daylighting to a building. Different control strategies, window configurations, surface reflectivities, and so forth, can greatly influence the energy savings provided by these systems.

Note: Daylight is typically defined as diffuse light and is very different from sunlight (direct solar radiation).

The TRACE 700 Daylighting algorithm is identical to that used by the DOE-2 computer program except for the user interface. It is comprised of three main stages, as follows.

- 1** A preprocessor calculates a set of daylight factors (interior illuminance divided by exterior horizontal illuminance) for later use in the hourly-loads calculation. The program automatically calculates the three-dimensional coordinates of one or two reference points in a space, using either the room and glass dimensions or optional aspect ratios defined by the user. The algorithm then integrates over the area of each window to obtain the contribution of direct light from the window to the illuminance at the reference points, and the contribution of light from sky and ground, which enters the window and reflects from the walls, floor, and ceiling before reaching the reference points. Taken into account are such factors as window size and orientation, glass visible transmittance, inside surface reflectance of the space, sun-controlled devices such as blinds and overhangs, and the illuminance distribution of the sky. Because this distribution depends on the position of the sun and the of 20 different solar altitude and azimuth values, covering the annual range of sun positions.
- 2** An hourly daylight-illuminance glare calculation is performed. The illuminance contribution from each window is found by interpolating the stored daylight factors using the current-hour sun position and cloud cover, and then multiplying by the current-

hour exterior horizontal illuminance obtained from the **Step 1** calculation. If applicable, the solar-gain threshold is tested to determine whether the window blinds or drapes should be closed to maintain a user-defined comfort level. Adding the illuminance contributions from all the windows (including skylights) then gives the total illumination (daylight effect) at each reference point.

- 3** Stepped and continuously dimming control systems are simulated to determine the electrical lighting energy needed to make up the difference, if any, between the daylighting level and the required illuminance. The effect of the diminished lighting level (and possibly reduced solar heat gain if the internal shading device is employed) is calculated and passed to the load phase.

Application considerations

- Daylighting does not necessarily mean an increase in the amount of fenestration on a building. Proper placement and configuration for the fenestration is as important to a properly designed daylighting system as the amount of fenestration.
- When designing a building with daylighting, be aware of the possible increase in solar heat gain and the possibility of glare from sunlight.


Related reading

- For additional information related to daylighting, refer to *Daylight in Buildings: A Source Book on Daylighting Systems and Components* at: <http://gaia.lbl.gov/iea21/>

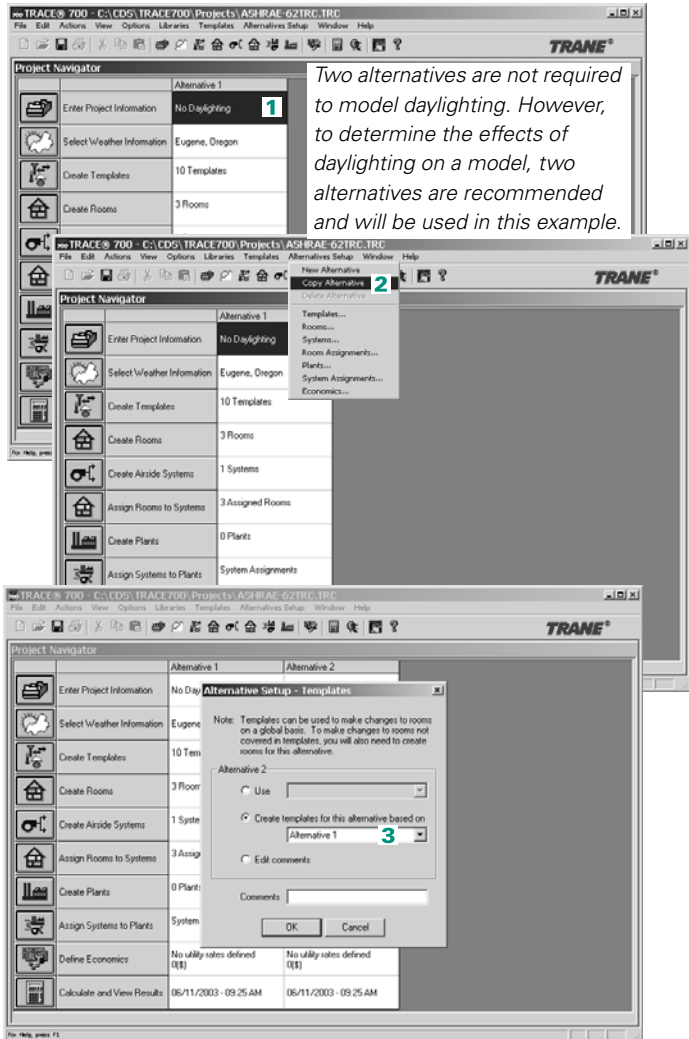
Sample scenario

Daylighting controls will be added to all of the perimeter rooms in a building. All windows were input using dimensions (rather than percent glass), and a standard stepped controller will be used. The user would like to find the savings that daylighting will provide for the building.

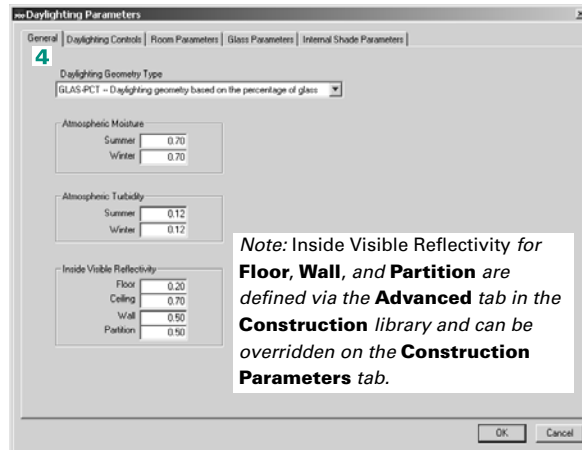
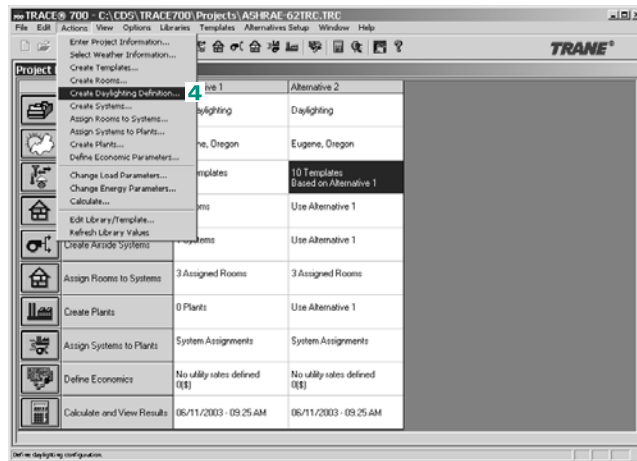
Note: Assuming that the other default inputs are acceptable, this scenario can be modeled in TRACE 700 with as few as three inputs.

 To model daylighting:

- 1 Start by modeling the first alternative completely. It is required that all glass be input using the same method (percent or dimensions) for daylighting. For more-accurate modeling of daylighting, the dimensions method is recommended. After Alternative 1 has been completed, a second alternative can be created with daylighting.
- 2 To create the second alternative, click **Copy Alternative** on the **Alternatives Setup** menu to create a copy of Alternative 1.
- 3 With the second alternative created, the templates from Alternative 1 must be copied so that the design and system section of Alternative 2 will be recalculated with daylighting. Right-click Alternative 2 and click **Templates** on the list. To make the copy of the templates editable, select **Create Templates for this Alternative based on Alternative 1** and click **OK**.



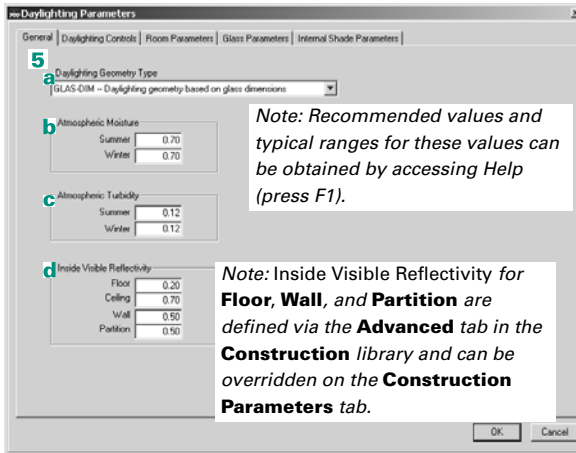
- 4 To activate Daylighting, click **Create Daylighting Definition** on the **Actions** menu. The **Daylighting Parameters** screen should open, displaying where the daylighting definitions will be created and added to the spaces. The **Daylighting Parameters** screen should open to the **General** tab.



*Note: Inside Visible Reflectivity for **Floor, Wall, and Partition** are defined via the **Advanced** tab in the **Construction** library and can be overridden on the **Construction Parameters** tab.*

5 Daylighting Geometry Type, Atmospheric Moisture, Atmospheric Turbidity, and Inside Visible Reflectivity are input from the **General** tab.

*Note: Select the Daylighting Geometry Type that reflects how the glass was input, in this example, as **GLAS-DIM**.*



- a** The Daylighting Geometry Type tells the program how the glass was input and is used to determine the fraction of the available daylight, passing through the glazing area, that can be used to offset the power consumption of the electric lights.
- b** The Atmospheric Moisture represents the amount of perceptible water vapor in the atmosphere and affects the calculation of the luminance of clear skies (this is not the amount of rainfall).
- c** The Atmospheric Turbidity is a measure of aerosols (particulate pollutants and water droplets) in the atmosphere and affects the calculation of the luminance of clear skies.
- d** The Inside Visible Reflectivity is the fraction of visible (not solar) light that is reflected, rather than absorbed, by the opaque surface. This value is used to help calculate the luminance of both natural and electric lighting within a space.

6 Click the **Daylighting Controls** tab, which contains standard and user-defined Daylighting Control Strategies. No inputs are required on this tab for the example scenario because it is using a default control type.

*Note: To create a custom controls template, click **Copy** and enter a description. This activates the fields under the **Controls** and **Geometry** sections.*

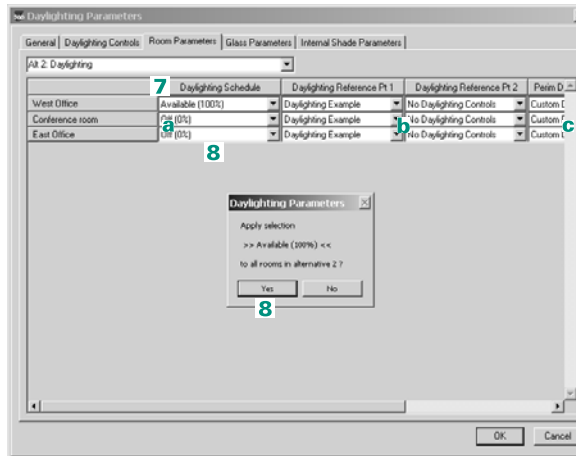
*Note: Values under the **Controls** section should be input starting at the top and working down:*

- a The Percent of Space Affected represents the fraction of the space floor area for which the lights are controlled by the specified daylighting controls.
- b The Lighting Setpoint represents the design lighting level in the space, in footcandles.
- c The Lighting Control Type is the type of daylighting control being used in the template (continuous or stepped). Depending on the Lighting Control Type selected, either input the Minimum Power and Lighting Percent or the Light Control Steps to simulate how the selected controls will operate.
- d The Light Control Probability is the probability that manually controlled, stepped controls are utilized.

*Note: Under the **Geometry** section, input the Reference Height (A) of the daylight sensor. All other values under the **Geometry** section will be auto-calculated if not input. Multiple templates can be created and used in the same file and even in the same space.*

6 Click the **Room Parameters** tab to select the **Alternative**, the **Daylighting Schedule**, the **Daylighting Reference Points**, and the **Perimeter Depth**.

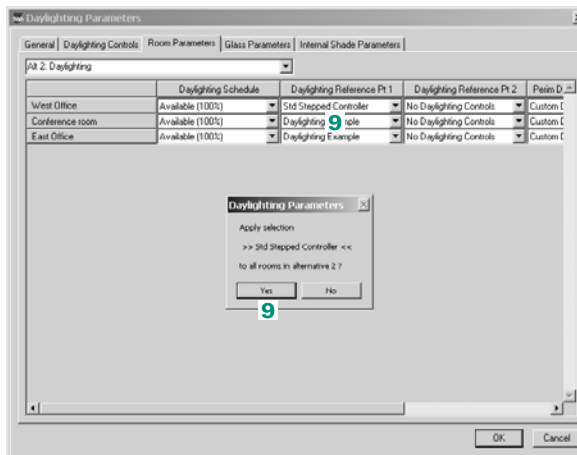
7 For this **Daylighting** schedule, choose **Available (100%)** and click **Yes** to apply this schedule to all rooms.



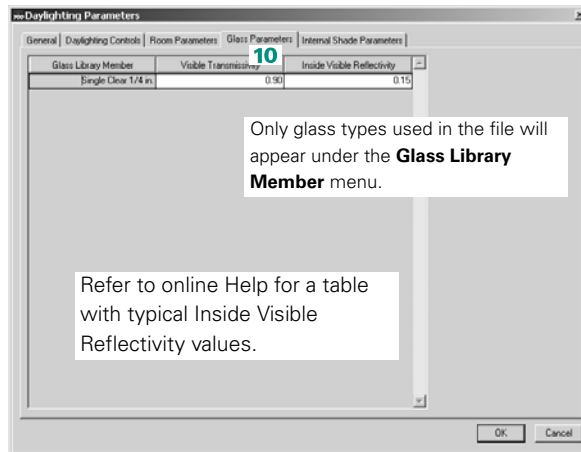
- a The Daylighting Schedule acts as an on/off switch. Utilization percent hours > 1 percent means the daylighting controls are available, while utilization percent hours = 0 means the daylighting controls are deactivated and no daylight reduction of lighting energy is allowed that hour. Typically, the schedule will be *available 100 percent, off 0 percent*, or a custom schedule that neglects daylighting during design but applies it during energy analysis (for details on creating schedules, refer to “Create schedules” on page 2–19).
- b The Daylighting Reference Points are used to select the templates created on the **Daylighting Controls** tab. Up to two Daylighting Reference Points are allowed per space.
- c The Perimeter Depth is used to calculate the distance of the Daylighting Reference Point from the perimeter wall. In addition, if the glass dimension method is used, Perimeter Depth is used to estimate the field of view seen by the daylighting sensor. Perimeter Depth can be selected as the room length or width, or manually input for each space.

8 For **Daylighting Reference Point 1**, choose **Std Stepped Controller** and click **Yes** to apply this to all rooms.

Note: If daylighting is added to a space that has no fenestration, then the daylighting controls will be ignored for that space.



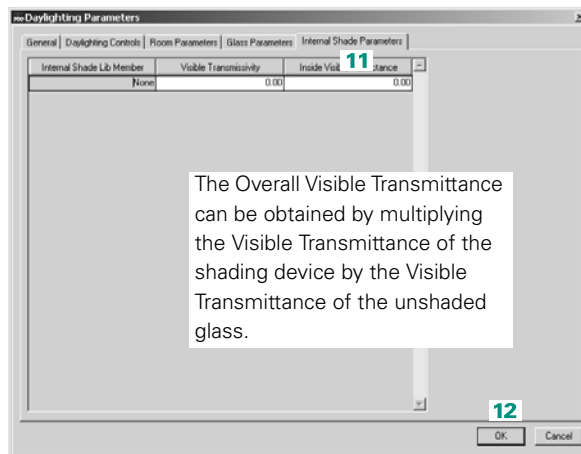
10The **Glass Parameters** tab allows the user to input the Visible Transmissivity and the Inside Visible Reflectivity. No inputs are required on this tab for the example scenario.



The Visible Transmissivity represents visible transmittance of the glass at normal incidence. Do not confuse visible (daylight) transmittance with total solar transmittance, which determines how much solar radiation is transmitted. The Inside Visible Reflectivity is the fraction of visible (not solar) light that is reflected on the inside surface of the glazing. This value is used to help calculate the luminance due to both natural and electric lighting within a space.

11The **Internal Shade Parameters** tab allows the user to input the Visible Transmissivity and the Inside Visible Reflectance of the glass and internal shade combination at normal incidence. No inputs are required on this tab for the example scenario.

12 When completed, click **OK** and the Daylighting Parameters will close. The second alternative can now be calculated and the effects of daylighting can be seen by comparing the output reports.



Additional Items

- 1 User-defined templates are available only for the file in which they were created.
- 2 Typical values and explanations for all fields can be found by pressing F1 to access online Help.
- 3 Daylighting can affect all sections of the building simulation (depending on the daylighting schedule selected on the **Room Parameters** tab). For cooling-load design, the cooling load and airflow will both change based on the lower lighting load, possible increased solar loads, changes in plenum temperature, and changes in time of peak. The heating-design simulation will also be affected, but the effects may be smaller than the effects on the cooling-design simulation, due to the typical neglecting of the solar and internal loads in heating-design calculations. In TRACE 700, two alternatives (one with daylighting and one without daylighting) can be used compare the overall effects of daylighting on the rooms, systems, plants, and life-cycle costs. The checksums reports can be used to view the effects on the design calculations for the rooms and systems—usually a reduction in cooling capacity and airflows occurs. The energy consumption reports can be used to view the effects on the plants—usually lower lighting energy, lower cooling energy, and possibly higher heating energy (because the heat given off by the lights in the spaces is less). The economic reports can be used to see the reduction in utility costs and the effects on the life-cycle cost for the building.

*Note: For conservativeness, it may be desirable to disregard daylighting during the sizing calculations. This can be done by creating a custom utilization schedule, which can be selected on the **Room Parameters** tab (refer to step 8 of the daylighting example for the location of the daylighting utilization schedule). The custom schedule would have the cooling-design and heating-design daytypes input as midnight-to-midnight 0 percent (to turn off the daylighting controls during the design simulation). The Weekday, Saturday, and Sunday daytypes in the custom schedule would define the hours that daylighting controls should be available to operate as Available 100%. For example, Weekday to Sunday could be set to 100 percent from midnight to midnight, to have the daylighting controls available to reduce the lighting power during any hour of the energy-analysis simulation. It is recommended that a full 8760 simulation be performed if the*

daylighting controls are going to be neglected during the design simulation.

- 4** For additional information related to creating custom schedules, refer to “Creating schedules” on page 6–137.
- 5** For additional information related to performing a full 8760 simulation, refer to “Adding weather locations and activating the 8760 calculation methodology” on page 6–167.
- 6** For additional information related to daylighting, visit:
<http://www.eere.energy.gov/>
or
http://eande.lbl.gov/Task21/LBL_11353/titlepg.html

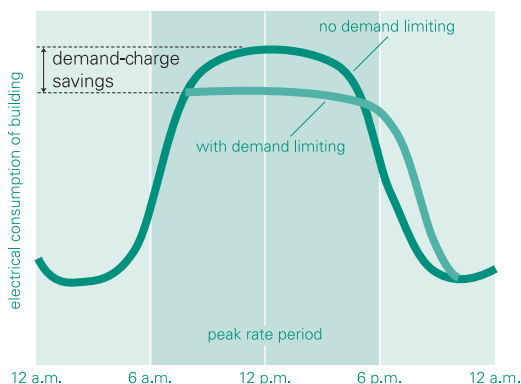
Demand limiting

Many utility companies face a shortage of generating capacity during periods of high demand. To discourage energy use at these times, they may implement time-of-day rate structures that charge a premium for electricity used during on-peak periods. *Ratchet clauses* (minimum demand charges) levy a further penalty.

Note: Under a ratchet clause, the peak demand set during a given month establishes the demand charge for the succeeding 12-month (typical) period. The higher demand rate remains in effect even if monthly demand drops in succeeding months.

Demand limiting is a control strategy that restricts the amount of electrical demand for the HVAC system. To accomplish this, the building automation system (BAS) implements one or more temporary *corrective* actions when electrical demand exceeds a predefined level. It increases the temperature set point in the zones, modulates the speed of electric motors, and/or cycles off electric equipment.

Figure 5–11 Effect of demand limiting on electrical consumption



Normal operation is restored at the end of the demand-limiting period, which usually lasts 15 to 30 minutes. To avoid compromising occupant comfort, the control strategy usually includes overrides that restore normal operation *before* the end

of the demand-limiting period if the space temperature exceeds a predefined limit.


Application consideration.


- Ensure that the building automation system:
 - a Monitors the entire electrical load
 - b Controls the HVAC system and any other electric devices that contribute to the energy consumption of the building
 - c Includes a demand-limiting function
 - d Provides a means to ensure that occupant comfort takes precedence over electrical demand

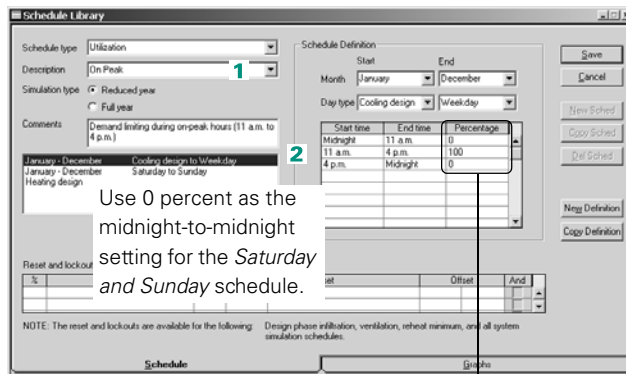
Sample scenario

The targeted, annual electrical demand for a building is 1,400 kW. Determine the effect of limiting demand to 1,200 kW during on-peak periods. Assume that:

- Space temperature can drift as much as 3°F from the set point
- Heating equipment will operate as needed to ensure that the space temperature remains within this range


 Use the Library/Template Editors program to define when the on-peak periods occur.

- 1  In the **Schedule** library, create a new **Utilization** schedule and rename it as **On Peak**.
- 2 Assuming that on-peak periods only occur on weekdays from 11 a.m. to 4 p.m., define the cooling and heating design schedules as shown here.



Use 0 percent as the midnight-to-midnight setting for the *Saturday and Sunday* schedule.

The on-peak period is in effect during any hour with a percentage greater than 0. Percentages greater than 0 are applied to the maximum demand limit (refer to Step 4 on page 5–45).

 In the **Create Plants** section of your TRACE 700 project:

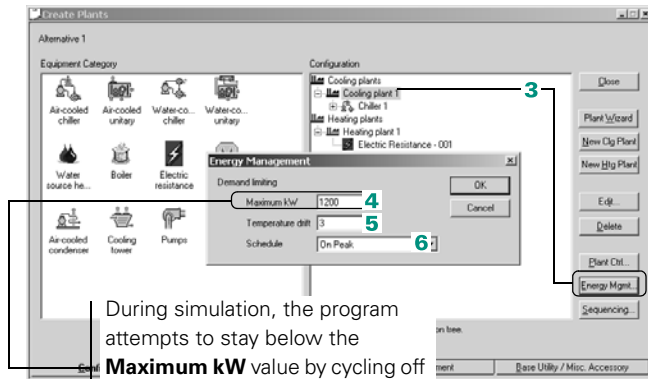
3 Choose any plant and click **Energy Mgmt** to display the entries for demand limiting.

4 Specify the **Maximum kW** (or upper control limit) for the overall electrical demand of the building.

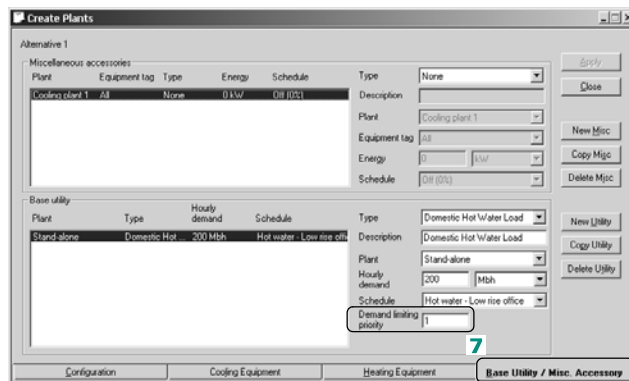
5 Set the maximum amount that the room temperature can drift when demand limiting is in effect (3°F in this case).

6 Choose the schedule that describes when demand limiting is permitted. (Use the **On-Peak** schedule defined in steps 1 and 2.)

7 Assign a demand-limiting priority to each piece of equipment to set the shutdown order—assign the appropriate priority to the domestic hot water (on the **Base Utility / Misc. Accessories** tab) first.



During simulation, the program attempts to stay below the **Maximum kW** value by cycling off equipment, based on the assigned demand-limiting priority.



- 8 Now assign a demand-limiting priority to the chiller (in the **Cooling Equipment Controls** window – click **Controls** on the **Cooling Equipment** tab)

The screenshot shows the 'Cooling Equipment Controls' dialog box. The 'Cooling Equipment' tab is active. The 'Demand limiting priority' is set to 2. A red circle with the number 8 highlights the 'Controls...' button on the right side of the dialog.

- 9 Finally, assign a demand-limiting priority to the electric heating coils (on the **Heating Equipment** tab).

*Note: TRACE 700 can also model demand limiting for fans. Shutdown priorities are set in the **Advanced Options** dialog box, which is available from the **Options** tab of **Create Systems**.*

The screenshot shows the 'Heating Equipment' dialog box. The 'Heating Equipment' tab is active. The 'Demand limiting priority' is set to 3. A red circle with the number 9 highlights the 'Demand limiting priority' field.

Duty cycling

Duty cycling helps avoid unnecessarily high peaks in electrical demand caused by *synchronized* equipment operating schedules. This control strategy is particularly appropriate for HVAC systems with greater heating or cooling capacity than is needed to meet load conditions.

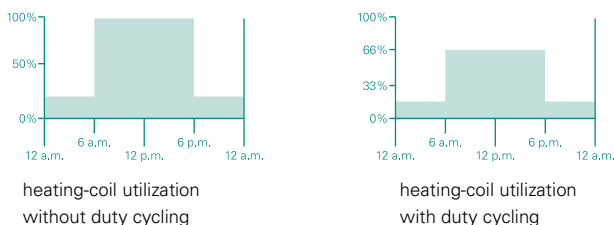


The TRACE 700 program models duty cycling only for the main cooling fan and/or the main heating fan.

During morning warm-up, for example, a duty-cycling strategy would energize the electric heating coil in each VAV terminal at a slightly different time. Preventing the coils from energizing simultaneously reduces the electrical demand peak. (Depending on the local rate structure, demand charges can be a significant percentage of the monthly utility bill.)

Duty cycling can also be effective for an application with several packaged air-conditioning systems. In this case, staggering the operation of compressors (or compressors and fans) decreases the demand peak.

Figure 5-12 Comparison of heating utilization schedules



Application considerations

- A building automation system is required to implement duty cycling. To ensure occupant comfort, the BAS should temporarily suspend duty cycling if the temperature in the space is outside the accepted range.
- Duty-cycled equipment starts more often, which accelerates wear and increases maintenance costs.
- The sound of equipment being turned on and off at regular intervals may disturb occupants.

Sample scenario

A fan is subject to duty cycling for no more than 20 minutes each hour between 6 a.m. and 6 p.m. Duty cycling is not permitted if the temperature in the controlled space drifts more than 3°F from the set point or if the relative humidity exceeds the design target by more than 10 percent.



In TRACE 700, duty cycling is modeled similarly to the optimum start/stop strategy: refer to page 5–6. As in that scenario, duty cycling is implemented by a building automation system (BAS).

- 1 Use the Library/Template Editors program to create a custom fan schedule from the scenario description. The **6 a.m. to 6 p.m.** schedule defines when the supply fan normally operates—that is, Monday through Friday from 6 a.m. until 6 p.m. (The schedule definitions for cooling design and heating design are identical.)

A separate definition for **Saturday and Sunday** (not shown) schedules the fan off from midnight to midnight.

- 2 On the **Fans** tab in the **Create Systems** window of your TRACE 700 project, choose the desired operating schedule for the supply (primary) fan.

Schedule Library

Schedule type: Utilization
Description: 6 a.m. to 6 p.m. **1**
Simulation type: Reduced year
Full year
Comments: January - December: Cooling design to Week-day
January - December: Saturday to Sunday
Heating design

Del Definition

Schedule Definition

Start: January, End: December
Day type: Cooling design, Week-day
Start time: 6 a.m., End time: 6 p.m., Percentage: 100
Midnight: 0, 6 p.m.: 0

Save, Cancel, New Sched, Copy Sched, Del Sched, New Definition, Copy Definition

Reset and lockout table

%	Sensor type	Op	Reset	Offset	And

NOTE: The reset and lockouts are available for the following: Design phase infiltration, ventilation, reheat minimum, and all system simulation schedules.

Schedule, Graphs

Create Systems - Fan Overrides

Alternative 1
System description: System - 001, Single Zone
Fan cycling schedule: No fan cycling

Apply, Cancel, Overrides...

Type	Static Pressure (in. w.g.)	Full Load Energy Rate	Full Load Energy Rate Units	Schedule 2
Primary: Cq4003 - FC Centrifugal const vol	1	0.00032	kW/CFm in w/g	6 a.m. to 6 p.m.
Secondary: P4003 - FC Centrifugal const vol	0.5	0.00032	kW/CFm in w/g	Available (100%)
Return	0	0	kW/CFm	Available (100%)
System exhaust	0	0	kW/CFm	Available (100%)
Floor exhaust	0	0	kW/CFm	Available (100%)
Optional ventilation	0	0	kW/CFm	Available (100%)
Auxiliary	0	0	kW/CFm	Available (100%)

Selection, Options, Dedicated OA, Temp/Humidity, **Fans**, Coils, Schematic

- Use the Library/Template Editors program to create a custom duty cycling schedule. The **Duty Cycling** schedule describes when this control strategy can be used—in this case, on weekdays from 6 a.m. until 6 p.m. The schedule also establishes criteria that prevent duty cycling if it impairs thermal comfort.

A percentage of 0 prevents duty cycling if any of these conditions occur when the duty-cycling schedule is in effect:

- Room dry-bulb temperature exceeds the thermostat set point for cooling by more than 3°F
- Room dry-bulb temperature is more than 3°F cooler than the thermostat set point for heating
- Room relative humidity exceeds the design target by more than 10 percent (not shown in above picture)

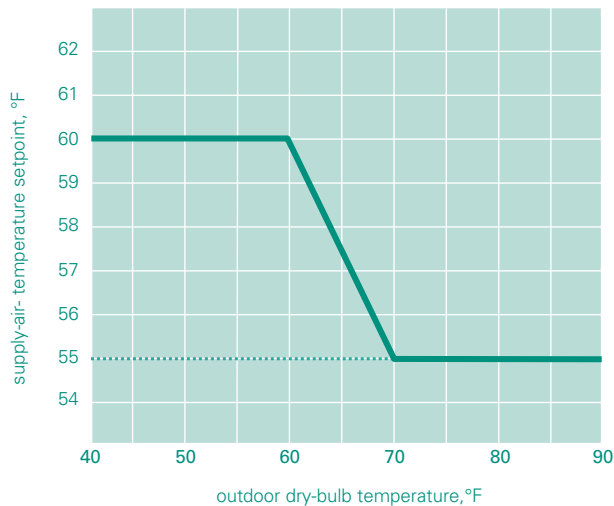
- On the **Options** tab, click **Advanced Options** to display the optional airside control strategies.
- Select the custom schedule that was created in **Step 3**.
- Enter a **pattern length** to set the duration of each duty cycle (60 minutes in this example).
- Set the **maximum offtime** to define how long the fan can remain off during a duty cycle. In this case, the fan can remain off for up to 20 minutes, but not longer.

Supply air temperature reset

Supply air temperature reset is a control scheme that allows an airside system to modulate the supply air temperature based on outside air temperature, worst-case room demand, or a combination of the two. When enabled, the temperature of supply air is increased, which allows for reduced compressor energy or reheat energy, but also increases fan energy in a VAV system.

When supply air temperature reset is based on *outside air temperature*, the supply air temperature can be increased as the outside air temperature decreases, allowing for more economizer operation. This is done in a linear fashion as shown in Figure 5–13.

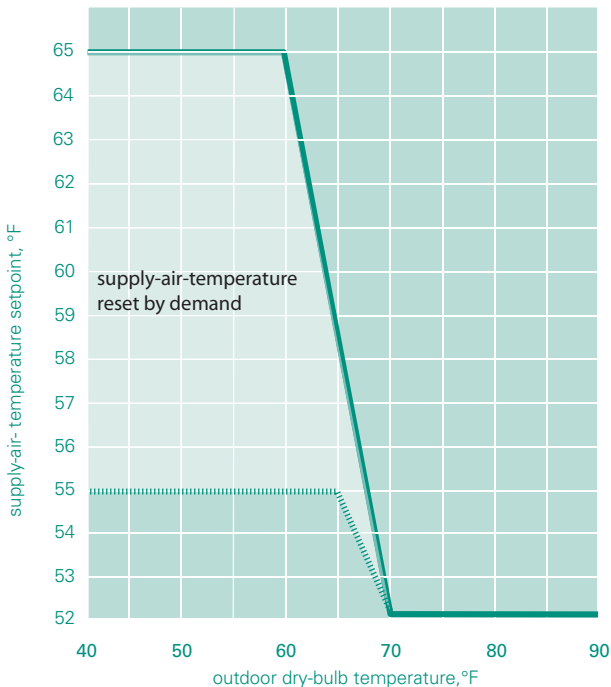
Figure 5–13 Supply air temperature reset based on outside air temperature



Supply air temperature reset can also be based on the *worst-case space* load demands. If the worst-case space does not require conditioned air at the design supply air temperature, the temperature can be reset upward.

The two individual strategies can also be combined so that the supply air temperature is reset based on both outside air temperature and worst case room (Figure 5–14).

Figure 5–14 Supply air temperature reset based on worst case room and outside air



Application considerations

- Cooling loads that are being served by higher supply air temperatures often require more air and increased fan energy.
- When the outdoor air temperature is less than the supply temperature, the compressors can be shut off and an airside economizer can provide the needed cooling.
- The use of warmer supply air can result in higher space humidity levels, especially during humid weather.

Related reading

- *Rooftop VAV Systems Applications Engineering Manual* (Trane literature number SYS-APM007-EN)

Sample scenarios

Table 5–1 Sample Scenarios

Topic	
Scenario 1 (page 52)	Supply air temperature reset based on worst case room
Scenario 2 (page 53)	Supply air temperature reset based on outside air temperature
Scenario 3 (page 53)	Supply air temperature reset based on outside air temperature and worst case room loads

Note: For further discussion of creating utilization schedules, refer to “Creating schedules” on page 6–137. For further discussion of creating alternatives, refer to “Creating alternatives” on page 6–131.

Scenario 1. Supply air temperature reset based on worst case room.

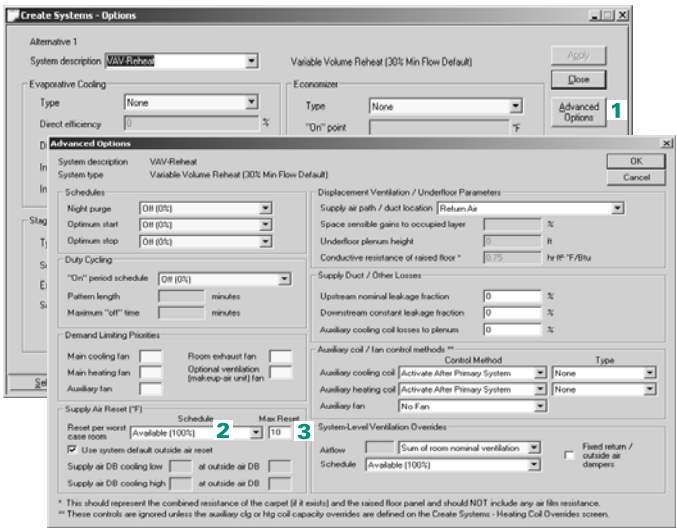
- 1

In **Create Systems**, select the **Options** tab for the system to which supply air reset is to be applied. Click the **Advanced Options** button.
- 2

Select a utilization schedule that accommodates supply air temperature reset. A custom schedule can be applied.
- 3

(Optional) Enter the maximum reset temperature difference.

Note: When the utilization schedule reads 1% or greater, supply air temperature reset will be enabled.



Scenario 2. Supply air temperature reset based on outside air temperature.

See Figure 5–13 for a graph of this strategy.

- 1 Uncheck **Use system default outside air reset** to input a new reset schedule.
- 2 Enter the appropriate values for the air reset schedule.

Advanced Options

System description: VAV-Reheat
System type: Variable Volume Reheat (30% Min Flow Default)

Schedules:
Night purge: Off (0%)
Optimum start: Off (0%)
Optimum stop: Off (0%)

Duty Cycling:
"On" period schedule: Off (0%)
Pattern length: minutes
Maximum "off" time: minutes

Demand Linking Priorities:
Main cooling fan: ☐ Room exhaust fan: ☐
Main heating fan: ☐ Optional ventilation (make-up-air unit) fan: ☐
Auxiliary fan: ☐

Supply Air Reset (°F):
Reset per worst case room: ☐ Off (0%)
Schedule: ☐ Off (0%)
Max Reset: ☐ Off (0%)
☐ Use system default outside air reset
Supply air DB cooling low: 55 at outside air DB: 70
Supply air DB cooling high: 60 at outside air DB: 60

Displacement Ventilation / Underfloor Parameters:
Supply air path / duct location: Return Air
Space sensible gains to occupied layer: %
Underfloor plenum height: ft
Conductive resistance of raised floor: 0.75 hr Btu/F/ftu

Supply Duct / Other Losses:
Upstream nominal leakage fraction: %
Downstream constant leakage fraction: %
Auxiliary cooling coil losses to plenum: %

Auxiliary coil / fan control methods:
Control Method: Type
Auxiliary cooling coil: Activate After Primary System: None
Auxiliary heating coil: Activate After Primary System: None
Auxiliary fan: No Fan

System-Level Ventilation Overrides:
Airflow: Sum of room nominal ventilation
Schedule: Available (100%)
☐ Fixed return / outside air dampers

* This should represent the combined resistance of the carpet (if it exists) and the raised floor panel and should NOT include any air film resistance.
** These controls are ignored unless the auxiliary coil or hfg coil capacity overrides are defined on the Create Systems - Heating Coil Overrides screen.

Scenario 3. Supply air temperature reset based on outside air temperature and worst case room loads.

See Figure 5–14 for a graph of the strategy.

- 1 Select an appropriate utilization schedule or create a custom schedule.
- 2 Uncheck **Use system default outside air reset** to input a new reset schedule.
- 3 (Optional) Enter a maximum reset differential.
- 4 Enter the appropriate values for the air reset schedule.

Advanced Options

System description: VAV-Reheat
System type: Variable Volume Reheat (30% Min Flow Default)

Schedules:
Night purge: Off (0%)
Optimum start: Off (0%)
Optimum stop: Off (0%)

Duty Cycling:
"On" period schedule: Off (0%)
Pattern length: minutes
Maximum "off" time: minutes

Demand Linking Priorities:
Main cooling fan: ☐ Room exhaust fan: ☐
Main heating fan: ☐ Optional ventilation (make-up-air unit) fan: ☐
Auxiliary fan: ☐

Supply Air Reset (°F):
Reset per worst case room: ☐ Available (100%)
Schedule: ☐ Available (100%)
Max Reset: ☐ 10
☐ Use system default outside air reset
Supply air DB cooling low: 52 at outside air DB: 70
Supply air DB cooling high: 70 at outside air DB: 65

Displacement Ventilation / Underfloor Parameters:
Supply air path / duct location: Return Air
Space sensible gains to occupied layer: %
Underfloor plenum height: ft
Conductive resistance of raised floor: 0.75 hr Btu/F/ftu

Supply Duct / Other Losses:
Upstream nominal leakage fraction: %
Downstream constant leakage fraction: %
Auxiliary cooling coil losses to plenum: %

Auxiliary coil / fan control methods:
Control Method: Type
Auxiliary cooling coil: Activate After Primary System: None
Auxiliary heating coil: Activate After Primary System: None
Auxiliary fan: No Fan

System-Level Ventilation Overrides:
Airflow: Sum of room nominal ventilation
Schedule: Available (100%)
☐ Fixed return / outside air dampers

* This should represent the combined resistance of the carpet (if it exists) and the raised floor panel and should NOT include any air film resistance.
** These controls are ignored unless the auxiliary coil or hfg coil capacity overrides are defined on the Create Systems - Heating Coil Overrides screen.

Additional items

- 1 TRACE will not use the supply air temperature reset fields during the design simulation.

- 2** Do not specify a reset supply air temperature lower than the design supply air temperature.
- 3** System types that have room-controlled cooling coils controlled via the room thermostat cannot use supply air temperature reset. Examples of these systems include, but are not limited to: single zone, fan coils, packaged terminal air conditioner, and water-source heat pump.

6

Advanced Usage and General Modeling Tips

Modeling examples in this chapter

Modeling tips

- Common modeling mistakes, page 6–3
- Frequently asked questions, page 6–20
- Comparing input data, page 6–37
- No- or low-heating energy consumption, page 6–39
- Modeling large rooms and zones, page 6–45
- Zoning of rooms, page 6–47
- Oversizing and undersizing, page 6–51
- Balancing airflows, page 6–60
- Selecting a DX unit using TRACE 700 output, page 6–68
- Selecting a chilled-water cooling coil using TRACE 700 output, page 6–74
- Modeling for LEED®, page 6–80

Input tips

- Quick building inputs via the New File Wizard, page 6–110
- Using TRACE 700 Chiller-Plant Analyzer, page 6–114
- Inputting an existing load profile, page 6–118
- Creating spreadsheets and tables from calculation results (TRACE 700 Visualizer), page 6–122
- Using templates, page 6–125
- Creating alternatives, page 6–131
- Creating schedules, page 6–137
- Creating equipment and unloading curves, page 6–143
- Creating utility rates, page 6–150
- Adding weather locations and activating the 8760 calculation methodology, page 6–167

- Altering a load design file for energy analysis, page 6–170

Advanced usage

- Archiving and un-archiving instructions (storing library members with project files), page 6–175
- Printing used library members, page 6–176
- Combining files, page 6–177
- Creating a new file based on an existing file, page 6–179
- How to sort output, page 6–180
- gbXML import and export, page 6–181
- Importing a load design Version 3.x or Version 2.x file, page 6–189

Common modeling mistakes

This section describes modeling errors that are frequently made in TRACE 700, and indicates whether the errors apply to load design, energy analysis, or both.

IMPORTANT NOTE: *The graphics illustrate many, but not all, of the errors.*

Note: The modeling situations listed in this section are not always mistakes, but can cause inaccurate results if used inappropriately. In certain instances, some of these situations can be used successfully for unique modeling needs. Contact C.D.S. Support for additional information.

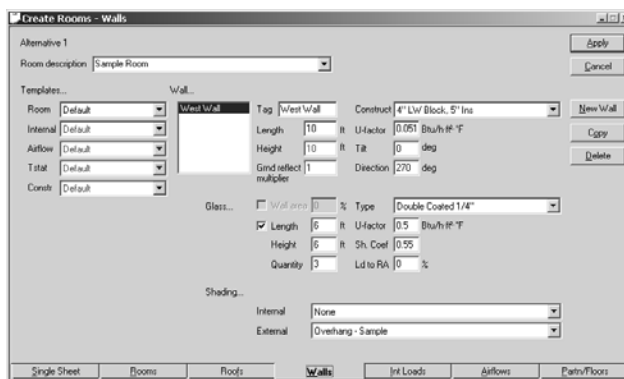
Rooms Tab of Create Rooms

- Large areas are being modeled as a single space. This will typically lead to an underestimation of loads and energy consumption. Refer to “Modeling large rooms and zones” on page 6–45 for a detailed explanation. *Load Design and Energy*
- The inputs for floor-to-floor height and plenum height conflict. The floor-to-floor height is the vertical distance between floors, including the plenum height and excluding the floor slab thickness. The plenum height is the vertical distance between the ceiling and the floor slab surface of the floor above. The

plenum height is subtracted from the floor-to-floor height to determine the height of the space that is conditioned. Not correcting this input can lead to underestimation of airflows and loads. For additional information refer to Figure 6–1 on page 6–30. *Load Design and Energy*

- The input values for the design cooling and heating dry bulb are not the same as the worst-case temperatures in the selected **Thermostat** schedules. For example, the design conditions for the selected room are input as 74°F cooling and 70°F heating. The cooling and heating systems will be sized based on these values. If the **Thermostat** schedule shows a minimum cooling setpoint of 73°F in the summer, the cooling coil will probably be undersized. Similarly, if the heating **Thermostat** schedule shows a maximum space setpoint of 72°F in the winter, the heating coil will probably be undersized. *Load Design and Energy*
- The default values for the design thermostat setpoints are being used (75°F for cooling, 68°F for heating, and 50 percent RH). For accurate results, the actual space setpoints should be entered. *Load Design and Energy*
- The default values for the thermostat driftpoints, 90°F and 55°F respectively, are being used. This means that whenever there are 5 percent or less of the people in the space (determined from the people schedule), the room will be allowed to drift up to 90°F or down to 55°F before the coils turn back on. If the building control system is not going to allow the room setpoints to setback this far, the values need to be overridden. Not correcting this input will result in an underestimation of the cooling and heating energy during hours of reduced occupancy. *Energy Only*
- Cstat and Hstat have been selected for the **Thermostat** schedules. These schedules will allow the building to drift up to 95°F and down to 55°F, depending on the time of day (the schedules can be viewed by clicking **Schedules** on the **Libraries** menu). Typically, users need to either create their own **Thermostat** schedules or select *none* and let the program use the driftpoints (the schedules override the driftpoints). Not correcting this input will result in an underestimation of the cooling and heating energy at night. *Energy Only*

Roofs and Walls tabs of Create Rooms



- Roofs with no area (length × width) have been input. Roofs should be deleted, not zeroed out, if they do not exist. This can lead to errors in the calculations and output values. *Load Design and Energy*
 - The entered area of the window is larger than the entered area of the wall. Glass area is subtracted from the entered wall area—therefore this is not a valid input. This will result in an underestimation of solar and conduction loads. *Load Design and Energy*
 - The custom internal shading selected has a higher U-factor and/or Shading Coefficient than the glass type selected. The values input for the custom shading device represent the *combined* U-factor and SC for the glass and shading device. *Load Design and Energy*
- Note: The values used in the simulation are the values input for the custom internal shading device (that is, the values input for the glass U-factor and SC are ignored, unless the shading device is scheduled off or not selected).*
- Overhang–Sample, or any of the other Sample shadings, has been selected for the external glass-shading device. Creating a custom shading device in the Library/Template Editors program will result in more-accurate estimations for the glass solar loads. Be sure to select *none* if there is no overhang shading the windows. *Load Design and Energy*

Internal Loads tab of Create Rooms

- People types and their respective heat gains have been specified, but the actual number of people entered is zero. This will cause the program to neglect any heat given off by people in the space and to neglect ventilation for the space if the ventilation was entered as cfm/person. *Load Design and Energy*
- The **Cooling Only (Design)** schedule is selected for any of the internal loads. This schedule should only be used for design calculations, not for energy analysis. It simulates 100 percent of the internal loads in the building 24 hours a day (except during the heating-design portion of the calculation), which may not be what is actually occurring in the building. This tends to lead to an overestimation of cooling energy and an underestimation of heating energy. To view the schedule, click **Schedules** on the **Libraries** menu and select **Utilization** as the **Schedule** type. Here, the user should be able to view the schedule and find schedules that more closely follow the actual operation of the building. *Energy Only*
- The internal loads are scheduled as **Available 100%**. This schedule, typically, should not be used for internal loads. It simulates 100 percent of the internal loads in the building 24 hours a day, which may not be what is actually occurring in the building. In addition, it also tells the program to take credit for the internal loads during the heating-design calculation. This tends to lead to an overestimation of cooling energy, an underestimation of heating energy, and undersizing of the heating coils, because the internal loads are meeting all or most of the heating loads. To

view the schedule, click **Schedules** on the **Libraries** menu and select **Utilization** as the **Schedule** type. Here, the user should be able to view the schedule and find schedules that more-closely follow the actual operation of the building. *Load Design and Energy*

- The custom schedules for internal loads have values greater than zero for the heating-design day type. This tells the program to take credit for the internal loads during the heating-design calculation. This tends to lead to undersizing of the heating coils and is not common design practice. To view the schedule, click **Schedules** on the **Libraries** menu and select **Utilization** as the **Schedule** type. Here, the user should be able to view the schedule and the individual day types. *Load Design and Energy*
- The lighting type selected has less than 100 percent load to space, which will cause a portion of the lighting load to go to the plenum. Make sure that all rooms using this lighting type have a plenum. If some rooms do not have a plenum, then select one of the 100 percent load to space lights. *Load Design and Energy*
- Click **Internal and Airflow Loads** on the **Libraries** menu, and select **Miscellaneous Loads** as the **Library type**. The custom miscellaneous load has zero percent load to space and zero percent load to plenum. Because zero percent of the load is seen in the building, no heat gain will be applied to the space. *Load Design and Energy*
- The energy meter is selected as none. The heat given off by the miscellaneous equipment will still be calculated correctly, however, the energy consumed by the miscellaneous equipment will be neglected. Typically, electricity or gas should be selected for this field. *Energy Only*
- The energy meter is selected as a cooling load or a heating load. The energy meter tells the program what utility type is being used to produce the given internal load. Typically, electricity or gas should be selected for this field. For example, if heat gain from a computer is being modeled, then electricity should be selected. If heat gain from a Bunsen burner is being modeled, then gas should be selected as the energy meter. *Energy Only*

Airflows tab of Create Rooms

The screenshot shows the 'Create Rooms - Airflows' dialog box. The 'Ventilation' section is active, displaying the following settings:

- Main supply:** Cooling: 1000 cfm, Heating: 100 % Cfg Airflow
- Ventilation:** Apply ASHRAE Std62.1-2004/2007: No, Type: General Office Space, Cooling: 250 cfm, Heating: 250 cfm, Schedule: People - Hospital
- Auxiliary supply:** Cooling: 0 air changes/hr, Heating: 0 air changes/hr
- Room exhaust:** Rate: 30 cfm/person, Schedule: Available (100%)

- The ventilation schedule is using an internal-loads schedule (any schedule that starts with People, Lights, or Misc is an internal-loads schedule). Internal-loads schedules should never be used for ventilation. Internal-loads schedules are zero percent for the heating-design calculation. This will cause the program to neglect the ventilation load for heating design. This tends to lead to undersizing of the heating coils and is not common design practice. To view the schedule, click **Schedules** on the **Libraries** menu and select **Utilization** as the **Schedule** type. Here you can view the schedule and find schedules that will give more accurate results. Typically, selecting a ventilation schedule for the ventilation, or copying the people schedule and making heating design 100 percent midnight-to-midnight, will give more accurate results. *Load Design and Energy*
- The heating design day type for the ventilation schedule has hours that are not 100 percent. The time that the heating load is peaking may be during one of the hours when the ventilation is scheduled off. This tends to lead to undersizing of the heating coils and is not common design practice. *Load Design and Energy*

Note: Because the heating design calculation assumes no solar loads and constant ambient conditions, the hour of peak does not affect the conditions of the outdoor air. Also, this portion of the schedule only effects the heating design calculation. Therefore,

energy analysis (other than the size of your heating plant and/or coils) and cooling design should be mostly unaffected.

