System Catalog

Trane Intelligent VAV Systems

APP-PRC010B-EN

April 2025

What is an Intelligent VAV System?

Trane systems are comprehensive approaches to HVAC system design that support what is best for the building, best for business, and right for the environment. Trane's Intelligent VAV system is designed to provide superior energy efficiency and maintain comfort, while reducing environmental impact.

Higher efficiency. Systems from Trane reduce energy costs associated with comfort cooling and heating and ensure that your system complies with all applicable codes and standards.

Maintained comfort. Intelligent VAV utilizes both centralized and local HVAC equipment to provide localized temperature and humidity control. Large, noise-making equipment can be located away from sound-sensitive spaces.

Responsible environmental impact. Trane's Intelligent VAV system can be designed to reduce energy consumption, utilize more environmentally friendly refrigerants, and use less refrigerant. Systems can be designed to be all-electric, meaning that no fossil fuels are needed in the heating of the building. This will result in lower overall emissions as we transition to a cleaner electrical grid.

Intelligent VAV Systems

Trane Intelligent VAV systems combine multiple technologies to deliver both localized comfort and building decarbonization. They provide simultaneous heating and cooling, plus ventilation and humidity management—all differentiated for the needs of multiple zones. Intelligent operation via Tracer® controls, programmed by Trane, means every Intelligent VAV system is coordinated for comfort and energy efficiency. By utilizing secure remote connectivity, Trane can deliver analytics and service that prolong the lifespan of the equipment and ensure the building operates efficiently throughout its entire life cycle.

A Comprehensive Approach to System Performance.

Variable Air Volume (VAV) systems are highly regarded for their ability to provide localized comfort to serve various occupant needs throughout a building. More recently, Trane introduced Intelligent VAV systems—packaged systems that include all the necessary equipment and controls. Now, Trane's third-generation Intelligent VAV systems combine updated equipment and improved control technologies to meet decarbonization objectives and higher standards for indoor air quality. As a true designed-by-Trane system, Intelligent VAV systems can deliver effciency improvements of 20 to 30 percent compared to traditional VAV systems (see page 7). Trane's Intelligent VAV systems combine updated equipment and improved control technologies to meet decarbonization objectives and higher standards for indoor air quality while maintaining occupant comfort. Our "pre-packaged" product includes everything needed for a top-to-bottom system in a single solution: IntelliPak rooftop units, Water cooled Self contained unit or Performance Climate Changer air handling units, VAV terminal units, Wireless communication Air-Fi, Symbio® unit controls, Tracer® system controls, ductwork and more (see page 20).

- IntelliPak® rooftop units with up to 19.1 IEER with multiple efficiency tiers.
- Water cooled Self contained units with up to 22.8 IEER.
- All-electric options provide heating and cooling simultaneously without burning fossil fuels in the building.
- Newly optimized control strategies are assigned and programmed by Trane to ensure the system's efficiency matches or exceeds ASHRAE® Guideline 36.
- Performance Climate Changer air handling available as a chilled water or DX system.

Decarbonize by Addressing Electrification of Heat, Energy Efficiency, and Refrigerant Management

Decarbonization is the process of reducing and eliminating carbon emissions. Whether the project objective is regulatory compliance, or the building owner's sustainability standards and environmental, social, and governance (ESG) goals, Trane's Intelligent VAV systems provide a solution through Electrification of Heat, Energy Efficiency and Refrigerant Management.

Electrify heating and eliminate direct emissions. Systems can be designed as all-electric to eliminate emissions that come directly from a building's fossil fuel heating systems. In locations where utilities operate on clean, renewable energy sources, electrified heating takes full advantage of the decarbonization benefits.

Meet new energy efficiency requirements. Trane rooftop units and water cooled self-contained units meet or exceed the U.S. Department of Energy's minimum efficiency requirements.

Use the lowest amount of energy possible. Control sequences are factory-programmed to match ASHRAE Guideline 36 (or better). Trim and respond control methods ensure Intelligent VAV systems use the least amount of energy possible to maintain comfortable environments.

Get more from the latest equipment advancements. Energy recovery, staged and variable speed compressors help lower energy use and the related cost and emissions. Central fans deliver cooling and ventilation together, minimizing energy use. Variable speed fans on fan powered VAV units further reduce the energy use of the system.

Advanced services. Connectivity at the equipment or system level allows for preventative service and analytics that can identify areas of opportunity to improve efficiency or performance of the system. While Artificial Intelligence-driven Trane Autonomous control can optimize the full building in the long run.

Refrigerant Management

The HVAC industry has transitioned to low global warming potential refrigerants, which will reduce greenhouse gas emissions in case of a leak. A new class of refrigerant A2L, with low toxicity and low flammability have emerged to allow the HVAC industry to comply with environmental, regulatory, energy efficiency, safety and market requirements. Despite their mild flammability, standards like UL 60335-2-40 and ASHRAE Standard 15 ensure safe usage. Trane addresses these challenges by incorporating leak detection systems (LDS) in all applicable equipment, ensuring safety, regulatory compliance, and efficient operation. Trane's unit controllers are configured for A2L refrigerant leak detection and mitigation, providing early warnings, starting and/or maintaining supply fan operation, and disabling compressors upon detection. For Multiple-Zone applications, system controls ensure proper ventilation and coordination with VAV terminals to maintain air paths during mitigation. Trane provides both unit and system control solutions to ensure immediate detection and response to maintain a safe environment in the building while minimizing refrigerant leaks to the atmosphere.