- The input value for heating supply does not match the input value for the VAV minimum airflow. This will cause erroneous airflow values. In addition, TRACE 700 should typically be allowed to calculate the supply airflows based on the input loads by selecting **Main Supply** units of “To Be Calculated.” *Load Design and Energy*

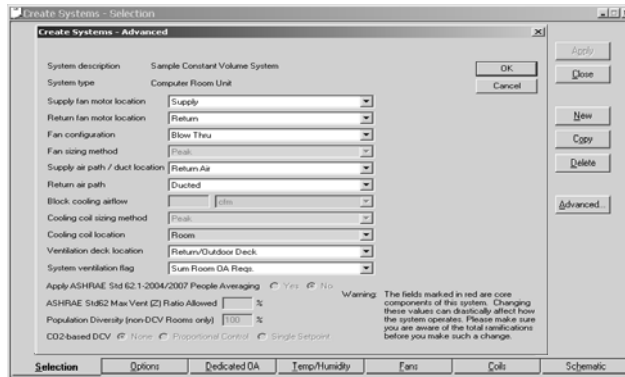
Note: The VAV minimum airflow only applies to variable-volume systems. The VAV minimum airflow is ignored for constant-volume systems.

- The entered VAV minimum stop may be too low for some rooms. This can lead to spaces having a higher specified ventilation rate than the minimum airflow. This will result in insufficient ventilation airflow in heating mode. This typically leads to heating ventilation being different than cooling ventilation at the room and/or the system level. The **Airflows** section of the **Room Checksums** can be used to check for this condition. *Load Design and Energy*

Note: In most VAV systems, a zero for the VAV minimum will cause the box to close completely when the room calls for heating.

- The VAV minimum-airflow schedule is not using the schedule **Available 100%**. For most cases, this will cause low airflows to the space and incorrect results. The only time this schedule should be changed is for a VAV box with two minimum stop settings. The VAV system may not operate properly if any other schedule is used, and cooling and heating energy may be underestimated. *Load Design and Energy*
- The airflows are not balanced in room(s) in which room exhaust is entered. Airflows must be balanced at the space level for TRACE 700 to calculate the space energy balance properly. Please refer to “Balancing airflows” on page 6–60 for additional details. *Load Design and Energy*

Selection tab of Create Systems



- For the VAV systems, the fan- and/or coil-sizing methodology has been changed from block to peak. VAV systems should be sized according to the block methodology. This will lead to the program simulating a system that does not actually exist and may cause the system to be oversized. *Load Design and Energy*
- For the constant volume systems, the fan- and/or coil-sizing methodology has been changed from peak to block. Constant volume systems should be sized according to the peak methodology. This will lead to the program simulating a system that does not actually exist, and may cause the system to be undersized. *Load Design and Energy*

*Note: For more information related to the sum-of-the-peaks and block- sizing methodologies, refer to the topic **Block vs. Sum-of-Peaks** in TRACE 700 Help.*

- The supply-duct location is return air, and the return-air path is ducted (**Advanced** button in **Create Systems**). This essentially tells the program that the supply duct is inside the return duct. *Load Design and Energy*
- The supply-duct location is return air, and the return-air path is plenum. If the building does not have a plenum (i.e., by entering the **Plenum Height** as zero on the **Rooms** tab of **Create Systems**), these values should be changed to reflect how the air will actually travel in the building. *Load Design and Energy*

- The location of the cooling coil has been changed from the default value for the airside system. This can lead to the program simulating a system that does not actually exist and may cause erroneous results. *Load Design and Energy*
- The ventilation-deck location has been changed from Return/Outdoor Deck. Return/Outdoor Deck simulates the ventilation (outdoor) air being mixed with the return air immediately prior to being sent to the main cooling/heating coils. This is common in most conventional systems that use dampers to mix the two air paths. Any other selection is atypical for most HVAC systems (except Room Direct or Plenum for Dedicated Outdoor Air Systems that supply outdoor air directly to the space). *Load Design and Energy*

Options tab of Create Systems

The screenshot shows the 'Create Systems - Options' dialog box. The 'Alternative 1' tab is active. The 'System description' is set to 'Sample Variable Volume System'. The 'VAV w/Reboard Heating' section has a 'Type' dropdown set to 'None'. The 'Economizer' section has a 'Type' dropdown set to 'None', an 'On' point set to '75', and a 'Max outdoor air' set to '100'. The 'Evaporative Cooling' section has a 'Type' dropdown set to 'None', and 'Direct' and 'Indirect' efficiency and schedule fields. The 'Stage 1 Air-to-Air Energy Recovery/Transfer' section has a 'Type' dropdown set to 'Total-energy wheel (OA preconditioner)', 'Sup-side deck' set to 'Return / outdoor air upstream', 'Exh-side deck' set to 'Room exhaust', and a 'Schedule' dropdown set to 'Available (100%)'. The 'Stage 2 Air-to-Air Energy Recovery/Transfer' section has a 'Type' dropdown set to 'None (default)', 'Sup-side deck' set to 'Ventilation upstream', 'Exh-side deck' set to 'Outdoor & room exhaust mix', and a 'Schedule' dropdown set to 'Available (100%)'. The 'Options' tab is selected at the bottom, along with 'Dedicated OA', 'Temp/Humidity', 'Fans', 'Coils', and 'Schematic'.

- For the energy recovery / transfer devices on the **Options** tab of **Create Systems**, the airstreams that will be used are not selected correctly. If the proper airstreams are not selected, the energy recovery / transfer device will not function correctly or may not function at all. Refer to “Coil loop for exhaust-air energy recovery” on page 4–8, “Total-energy (enthalpy) wheel” on page 4–15, “Fixed-plate heat exchanger” on page 4–21, “Heat pipe” on page 4–27, or “Sensible wheel” on page 4–34, for instructions on properly modeling energy recovery / transfer devices. *Load Design and Energy*

Temp/Humidity tab of Create Systems

Alternative 1
System description: Simple Constant Volume System Parallel Fan-Powered VAV

Design Air Temperature:

- Cooling supply: Max 75 °F, Min 75 °F
- Leaving cooling coil: Max , Min
- Heating supply: Max 55 °F, Min 55 °F
- Supply duct temperature difference: 0 °F
- Reheat temperature difference: 25 °F

Direct/Indirect Dehumidification Methods (System Simulation only)

- Type: None
- Maximum room relative humidity: %
- Main cooling coil minimum allowable leaving (when throttling a chilled water coil downward during dehumidification or "cold coil" mode): °F

Variable Fan Speed for capacity control (System Simulation only)

- Number of fan speeds: None
- Percent airflow at low speed: %
- Percent airflow at medium speed: %

Humidification:

- Design humidity ratio difference: grains
- Minimum room relative humidity: 30 %

Selection Options Dedicated OA Temp/Humidity Fans Coils Schematic

- The input cooling supply-air temperature (75°F) is too high. The cooling supply-air temperature must be lower than the entered room set point for cooling in **Create Rooms**. This will cause cooling energy to be underestimated and result in erroneous airflows. *Load Design and Energy*
- The input heating supply-air temperature (55°F) is too low. The heating supply-air temperature must be greater than the entered room setpoint for heating in **Create Rooms**. This will cause heating energy to be underestimated and result in erroneous airflows. *Load Design and Energy*
- A Reheat Temperature Difference (25°F) has been input. This value is typically used to model reheat done during cooling design (typically for dehumidification). Inputting this value can lead to extremely low leaving cooling-coil conditions and oversizing of the cooling coil. *Load Design and Energy*

Fans tab of Create Systems.

Alternative 1

System description: Simple Constant Volume System Parallel Fan-Powered VAV

Fan cycling schedule: No fan cycling

Buttons: Apply, Cancel, Overrides...

	Type	Static Pressure (in. wg)	Full Load Energy Rate	Full Load Energy Rate Units	Schedule
Primary	None	0	0	kW/Cfm	Lights - Elementary kitchen
Secondary	None	0	0	kW/Cfm	Available (100%)
Return	None	0	0	kW/Cfm	Available (100%)
System exhaust	None	0	0	kW/Cfm	Available (100%)
Floor exhaust	None	0	0	kW/Cfm	Available (100%)
Optional ventilation	None	0	0	kW/Cfm	Available (100%)
Auxiliary	None	0	0	kW/Cfm	Available (100%)

Selection Options Dedicated OA Temp/Humidity **Fans** Coils Schematic

- The fan type has not been selected. Without a fan type, the program cannot calculate fan energy. *Energy Only*
- The fan static pressure has not been input. Without a fan static pressure, the program will not calculate fan heat pickup and possibly not fan energy. *Load Design and Energy*
- A fan schedule (Lights-Elementary kitchen) has been input. Typically, the fan-cycling schedule should be used to cycle the fan, not the fan schedule. *Energy Only*

Note: The fan schedule overrides the fan-cycling schedule. Refer to "Frequently asked questions" on page 6–20 for additional information.

Coils tab of Create Systems

Alternative 1
System description: System - 001 Parallel Fan-Powered VAV

Capacity Overrides

	Capacity	Capacity Units	Schedule
Main cooling	100	% of Design Cooling Capacity	Cooling Only [Design]
Auxiliary cooling	52	MBh	Available (100%)
Main heating	0	% of Design Capacity	Available (100%)
Auxiliary heating	100	% of Design Capacity	Lights - Hospital
Preheat	0	% of Design Capacity	Available (100%)
Reheat	100	% of Design Capacity	Custom Schedule
Humidification	100	% of Design Capacity	Available (100%)

Diversity:
People: 100 %
Lights: 100 %
Misc loads: 100 %

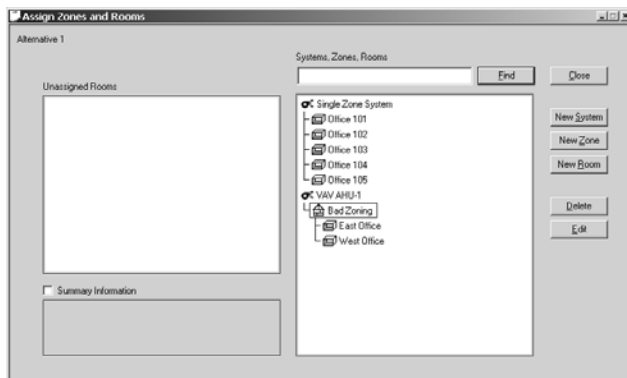
Warning: The fields marked in red require other entries for a correct simulation. Contact C.D.S. Support at 608-787-3926 for a detailed explanation.

Selection Options Dedicated OA Temp/Humidity Fans Coils Schematic

- A capacity (52 MBh) for the auxiliary cooling coil has been input. Only the induction system types (2-pipe and 4-pipe Induction) have an auxiliary cooling coil by default—it is the secondary induction coil located in each room. However, it is possible to add an auxiliary coil to any of the other system types by specifying a capacity value/units (typically as 100 percent of Design Capacity.) This auxiliary coil is sized according to the skin-envelope load. In addition, this auxiliary cooling coil can only operate during the summer period months as defined on the **Load Parameters** screen. Activating this coil can lead to erroneous load calculations and energy analysis. *Load Design and Energy*
- A capacity (100 percent of design capacity) for the auxiliary heating coil has been input. Only the 2-pipe Induction, 4-pipe Induction, VAV w/ Baseboard Skin Heating, Changeover-Bypass VAV with Local Heat, and VAV w/ Forced Flow Skin Heating system types have an auxiliary heating coil (it is the secondary induction coil located in each room for those systems.) However, it is possible to add an auxiliary coil to any of the other system types by specifying a capacity value/units (typically as 100 percent of Design Capacity.) This auxiliary coil is sized according to the skin-envelope load. In addition, this auxiliary heating coil can only operate during the non-summer period months as defined on the **Load Parameters** screen. Refer to online Help for additional details. *Load Design and Energy*

- Some of the coils in the systems have been zeroed out. For most cases, this is strongly recommended against. For example, if either the reheat coil or the main coil is zeroed out in a VAV system, the design and energy-analysis calculations will be incorrect. In this system, reheat and main heating are actually the same physical coil. Please refer to the **System Type Characteristics** section of the Help file for additional information related to coil sizing and location. *Load Design and Energy*
- Schedules have been entered for the coils. For most cases, this is strongly recommended against. The default schedules need to be used in order for the coils to operate in response to the thermostats. The schedules for internal loads, ventilation, fan cycling, and so on, are the proper place to adjust the loads seen by the coils. *Energy Only*

Zoning



- Multiple rooms are assigned directly to a Single Zone System. Refer to “Zoning of rooms” on page 6–47 for instructions on proper zoning of single-zone systems, and for details on how zoning affects this system and other system types. *Load Design and Energy*
- Only thermally similar rooms should be zoned together. If thermally dissimilar rooms are zoned together, oversizing and poor space temperature control will typically occur. *Load Design and Energy*

Cooling Equipment and Heating Equipment tabs of Create Plants

Alternative 1

Cooling plant: Central Chiller Plant Heat rejection type: Eqf021 - Condenser fan

Equipment tag: wCC-3

Equipment category: Water-cooled chiller

Equipment type: Default water-cooled chiller

Sequencing type: Single

Thermal storage: None

Capacity: 1

Schedule: Storage

Operating mode	Capacity tons	Energy rate kW/ton
Cooling		0.52
Heat recovery		
Tank charging		
Tank charging & heat recovery		

Pumps	Type	Full load consumption
Primary chilled water	1 g6001 - Cnst vol chl water pump	0 B water
Condenser water	1 g6010 - Cnst vol cond water pump	0 B water
Heat recovery or aux condenser	None	0 B water

Buttons: Apply, Cancel, New Equip, Copy Equip, Delete Equip, Controls

Tabs: Configuration, Cooling Equipment, Heating Equipment, Base Utility / Misc. Accessory

- For any WSHP system, the thermal storage has been removed. The thermal storage associated with the WSHP is the water loop. Without the water loop, the results for the energy consumption of the WHSP compressors will be highly inaccurate. *Energy Only*
- The Equipment Type has been left at the default value (Default Air-cooled Chiller, Default Boiler, and so on). For accurate energy analysis, the program needs to know the specific type of equipment used in the building. The equipment type tells TRACE 700 the type of fuel that will be consumed by the equipment, the unloading curve, auxiliary energy consumers, full-load energy rate, and so on. Not selecting the appropriate equipment type can lead to highly inaccurate energy-consumption results. *Energy Only*
- Multiple pieces of equipment are assigned to the same plant, but the sequencing type is set to single. This is not a valid input and can lead to the chiller plant operating incorrectly. *Energy Only*
- Multiple pieces of equipment are assigned to the same plant, but the capacities of the individual pieces of equipment have not been input. This is not a valid input and will lead to the first piece of equipment handling the entire load. *Energy Only*
- For any type of heat-pump equipment, the heat-recovery capacity and/or heat-recovery energy rate of the heat pump has been deleted on the **Cooling Equipment** tab of **Create Plants**. This value tells the program how much heating, and at what efficiency,

the heat pump can provide based on the cooling capacity. Removing these values disables the heating energy consumption of the heat pump unit. *Energy Only*

- The pump full-load consumption has not been input. Without a pump head or size, the program cannot calculate pump energy. *Energy Only*

Base Utility / Misc. Accessory tab of Create Plants

- Gallons is not a valid input for a domestic hot-water base utility, because the program does not know the change in temperature that will occur to water traveling through the heating equipment. To correctly model domestic hot water, input the data using units of therms, kWh, or MBh. The user can also create a custom base utility in the libraries with units of gpm, and input the delta T across the water-heating equipment. *Energy Only*

Economics and utilities

The screenshot shows the 'Economics' dialog box with the following details:

- Alternative 1**
 - Equipment installed cost: 0
 - Yearly maintenance expense: 0
 - Additional first cost: 0
 - Revenue penalty: 0
 - Building area override: 0
 - Building capacity override: 0
- Utility Rate**
 - Company: A sample with all utilities
 - Utility: Electric consumption
 - Inflation: 0 %
 - Time-of-day schedule: Northern Power
- Recurring/Additional Depreciable Cost**

Cost	Year Incurs	Econ Life	Depx Taxes
10000.00	2015	10	10

- The default utility rates have been selected. Creating a custom utility rate and, if applicable, a **Time-of-Day** schedule in the Library/Template Editors program will result in more-accurate estimations of the energy costs. Please refer to “Creating utility rates” on page 6–150 for instructions on creating your own utility rate. *Energy Only*
- The utility rate has off-peak rates entered, but there is no **Time-of-Day** schedule selected. TRACE 700 assumes that if there is no **Time-of-Day** schedule, then all hours are on-peak. A **Time-of-Day** schedule needs to be added to each of the energy sources that have on- and off-peak charges. To create a **Time-of-Day** schedule, select **Time-of-Day** as the **Schedule type** in the **Schedules** library, and copy or create a new **Time-of-Day** schedule. *Energy Only*
- The utility company has been applied to all Utility types and a **Time-of-Day** schedule is selected. Verify that all utility types have on-peak and off-peak rates. Otherwise, not all off-peak consumption will be accounted for in the economic calculations. The user can also disassociate the **Time-of-Day** schedule from individual utilities to correct this problem. *Energy Only*
- No demand charge has been input in the utility rate. This is often a sign that a blended rate is being used. Blended rates combine the charges for electric demand and consumption, and give inaccurate estimated energy costs. Demand charges can be 50 percent or more of the cost of electricity, and need to be modeled separately to give an accurate picture of the cost to

operate the building. If the utility company charges for demand, demand must be modeled separately from consumption. *Energy Only*

- The recurring cost is input with an actual year incurred (for example, 2015). This means that the cost will never appear in the calculation results, because TRACE 700 will try to add in the cost 2015 years from the start of the study. For accurate results, the user should enter the number of years *after the start of the study* that the cost is incurred, rather than the actual date. *Energy Only*

Version

- Verify that the most-current version of the program is installed. To determine what version of the program is installed, click **About TRACE 700** on the **Help** menu. The most-current version can be reached by clicking **Help**, then clicking **Trane on the Web**, and finally clicking **Check for updates**.

When you have downloaded the update (assuming that an update with a higher version number exists), you need to double-click the executable patch to apply it. Please ensure that TRACE 700 is closed during the update process, and click **Yes** to **Exporting and Importing Custom Library Members**. *Load Design and Energy*

Frequently asked questions

This section contains some frequently asked questions regarding TRACE 700. Additional questions and answers can be found in the online C.D.S. Software Knowledge Base found on www.tranecds.com.

- Q** How does TRACE 700 determine cooling supply airflow and temperature?
- A** TRACE 700 performs an iterative psychrometric analysis to determine cooling supply-air temperatures and solves the sensible-heat equation to determine supply airflow volumes.

Sensible-Heat Equation:

$$Q_s = DSHP \times SA \times (T_{rm} - T_{sadb})$$

where,

- Q_s = sensible load in the space. Q_s is calculated based on the input walls, windows, lights, people, and so forth. Q_s can be found on the **Checksums** report.
- $DSHP$ = density specific heat product. $DSHP$ can be found on the **Title Page** report.
- SA = supply airflow. SA is typically a variable but can be input at the room or system level. SA can be found on the **Checksums** report.
- T_{rm} = room setpoint. T_{rm} is a required input on the **Rooms** tab of **Create Rooms**.
- T_{sadb} = supply-air temperature. T_{sadb} is typically a variable but can be input on the **Temperatures** tab of **Create Rooms**. T_{sadb} can be found on the **Checksums** report.

Depending on what values in the equation are known and/or input, TRACE 700 will calculate differently. The following paragraphs discuss the different calculation scenarios.

If the cooling supply temperature and airflow are not specified, TRACE 700 iterates to find the supply-air temperature that satisfies the specified room relative humidity and thermostat

setpoint. Sometimes this calculation can lead to high supply-air temperatures and high airflows due to proportionally low latent loads in the spaces. To correct the high airflow and supply-air temperature issue, the user can input a more realistic supply-air temperature range (minimum and maximum values) on the **Temperatures** tab of **Create Systems**.

If a supply-air temperature is input and the supply-air flow is not input, TRACE 700 solves for the supply airflow using the sensible-heat equation. The program will also determine the resulting room relative humidity based on the specified supply-air temperature, and will report it on the **Psychrometric State Points** report.

If a VAV system is being modeled, the user can enter the **Block Cooling Airflow** on the **Advanced** tab of **Create Systems**. TRACE 700 will calculate the system-level, cooling-coil leaving conditions using the sensible-heat equation. The program will also determine the resulting room relative humidity, based on the specified airflow, and will report it on the **Psychrometric State Points** report.

If a system with a room-level cooling coil (such as a fan-coil system) is being modeled and the user enters room-level airflows, TRACE 700 will calculate the room-level, cooling-coil leaving conditions using the sensible-heat equation and the input airflows. The program will also determine the resulting room relative humidity, based on the specified airflow, and will report it on the **Psychrometric State Points** report.

If a system that has a zone-level coil (single zone, VTCV), or a system-level coil (terminal reheat) that uses peak fan sizing, is being modeled, there is currently no way to specify a system-level CFM. Note that the peak fan-sizing method is typically used for constant-volume systems. To specify a supply airflow for these system types, the user will need to input the airflows at the room level on the **Airflows** tab of **Create Rooms**, or in the **Airflows** template(s), and TRACE 700 will sum the room-level values to get the supply airflow. The program will also determine the resulting room relative humidity based on the specified airflow and will report it on the **Psychrometric State Points** report. If the desired relative humidity is not achieved, it may be necessary to input the supply air temperature.

If both the supply-air temperature and the supply airflow are specified, the coil capacity is locked in, based on over-specification of the sensible-heat equation. TRACE 700 can only compare the calculated load to the specified coil capacity and report the difference between the two numbers as the over-sizing or under-sizing of the coil. For more information related to over/undersizing, please refer to “Oversizing and undersizing” on page 6–51.

Q How are split systems modeled?

A TRACE 700 treats a split system (defined as compressor and condenser outside and DX evaporator coil inside) exactly like any other air-cooled DX system. To model this, the user can choose either a rooftop or an air-cooled condensing unit from the **Equipment** library.

If the *split system* consists of a chiller with a remote condenser (air- or water-cooled), pick a different piece of equipment in **Create Plants**. The piece of equipment depends on the type of compressor being modeled and whether it is air- or water-cooled. There are several types of compressors with both air- and water-cooled options, including scroll, reciprocating, centrifugal, and helical-rotary.

The added inefficiency of the split system over a non-split system would be included via a decrease in the efficiency of the compressor in the selection.

Q What is exhaust heat, and why is it negative?

A Exhaust heat is heat that is picked up by the return air in the plenum but is exhausted out of the building before it can return to the cooling coil. As the return air travels through the return-air plenum, it absorbs some of the load that is in the plenum (i.e., lights, roof load, and so forth). As a result, the return-air temperature rises. However, some of this air is exhausted before it returns to the cooling coil. Because the coil never sees the load, the program removes the portion of the return-air load that is exhausted from the coil totals to balance the load. Exhaust heat is not a credit. It is an energy balance.

Note: Exhaust heat will be zero if the system exhaust is zero.

Q The **Checksums** report shows that the heating coil peaks during **Heating Design**. What is **Heating Design**?

A TRACE 700 performs a separate calculation to determine heating coil sizes based on the heating-design temperature. As a result, the heating loads are determined not from the monthly weather data but from the heating-design temperature, which does not have a month and time associated with it. In TRACE 700 terminology, and for reporting purposes, this heating design month is designated as **Heating Design** on the **Checksums** reports.

Heating Design is only used for heating-coil and fan sizing, and only affects energy consumption in that it sets the heating-equipment capacity, thereby allowing the program to determine the part-load point and unloading status for all other conditions. Note that the actual part-load conditions used for energy analysis are based on the hourly analysis data.

Utilization schedules include a special *Heating* definition used only for heating-design calculations during the program's Design phase. (The Heating definition is not included in the energy analysis simulation, only in the heating-design calculations.) Per recommendations from ASHRAE, many scheduled loads are typically not included in the heating-design calculations. For example, loads associated with people, lights, and certain miscellaneous equipment should be excluded from the Heating design calculation to avoid taking credit for the heat they generate. To accomplish this, set the utilization value to 0 percent for the Heating calculation. Also, by default, Trace 700 will automatically neglect solar loads during the **Heating Design** calculation.

By the same token, it is important to account for scheduled loads, such as ventilation and infiltration, which contribute significantly to the building heating load. To include a load—ventilation, infiltration, and so forth—in the heating design calculations, set utilization value to 100 percent for the Heating definition.

For additional information related to schedules, please refer to “Creating schedules” on page 6–137.

- Q** Can I change the default weather location?
- A** To change the default weather location, first close any open files. Then, on the **File** menu, click **Customize settings**. In the default Location field, type in the desired weather-file description, exactly as it appears in the library.
- Q** How do I model a latent miscellaneous load?
- A** To do this, you must first create a custom miscellaneous equipment library member. Click **Internal and Airflow Loads** on the **Libraries** menu and select the library type as **Miscellaneous Loads**. Press **New** or **Copy** to create a custom miscellaneous load. Here, you can define the total load and the percentage of the load that is sensible. The remaining percentage is considered latent load. Fill in all other relevant fields for the custom miscellaneous load and click **Save**. Now you can utilize this new library member in any project file.
- Q** Can SEER (Seasonal Energy Efficiency Ratio) be input for energy rates?
- A** SEER is a measurement of overall energy efficiency. SEER is defined as the total cooling of a central unitary air conditioner in Btus during its normal annual usage period for cooling, divided by the total electric energy input in watt-hours during the same period. The Seasonal Energy Efficiency Ratio is a standard method of rating air conditioners based on three tests. All three tests are run at 80°F inside and 82°F outside. The first test is run with humid indoor conditions, the second with dry indoor conditions, and the third with dry conditions cycling the air conditioner on for 6 minutes and off for 24 minutes. In other words, the SEER is a combined efficiency calculated from three different conditions. (Note: The published SEER may not represent the actual seasonal energy efficiency of an air conditioner in different climates.) ARI Standard 210/240-94 provides detailed information about SEER and how it is calculated. Refer to the following Web site for more information about ARI Standard 210/240-94: <http://www.ari.org/std/individual/210.240-94.pdf>.

TRACE 700 requires a full-load energy rate at design conditions, an unloading curve at constant condenser temperature, and an ambient relief and/or modification curve. This data will give the program detailed information about the energy consumed by the equipment under a wide variety of operating conditions.

Plainly put, the combined energy efficiency that a SEER provides is not detailed-enough information for TRACE 700 to calculate accurate energy consumption data on an hour-by-hour basis.

Q How is a rooftop modeled?

A The answer depends on the type of rooftop that is being used. Most rooftops fall into one of three categories: constant volume, variable volume, and constant-volume fan with variable-volume terminal devices.

For a constant-volume RTU, there are three airside-system types that are typically used: single zone, variable temperature constant volume, and terminal reheat.

The single-zone and VTCV system types are very similar. They should be used to model RTUs that have one heating coil, one cooling coil, and a constant-volume fan that serves one or multiple spaces. For the single zone and VTCV system types to serve multiple rooms in TRACE 700, a zone must be created in **Assign Rooms to Systems**, and all rooms served by the RTU must be assigned to that one zone.

Each zone assigned to this system type, or each room directly assigned to the system type, will be modeled as a separate RTU. Please refer to “Zoning of rooms” on page 6–47 for more details on zoning with SZ and VTCV systems.

The terminal reheat system type has one system-level cooling coil, one system-level heating coil, and multiple zone-level main and/or reheat heating coils (the heating coil in the terminal device). The terminal reheat system is very similar to a typical VAV with reheat system, except that the airflow for the rooms and from the supply fan is constant. Zones should be created for this system if one terminal device will serve multiple rooms. All rooms and zones assigned to this system type will be served by the same supply fan and cooling coil.

For a variable volume (at the supply fan and at the terminal devices) RTU, there are several different airside system types that are typically used: Variable Volume Reheat, VAV with Baseboard Heating, Series Fan-Powered VAV, and so forth. The schematic drawing of the systems in **Create Systems** can be used to help find the correct system type, based on the location

of the heating coils, what type of terminal devices will be used, and so forth. For these system types, zones should be created if one terminal device will serve multiple rooms. The same supply fan and cooling coil will serve all rooms and zones assigned to these system types.

For a system with a constant-volume fan and variable-volume terminal devices (also known as a VariTrac system), there are three airside-system types that are typically used: Changeover-Bypass VAV, Changeover-Bypass VAV with Local Heat, and Changeover-Bypass VAV with Reheat. The schematic drawing of the systems in **Create Systems** can be used to help find the correct system type, based on the heating coil location(s). For these system types, zones should be created if one terminal device will serve multiple rooms. The same supply fan and cooling coil will serve all rooms and zones assigned to these system types.

For the compressors and whatever type of heating will be used, the user will need to go to **Create Plants**. The Air-Cooled Unitary equipment category contains all of the rooftop compressor models. The specific type of rooftop can be selected using the **Equipment Type** menu on the **Cooling Equipment** tab. For the heating side, a gas-fired heat exchanger, boiler, and/or electric resistance equipment category can be used depending on what is appropriate for the model. The specific type of heating equipment can be selected using the **Equipment Type** menu on the **Heating Equipment** tab. If two different heating sources will be used in the same system (gas-fired heat exchanger and electric resistance reheat), two separate heating plants will need to be created. The appropriate coils should be assigned to the heating plant(s) in **Assign Systems to Plants**.

- Q** On the **System, Zone, or Room Checksums** reports, why are the ventilation airflows for cooling and heating not equal?
- A** Three scenarios can typically cause ventilation airflows to differ.
1. For a VAV system, the minimum stop position for the VAV box has been set too low or has not been input.

To remedy this situation, look at the **Room Checksums** reports and find a room with unequal ventilation rates. If the reported minimum airflow (Refer to the **Airflows** section of the report) is lower than the cooling ventilation airflow, the minimum stop for

the VAV box will need to be raised to at least the cooling ventilation airflow. If the VAV minimum stop input on the **Airflows** tab of **Create Rooms** is higher than the cooling ventilation airflow, check the VAV minimum airflow schedule. If a schedule other than **Available 100%** is used, change back to the default schedule.

2. A schedule is being used that causes the ventilation rates to differ between the cooling-design and heating-design calculations.

For example if a standard TRACE 700 internal load schedule (People – Office, Lights – School, and so on) is being used for the ventilation, zero ventilation will be calculated for the heating-design portion of the simulation. This is because standard TRACE 700 internal load schedules are 0 percent for the heating-design calculation so that credit will not be taken for the heat generated by the internal loads. Selecting a standard TRACE 700 internal-load schedule for ventilation tells TRACE 700 to zero the ventilation for the heating-design calculation as well. To remedy this situation, select a ventilation schedule for the ventilation, or copy the internal-load schedule and set the heating-design definition to 100 percent.

3. The user has input different ventilation rates for cooling and heating.

The easiest way to check for this problem is to click **Component Tree** on the **View** menu, click the **Airflows** icon on the left side of the screen, and scroll through the inputs for ventilation airflow on the right side of the screen. If the input values or units for ventilation differ, the user will need to correct the inputs.

- Q** How is baseboard/radiant heating added to one of the existing system types?
- A** Baseboard/radiant heating can be added to any system (if the system does not include this function by default) by specifying a capacity of **100% of Design Capacity** for the Auxiliary Heating

Coil on the **Coils** tab of **Create Systems**. This auxiliary heating system will be sized according to the skin-envelope load.

Q What is the difference between the schedule for the fans and the fan-cycling schedule, and how do they interact?

A The schedule for the fan, found on the right side of the **Fans** tab of **Create Systems**, tells TRACE 700 whether the fan is available to run that hour or is turned off. For VAV systems, if the fan schedule is greater than 0 percent, the fan is available to run that hour. If the fan schedule is 0 percent, the fan is off. For constant-volume systems, the hourly percentages in the fan schedule are used to calculate fan energy. It is recommended that fan schedules not be used or should be input using only 0 percent for off and 100 percent for on, in order to avoid confusion. Generally, the fan-cycling schedule discussed below should be used to simulate most common fan-control strategies.

The fan-cycling schedule, found in the upper left-hand corner of the **Fans** tab of **Create Systems**, tells TRACE 700 whether the supply fan is allowed to cycle with the cooling and/or heating load, and whether occupancy is a consideration. During normal operation, only VAV systems let the fans modulate in response to room load. Choosing an entry other than **No fan cycling** for the fan-cycling schedule lets the fans of constant-volume systems (or VAV fans with minimum stops) cycle with the corresponding cooling or heating load. The resulting fan energy consumption is proportional to the part-load ratio (heating load/design-heating load) for that hour. For example, if the part-load heating ratio is 30 percent, TRACE 700 simulates fan operation at full bhp for 18 minutes (30 percent) of that hour.

The following types of fan-cycling schedules are available:

No fan cycling: No demand-related fan cycling occurs—the fan follows its schedule in time-clock fashion.

Cycle with heating load only: Fan cycles only with the heating load, regardless of occupancy.

Cycle with cooling load only: Fan cycles only with the cooling load, regardless of occupancy.

Cycle with all loads: Fan cycles with cooling and heating loads, regardless of occupancy.

Cycle with occupancy: Fan cycles with cooling and heating loads, but only when the room is unoccupied (i.e., when the people utilization schedule specifies 5 percent or less of design occupancy).

Note: The fan schedules, when scheduled at 0 percent, override all other fan-related schedules, including duty cycling, optimum start, and optimum stop. Example: If the system includes an economizer with OA dampers on the RA/OA deck and a main fan schedule reads 0 percent for a particular hour, the fan cannot be made to come on during that hour by the action of any other schedule.

- Q** On the **Rooms** tab of **Create Rooms**, what is the difference between **Thermostat** schedules and the thermostat driftpoints, and how do they interact?
- A** The thermostat driftpoints are the temperatures that the room is allowed to drift up to, or down to, during periods of low or no occupancy. If the room temperature starts to go outside the driftpoint temperatures, the cooling or heating coils will be activated (assuming the coils are available to operate). TRACE 700 will allow the room to drift up to, or down to, the driftpoint temperatures during the hours in which the people schedule for the room reads 5 percent or less. If the people schedule reads greater than 5 percent, the cooling thermostat will try to control the room to the design setpoints.

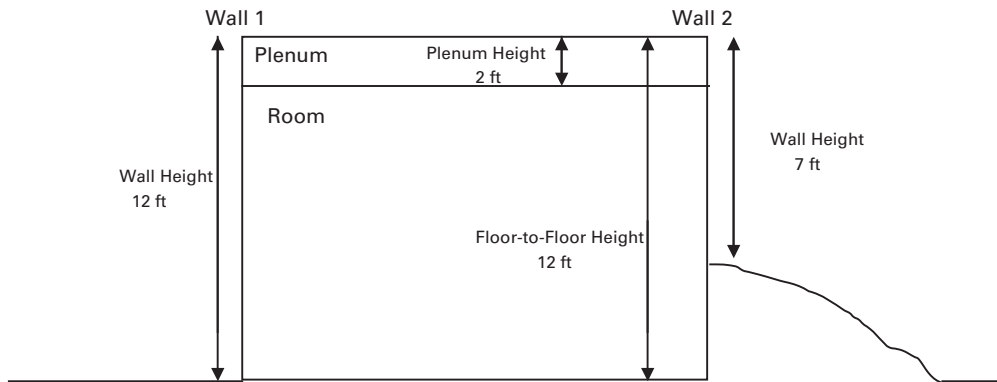
The **Thermostat** schedules allow the user to enter heating and cooling setpoints based on time instead of occupancy.

Thermostat schedules are created using the Library/Template Editors program.

Note: If a cooling-thermostat schedule is selected (other than the default None), the program will ignore the entered cooling setpoints and driftpoints for the energy simulation. However, the setpoints will still be used during the design calculations. The heating-thermostat schedules and driftpoints work identically.

- Q** What is the difference between Floor-to-Floor Height and Wall Height, and how does plenum height work in conjunction with these two inputs?
- A** The Wall Height is used to define the size of the exterior wall exposed to ambient conditions and solar loads. Wall Height is multiplied by the Wall Length to calculate the gross area of the external walls. This area should include any window area and the wall area above an acoustic ceiling (the plenum), if it exists. Unless the user has unchecked **Wall Load to Plenum**, the load for the portion of the wall above the acoustic ceiling will be assigned to the plenum during the heat-balance calculations (assuming that the entered plenum height is greater than zero). Also, if a wall is 100 percent glass, the wall dimensions must still be entered.

Figure 6–1 Floor-to-floor height to wall height relationship



The Floor-to-Floor Height is the vertical distance between floors, including the plenum height. For floors except the top floor, the F-T-F Height is the distance measured from the floor slab surface to the bottom of the next higher floor slab surface. For the top floor, the F-T-F Height is the distance between the floor slab surface and the internal roof surface. This value is used in conjunction with the entered Plenum Height to calculate the percent of non-glass wall conduction load that is assigned to the return-air path and the volume of the room (used to calculate any airflows entered with the units of air changes per hour).

The Plenum Height is the vertical distance between the ceiling and the floor slab surface of the floor above. If no plenum exists, the user should enter a value of zero. This value is used in conjunction with the entered Floor-to-Floor Height to calculate the percent of non-glass wall conduction load that is assigned to the return-air path and the volume of the room (used to calculate any airflows entered with the units of air changes per hour). The plenum height is also used to decide if the roof conduction and solar heat-gain loads are to be directed into the plenum or directly into the room. Refer to F1 Help for additional details.

*Note: Entering a plenum height does not tell the program if the system has a ducted return or a plenum return. The return air path can only be selected on the **Advanced** button in **Create Systems**.*

- Q** Why does purchased chilled water only have a COP of 1 when a chiller has a COP of 6?
- A** The COP (Coefficient of Performance) is a dimensionless term used to report the efficiency of cooling and heating equipment and systems. For cooling equipment, COP can be defined as the ratio of the rate of heat removal to the rate of energy input to the compressor.

Note: Both sides of the ratio must use the same units.

Stated another way:

$$COP = \frac{\text{Cooling provided}}{\text{Energy used to provide cooling}}$$

Example 1 – Chiller/Cooling Plant COP

To calculate the COP of a chiller providing 500 tons of cooling for one hour, at design conditions, with an efficiency of 0.55 kW/ton, the following calculation would be used:

$$500 \text{ tons} \times 0.55 \text{ kW/ton} \times 1 \text{ hour} = 275 \text{ kWh}$$

Therefore, to produce 500 ton-hours of cooling, the chiller consumed 275 kWh of electricity.

$$\begin{aligned} 12,000 \text{ Btu/hr} &= 1 \text{ ton of cooling} \\ 1 \text{ kW} &= 3,413 \text{ Btu/hr} \end{aligned}$$

$$\begin{aligned} \text{Cooling provided} &= 500 \text{ ton-hours} \times 12,000 \text{ Btu/hr/ton} = 6,000,000 \text{ Btu} \\ \text{Energy used to provide cooling} &= 275 \text{ kWh} \times 3,413 \text{ Btu/hr/kW} = 938,575 \text{ Btu} \end{aligned}$$

$$\begin{aligned} \text{COP of chiller} &= \frac{6,000,000 \text{ Btu}}{938,575 \text{ Btu}} \\ &= 6.4 \end{aligned}$$

A COP of 6.4 indicates that for every Btu of energy input into the compressor, 6.4 Btus of cooling are provided.

Depending on how COP is defined, the term may or may not include the energy consumption of ancillary equipment such as chilled-water pumps, condenser-water pumps, cooling towers, and/or condenser fans.

*Note: This example is meant as a generalization. For the standard chillers provided in the **Equipment** library, the chiller COP includes only the compressor energy because the ancillary equipment is called out separately via the miscellaneous accessories.*

Therefore, an overall system COP for Example 1 might be:

$$\begin{aligned} \text{Cooling tower} &= 50 \text{ kWh} \\ \text{Chilled-water pump} &= 45 \text{ kWh} \\ \text{Condenser-water pump} &= 40 \text{ kWh} \\ \text{Chiller} &= 0.55 \text{ kW/ton} \times 500 \text{ ton-hours} = 275 \text{ kWh} \\ \text{System energy consumption} &= 50 \text{ kWh} + 45 \text{ kWh} + 40 \text{ kWh} + 275 \text{ kWh} = 410 \text{ kWh} \end{aligned}$$

$$\begin{aligned} \text{Cooling provided} &= 500 \text{ ton-hours} \times 12,000 \text{ Btu/hr/ton} = 6,000,000 \text{ Btu} \\ \text{Energy used to provide cooling} &= 410 \text{ kWh} \times 3,413 \text{ Btu/hr/kW} = 1,399,330 \text{ Btu} \end{aligned}$$

$$\begin{aligned} \text{COP of chiller} &= \frac{6,000,000 \text{ Btu}}{1,399,330 \text{ Btu}} \\ &= 4.3 \end{aligned}$$

A COP of 4.3 indicates that for every Btu of energy input into the system, 4.3 Btu of cooling are provided.

The cost of energy to meet the 500 ton-hours of cooling load using this chiller plant could be estimated as:

$$410 \text{ kWh} \times \$0.05 \text{ per kWh} = \$20.50$$

(if no demand charge, customer charge, and so on exists in the utility rate structure)

Assuming that we own the chiller plant and want to sell chilled water to a neighboring building, the price for the purchased chilled water (PCW) would be determined as follows:

$$\begin{aligned} 1 \text{ therm} &= 100,000 \text{ Btu} \\ \frac{6,000,000 \text{ Btu}}{100,000 \text{ Btu/therm}} &= 60 \text{ therms of cooling} \end{aligned}$$

From above, it costs \$20.50 to produce the 60 therms (500 ton-hours) of cooling. This would yield a cost of:

$$\frac{\$20.50}{60 \text{ therms}} = \$0.34 \text{ per therm}$$

The charge to the neighboring building for the purchased chilled water in this scenario would be \$0.34 per therm plus a profit margin. In this scenario we will use a profit margin of \$0.11 per therm.

The cost of using the PCW to meet the 500 ton-hours of cooling load would be:

$$\begin{aligned} \text{Cost of PCW} &= 60 \text{ therms} \times (\$0.34 \text{ per therm} + \$0.11 \text{ per therm}) \\ &= \$27.00 \end{aligned}$$

Example 2 – Purchased Chilled Water COP

To calculate the COP of the purchased chilled water (PCW) that is used to provide 500 tons of cooling for one hour, the following calculations would be used:

$$COP \text{ of PCW} = \frac{\text{Cooling provided}}{\text{Energy used to provide cooling}}$$

$$\begin{aligned}\text{Cooling provided} &= 500 \text{ ton-hours} \times 12,000 \text{ Btu/hr/ton} = 6,000,000 \text{ Btu} \\ \text{Energy used to provide cooling} &= 500 \text{ ton-hours of PCW} \times 12,000 \text{ Btu/hr/ton} = 6,000,000 \text{ Btu}\end{aligned}$$

$$\begin{aligned}COP \text{ of PCW} &= \frac{6,000,000 \text{ Btu}}{6,000,000 \text{ Btu}} \\ &= 1\end{aligned}$$

A COP of 1.0 indicates that for each Btu of purchased chilled water consumed, a Btu of cooling is provided.

Note: Inputting a COP greater than 1 for purchased chilled water will cause an underestimation of the amount of purchased chilled water consumed by the building. For example, if a COP of 2 is used for purchased chilled water, then for every therm of purchased chilled water consumed, 2 therms of cooling will be provided.

- Q** Is the Cooling Energy Rate (**Cooling Equipment** tab of **Create Plants**) determined at the design condenser temperature? Does it change at off-design conditions?
- A** The Cooling Energy Rate (efficiency rate of the compressor) represents the energy consumption of the compressor at cooling-design conditions. To calculate the hourly energy consumption for the compressor, TRACE 700 utilizes a primary unloading curve to account for changes in load (determined based on a constant entering condenser-water temperature), an ambient relief curve to account for changes in condenser-water temperatures (water-cooled equipment) or outside-air dry-bulb temperatures (air-cooled equipment), and the design-cooling energy rate. For increased accuracy, a capacity-correction curve

can also be included in the calculation to account for changes in capacity based on changing temperatures.

Note: The full-load energy rate has to be determined at the temperature of the design condenser temperature, or the amount of ambient relief applied will be incorrect.

- Q** For water- or ground-source heat pumps, how does TRACE 700 change the hourly compressor-energy consumption? Does the calculation change based on the heat pump providing cooling or heating?
- A** For GSHP systems, TRACE 700 accounts for changes in the mean ground temperature based on IGSHA (International Ground Source Heat Pump Association) derived equations. The combination of the mean ground temperature and the loads seen by the equipment during the current hour determine the actual water-loop temperature. The difference between the actual condenser entering-water temperature and the design entering-water temperature yields a sink-temperature difference. In cooling mode, the energy consumption of the compressor is then calculated based on the entered design Cooling Energy Rate, the load seen by the compressor paired with the compressor unloading curve, and the heat-sink temperature difference paired with the ambient modification curve. Water-source heat-pump calculations are done similarly, except that the ground temperature is not factored into the calculation.


In heating mode, TRACE 700 uses the heat-recovery energy rate (the design energy consumption of the compressor in heating mode), the secondary unloading curve, and the ambient relief curve to calculate the energy consumption of the WSHP compressor. In the case of GSHPs, the unloading curve is the same regardless of mode, and the ambient modification curve for heat-recovery mode is now based upon the minimum entering condenser-water temperature (approximately 40°F) rather than the design entering condenser water temperature (approximately 85°F) used for cooling. The full load energy rate for heating mode should be determined at the temperature specified for the Minimum Condenser Temp (which is actually loop temp for WSHP and GSHP). The Heat Sink Delta T = $T_{LoopAvg} - MinCondTemp$.

- Q** What should be selected for the Heating Plant for a ground-source heat-pump system? What should be selected for the **Heat Rejection** type?
- A** The heating equipment is used to define a backup heating plant. The backup heating equipment is used to keep the water loop from falling below the minimum condenser-water temperature. Typically, a boiler should be selected as the backup heating source. The heat-rejection equipment, selected as the **Heat Rejection** type, is used as a backup to keep the water loop from exceeding the design condenser entering-water temperature. Typically, a cooling tower should be selected.

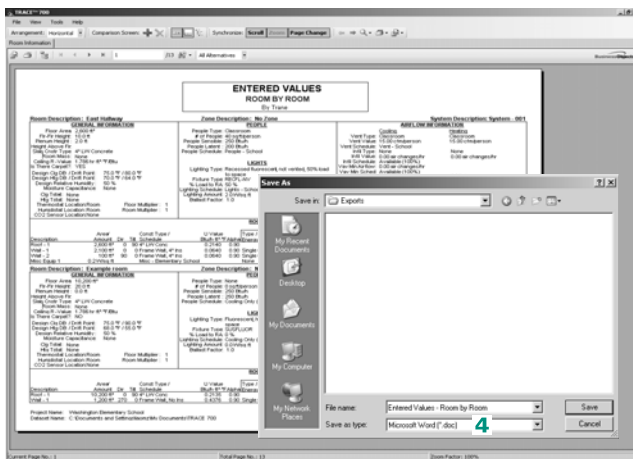
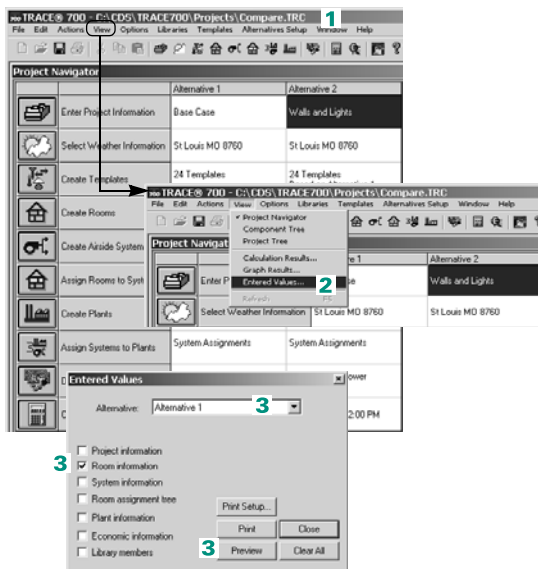
Note: If the entered GSHP system has a large enough water loop (entered as the thermal storage capacity); the minimum condenser-water temperature is input accurately; and the load profile is realistic; then the backup heating equipment and heat-rejection equipment may never be activated.

Comparing input data

In TRACE 700, it is often useful to compare the inputs of one alternative to the inputs of another. Microsoft Word can be used to help make comparisons of input values easier.

 To compare alternative inputs:

- 1 Open the file in TRACE 700.
- 2 On the **View** menu, click **Entered Values**.
- 3 Select the first alternative, select the section of the program to compare, and click **Preview**.
- 4 Click the envelope at the top of the **Entered Values** report, click **Rich Text Format** or **MS WORD** on the **Save as type** list, choose the destination for the export, and click **OK**.
- 5 Select **All** as the **Page Range** to export all pages and click **OK**.



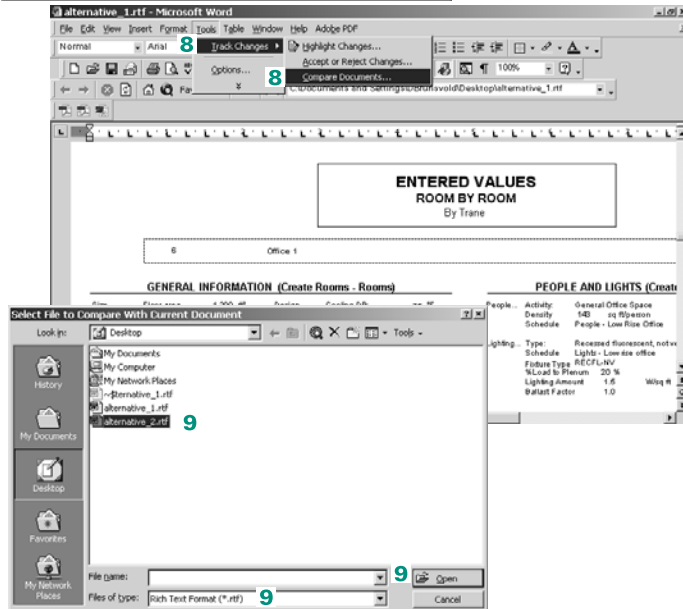
- 6 Select a destination directory for exporting the file, name the file, and click **Save**.
- 7 Repeat the same process for the Alternative 2 input data.



- 8 Open the file for Alternative 1 in MS Word, click **Track Changes** on the **Tools** menu, and click **Compare Documents**.

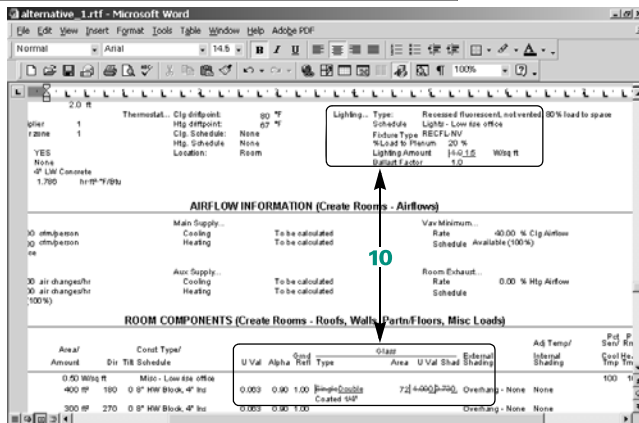
*Note: The location and actual name of **Track Changes** may vary depending on your version of MS Word.*

- 9 Select the **Files of Type** as **Rich Text Format** or **MS Word** (whichever was selected in step 4), select the export file containing Alternative 2 data, and click **Open**.



- 10 The differences between the alternatives (lighting density and glass type, in this case) will be shown in red automatically.

Note: If the alternatives are too dissimilar, then all of the data will be highlighted in red.



No- or low-heating energy consumption

There are several reasons why an energy simulation can calculate no/low amounts of heating energy despite showing realistic heating loads in the design calculation. The following points are common reasons why heating energy is often underestimated.

Note: Not all of these inputs are necessarily incorrect. Some are reasons that heating energy may be minimized or eliminated.

Example 1

- 1 The default values for the thermostat driftpoints, 90°F and 55°F respectively, are being used. This means that whenever there are 5 percent or less of the people in the space (determined from the people schedule), the room will be allowed to drift up to 90°F or down to 55°F before the equipment turns back on. If the building control system is not going to allow the room setpoints to setback this far, or at all, the default values need to be set to more realistic values.
- 2 The selected **Thermostat** schedules allow the building to drift to an unrealistic temperature at night. For example, the CSTAT and HSTAT schedules will allow the building to drift up to 95°F and down to 55°F, depending on the time of day. The values used in the schedules can be viewed by clicking **Schedules** on the **Libraries** menu and selecting **Thermostat** as the schedule type. Typically, users need to either create their own **Thermostat** schedules, or select *none* and let the program use the driftpoints (the schedules override the driftpoints). Not correcting this input will result in an underestimation of the cooling and

heating energy at night. Refer to “Frequently asked questions” on page 6–20 for information regarding how driftpoints and thermostat schedules interact.

- 3 Large areas are being modeled as a single space. This can cause the internal loads to negate the envelope losses, leading to an underestimation or elimination of the heating loads in the energy simulation. Because internal loads are typically neglected during the heating design calculations, reasonable heating-design results may be returned using this assumption. Modeling interior and perimeter areas as separate rooms will eliminate this modeling error. Refer to “Modeling large rooms and zones” on page 6–45 for a detailed explanation.

Example 2

The screenshot shows the 'Create Rooms - Internal Loads' dialog box. The 'Alternative' is set to 'Alternative 1'. The 'Room description' is 'Single Room'. Under 'Templates...', 'Room' is 'Default', 'Internal' is 'Default', 'Airflow' is 'Default', 'Total' is 'Default', and 'Control' is 'Default'. 'People.. Activity' is 'General Office Space', 'Density' is '143 sq ft/person', 'Schedule' is 'Cooling Only (Design)' (marked with a red 1), 'Sensible' is '250 Btu/h', and 'Latent' is '200 Btu/h'. 'Lights.. Type' is 'Recessed fluorescent, not vented, 90% load to space', 'Heat gain' is '1 ft' (marked with a red 2), and 'Schedule' is 'Available (100%)'. Under 'Miscellaneous loads...', 'Misc Load 1' is selected, 'Tag' is 'Misc Load 1', 'Type' is 'Std Office Equipment', 'Energy' is '0.5 W/sq ft', and 'Schedule' is 'Custom Schedule' (marked with a red 3). The 'Energy meter' is 'Electricity'. At the bottom, there are tabs for 'Single Sheet', 'Rooms', 'Roofs', 'Walls', 'Int Loads', 'Airflows', and 'Patio/Floors'.

- 1 The **Cooling Only (Design)** schedule is selected for any of the internal loads. This schedule should typically only be used for design calculations, not for energy analysis. It simulates 100 percent of the internal loads in the building 24 hours a day (except during the heating-design portion of the calculation), which may not be what is actually occurring in the building. This tends to lead to the internal loads meeting the heating loads. To view the schedule, click **Schedules** on the **Libraries** menu and select **Utilization** as the schedule type. Here the user should be able to view the schedule and find schedules that more-closely follow the actual operation of the building.
- 2 The internal loads are scheduled as **Available 100%**. This schedule should not be used for internal loads. It simulates 100 percent of the internal loads in the building 24 hours a day, which may not be what is actually occurring in the building. In addition, it also tells the program to take credit for the internal loads during the heating-design calculation. This schedule tends to lead to an underestimation of heating energy

and undersizing of the heating coils, due to the internal loads meeting all or most of the heating loads. To view the schedule, click **Schedules** on the **Libraries** menu. Here the user should be able to view the schedule and find schedules that more closely follow the actual operation of the building.

- 3 The custom schedule(s) for internal loads have values greater than zero for the heating-design day type. This tells the program to take credit for the internal loads during the heating-design calculation. This tends to lead to undersizing of the heating coils and is not common design practice. To view the schedule, click **Schedules** on the **Libraries** menu. Here the user should be able to view the schedule and the individual day types.

Example 3

- 1 No infiltration has been input on the **Airflows** tab of **Create Rooms**. Infiltration is air from outside the building that leaks into the room, often adding to the heating requirement.
- 2 No VAV minimum airflow has been input for VAV systems. This can result in no (or minimal) airflow being supplied to the space in heating mode.

Example 4

The screenshot shows the 'Create Systems - Design Temperatures' dialog box. The 'System description' is 'RTU-1' and the 'Fan Coil' is selected. The 'Design Air Temperature' section has 'Cooling supply' (Max 55°F, Min 55°F), 'Leaving cooling coil' (Max, Min), 'Heating supply' (Max 55°F, Min 55°F), 'Supply duct temperature difference' (0°F), and 'Reheat temperature difference' (0°F). The 'Direct/Indirect Dehumidification Methods' section has 'Type' (None), 'Maximum room relative humidity' (%), and 'Main cooling coil minimum allowable leaving (when throttling a chilled water coil downward during dehumidification or "wild coil" mode)' (°F). The 'Variable Fan Speed for capacity control' section has 'Number of fan speeds' (None), 'Percent airflow at low speed' (%), and 'Percent airflow at medium speed' (%). The 'Humidification' section has 'Design humidity ratio difference' (grains) and 'Minimum room relative humidity' (%). The 'Selection' tab is active, and the 'Temp/Humidity' sub-tab is selected.

- 1 The heating supply-air temperature has been input at an unrealistically low temperature. The capacity of the heating coil is calculated based on the airflow through the coil and the temperature difference across the coil. If coil capacity is underestimated, the energy consumed by the coil will also be underestimated.

Example 5

The screenshot shows the 'Create Systems - Fan Overrides' dialog box. The 'System description' is 'RTU-1' and the 'VAV w/Rebaseboard Heating' is selected. The 'Fan cycling schedule' is 'No fan cycling'. The 'Overrides' section contains a table with the following data:

	Type	Static Pressure (in. w.g.)	Full Load Energy Rate	Full Load Energy Rate Limit	Schedule
Primary	AF Centrifugal const vol	2.5	0.0002	kW/Cfm w/g	Off (0%)
Secondary	None	0	0	kW/Cfm	Available (100%)
Return	None	0	0	kW/Cfm	Available (100%)
System exhaust	None	0	0	kW/Cfm	Available (100%)
Room exhaust	None	0	0	kW/Cfm	Available (100%)
Optional ventilation	None	0	0	kW/Cfm	Available (100%)
Auxiliary	None	0	0	kW/Cfm	Available (100%)

The 'Schedule' column is highlighted with a red box and a callout '1'. The 'Selection' tab is active, and the 'Fans' sub-tab is selected.

- 1 The selected fan schedule does not allow the fan to run at hours when heating loads occur. If the fan is turned off, the heating coils cannot consume energy. Schedules for fans should be used only when the fans are turned off for certain time periods and not allowed to turn back on no matter what the temperature is in the space. The schedules Off (0 percent) and Heating Only (Design) would be two examples of

incorrect schedule selection. Refer to “Frequently asked questions” on page 6–20 for additional details regarding how fan schedules and fan cycling operate in TRACE 700.

Example 6

Alternative 1

System description: RTU-1 Single Zone

Capacity Overrides

	Capacity	Capacity Units	Schedule
Main cooling	100	% of Design Cooling Capacity	Available (100%)
Auxiliary cooling		% of Design Cooling Capacity	Available (100%)
Main heating	0 1	% of Design Capacity	Available (100%)
Auxiliary heating		% of Design Capacity	Available (100%)
Preheat	100	% of Design Capacity	Off (0%) 2
Reheat	100	% of Design Capacity	Available (100%)
Humidification	100	% of Design Capacity	Available (100%)

Warning: The fields marked in red require other entries for a correct simulation. Contact C.D.S. Support at 800-787-3526 for a detailed explanation.

Selection Options Dedicated OA Temp/Humidity Fans **Coils** Schematic

- 1 The heating coil(s) capacity has been zeroed out. This will cause the program to eliminate all energy associated with the coil(s).
- 2 The heating coil(s) have been scheduled off during hours when heating loads occur. If the coil(s) are turned off, they cannot consume energy. Schedules for coils should be used only when the coils are turned off for certain time periods and not allowed to turn back on no matter what the temperature is in the space.

Example 7

Alternative 1

Heating plant: Boiler Plant

Equipment tag: Boiler - 1

Equipment category: Boiler

Equipment type: Gas Fired Hot Water Boiler

Capacity: MWh

Energy rate: 83.3 Percent efficient

Thermal storage

Type: None

Capacity: 0 Ton/hr

Schedule: Storage

Hot water pump

Type: Heating water circ pump

Full load consumption: 0 ft water

Equipment schedule: Off (0%) **1**

Demand limiting priority:

Configuration Cooling Equipment **Heating Equipment** Base Utility / Misc. Accessory

- 1 The heating equipment schedule does not allow the heating equipment to run during hours when heating loads occur. If the heating

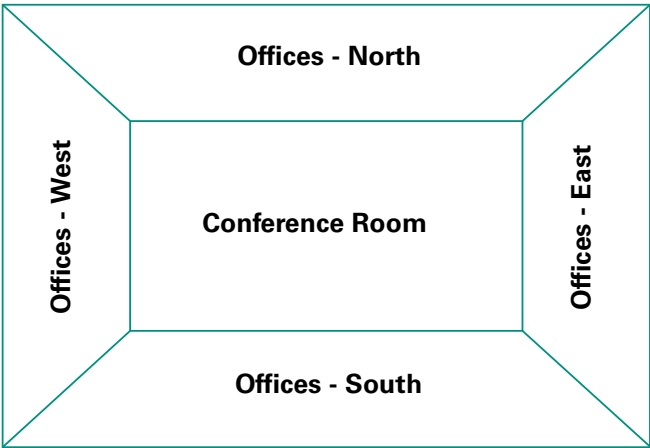
equipment is turned off, then it cannot consume energy or meet the calculated heating loads.

Note: Switching to a full-year (8760 analysis) will typically provide a more-accurate estimation of heating energy consumption. Refer to “Adding weather locations and activating the 8760 calculation methodology” on page 6-167.

Modeling large rooms and zones

As a time-saving measure, users will occasionally choose to model large, thermally diverse areas as a single space. The ramifications of this simplified model for load–design and energy analysis are discussed below.

Figure 6–2 Large Room Example



Energy analysis

In the building above, five separate thermal zones are shown. Inside of the zones are thermally similar rooms. The loads (positive loads indicate heat gains, negative loads indicate heat losses) for the zones during a typical fall morning are as follows:

Table 6–1 Zone loads

	Internal Loads	Envelope Loads	Space Load
Office - North	10,000 Btu/h	-16,000 Btu/h	-6,000 Btu/h
Office - East	6,000 Btu/h	-8,000 Btu/h	-2,000 Btu/h
Office - South	10,000 Btu/h	-12,000 Btu/h	-2,000 Btu/h
Office - West	6,000 Btu/h	-10,000 Btu/h	-4,000 Btu/h
Conference Room	16,000 Btu/h	0 Btu/h	16,000 Btu/h
Total	48,000 Btu/h	-46,000 Btu/h	2,000 Btu/h

If these five zones are modeled separately, all of the offices will be in heating and the conference room will be in cooling.

However, if these five zones are modeled as one large room, then 2,000 Btu/h of cooling and no heating are required. In the case of the one-room model, the heating and cooling energy consumptions would both be underestimated.

Load design

In load design, the above situation does not apply because the cooling and heating calculations are done separately, and internal loads are typically neglected for heating design. However, large rooms and/or zones can still cause problems.

For *constant-volume systems* modeled using one large room, a single time-of-peak is assumed. In a constant-volume system, a sum-of-the-peaks methodology must be used to properly size the equipment. If one of the spaces has a different time-of-peak than the others, the system will be undersized when a one-room and/or one-zone model is used. In the example shown above, the Office–East would peak in the morning and the Office–West would peak in the afternoon. If a single time-of-peak is assumed, the maximum airflow for at least one of the rooms, and the system serving it, would be undersized. Modeling this example as one large room can cause an underestimation of the capacity of the system by as much as 30 to 40 percent.

For *variable-volume systems* modeled using one large room, a single time-of-peak is also assumed. In a variable-volume system, a block methodology must be used to properly size the system. Modeling this example as one large room may allow the program to calculate a reasonable estimate for the size of the system, provided that all of the spaces are occupied and operated similarly. However, determining precise airflows to the individual rooms and/or zones is not possible when a single room is used.

*Note: For additional information related to the sum-of-the-peaks and block-sizing methodologies, refer to the topic **Block vs. Sum-of-Peaks** in TRACE 700 Help.*

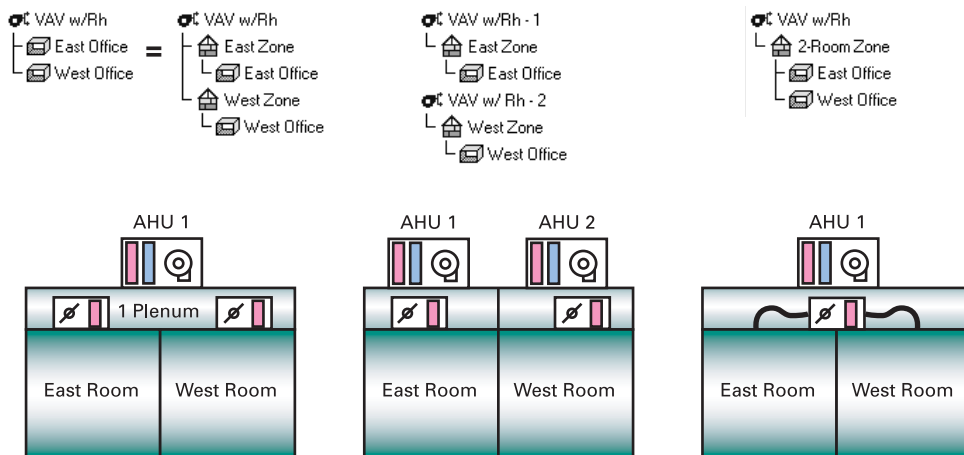
Zoning of rooms

Room and zone assignments

In TRACE 700, the **Assign Rooms to Systems** section of the program is used to configure the rooms and zones on the airside systems. Airside systems can have system-, zone-, or room-level coils and fans. For accurate simulations, correct zoning is essential, because the level of the fans and coils will affect how the rooms and zones should be configured. The following three examples show proper configurations.

System-level coils

Figure 6–3 Typical VAV example



*Note: To model the far right example for energy analysis, the user would also have to specify a **Thermostat location of Zone** for the rooms served by the same terminal device.*

The following systems have system-level fans, system-level main-cooling coils, and system-level preheat coils by default:

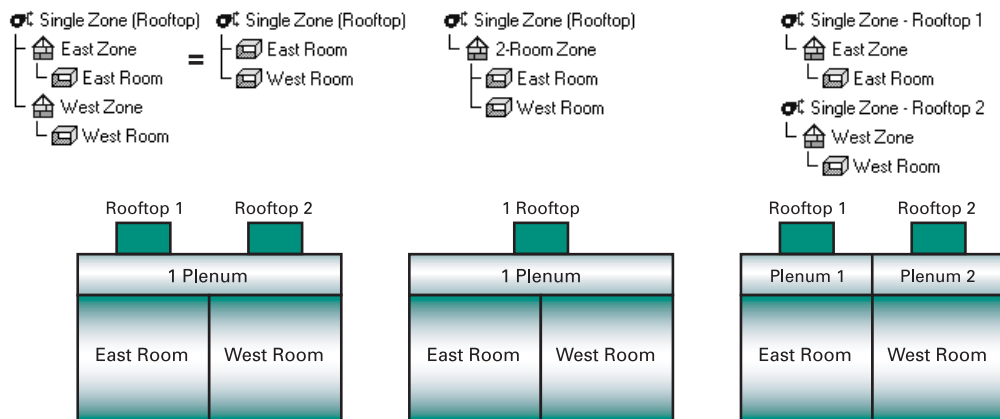
terminal reheat, all *VAV* systems, all *constant-volume mixing* systems, and all *induction* systems.

In TRACE 700, a system-level unit serves all rooms and zones assigned to that system. For system-level units, each airside system would represent an air handler or RTU, and the zoning would work as shown above.

After calculations have been completed, the user would want to look at the **System Component Selection** report for all coil and fan sizing information. Alternately, the user could refer to the **Zone** or **Room Checksums** for VAV box sizing information, and the **System Checksums** for supply-fan, preheat-coil, and main cooling-coil sizing information.

Zone-level coils

Figure 6–4 Single zone or VTCV only



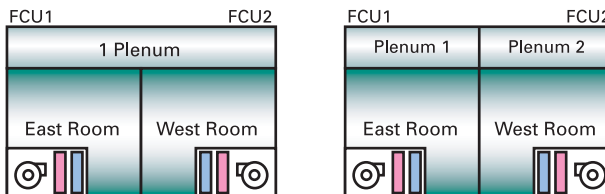
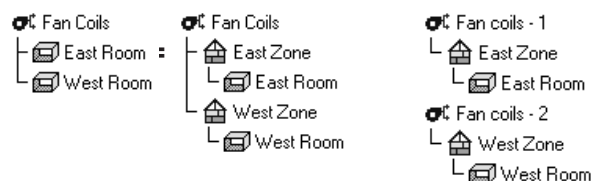
In TRACE 700, single zone (SZ) and variable-temperature, constant-volume (VTCV) units represent zone-level pieces of equipment. These two system types (SZ and VTCV) are commonly used to model constant-volume rooftops and, by default, are the only zone-level systems available by default. For zone-level systems, each zone represents a separate RTU and the zoning would work as shown in Figure 6–4.

It is important to note that a room assigned directly to a system is a separate zone in TRACE 700. Therefore, if multiple rooms are to be served by a single SZ or VTCV unit, the rooms must be assigned to the same single zone underneath the system (refer to the middle example above).

After calculations have been completed, the user would want to look at the **System Component Selection** report or **Zone Checksums**, *not* the **Room** or **System Checksums**, for coil- and fan-sizing information.

Room-level coils (fan coils)

Figure 6–5 Fan Coils



The following systems have room-level fans, room-level main-cooling coils, and room-level main-heating coils by default: computer-room unit, fan coil, incremental heat pump, PTAC, radiation, unit heaters, unit ventilators, and WSHP.

With room-level systems, each room assigned to the system gets a separate unit. If a building with 200 rooms is going to be conditioned by 200 fan-coil units with similar input criteria, as defined in the **Create Systems** window of TRACE 700, then only one airtide system needs to be created. All rooms would be assigned to this system, and TRACE 700 would calculate individual fan and coil sizes for each of the 200 fan-coil units.

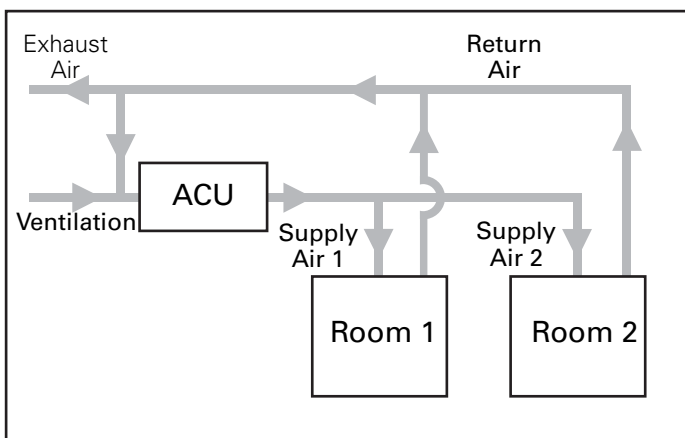
After calculations have been completed, the user would want to look at the **System Component Selection** report or **Rooms Checksums** for all coil- and fan-sizing information.

Oversizing and undersizing

Over/undersizing, which appears on the **Checksums** and **Airflow Loads** reports, typically occurs with constant-volume system types, especially Single Zone (SZ), Fan Coil (FC), Variable Temperature Constant Volume (VTCV), and Multizone (MZ) systems.

The following airside system and rooms will be used to illustrate over/undersizing and how it is calculated in TRACE 700.

Figure 6–6 Airside system and rooms



The sensible-heat equation will be used to calculate the sensible loads, airflows, and sensible over/undersizing.

$$Q_s = DSHP \times SA \times (T_r - T_s)$$

where:

- **Q_s** is the sensible load in the space, calculated based on the input walls, windows, internal loads, and so forth. A positive value indicates heat gains, and a negative value indicates heat losses. **Q_s** can be found on the **Checksums** report.

- **DSHP** is the density specific heat product (1.085 at sea level). For simplification purposes, 1.1 is used. DSHP is calculated for each weather location and can be found on the **Title Page** report.
- **SA** is the supply airflow. This can either be input on the **Airflows** tab of **Create Rooms** or calculated by TRACE 700 using the sensible-heat equation. **SA** can be found on the **Checksums** report.
- **T_r** is the room set-point temperature entered on the **Rooms** tab of **Create Rooms**. We will assume 75°F for cooling and 70°F for heating.
- **T_s** is supply-air dry bulb (SADB), which is either input on the **Temperatures** tab of **Create Systems** or calculated by TRACE 700 using the sensible-heat equation. **T_s** can be found on the **Checksums** report.

If only the sensible over/undersizing is considered, then the over/undersizing would be equal to the difference between Q_s and $DSHP \times SA \times (T_r - T_s)$.

$$\text{over/undersizing} = (DSHP \times SA \times (T_r - T_s)) - Q_s$$

For cooling design reports:

- a positive value (+) denotes overcooling (or oversizing of the cooling coil)
- a negative value (-) denotes undercooling (or undersizing of the cooling coil)

For heating design reports:

- a positive value (+) denotes underheating (or undersizing of the heating coil)
- a negative value (-) denotes overheating (or oversizing of the heating coil)

Seven scenarios will be used to calculate over/undersizing and explain why it occurs and how to minimize it.

Scenario 1

Over/undersizing on heating for a constant-volume system with heating supply-air dry bulb and airflow specified by the user.

Room 1

- Cooling $Q_s = 11,000$ Btu (calculated by TRACE 700 based on heat gains)
- Heating $Q_s = -5,500$ Btu (calculated by TRACE 700 based on heat losses)
- SA = 500 cfm (input by user)
- Heating $T_s = 105^\circ\text{F}$ (input by user)

In this scenario, the over/undersizing on heating would be:

$$\begin{aligned}\text{over/undersizing} &= (1.1 \times 500 \times (70 - 105)) - (-5,500) \\ &= -13,750 \text{ Btu}\end{aligned}$$

This would indicate overheating of 13,750 Btu, because the space would need only 143 cfm at a supply-air dry bulb of 105°F to properly condition the space. To minimize the overheating, remove the heating supply-air dry bulb and/or the supply airflow, and allow the program to calculate the value(s).

Scenario 2

Over/undersizing on cooling for a constant-volume system with cooling supply-air dry bulb* and airflow specified by the user.

Room 1

- Cooling $Q_s = 11,000$ Btu (calculated by TRACE 700 based on heat gains)
- Heating $Q_s = -5,500$ Btu (calculated by TRACE 700 based on heat losses)
- SA = 500 cfm (input by user)
- Cooling $T_s = 50^\circ\text{F}$ (input by user)

In this scenario, the over/undersizing on cooling would be:

$$\begin{aligned}\text{over/undersizing} &= (1.1 \times 500 \times (75 - 50)) - 11,000 \\ &= 2,750 \text{ Btu}\end{aligned}$$

This would indicate overcooling of 2,750 Btu, because the space would need only 400 cfm at a supply-air dry bulb of 50°F to properly condition the space.

Note: If the selected system has the ability to reheat at the terminal device, this is the amount of reheat that would be done

* Inputting the leaving cooling-coil temperature will cause the same situations to occur as inputting the supply-air dry bulb. The relationship between the two inputs is shown below:

Supply Air Dry Bulb =
Leaving Cooling Coil
Temperature + Duct Heat
Gain + Fan Heat Gain (draw-
thru fan configurations only)

at cooling design. To minimize the overcooling, remove the cooling supply-air dry bulb and/or the supply airflow and allow the program to calculate the value(s).

Scenario 3

* Inputting the leaving cooling-coil temperature will cause the same situations to occur as inputting the supply-air dry bulb. The relationship between the two inputs is shown below:

Supply Air Dry Bulb =
Leaving Cooling Coil
Temperature + Duct Heat
Gain + Fan Heat Gain (draw-
thru fan configurations only)

Over/undersizing on heating for a constant-volume system with cooling supply-air dry bulb* entered by the user or calculated by TRACE 700, and the heating supply-air dry bulb specified by the user.

Room 1

■ Cooling $Q_s = 11,000$ Btu (calculated by TRACE 700 based on heat gains)

■ Heating $Q_s = -5,500$ Btu (calculated by TRACE 700 based on heat losses)

■ Cooling $T_s = 55^\circ\text{F}$ (Input by user or calculated by TRACE 700)

■ Heating $T_s = 100^\circ\text{F}$ (input by user)

Because constant-volume systems supply the same airflow for both heating and cooling conditions, TRACE 700 calculates the design cooling and heating airflows separately and selects the larger of the two airflows as the design supply airflow for the system. This same supply airflow is then used for heating design and for cooling design.

Cooling:

$$11,000 = 1.1 \times SA \times (75 - 55)$$

$$SA = 500 \text{ cfm}$$

Heating:

$$-5,500 = 1.1 \times SA \times (70 - 100)$$

$$SA = 167 \text{ cfm}$$

In this scenario, the over/undersizing on heating would be:

$$\begin{aligned} \text{over/undersizing} &= (1.1 \times 500 \times (70 - 100)) - (-5,500) \\ &= -11,000 \text{ Btu} \end{aligned}$$

This would indicate overheating of 11,000 Btu, because the space would need 167 cfm at a supply-air dry bulb of 100°F to properly condition the space. Rooms typically do not need as much airflow for heating as for cooling. Oversizing therefore

occurs because there is too much airflow for the design-heating load. The program tries to reduce the design supply-air dry bulb for heating, but cannot reduce it below the Minimum Heating Supply-Air Dry-Bulb Temperature or the Room Design-Heating Dry-Bulb Temperature. To minimize the overheating, remove the heating supply-air dry bulb and allow the program to calculate the value(s).

Scenario 4

* Inputting the leaving cooling-coil temperature will cause the same situations to occur as inputting the supply-air dry bulb. The relationship between the two inputs is shown below:

Supply Air Dry Bulb =
Leaving Cooling Coil
Temperature + Duct Heat
Gain + Fan Heat Gain (draw-
thru fan configurations only)

Over/undersizing on heating for a variable-volume system with cooling supply-air dry bulb* entered by the user or calculated by TRACE 700, and the heating supply-air dry bulb specified by the user.

Room 1

- Cooling $Q_s = 11,000$ Btu (calculated by TRACE 700 based on heat gains)
- Heating $Q_s = -5,500$ Btu (calculated by TRACE 700 based on heat losses)
- Cooling $T_s = 55^\circ\text{F}$ (Input by user or calculated by TRACE 700)
- Heating $T_s = 100^\circ\text{F}$ (input by user)
- VAV minimum stop = 50 percent of cooling supply airflow (entered on **Airflows** tab of **Create Rooms**)

The cooling supply cfm would be calculated using the sensible-heat equation. The heating supply cfm would be calculated using the cooling supply cfm and the minimum stop.

Cooling:

$$11,000 = 1.1 \times SA \times (75 - 55)$$

$$SA = 500 \text{ cfm}$$

Heating:

$$SA = 500 \times 50\%$$

$$SA = 250 \text{ cfm}$$

In this scenario, the over/undersizing on heating would be:

$$\begin{aligned} \text{over/undersizing} &= (1.1 \times 250 \times (70 - 100)) - (-5,500) \\ &= -2,750 \text{ Btu} \end{aligned}$$

* Inputting the leaving cooling-coil temperature will cause the same situations to occur as inputting the supply-air dry bulb. The relationship between the two inputs is shown below:

Supply Air Dry Bulb =
Leaving Cooling Coil
Temperature + Duct Heat
Gain + Fan Heat Gain (draw-
thru fan configurations only)

This would indicate overheating of 2,750 Btu, because the space would need only 167 cfm at a supply-air dry bulb of 100°F to properly condition the space. Any time a heating supply-air dry bulb is entered for a variable-volume system, oversizing or undersizing of the coil should be expected. To minimize the overheating, remove the heating supply-air dry bulb and allow the program to calculate the value.

Scenario 5

Over/undersizing on heating for a constant-volume system with cooling supply-air dry bulb* entered by the user or calculated by TRACE 700.

Room 1

- Cooling $Q_s = 11,000$ Btu (calculated by TRACE 700 based on heat gains)
- Heating $Q_s = -8,250$ Btu (calculated by TRACE 700 based on heat losses)
- Cooling $T_s = 55^\circ\text{F}$ (Input by the user or calculated by TRACE 700)

The heating supply-air dry bulb will typically be calculated from the sensible-heat losses and the supply cfm calculated during the cooling calculations.

Cooling:

$$11,000 = 1.1 \times SA \times (75 - 55)$$

$$SA = 500 \text{ cfm}$$

Heating:

$$-8,250 = 1.1 \times 500 \times (70 - T_s)$$

$$\text{Heating } T_s = 85^\circ\text{F}$$

(calculated by TRACE)

Room 2

- Cooling $Q_s = 11,000$ Btu (calculated by TRACE 700 based on heat gains)
- Heating $Q_s = -2,750$ Btu (calculated by TRACE 700 based on heat losses)
- Cooling $T_s = 55^\circ\text{F}$ (Input by the user or calculated by TRACE 700)

- Heating $T_s = 85^\circ\text{F}$ (calculated by TRACE 700 based on the worst-case room assigned to the system).

Cooling:

$$11,000 = 1.1 \times SA \times (75 - 55)$$

$$SA = 500 \text{ cfm}$$

Heating:

$$SA = 500 \text{ cfm}$$

In this scenario, the over/undersizing on heating would be:

$$\begin{aligned} \text{over/undersizing} &= (1.1 \times 500 \times (70 - 85)) - (-2,750) \\ &= -5,500 \text{ Btu} \end{aligned}$$

This would indicate overheating of 5,500 Btu, because the space would need only 167 cfm at a supply-air dry bulb of 85°F to properly condition the space.

Constant-volume systems supply the same airflow for both heating and cooling conditions. TRACE 700 calculates the design cooling and heating airflows separately and selects the larger of the two airflows as the design supply airflow for the system. This same supply airflow is used for heating design and for cooling design.

When multiple spaces are conditioned by the same coil, a single supply-air dry bulb is calculated. This often will cause one room to set the heating supply-air dry bulb, and other rooms to be overheated. Rooms that have very different thermal properties (internal versus external rooms) will experience large amounts of overheating, as is shown in scenario 5.

Scenario 6

Over/undersizing on cooling for a variable-volume system.

Room 1 – East facing

- Cooling space $Q_s = 11,000$ Btu (Maximum sensible load calculated by TRACE 700 based on heat gains at the time of the space peak—9 a.m. for this example)
- Cooling coil $Q_s = 5,000$ Btu (Sensible load calculated by TRACE 700 based on heat gains at the time of the system [cooling-coil] peak—3 p.m. for this example)

- Cooling $T_s = 55^\circ\text{F}$ (Input by the user or calculated by TRACE 700)
- VAV minimum stop = 50 percent of cooling supply airflow (entered on **Airflows** tab of **Create Rooms**)

The cooling supply cfm would be calculated using the sensible-heat equation and the loads at the time of the space peak—9 a.m. for this east-facing office. The minimum supply cfm would be calculated using the cooling supply cfm and the minimum stop.

Cooling:

$$11,000 = 1.1 \times SA \times (75 - 55)$$

$$SA = 500 \text{ cfm}$$

Minimum airflow supplied to space:

$$SA = 500 \times 50\%$$

$$SA = 250 \text{ cfm}$$

When sizing the cooling coil, oversizing would appear in this example based on the minimum airflow requirements:

$$\begin{aligned} \text{over/undersizing} &= (1.1 \times 250 \times (75 - 55)) - 5,000 \\ &= 500 \text{ Btu} \end{aligned}$$

This would indicate overcooling of 500 Btu, because the space would need only 227 cfm, but the minimum stop on the VAV box is 250 cfm. Any time the minimum airflow is more than what is required to condition the space, oversizing of the coil should be expected.

Scenario 7

Over/undersizing on cooling for a system with cooling supply-air dry bulb specified by the user, and a ventilation rate greater than the supply airflow needed to condition the space.

Room 1

- Cooling $Q_s = 11,000$ Btu (calculated by TRACE 700 based on heat gains)
- Ventilation cfm = 600 cfm (input by the user)
- Cooling $T_s = 55^\circ\text{F}$ (input by the user)

Required supply airflow to condition the space:

$$11,000 = 1.1 \times SA \times (75 - 55)$$
$$SA = 500 \text{ cfm}$$

Because the user-input ventilation rate is larger than the airflow required to cool the space, TRACE 700 will use the ventilation rate as the supply airflow for the space. In this scenario, the over/undersizing on cooling would be:

$$\text{over/undersizing} = (1.1 \times 600 \times (75 - 55)) - 11,000$$
$$= 2,200 \text{ Btu}$$

This would indicate overcooling of 2,200 Btu, because the space would need only 500 cfm at a supply-air dry bulb of 55°F to properly condition the space.

Note: If the system selected has the ability to reheat at the terminal device, this is the amount of reheat that would be done at cooling design. To minimize the overcooling, remove the cooling supply-air dry bulb and allow the program to calculate the value.

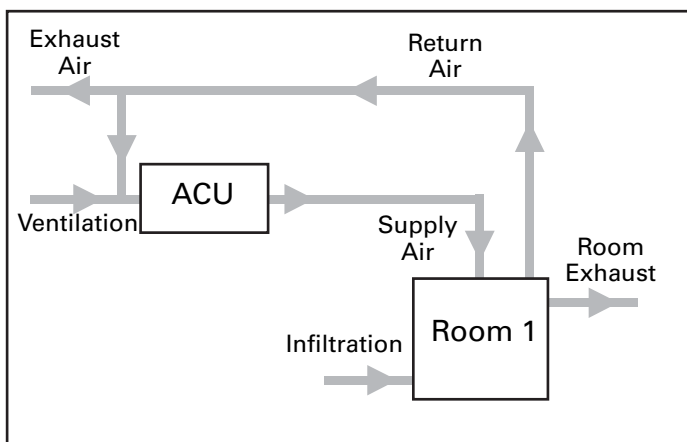
Summary points and additional items

- 1** For cooling design reports:
 - a** a positive value (+) denotes overcooling (or oversizing of the cooling coil)
 - b** a negative value (-) denotes undercooling (or undersizing of the cooling coil)
- 2** For heating design reports:
 - a** a positive value (+) denotes underheating (or undersizing of the heating coil)
 - b** a negative value (-) denotes overheating (or oversizing of the heating coil)
- 3** Over/undersizing is an actual load on the coil that cannot be ignored.
- 4** There are many other situations that can cause over/undersizing. These situations are all caused by a space being either over- or under-conditioned due to the system selected, the user inputs, or both.

Balancing airflows

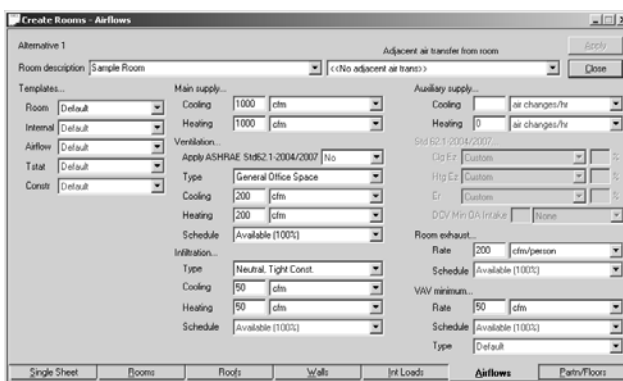
The following one-room example will be used to illustrate how airflows are balanced in TRACE 700, where the airflow values can be input, and where the airflow results can be viewed.

Figure 6-7 One-room airflow balancing



Ventilation, Infiltration, Supply Air (Main Supply), and Room Exhaust can be input on the **Airflows** tab of **Create Rooms**.

Note: Supply Air (Main Supply) typically should not be input. TRACE 700 can calculate this value based on the input loads.



The calculated results for the airflows can be viewed on the **Checksums** reports. For room-level data, the **Room Checksums** should be used to view Ventilation, Infiltration, Supply Air, Return Air, Exhaust, and Room Exhaust.

AIR FLOWS		
	Cooling	Heating
Vent	200	200
Infil	50	50
Supply	1,000	1,000
Min Stop/Rh	0	0
Return	850	850
Exhaust	50	50
Rm Exh	200	200
Auxil	0	0

In all steady-state situations (real-life or simulated), the amount of air that enters the space must be equal to the amount of air that leaves the space. Two equations can be used to represent this:

Room level balance:

$$\text{infiltration} + \text{supply air} = \text{room exhaust} + \text{return air}$$

System level balance:

$$\text{ventilation} + \text{infiltration} = \text{room exhaust} + \text{exhaust}$$

Four examples will be used to help explain how these equations affect the one-room calculation.

Scenario 1 – No infiltration, no room exhaust

- Ventilation = 200 cfm
- Supply Air = 1000 cfm
- Infiltration = 0 cfm
- Room Exhaust = 0 cfm

AIRFLOWS		
	Cooling	Heating
Vent	200	200
Infil	0	0
Supply	1,000	1,000
Min Stop/Rh	0	0
Return	1,000	1,000
Exhaust	200	200
Rm Exh	0	0
Auxil	0	0

Based on these inputs, TRACE 700 will calculate:

$$\begin{aligned} \text{exhaust air} &= \text{ventilation} + \text{infiltration} - \text{room exhaust} \\ &= 200 + 0 - 0 \\ &= 200 \text{ cfm} \end{aligned}$$

$$\begin{aligned} \text{return air} &= \text{supply air} + \text{infiltration} - \text{room exhaust} \\ &= 1000 + 0 - 0 \\ &= 1000 \text{ cfm} \end{aligned}$$

Scenario 2 – Infiltration, no room exhaust

- Ventilation = 200 cfm
- Supply Air = 1000 cfm
- Infiltration = 50 cfm
- Room Exhaust = 0 cfm

AIRFLOWS		
	Cooling	Heating
Vent	200	200
Infil	50	50
Supply	1,000	1,000
MinStop/Rh	0	0
Return	1,050	1,050
Exhaust	250	250
Rm Exh	0	0
Auxil	0	0

Based on these inputs, TRACE 700 will calculate:

$$\begin{aligned} \text{exhaust air} &= \text{ventilation} + \text{infiltration} - \text{room exhaust} \\ &= 200 + 50 - 0 \\ &= 250 \text{ cfm} \end{aligned}$$

$$\begin{aligned} \text{return air} &= \text{supply air} + \text{infiltration} - \text{room exhaust} \\ &= 1000 + 50 - 0 \\ &= 1050 \text{ cfm} \end{aligned}$$

Scenario 3 – Infiltration, with room exhaust less than or equal to the sum of ventilation and infiltration

- Ventilation = 200 cfm
- Supply Air = 1000 cfm
- Infiltration = 50 cfm
- Room Exhaust = 250 cfm

AIRFLOWS		
	Cooling	Heating
Vent	200	200
Infil	50	50
Supply	1,000	1,000
MinStop/Rh	0	0
Return	800	800
Exhaust	0	0
Rm Exh	250	250
Auxil	0	0

Based on these inputs, TRACE 700 will calculate:

$$\begin{aligned}\text{exhaust air} &= \text{ventilation} + \text{infiltration} - \text{room exhaust} \\ &= 200 + 50 - 250 \\ &= 0 \text{ cfm}\end{aligned}$$

$$\begin{aligned}\text{return air} &= \text{supply air} + \text{infiltration} - \text{room exhaust} \\ &= 1000 + 50 - 250 \\ &= 800 \text{ cfm}\end{aligned}$$

Scenario 4 – Infiltration, with room exhaust greater than the sum of ventilation and infiltration

- Ventilation = 200 cfm
- Supply Air = 1000 cfm
- Infiltration = 50 cfm
- Room Exhaust = 350 cfm

AIRFLOWS		
	Cooling	Heating
Vent	200	200
Infil	50	50
Supply	1,000	1,000
Min Stop/Rh	0	0
Return	800	800
Exhaust	0	0
Rm Exh	250	250
Auxil	0	0

Based on these inputs, TRACE 700 will calculate:

$$\begin{aligned}\text{exhaust air} &= \text{ventilation} + \text{infiltration} - \text{room exhaust} \\ &= 200 + 50 - 350 \\ &= -100 \text{ cfm}\end{aligned}$$

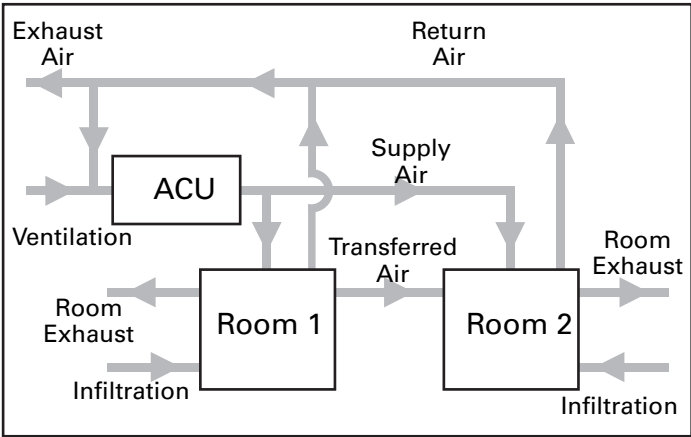
The airflows do not balance—therefore, the results will not be valid. In a one-room building, it is not possible to continually exhaust 100 cfm more of air than is brought into the building. If a building was set up to operate in this manner, eventually infiltration would increase or room exhaust would decrease so that the airflows would balance (TRACE 700 will automatically decrease the room exhaust to balance the airflows). For airflows to balance, the following equation must be followed:

$$\text{ventilation} + \text{infiltration} \geq \text{room exhaust}$$

Refer to **Summary Point 1** on page 67 for a more detailed explanation of this scenario.