For more information on system controls for A2L refrigerant equipment, see BAS-APG036-EN.

Deliver a System that Provides State-of-the-Art Indoor Air Quality and Comfort

Meet higher expectations for comfort and indoor air quality in commercial buildings. Intelligent VAV systems capably control the temperature, ventilation and humidity—zone by zone. With the ability to provide heating and cooling at the same time, this solution is ideal for buildings with spaces that have dissimilar cooling and heating requirements. "Intelligent" VAV means systems use smart building strategies to deliver the right temperature to the right spaces, while operating in energy-saving mode when people are not present.

Intelligent Design

Brings the right amount of outdoor air in. Ventilate spaces properly without additional air conditioning equipment. Control strategies and flow measuring with Traq™ dampers ensure optimal ventilation without excessive energy use.

Ensures that indoor air feels fresh and clean. Continuous dehumidification is a fortunate characteristic of the system design—no extra equipment is needed to maintain comfortable humidity levels.

Maintains a low sound level. Unlike systems which place noisy equipment in or near the occupied space, air handlers, water cooled self-contained units and rooftop units can be located away from sound-sensitive areas. VAV terminal units are available with integral sound attenuators and variable speed fans for improved acoustical performance near occupied spaces.

Focus on Business Advantages for Your Clients

Deliver a designed solution. Trane's packaged systems offer a comprehensive and efficient solution for HVAC needs by integrating all components into a single, well-designed system. This approach simplifies the processes of designing, selecting, ordering, installing, operating, and servicing, ensuring seamless compatibility and optimal performance. By utilizing one or more large rooftop or water-cooled units instead of multiple individual zone units, these systems reduce equipment costs and installation time. Additionally, the integrated design minimizes the need for specialized third-party technicians, making the system more user-friendly and easier to maintain.

Ensure future serviceability. Accessibility is key to prompt, cost-efficient service. Intelligent VAV systems allow air handling units, self-contained water cooled units and rooftop units to be installed away from the occupied space. Selecting Air-Fi® Wireless communication within the building means a more reliable communication and ease of relocation of zone sensors. Trane's Connected Mechanical Service Agreement allows to monitor the equipment continuously to identify potential problems minimizing disruptions due to service.

Optimized Performance Stays Optimized

Our experience shows that when building operators understand what the system is supposed to do, they allow the building automation system (BAS) to do its job. When they don't have that insight, they tend to run in manual control mode, potentially negating some of the savings. A good example is found within our trim and respond user interface that provides a description of what that the program is currently doing and conditions that will cause it to change.

Now there's a new way to further optimize your high-performing building systems. Trane Autonomous Control is an artificial intelligence-enabled service that works with your Tracer® SC+ controls. Constantly observing, correcting, and improving, it's technology that never rests. To find and implement improvements, Trane Autonomous Control factors in energy usage patterns, weather, occupancy predictions and other variables across multiple locations, which is a challenge without an automated solution.

Components of an Intelligent VAV System

A typical VAV system consists of a rooftop unit, water-cooled self-contained unit, or air handling unit which serves several individually controlled thermal zones. Each zone has a VAV terminal unit that varies the quantity of conditioned air delivered to maintain the desired temperature in the zone.

Systems may use a rooftop unit or water-cooled self-contained unit with a direct expansion refrigeration system designed to cool and dehumidify the air. Other systems may use an air handling unit that uses a cooling coil to produce cool, dehumidified air. The coil is often a chilled water coil—that is, a coil where cold water is circulated throughout to provide heat transfer and absorb heat from the zones. Alternatively, some coils may utilize refrigerant and be connected to a direct expansion condensing unit or variable refrigerant flow unit using refrigerant piping.

A rooftop unit, water cooled self-contained unit, or air handling unit serves the same purpose with similar components. The unit typically includes filters, a cooling coil, possibly a heating coil, a variable-speed supply fan, possibly a return or relief fan, optional heat recovery and controls. Heat may be provided by staged or modulating hot water, steam, gas or electric sources. A rooftop unit or air handling unit will also utilize an airside economizer. A water-cooled self-contained unit will generally utilize a waterside economizer but an airside economizer is also an option.

VAV terminal units commonly have a zone temperature sensor installed in each independently controlled zone. The VAV box contains a damper used to modulate the flow of air, an option reheat coil, and controls to communicate with the zone temperature sensor. The reheat coil may utilize hot water, staged electric, or modulating SCR electric.

There are a variety of other components which are used to complete the system:

- Supply ductwork and supply air diffusers are used to deliver conditioned air to the occupied spaces
- Return-air grilles, ceiling plenum, and return ductwork
- For systems that utilize a hydronic cooling system, water chiller(s) with associated water distribution pumps and heat rejection equipment
- For systems that utilize a hydronic heating system, a heating system which may contain a heat pump chiller, heat recovery and/or boiler and associated water distribution pumps.

Finally, system level controls are used to control and optimize the operation of the entire system.

For more information on chilled-water systems

Air handling units often utilize hydronic systems to provide chilled water for cooling and hot water for heating. For more information on these systems, see Trane's Comprehensive Chilled Water Systems (APP-PRC006*-EN) and Comprehensive Chiller-Heater Systems (SYS-APG003*-EN).