When more than one room is involved, modeling becomes more complicated. Two more scenarios will be used to illustrate how airflows are calculated.

Figure 6–8 Multiple-room airflow balancing



Scenario 5 – Two rooms with balanced airflows and no transferred air.

Room 1

- Ventilation = 200 cfm
- Supply Air = 1000 cfm
- Infiltration = 0 cfm
- Room Exhaust = 0 cfm
- Transferred Air = 0 cfm

AIRFLOWS		
	Cooling	Heating
Vent	200	200
Infil	0	0
Supply	1,000	1,000
MinStop/Rh	0	0
Return	1,000	1,000
Exhaust	200	200
Rm Exh	0	0
Auxil	0	0

Room 2

- Ventilation = 300 cfm
- Supply Air = 1000 cfm
- Infiltration = 0 cfm
- Room Exhaust = 250 cfm
- Transferred Air = 0 cfm

AIRFLOWS		
	Cooling	Heating
Vent	300	300
Infil	0	0
Supply	1,000	1,000
MinStop/Rh	0	0
Return	750	750
Exhaust	50	50
Rm Exh	250	250
Auxil	0	0

Based on these inputs, TRACE 700 will calculate:

$$\begin{aligned}\text{Room 1 exhaust air} &= \text{ventilation} + \text{infiltration} - \text{room exhaust} \\ &= 200 + 0 - 0 \\ &= 200 \text{ cfm}\end{aligned}$$

$$\begin{aligned}\text{Room 1 return air} &= \text{supply air} + \text{infiltration} - \text{room exhaust} \\ &= 1000 + 0 - 0 \\ &= 1000 \text{ cfm}\end{aligned}$$

$$\begin{aligned}\text{Room 2 exhaust air} &= \text{ventilation} + \text{infiltration} - \text{room exhaust} \\ &= 300 + 0 - 250 \\ &= 50 \text{ cfm}\end{aligned}$$

$$\begin{aligned}\text{Room 2 return air} &= \text{supply air} + \text{infiltration} - \text{room exhaust} \\ &= 1000 + 0 - 250 \\ &= 750 \text{ cfm}\end{aligned}$$

Scenario 6 – One room with room exhaust and air transferred from the adjacent space.

Room 1

- Ventilation = 250 cfm
- Supply Air = 1000 cfm
- Infiltration = 0 cfm
- Room Exhaust = 0 cfm
- Transferred Air = -250 cfm

Room 2

- Ventilation = 0 cfm
- Supply Air = 1000 cfm
- Infiltration = 0 cfm
- Room Exhaust = 250 cfm
- Transferred Air = 250 cfm

Based on these inputs, TRACE 700 will calculate:

$$\begin{aligned}\text{Room 1 exhaust air} &= \text{ventilation} + \text{infiltration} - \text{room exhaust} \\ &= 250 + 0 - 0 \\ &= 250 \text{ cfm}\end{aligned}$$

$$\begin{aligned}\text{Room 1 return air} &= \text{supply air} + \text{infiltration} - \text{room exhaust} \\ &= 1000 + 0 - 0 \\ &= 1000 \text{ cfm}\end{aligned}$$

$$\begin{aligned}\text{Room 2 exhaust air} &= \text{ventilation} + \text{infiltration} - \text{room exhaust} \\ &= 0 + 0 - 250 \\ &= -250 \text{ cfm}\end{aligned}$$

The airflows for room 1 balance, but the airflows for room 2 do not balance—the results will not be valid. There is no field to input transfer air—therefore, it cannot be directly modeled in TRACE 700 or in any other simulation software that balances airflows at the space level.

The same airflow-balancing rules that applied in the one-room model are true in multiple-room models, as follows:

Room level balance:

$$\text{infiltration} + \text{supply air} = \text{room exhaust} + \text{return air}$$

System level balance:

$$\text{ventilation} + \text{infiltration} = \text{room exhaust} + \text{exhaust}$$

$$\text{ventilation} + \text{infiltration} \geq \text{room exhaust}$$

There are three possible ways to model a scenario where air is transferred from one space to another.

- 1** If the air transferred from room 1 to room 2 is not used to condition the space, all or a portion of the room exhaust can be entered on room 1. This will allow the program to calculate the correct amount of return air and keep the airflows balanced assuming that the airflows in each of the spaces are balanced.
- 2** If air is transferred from one space to another, and the transferred air conditions room 2, the two spaces are actually being treated as one in the building. Model the two spaces as one in

TRACE 700 and make sure that the airflows balance for the combined room.

- 3 If the amount of room exhaust is small, the assumption can be made that room exhaust is not a significant factor. If room exhaust is not entered, then 250 cfm of extra return air will be calculated in the scenario above. This will change the plenum temperature slightly and increase the exhaust value by 250 cfm.

Summary points and additional items

- 1 In real life, it is possible to pressurize a space by having unequal amounts of air enter and leave the space—100 cfm more could enter the space than leaves the space. This would result in positive pressurization of the space. However, it is not possible to continually have more airflow entering the space than leaves the space. If 100 ft³ of extra air enters the space every minute, the pressure will continue to rise until the air finds a way out. When this pressure has been reached, the airflows will return to steady state and the amount of air entering and leaving the space will equalize. The air can leave the space as exfiltration (modeled as room exhaust with no fan) or as return air. Conversely, it is not possible to have a room where more airflow leaves the space than enters it. Infiltration can be used to balance the airflows and approximate the steady-state conditions for the space. Remember that TRACE 700 can only model the airflows at the balanced steady-state condition. It cannot model the temporary imbalance in airflows that causes space pressurization.
- 2 In real life, it is possible to exhaust air from a space without supplying an equal or greater amount of ventilation plus infiltration to that space. However, if room exhaust exceeds infiltration plus ventilation in that space, then somewhere in the building, a balancing amount of air is going to find a way in. That airflow can enter the building as ventilation or as infiltration. TRACE 700 requires that the user tell the program how that air is going to enter the building. In addition, that added airflow must be balanced with the room exhaust using the equation

$$\text{ventilation} + \text{infiltration} \geq \text{room exhaust}$$

at the space level.

Selecting a DX unit using TRACE 700 output

This section discusses the steps for properly selecting DX equipment using the TRACE 700 output reports. It will be assumed that no mistakes have been made in the modeling process and that all results are accurate for the building and systems.

Related reading

- "Cooling-Coil Heat Transfer," *Engineers Newsletter* (volume 31, number 1)
- "The DX Refrigerant Cooling Coil Conundrum," *Engineers Newsletter* (volume 17, number 1)

Sample scenario

The design team has decided to use a VAV rooftop unit with a DX cooling coil to cool the proposed building. TRACE 700 has been used to estimate the design load and airflows. The design data will need to be input into a selection program to find an appropriate piece of equipment that meets the load and airflow requirements. In this scenario, TOPSS will be used to select a DX cooling coil in a rooftop unit.

- After calculating the TRACE 700 file, there are several output reports that can be used to get the data required to select the cooling coil. For the Variable Volume Reheat system used in this example, the **System Checksums** report and the **System Component Selection Summary** report can be used.

System Checksums
By Time

Variable Volume Reheat (DB) Min Time Default

COOLING COIL PEAK

Coil Name	Zone	Flow Rate (cfm)	Pressure Drop (in. wg)	Power (kW)
Zone 001	001	100.0	0.1	0.0
Zone 002	002	100.0	0.1	0.0
Zone 003	003	100.0	0.1	0.0
Zone 004	004	100.0	0.1	0.0
Zone 005	005	100.0	0.1	0.0
Zone 006	006	100.0	0.1	0.0
Zone 007	007	100.0	0.1	0.0
Zone 008	008	100.0	0.1	0.0
Zone 009	009	100.0	0.1	0.0
Zone 010	010	100.0	0.1	0.0
Zone 011	011	100.0	0.1	0.0
Zone 012	012	100.0	0.1	0.0
Zone 013	013	100.0	0.1	0.0
Zone 014	014	100.0	0.1	0.0
Zone 015	015	100.0	0.1	0.0
Zone 016	016	100.0	0.1	0.0
Zone 017	017	100.0	0.1	0.0
Zone 018	018	100.0	0.1	0.0
Zone 019	019	100.0	0.1	0.0
Zone 020	020	100.0	0.1	0.0
Zone 021	021	100.0	0.1	0.0
Zone 022	022	100.0	0.1	0.0
Zone 023	023	100.0	0.1	0.0
Zone 024	024	100.0	0.1	0.0
Zone 025	025	100.0	0.1	0.0
Zone 026	026	100.0	0.1	0.0
Zone 027	027	100.0	0.1	0.0
Zone 028	028	100.0	0.1	0.0
Zone 029	029	100.0	0.1	0.0
Zone 030	030	100.0	0.1	0.0
Zone 031	031	100.0	0.1	0.0
Zone 032	032	100.0	0.1	0.0
Zone 033	033	100.0	0.1	0.0
Zone 034	034	100.0	0.1	0.0
Zone 035	035	100.0	0.1	0.0
Zone 036	036	100.0	0.1	0.0
Zone 037	037	100.0	0.1	0.0
Zone 038	038	100.0	0.1	0.0
Zone 039	039	100.0	0.1	0.0
Zone 040	040	100.0	0.1	0.0
Zone 041	041	100.0	0.1	0.0
Zone 042	042	100.0	0.1	0.0
Zone 043	043	100.0	0.1	0.0
Zone 044	044	100.0	0.1	0.0
Zone 045	045	100.0	0.1	0.0
Zone 046	046	100.0	0.1	0.0
Zone 047	047	100.0	0.1	0.0
Zone 048	048	100.0	0.1	0.0
Zone 049	049	100.0	0.1	0.0
Zone 050	050	100.0	0.1	0.0
Zone 051	051	100.0	0.1	0.0
Zone 052	052	100.0	0.1	0.0
Zone 053	053	100.0	0.1	0.0
Zone 054	054	100.0	0.1	0.0
Zone 055	055	100.0	0.1	0.0
Zone 056	056	100.0	0.1	0.0
Zone 057	057	100.0	0.1	0.0
Zone 058	058	100.0	0.1	0.0
Zone 059	059	100.0	0.1	0.0
Zone 060	060	100.0	0.1	0.0
Zone 061	061	100.0	0.1	0.0
Zone 062	062	100.0	0.1	0.0
Zone 063	063	100.0	0.1	0.0
Zone 064	064	100.0	0.1	0.0
Zone 065	065	100.0	0.1	0.0
Zone 066	066	100.0	0.1	0.0
Zone 067	067	100.0	0.1	0.0
Zone 068	068	100.0	0.1	0.0
Zone 069	069	100.0	0.1	0.0
Zone 070	070	100.0	0.1	0.0
Zone 071	071	100.0	0.1	0.0
Zone 072	072	100.0	0.1	0.0
Zone 073	073	100.0	0.1	0.0
Zone 074	074	100.0	0.1	0.0
Zone 075	075	100.0	0.1	0.0
Zone 076	076	100.0	0.1	0.0
Zone 077	077	100.0	0.1	0.0
Zone 078	078	100.0	0.1	0.0
Zone 079	079	100.0	0.1	0.0
Zone 080	080	100.0	0.1	0.0
Zone 081	081	100.0	0.1	0.0
Zone 082	082	100.0	0.1	0.0
Zone 083	083	100.0	0.1	0.0
Zone 084	084	100.0	0.1	0.0
Zone 085	085	100.0	0.1	0.0
Zone 086	086	100.0	0.1	0.0
Zone 087	087	100.0	0.1	0.0
Zone 088	088	100.0	0.1	0.0
Zone 089	089	100.0	0.1	0.0
Zone 090	090	100.0	0.1	0.0
Zone 091	091	100.0	0.1	0.0
Zone 092	092	100.0	0.1	0.0
Zone 093	093	100.0	0.1	0.0
Zone 094	094	100.0	0.1	0.0
Zone 095	095	100.0	0.1	0.0
Zone 096	096	100.0	0.1	0.0
Zone 097	097	100.0	0.1	0.0
Zone 098	098	100.0	0.1	0.0
Zone 099	099	100.0	0.1	0.0
Zone 100	100	100.0	0.1	0.0

CLG SPACE PEAK

HEATING COIL PEAK

TEMPERATURES

AIR FLOWS

ENGINEERING DATA

- From these reports, the Total Capacity, Peak Airflow, Entering Dry Bulb, Entering Wet Bulb, and so forth, can be taken.

System Component Selection Summary
By Time

Alternative 1

System Description: System 001
Number of Zones: 10
Number of Rooms: 10

Component Selection

Component	Zone	Room	Location	Quantity
Cooling	Zone 001	Room 001	Zone	1
Heating	Zone 001	Room 001	Zone	1
Miscellaneous	Zone 001	Room 001	Zone	1

Cooling Coil Selection

Coil Name	Zone	Room	Location	Quantity
Zone 001	001	001	Zone	1
Zone 002	002	002	Zone	1
Zone 003	003	003	Zone	1
Zone 004	004	004	Zone	1
Zone 005	005	005	Zone	1
Zone 006	006	006	Zone	1
Zone 007	007	007	Zone	1
Zone 008	008	008	Zone	1
Zone 009	009	009	Zone	1
Zone 010	010	010	Zone	1

Heating Coil Selection

Coil Name	Zone	Room	Location	Quantity
Zone 001	001	001	Zone	1
Zone 002	002	002	Zone	1
Zone 003	003	003	Zone	1
Zone 004	004	004	Zone	1
Zone 005	005	005	Zone	1
Zone 006	006	006	Zone	1
Zone 007	007	007	Zone	1
Zone 008	008	008	Zone	1
Zone 009	009	009	Zone	1
Zone 010	010	010	Zone	1

Miscellaneous Component Selection

Component	Zone	Room	Location	Quantity
Zone 001	001	001	Zone	1
Zone 002	002	002	Zone	1
Zone 003	003	003	Zone	1
Zone 004	004	004	Zone	1
Zone 005	005	005	Zone	1
Zone 006	006	006	Zone	1
Zone 007	007	007	Zone	1
Zone 008	008	008	Zone	1
Zone 009	009	009	Zone	1
Zone 010	010	010	Zone	1

The following numbers will be used during the selection process.

Total Capacity = 374 Tons = 448.9 MBh

Sensible Capacity = 369.4 MBh

Supply Airflow at Space Sensible Peak Load = 19,575 cfm

Supply Airflow at Cooling Coil Peak Load = 19,329 cfm

Entering Cooling Coil Conditions (DB/WB) = 76.5°F / 63.8°F

Entering Main Heating Coil (DB) = 53.7°F

Altitude (from **Title Page** report) = 812 feet

3 These results will need to be input into the selection program. In this case, the Trane selection software (TOPSS) will be used.

4 While inputting the results from TRACE 700, TOPSS will give warning and error messages if appropriate. In this case, when inputting the maximum supply airflow for the unit, an error message is displayed stating that the maximum airflow for the 40-ton unit has been exceeded.

5 Go to the **Temp/Humidity** tab of **Create Systems** and input a more reasonable Cooling Supply Air Temperature Maximum and Minimum. For this example, use 57°F maximum and 54°F minimum.

Note: If the user already knows what supply-air temperature or range of temperatures the unit should use, this step can be done before the initial calculation. However, this can lead to over/undersizing of the coil(s) and humidity issues. Please refer to “Oversizing and undersizing” on page 6–51 and “Frequently asked questions” on page 6–20 for additional information related to the ramifications of inputting temperatures.

Note: When using a selection program it is often easy to over-specify the unit. TOPSS changes the colors of required inputs to red, optional inputs to blue, and all other inputs to white.

Note: This example:
 NCC=40 ton
 CEDB=76.5
 CEWB=63.8
 UF=YC: cooling, NGH
 HC=low heat
 Heating EAT=53.7
 Power=460/60/3
 ESP=2.0
 UAFD=downflow
 DA=19,575

To lower the airflow to an acceptable value, the user will need to review the inputs and outputs in TRACE 700. After verifying that the envelope, internal loads, airside system, and so forth, have been input accurately, the output reports can be focused on. In this case, the **Temperatures** section and **Cooling Coil Selection** section of the **System Checksums** report show the reason that the airflow is too large for the unitary equipment. To meet the relative humidity requirements of the building, the unit only has to supply air at 61.3°F. Based on the room setpoint of 75°F, this equates to a 13.7°F temperature difference and a high supply airflow. To lower the supply airflow, all the user needs to do is increase the temperature difference between the SA and room setpoint. One way to do this is to lower the supply-air temperature.

6 After recalculating the file, the new results can be used to select the unit:

Total Capacity = 37.2 Tons = 446.1 MBh

Sensible Capacity = 356.6 MBh

Supply Airflow at Space Sensible Peak Load = 14,863 cfm

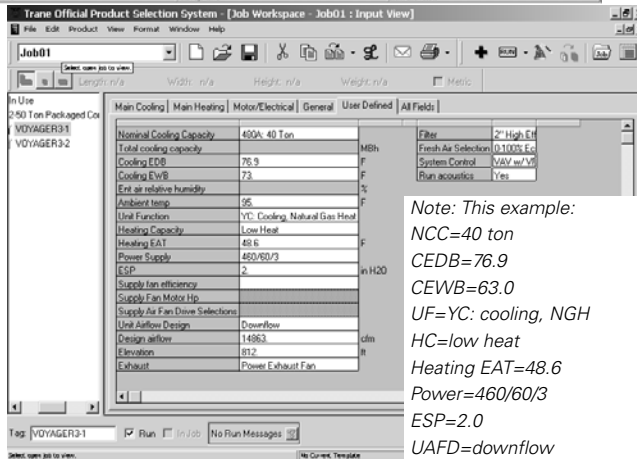
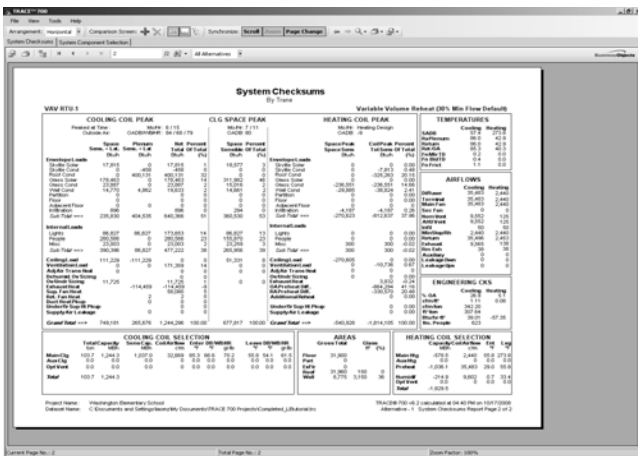
Supply Airflow at Cooling Coil Peak Load = 14,676 cfm

Entering Coil Conditions (DB/WB) = 76.9°F / 63.0°F

Entering Main Heating Coil (DB) = 48.6°F

Altitude (from **Title Page** report) = 812 feet

- 7 After inputting the new results in TOPSS, click **Run** and view the selection data and run messages for each of the units. Refer to “Additional items” on page 6–72 for recommendations on selecting the appropriate unit for the selection results.



Note: This example:

$NCC=40 \text{ ton}$

$CEDB=76.9$

 $CEWB=63.0$

UF=YC: cooling, NGH

HC=low heat

Heating EAT=48.6

$$Power = 460/60/3$$

ESP=2.0

UAFD=downflow

$$DA=14,863$$

Elev=812

$$Exhaust = Pwr \text{ Exh Fan}$$

Filter=2" High Eff Throw

Fresh air=0-100% diff enth

Sys cont=VAV/NFD/bypass

Additional items

- 1 General rules of thumb and advice for HVAC cooling coil selections:
 - a 500 to 600 ft/min for the maximum coil face velocity to avoid moisture carryover (some coils can go as high as 750 ft/min. Refer to the recommendations from the manufacturer)
 - b As the face velocity increases, the capacity of the coil and the pressure drop across the coil increase.
 - c Fin spacing typically ranges from 80 to 168 fins per ft for comfort cooling.
- 2 In order to keep the dry bulb temperature in the space at the setpoint temperature, the sensible capacity of the unit must be at least equal to the sensible load calculated by TRACE 700. In order to keep the humidity level in the space at or below design conditions, the latent capacity of the unit must be at least equal to the latent load calculated by TRACE 700.
- 3 The supply airflow under the **Cooling Coil Selection** portion of the **Checksums** report is a result of the psychrometric analysis performed by the program. The program knows the space load (sensible and total) to be satisfied at every hour. At the time of coil peak (in this example, month 7, hour 16), the program performs a psychrometric analysis to determine the required airflow and coil leaving temperature to satisfy the space load. For a VAV system, this coil leaving temperature is fixed.

The psychrometric analysis uses a least squares fit estimate for a generic coil curve, as it iterates to determine return air temperature, coil leaving temperature, and supply airflow. The value of 14,863 cfm in the **Airflows** section of the report comes from the space peak sensible load, which in this example occurs at month 7, hour 17:

$$\begin{aligned} \text{supply airflow}_{\text{design}} &= \frac{Q_{\text{space, sensible}}}{DSHP \times \Delta T_{\text{space}}} \\ &= \frac{289,209 \text{ Btu/h}}{1.081 \times (75^{\circ}\text{F} - 57^{\circ}\text{F})} \\ &= 14,863 \text{ cfm} \end{aligned}$$

As is listed at the top of the **Checksums** report, the system is a variable-air-volume system. Thus, the airflow at the time when the load on the coil peaks may be different than the airflow at the

time when the space peaks. This is the main reason for the discrepancy in Coil Airflow versus Supply Airflow. In a nutshell, the supply airflow (14,863) should be used to select the fan and the coil airflow (14,676) should be used in the coil selection.

The problem, however, is in selecting a piece of cooling equipment when the fan and coil have different peak airflows. Selection of the cooling unit prompts the user for only one airflow. Therefore, the fan airflow, the higher of the two, should be used to select an air handler. Conservative selections should also use the coil airflow as a check for coil leaving conditions (dry bulb and humidity) with this smaller airflow. Also be sure to verify that the higher airflow will not cause moisture carryover for the selected cooling coil.

- 4 Trane Official Product Selection Software (TOPSS) can be ordered by contacting C.D.S. at www.tranecds.com, or from the TRACE 700 application, click **Help ► Trane on the Web**.

Note: Because the airflow is constant in a constant volume system, the airflows at the time of coil and space peak will be the same.

Note: For additional information regarding how TRACE 700 calculates airflows and the other numbers reported on the output reports, refer to "Frequently asked questions" on page 6–20, or to the Design Output Interpretation Manual located in the documentation folder which is typically found at C:\CDS\TRACE700\Documentation.

Note: It is recommended against using the calculated cooling-coil leaving wet-bulb temperature because TRACE 700 simulates using a generic cooling-coil model, which might have performance characteristics different from the actual coil selected by the user.

Selecting a chilled-water cooling coil using TRACE 700 output

This section discusses the steps for properly selecting chilled-water cooling coils using the TRACE 700 output reports. It will be assumed that no mistakes have been made in the modeling process and that all results are accurate for the building and systems.

Related reading

- "Cooling-Coil Heat Transfer," *Engineers Newsletter* (volume 31, number 1).

Sample scenario

The design team has decided to use an air handler with a chilled-water coil. The design data from TRACE 700 will need to be input into a selection program to find an appropriate cooling coil.

- 1** After calculating the TRACE 700 file, there are several output reports that can be used to get the data required to select the cooling coil. For the Variable Volume Reheat system used in this example, the **System Checksums** report and the **System Component Selection Summary** report can be used. _____

From these reports, the Total Capacity, Peak Airflow, Entering Dry Bulb, Entering Wet Bulb, Leaving Dry Bulb, and so forth, can be taken, where:

Total Capacity = 91.5 Tons = 1098.5 MBh

Sensible Capacity = 735.9 MBh

Supply Airflow at Space Sensible Peak Load = 26,333 cfm

Supply Airflow at Cooling Coil Peak Load = 24,227 cfm

Entering Cooling Coil Conditions (DB/WB) = 82.8°F / 67.5°F

Leaving Cooling Coil Conditions (DB) = 55°F

Altitude (from Title Page report) = 263 feet

[illegible]

- 2 These results will need to be input into the coil selection program. In this case, the Trane selection software (TOPSS) will be used to select the cooling coil.

Note: When using a selection program, it is often easy to over-specify the unit. TOPSS changes the colors of required inputs to red, optional inputs to blue, and all other inputs to white. Specifying only red fields will ensure that over-specification does not occur.

- 3 Start by inputting the type of coil (chilled water), the coil utilization (for this example, we will assume a standalone or shipping coil, but you may also select a specific air-handler casing, which would then define the coil size), the elevation (263 ft), the airflow through the coil at the time of the coil peak load (24,227 cfm), and the entering air conditions (82.8°F DB / 67.5°F WB).

- 4 Next, the capacity of the coil must be input. Delete the unwanted default Leaving dry temperature of 55°F and press Enter. Removing this value should activate the *Total capacity* field. Input 1098.5 MBh for the Total capacity of the cooling coil.

Note: The TRACE 700 Output Interpretation Manual recommends the following. For a cooling coil, the following data should be used: the capacity of the coil, airflow at time of coil peak, and entering air conditions.

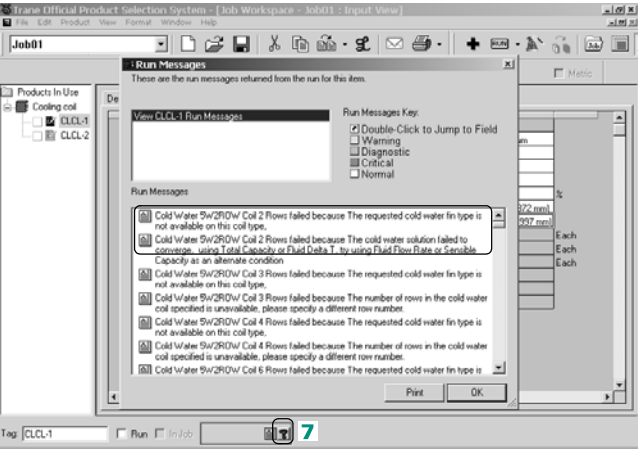
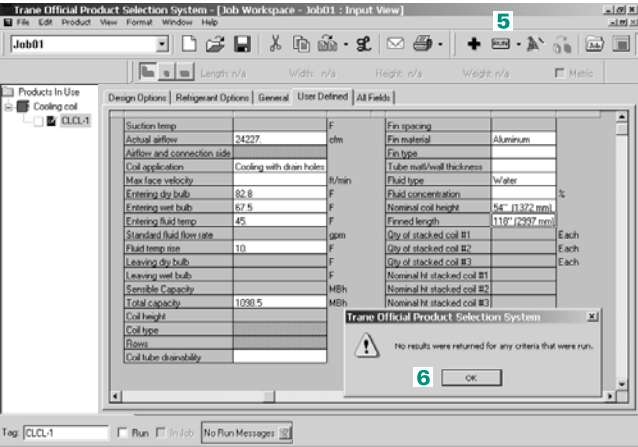
Note: To activate any unavailable field in TOPSS, double-click the field and the program will tell you what data should be removed to allow input into the field.

If a specific air-handler size was selected in Step 3, the size of the coil may already have been determined. However, for this example, where we are selecting a standalone (shipping) coil, the surface area of the coil must be calculated. This is often determined by using a maximum allowable coil-face velocity. Assuming a maximum face velocity of 550 ft/min., the face area of the coil is:

Coil Size = 24,227 cfm / 550 ft/min. = 44.05 ft²

Assuming that, in this example, the maximum nominal coil height is 4.5 ft (to fit into the space for the air handler), the resulting finned length is 9.79 ft (44.05 ft / 4.5 ft, rounded up). Those dimensions equate to a nominal coil height of 54 inches and a finned length of 118 inches.

- 5 Enter the calculated nominal coil height and finned length—this should eliminate the last of the required (red) inputs. Click **Run** at the top of the screen.
- 6 In this case, the selection program tells you that no cooling coils meet the entered criteria.
- 7 To find recommendations on what input criteria are causing problems, and to find out how to make input adjustments so that a valid cooling-coil selection can be obtained, click **Run Messages** (the question mark icon) at the bottom of the screen.



8 In this case, a larger fluid temperature rise (12°F instead of the default 10°F) and a lower entering fluid temperature (43°F instead of the default 45°F) are one of the input criteria sets that can be changed to get valid cooling-coil selections. After the change, click **Run** and view the coil-selection data and run messages for each of the coils. Refer to additional items 1–5 listed below for recommendations on selecting the appropriate coil for the selection results.

Additional items

- 1** General rules of thumb and advice for HVAC cooling coil selections:
 - a** 500 to 600 ft/min for the maximum coil-face velocity to avoid moisture carryover (Some coils can go as high as 750 ft/min. Refer to the recommendations from the manufacturer).
 - b** As the face velocity increases, the capacity of the coil and the pressure drop across the coil increase.
 - c** 3 to 6 ft/sec. for fluid velocity in tubes (Above 8 ft/sec can cause tube erosion. Under 1 ft/sec can cause reduced heat transfer due to laminar fluid flow through tubes).
 - d** As the fluid velocity increases, the capacity of the coil and the pressure drop through the coil increase.
 - e** Fin spacing typically ranges from 80 to 168 fins per ft for comfort cooling.
- 2** In order to keep the dry-bulb temperature in the space at the setpoint temperature, the sensible capacity of the cooling coil must be at least equal to the sensible load calculated by

TRACE 700. In order to keep the humidity level in the space at or below design conditions, the latent capacity of the cooling coil must be at least equal to the latent load calculated by TRACE 700.

- 3 If a coil that meets both the sensible and latent loads cannot be found using the input criteria from the example, try removing the total capacity and inputting only the sensible capacity.
- 4 The airflow under the **Cooling Coil Selection** portion of the **Checksums** report is a result of the psychrometric analysis performed by the program. The program knows the space load (sensible and total) to be satisfied at every hour. At the time of coil peak (in this example, month 7, hour 18), the program performs a psychrometric analysis to determine the required airflow and coil leaving temperature to satisfy the space load. For a VAV system, this coil leaving temperature is fixed.

The psychrometric analysis uses a least-squares fit estimate for the coil curve, as it iterates to determine return-air temperature, coil leaving temperature, and supply airflow. The value of 26,333 cfm in the **Airflows** section of the report comes from the space peak sensible load, which in this example occurs at month 6, hour 18:

$$\begin{aligned}
 \text{supply airflow}_{\text{design}} &= \frac{Q_{\text{space, sensible}}}{DSHP \times \Delta T_{\text{space}}} \\
 &= \frac{544,104 \text{ Btu/h}}{1.0924 \times (75^\circ\text{F} - 56.1^\circ\text{F})} \\
 &= 26,354 \text{ cfm}
 \end{aligned}$$

As is listed at the top of the **Checksums** report, the system is a variable-air-volume system. Therefore, the airflow may be different at the time when the load on the coil peaks than at the time when the space peaks. *This is the primary reason for the discrepancy in Coil Airflow versus Supply Airflow.* In a nutshell, the *supply airflow* (26,333) should be used to select the fan, and the *coil airflow* (24,227) should be used in the coil selection.

The problem, however, is in selecting an air handler when the fan and coil have different peak airflows. Selection of an air handler prompts the user for only one airflow. Therefore, the fan airflow, the higher of the two, should be used to select an air handler. Conservative selections should also use the coil airflow as a

check for coil leaving conditions (dry bulb and humidity) with this smaller airflow. Also be sure to verify that the higher airflow will not cause moisture carryover for the selected cooling coil.

- 5 Trane Official Product Selection Software (TOPSS) can be ordered by contacting C.D.S. at www.tranecds.com, or from the TRACE 700 application, click **Help ► Trane on the Web**.

Note: Because the coil airflow is generally constant in a constant-volume system, the airflow at the time of coil and space peak will be the same. However, this is not true for mixing systems in which the fan is constant volume but the cold deck mixes with a bypass or hot deck to achieve the final supply temperature to the spaces. For example, the cooling coil in a multizone system need only be sized for the maximum block building load (and the associated block coil airflow) while its fan must be sized to handle the peak airflows to all the spaces. At the time of the building block cooling coil peak, the cooling coil on the cold deck sees only this block coil airflow while the remaining supply is bypassed through the hot deck.

*Note: If a different cooling supply-air dry-bulb temperature is required based on the cooling-coil selection, revised supply-air temperatures should be input in TRACE 700 on the **Temperatures** tab of **Create Systems**. The simulation should then be rerun so that the fan and terminal boxes are properly sized.*

Modeling for LEED®

USGBC's Leadership in Energy and Environmental Design (LEED) program updates its products to closely align with the latest industry standards. LEED version 3, the most recent version of LEED (also known as LEED 2009) incorporates the latest standards such as ASHRAE 90.1-2007 and ASHRAE 62.1-2007.

TRACE 700 has been updated to reflect the latest changes in ASHRAE standards and can be used to achieve LEED credits under version 3. Specifically, TRACE 700 can model a building's energy use to determine its efficiency for LEED Energy and Atmosphere credit 1 (EAc1), option 1. How to model the *proposed building* and *baseline building* in order to compare energy efficiency is outlined below.

Refer to "Additional LEED credits" on page 6–90 for a list of credits TRACE 700 may help to achieve.

Note: If LEED version 2.2 is used, the following guidelines still apply. However, version 2.2 references ASHRAE Standard 90.1-2004, not 2007. TRACE is compatible with both versions of the standard. Ultimately, it is the user's responsibility to ensure compliance with the appropriate standard's requirements. Contact C.D.S. support with any compatibility questions not covered in this guide.

Before you begin the TRACE analysis, we recommend that you review the following:

- *LEED Reference Guide for Green Building Design and Construction version 3*, specifically Energy and Atmosphere Prerequisite 2 (EAp2) requirements and Energy and Atmosphere Credit 1 (EAc1) requirements
- *ASHRAE Standard 90.1-2007*, specifically sections 5.4, 6.4, 7.4, 8.4, 9.4, 10.4, and Table G3.1
- *ASHRAE Standard 90.1-2007 User's Manual*



This section provides an overview of the steps required to model the proposed building. For more detailed information on how to perform specific tasks in TRACE, refer to the applicable section in this manual. To learn TRACE basics, refer to the *Getting Started* guide.

Proposed building

Start a LEED model with the proposed design. As a general rule, the building should be modeled per its design specifications.

When complete, the proposed building must:

- Comply with the mandatory requirements of ASHRAE 90.1-2007
- Meet the requirements of LEED EAp2 and EAc1
- Match the design parameters

The following is a recommended workflow for building the proposed building in TRACE. Many methods exist, yet differ depending on company policies and practices. Please treat this as one possible path to follow.

Collect data

To save time, collect and organize the data for the proposed building prior to beginning the analysis. While the following is not an extensive list, information you will need includes:

- Envelope construction information (e.g. wall constructions, roof constructions, window types)
- Occupancy capacities and schedules per space type
- Interior lighting power densities and fixture types per space type
- Exterior lighting power densities
- Receptacle (miscellaneous) load design per space type
- Thermal (HVAC) zoning (determine space types with common thermal properties)
- HVAC system design (e.g. system types and configuration, temperature setpoints/driftpoints, control methods)
- Equipment design (e.g. manufacturer selections, sequencing, efficiency)
- Local utility rate structure
- Energy Conservation Measures (e.g. daylighting, shading devices)
- Exceptional Calculation Method items (e.g. photovoltaics)

Note: Refer to EAc1 from the LEED Reference Guide for more information on the Exceptional Calculation Method.



Copying existing libraries and adjusting their values may save time and provide reasonable defaults for unknown data.

Build TRACE libraries

Open the Library/Template Editor in TRACE 700. Construct any library values needed to accurately model the proposed building. Chapter 6 of this manual contains information on how to create various library values in TRACE (e.g., schedules, unloading curves, utility rates).

Note: Simply changing U-values to match construction documents may not be sufficient to accurately model such components. Because TRACE accounts for the thermal mass of walls, roofs, etc., modeling the make-up of these components is critical to ensure accurate results.

Create templates

The thermal zones determined during the planning stage can serve as the space types used to create templates. For example, one thermal zone may define an office space while another defines conference rooms. Use these space types and the libraries developed in the previous step to create templates. For more information, refer to “Using templates” on page 6–125.

Note: Importing a gbXML file generated by a CAD program will create templates automatically based on the zone assignments defined by the CAD programmer. TRACE users simply have to update template information upon completion of the import process (e.g. construction types, schedules).

Create rooms

The easiest and quickest method to create rooms is to import a gbXML file. Refer to “gbXML import and export” on page 6–181 for detailed information on this feature.

In the absence of a gbXML file, users are required to manually enter spaces. Utilizing templates created in the previous step significantly reduces data entry. While constructing spaces, do not forget wall and glass dimensions, room-to-room air transfers (see “Balancing airflows” on page 6–60), and partitions.

Note: Although not necessarily a strategy used to reduce energy consumption, ASHRAE Standard 62.1-2007 is important to the overall health of the building and its occupants. TRACE 700 provides users the ability to model this ventilation strategy. Refer to “ASHRAE Standard 62.1” on page 4–91 for more information.

Create systems

Construct the HVAC systems found in the proposed building. Chapters 4 and 5 of this manual provide information regarding various system types and control strategies.

The Create Systems section of TRACE defines how supply air is delivered and determines where coils and fans are placed in the air stream. It does not dictate the type of equipment (DX, chilled water, etc.) or how many pieces of equipment are installed.

Note: Energy Conservation Measures (ECMs) found in a proposed building may include supply air temperature reset, economizers, optimum start/stop control strategies, and various forms of energy recovery. Utilizing these strategies singularly or in combination could produce significant energy savings over the life of a building. TRACE 700 has the capabilities to model these and others. Refer to Chapter 5, "System Control Strategies," for more information.

Assign rooms to systems

A critical step in any TRACE model involves appropriately assigning rooms to their associated systems. "Zoning of rooms" on page 6–47 contains detailed information on this important step.

Create plants

Select the cooling and heating plants, using the custom equipment you previously defined in the TRACE libraries, if applicable. Additionally, define any non-HVAC energy loads (e.g., loads that consume energy, but do not need to be conditioned) on the **Base Utility/Misc. Accessory** tab. Consider items such as exterior lighting, elevators, process loads, etc. Model domestic hot water here as well. For more information on how to model domestic hot water, please refer to "Domestic hot water assigned to a boiler" on page 3–62.

After the plant information has been entered, assign the various system coils to their associated plants through **Assign Systems to Plants**.

Note: ECMs are not just found at the system level.

- *Plant controls, as well as the type of plant employed, may provide significant energy savings. Chapter 3, “Cooling and Heating Plants,” details various chiller plant arrangements and control methods. Variable primary flow chillers, thermal storage, cogeneration, and chiller tower optimization are only a few of the examples found in the chapter.*
- *Many types of free cooling are available in the program, such as plate-and-frame, refrigerant migration, and strainer-cycle options.*
- *Aside from chillers, TRACE also models geothermal systems (“Central geothermal chillers” on page 3–76) and ground-source heat pumps (“Ground-source heat-pump system” on page 3–72).*
- *Appendix G also requires all building end-use energy consumption be captured in the model. The “Base Utility / Misc. Accessory tab of Create Plants” on page 6–17 details how to model the energy use from items such as parking lot lights and elevators. Additionally, receptacle loads are modeled on a room-by-room basis as **miscellaneous loads** through the **Internal Loads** tab of **Create Rooms**.*

Apply daylighting (if applicable)

Utilizing this strategy could reduce the lighting load and equipment size required for the space. If this strategy is to be used, please refer to “Daylighting” on page 5–33 for more information.

Define utility rate structures

Once the proposed building model is complete, defining the utility rate converts the building’s energy use into costs. The resulting cost will be compared against the baseline building’s energy cost, ultimately determining the number of points achieved under EAc1. Appendix G allows the user to model either the local utility rate structure or the average energy prices reported by the Department of Energy’s (DOE) Energy Information Administration (EIA) (<http://tonto.eia.doe.gov/state/>). In either case, TRACE provides the ability to model most utility rate structures. Refer to “Creating utility rates” on page 6–150 for more information.

Import weather

ASHRAE 90.1-2007 requires the analysis utilize a full-year weather file. The standard weather files included with TRACE do not meet this requirement and users need to import a full-year weather file in order to comply. Refer to “Adding weather locations and activating the 8760 calculation methodology” on page 6–167 for details on how to conduct a full-year analysis in TRACE. The recommended file formats include TMY, TMY2, TMY3, or IWC. Full-year weather files using these formats can be found at www.DOE2.com under the Weather Utilities section. Additionally, full-year weather files can be purchased through ASHRAE. There are many sources for weather; however, in order for TRACE to use the file, it must be in one of the following formats: CEC, CTZ, CWC, IWC, TMY, TM2, TM3, TRY, WTR, or WY2.

Calculate and calibrate

Prior to modeling the baseline building, the proposed building should be calculated and reviewed for accuracy. Due to the vast number of inputs, reviewing output data to ensure the proposed building is modeled accurately is critical. Output data should be compared against mechanical schedules (if available) or other design documents detailing expected operation. Following are guidelines for troubleshooting potential mismatches between output reports and design documents. This list is not all-encompassing and is offered only as a basic outline.

Design values mismatch

- Verify envelope loads match design criteria
- Verify internal loads match design criteria (e.g. densities, schedules)
- Verify thermostat setpoints/schedules
- Verify supply air temperatures accuracy
- Verify airflow values

Energy values mismatch

- Verify design loads match
- Verify equipment efficiencies
- Verify proper setup and sequencing
- Verify unloading curves

- Verify schedules
- Verify fan/coil schedules

Economic mismatch

- Verify design loads
- Verify energy values
- Verify defined utility rate
- Verify any other economic parameters defined

Baseline building

Once the proposed building has been modeled correctly, create a second alternative based on the first. This second alternative will be changed to represent the baseline building. For information on creating an alternative, refer to “Creating alternatives” on page 6–131.

Prior to entering data for this alternative, refer to Table G3.1 from Appendix G of ASHRAE Standard 90.1-2007 to determine what changes need to be made. Table G3.1 provides a guide for how the second alternative will be adjusted to create the baseline building. Remember, the mandatory requirements from ASHRAE 90.1-2007 apply to the baseline model as well. Additionally, refer to the *LEED Reference Guide* to better understand additional baseline requirements not defined by ASHRAE 90.1 (e.g. process loads).

Note: Generally, details not specifically addressed by ASHRAE 90.1-2007 will be identical between the proposed and baseline alternatives. Using the proposed building as the first alternative helps ensure that such details remain identical between the two alternatives.

Collect data

As with the proposed building, we recommend collecting the appropriate data prior to entering information in TRACE. A crucial piece of information needed is the climate zone, which can be determined using Appendix B from ASHRAE 90.1-2007. This information is needed to determine envelope parameters and some system control schemes.



Many of the baseline building's values can be changed through **Create Templates**. This will significantly decrease the time it takes to build the baseline alternative and make future adjustments much easier.

Adjust envelope parameters

As with the proposed building, simply changing the U-values for the various envelope components may not be sufficient. Appendix G (Tables 5.5-1 through 5.5-8) directs the use of lightweight materials in the construction of the baseline. Users may select one of the **ASHRAE 90.1-2007 Compliant Envelope Library** values to describe the baseline building envelope (nonresidential only). These library values were created using construction information found in ASHRAE 90.1-2007 and comply with the Appendix G requirement. Additionally, they correspond to the envelope parameters defined by Tables 5.5-1 through 5.5-8. Changing these envelope parameters through the templates will significantly reduce input time.

*Note: TRACE **default** glass U-values were created using center-of-glass values. If assembly U-values are desired, users may override the existing glass U-value with an assembly value or they may import a Window 5 assembly glass type. For additional information on importing Window 5 data, please consult the TRACE 700 help files by searching "Import – Glass."*

Note: TRACE only allows Shading Coefficient values to be entered. SHGC values can be converted to SC by dividing the SHGC value by 0.86.

ASHRAE 90.1-2007 requires the baseline building fenestration to not exceed 40 percent (refer to ASHRAE 90.1-2007, Appendix G, Table G3.1 for the requirement definition). If the proposed building has greater than 40 percent fenestration, the baseline building fenestration will have to be adjusted to 40 percent. For a detailed explanation of how to apply this requirement, consult the *ASHRAE 90.1-2007 User's Manual*. If an adjustment needs to be made in the baseline alternative, consider making the adjustment through the Component Tree view (refer to "Component Tree view" on page 2–8 for additional information).

Define lighting power densities

The same method for defining the lighting power densities in the proposed (Building Area Method or Space-by-Space Method) must be used in the baseline. Refer to Section 9 of ASHRAE 90.1-2007 for the mandatory requirements plus a description of the two types of methods. Simply adjust the baseline

alternative's lighting power densities per those found in ASHRAE 90.1-2007. Adjusting these values through Create Templates is the preferred method.

*Note: Exterior lighting is modeled through **Create Plants** on the **Base Utilities/Misc. Accessories** tab. Refer to ASHRAE 90.1-2007, section 9, for allowable exterior lighting power densities and the ASHRAE 90.1-2007 User's Manual for information on how to apply these values.*

Adjust airflow requirements

EAc1 requires the baseline building's performance to be calculated according to Appendix G.3.1.2.5 of ASHRAE Standard 90.1-2007, which reads: "Ventilation. Minimum outdoor air ventilation rates shall be the same for the proposed and baseline building designs." An interpretation of this statement was issued in June 2008 to alleviate some industry confusion. In short, the interpretation states, "As currently written, Appendix G is neutral with regard to ventilation energy so no credit is allowed for improved ventilation system design that would be allowed under ASHRAE 62.1." Therefore, the TRACE user must ensure the design system ventilation matches between the proposed and baseline buildings.

Note: The following procedure applies to projects that are following ASHRAE Standard 90.1-2007 (without addenda) and have defined the ventilation in the Proposed alternative based on Standard 62.1-2007. Addendum DA to Standard 90.1-2007 had its first public review in February 2010 and has an exception that states that if the Proposed alternative is designed based on the Ventilation Rate Procedure in Standard 62.1, then the Baseline alternative shall also be calculated using the Ventilation Rate Procedure with the following change: "Baseline zone air distribution effectiveness shall be changed to $(E_z)=1.0$ per each Proposed zone having a zone air distribution effectiveness $(E_z)>1.0$." Addendum DA will be voted on in an upcoming ASHRAE meeting and might be included in 90.1-2010. If this happens, then the following procedure will not apply to any project that will follow ASHRAE Standard 90.1-2010.