Intellipak® rooftop unit

System Benefits

VAV systems have a proven track record of reliable, efficient performance. Using new design strategies and advanced technologies, Intelligent VAV systems are more efficient than traditional VAV systems.

Recent technologies—including energy recovery, variable-speed compressors and fans, and optimized controls—enable intelligent VAV systems to be 20 percent to 30 percent more efficient than traditional VAV systems.

System Flexibility

Intelligent VAV systems utilize centralized and terminal equipment to provide localized comfort and control. The rooftop, water-cooled self-contained, or air handler will provide a supply of conditioned air to the zones where a VAV terminal unit modulates the flow of air and local reheat to maintain space temperature and comfort. This system also provides outdoor air for ventilation without additional air conditioning equipment. Intelligent VAV systems utilize a combination of sheet metal and flexible ductwork that allows some flexibility in locating and relocating VAV boxes and supply air diffusers. Using Air-Fi® wireless controls also allows building owners to relocate zone temperature sensors without running wires as needed.

Airside Economizer Operation

Systems can be equipped with airside economizers to take advantage of free cooling opportunities to use the cool ambient air to offset loads. When it is cool outside, the system will increase the intake of outdoor air to offset space cooling loads. As the outdoor temperature increases, the system will use the mechanical refrigeration system to augment the cooling offset by outdoor air. Depending upon climate, the use of an airside economizer can provide significant energy savings.

Waterside Economizer Operation-Water Cooled Self-Contained Unit

In water-cooled equipment, the waterside economizer substantially reduces the compressor energy requirements because it uses the cooling water before it enters the condensers. Additional equipment room space is not required since the coils are contained within the overall unit dimensions.

Disadvantages include higher airside pressure drop and a higher water pressure drop.

IntelliPak® Rooftop Unit Efficiency

Over the past two decades, minimum rooftop unit efficiency has steadily increased. Trane IntelliPak rooftop units have continued to meet and exceed these regulatory requirements.

IntelliPak is available in multiple efficiency tiers:
- IntelliPak 1 - up to 19 IEER
- IntelliPak 2 - up to 19.1 IEER
- IntelliPak 3 - up to 18.2 IEER

IntelliPak rooftops are designed to fit existing rooftop curbs, allowing substantial efficiency increases upon retrofit. Units also have multiple communication options to fit existing building automation infrastructure.

Water Cooled Self-Contained Unit Efficiency

Since the early 1990's water-cooled, self-contained systems have been used in high-rise office buildings because of their high efficiency and lower installed costs. Trane's new water-cooled, self-contained units meet and exceed efficiency requirements with 16.2-18.8 EER and 19.6-22.8 IEER

All-Electric Comfort

Systems can be designed to provide year-round comfort using electricity only, without fossil fuels to meet electrification requirements.

IntelliPak® Packaged Units

Packaged rooftop units can be equipped with electric heat or staged electric heat in place of gas fired heat exchangers to preheat the ambient air. Some units can be equipped with exhaust air energy recovery, allowing heat to be transferred from the exhaust air stream to the outdoor air stream.

Water-Cooled Self-Contained Units

Water cooled self-contained units can be equipped with a variety of heating options. Systems can use SCR electric heat or staged heat to preheat the ambient air. Alternatively, hydronic coils can be used for heat. Heat for the coils may come from an all-electric chilled- and hot-water system or from a geothermal system without the use of a boiler.

Performance Climate Changer Air Handling Units

Air handling units can be equipped with a variety of heating options: exhaust energy recovery or modulating electric heat can be incorporated to preheat the ambient air. Alternatively, hydronic coils can be used for heat either from an all-electric chilled- and hot-water system or from a geothermal system without the use of a boiler.

VariTrane® VAV Terminal Units

VAV boxes from Trane can be equipped with SCR and staged electric heat. Additionally, VAV boxes can be equipped with hydronic coils. Heat for the coils may come from an all-electric chilled- and hot-water system or from a geothermal system without the use of a boiler.

Utilizing Chiller Heat Recovery in VAV systems enhances energy efficiency and cost savings by repurposing heat, that would otherwise be wasted, during hours of simultaneous cooling and heating. In these systems, the heat captured by the cooling coil in the AHU can be recovered by the chiller to heat the zones that require heating. While two- or three-row heating coils can deliver the necessary reheat capacity , they do increase fan and pumping energy. However, the overall energy benefits generally outweigh these increases, optimizing both energy use and cost savings.

A geothermal HVAC system uses the earth as a heat sink when cooling and a heat source when heating. Because the earth's temperature is generally more moderate than the outdoor air temperature, the stored energy is effectively and efficiently recovered when heating is required. These benefits allow a geothermal system to operate 10 to 30 percent more efficiently than comparable conventional HVAC systems.

Additional information on geothermal systems

Trane Applications Engineering Manual
"Central Geothermal Systems" (SYS-APM009*-EN).

Optimized Controls

Intelligent VAV systems combine equipment with industry-leading energy efficiency with the latest and best control strategies. These strategies allow the system to maintain comfort while also reducing the amount of energy used. For more information on the specific control strategies, see “Optimized System Control Strategies” on page 22.