- 1 Model the ventilation in the proposed alternative following the steps shown in the “ASHRAE Standard 62.1” procedure on page 93.
- 2 Run the design calculations of the proposed alternative to obtain the total building outdoor airflow, which can be found in the **Airflows** section of the **System Checksums** report.
- 3 Divide that number by the square footage of the building, which is listed in the **Areas** section of the **System Checksums** report. This will provide a cfm/sq ft value to be applied as the cooling and heating ventilation rate for all rooms in the Baseline alternative, preferably using templates.
- 4 Finally, for the Baseline alternative, set the Standard 62.1-2004/2007 inputs in **Create Templates** and **Create Rooms** to **No** to prevent the program from running the Standard 62.1-2007 zone calculations again.

The screenshot shows the 'Create Rooms - Airflows' dialog box. The 'Ventilation' section is active, and the 'Apply ASHRAE Std62.1-2004/2007' checkbox is unchecked, labeled with a green '4'. Below it, the 'Cooling' and 'Heating' rates are both set to '0.1297 cfm/sq ft', with a green '5' next to the 'Cooling' value. The 'Infiltration' section shows 'Type' as 'None' and 'Rate' as '0 air changes/hr'. The 'Room exhaust' section shows 'Rate' as '0 air changes/hr' and 'Schedule' as 'Available (100%)'. The 'VAV minimum' section shows 'Rate' as '0.4 cfm/sq ft' and 'Schedule' as 'Available (100%)'. The 'Main supply' and 'Auxiliary supply' sections show 'Cooling' and 'Heating' rates as 'To be calculated'.

- 5 Set the cooling and heating ventilation inputs to the cfm/sq ft rate from Step 3.
- 6 Go to **Create Systems**, click **Advanced**, and set the **System ventilation flag** to **Sum Room OA Reqs** in the Baseline alternative to prevent the program from running multi-zone calculations of Standard 62.1-2007.

Create Systems - Advanced

System description: Baseline System 5 OK Cancel

System type: Variable Volume Reheat (30% Min Flow Default)

Supply fan motor location: Supply

Return fan motor location: Return

Fan configuration: Draw Thru

Fan sizing method: Block

Supply air path / duct location: Other

Return air path: Ducted

Block cooling airflow: cfm

Cooling coil sizing method: Block

Cooling coil location: System

Ventilation deck location: Return/Outdoor Deck

System ventilation flag: Sun Room OA Req. 6

Apply ASHRAE Std 62.1-2004/2007 People Averaging: ☒ Yes ☐ No

ASHRAE 55/62 Max Vent (2) Ratio Allowed: 25 %

Population Diversity (non-DV Rooms only): 100 %

CO2-based DCV: ☒ None ☐ Proportional Control ☐ Single Setpoint

Warning: The fields marked in red are core components of this system. Changing these values can drastically affect how the system operates. Please make sure you are aware of the total ramifications before you make such a change.

Note: Since the demand control ventilation functionality in TRACE 700 requires the use of the ASHRAE 62.1 feature, users will need to model demand control ventilation using a different method if both the proposed and baseline alternatives require this control strategy. In that scenario, users should model this feature through custom ventilation schedules. Simply create a ventilation schedule matching the occupancy schedule with the only difference being the Heating Design schedule. Typically, the Heating Design portion of the Utilization schedule will read 0% for occupancy schedules. When creating a ventilation schedule, it is recommended the Heating Design portion of the schedule read: Midnight to Midnight 100%.

Select system type

Appendix G, Table G3.1.1A dictates the system type utilized and how to select the appropriate type for the baseline building.

Table 6–2 ASHRAE 90.1-2007 systems and the TRACE equivalent

ASHRAE 90.1-2007 Appendix G Baseline System	Equivalent TRACE 700 System
System 1 – PTAC	Packaged Terminal Air Conditioner
System 2 – PTHP	Incremental Heat Pump
System 3 – PSZ-AC	Single Zone
System 4 – PSZ-HP	Single Zone
System 5 – Packaged VAV with Reheat	Variable Volume Reheat (30% Min Flow Default)
System 6 – Packaged VAV with PFP Boxes	Parallel Fan Powered VAV
System 7 – VAV with Reheat	Variable Volume Reheat (30% Min Flow Default)
System 8 – VAV with PFP Boxes	Parallel Fan Powered VAV

Note: Applying the Appendix G baseline system requirements may be confusing. Refer to section G3.1.1 and Table G3.1.1A (to include notes) in ASHRAE 90.1-2007 plus the ASHRAE 90.1-2007 User's Manual prior to selecting the appropriate system for selection criteria, exceptions, and number of baseline systems required. The number of rooms and zones assigned to a system in TRACE is critical to properly modeling the proposed and baseline alternatives. Fully understanding this is essential.

System requirements

Appendix G and the mandatory requirements found in Section 6 of ASHRAE 90.1-2007 set rules for determining whether various ECMs will be employed in the baseline building. Do not assume your baseline building does not include these items. Common control strategies are listed in the following table, along with references.

Note: This is not a complete list. ASHRAE 90.1-2007 is the primary source for determining if these or other control strategies are required in the baseline model.

Strategy	TRACE User's Manual page, or location in TRACE 700	ASHRAE Standard 90.1-2007 reference
Energy recovery	page 4–15	G3.1.2.10
Demand control ventilation	page 4–91	6.4.3.9
Airside economizer	page 5–2	G3.1.2.6
Optimum start	page 5–6	6.4.3.3.3
Supply air temperature reset	page 5–50	G3.1.3.12
VAV minimum airflow requirement	Create Templates or Create Rooms, Airflows tab	G3.1.3.13
Design airflow rates	Create Systems, Temp/Humidity tab	G3.1.2.8
Fan cycling schedule	Create Systems, Fans tab	6.4.3.3.1

*Note: Some ASHRAE 90.1-2007 directed control strategies use airflow as a criteria in determining their use. If this is the case, calculate the **Design** portion of the baseline alternative to determine system level airflows (e.g. **System Checksums** report). Changes mentioned previously (e.g. envelope) should be made prior to calculation to ensure an accurate value is determined.*

System fan sizing

System fan energy for the baseline building is determined using a formula found in Appendix G. TRACE can automatically perform this calculation (for both ASHRAE Standard 90.1-2004 and 2007). This feature will determine the fan(s) location and accomplish the calculation at the appropriate level.

To calculate system fan energy, follow the procedure below.

- 1 Check **Apply ECB/PRM rules to fan sizing**.
- 2 Select the appropriate standard to be used for the calculation.

*Note: When using the ASHRAE Standard 90.1- 2007 calculation method, define pressure drop adjustments on the **Fans** tab of **Create Systems**. If credit is taken for more than one pressure drop adjustment, total the number of pressure drop adjustments and enter that value.*

- 3 To identify the baseline alternative, access the **Calculate and View Results** screen. Select the baseline alternative using the drop-down menu for the **Performance** rating method.

The image displays three screenshots from the TRACE 700 software interface, illustrating the steps for calculating system fan energy.

Change Energy Parameters: This window shows simulation settings. The 'Simulation hours' are set to 'Reduced year', 'Calendar code' is 'Standard (1976)', 'First month' is 'January', and 'Last month' is 'December'. The 'Resource Utilization Factors' table lists Electricity (33.33), Gas (95), Oil (95), Steam (75), and Hot water (75).

Create Systems - Fan Overrides: This window shows 'Alternative 2' selected. The 'System description' is 'Baseline System 5' and the 'Fan cycling schedule' is 'Cycle with occupancy'. A table lists fan types and their parameters:

	Type	Static Pressure	Full Load Energy Rate	Full Load Energy Rate Unit	Schedule
Primary	90.1 04 Min VAV FC Centrifugal	3	0.000351	Wt/Cfm in vsg	Available (100%)
Secondary	None	0	0	Wt/Cfm	Available (100%)
Chiller	None	0	0	Wt/Cfm	Available (100%)
System exhaust	90.1 04 Min VAV FC Centrifugal	1	0.000351	Wt/Cfm in vsg	Available (100%)
Room exhaust	None	0	0	Wt/Cfm	Available (100%)
Control ventilation	None	0	0	Wt/Cfm	Available (100%)
Auxiliary	None	0	0	Wt/Cfm	Available (100%)

The '90.1 Fan Power Adjustment' is set to '1.4 in. vsg'.

Calculate and View Results: This window shows the 'Design' tab selected. The 'Base Alternative For' is 'Alternative 2'. The 'Economic comparison' is 'To be calculated', 'Energy cost budget' is 'None', and 'Performance rating method' is 'None'.

Once the baseline system fan energy has been calculated, TRACE will apply this energy to the primary fan (if it is the only qualifying fan listed on the system). In the case when more than one fan has been entered for the system (e.g. exhaust fan), a portion of the system fan energy will be applied to each qualifying fan. The amount each fan receives is based on the **Full Load Energy Rate** defined by the user for each baseline fan. The fan power ratio for the baseline must be the same as the proposed.

Note: ASHRAE 90.1-2007 considers most, but not all fans, in the baseline system fan energy calculation. Consult Appendix G to determine which fans are considered in the calculation.

Note: Fan placement in TRACE depends on the system type selected.

- *Packaged Terminal Air Conditioners and Incremental Heat Pump systems have fans at the **room** level.*
- *The Single Zone system has a fan at the **zone** level.*
- *All VAV systems used to model Appendix G baseline systems have fans at the **system** level.*

This distinction is important when analyzing the automatic fan sizing feature in TRACE. The system fan power is determined at the level of the primary fan. Therefore, the primary fan for an Incremental Heat Pump system is at the room level, which means that the equivalent Appendix G system fan power value will be calculated on a room-by-room basis for this system. Refer to “Zoning of rooms” on page 6–47 for more information.

Equipment designation

As with the system type, the type of equipment used in the baseline building is designated by Appendix G, Table G3.1.1B. Details regarding the particular equipment types can be found in Section 6 of ASHRAE Standard 90.1-2007. C.D.S. offers **90.1-2004** and **90.1-2007 Minimally Compliant Equipment Libraries**, which include the equipment found in these tables.

Before selecting equipment, the baseline equipment capacities need to be determined (equipment types are categorized by size in ASHRAE 90.1-2007, Section 6). Appendix G requires both the cooling and heating capacities in the baseline building be oversized. (See “Oversizing plants” on page 6–95.) Once baseline capacities are determined, select the appropriate equipment from the tables in Section 6 of ASHRAE 90.1-2007.

Oversizing plants

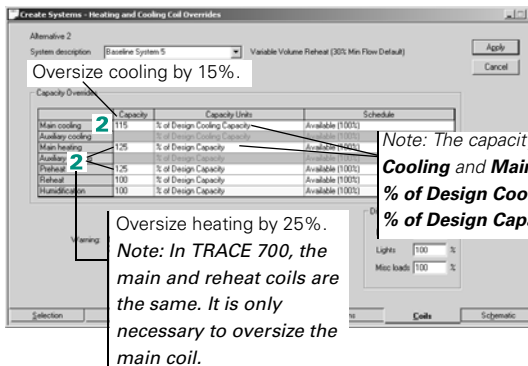
One of the often overlooked Appendix G requirements for the baseline building is the requirement to oversize cooling plants by 15 percent and the heating plants by 25 percent. TRACE offers two methods for modeling oversizing. Choose only *one* of these methods.

- Method 1: Oversize the coils (Recommended)
- Method 2: Oversize the plants

Method 1: Oversize the coils.

- 1 In **Create Systems**, select the **Coils** tab.
- 2 Oversize the cooling and heating coils as shown.

Oversizing the coils will automatically carry over to the equipment section and size the plants appropriately. Additionally, this method increases the design sizing of the equipment. Users will see this reflected in the design reports (e.g., **System Checksums**).



Method 2: Oversize the plants

Note: Unlike Method 1, this method does not affect the design sizing, but instead adds capacity.

- 1 Check the **Link airside coil capacities to equipment capacities** box.
- 2 On the **Create Plants - Cooling Equipment** tab, select **% Plant Capacity** and enter 115 for oversizing.
- 3 On the **Create Plants - Heating Equipment** tab, select **% Plant Capacity** and enter 125 for oversizing.

Change Energy Parameters

Simulation hours: Full year
 Calendar code: 8760 Standard
 First month: January
 Last month: December

Resource Utilization Factors:

Electricity	33.33
Gas	95
Oil	95
Steam	75
Hot water	75
Chilled water	130

☒ Link airside coil capacities to equipment capacities?
☒ Apply ECB/PRM rules to fan sizing?

Pre: ASHRAE Standard 90.1

Create Plants

Alternative 2

Cooling plant: Baseline VAV Rooftop
 Equipment tag: Air-cooled unitary - 001
 Equipment category: Air-cooled unitary
 Equipment type: 90.1-04 Min/AC SS/SP Dth-VAV > 760 h
 Sequencing type: Single

Heat rejection: 90.1 Min/Air Cooled Condenser
 Hourly ambient wet bulb offset: °F
 Thermal storage: None
 Capacity: 0 tons
 Schedule: Storage

Operating mode	Capacity	Energy rate
Cooling	115	0.974
Heat recovery	None	None
Link charging	None	None
Link charging & heat recovery	None	None

Pumps: None
 Primary chilled water: None
 Condenser water: None

Full load consumption: 0 ft water

Create Plants

Alternative 2

Heating plant: Baseline Fossil Fuel Boiler
 Equipment tag: Boiler - 001
 Equipment category: Boiler
 Equipment type: 90.1-04 Min Gas Fired Hot Water <300 Mbbh

Capacity: 125
 Energy rate: 75

Hot water pump: Heating water circ pump
 Type: Heating water circ pump
 Full load consumption: 50 ft water

Equip. Demand priority: None

Therm: None

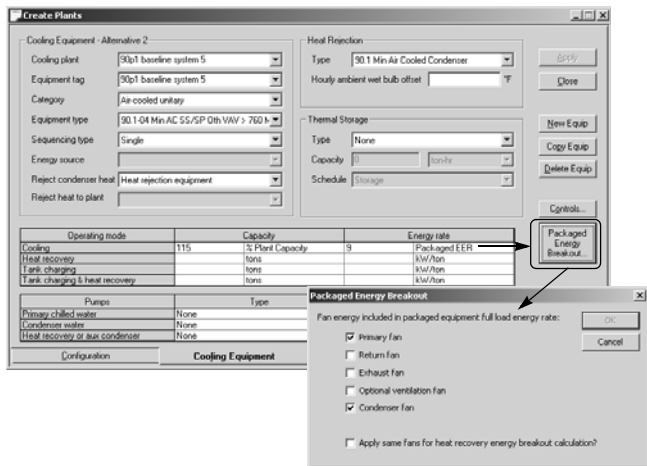
Base Utility / Misc. Accessory

Note: If multiple pieces of equipment are included in one plant, the total of the equipment capacities should not exceed the oversizing amount. For example, a chiller plant consisting of two same-sized chillers would set each chiller to 57.5% for a total plant capacity of 115%.

Compressor-only energy rate

In TRACE, the **Energy rate** entry under the **Cooling Equipment** tab of **Create Plants** describes the compressor-only energy rate for the piece of equipment. This is important because the efficiency reported for packaged systems (e.g., rooftops, water source heat pumps, packaged terminal air conditioners, etc.) often includes fan, condenser, and compressor efficiencies.

Users may enter the EER or COP value found in the ASHRAE 90.1-2007 equipment tables and define which components are included in the energy value. TRACE will use this information along with the associated component energy values to break out the compressor values for the equipment calculation.



Users may also manually break out the efficiency into the individual packaged components. If the manual method is used, the individual component energy rates need to be defined in the appropriate place.

- 1 Fan energy rates are accounted for in **Create Systems** under the **Fans** tab.
- 2 Condenser energy rate is entered with the associated piece of heat rejection equipment in the **Heat Rejection** library.
- 3 Compressor energy rate is entered on the **Cooling Equipment** tab of **Create Plants**.

Example

Utilizing ASHRAE Standard 90.1-2007, System 5 supply cfm equals 45,000 and the Appendix G designated packaged equipment efficiency is 9.5 EER (Table 6.8.1A). Additionally, the building requires 150 tons of cooling. Users may run the design portion of the calculation for the baseline building and then use the **System Checksum Report(s)** to determine building cooling capacity and cfm. Using this information and Appendix G, users may now break out the compressor energy rate from the given 9.5 EER.

Steps 1 and 2 illustrate the manual system fan power calculation per section G3.1.2.9 of ASHRAE Standard 90.1-2007. As discussed previously, TRACE can accomplish this calculation automatically. Users may obtain the system fan power value from

the **Equipment Energy Consumption Report** if they wish to take advantage of this feature. If this is done, skip to step 3.

- 1 Determine the system fan brake horsepower using Table G3.1.2.9. In this case, System 5 is a variable-volume system with 45,000 cfm total supply air.

According to Table G3.1.2.9:

Baseline Fan Motor Brake Horsepower =

$$CFM_S \times 0.0013 + A$$

Where A is calculated per section 6.5.3.1.1:

$$A = \text{sum of } (PD \times CFM_D / 4131)$$

Where PD equals each applicable pressure drop adjustment from Table 6.5.3.1.1B

Assume "Fully ducted return and/or exhaust air systems"; therefore, per the Table:

$$PD = 0.5 \text{ in. w.c.}$$

Thus,

$$A = 0.5 \times 45,000 / 4131 = 5.45$$

Applying this to the Baseline Fan Motor Brake Horsepower formula:

$$45,000 \times 0.0013 + 5.45 = 63.95 \text{ bhp}$$

- 2 Next, calculate the system fan power using the formula found in section G3.1.2.9 and the system brake horsepower from step 1.
System Fan Power equation for systems 3 through 8:

$$P_{fan} = bhp \times 746 / \text{Fan Motor Efficiency}$$

Where the Fan Motor Efficiency is from Table 10.8
(Select the next motor size greater than the bhp from step 1 per enclosed motor at 1800 rpm)

$$(63.95 \times 746) / 0.941 = 50,698 \text{ W} \approx 50.7 \text{ kW}$$

- 3 Convert 9.5 EER into kW/ton and multiply by the building load (in tons) to determine machine power in kW. Remember, the baseline building cooling equipment needs to be oversized 15%. If this was *not* accounted for when determining system tonnage by adjusting the coil size in the **Coils** tab of **Create Systems**, then add 15% to the building load:

$$EER = 12 / \text{kW/ton}$$

$$12 / 9.5 = 1.263 \text{ kW/ton}$$

$$1.263 \text{ kW/ton} \times 150 \text{ tons} \times 115\% = 217.9 \text{ kW}$$

- 4 Subtract the calculated system fan power from the total packaged efficiency:

$$217.9 \text{ kW} - 50.7 \text{ kW} = 167.9 \text{ kW}$$

- 5 Determine condenser energy. For this example, the condenser is air-cooled. According to Table 6.8.1G, air-cooled condenser performance requirements must meet or exceed 176,000 Btu/h x hp. Therefore:

$$= \left(\left[\frac{176,000 \text{ Btu}}{\text{h} \times \text{hp}} \right] \left[\frac{1 \text{ hp}}{0.746 \text{ kW}} \right] \left[\frac{1 \text{ ton} \times \text{h}}{12,000 \text{ Btu}} \right] \right)^{-1}$$

$$= 0.050871 \text{ kW/ton}$$

$$0.050871 / 0.941 \text{ motor efficiency} = 0.054 \text{ kW/ton}$$

- 6 The tons portion of the condenser energy (the denominator) is heat rejection and not cooling load. The following approximation can be used to determine the heat rejection load:

$$Q_{\text{cond}} = (1 + 1/\text{COP}) \times Q_{\text{evap}}$$

$$Q_{\text{cond}} = [1 + 1/(0.293 \times 9.5 \text{ EER})] \times 172.5 = 234.6 \text{ tons}$$

- 7 Multiply the condenser fan power by the heat rejection load to obtain the condenser fan power in kW:

$$0.054 \text{ kW/ton} \times 234.6 \text{ tons} = 12.7 \text{ kW}$$

- 8 Subtract the condenser energy rate from the energy rate calculated in step 4.

$$167.9 \text{ kW} - 12.7 \text{ kW} = 155.2 \text{ kW}$$

- 9 Override the default value found in the **Energy rate** section on the **Cooling Equipment** tab with the value from step 7. The default value was determined using the efficiency rating

associated with the particular piece of equipment per Tables 6.8.1 from the 2004 standard. As long as the previous steps were followed utilizing values from the 2007 standard, the value from step 7 will make the selected equipment compliant with the 2007 standard.

Additional equipment considerations

As with the baseline building systems, Appendix G dictates additional equipment requirements based on the system type. Following is a list of additional equipment requirements that may need to be included. Many of the equipment types found in the **90.1-2004** and **90.1-2007 Minimally Compliant Equipment Libraries** contain their applicable requirements.

Note: This is not a complete list. ASHRAE 90.1-2007 is the primary source for determining if these or any other equipment requirements exist.

- Type and number of boilers
- Type and number of chillers
- Heat pump requirements
- Hot water reset
- Chilled water reset
- Pump requirements

Utility rate structures

Use the same rate used in the proposed alternative.

Calculating the file

Appendix G requires the baseline building be rotated in four directions, with the report of the results to include the average of the four rotations. TRACE includes an automatic rotation feature that satisfies this requirement. Users may access this feature through **Calculate and View Results** by selecting the **Rotate and Average PRM Results** checkbox. As with the fan sizing feature, TRACE applies the automatic rotation to the alternative designated in the drop-down menu for the **Performance Rating Method**.

Note: Calculation time will increase significantly when this option is chosen because the simulation must run for each direction.

	Alternative 1	Alternative 2
Design	Results Exist 09/02/10 03:26 PM	Results Exist 09/02/10 03:26 PM
System	Results Exist 09/02/10 03:26 PM	Results Exist 09/02/10 03:26 PM
Energy	Results Exist 09/02/10 03:26 PM	Results Exist 09/02/10 03:26 PM
Economics	Results Exist 09/02/10 03:26 PM	Results Exist 09/02/10 03:26 PM

Alternative 2: Design Calculation
Results exist for this calculation. It was last calculated 09/02/10 03:26 PM.
Template data has been modified.
Room data has been modified.
System data has been modified.

☐ Perform special building block calculations during Design (execution time will increase)

Base Alternative For: To be calculated

Economic comparison: To be calculated

Energy cost budget: None

Performance rating method: Alternative 2

☒ Rotate and average PRM results

For Help, press F1

Completing the analysis

After calculating the baseline alternative, the proposed and baseline results should be compared. The **LEED Energy Performance Summary Report** provides results in a format similar to the EAp2 and EAc1 templates (for both version 2.2 and version 3). If the baseline energy cost is less than the proposed, further analysis is required. Consider these three basic steps when determining potential causes:

- Identify areas where the baseline consumes more energy (e.g. space heating, space cooling, fans)
- Verify inputs for these areas (e.g. crosscheck ASHRAE 90.1-2007 requirements)
- Verify proposed design inputs (e.g. schedules, envelope)

If the baseline alternative energy cost is greater, verify the unmet hours for both alternatives comply with the ASHRAE 90.1-2007 requirement. If the unmet hours do not comply with the requirement, review the following for methods of reducing or eliminating them.

Unmet hours

Unmet load hours are triggered in TRACE when space conditions are outside the thermostat setpoints. Unmet hours occur for a wide variety of reasons. They are restricted to hours when the excess load on a coil is at least 1 percent greater than the design coil capacity, and at least one room attached to that coil is in excess of 1.5°F of the thermostat setpoint for that hour.

Strategies that may help reduce or limit the number of unmet load hours are presented below. The different approaches target commonly overlooked assumptions in the TRACE data entry process, as well as the complex interactions that typically occur in building simulations. Each building model is unique, and as such, the impact of each approach may be different. In some cases, the number of unmet load hours may even increase. **It is important to understand the underlying cause of the loss of space control rather than arbitrarily adjusting data entries to reduce or eliminate the unmet hours.**

Note: These strategies may increase the building model's total energy consumption for various reasons.

Step #1 – Identify unmet hours

The **Energy Cost Budget / PRM Summary** report provides the total, simultaneous number of cooling and heating unmet hours per alternative. Although this provides a good overview regarding problematic alternatives, refer to the **Building Temperature Profile** report for a detailed accounting of unmet hours. This report lists rooms (by system) showing the number of cooling and heating unmet hours associated with each. A section of the report displays the time-of-day, daytype, and month the unmet hours occur. This information can help identify potential causes for the unmet hours. For example, if a space consistently has unmet load hours on Mondays around the time occupancy begins, an optimum start schedule may help eliminate those hours due to pull-up/pull-down loads.

*Note: The unmet load hours that are displayed in the **Building Temperature Profile** report are not additive because any one space can trigger an unmet load hour, but if multiple spaces have unmet conditions for the same hour, then only a single hour is tallied. This means that there are a total of 8760 unmet load hours possible for either heating or cooling.*

Step #2 – Review inputs

Once the problem areas have been identified, focus on the data entry process. The **Scan for Errors** feature (found through **Calculate and View Results**) reports many of the items discussed below. Utilizing this feature (particularly prior to calculating) will help identify potential errors. Keep in mind many

of the results are simply warnings and do not necessarily require action ... only your attention to ensure the model was set up as intended.

- Verify that design and simulation schedule assumptions are accurate.

Perhaps the single largest area of uncertainty in a building simulation model occurs in the scheduling of internal loads. TRACE allows you to differentiate design and simulation internal load schedules for proper coil sizing. If the design schedules are too moderate, coils could be undersized. Alternatively, if the simulation schedules are overly conservative, this could also lead to undersized coils due to dynamic building changes that are not accounted for during design calculations.

- Verify correct thermal zoning and thermostat placement.

Proper thermal zoning of spaces, as well as properly modeling thermostat locations, is vital to proper building simulation. Ensure spaces are properly zoned per design documents and are modeled correctly in the **Assign Rooms to Systems** section.

- Verify accuracy of drift point entries or thermostat schedules.

When a space is unoccupied (less than 5 percent occupancy) and there is no thermostat schedule applied, drift temperatures are used as the thermostat setpoints. If there is a wide variance between the occupied setpoint and the drift point, the HVAC equipment may not be able to handle the pull-up or pull-down load in the one-hour time increment as the building becomes occupied. Verify the temperatures entered are an accurate representation of the actual building thermostat controls. The same suggestion applies when utilizing thermostat schedules. However, realize thermostat schedules are not affected by occupancy like drift points. Instead, they follow the user-defined schedule.

- Limit restrictions to fan operation.

TRACE has fan control options allowing the program to intelligently cycle the fan to meet changing load conditions. Avoid scheduling fans manually because the simulation may not match up with the expected fan operation schedule. Leaving the fan schedules set to **Available (100%)** and applying a fan cycling

schedule provides the most accurate method for controlling the fan operation. Scheduling a fan as something other than **Available (100%)** can quickly lead to a high number of unmet load hours.

- Verify that diversity has been accurately defined.

One way to reduce design coil capacity for VAV systems is to apply a diversity factor for internal loads. This factor allows you to credit VAV system capacity for shifting loads in a building (e.g., each space has to be designed to handle its worst case loads, but at any given point in time there are less than design internal loads in the building). If the diversity factors are overly optimistic and do not mesh with the occupancy schedules for simulation, coils could be undersized. This approach does not apply to constant volume systems. To access the diversity input, go to the **Coils** tab of **Create Systems**.

- Apply an optimum start schedule.

TRACE design coil capacities are determined at steady state conditions assuming the space is always controlled to the desired design space setpoint. In some instances, pull-up or pull-down loads associated with dynamic building operation can exceed the capacity of a coil. These dynamic conditions are not accounted for in the design process. A common example of when this might occur is when a building has night setback thermostat controls that allow the building to drift during unoccupied hours. When the building becomes occupied, the design coil capacity may not be large enough to condition the space(s) to the desired setpoint in a single hour, thus triggering unmet load hours. Applying this control strategy allows the building automation system to condition the spaces in advance in order to reach the desired setpoint when the building becomes occupied. ASHRAE Standard 90.1-2004 and 2007 require optimum start controls to be modeled for systems larger than 10,000 cfm.

It is recommended that users select the **Available (100%)** schedule for the optimum start schedule. Doing so will allow the program to activate the system as early as is necessary to maintain space control (if possible) under pull-up or pull-down situations.

*Note: Only an optimum start schedule is needed to combat unmet hours, **not an optimum stop schedule.***

Step #3 – Additional considerations

If the preceding strategies did not resolve your unmet load hours issue, investigate the following items.

- Verify envelope parameters (walls, floors, roofs, etc.) are correctly defined.

TRACE considers the thermal mass effects of the building's envelope. Typically, loads in a high mass building will peak later (and at a lower value) than loads in a low mass building. Incorrectly defining envelope parameters will have an impact on the program's ability to accurately calculate the thermal mass effects of the building. If you choose to create custom elements (e.g. walls, roofs, floors), be sure to correctly define the library value. Remember, construction types should always begin with outside/inside surface resistance and end with the opposite outside/inside surface resistance.

- Verify correct application of ASHRAE Standard 62.1 in TRACE.

When modeling ASHRAE Standard 62.1 in TRACE, ensure the feature is activated on both the **Create Rooms - Airflows** tab and **Create Systems - Selection** tab (**Advanced** button). Doing so ensures an accurate ventilation load calculation. See "ASHRAE Standard 62.1" on page 4–91 for more information.

- Utilize an appropriate ventilation schedule.

Users often wish to schedule ventilation to follow the occupancy schedule. The concept is sound, but incorrectly modeling this causes problems. The standard occupancy schedules in TRACE do not work well for ventilation. Since ASHRAE recommends not taking credit for internal heat gains, standard occupancy schedules in TRACE set the heating design schedule values to 0 percent. When used as a ventilation schedule, the 0 percent value for heating design exempts ventilation from the heating design calculation. Instead, a more conservative approach would be to utilize a standard TRACE ventilation schedule. If you view the standard ventilation schedule with its corresponding standard occupancy schedule, you will see the only difference is the heating design value is set to 100 percent for ventilation.

Similarly, using a ventilation schedule of **Available (100%)** may not always be appropriate. Depending on code requirements, introducing ventilation only during occupied periods can provide substantial energy savings. Utilizing the **Available (100%)** schedule brings ventilation air into the space 24/7 unless ASHRAE Standard 62.1 with ventilation reset control is enabled.

- Check VAV airflow.

Typically this occurs with VAV systems and manifests as unmet heating hours. Since heating airflow is limited by the minimum stop of a VAV box, sufficient airflow may not reach the space to satisfy the load. You can detect this by reviewing the **Room Checksums** report. If the heating supply temperature appears unusually high, consider increasing the VAV minimum for the space. Likewise, if the space does not receive the required ventilation during heating due to the minimum stop, select *Actions > Change Load Parameters* from the menu bar. On the **Change Load Parameters** screen, check the **Force VAV minimum always >= nominal ventilation during design** box. This will adjust the VAV minimum automatically to ensure the space receives the defined amount of ventilation.

- Correctly define the return air path.

Those modeling spaces without plenums often forget to change the return air path from **Plenum** to **Ducted**. To do so, go to the **Create Systems – Selections** tab and select the **Advanced** button. Making this change ensures TRACE does not calculate a plenum temperature. Not doing so could result in additional load on the system.

If you have a situation where some rooms on the system do have a plenum and some do not, you can do one of two things: you can define a one-foot plenum for those rooms not having one, or you can place the rooms without plenums on a separate system.

- Verify coil sizing and scheduling.

Much like with fan scheduling, applying a schedule other than **Available (100%)** can quickly lead to a high number of unmet load hours. In other words, if TRACE needs the coil to satisfy a load and the coil is scheduled off, then the load will not be satisfied and will be carried over to the next hour. Likewise, undersizing coils or turning coils off can lead to unmet hours.

Step #4 – Increase capacity

If all other approaches fail, consider increasing the system coil or plant capacity in an attempt to reduce unmet load hours.

Increase the appropriate coil capacities on the **Create Systems – Coils** tab. This may be an iterative process if the desired increase in capacity has a limited effect on the number of unmet hours.

*Note: Coil capacities will automatically be carried over to the plants they are assigned to, thus increasing the plant size automatically. Changing equipment capacities under the **Create Plants** section of the program has no impact on the system simulation unless you have checked the box to link the equipment capacity to the system coil capacities on the **Change Energy Parameters** screen. If you have already adjusted the capacities of the coils in the **Create Systems** section, the plant linking feature should not be utilized. Generally, the equipment capacities are only used for energy calculations.*

It is important to verify the increase in capacity is realistic given the building design properties.

LEED template submittal

The LEED version 3 EAp2 and EAc1 templates provide guidance on the reports to include with the submittal. Aside from those required, the following reports provide information reviewers may find helpful.

- **Room Information** from Entered Values reports
- **Plant Information** from Entered Values reports
- **Library Information** from Entered Values reports
- **System Checksums** from Design Reports
- **LEED Energy Performance Summary Report** from Analysis Reports
- **PRM Fan Details** from Analysis Reports

Additional LEED credits

TRACE can help provide information to qualify for additional LEED credits. For example, under the LEED New Construction version 3 rating structure, TRACE may help with the following credits:

Energy and Atmosphere prerequisite 2 (EAp2): Minimum Energy Performance

This prerequisite for achieving LEED certification requires the proposed building meet a minimum standard of energy efficiency.

Energy and Atmosphere credit 1 (EAc1), option 1: Optimize Energy Performance

TRACE 700 provides many features that help evaluate a building's overall energy use and determine its efficiency. These features are discussed in length during the C.D.S. ASHRAE Standard 90.1/ LEED seminar. Contact C.D.S. for more information regarding this training class.

Energy and Atmosphere credit 5 (EAc5), option D: Measurement & Verification

The model used for EAc1 can be used towards achieving this credit. Reference the "International Performance Measurement & Verification Protocol: Concepts and Options for Determining Energy Savings in New Construction Volume III" for detailed information on how to appropriately adjust the model from EAc1 to be used for this credit.

Energy and Atmosphere credit 6 (EAc6): Green Power

The model used for EAc1 can identify the baseline electrical consumption needed to achieve Green Power credits.

Water Efficiency credit 2 (WEc2): Innovative Wastewater Technologies

The Equipment Energy Consumption report shows the amount of make-up water associated with the cooling coil condensate. This information may be helpful in achieving this credit.

Indoor Environmental Quality prerequisite 1 (EQp1): Minimum Indoor Air Quality Performance

TRACE 700 conducts the ASHRAE 62.1-2007 calculation per user defined rates and effectiveness values. The **ASHRAE Std 62.1-2004/2007** report details calculation results aiding the user in their efforts to optimize the design.

**Indoor Environmental Quality credit 2 (EQc2):
Increased Ventilation**

TRACE 700 allows users to define the outdoor air ventilation rates for the ASHRAE 62.1 calculation. By manually increasing the ASHRAE 62.1 outdoor air ventilation rate 30%, showing compliance with this credit is simplified.

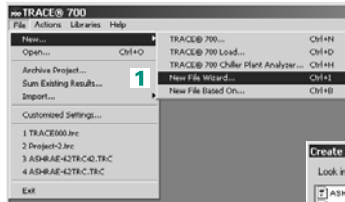
**Indoor Environmental Quality credit 8.1 (EQc8.1):
Daylighting & Views**

Credits are awarded when a specified level of daylighting is achieved. When users create daylighting definitions within TRACE, the program generates a special report showing the footcandles of daylight present in the spaces with daylighting controls.

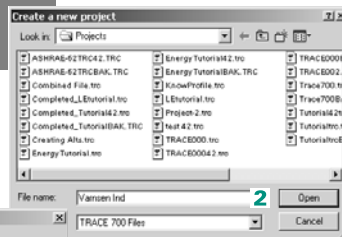
Quick building inputs via the New File Wizard

The New File Wizard is intended to be used to quickly model buildings in TRACE 700. In this example, a rectangular 15-story office building in Davenport, Iowa, will be modeled.

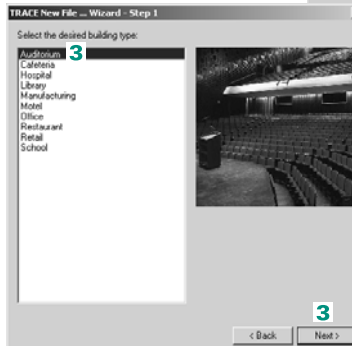
- 1 Start by opening TRACE 700, clicking **New** on the **File** menu, and clicking **New File Wizard**.



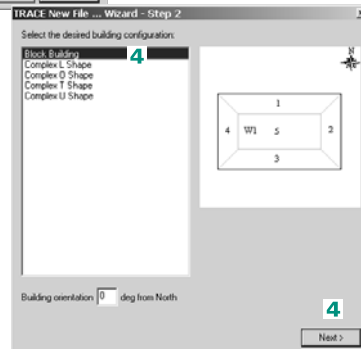
- 2 Enter a name for the project and click **Open**.



- 3 Select the type of building to be modeled and click **Next**.



- 4 Select the shape of building to be modeled, input the orientation of the building, and click **Next**.



5 Input the dimensions, percent glass, and so on, of the building and click **Next**.

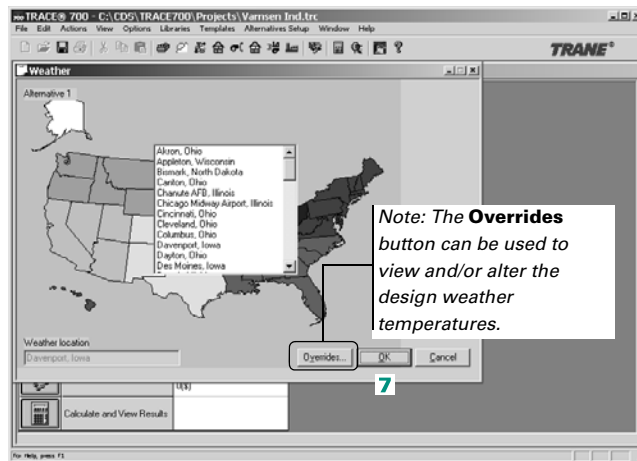
6 The New File Wizard closes and the TRACE 700 Project Navigator window appears. The New File Wizard creates sets of templates for the spaces, 5 rooms per wing, the weather location should be the default weather location, and the rest of the file should be blank. Click **Enter Project Information**, input the project information, and click **OK**.

*Note: Avoid using punctuation and special characters in the **Project Information** section. Also, this information will appear on the **Title Page** report and the **Economics Summary** report.*

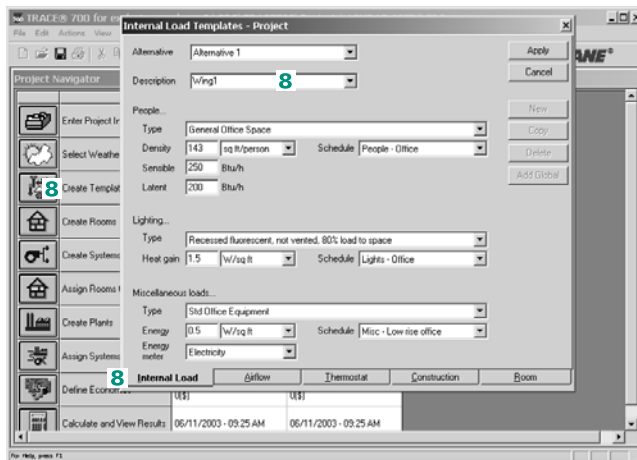
Perimeter depth should typically not exceed 25 feet or the envelope losses could be negated by the internal loads. Also, you may want to note the number associated with each of the spaces in the building, as TRACE 700 will name the rooms based on these numbers. In this example, TRACE 700 will create five rooms named using the Wing number the Room number, and the Direction—W1-R1N, W1-R2E, W1-R3S, W1-R4W, and W1-R5Int.

- 7 Click **Select Weather Information**, click the appropriate region of the country, click the nearest weather location, and click **OK**.

Note: If the desired weather location does not exist, select a weather location with a similar temperature profile or refer to “Adding weather locations and activating the 8760 calculation methodology” on page 6–167 for directions on importing new weather locations in TRACE 700.



- 8 Click **Create Templates**, click the **Internal Load** tab, click **Wing1** on the **Description** list, and edit the data to properly model the internal loads in the building. In addition, the **Wing1 Airflow, Thermostat, and Construction** templates should be altered to properly model the building. When all of the templates have been edited, click **Close**.



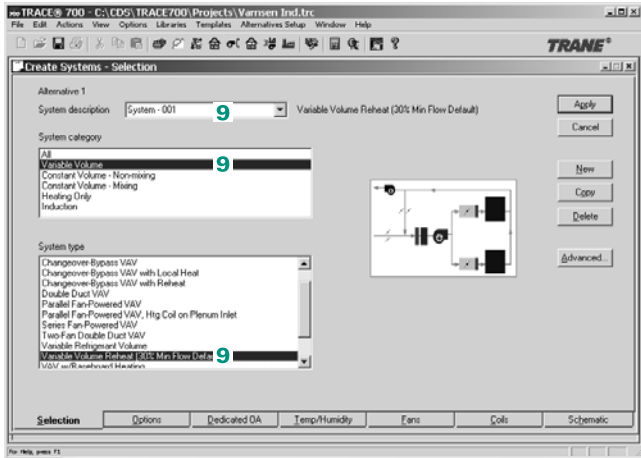
Note: Templates are used to edit the room inputs quickly and to make changes globally rather than on a room-by-room basis

*Note: You can check the room level inputs in the **Create Rooms** section if desired.*

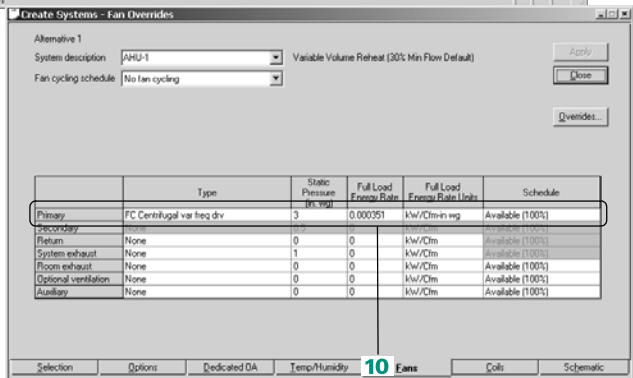
Note: After editing the templates, the remaining sections of TRACE 700 can be input similar to a standard file. Brief instructions for how to input the airside systems and assign the rooms to the airside systems are included in the remaining steps for this section.

- 9 Click **Create Systems**, name the system, and select the appropriate airside system.

On the **Options** tab, input a make-up air unit, an economizer, and an evaporative cooling and/or heat-recovery device if appropriate.

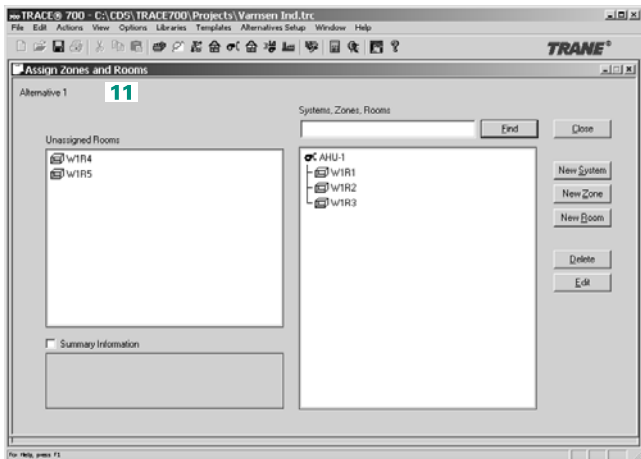


- 10 On the **Fans** tab, input the **Fan Types** and the **Static Pressures** to account for fan heat pick-up and fan energy for all of the fans that exist in the building. Click **Close**.



- 11 Click **Assign Rooms to Systems**, and drag and drop all of the rooms to the airside system(s) created in the last section.

At this point, TRACE 700 can calculate design loads and a yearly load profile. If the remaining sections of TRACE 700 are completed, the file can be used for energy and economic analysis.

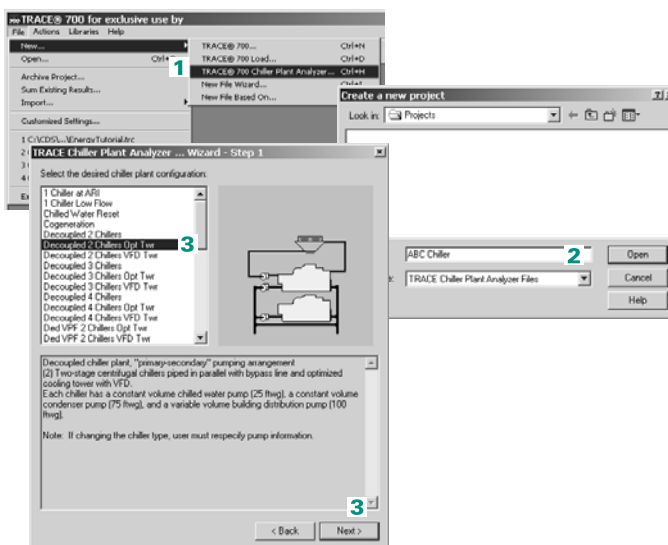


Using TRACE 700 Chiller-Plant Analyzer

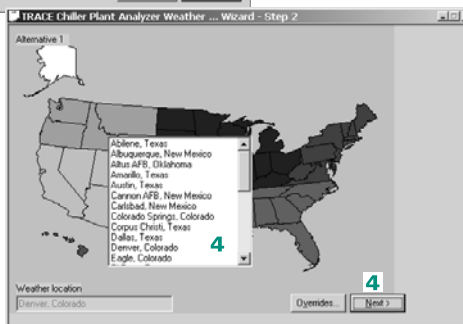
When using Chiller Plant Analyzer, no changes can be made to any inputs in **Create Templates**, **Create Rooms**, **Create Systems**, or **Assign Rooms to Systems**.

The TRACE 700 Chiller Plant Analyzer is intended to be used to quickly model chiller plants using an approximate or custom load profile. In this example, a chiller plant with two chillers in a decoupled arrangement will serve an office building in Dallas, Texas.

- 1 Open TRACE 700, click **New** on the **File** menu and click **Chiller Plant Analyzer**.
- 2 Enter a name for the project and click **Open**.
- 3 Select the type of chiller plant to be modeled. If the exact plant is not available, choose something similar and click **Next**.
- 4 Click the appropriate region of the country, click the weather location for the model, and click **Next**.

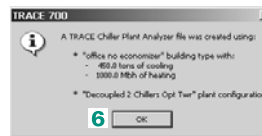
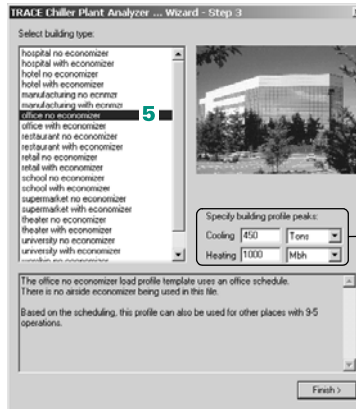


Note: If the desired weather location does not exist, select a weather location with a similar temperature profile or refer to “Adding weather locations and activating the 8760 calculation methodology” on page 6–167 for directions on importing new weather locations in TRACE 700.



- 5 Select the type of building to be modeled. If the desired building type is not on the list, select a building that would be operated similarly. The last sentence in the description usually gives a clue to what other types of buildings can be modeled using the profile.

Note: Chiller Plant Analyzer contains load profiles generated from typical building types for each region of the country. Overriding the building profile peaks scales the existing load profile.