Applying the optimized control strategies is easy when using the Synchrony® interface of Tracer® SC+ system controller. Trim and respond, as defined by ASHRAE® Guideline 36 “*High-Performance Sequences of Operation for HVAC Systems*” has been built into Tracer® SC+ as an application that can be used to adjust duct static pressure setpoint and discharge air temperature setpoints to reduce energy consumption. This guideline aims to maximize system energy efficiency, provide control stability, and allow real-time fault detection and diagnostics.

Trim and respond is designed to reset a system variable, such as a pressure or temperature setpoint. It changes the setpoint at a fixed rate (trim) until a downstream device is no longer satisfied and a “request” is generated. When enough “requests” are present in a specific time frame, the set point is adjusted in response (respond). For more information on Guideline 36, see “Optimized Controls and ASHRAE Guideline 36” on page 22.

Indoor Environmental Quality

Intelligent VAV systems provide significant comfort because they’re able to provide individual zone comfort. Each zone receives its supply of primary air that has been conditioned and filtered. The amount of primary air is varied by the VAV box to maintain zone temperature. If heat is needed, VAV boxes with reheat activate the heater to temper the supply air. Systems with parallel fan powered VAV boxes can activate a terminal fan inside the VAV box to draw warm air from the return air plenum to serve as a first stage of heat, before activating the VAV box heater.

Centralized systems offer the largest number of filtration and air cleaning options, allowing for a variety of technologies to be used to maintain air cleanliness. Examples include a variety of filter types, varying filter efficiencies, and other air cleaning technologies.

Centralized systems can be designed to properly separate the noise-making components from critical occupied spaces meaning low sound levels can be attained with proper design.

Simplified Maintenance

All HVAC systems require periodic service to ensure proper and efficient operation. Rooftop units, water-cooled self-contained and air handlers are installed outside and away from occupied spaces, allowing service to occur without disruption to the building occupants.

Using Trane Air-Fi® wireless controls for unit controller communication allows technicians to access the system from outside the space for troubleshooting and maintenance.

Trane Symbio® unit controls can generate automated data logs. For example, IntelliPak® rooftop units have up to 109 data logs with 30 days of data history available. The benefit of automated data collection is the ability to troubleshoot issues and check in on system performance without the need first set up trends, and then wait for symptoms to reappear to investigate issues, which leads to faster resolution.

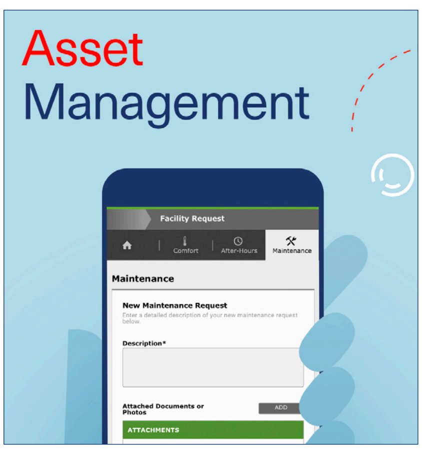
Even when away from the building, a building management system (BMS) allows operators to monitor system status. Trane controls allow secure remote access using a phone, a tablet, or PC using industry standard security protocols. The mobile app can make a set point or schedule change anywhere.

Building Management System Features Worth Specifying

Building Management Systems (BMS) control and monitor systems including HVAC and lighting, serving one building or multiple facilities in different locations. Some features can be particularly useful in offices, school, and other vertical markets where VAV systems are commonly applied. Tracer® Ensemble® provides the ultimate user experience by combining custom reporting and dashboards to view and optimize assets. Easily access alarms, setpoints, and schedules from virtually anywhere through a secure remote access.

Dashboards

Animated equipment illustrations and user created dashboards support intuitive system management. Equipment graphics are consistent from one building to the next, which makes it easier to onboard new users. Custom graphics are also available for site layouts, non-Trane equipment, and third-party systems such as lighting. System data logs can also be displayed for more insight into problems or better system understanding.

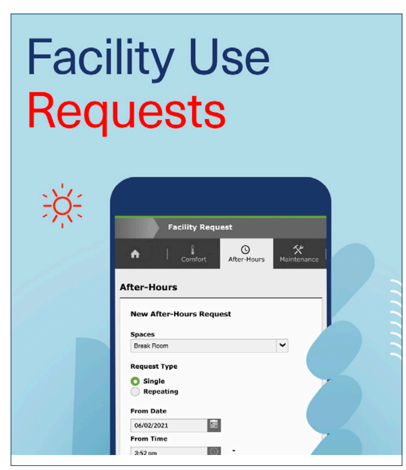


Built-In Asset Management

Most asset management software does little to help address maintenance more pro-actively. Trane's Work Order Management solution is fully integrated into the BMS which allows work order management and corrective and preventive maintenance scheduling without the need to log into a separate software.

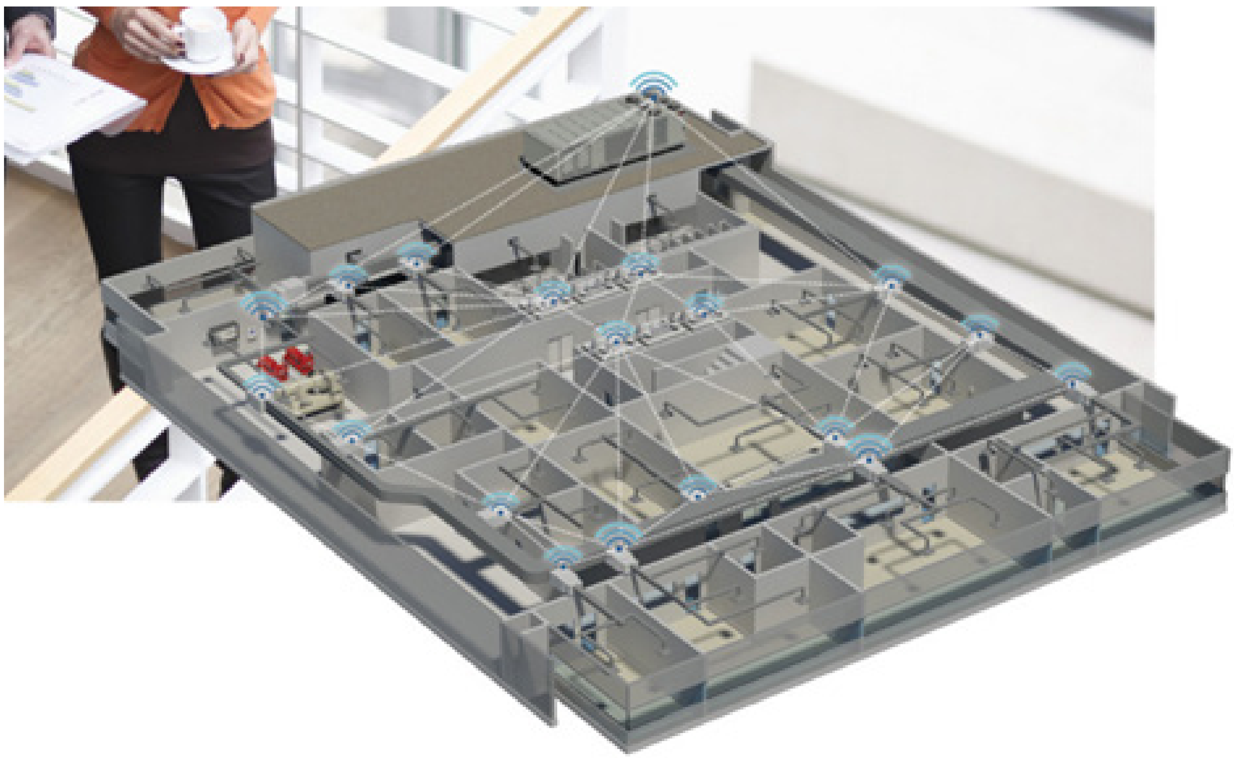
Facility Requests

Trane Tenant Services empower tenants and occupants to report issues, adjust comfort settings, and request after-hours access directly-—without involving the busy facility management team. Built into Tracer Ensemble, Tenant Services allows the facility staff to monitor from the same BMS the tenants requests and can send invoices for building use outside of normal billing hours. It makes billing tenants faster and more accurate.



Installation Ease

Air-Fi® wireless controls are the Trane standard choice for Intelligent VAV systems communication media because it is reliable and flexible. Redundant communication paths are created via a wireless mesh network and signal range is twice that of other systems creating four times the potential paths for message transmission. The system is flexible in that it allows for easy relocation of sensors or adding additional devices without needing to pull wire. The wireless system allows for easier installation in that communication and sensor wire is eliminated.



System Components

IntelliPak® Packaged Rooftop Units

Trane IntelliPak® rooftop units (20 to 150 tons) provide high effciency and cost effectiveness with pre-packaged, factory-installed controls. Factory-installed options include exhaust air energy recovery, outdoor airflow measurement for demand-controlled ventilation, variable-speed compressors and fans, modulating SCR electric or gas heat, and a variety of air cleaning options.

Key Features

- **IntelliPak® Packaged Rooftop Units (20 to 150 tons)**
- **Pre-engineered, factory-assembled cooling, heating, and ventilation in a single piece of equipment**
- **Effciency tiers available to match project budget and energy use goals**
- **Staged and modulating electric and gas heat options, along with hot water and steam coils**
- **Modulating hot gas reheat for dehumidification reheat**
- **Ultra-high effciency models available with eFlex™ variable-speed compressor and condenser fan control**
- **Integral ventilation control, including options for demand-controlled ventilation and air economizing—with fault detection and diagnostics**
- **Outdoor airflow measurement with Traq™ dampers**
- **Air-to-air energy recovery options**
- **Various levels of filtration available**
- **Pre-programmed, factory-installed Symbio® 800 DDC controls with wired or Air-Fi® Wireless communications**
- **Symbio Web UI is the web-based user interface that allows for easy installation and maintenance of the rooftop unit**
- **Low-GWP R-454B refrigerant with fcatory installed leak detection system**