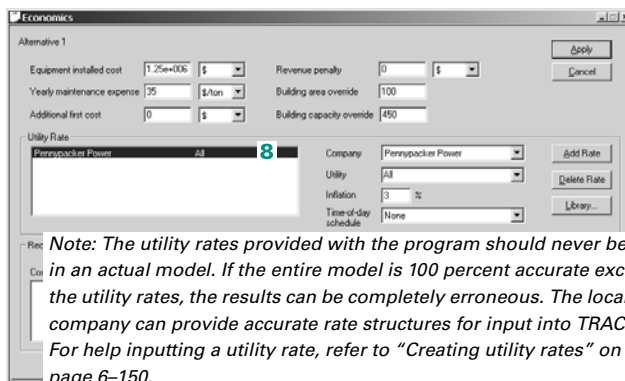
- 6 A summary of the data input to this point will appear. Click **OK**.



- 7 Click **OK** to start entering economic information.

To add a utility rate that has already been input into TRACE 700, click **Add Rate** and select the Company (if appropriate, select the **Time-of-day** schedule as well). Typically, installed costs and maintenance costs should be input as well. When finished, click **Apply** and then click **Close**.

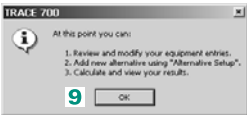
- 8 Input the desired economic information. The only required input on this is screen is the utility rate.



Note: The utility rates provided with the program should never be used in an actual model. If the entire model is 100 percent accurate except for the utility rates, the results can be completely erroneous. The local utility company can provide accurate rate structures for input into TRACE 700. For help inputting a utility rate, refer to "Creating utility rates" on page 6–150.

9 At this point, the basics of the model have been input. Click **OK**.

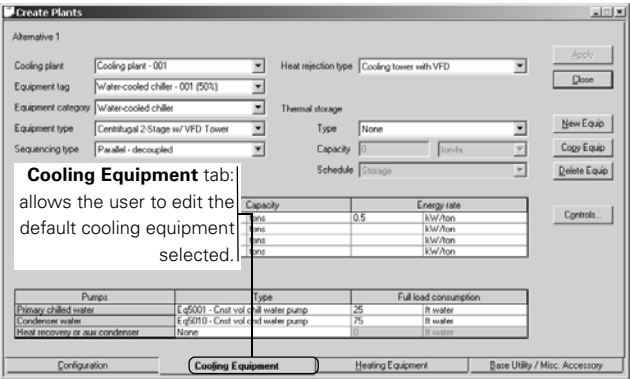
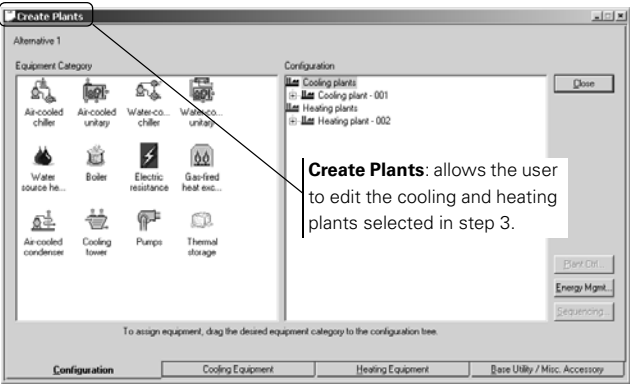
10 The five sections of **Chiller Plant Analyzer** should appear.



From here, clicking the icons will allow viewing and editing of the individual sections.

Enter Project Information: general information can be entered to identify the project. This information is optional and is used for identification purposes only. It will be printed on the **Economic Summary** report.

Select Weather Information: allows the user to reselect the weather location or to override the design temperatures to make the weather profiles more or less severe.



*Note: TRACE 700 always opens to the first chiller. By clicking the **Equipment** tag, the other chillers in the plant can be selected.*

Heating Equipment tab: works exactly the same as the **Cooling Equipment** tab.

11 When inputs for all of the sections have been completed, click **Calculate and View Results**, then click **Select All**, and finally click **Calc Now**.

Calculate and View Results

	Alternative 1	
Design	<input type="checkbox"/>	Created by wizard.
System	<input type="checkbox"/>	Created by wizard.
Energy	<input checked="" type="checkbox"/>	Ready
Economics	<input checked="" type="checkbox"/>	Ready

Alternative 1: Economics Calculation

Ready

☐ Perform special building block calculations during Design (execution time will increase)

Base alternative for economic comparison

[To be calculated] ▾

For Help, press F1

Calc Now
Select All
Clear All
Energy Param...
View Results...
Close

- 1 Additional alternatives can be created in a similar manner to Alternative 1 from the **Alternative Setup** menu.
- 2 If the user would like to input a custom load profile instead of using the default profile, then please start on step 8 of “Inputting an existing load profile” on page 6–118.
- 3 The accuracy of Chiller Plant Analyzer directly relates to the accuracy of the load profile, the inputs for the chiller plants, and the utility rate. It is up to the user to model reality.
- 4 To transfer files to another PC, the files must first be archived. Refer to “Archiving and un-archiving instructions (storing library members with project files)” on page 6–175 for instructions on archiving and unarchiving files.

Inputting an existing load profile

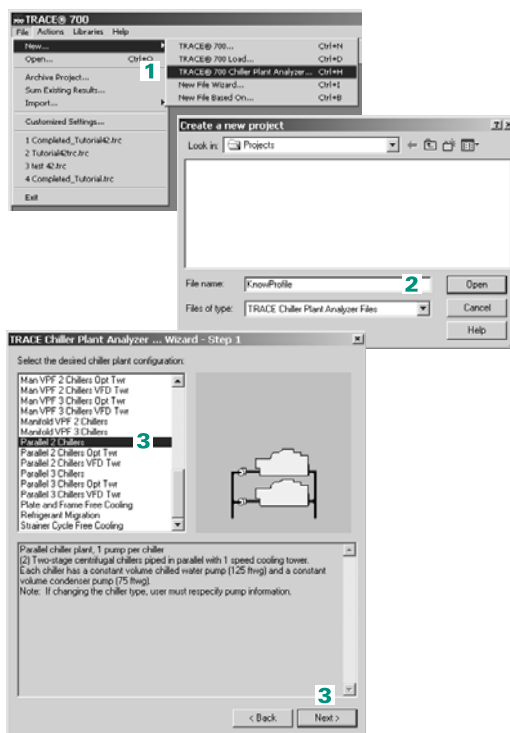
If the user has a known load profile and wants to directly input that profile into TRACE 700, TRACE 700 Chiller Plant Analyzer can be used.

Changes to the rooms, airside systems, and templates are not allowed with TRACE 700 Chiller Plant Analyzer.

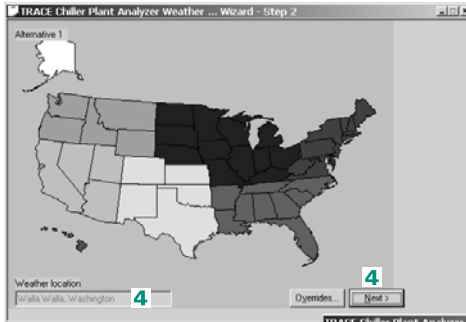
- 1 Open TRACE 700, click **New** on the **File** menu and click **TRACE 700 Chiller Plant Analyzer**.

- 2 Enter a name for the project and click **Open**.

- 3 Select the desired plant configuration for the cooling equipment and click **Next**.



- 4 Select the region, and then the city, where the building is located and click **Next**.

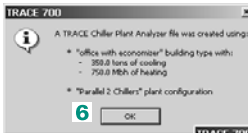


- 5 Select the type of building to be modeled, input peak cooling and heating loads, and click **Finish**.

Note: If the exact building type is not available, select something with similar loads and/or occupancies.



- 6 A summary of the data input to this point will appear. Click **OK**.



- 7 Click **OK** to start entering economic information.



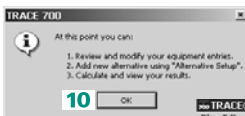
- 8 Input the desired economic information. Start by inputting all appropriate costs (maintenance, installed cost, and so on). Then either click **Libraries** to create a custom utility rate or select a custom utility rate that was previously created.

Recurring/Additional Depreciable Cost			
Cost	Year Incur	Econ Life	Deprec. Taxes
15000.00	10	10	10

Utility Rate	
Northern Power Company	Electric consumption
Northern Power Company	Electric demand
Northern Power Company	Gas

- 9 When completed, click **Apply**, click **Close**, and then click **OK**.

Note: Do not use a default rate (Northern Power, for example). The default rates are inaccurate and intended only as examples of how to input custom rates. For instructions on how to create utility rates, please refer to "Creating utility rates" on page 6–150.



10 Click **OK** on the message that comes up.

11 Click **Enter Project Information** and enter any desired data.

12 Click **Calculate and View Results**, then click **Select All**, and finally click **Calc Now**.

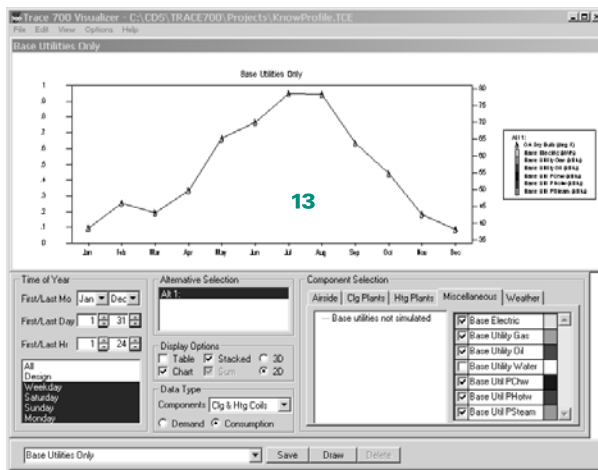
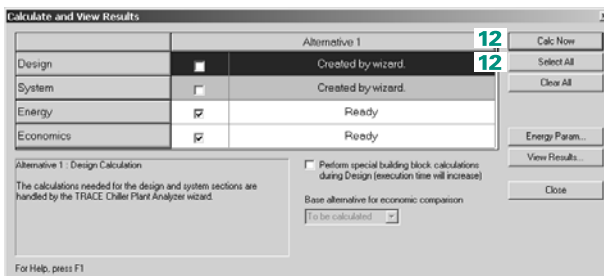
13 Do one of the following:

- a After the calculations have completed, close the **Chiller Plant Analyzer Summary** report, click **View Results**, and then click **Profiles and Energy Consumption**. The TRACE 700 Visualizer should open.

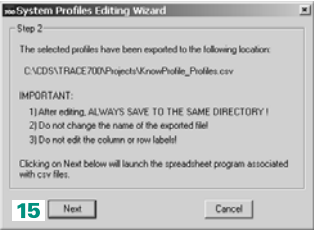
Or:

- b After the calculations have completed, close the **Chiller Plant Analyzer Summary** report, close **Calculate and View Results**, and click **Modify Load Profile** on the **Actions** menu. The TRACE 700 Visualizer should open.

14 Click **Modify System Profiles** on the **Edit** menu, select either **Edit Hourly Demands** or **Edit Monthly Consumptions**, and click **OK**. For inputting a known load profile, select **Edit Hourly Demands**.



15 Read and follow the instructions listed on the next screen to open the load profile in a spreadsheet.



16 The spreadsheet should have one column for cooling loads and one for heating loads. Input the known load profile and save the changes. Do not make changes to the headings or to any columns, other than the cooling and heating values.

Month	Day Type	Hour	Cooling tons	Heating MWh
Jan	Dsn	1	0	0
Jan	Dsn	2	0	0
Jan	Dsn	3	0	0
Jan	Dsn	4	0	0
Jan	Dsn	5	0	0
Jan	Dsn	6	0	0
Jan	Dsn	7	0	-394.61
Jan	Dsn	8	0	-467.07
Jan	Dsn	9	0	-136.13
Jan	Dsn	10	0	-67.12
Jan	Dsn	11	0	-37.52
Jan	Dsn	12	0	-13.69
Jan	Dsn	13	3.19	-3.24
Jan	Dsn	14	6.35	0
Jan	Dsn	15	7.66	0
Jan	Dsn	16	6.66	0

17 Save the file and close the spreadsheet program. Click **OK** and close the TRACE 700 Visualizer.

18 Edit the inputs for the cooling and heating plants to accurately reflect your model, and recalculate the file using the new load profile.

*Note: Use the **Alternative Setup** menu to create additional alternatives.*

Creating spreadsheets and tables from calculation results (TRACE 700 Visualizer)

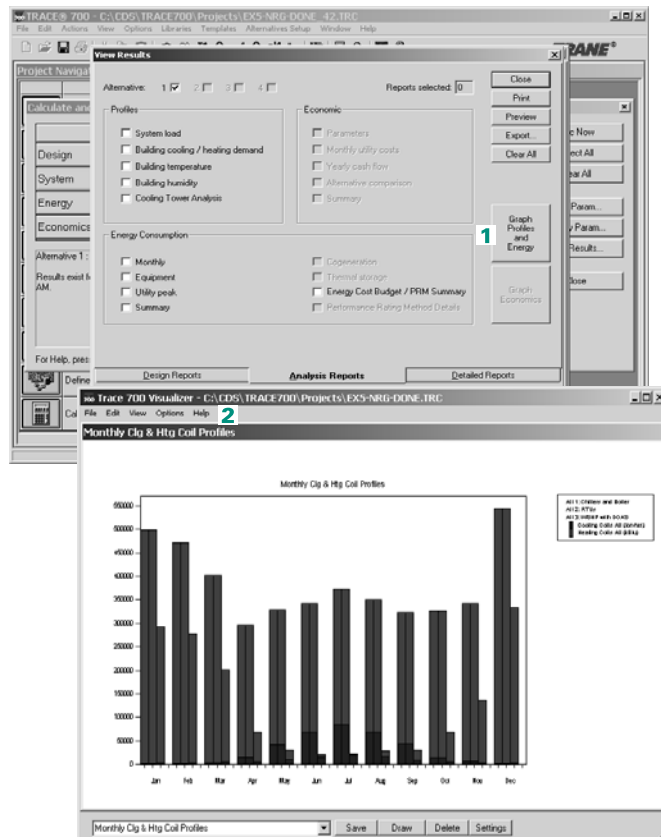
The TRACE 700 Visualizer allows the user to create custom charts and tables, view trends, and get additional details about the loads, airflows, and energy consumption calculated by TRACE 700 during the energy-analysis simulation.

In order for the Visualizer to be available to be selected, the first three sections (design, system, and energy) must be calculated for the file.

- 1 After the file has been calculated completely, go to **View Results**, click the **Analysis Reports** tab, and click **Profiles and Energy Consumption**.

- 2 After clicking **Profiles and Energy Consumption**, the TRACE 700 Visualizer should open.

*Note: If Visualizer opens but no data appears, click **Open** on the **File** menu, click the .trc file to be viewed, and click **Open**.*



3 To view one of the standard charts or tables, click the desired graph on the list in the bottom left-hand corner and click **Draw**.

4 To create a custom graph or chart, click **Settings** at the bottom of the screen or click **Settings** on the View menu.

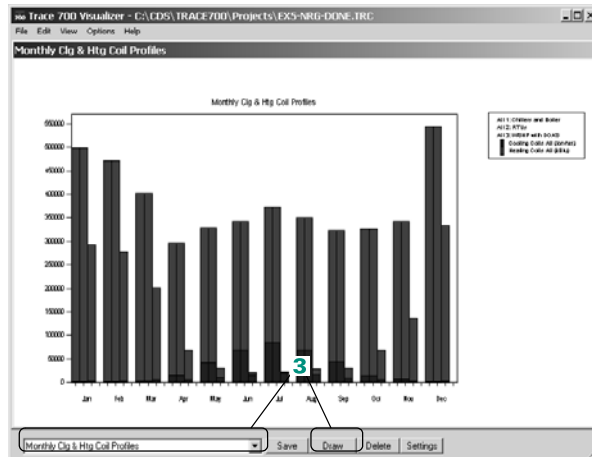
a From the **Data Type** section, choose to view either consumption (overall monthly numbers) or demand (hour-by-hour numbers) and the general component category that you want to view.

b From the **Time of Year** section, select the months, days, hours, and day types that should be included in the graph.

c From the **Alternative Selection** section, choose which alternatives to include.

d From the **Display Options** section, choose whether a chart or a table should be created.

e From the **Component Selection** section, use the tabs and check boxes to select the variables to be viewed.



a Data Type

Components: Clg & Htg Coils

☒ Demand ☐ Consumption ☐ Cost

b Time of Year

First/Last Mo: Jan Jan

First/Last Day: 1 31

First/Last Hr: 1 24

All
Design
Weekday
Saturday
Sunday
Monday

c Alternative Selection

Alt 1: Chillers and Boiler
Alt 2: RTUs
Alt 3: WSHp with DOAS

d Display Options

☒ Table ☐ Stacked ☐ 3D
☐ Chart ☐ Year Total ☒ 2D

e Component Selection

Airside Clg Plants Htg Plants Miscellaneous Weather

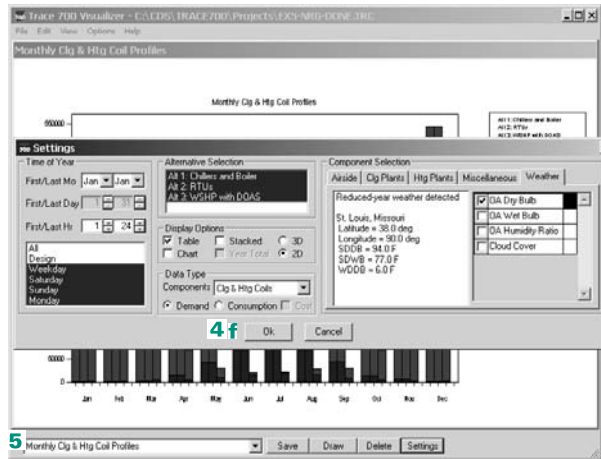
Reduced-year weather detected

St. Louis, Missouri
Latitude = 38.0 deg
Longitude = 90.0 deg
SDDb = 94.0 F
SDWB = 77.0 F
WDDB = 6.0 F

☒ OA Dry Bulb
☐ OA Wet Bulb
☐ OA Humidity Ratio
☐ Cloud Cover

- f Click **OK** to accept changes that were made and view the custom graph or chart.

Note: In this example, the hourly outdoor-air dry bulb, cooling loads, and heating loads for January for Alternative 1 and Alternative 2 were displayed in a table format.



- 5 To save the custom table or chart, input a custom name in the lower left-hand corner and click **Save**.

Month	Day	Hour	Outdoor Air Dry Bulb (deg F)	Cooling Coils Air (ton)	Heating Coils Air (MWh)	Cooling Coils All (ton)	Heating Coils All (MWh)	Cooling Coils All (ton)
Jan	Wkday	1	27.10	2.01	-841.25	2.01	-841.25	0.00
Jan	Wkday	2	25.70	1.94	-867.71	1.94	-867.71	0.00
Jan	Wkday	3	24.79	1.87	-894.96	1.87	-894.96	0.00
Jan	Wkday	4	24.50	1.80	-890.65	1.80	-890.65	0.00
Jan	Wkday	5	24.69	1.73	-883.47	1.73	-883.47	0.00
Jan	Wkday	6	26.20	1.66	-858.97	1.66	-858.97	0.00
Jan	Wkday	7	28.10	1.60	-823.41	1.60	-823.41	0.00
Jan	Wkday	8	30.70	0.00	-737.12	0.00	-737.12	5.22
Jan	Wkday	9	33.90	8.11	650.01	8.11	650.01	14.27
Jan	Wkday	10	36.50	11.46	874.97	11.46	874.97	17.96
Jan	Wkday	11	39.40	11.93	491.07	11.93	491.07	19.92
Jan	Wkday	12	42.00	12.18	-440.00	12.18	-440.00	20.52
Jan	Wkday	13	43.90	0.00	-424.84	0.00	-424.84	6.71
Jan	Wkday	14	45.20	10.03	-396.35	10.03	-396.35	18.90
Jan	Wkday	15	45.59	12.60	-372.98	12.60	-372.98	22.90
Jan	Wkday	16	45.29	12.54	-378.41	12.54	-378.41	22.23
Jan	Wkday	17	44.40	12.27	-388.60	12.27	-388.60	22.47
Jan	Wkday	18	42.90	11.98	-442.74	11.98	-442.74	18.40
Jan	Wkday	19	41.00	2.21	-488.96	2.21	-488.96	4.66
Jan	Wkday	20	38.79	2.19	-543.97	2.19	-543.97	3.08

Additional items and notes

- 1 Whenever a chart or table is being viewed, a temporary file is created that stores all of the data contained in the table or chart. This temporary file is located in the directory where the .trc file is located. The filename of the temporary file is Filename_Profiles.csv. The Filename_Profiles.csv file can be opened with any spreadsheet program and edited, used for hand calculations, or used to create graphs outside of TRACE 700.

Using templates

Templates are intended to help simplify and speed up the process of entering and changing room information. They are based on the idea that several pieces of information are common for many, if not all, of the rooms or types of rooms in a building. Examples of this type of similar information include design thermostat setpoints, wall/roof/floor construction types, amount and type of lighting, and so on. Templates are similar to the concept of Master Cards in TRACE/Load Design 600.

The templates were designed for use in conjunction with the **Create Rooms – Single Sheet** tab to allow the user to enter room information on one screen. This allows much quicker entry of room data. In addition, because the user does not need to repeatedly select construction types, densities, and so on, templates reduce the chances of input errors. Finally, templates also make changes to files, and comparisons between alternatives, much easier.

There are five types of templates. However, the **Room** template acts as a *super* template. It does not contain any specific room data, but it allows grouping of the other four templates listed below:

- **Internal Load** template
- **Airflow** template
- **Thermostat** template
- **Construction** template

Templates are generally created for each type of room in a building—office areas, conference rooms, hallways, rest rooms, and so on. After the templates have been set up, they are applied, as appropriate, to the individual rooms in the **Create Rooms** section. The templates will bring in values that would be typical for the room type being entered in **Create Rooms**, and allow the user to override these inputs with any atypical values for that specific room.

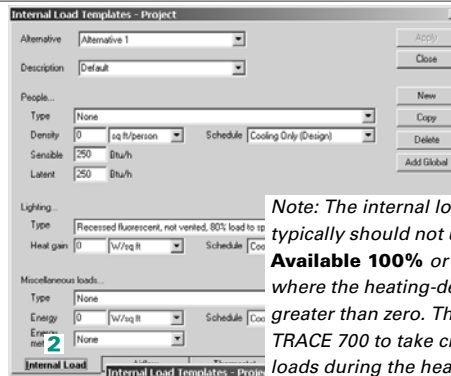
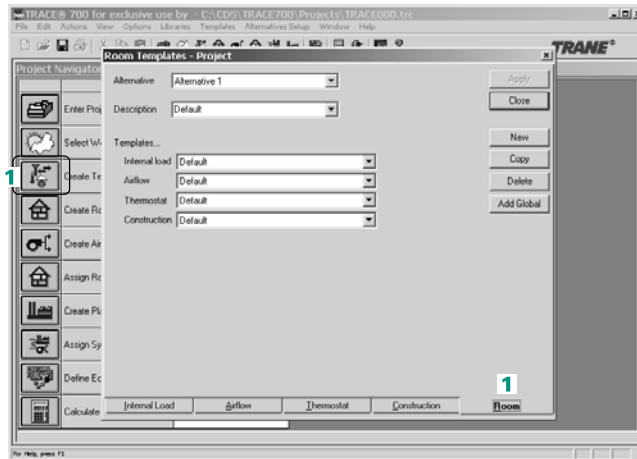
In the following scenario, a set of templates for the office areas of a building will be created and applied in **Create Rooms**.

- 1 The first step in using templates is to *create* the templates. Click **Create Templates**—TRACE 700 will open to the **Room** template.

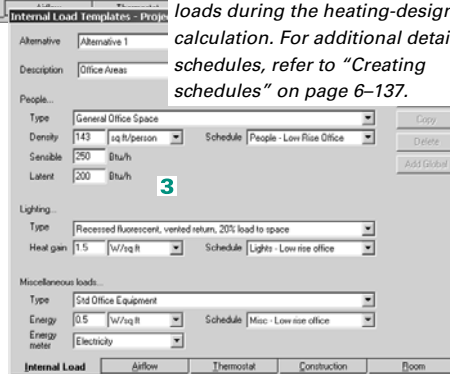
*Note: It is much easier to create templates before the rooms have been input. Applying templates after the rooms have been input is time consuming and often difficult to do. Refer to **Additional Items** in this section for instructions on reverting inputs to templated values.*

- 2 No templates have been input into this file. Therefore, the **Internal Load** tab should be selected.

- 3 From the **Internal Load** tab, the general characteristics of the office areas' internal loads will be input. Click **New** and enter **Office Areas** into the **Description** field. Enter the appropriate **Type**, **Density**, **Loads**, and **Schedule** for the people. Repeat this for **Lighting** and **Miscellaneous loads**.



*Note: The internal load schedules typically should not use the schedule **Available 100%** or any schedule where the heating-design day type is greater than zero. This will cause TRACE 700 to take credit for internal loads during the heating-design calculation. For additional details on schedules, refer to “Creating schedules” on page 6–137.*



4 With the general characteristics for the office areas' internal loads defined, select the **Airflow** tab. Here, the general characteristics of the office areas' airflows will be input. Click **New** and enter **Office Areas** into the **Description** field. Input the appropriate **Type**, airflow rate (if the default value needs to be adjusted), and **Schedule** for the **Ventilation**. Repeat this for all relevant fields on the **Airflow** template.

*Note: In almost all cases, the **Auxiliary supply** and **VAV minimum** schedule should be left at their default values. Also, the airflow schedules must not be internal load schedules or any schedule where the heating-design day type is zero. This will cause TRACE 700 to neglect airflow loads during the heating-design calculation. For additional details on schedules, refer to "Creating schedules" on page 6-137.*

5 With the general characteristics for the office areas' airflows defined, select the **Thermostat** tab. In this scenario, all of the rooms in the building will be conditioned to the same thermostat setpoints, allowing a single **Thermostat** template to be used for the entire building. Click **New** and enter **Building** in the **Description** field. Input the **Cooling dry-bulb** setpoint, **Heating dry-bulb** setpoint, and **Relative humidity**. If the file will be used for energy analysis, then the **Cooling driftpoint** and **Heating driftpoint**, or the **Cooling thermostat schedule** and **Heating thermostat schedule**, should be input as well.

*Note: Typically users need to either create their own **Thermostat** schedules or select **none** and let the program use the driftpoints (**Thermostat** schedules override the driftpoints and setpoints for energy analysis calculations). Also, the thermostat driftpoints activate whenever there are 5 percent or less of the people in the space (determined from the people schedule on a room-by-room basis).*

6 With the general characteristics for the building thermostat setpoints defined, click the **Construction** tab. In this scenario, the envelope components of the building will be constant throughout the building. Therefore, a single **Construction** template can be used for the entire building. Click **New** and enter **Building** into the **Description** field. Next, select the appropriate **Construction types** for the building, override **U-factors** and **Shading coefficients** if necessary, and input the **Wall**, floor-to-floor, and **Plenum** heights. If the building does not contain a certain construction type, use the default value. In this scenario, the building has no skylights—therefore, the default construction value will be used in the template.

Note: Typically the wall height and floor-to-floor height will be the same value. Refer to online Help for additional details.

7 Finally, select the **Room** template so that the individual templates can be grouped together. Click **New** and enter **Office Areas** in the description field. Next, select the appropriate **Internal Load**, **Airflow**, **Thermostat**, and **Construction** templates for the room type.

8 Click **Close Templates** and click **Create Rooms**. To start inputting the room data, give the room a name (**Office 101**, in this case). For the **Room** template, select **Office Areas**.

9 The user now needs to input the appropriate room-specific data (size of the space, walls, windows, roofs, partitions, and floors) and override any data from the templates that is not appropriate for the space. In this scenario, the roof, wall, glass, and floor area need to be input. The **Single Sheet** tab, paired with the data from the templates, can be used to input all of this data. Because this is the first room to be defined with the templates, it is usually recommended that the individual tabs be checked to verify the inputs for the space.

10 Now that Office 101 has been created, the other offices in the building can be modeled using the same set of templates. Remember, templates for *each type* of room (offices, hallways, restrooms, and so forth) should be created, rather than one set of templates per room entered in **Create Rooms**.

In a typical TRACE 700 file, templates for the other types of rooms (conference rooms, hallways, and so on) in the building would now be created. In this scenario, only offices will be modeled. A sample room will be input to show how to apply the templates. The room is 1,500 ft², has a flat roof, one east-facing exterior wall with 30 percent glass, and is fairly typical of the other office spaces.

Additional items and notes

- 1 Any changes made to the template(s) will change the data in all of the rooms that use that template. Therefore, if the glass type specified in the project changes, all that the user needs to do is change the glass type in the **Construction** template(s) used by the rooms. If no templates were used in the file, then each wall would need to be manually changed to the new glass type. This is one of the ways that templates help save time.
- 2 When a templated value is overridden in **Create Rooms**, the color of the entry changes from red to black. It is important to understand this distinction. When you reapply or change an existing template, only the values in red are affected. Entries in black must be changed manually or reverted back to the templated value.
- 3 To go back to an original template value, click ***Template** on the list for that parameter, or type in ***** and press enter for the numeric fields.
- 4 Do not use any non-alphanumeric characters in the names of templates or rooms.
- 5 Create templates before creating rooms.
- 6 *Project* templates apply to only one file.
- 7 *Global* templates can be used in any number of files. They are created from the Library/Template Editors program. Global templates are created in a very similar process and are used when the same type of buildings will be modeled repeatedly.
- 8 A Project template cannot be exported to a Global Template.
- 9 Create a Global template to make it available for any file, then add the Global Room (or individual) template into the Project.
- 10 When editing information, always check the upper left-hand corner of the screen to ensure that the correct alternative is being edited. Also verify that the correct template is being edited.
- 11 For additional details on how to use alternatives and templates, please refer to "Creating alternatives" on page 6–131.
- 12 In **Component Tree** view, the user can press ALT+Z to revert the selected overridden value to a *templated* value quickly.

Creating alternatives

Alternatives can be created efficiently using three options:

Use/Copy, **Create based on**, and **Create new**.

- **Use/Copy:** Simulation will use data from another alternative, which minimizes calculation time and will not increase file size.

Note: The Use/Copy option should only be applied to sections of the alternative where no changes will be made, because the user will not be able to edit information in any section that uses data from another alternative.

- **Create based on:** TRACE 700 will create an editable copy of information from another alternative, which will increase the file size and the calculation time. However, the user can edit information in any section that is created based on data from a previous alternative. This option should be used when changes need to be made to a section, but inputs similar to a previous alternative will be used.
- **Create new:** TRACE 700 will create a new section with no data, which will increase the file size and increase calculation time. The user can input completely new information in any section that is *new*. This option should be used when changes need to be made to a section or alternative, but inputs are not similar to the other alternatives.

Application considerations

- The first step in creating alternatives is to determine how similar the existing alternative and the new alternative will be. In general, the more sections that use data from another alternative, the better. However, if changes need to be made to a portion of an alternative, **Create based on** (if the alternatives are similar) or **Create new** (if the alternatives are very dissimilar) should be used for the appropriate section(s). Two examples will be used to illustrate how to create alternatives in TRACE 700:

*Multiple air-handlers served by a chiller plant vs. a large central air-handler served by the same chiller plant,
and
A glass comparison.*

Sample scenario 1

In this first scenario (multiple AHUs in Alternative 1 and a central AHU in Alternative 2), the alternatives will only require a change to the **Airside Systems** section. In this case, the second alternative will be copied from Alternative 1. The illustrations that follow demonstrate how to create a new alternative by copying an existing alternative (Step 1), naming the new alternative (Step 2), and editing the appropriate sections of the new alternative (Steps 3 and 4).

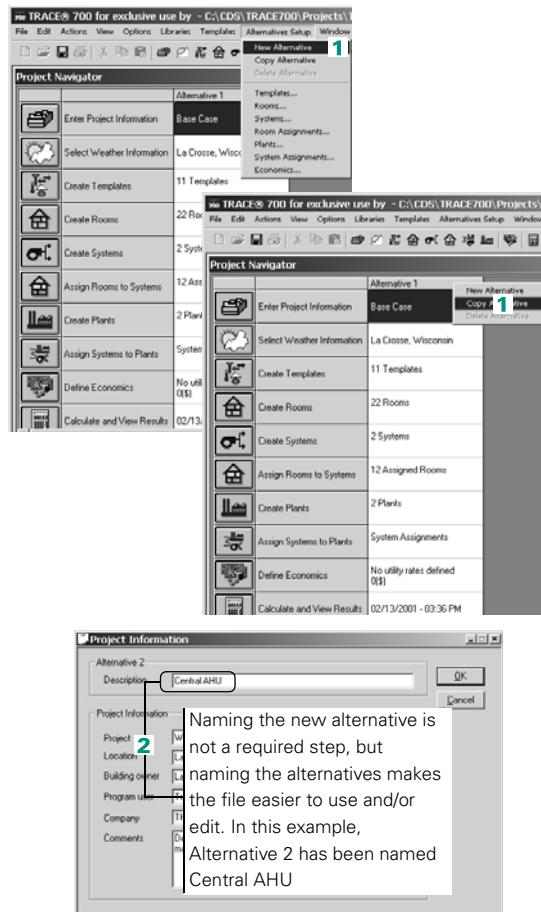
To copy Alternative 1:

- 1 Select Copy Alternative from the **Alternatives Setup** list. A second alternative is created that uses the data from Alternative 1.

*Note: The **Alternatives Setup** menu can also be displayed by right-clicking the gray bar labeled Alternative 1.*

- 2 To name the new alternative, double-click the project information for Alternative 2 to display the **Project Information** window, and edit the **Description** field.

*Note: The **Project Information** window can also be displayed by clicking Alternative 2 and then clicking **Enter Project Information**.*



- Right-click any section of Alternative 2. On the list that appears, click the section to be *Created new* (for this example, click **Systems**). Select **Create new systems for this alternative** and click **OK**.

*Note: The list can also be displayed by clicking **Alternatives Setup**.*

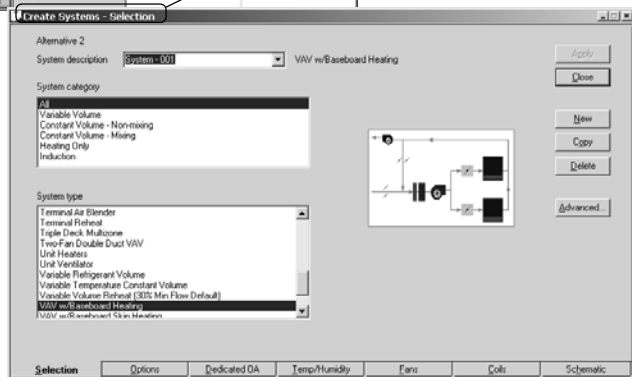
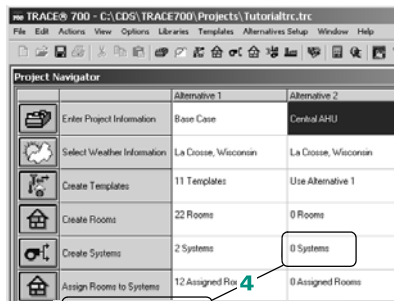
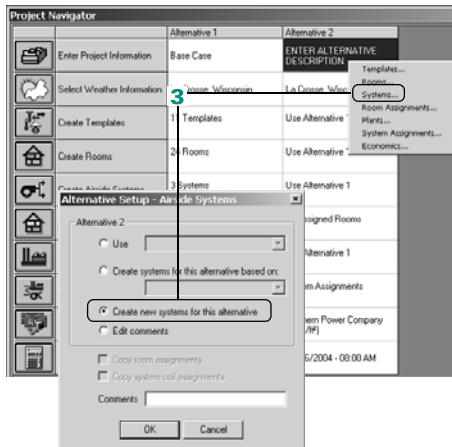
- The Systems for Alternative 2 are now empty. To input the new systems data, double-click **Create Systems** for Alternative 2 to display the **Create Systems** window and enter the new data.

*Note: The **Create Systems** window can also be displayed by clicking Alternative 2 and then clicking **Create Systems**.*

After the new systems data has been input and the rooms have been assigned to the system, Alternative 2 can be calculated.

The appropriate sections of the new alternative need to be changed from *Use* to *Create based on* or *Create new*. In this example, the **Airside Systems** section needs to be edited and most of the airside inputs will be different in Alternative 2. As a result, *Create new* will be used.

Note: Templates cannot be Created New.



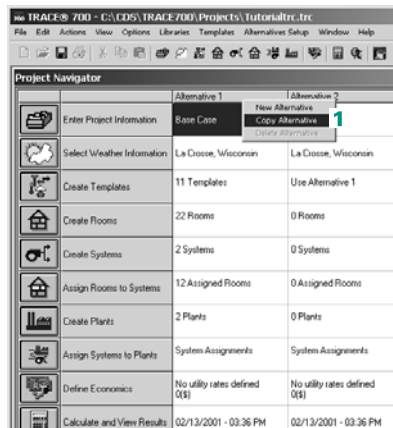
Sample scenario 2

In this second scenario, (a glass comparison between Alternative 1 and Alternative 3), the third alternative will only require a change to the **Templates** section. In this case, the third alternative will be copied from Alternative 1. The illustrations that follow demonstrate how to create a new alternative by copying an existing alternative (Step 1), naming the new alternative (Step 2), and editing the appropriate sections of the new alternative (Steps 3 and 4).

To copy Alternative 1:

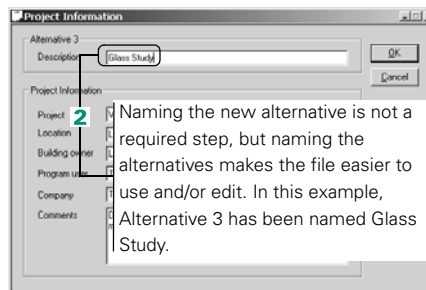
- 1 Right-click the gray bar labeled *Alternative 1*, then click **Copy Alternative** on the menu that appears. A third alternative is created that uses the data from Alternative 1.

*Note: The menu can also be displayed by clicking any line in Alternative 1 and then clicking **Copy Alternative** on the **Alternatives Setup** menu.*



- 2 To name the new alternative, double-click the project information for *Alternative 3* to display the **Project Information** window, and edit the **Description** field.

*Note: The **Project Information** window can also be displayed by clicking Alternative 3 and then clicking **Enter Project Information**.*



The appropriate sections of the new alternative need to be changed from *Use* to *Create based on* or *Create new*. In this example, the **Templates** section needs to be edited and most of the templates' inputs will be identical for the two alternatives. As a result, *Create based on* will be used.

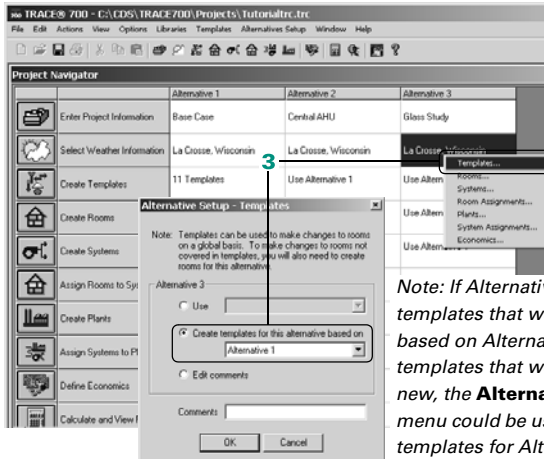
Note: *Templates cannot be Created New.*

- 3 Right-click any section of *Alternative 3*. On the list that appears, click the section to be edited (for this example, click **Templates**). Select **Create templates for this alternative based on**, click **Alternative 1** on the list and click **OK**.

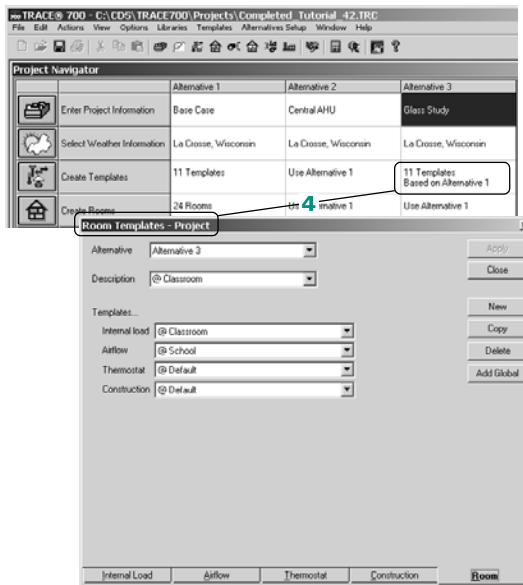
Note: The list can also be displayed by clicking **Alternatives Setup**.

- 4 To input the new templates data, display the **Templates** window(s) by double-clicking the **Templates** section for *Alternative 3* and editing the data.

Note: The **Templates** window(s) can also be displayed by clicking *Alternative 3* and clicking **Templates**.



Note: If *Alternative 2* had templates that were created based on *Alternative 1* or templates that were created new, the **Alternatives Setup** menu could be used to base the templates for *Alternative 3* on *Alternative 2*.



Additional items

- 1 If the templates, rooms, and systems sections of an alternative all *use* the same data as the previous alternative, then the design and system sections of the calculation will not need to be recalculated. This will result in a smaller file size, and much quicker calculation time, than a completely unique two-alternative file.
- 2 If a user tries to edit a section that is *using* the data from a previous alternative, the user will be able to view the data but no changes will be allowed. To make changes, the user will need to either create the section based on a previous alternative or create a new section for the alternative.
- 3 It is not possible to copy the data from an entire alternative to another alternative unless the source alternative is completely unique. If one section of the source alternative uses data from another alternative, the entire alternative cannot be copied. However, individual sections of the source alternative can be **Used** or **Created based on**. For example, the entire Alternative 3 could not be copied to Alternative 4—in this Scenario, only Alternative 1 could be copied to Alternative 4. Alternative 4 could, however, have templates based on Alternative 3 because the templates for Alternative 3 are unique.
- 4 When editing information, always be sure to check the upper left-hand corner of the screen to ensure that the correct alternative is being edited.
- 5 For additional details on how to use templates (from Scenario 2), please refer to “Using templates” on page 6–125.
- 6 If more than 4 alternatives are desired, refer to “Creating a new file based on an existing file” on page 6–179 for information regarding creating additional alternatives.

Creating schedules

In this example, a schedule for the people in an office building will be created. The design options of the schedule will be as conservative as possible, and the energy analysis portions of the schedule will be as representative of the actual occupancy as possible.

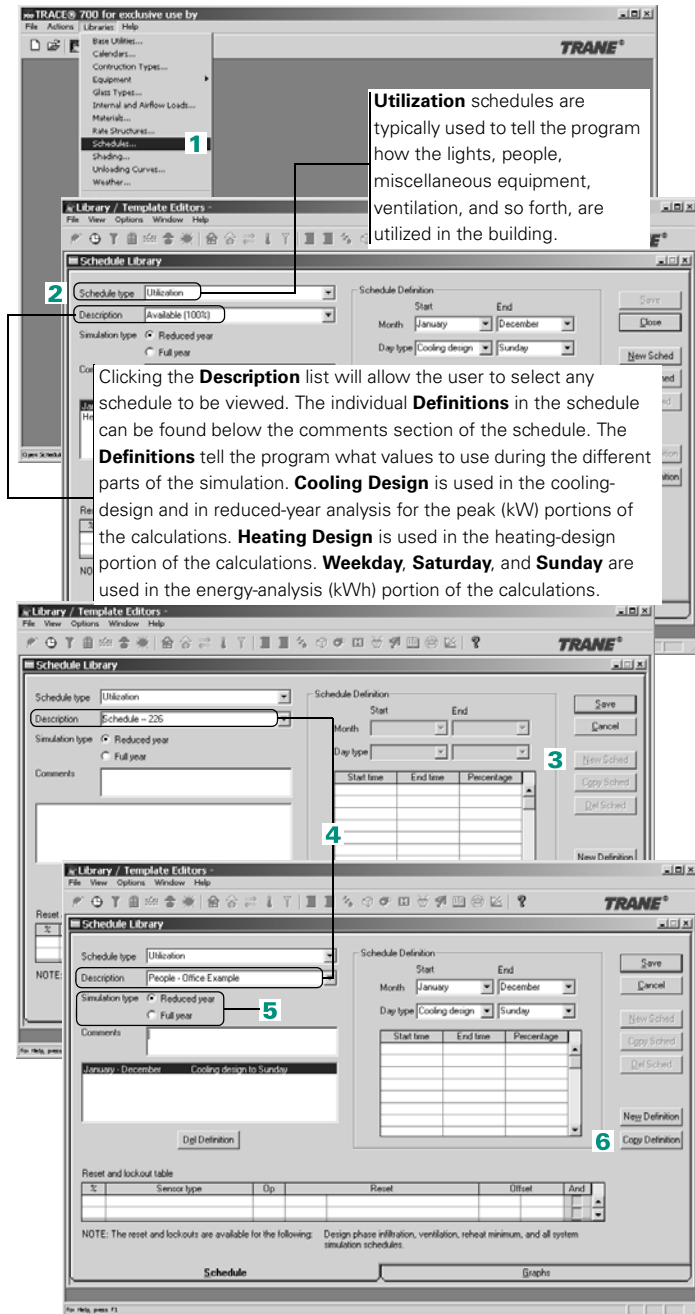
Five types of schedules are used in TRACE 700.

- *Utilization Schedule*: This type of schedule is used primarily to vary/control the internal loads, airflows, fans, coils, control strategies, and base utilities. Utilizations schedules are used in almost every section of TRACE 700.
- *Thermostat Schedule*: This type of schedule allows you to vary the thermostat setpoints by hour and is selected on the **Rooms** tab of **Create Rooms** and the **Thermostat** tab of **Create Templates**.
- *Time-of-Day Schedule*: This type of schedule is used to determine what are hours on-peak, off-peak, etc. for the associated utility rate and is used only in the **Economics** section of TRACE.
- *Equipment Operation Schedule*: This type of schedule allows you to designate the sequence in which cooling or heating equipment operates when there are multiple pieces of equipment working together. Equipment operation schedules are used only on the **Cooling Equipment** and **Heating Equipment** tabs of **Create Plants**.
- *Thermal Storage Schedule*: This type of schedule dictates how the chillers and thermal storage tanks operate during the simulation. **Thermal storage** schedules are used in only in **Create Plants**.

- 1 Click **Schedules** on the **Libraries** menu.
- 2 The Library/Template Editors program should open to the **Utilization** schedules.
- 3 To create a custom schedule, click **New Sched.**
- 4 In the **Description** field, delete the default schedule name and enter a name of your choice. Avoid using any punctuation in the name.
- 5 For the **Simulation type**, select **Reduced year** if you are using the default calculation methodology or if all of your weekdays are utilized the same. Select **Full year** if Mon-Fri have different utilizations, you are using the 8760 calendar *and* using imported 8760 weather.

Note: Reduced year schedules can be used in 8760 simulations. Full year schedules should not be used in reduced-year simulations. Please call C.D.S.Support at 608-787-3926 with questions about 8760 analysis/Full year vs. Reduced year analysis.

- 6 Click **New Definition** to start defining the schedule.