IntelliPak® Packaged Rooftop Units, continued

	IntelliPak 1	IntelliPak 2	IntelliPak 3
Cooling capacity	20 - 130 tons	90 - 150 tons	20 - 75 tons
Efficiency options			
Standard	✓	✓	✓
High	✓	✓	✓
Ultra-high (eFlex variable speed compressor)	20 - 75 tons	✓	✓
Heat options			
Staged electric	✓	✓	✓
Staged gas	✓	✓	✓
Modulating gas	✓	✓	✓
Water coil	✓	✓	CT
Steam coil	CT	✓	CT
Exhaust air energy recovery	CT	CT	CT
Filtration options	• MERV 7 - 16 • HEPA filters	• MERV 8 - 17 • HEPA filters	• MERV 7 - 14
Cabinet	Double wall insulation	Double wall insulation	Double wall insulation
Condenser coil corrosion protection	✓	✓	✓
Stainless steel drain pan	✓	✓	✓
Direct-drive plenum fans	20 - 75 tons	✓	✓
Relief fans	✓	✓	✓
Return fans	✓	✓	CT
Modulating hot gas reheat	✓	✓	✓
High fault SCCR	✓	✓	✓
Unit controller	Symbio™ 800	Symbio™ 800	Symbio™ 800
Human machine interface	• 7-inch touchscreen display • Symbio Web-UI • Symbio Service and Installation mobile app		
CT = Contact your Trane sales representative			

Water-Cooled Self-Contained Units

Trane's Water Cooled Self-Contained units (20-110 tons) deliver high efficiency performance. Self contained units offer floor by floor cooling without having to run a central system. When the waterside economizer (WSE) is added to the unit the overall system efficiency is unparalleled. When the WSE is combined with the variable speed compressor part load performance is maximized.

Key Features

- **Packaged one-piece water-cooled unit**
- **High efficiency system with full load EER's up to 18.8 and IEER's up to 21.7**
- **Dual circuits / multiple compressors**
- **Variable speed compressors Electric heat**
- **Fan arrays with multiple ECM fans for high efficiency and redundancy**
- **Low leak double wall construction**
- **Waterside Economizer for high efficiency operation at full and part load**
- **Various levels of filtration available**
- **Pre-programmed factory installed Symbio 500 DDC controls with wired or Air-Fi wireless communications.**
- **Symbio Web UI is the web-based user interface that allows for easy installation and maintenance.**
- **Low-GWP R-454B refrigerant with factory installed leak detection system**

Water-Cooled Self-Contained Unit	
Cooling capacity	20 - 110 tons
EER range	16.2 to 18.8
Ultra-high (eFlex variable speed compressor)	✓
Staged electric heat	CT
Hot water heating coil	CT
Steam coil	CT
Filtration options	• MERV 7 - 16 • HEPA filters
Cabinet	Double wall insulation
Condenser coil corrosion protection	CT
Stainless steel drain pan	CT
Direct-drive plenum fans	Standard ECM fans
High fault SCCR	CT
Unit controller	Symbio™ 500
Human machine interface	• 7-inch touchscreen display • Symbio Web-UI
CT = Contact your Trane sales representative	

Performance Climate Changer Air Handling Units

Trane Performance Climate Changer air handling units (AHU) provide unparalleled configurability with a multitude of factory-installed options for fans, air-to-air energy recovery, cooling and heating coils, and air cleaning options. Performance Climate Changers AHUs can be paired with hydronic systems, such as a chilled water and hot water system, direct expansion condensing units, and VRF condensing units using a linear expansion valve (LEV) kit. Trane's full Performance Climate Changer AHU lineup ranging from catalog to fully custom AHUs with configurations to meet any need are available with pre-configured, factory-installed controls for easy setup and operation.

Key Features

- **Configurable indoor or outdoor models**
- **Variable air handler aspect ratios available**
- **Low-leak, thermally isolated casing design**
- **Wide variety of fan options**
- **Outdoor airflow measurement with Traq™ dampers**
- **Air-to-air energy recovery options**
- **Various levels of filtration available**
- **Air cleaning system options**
- **Pre-programmed, factory-installed Symbio® 500 DDC controls with wired or Air-Fi®**
- **Wireless communications**
- **Low-GWP R-454B refrigerant DX coil with factory installed leak detection system when applicable**

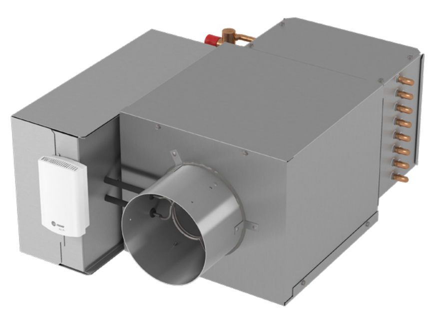
Trane offers a broad range of AHUs, each with an extensive list of standard and optional capabilities.

	Catalog (UCCA)	Semi-Custom (CSAA)	Variable Aspect Ratio (PSCA)
Unit size	3 - 30	3 - 120	3 - 120
CFM range	up to 15,000 cfm	up to 60,000 cfm	up to 60,000 cfm
Heat options			
Staged electric	✓	✓	✓
Staged gas		✓	
Modulating SCR electric	✓	✓	✓
Modulating gas		✓	
Water coil	✓	✓	✓
Steam coil	✓	✓	✓
Air-to-air energy recovery		✓	
Filtration options	• 2-inch MERV 8-13 • 4-inch MERV 11-13	• 2-inch MERV 2-15 • 4-inch MERV 8-15 • Bag and cartridge • HEPA • Pre and final filtration	• 2-inch MERV 2-15 • 4-inch MERV 8-15 • Bag and cartridge • HEPA • Pre and final filtration
Factory-installed options	• Double-wall insulation • Direct-drive plenum fans • Motorized impeller fans • 6" Baserails	• Double-wall insulation • Direct-drive plenum fans • Motorized impeller fans • Fan arrays • Relief fans • Return fans • TRAQ ventilation airflow monitoring • CDQ desiccant dehumidification • Air blender • Humidifier • Stacked configurations	• Double-wall insulation • Direct-drive plenum fans • Fan arrays • Relief fans • Return fans • TRAQ ventilation airflow monitoring • Air blender • Humidifier • Stacked configurations • Variable aspect ratio
Unit controller	UC 600	Symbio™ 500	Symbio™ 500
Controller interface	Tracer TU	Symbio™ UI	Symbio™ UI

VariTrane® VAV Terminal Units

VariTrane® VAV terminal units (200 to 8,000 cfm) offer low leakage, tested, repeatable performance with pre-packaged, factory-installed controls, to deliver superior occupant comfort and energy efficiency with quiet acoustical performance. They can be equipped with terminal fans and various reheat options. Featuring reliable components like the patented Trane flow ring and the Symbio® 210 unit controller, VariTrane® VAV terminal units meet ultra-low leak requirements, preventing conditioned air leakage and energy waste. All units are UL listed for safety and comply with industry standards such as AHRI Standard 880-2017 and Standard 885-2008.

Each VariTrane® VAV box undergoes factory commissioning, where airflow, temperature setpoints, and addressing are calibrated in a controlled environment. This factory testing ensures that units function correctly upon installation, offering better control over cost and quality, leading to faster installation and reduced project costs.



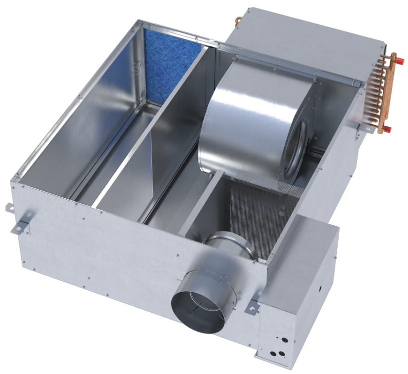
Key features

- **The Trane flow ring for precise airflow measurement and control**
- **A durable, heavy-gauge air valve cylinder**
- **Options for electric or hot-water heat with staged, two-position, or modulating control**
- **Choices for single duct, dual duct, and fan-powered units**
- **Pre-programmed, factory-commissioned Symbio® 210 DDC controls with wired or Air-Fi® Wireless communications**
- **Retrofit dampers available for upgrading existing systems**
- **Symbio Web UI is the web-based user interface that allows for easy installation and maintenance of the unit**

VariTrane® Fan-Powered Series

VSCG • VSEG • VSWG

Series fan-powered units have fans which are always energized in occupied mode. When energized, the fan can be controlled for constant-speed or variable-speed operation. They are common in applications such as conference rooms, cafeterias, etc., that desire higher supply airflow rates at all conditions.

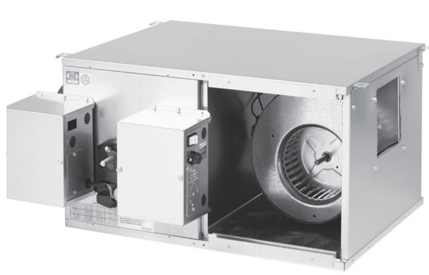


Key Features

- Suppressor—optional integral sound attenuator provides market-leading acoustical performance.
- 1.8 pounds per cubic foot (PCF) density standard insulation—provides a barrier against fan noise.
- Up to 4-row hot water heating coil—maintains heating capacity with lower hot water temperatures from electrified heating systems.
- ECM with variable fan airflow control (ECV)—offers fan savings, reduced operational cost and better part load acoustics.
- Optional MERV 13 filter—provides superior indoor air quality.
- Small footprint—fits in narrower plenum spaces.
- Factory mounted and preprogrammed controls.
- Top and bottom access flip-able—standard configuration allows for left or right-handed installation, without field modifications.
- Airflow performance ranging up to 2500 CFM 1" total static pressure supports MERV 8 and 13 high efficiency filtration and increased pressure drop of attenuators.
- Optional LEED wrap for preventing contamination during the construction phase.

VPCF •VPEF • VPWF

Parallel fan-powered units offer energy savings with intermittent fan control. The fan energizes only in heating mode when the space needs heat. When energized, the fan can be controlled for constant speed or variable-speed operation. Additional energy savings are obtained by using warm plenum air for free reheat. Motor heat is never wasted in parallel units. They are an excellent choice when minimal zone heating is needed.