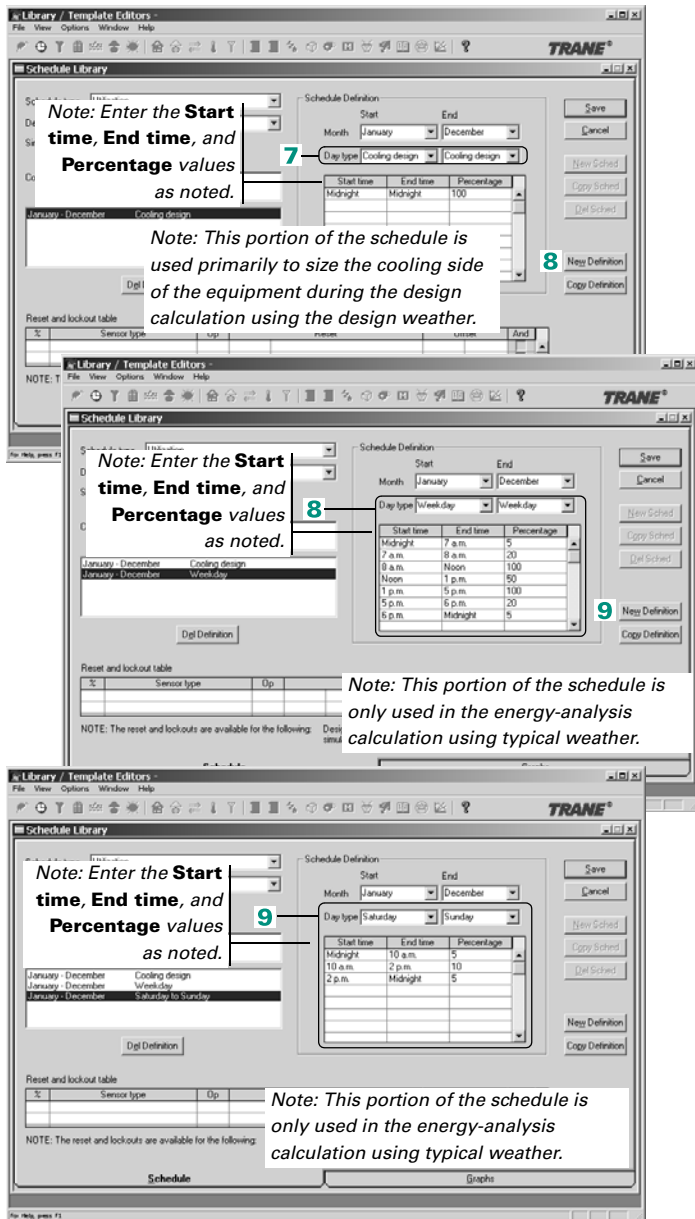


- 7 Begin by selecting the **Day types** that you would like to define. In this case, the **Cooling design** portion of the schedule will be defined to give the most-conservative cooling-design loads and airflows.

Note: For a less conservative cooling design calculation, the cooling design day type can be scheduled identically to the weekday day type.

- 8 Click **New Definition** to define the next set of **Day types** in the schedule. In this step, the **Weekday** portion of the schedule will be defined to give an accurate representation of how the offices will actually be occupied.

- 9 Click **New Definition** to define the next set of **Day types** in the schedule. In this step, the **Saturday** and **Sunday** portions of the schedule will be defined together to give an accurate representation of how the offices will actually be occupied on the weekend.

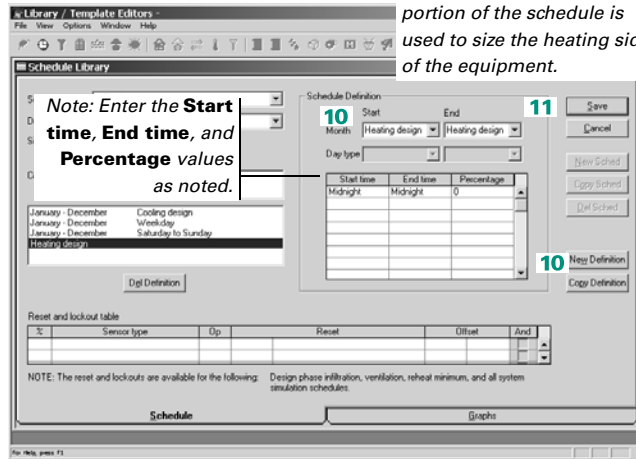


10 Click **New Definition** to define the next set of **Day types** in the schedule. In this step, the **Heating design** portions of the schedule will be defined to give the most-conservative heating-design loads.

11 Click **Save** to add the schedule to the existing library members.

*Note: If the schedule was created while either **Create Rooms** or **Create Systems** was open, **Create Rooms/Systems** may need to be closed and reopened so that menus can refresh to include the new custom schedule.*

*Note: The **Heating design** portion of the schedule is used to size the heating side of the equipment.*



IMPORTANT NOTE:

It is strongly recommended to not use internal load (people, lights, and/or miscellaneous equipment) schedules for ventilation or infiltration in TRACE 700. Because internal loads are typically neglected in heating-design calculations (per ASHRAE recommendations), using an internal-loads schedule for ventilation or infiltration will cause ventilation loads to be neglected (represented by using zero in the schedule) during the heating-design calculations. Separate schedules for ventilation, infiltration, and internal loads should typically be used. Ventilation schedules should have a heating-design definition of midnight-to-midnight 100 percent and internal-load schedules should have a heating-design definition of midnight-to-midnight 0 percent. Because no temperature variation or solar loads are accounted for during the heating-design calculation, all hours should be scheduled the same.

Additional items

- 1 If the schedules do not apply year-round, definitions can be created on a partial-year basis. For example, if, during the summer months, the offices are occupied differently, a separate definition can be created.

Schedule Library

Schedule type: Utilization
Description: People - Office Example
Simulation type: ☒ Reduced year ☐ Full year
Comments:
January - May: Weekday
August - August: Weekday
September - December: Weekday
January - December: Saturday to Sunday
Heating design

Schedule Definition
Start: June End: August
Day type: Weekday

Start time	End time	Percentage
Midnight	7 a.m.	5
7 a.m.	8 a.m.	20
8 a.m.	Noon	40
Noon	1 p.m.	30
1 p.m.	5 p.m.	40
5 p.m.	6 p.m.	20
6 p.m.	Midnight	5

Reset and lockout table

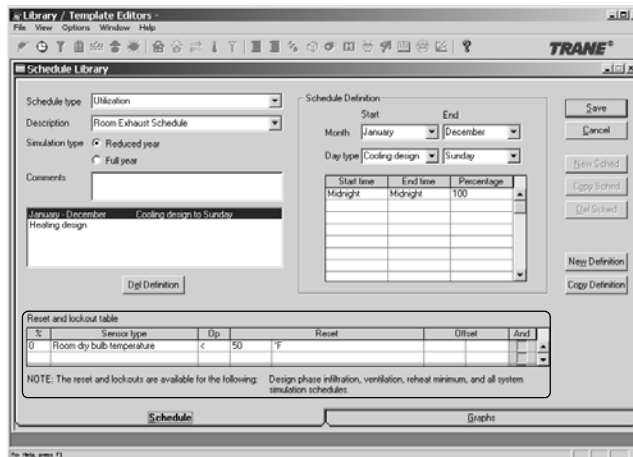
%	Sensor type	On	Reset	Offset	And

NOTE: The reset and lockouts are available for the following: Design phase initiation, ventilation, reheal minimum, and all system simulation schedules.

Schedule Graphs

Note: Definitions cannot wrap around a year. For example, September to May would not be a valid input for the Start and End Months. January to May and September to December would have to be input as two separate definitions to complement the definition for Weekday above.

- 2 For people schedules, 5 percent or less is considered unoccupied. TRACE 700 will use the unoccupied thermostat setpoints at any time the people schedule reads 5 percent or less (unless a **Thermostat** schedule has been input, in which case the **Thermostat** schedule will determine the setpoint in the space).
- 3 The *Reset and lockout* table (found at the bottom of the **Schedules** tab in the **Schedules** library) can be used to simulate different control strategies. For example, if the room exhaust fan were to turn off only when the temperature in the space was less than 50°F, the following schedule, and reset and lockout, information would be input.
- 4 The above *Reset and lockout* table tells TRACE 700 to reset the room exhaust airflow to 0 percent (off) when the room dry-bulb

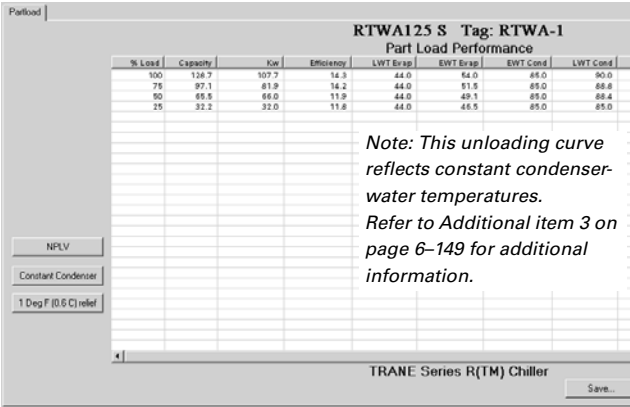


temperature is less than 50°F. There are a variety of sensors, operators, and reset values available. In addition, *and statements* and *offset values* can be used to add more complexity to the reset and lockout controls. Reset and lockout controls can be applied to the following schedule entries. Schedules used for items not specified will ignore these entries.

- Ventilation
- Infiltration
- VAV minimum
- Main cooling fan
- Main heating fan
- Auxiliary fan
- Room exhaust
- Main cooling coil
- Direct evaporative cooling
- Indirect evaporative cooling
- Auxiliary cooling coil
- Optional ventilation cooling coil
- Main heating coil
- Preheat coil
- Reheat coil
- Humidification coil
- Auxiliary heating coil
- Optional ventilation heating coil
- System exhaust-air heat-recovery coil
- Room exhaust-air heat-recovery coil
- Supply air reset (Discriminator)
- Economizer
- Nighttime OA purge
- Optimum start
- Optimum stop
- Duty cycling

Creating equipment and unloading curves

The compressor full-load energy rate and unloading curve (*at constant condenser temperature*) need to be obtained from a selection program, sales representative, or other source. The following example was obtained from the Trane Official Product Selection Software (TOPSS). For added detail, an ambient relief curve should be generated from the constant condenser-temperature unloading curve and the corresponding condenser relief curve (refer to the points in “Additional items” on page 6–149 for instructions on creating a custom ambient relief curve).



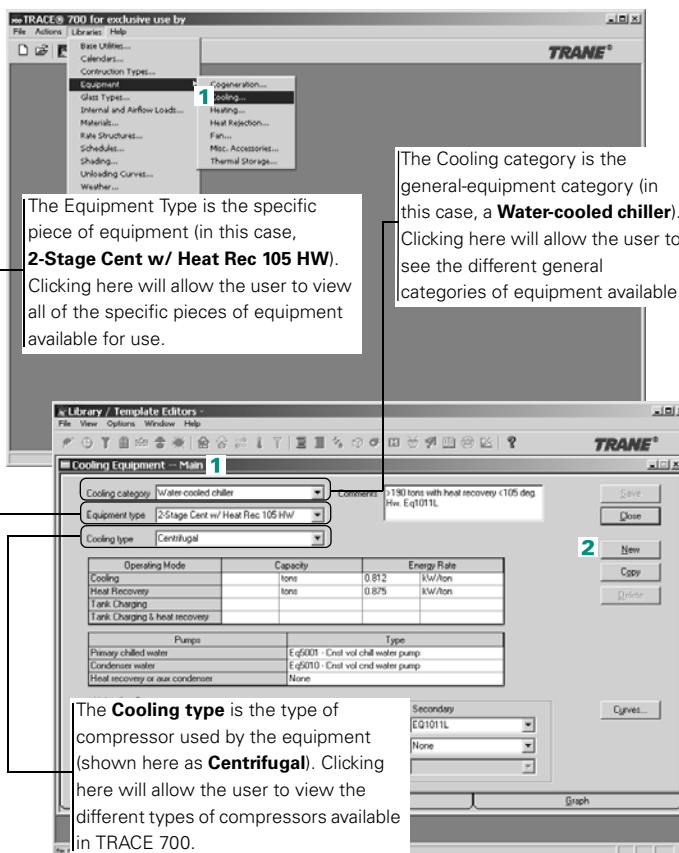
Note: IPLV, SEER, NPLV, and so forth, are not valid inputs for TRACE 700. They combine unloading curves and full-load energy rates, and are not specific enough for detailed energy analysis.

In the following example, a custom water-cooled rotary liquid chiller will be created from data provided by an equipment-selection program.

1 Click **Equipment** on the **Libraries** menu, and then click **Cooling** on the **Equipment** menu. The Library/Template Editors program will display the **Cooling Equipment** window.

2 To create a custom piece of equipment, click **New**. To copy an existing piece of equipment, select the desired piece of equipment and click **Copy**.

In this case, click **New** to create a completely new water-cooled, helical-rotary chiller.



- 3 Select the **Cooling category** as **Water-cooled chiller**. Name the new piece of equipment by deleting the default **Equipment type** and entering a new name (**Helical-Rotary Chiller – Practice**).

Note: Avoid using any punctuation in the name.

Select the **Cooling type** as **Helical rotary**.

- 4 Input the **Energy Rate** (required) and the **Cooling Capacity** (optional) from the selection. The **Energy Rate** is:
 $107.72 \text{ kW}/128.76 \text{ tons} = 0.837 \text{ kW/ton}$.

These values can also be input or overridden on the **Cooling Equipment** tab of the **Create Plants** section.

- 5 Select the **Type** of **Pumps** to be associated with the equipment. If the equipment is not associated with a pump, then select **None** as the pump type.

- 6 Click **Curves** to input the custom unloading curve from the selection software.

The **Energy Rate** should only include the compressor energy at design conditions.

Operating Mode	Capacity	Energy Rate
Cooling	128.76 tons	0.837 kW/ton
Heat Recovery	tons	kW/ton
Tank Charging	tons	kW/ton
Tank Charging & heat recovery	tons	kW/ton

Pumps	Type
Primary chilled water	Constant volume pump
Condensate water	Constant volume pump
Heat recovery or aux condensate	None

Unloading Curves

Curve type... Power consumed: 1-stage, Ambient modification: 1-stage - Amb Mod, Capacity: 1-stage - Amb Mod

Pump sizes are input on the **Cooling Equipment** tab of the **Create Plants** section.

Operating Mode	Capacity	Energy Rate
Cooling	128.76 tons	0.837 kW/ton
Heat Recovery	tons	kW/ton
Tank Charging	tons	kW/ton
Tank Charging & heat recovery	tons	kW/ton

Pumps	Type
Primary chilled water	E q6001 - Const vol chl water pump
Condensate water	E q6010 - Const vol cond water pump
Heat recovery or aux condensate	None

Unloading Curves

Curve type... Power consumed: 1-stage, Ambient modification: 1-stage - Amb Mod, Capacity: 1-stage - Amb Mod

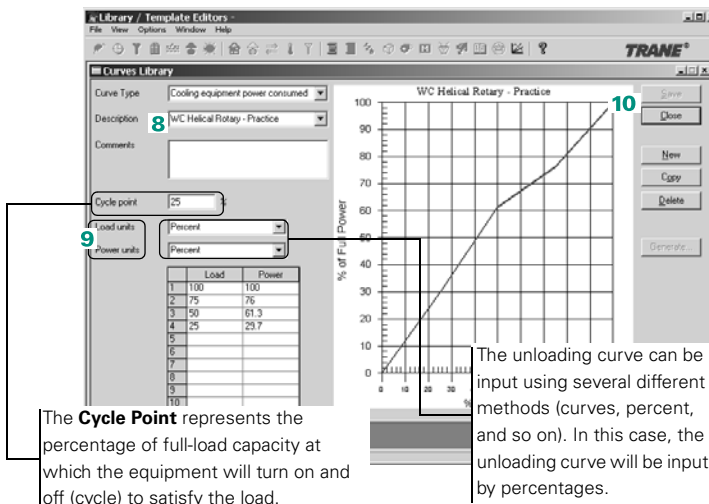
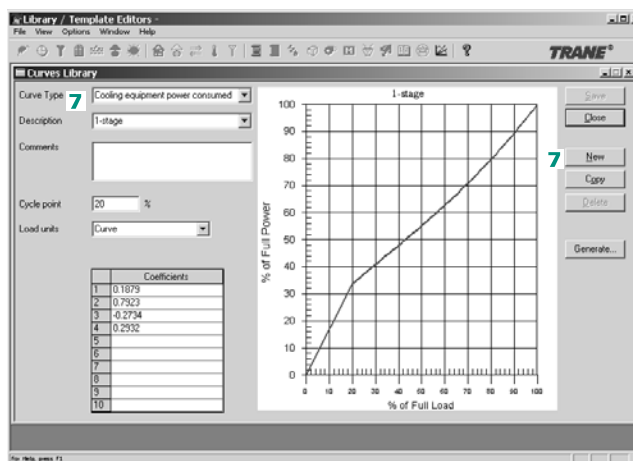
7 The **Curve Type** defines the type of curve being created. Select a **Cooling equipment power consumed** curve and click **New**.

8 Name the new curve by deleting the default **Description** and entering a new name (**WC Helical Rotary – Practice**). Avoid using any punctuation in the name.

9 Select **Percent** for the **Load units** and the **Power units**, then input the *constant condenser-temperature* unloading curve from the selection. Selecting the **Load units** as **Percent** will activate the **Power units** field. Be sure to select **Percent** for both fields before entering values. The points for the curve are calculated based on the percent load and kW columns of the selection.

*Note: If the units for **Load** and/or **Power** are input as kW, Mbh, tons, or therms, it is recommended that the capacity of the equipment be input in Step 4.*

10 Click **Save** and then **Close** to return to the **Cooling Equipment** library.



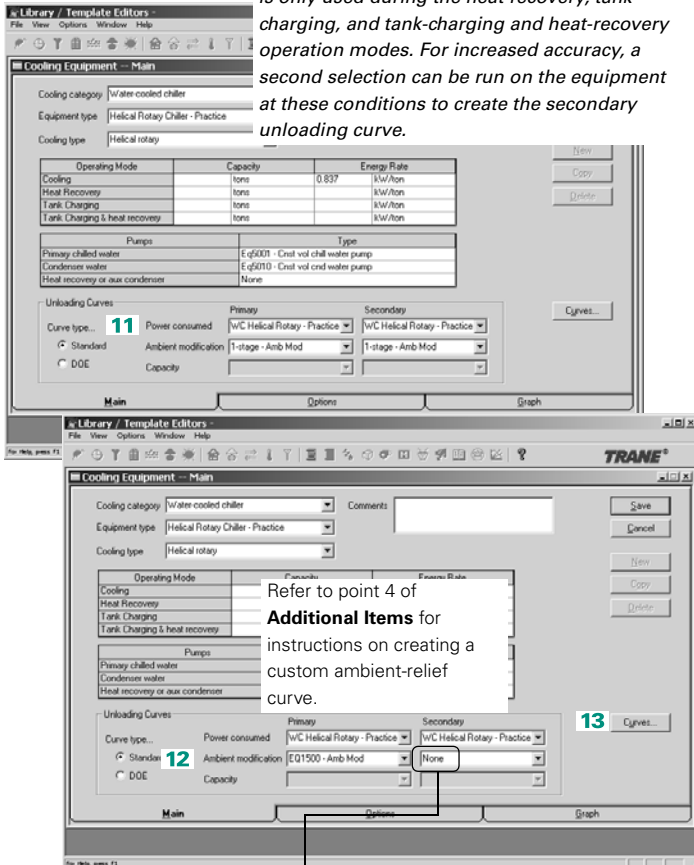
11 Select the **Primary Power consumed** curve that was just created (required) and the **Secondary Power consumed** curve (optional).

12 Select the desired **Ambient modification** curve (required) and the Secondary **Ambient modification** curve (optional). For this example, the standard library member **EQ1500 – Amb Mod** will be used.

13 For increased accuracy, click **Curves** to input a custom **Ambient modification** curve. The **Curves** library will open on top of the **Cooling Equipment** library and the curve can be input similar to the cooling equipment **Power consumed** curve.

*Note: The **Ambient modification** (also called ambient relief) curve will modify the power consumption after the **Power consumed** curve has been used to determine constant condenser-temperature power consumption.*

*Note: The **Secondary Power consumed** curve is only used during the heat recovery, tank charging, and tank-charging and heat-recovery operation modes. For increased accuracy, a second selection can be run on the equipment at these conditions to create the secondary unloading curve.*



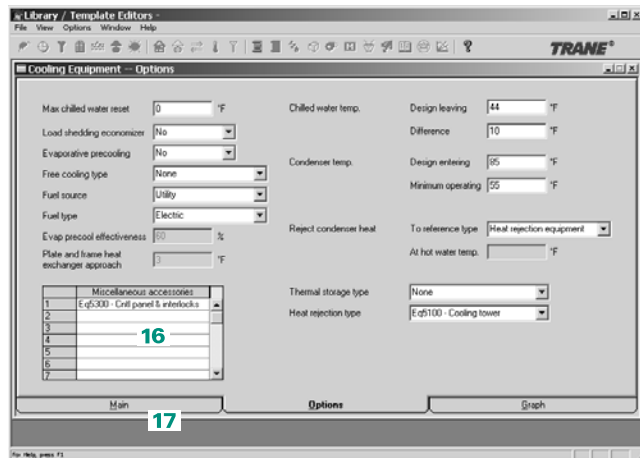
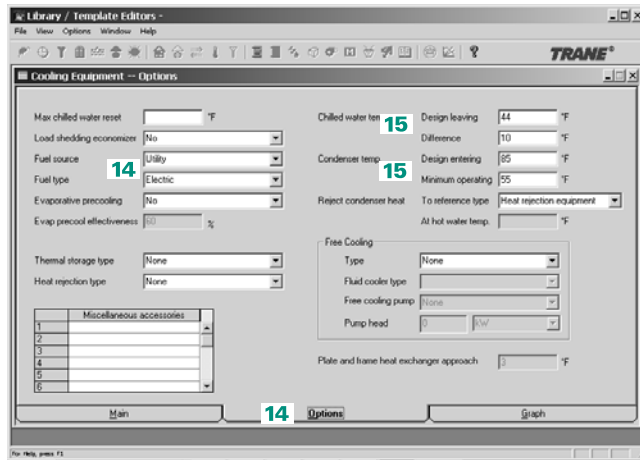
*Note: For heat-recovery chillers, select **None** for the **Secondary Ambient modification** curve. The tower or condenser fan is normally bypassed during heat-recovery mode in order to maintain the highest possible leaving-condenser temperature.*

14 Click the **Options** tab to further define the equipment. **Free cooling type**, **Fuel type**, **Water temperatures**, **Accessories**, and so on, can be defined on the **Options** tab. For this example, ensure that **Utility** is selected as the **Fuel source** and **Electric** is selected as the **Fuel type**.

15 Enter the **Chilled water temp. Design leaving** and **Difference** temperatures from the selection, and also the **Condenser temp. Design entering** and **Minimum operating** temperatures from the selection.

16 Any accessories that run with the equipment (controls, solution pumps, interlocks, and so on) can be selected as **Miscellaneous accessories**.

17 Click the **Main** tab and click **Save** to add the cooling equipment to the existing library members.



Additional items

- 1 The **Graphs** tab can be used to view the **Power consumed** curves and the **Ambient relief** curves for the selected equipment.
- 2 The DOE curves are defined using different variables than the TRACE 700 standard energy-consumption and ambient-relief unloading curves. Additionally, the capacity curve provides a way to adjust chiller capacities at off-design conditions. For capacity and ambient-relief curves, bi-quadratic equations may be used, as defined in the **Curves** library.
- 3 The **Power consumed** curve must be at constant condenser temperature. If a curve that includes ambient modification and/or relief is entered, an unrealistically efficient piece of equipment will be created. If the only curve available includes ambient relief, the Web site <http://www.tranecds.com/commercial/software/unloading.xls> contains a spreadsheet that will convert the existing curve to an approximation of the **Power consumed** curve without ambient modification and/or relief.
- 4 For increased accuracy, an **Ambient modification** curve should be created for the equipment. Please note that different compressor types and compressor designs will have different ambient-relief curves. Using the correct ambient modification is therefore essential for accurate modeling. The following Web site contains a spreadsheet for calculating ambient-relief curves: <http://www.tranecds.com/commercial/software/condenser%20relief%20calculator.xls>
- 5 Trane Official Product Selection Software (TOPSS) can be ordered by contacting C.D.S. at www.tranecds.com, or from the TRACE 700 application, click **Help ► Trane on the Web**.
- 6 The unloading curves and ambient relief curves should be based on compressor-only values. Some manufacturers include supply-fan and condenser-fan data in the capacity and power values they publish.

Creating utility rates

Several different types of utility rates will be discussed in this section: *stepped*, *time-of-day*, *stepped with a kWh/kW flag*, and *time-of-use*. Example utility rates will be used to help illustrate each of the rates. In the example rates, the rate structure charged by the utility company will be given, the individual portions of the structure will be entered into TRACE 700, and a sample calculation will be provided to help explain the charges.

Stepped rate

In this type of rate, the utilities are billed at one rate until the next cut-off is reached. The rate structure is shown below.

Electricity (consumption):

- *Customer Charge = \$50.00 charged each month regardless of usage*
- *Rate = \$0.062/kWh for the first 2,500 kWh and \$0.032/kWh for all remaining kWh*
- *Fuel Cost Adj = \$0.0189/kW*

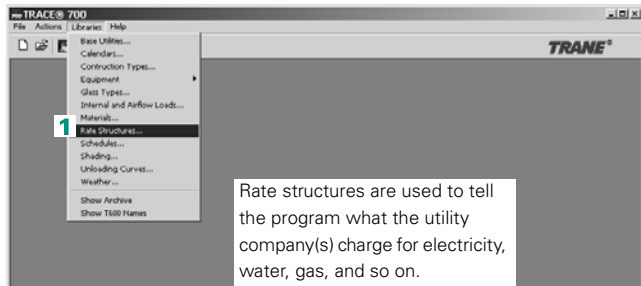
Electricity (demand):

- *Rate = \$8.45/kW for all kW over 10 kW*
- *A ratchet rate of 75 percent of the highest kW demand at this location, as determined during the preceding 11 billing months, is charged by this utility.*

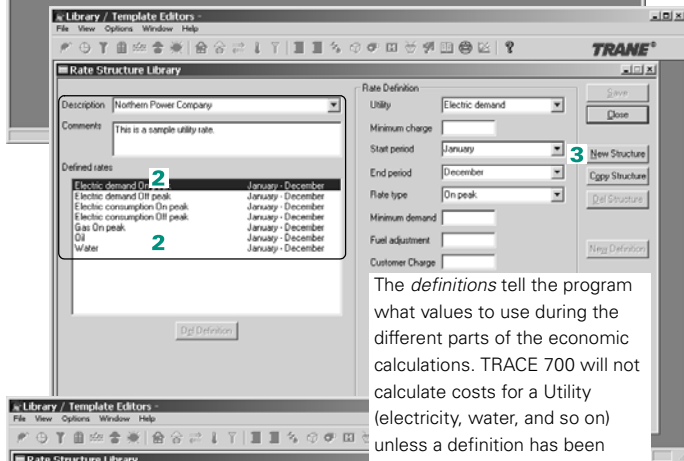
Gas:

- *Customer Charge = \$10.00 charged each month regardless of usage*
- *Rate = \$0.530/therm for the first 200 therms, \$0.499/therm for the next 300 therms, and \$0.485/therm for all remaining therms*

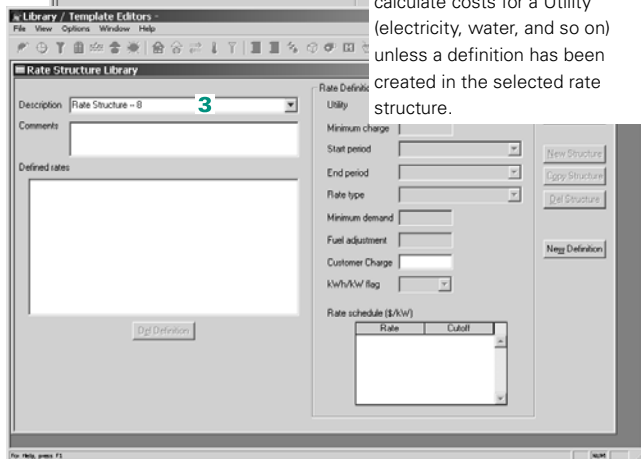
- 1 Click **Rate structures** on the **Libraries** menu. The Library/Template Editors program should open to the **Rate Structure** library.



- 2 Select the rate structure to be viewed from the **Description** list. The individual **Defined rates**, also known as *definitions*, can be found below the comments section of the rate structure.



- 3 To create a custom rate structure, click **New Rate Structure**. A new **Rate Structure** library window will open with a default rate structure name in the **Description** field.



- 4 In the **Description** field, delete the default rate structure name and enter a name of your choice. Avoid using any punctuation in the name.
- 5 Click **New Definition** to start defining the rate structure.

- 6 Select the utility that you would like to define first. In this case, start with **Electric consumption**. Next, select the **Rate type** (On peak, Off peak, and so on). If there is only one set of rates (in other words, no **Time-of-Day** schedule), the utility should be defined as On peak. Define the remaining parameters as necessary.

In this example, the utility charges \$0.062/kWh for the first 2,500 kWh, \$0.032/kWh for all remaining kWh, a customer charge of \$50.00 each month regardless of usage, and a fuel adjustment charge of \$0.0189/kWh.

*Note: Minimum charge is not the same as customer charge. Refer to **F1 Help** for additional details regarding how these two charges differ. Also, if on-peak and off-peak rates are being defined, the customer charge should only be included in one of the rates—preferably the rate that occurs each month.*

Assuming that 6,000 kWh are consumed during January, the charges from the utility company would be as follows:

- *Customer charge = \$50.00*
- *Usage charges = (2,500 kWh × \$0.062/kWh) + (3,500 kWh × \$0.032/kWh) = \$267*
- *Fuel adjustment charge = 6,000 kWh × \$0.0189/kWh = \$113.40*
- *Total charges for consumption = \$50 + \$267 + \$113.40 = \$430.40*

7 Click **New Definition** to define the next utility in the rate structure. This time, **Electric demand** will be defined. Define required parameters as necessary.

IMPORTANT NOTE: Zero cannot be entered as the rate. However, 0.00001 can be entered to approximate zero. In addition, minimum demand and ratchet are synonymous.

In this example, the utility provides the first 10 kW for free and charges \$8.45 for all remaining kW. In addition, the utility charges a minimum demand charge of 75 percent of the previous 11 months' maximum demand.

Assuming that 100 kW is the maximum demand calculated for the previous 11 months, 80 kW is the peak demand in January, and 60 kW is the peak demand in February, the charges from the utility company would be as follows:

January:

- *Minimum demand = 100 kW × 75% = 75 kW*

Note: Because the 80 kW consumed during January is more than the 75 kW minimum, the minimum demand (ratchet) does not apply.

- *Demand charges = (10 kW × \$0/kW) + (70 kW × \$8.45/kW) = \$591.50*

February:

$$\blacksquare \text{ Minimum demand} = 100 \text{ kW} \times 75\% = 75 \text{ kW}$$

Note: Because the 60 kW consumed during February is less than the 75 kW minimum, the minimum demand does apply and 75 kW would be the demand for February.

$$\blacksquare \text{ Demand charges} = (10 \text{ kW} \times \$0/\text{kW}) + (65 \text{ kW} \times \$8.45/\text{kW}) = \$549.25$$

- 8 Click **New Definition** to define the next utility in the rate structure. This time, **Gas** will be defined. Define required parameters as necessary.

Note: Cutoffs must be entered as the actual value. In this case, the second Cutoff is at 500 therms, not 300 therms.

- 9 Click **Save**, close the **Rate Structure** library, select the **Define Economics** section of TRACE 700, click **Add Rate**, and click the newly-created custom utility rate on the **Company** list.

In this example, the utility charges \$0.530/therm for the first 200 therms, \$0.499/therm for the next 300 therms, and a customer charge of \$10.00 each month, regardless of usage.

Rate	Cutoff
\$0.530	200.000
\$0.499	500.000
\$0.485	

Assuming that 600 therms of gas are consumed in January, the charges from the utility company would be as follows:

January

- $\text{Customer charge} = \10.00
- $\text{Gas usage charges} = (200 \text{ therms} \times \$0.530/\text{therm}) + (300 \text{ therms} \times \$0.499/\text{therm}) + (100 \text{ therms} \times \$0.485/\text{therm}) = \$304.20$
- $\text{Total gas charges} = \$10 + \$304.20 = \314.20

Time-of-day rate

The time-of-day rate structure is shown below.

Electricity (consumption):

- *Customer Charge = \$14.00 charged each month regardless of usage*
- *Rate = \$0.065/kWh for on-peak and \$0.040/kWh for off-peak*
- *Fuel Cost Adjustment = \$0.01/kWh for all kWh*

Electricity (demand):

- *Rate = \$10.45/kW for on-peak and \$6.05/kW for off-peak*

Note: A ratchet rate of 80 percent of the highest On-peak kW demand at this location, as determined during the preceding 11 billing months, is also incurred.

Gas:

- *Customer Charge = \$10.00 charged each month regardless of usage*
- *Rate = \$0.505/therm*

Time-of-day Schedule:

- *8 a.m.–5 p.m. Monday through Friday are on-peak*
- *All remaining hours are off-peak*

Note: Screen shots will only be provided for each definition. Refer to the stepped rate for detailed pictures and instructions. Sample calculations will be done at the end of the inputs for this rate.

1 Click **Rate structures** on the **Libraries** menu. The Library/Template Editors program should open up to the **Rate Structure** library.

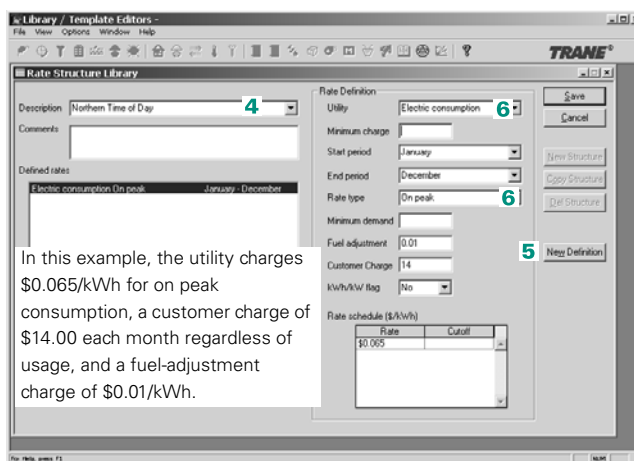
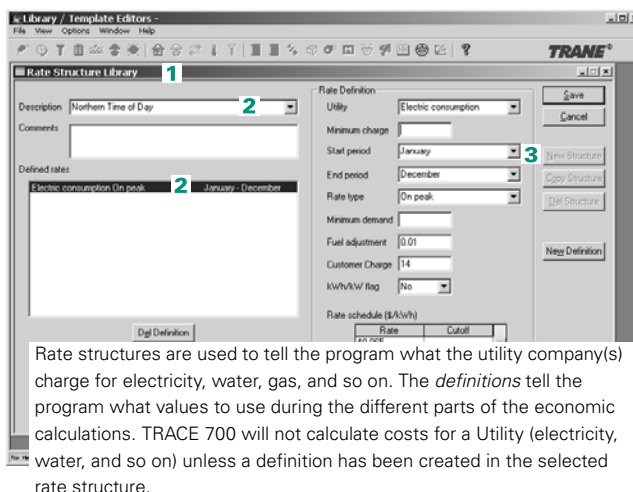
2 Click the rate structure to be viewed on the **Description** list. The individual **Defined rates**, also known as *definitions*, can be found below the comments section of the rate structure.

3 To create a custom rate structure, click **New Structure**. A new **Rate Structure** library window will open with a default rate structure name in the **Description** field.

4 In the **Description** field, delete the default rate structure name and enter a name of your choice. Avoid using any punctuation in the name.

5 Click **New Definition** to start defining the rate structure.

6 Select the utility that you would like to define first. In this case, start with **Electric consumption**. Next, select the **Rate type** (On peak, Off peak, and so on). In this case, start with On peak. Define the remaining parameters as necessary.



- 7 Click **New Definition** to define the next utility in the rate structure. This time, off peak electric consumption will be defined.

Note: Minimum charge is not the same as customer charge. Refer to F1 Help for additional details regarding how these two charges differ. Also, if on-peak and off-peak rates are being defined, the customer charge should only be included in one of the rates, preferably the one that occurs each month.

Rate Structure Library

Description: Northern Time of Day

Comments:

Defined rates:

Utility	Rate Type	Start Period	End Period
Electric consumption (On peak)	On peak	January	December
Electric consumption (Off peak)	Off peak	January	December

Rate Definition

Utility: Electric consumption

Minimum charge:

Start period: January

End period: December

Rate type: Off peak

Minimum demand:

Fuel adjustment: 0.01

Customer Charge:

kWh/kW flag: No

Rate schedule (\$/kWh)

Rate	Cutoff
\$0.040	

7 New Definition

In this example, the utility charges \$0.040/kWh for off peak consumption and a fuel-adjustment charge of \$0.01/kWh.

- 8 Click **New Definition** to define the next utility in the rate structure. This time, electric demand will be defined. Select the rate type (on-peak, off-peak, and so on). In this case, start with on-peak.

Rate Structure Library

Description: Northern Time of Day

Comments:

Defined rates:

Utility	Rate Type	Start Period	End Period
Electric consumption (On peak)	On peak	January	December
Electric consumption (Off peak)	Off peak	January	December
Electric demand (On peak)	On peak	January	December

Rate Definition

Utility: Electric demand

Minimum charge:

Start period: January

End period: December

Rate type: On peak

Minimum demand: 80

Fuel adjustment:

Customer Charge:

kWh/kW flag: No

Rate schedule (\$/kW)

Rate	Cutoff
\$10.450	

8 New Definition

In this example, the utility charges \$10.45/kW for all on-peak demand. In addition, the utility charges a minimum demand of 80 percent of the previous 11 months' maximum on-peak demand.

- 9 Click **New Definition** to define the next utility in the rate structure. This time, off-peak electric demand will be defined.

The screenshot shows the 'Rate Structure Library' window with the 'Rate Definition' tab selected. The 'Utility' field is set to 'Electric demand'. The 'Rate type' is 'Off peak'. The 'Rate schedule (\$/kW)' table shows a rate of \$6.050. The 'New Definition' button is highlighted with a red circle and the number 9.

In this example, the utility charges \$6.05/kW for all off-peak demand. In addition, the utility charges a minimum demand of 80 percent of the previous 11 months' maximum on-peak demand.

- 10 Click **New Definition** to define the next utility in the rate structure. This time, gas will be defined. Click **Save** and then click **Close**.

The screenshot shows the 'Rate Structure Library' window with the 'Rate Definition' tab selected. The 'Utility' field is set to 'Gas'. The 'Rate type' is 'On peak'. The 'Rate schedule (\$/therm)' table shows a rate of \$0.505. The 'New Definition' button is highlighted with a red circle and the number 10.

In this example, the utility charges \$0.505/therm and a customer charge of \$10.00 each month, regardless of usage.

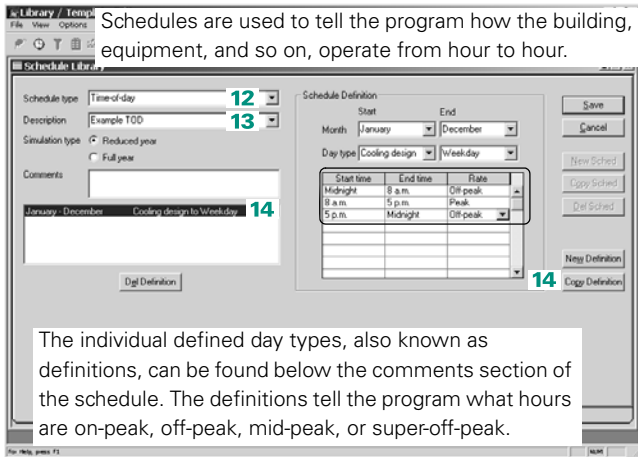
11Next, the **Time-of-day** schedule must be input to tell the program what hours are on-peak and what hours are off-peak. Click **Schedules** on the **Libraries** menu. The Library/Template Editors program should open up to the schedules.



12Select **Time-of-day** from the **Schedule Type** list.

13To create a custom schedule, click **New Schedule**. Give the schedule a name by deleting the default description and entering your own. Avoid using any non-alphanumeric characters in the name.

14Click **New Definition** to begin defining the schedule. In this example, 8 a.m. – 5 p.m. Monday through Friday is on-peak and all other hours are off-peak. Select the day types as **Cooling design to weekday** and enter the hours and the rate types.



Note: The cooling design day type should be set to reflect the day type in which the peak is expected to occur. For additional details on creating schedules, refer to "Creating schedules" on page 6–137. Also, peak and on-peak are synonymous in TRACE 700.

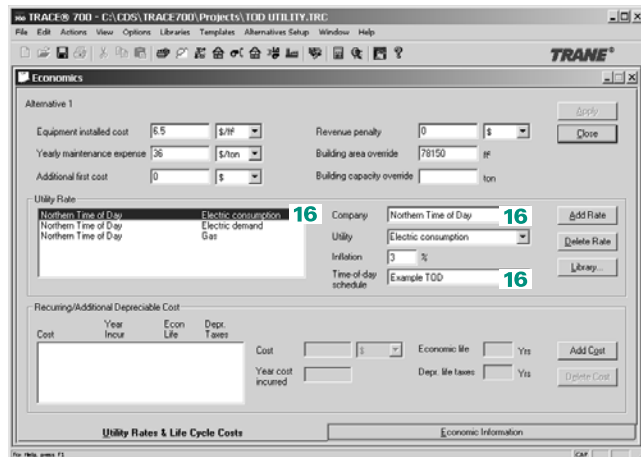
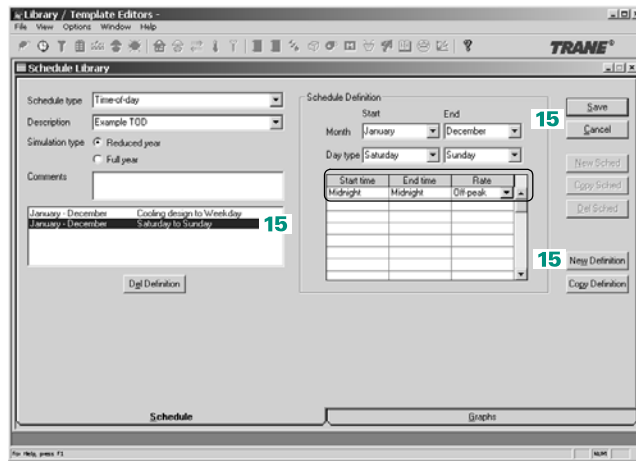
The individual defined day types, also known as definitions, can be found below the comments section of the schedule. The definitions tell the program what hours are on-peak, off-peak, mid-peak, or super-off-peak.

15 Now that the weekdays have been defined, the weekends must be defined by clicking **New Definition**. Select day types **Saturday to Sunday**, and enter the hours and rate type. Click **Save** and then click **Close**.

16 From the **Project Navigator** screen, go to the **Define Economics** section of the program and select the custom utility rate and the **Time-of-Day** schedule that were just created.

IMPORTANT NOTE:

Because there is not an off-peak rate defined for gas, the utilities must be selected individually and no time-of-day schedule should be selected for gas. If this is not done, all gas consumption that occurs during hours that are not defined as on-peak in the time-of-day schedule will be free.



Sample Calculation

Assuming that 6,000 kWh are consumed during January (3,500 kWh on-peak and 2,500 kWh off-peak), the charges from the utility company would be as follows:

- Customer charge = \$14.00
- On-peak usage charges = 3,500 kWh x \$0.065/kWh
= \$227.50
- On-peak fuel-adjustment charge = 3,500 kWh x \$0.01/kWh
= \$35.00

- *Total on-peak charges for consumption = \$14 + \$227.50 + \$35.00 = \$276.50*
- *Off-peak usage charges = 2500 kWh x \$0.040/kWh = \$100.00*
- *Off-peak fuel-adjustment charge = 2500 kWh x \$0.01/kWh = \$25.00*
- *Total off-peak charges for consumption = \$100.00 + \$25.00 = \$125.00*

Assume that 100 kW is the maximum demand calculated for the previous 11 months; that 80 kW is the maximum on-peak demand and 60 kW is the maximum off-peak demand in January; and that 65 kW is the maximum on-peak demand and 50 kW is the maximum off-peak demand in February. The charges from the utility company would be as follows:

January

- *Minimum demand = 100 kW x 80% = 80 kW. Because the 80 kW on-peak demand during January is equal to the 80 kW minimum, then the minimum demand does not apply.*
- *On-peak demand charges = 80 kW x \$10.45/kW = \$836.00*
- *Off-peak demand charges = 60 kW x \$6.05/kW = \$363.00*

February

- *Minimum demand = 100 kW x 80% = 80 kW. Because the 65 kW on-peak demand during February is less than the 80 kW minimum, then the minimum demand does apply and 80 kW would be the demand for February.*
- *On-peak demand charges = 80 kW x \$10.45/kW = \$836.00*
- *Off-peak demand charges = 50 kW x \$6.05/kW = \$302.50*

Assuming that 500 therms of gas are consumed in January, the charges from the utility company would be as follows:

January

- *Customer charge = \$10.00*
- *Gas usage charges = 500 therms x \$0.505/therm = \$252.50*
- *Total gas charges = \$252.50 + \$10.00 = \$262.50*

Stepped rate with a kWh/kW flag

The kWh/kW flag activates what is also called a floating cutoff. This allows the cutoff levels for each month to vary, depending on the maximum demand for each month.

Note: Only the consumption portion of the rate structure is shown below. For examples of standard stepped rates, please refer to the stepped-rate example on page 6–150.

Electricity (consumption):

Customer Charge = \$200.00 charged each month regardless of usage

Rate:

For the first 100 kWh per kW of billing demand per month:

- \$0.06 per kWh for the first 1,000 kWh
- \$0.05 per kWh for the next 9,000 kWh
- \$0.04 per kWh for all over 10,000 kWh

For the next 110 kWh per kW of billing demand per month:

- \$0.055 per kWh for the first 1,000 kWh
- \$0.035 per kWh for all over 1,000 kWh

For all kWh over 210 kWh per kW billing demand per month:

- \$0.03 per kWh for all kWh

To better illustrate how this rate structure works, a sample calculation for two months will be shown first, and then the inputs for TRACE 700 will be shown.

Month	Demand (kW)	Consumption (kWh)
January	250 kW	50,000 kWh
February	200 kW	35,000 kWh

January

The cutoffs are determined by the kWh/kW floating cutoffs:

- $100 \text{ kWh/kW} \times 250 \text{ kW} = 25,000 \text{ kWh}$
- $210 (100+110) \text{ kWh/kW} \times 250 \text{ kW} = 52,500 \text{ kWh}$

For the month of January, this translates to the following rate structure:

- $0-1,000 \text{ kWh @ } \$0.06/\text{kWh}$
- $1,001-10,000 \text{ kWh @ } \$0.05/\text{kWh}$
- $10,001-25,000 \text{ kWh @ } \$0.04/\text{kWh}$
- $25,001-26,000 \text{ kWh @ } \$0.055/\text{kWh}$
- $26,001-52,500 \text{ kWh @ } \$0.035/\text{kWh}$
- $52,501-\text{infinity kWh @ } \$0.03/\text{kWh}$

Actual consumption = 50,000 kWh (from table on page 6–132)

Consumption charges:

$$\begin{aligned} &1,000 \text{ kWh} \times \$0.06/\text{kWh} \\ &+ 9,000 (10,000-1,000) \text{ kWh} \times \$0.05/\text{kWh} \\ &+ 15,000 (25,000-10,000) \text{ kWh} \times \$0.04/\text{kWh} \\ &+ 1,000 \text{ kWh} \times \$0.055/\text{kWh} \\ &+ 24,000 (50,000-25,000+1,000) \text{ kWh} \times \$0.035/\text{kWh} \\ &+ \$200 \text{ (customer charge)} \\ &= \$2,205 \end{aligned}$$

February

The cutoffs are determined by the kWh/kW floating cutoffs:

- $100 \text{ kWh/kW} \times 200 \text{ kW} = 20,000 \text{ kWh}$
- $210 (100+110) \text{ kWh/kW} \times 200 \text{ kW} = 42,000 \text{ kWh}$

For the month of January, this translates to the following rate structure:

- $0-1,000 \text{ kWh @ } \$0.06/\text{kWh}$
- $1,001-10,000 \text{ kWh @ } \$0.05/\text{kWh}$

- 10,001-20,000 kWh @ \$0.04/kWh
- 20,001-21,000 kWh @ \$0.055/kWh
- 21,001-42,000 kWh @ \$0.035/kWh
- 42,001-infinity kWh @ \$0.03/kWh

Actual consumption = 35,000 kWh (from table above)

Consumption charges:

$$\begin{aligned}
 &1,000 \text{ kWh} \times \$0.06/\text{kWh} \\
 &+ 9,000 \text{ (10,000-1,000) kWh} \times \$0.05/\text{kWh} \\
 &+ 10,000 \text{ (20,000-10,000) kWh} \times \$0.04/\text{kWh} \\
 &+ 1,000 \text{ (21,000-20,000) kWh} \times \$0.055/\text{kWh} \\
 &+ 14,000 \text{ (35,000-21,000) kWh} \times \$0.035/\text{kWh} \\
 &+ \$200 \text{ (customer charge)} \\
 &= \$1,655
 \end{aligned}$$

Note: Rate structures are used to tell the program what the utility company(s) charge for electricity, water, gas, and so on. The individual defined rates, also known as definitions, can be found below the comments section of the rate structure. The definitions tell the program what values to use during the different parts of the economic calculations. TRACE 700 will not calculate costs for a utility (electricity, water, and so on) unless a definition has been created in the selected rate structure.

1 Click **Rate Structures** on the **Libraries** menu. The Library/Template Editors program should open up to the rate structures.

2 To create a custom rate structure, click **New Structure**. Give the rate structure a name by deleting the default description and entering your own. Avoid using any non-alphanumeric characters in the name.

3 Click **New Definition** to start defining the rate structure, and select the utility that you would like to define first. In this case, start with electric consumption.

The screenshot shows the 'Rate Structure Library' dialog box in the TRANE software. The 'Description' field is set to 'Floating Cut-Off Rate'. The 'Start period' is 'January' and the 'End period' is 'December'. The 'Rate type' is 'On peak'. The 'Minimum demand' is 100. The 'Fuel adjustment' is 0.00. The 'Customer Charge' is 200. The 'kWh/kW flag' is 'Yes'. The 'Rate schedule (\$/kWh)' table shows a rate of \$0.020 for a cutoff of 1000.000. The 'New Definition' button is highlighted with a green box.

In this example, the utility charges are based on the preceding rate structures, which include a kWh/kW flag. After selecting electric consumption, the kWh/kW flag should be selected as yes. Selecting yes causes the program to interpret cutoffs below 500 as having the units of kWh/kW (variable cutoffs) and cutoffs above 500 as having units of kWh (standard). The kWh/kW cutoff is a way that utility companies penalize the consumer by floating their kWh consumption cutoffs based on the kW demand required that month. TRACE 700 will use monthly kW demand to apply to the kWh/kW cutoff to determine the monthly kWh consumption cutoffs. Therefore, the kWh consumption cutoffs will change monthly based on the demand determined by the program.

Additional Items

- 1 Time-of-use rates are a cross between stepped rates and time-of-day rates. Please refer to "Stepped rate" on page 6–150 and "Time-of-day rate" on page 6–155 for instructions for inputting each individual definition.
- 2 If the rates do not apply year-round, definitions can be created on a partial-year basis. For example, if, during the summer months, the kW is charged differently, a separate definition can be created.

Note: Definitions cannot wrap around a year. For example, September to May would not be a valid input for the Start and End Months. January to May and September to December would have to be input as two separate definitions to compliment the definition.

Example for
Additional Item 2:

Rate Structure Library

Description: Northern Time of Day

Comments:

Defined rates:

- Electric demand On peak: June - August
- Electric consumption On peak: January - December
- Gas On peak: January - December
- Electric demand Off peak: January - December
- Electric consumption Off peak: January - December

Rate Definition:

Utility: Electric demand

Minimum charge:

Start period: June

End period: August

Rate type: On peak

Minimum demand:

Fuel adjustment:

Customer Charge:

kWh/kW flag: No

Rate schedule (\$/kWh):

Rate	Cutoff
\$1.000	

Buttons: Save, Cancel, New Structure, Copy Structure, Del Structure, New Definition, Del Definition

- 3 Select *Reduced year* for the **Time-of-Day** schedule if the default calculation methodology is being used, or if all of your weekdays are charged the same rate. Switch to *Full year* if Mon-Fri have different rates, if you are using the 8760 calendar, *and* if you imported 8760 weather. *Reduced year* schedules can be used in 8760 simulations. *Full year* schedules should not be used in reduced-year simulations.

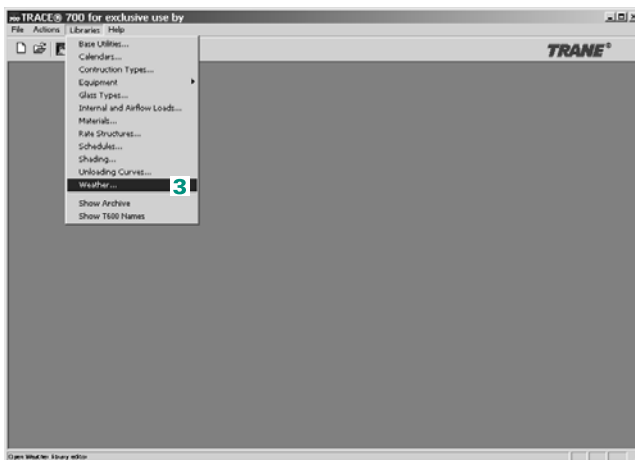
Adding weather locations and activating the 8760 calculation methodology

The TRACE 700 weather library contains more than 500 worldwide reduced-year weather locations. Users can add new reduced-year weather and new 8760 weather locations by using the weather import feature. This example discusses adding a new reduced-year and 8760 weather location (steps 1-9) and switching from the reduced year to 8760 methodology (steps 10-12).

1 Find the weather location that you want to import from <http://doe2.com/Download/Weather/> or another Web site that has 8760 weather or an importable format. Refer to Step 5 to determine importable formats.

2 Download the weather file and rename the weather.bin files to the appropriate extension. For example, a lacrosse.bin weather file in the .tmy format should be downloaded and then renamed to Lacrosse.tmy before the import occurs.

3 Click **Weather** on the **Libraries** menu -- the Library/Template Editors program opens to the **Weather** library.



4 Click **Import**.

5 On the **Files of Type** menu, select the type of weather that you would like to import (TMY, TM2, TRY WYEC, WYEC2, IWC, and so on). Select the weather file that you have downloaded and renamed, and click **Open**.

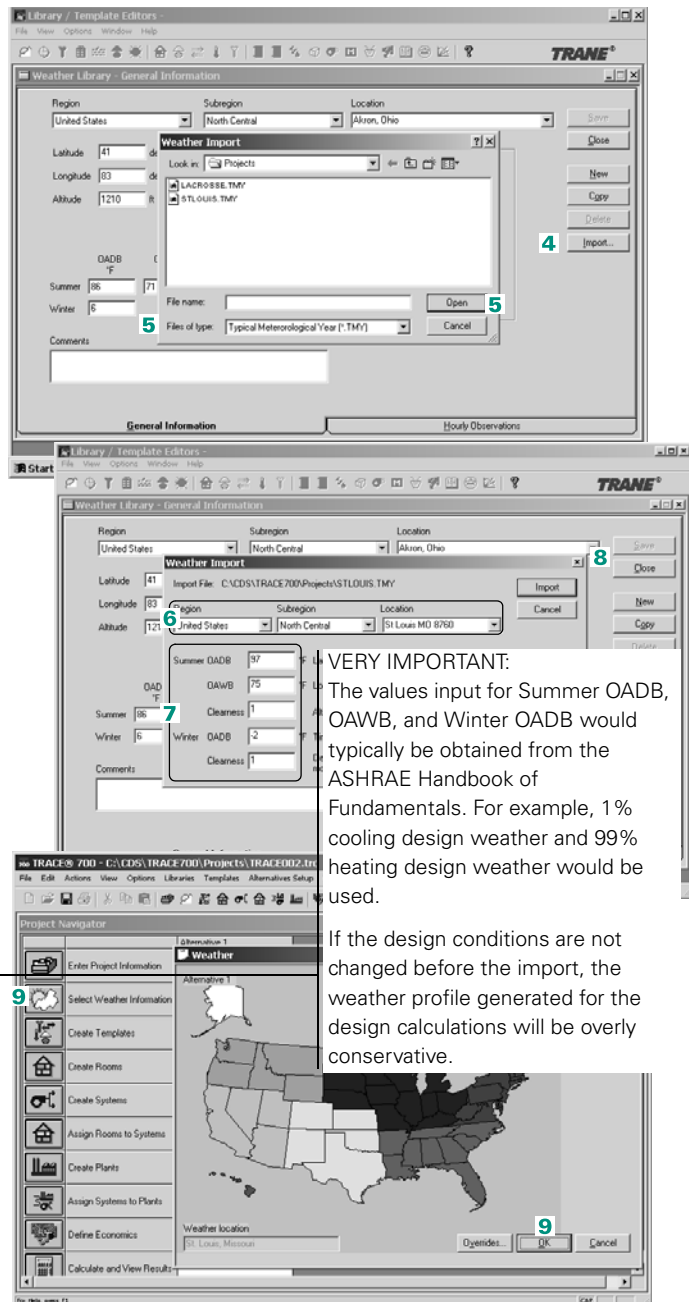
6 Select the Region and Subregion, and then input the name of the **Location**. Avoid using special characters like percent signs, apostrophes, quotation marks, and so on.

Note: You CANNOT use the same names that are currently being used by existing weather locations.

7 Change the design conditions that appear on the left-hand side of the **Weather Import** screen to the desired design conditions. Then click **Import**.

8 Save and then close the Library/Template Editors program and return to your project.

9 Click **Select Weather Information**, choose the appropriate subregion and the weather location, and click **OK**.



VERY IMPORTANT:
The values input for Summer OADB, OAWB, and Winter OADB would typically be obtained from the ASHRAE Handbook of Fundamentals. For example, 1% cooling design weather and 99% heating design weather would be used.

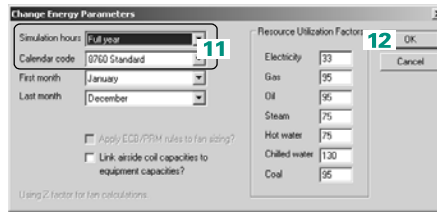
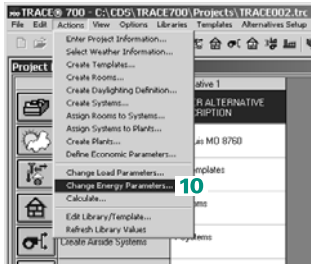
If the design conditions are not changed before the import, the weather profile generated for the design calculations will be overly conservative.

Do the following to activate the 8760/Full Year simulation: (only required to run an 8760/full year analysis—not needed if only adding a new weather location)

10 On the **Actions** menu, click **Change Energy Parameters**.

11 In the **Change Energy Parameters** window, change the Simulation hours to *Full year* and the Calendar code to *8760 Standard*.

12 Click **OK** and run all the sections of the simulation.



Note: When an 8760 weather file is imported, the actual (.tmy, .try, and so on) file is used during a full-year (8760) simulation. The original file must be kept in the location in which it resided during the import. During the import process, the associated reduced-year energy analysis weather and design weather are created. The reduced-year energy analysis weather is only used if the user selects a reduced-year simulation, whereas the design-year weather is used by the design simulation to calculate the design airflows and capacities of all coils.

Altering a load design file for energy analysis

The purpose of this section is to show what steps need to be taken to convert a typical file from a load-calculation-only model to a load, energy, and economic-analysis model. The actual inputting of the plants and economics will not be covered. Only changes and/or new inputs in the **Create Rooms** and **Create Systems** sections will be covered.

Rooms tab of Create Rooms

Room area inputs

Check to determine if large areas with exterior exposures (10,000 ft²+) are being modeled as a single space. An example of this would be a one-room input for an entire floor of a building. This will lead to the internal loads negating the envelope losses, and an underestimation of the design loads and energy consumption. Refer to “Modeling large rooms and zones” on page 6–45 for a detailed explanation. To correct this issue, use at least 5 rooms per building, floor, or wing (4 perimeter and one interior space). The New File Wizard can be used to accomplish this with minimal effort. Refer to “Quick building inputs via the New File Wizard” on page 6–110 for additional information.

Thermostat inputs

In the load-design calculations, TRACE 700 only requires inputs for the occupied cooling and heating setpoints. In energy analysis, TRACE 700 will need to know if these setpoints are constant, or if a control strategy that uses night setback or driftpoints will be used. The default values for the thermostat driftpoints are 90°F and 55°F respectively. This means that whenever there are 5 percent or less of the people in the space (determined from the people schedule on a room-by-room basis), the room will be allowed to drift up to 90°F or down to 55°F before the equipment turns back on. If the building control system is not going to allow the room setpoints to setback this far, the values need to be overridden. If the user would prefer to have TRACE 700 change the room setpoints based on the hour of the day, the **Thermostat** schedules can be used. Typically, users need to create their own **Thermostat** schedules (CSTAT and

HSTAT should never be used for the **Thermostat** schedules. They are intended to show the flexibility of the **Thermostat** schedules).

*Note: The schedules override the setpoint and drift-point entries for energy-analysis calculation, and inputting unrealistic driftpoints or creating unrealistic **Thermostat** schedules can lead to an underestimation of cooling and heating energy.*

Also, the cooling and heating setpoints should typically not be input as the same value. Thermostat setpoints should have at least a degree of separation to model the drift in the thermostat. Not correcting this input will result in cycling of the cooling and heating equipment, and possibly an overestimation of the energy used by the equipment.

Internal Load tab of Create Rooms

Internal load schedules

Ensure that the Cooling Only (Design) schedule is not selected for the internal loads. This schedule should typically only be used for design calculations, not for energy analysis. It simulates 100 percent of the internal loads in the building, 24 hours a day, for energy analysis. This tends to lead to an overestimation of cooling energy and an underestimation of heating energy. Select an internal-loads schedule that will provide a realistic load profile for the building.

Also, ensure that the internal loads are not scheduled as **Available 100%**. This schedule should typically not be used for internal loads. It simulates 100 percent of the internal loads in the building 24 hours a day, which may not be what is actually occurring in the building. In addition, it also tells the program to take credit for the internal loads during the heating-design calculation. This tends to lead to an overestimation of cooling energy, an underestimation of heating energy, and undersizing of the heating coils, due to the internal loads meeting all or most of the heating loads.

If custom schedules are being used for the internal loads, be sure to check the accuracy of the inputs for the Weekday, Saturday, and Sunday day types. To view the schedule, click **Schedules** on the **Libraries** menu and select **Utilization** as the **Schedule** type.

For additional details on schedules, please refer to “Creating schedules” on page 6–137.

Energy meter

Verify that the energy meter for the miscellaneous equipment has the correct utility type selected (usually electricity). If the energy meter is not selected, then the heat from the miscellaneous equipment will still be accounted for, but the energy consumed by the miscellaneous equipment will not be accounted for.

Airflows tab of Create Rooms

Ventilation schedules

Ensure that the ventilation schedule is not an internal-loads schedule or the same as the internal-load schedule used on the **Internal Load** tab (any schedule that starts with People, Lights, or Misc is an internal-load schedule). Internal-load schedules should never be used for ventilation. Internal-load schedules are zero percent for the heating-design calculation. This will cause the program to give no ventilation load for heating design. This tends to lead to undersizing of the heating coils. To view the schedule, click **Schedules** on the **Libraries** menu and select **Utilization** as the **Schedule** type. Here you should be able to view the schedule and find schedules that will give more-accurate results. Typically, selecting a ventilation schedule for the ventilation, or copying the people schedule and making heating design 100 percent midnight-to- midnight, will give more-accurate results. Also, if a custom schedule is being used, be sure that the heating-design day type for the ventilation schedule does not have hours that are less than 100 percent.

VAV minimum

Ensure that the entered VAV minimum stop is not too low (less than the entered ventilation rate). Low minimum stops may cause insufficient airflow in heating mode and improper ventilation for VAV systems only.

The VAV minimum stop schedule in all of the rooms should be the schedule **Available 100%**. The only time this schedule should be changed is for a VAV box with two minimum stop settings or for systems with morning warm-up. The VAV system may not

operate properly if any other schedule is used, and heating energy may be underestimated.

Options tab of Create Systems

Verify that any heat-recovery devices, economizers, or evaporative cooling have been input. A user may choose to ignore these items during the design calculations, but they must be accurately accounted for in energy-analysis calculations.

Fans tab of Create Systems

Fan type and static pressure

Verify that the fan static pressure and fan type have been input for every fan that exists on the system. Without fan static pressures and fan types, the program cannot calculate fan energy or fan heat pickup.

Fan schedule

Ensure that all available fan schedules include a heating-design definition that is midnight-to-midnight 100 percent. The schedule **Available 100%** is an example of a fan schedule that would be acceptable. If a fan is scheduled as **Cooling Only (Design)** or uses an internal loads schedule (**People – Office** for example), **Available 100%** or another appropriate schedule should be selected instead.

Also, be sure that if a fan schedule has been input (other than **Available 100%**), that the actual system has the ability to turn off the fan based on time. If the fans cycle in conjunction with driftpoints, then a fan-cycling schedule should be used instead (found at the top of the screen). If the fans turn off for a specific time period regardless of the temperature in the space, a fan schedule should be used. To view the schedule to verify accuracy, click **Schedules** on the **Libraries** menu and select **Utilization** as the **Schedule** type.

Coils tab of Create Systems

This tab should rarely be used, but can be used to remove or schedule coils on and off based on time. If a coil needs to be removed, it is typically best to schedule the coil off instead of zeroing the capacity. For most cases, it is strongly recommended not to zero out a coil or schedule it off. For example, if the reheat

coil or main coil are zeroed or turned off in a VAV with reheat system, the design and/or energy analysis calculations will be incorrect. In this system, the reheat and main-heating coils are actually the same coil (the heating coil in the terminal device). Main is used in heating mode and reheat is used in reheat mode. Please refer to the **System Type Characteristics** section of the Help file for additional information related to coil sizing and location. In general, schedules should not be entered for the coils. The default schedules need to be used for the coils to operate properly. The schedules for internal loads, ventilation, and so on, are the appropriate place to adjust the loads seen by the coils.

Additional items

- 1** It is usually easier to make changes to the **Create Rooms** section of the programs via the **Templates**. For instructions on using templates, please refer to “Using templates” on page 6–125.
- 2** For assistance inputting the plants, assigning the coils, and creating utility rates, please refer to the appropriate sections of this manual, for instance, “Creating utility rates” on page 6–150.

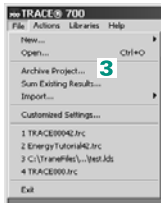
Archiving and un-archiving instructions (storing library members with project files)

To simplify the process of transferring TRACE 700 files between computers, an **Archive Project** utility has been created. This utility will generate a single compressed file containing *all* of the project information, including the custom library members used in the file.



To create an archive file:

- 1 Verify that the file name of the job to be archived is 15 characters or less. If longer than 15 characters, choose **File** and **Save As** and shorten the file name.
- 2 Close the project file by clicking **Close** on the **File** menu (if a project is open).
- 3 Click **Archive Project** on the **File** menu.
- 4 Select the desired file (*filename.TRC*) to be archived and click **Open**.



Note: After the archive process is complete, a message appears stating that the archive file (filename.TAF) has been created.

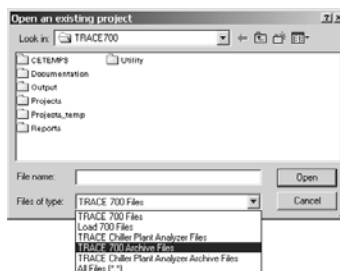
Note: Archiving is a good way to save files that might be retrieved at a later date.

- Filenames must be 15 characters or less. (No special characters, dashes, commas, and so forth.)
- Original Full Year 8760-hour weather files (*.TMY, *.TRY, and so forth) must be transferred separately.
- Chiller Plant Analyzer files must also transfer the filename.os1 separately.
- The archive utility will clean the project file, recovering unused memory. It will also attempt to fix corrupted data set items.
- A backup of the original project file will be created. (A date stamp will be added to the backup file name.)
- Only custom library members used in the file will be transferred with the archive file.
- The archived file will be located in the same directory in which the project file (.trc) is located.



To open an archive file:


- 1 To open an archive file, change the file type to *TRACE 700 Archive files* and select the appropriate *.TAF file.
- 2 Opening an archive file may take a few minutes. The duration depends on the complexity of the file (number of rooms and systems) and the number of custom library members.



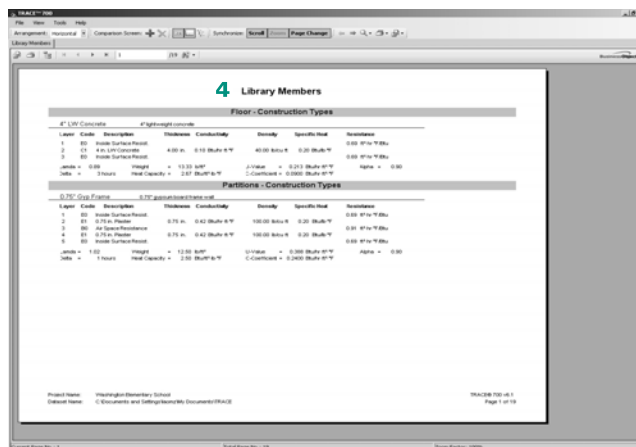
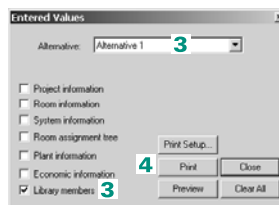
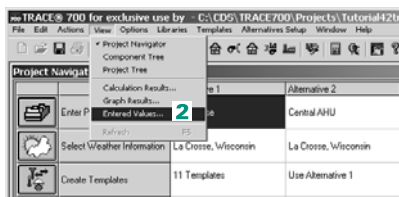
Note: When opening a TRACE 700 Archive File (filename.TAF), the utility will automatically extract the TRACE 700 project file (filename.TRC) and import the custom library members. If library members with the same name exist, TRACE 700 will prompt the user.

Printing used library members

When submitting an analysis for review, it is often necessary to print out all schedules, construction types, equipment, and so forth, used in the file. The **Entered Values** section of TRACE 700 allows users to print all library members used in a file.

 To print all library members used in an alternative:

- 1 Open TRACE 700 and the desired project file.
- 2 Click **Entered Values** on the **View** menu.
- 3 Select the alternative containing the library members you would like to print, and select the **Library members** box.
- 4 Click **Print** to print the library members or click **Preview** to preview them.

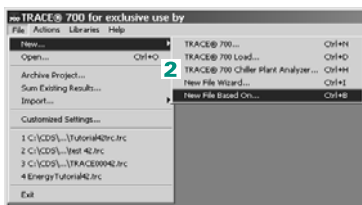


Combining files

When working on large projects, it is often useful to divide the model into separate files and then combine the individual projects into one merged file. The **New File Based On** feature allows this to be done.

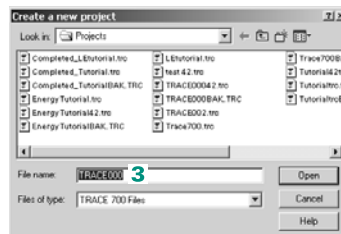
Note: It is VERY IMPORTANT to back up data before attempting the merge process.

- 1 If a project file is open, click **Close** on the **File** menu.
- 2 Click **New** and then **New File Based On** on the **File** menu.

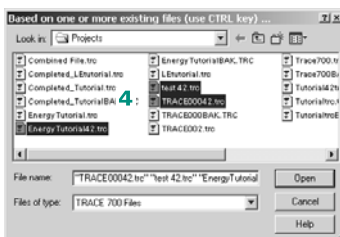


- 3 Enter a name for the **NEW** combined file and click **Open**.

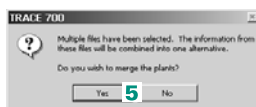
VERY IMPORTANT: If an existing file name is selected, THE FILE WILL BE ERASED!



- 4 Select the existing projects to be merged. Highlight the first file to be merged and then hold down the **Ctrl** key while clicking on the other file(s) to be merged.



- 5 Decide if you would like to merge the cooling and heating plants for the files.

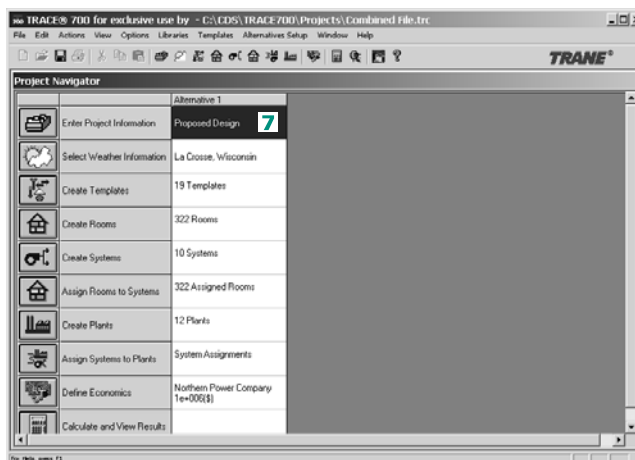


- 6 Select the alternative that will be merged into the file.

Note: For all files after the first file, a unique prefix will be entered so that the templates, airside systems, and so on, all have unique names.



- 7 TRACE 700 will create a new file with all of the selected files' data combined.



Additional item

- 1 All files that are to be combined should have the same weather location and the same input data under **Change Load Parameters** on the **Actions** list.

Creating a new file based on an existing file

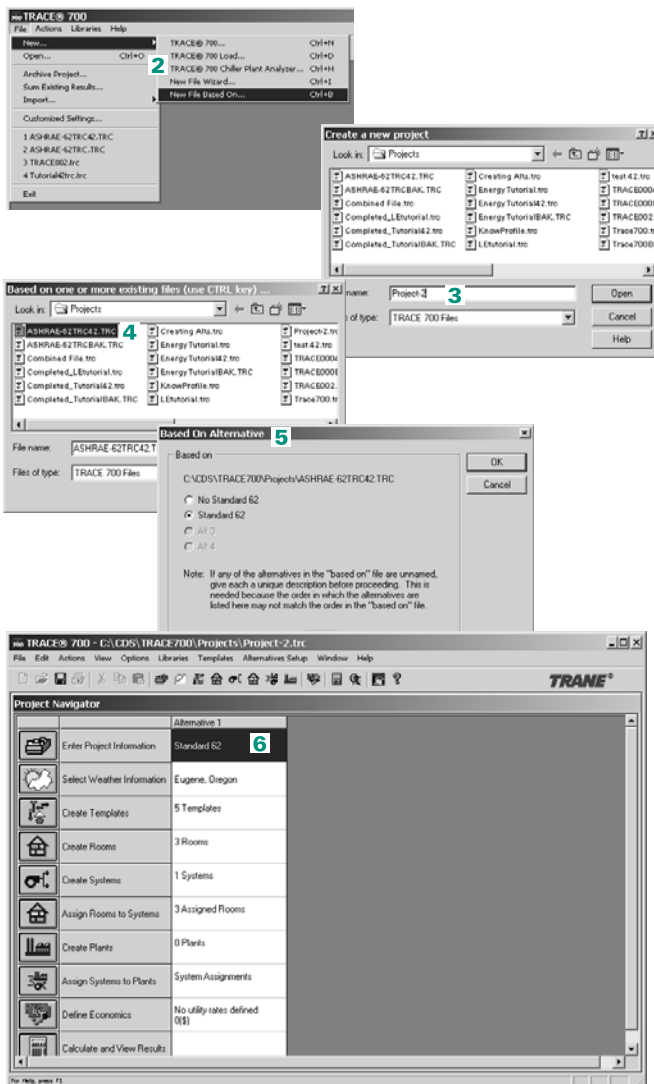
To create a new file using an alternative from another file, the **New File Based On** feature can be used.

*Note: **VERY IMPORTANT:** It is recommended that you back up or archive the existing file before beginning this process!*

- 1 If a project file is open, click **Close** on the **File** menu.
- 2 Click **New** and then **New File Based On** on the **File** menu.
- 3 Enter a name for the **NEW** file and click **Open**.

*Note: **VERY IMPORTANT:** If an existing file is selected, IT WILL BE ERASED!*

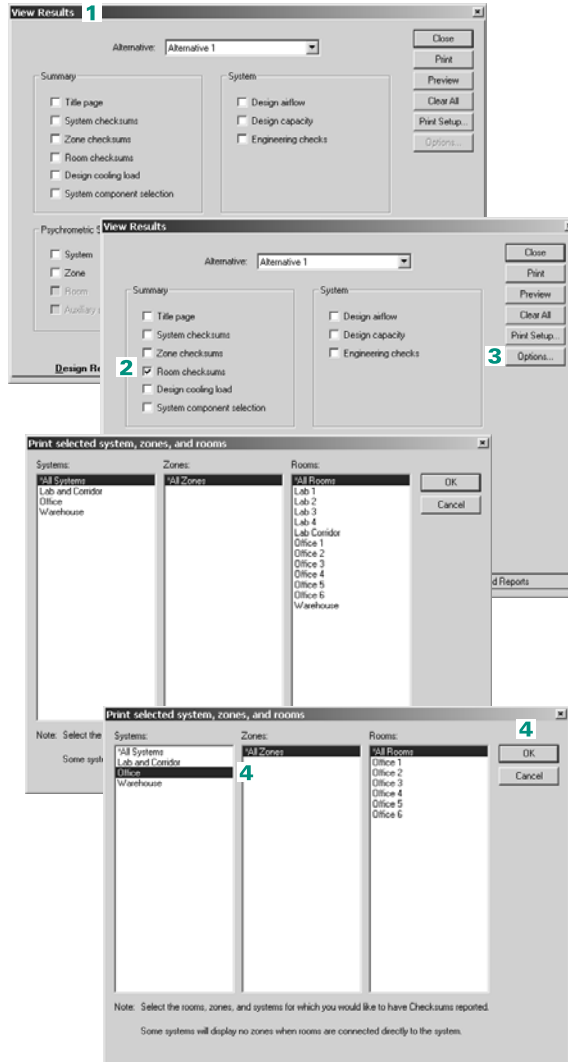
- 4 Select the existing project and click **Open**.
- 5 Select the alternative that will be used in the new file.
- 6 TRACE 700 will create a new file with the selected alternative as Alternative 1.



How to sort output

TRACE 700 creates **Checksums** output reports at three different levels – system, zone, and room. It is often desirable to view only certain room and/or system output reports.

- 1 After a file has been calculated, go to the **View Results** section of TRACE 700.
- 2 Select the desired **Checksums** report(s).
- 3 This will activate the **Options** button on the right-hand side of the screen. Click **Options** to view the reports available for sorting. All input system(s), zone(s), and room(s) should appear in the **Print selected system, zones, and rooms** screen.
- 4 Select the desired system(s), zone(s), or room(s) by clicking them and then click **OK**. The program will return to the **View Results** screen.
- 5 In this example, only the information for the Office system and rooms has been selected.
- 6 When back on the **View Results** screen, click **Print** to print the selected output reports, or click **Preview** to preview the selected output reports.



gbXML import and export

The import gbXML (Green Building XML) feature will import data into a TRACE 700 project file based on building dimensional information exported from a CAD drawing. The CAD software must have the capability of generating an XML file that meets the Green Building XML requirements, such as Autodesk® Building Systems 2005.

The generated TRACE 700 file will have the rooms defined (floors, walls, windows, and so forth). Note that users have the option of selecting what data to import from the CAD model into TRACE 700. The user will then need to define the template information for the file (internal load information, construction types, and ventilation airflows) to refine the room inputs. After running the simulation, output information from the TRACE 700 program can be exported back to the CAD model (space airflows, heat/cooling loads, and so forth).

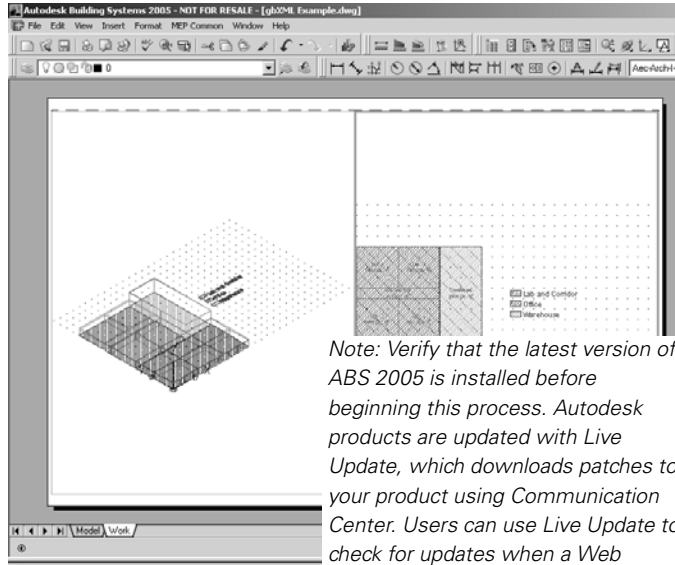
The gbXML standard is in the process of being accepted by most CAD vendors. Autodesk and Bentley will likely be the first two vendors to use this feature. The import has been implemented in TRACE 700 for a few years now (leading the industry) and the export functionality is available in version 4.1.5 or greater.

C.D.S. has completed similar development with VariTrane Duct Designer. VDD can now import files using ddXML. Analysis can then be performed on the duct design and sizing/pressure detail information can be returned directly to the CAD model through an export feature in the program.

For additional information specific to gbXML, go to <http://www.gbxml.org>.

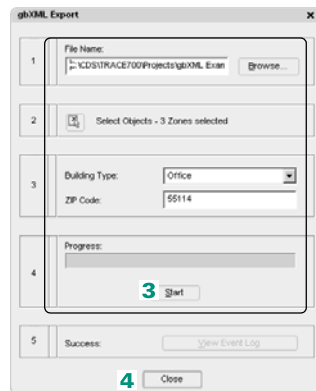
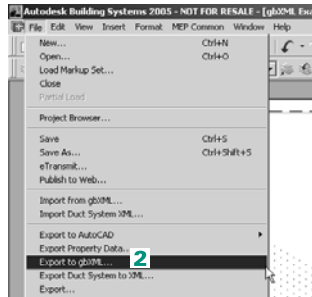
Exporting gbXML data from Autodesk Building Systems 2005

- 1 Open the drawing file in the Autodesk Building Systems (ABS) 2005 in this case.



Note: Verify that the latest version of ABS 2005 is installed before beginning this process. Autodesk products are updated with Live Update, which downloads patches to your product using Communication Center. Users can use Live Update to check for updates when a Web connection is established. If a product patch is available, notification of its availability is received on the AutoCAD status bar, and the patch can be either downloaded directly from an Autodesk server or modified first before being copied to users' workstations.

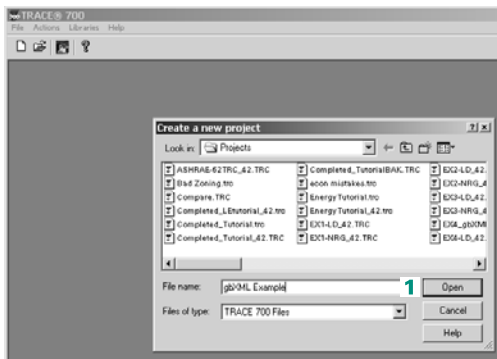
- 2 On the **File** menu, click **Export to gbXML**.
- 3 Select the destination for exporting the **gbXML** data and the number of zones to export, input the building type and zip code, and click **Start** to begin the export process.
- 4 When finished, click **Close** and exit out of ABS 2005.
- 5 Using Windows Explorer, place the gbXML export file into the TRACE 700 Projects directory. Typically, this will be C:\CDSTRACE700\Projects.



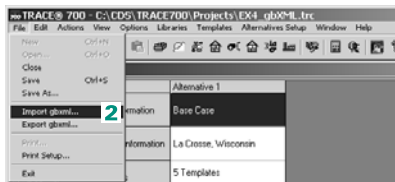
Importing gbXML data in TRACE 700

- 1 Open TRACE 700 and start a new file. On the **File** menu, click **New**, then TRACE 700, then enter a name for the file and click **Open**.

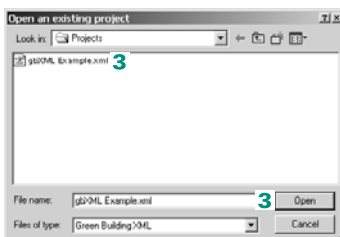
*Note: Verify that the latest version of TRACE 700 is installed before beginning this process. Updates can be downloaded by going to the **Help** menu, clicking **Trane on the Web**, and clicking **Check for Updates**, or by visiting the Download Center at www.tranecds.com.*



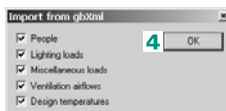
- 2 On the **File** list, click **Import gbXML**.



- 3 Navigate to the .xml file that was created during the export from ABS 2005 and click **Open**.



Note: If errors occur during the import process, please install the latest MSXML from Microsoft from: <http://support.microsoft.com/default.aspx?scid=fh;EN-US;sp>



- 4 Select the desired information to import from the gbXML file and click **OK**.

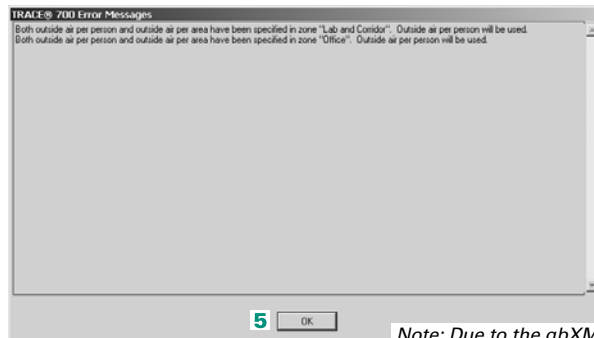
5 Note any error messages that occur during the import process and click **OK**. Be sure to verify the inputs that relate to the error messages in the TRACE 700 input file. In this case, ventilation airflows were input in two ways in the CAD file. Therefore, one of the methods was selected to be used in the import.

6 Verify/refine the inputs in **Create Rooms** and/or use templates to make changes in mass (refer to “Using templates” on page 6–125 for details on how templates work).

7 Add additional details to the airside systems in **Create Systems**.

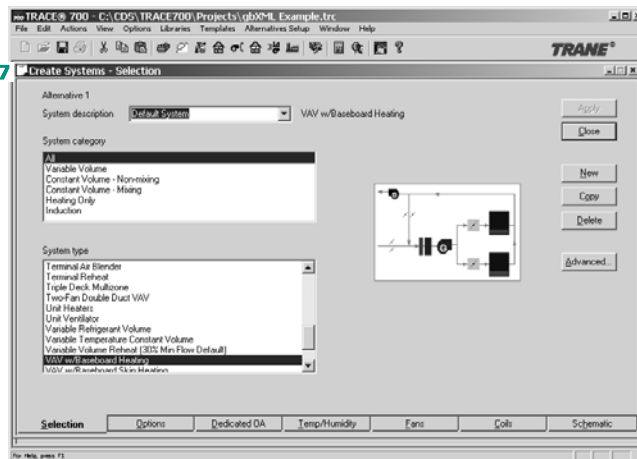
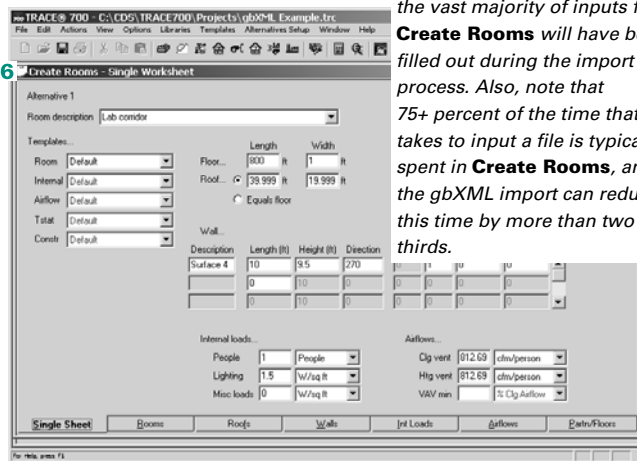
8 Reassign the rooms to the refined systems in **Assign Rooms to Systems** (for details on how to zone rooms in TRACE 700, please refer to “Zoning of rooms” on page 6–47). From this point on, the TRACE 700 project file will function as a typical TRACE 700 file.

Note: For details on creating cooling and heating plants, refer to Chapter 3 in this manual. For details related to inputting utility rate information, refer to “Creating utility rates” on page 6–150.



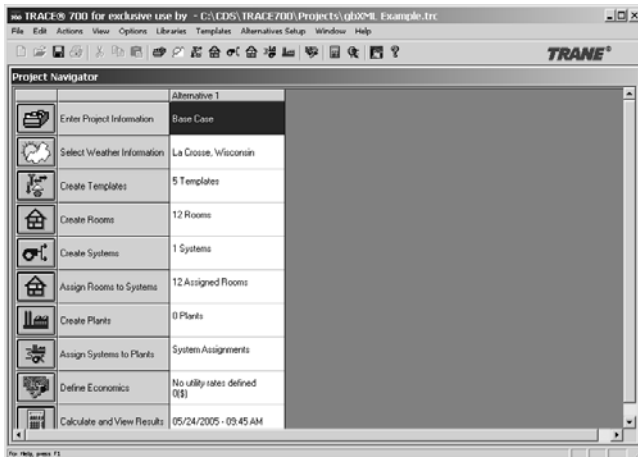
5

*Note: Due to the gbXML import, the vast majority of inputs for **Create Rooms** will have been filled out during the import process. Also, note that 75+ percent of the time that it takes to input a file is typically spent in **Create Rooms**, and the gbXML import can reduce this time by more than two thirds.*

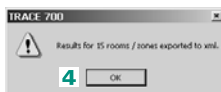
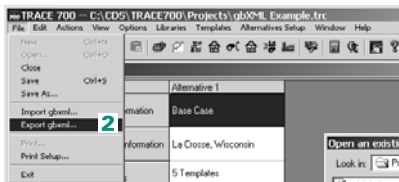


Exporting gbXML data from TRACE 700

- 1 Open TRACE 700, open the project file (filename.trc), and calculate at least the design section.

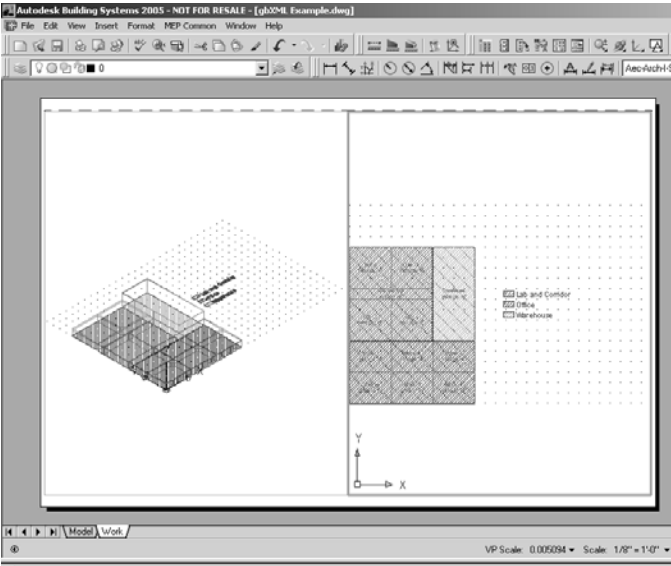


- 2 On the **File** menu, click **Export gbXML**.
- 3 Select the existing .xml file that was used during the import process.
- 4 When the export is complete, the information for the rooms plus zones will have been exported to the xml file.

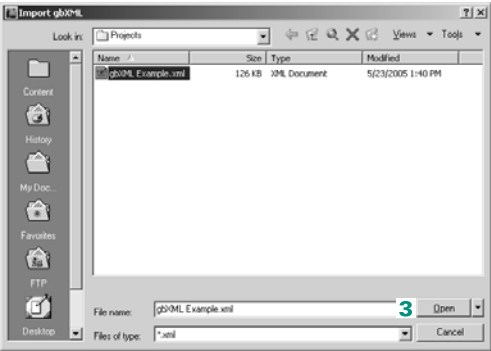
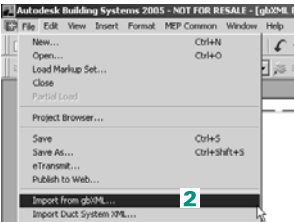


Importing gbXML data in Autodesk Building Systems 2005

- 1 Open ABS 2005 and open the drawing file.



- 2 On the **File** list, click **Import from gbXML**.
- 3 Select the xml file from which to import the data and click **Open**.
- 4 TRACE 700 calculation data should now be included with the drawing file.



gbXML results exported from TRACE 700

Room:

- Space Loads – These loads can be found in the **Space Loads** section of the **Room Checksums** report.

- Cooling Skylite Solar
- Cooling Skylite Conduction
- Cooling Roof Conduction
- Cooling Glass Solar
- Cooling Glass Conduction
- Cooling Wall Conduction
- Cooling Partition
- Cooling Exposed Floor
- Cooling Infiltration
- Cooling Lights
- Cooling People
- Cooling Miscellaneous Equipment
- Cooling Ceiling
- Cooling Ventilation
- Cooling Over-sizing
- Total Cooling
- Heating Skylite Solar
- Heating Skylite Conduction
- Heating Roof Conduction
- Heating Glass Solar
- Heating Glass Conduction
- Heating Wall Conduction
- Heating Partition
- Heating Exposed Floor
- Heating Infiltration
- Heating Lights
- Heating People

- Heating Miscellaneous Equipment
- Heating Ceiling
- Heating Ventilation
- Heating Over-sizing
- Total Heating
- **Coil Loads** – These values come from the **System Component Selection** report.
 - Main Cooling Coil Tonnage (if main cooling coil is at the room level)
 - Auxiliary Cooling Coil Tonnage (if auxiliary coil is present in system)
 - Main Heating Coil MBh (if main coil is at the room level)
 - Preheat Coil MBh (if preheat coil is at the room level)
 - Reheat Coil MBh (if reheat coil is at the room level)
 - Humidification Coil MBh (if humidification coil is present in system)
 - Auxiliary Heating Coil MBh (if auxiliary coil is present in system)
- **Fan Airflow** – These values come from the **System Component Selection** report
 - Primary Fan (if fan is at the room level)
 - Auxiliary Fan (if system required)
 - Room Exhaust Fan (user specified)
 - Diffuser

Additional items

- 1 Each room in CAD must have a unique name and special characters (punctuation, symbols, and so forth) should not be used in the room names.
- 2 If the dimensions of the room are changed in TRACE 700, the new dimensions will not be reflected in the CAD drawing.

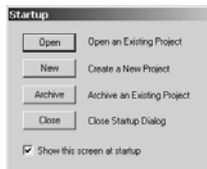
Note: If errors occur during the import or export process, please install the latest MSXML from Microsoft from <http://support.microsoft.com/default.aspx?scid=fh;EN-US;sp>

Importing a load design Version 3.x or Version 2.x file

Old TRACE Load 700 files (.lds extension) can be imported for use in TRACE 700 version 6.x (.trc extension). It is recommended that the import process be done from the TRACE 700 projects directory. Typically, the projects directory will be C:\CDS\TRACE700\PROJECTS\. Also, the import process should never be attempted from a network drive.

Note: This process is not required for version 4.x files.

- 1 Start by opening TRACE 700 version 6.x and choose to open an existing file.
- 2 Select the Files of Type as Load 700 Files. This should cause only .lds files to appear in the window.
- 3 Select the file to open and click **Open**. A message should appear that will ask you if you would like to import the old project file into the current version of TRACE 700.
- 4 Click **Yes**. TRACE 700 will create a file with the same name plus trc at the end and convert the .lds file to a .trc file. In this case, the file ASHRAE-62.lids would become ASHRAE-62trc.trc.



1
or