Key Features

- Available primary air inlet sizes: 4 in. to 16 in.
- Airflow range: 0 - 3,000 cfm
- Available parallel and series configuration with optional hot water and electric reheat
- Standard IAQ metal encapsulated insulation edges and access panels
- Optional electronically commutated motor (ECM) and modulating airflow control algorithms
- Optional Suppressor induction air inlet sound attenuator
- Optional LEED wrap for preventing contamination during the construction phase
- Optional factory mounted, wired, tested, and commissioned pressure independent controls
- DDC (Comm3 or Comm 4), LonTalk, BACnet communication
- Trane® Air-Fi® wireless communication

Trane Model Number	Inlet Size, in.	Nominal Airflow, cfm	Heat Options			Air-Fi™ Available
			Staged Electric	SCR Electric	Hot Water	
VariTrane® round inlet/round outlet terminal units (model VRRF)						
VRRF04	4 Ø	225	Not Available			✓
VRRF05	5 Ø	350				✓
VRRF06	6 Ø	500				✓
VRRF08	8 Ø	900				✓
VRRF10	10 Ø	1400				✓
VRRF12	12 Ø	2000				✓
VRRF14	14 Ø	3000				✓
VRRF16	16 Ø	4000				✓
VariTrane® single-duct VAV terminal units (models VC*F)[1]						
VC*F04	4 Ø	225	✓	✓	✓	✓
VC*F05	5 Ø	350	✓	✓	✓	✓
VC*F06	6 Ø	500	✓	✓	✓	✓
VC*F08	8 Ø	900	✓	✓	✓	✓
VC*F10	10 Ø	1400	✓	✓	✓	✓
VC*F12	12 Ø	2000	✓	✓	✓	✓
VC*F14	14 Ø	3000	✓	✓	✓	✓
VC*F16	16 Ø	4000	✓	✓	✓	✓
VC*F24	24 x 16	8000	✓	✓	✓	✓
VariTrane® fan-powered terminal units (models VP*F and VS*F)[2]						
VP*F04 / VS*F04	4 Ø	225	✓	✓	✓	✓
VP*F05 / VS*F05	5 Ø	350	✓	✓	✓	✓
VP*F06 / VS*F06	6 Ø	500	✓	✓	✓	✓
VP*F08 / VS*F08	8 Ø	900	✓	✓	✓	✓
VP*F10 / VS*F10	10 Ø	1400	✓	✓	✓	✓
VP*F12 / VS*F12	12 Ø	2000	✓	✓	✓	✓
VP*F14 / VS*F14	14 Ø	3000	✓	✓	✓	✓
VP*F16 / VS*F16	16 Ø	4000	✓	✓	✓	✓
VP*FRT / VS*FRT	8 x 14	1800	✓	✓	✓	✓
VariTrane® low-height fan-powered terminal units (models LP*F and LS*F)[3]						
LP*F04 / LS*F04	4 Ø	225	✓	✓	✓	✓
LP*F05 / LS*F05	5 Ø	350	✓	✓	✓	✓
LP*F06 / LS*F06	6 Ø	500	✓	✓	✓	✓
LP*F08 / LS*F08	8 Ø	900	✓	✓	✓	✓
LP*FRT / LS*FRT	8 x 14	1800	✓	✓	✓	✓

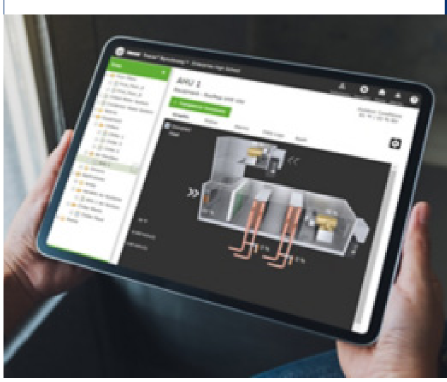
1. VC*F: VCCF = cooling only (no heat); VCEF = equipped with an electric heater; VCWF = equipped with a hot-water coil
2. VP*F = parallel fan-powered terminal unit, VS*F = series-fan powered terminal unit, unit where C = cooling only, E = electric heat, and W = hot water heat
3. LP*F = low height parallel fan powered terminal unit, LS*F = low height series fan powered terminal unit where C = cooling only, E = electric heat, and W = hot water heat

Tracer® Control System

Tracer® SC+ is a powerful building automation system that integrates HVAC, lighting and other systems to simplify command and provide better control over comfort and efficiency. Tracer Synchrony is the built-in intuitive web-based user interface that allows to monitor and control your facility from the device of your choice. Pre-engineered into every SC+ are Tracer® System Applications, which help ensure best-possible performance. Built on a foundation of open, industry-standard protocols, including BACnet, LonTalk, and Modbus, Tracer SC+ provides robust support for equipment from all generations and including both Trane and non-Trane.

Tracer® Ensemble® is a Trane Enterprise building management system. It is a cloud-based Software as a Service (SaaS) with a graphical interface for managing buildings and Building Automation System (BAS) controllers on both single and multiple buildings at once.

Tracer® Ensemble® provides the ultimate user experience by combining custom reporting and dashboards to view and optimize assets. Easily access alarms, setpoints, and schedules from virtually anywhere through a secure remote access. Ensemble optional features include Tenant Services™ and Work Order Management to maximize occupants' comfort while minimizing stressful procedures.



Key Features

- **Standard/flexible, pre-packaged applications with optimized system control sequences which meet ASHRAE® Standard 90.1 and ASHRAE® Guideline 36 (trim and respond)**
- **Intuitive, easy-to-use operator interface**
- **Enterprise control options for multiple sites or large buildings with single login**
- **Tenant services options for after-hours occupancy requests, billing, and facility maintenance**
- **Services to optimize building energy and performance including active monitoring and response**
- **Secure Remote access via Mobile apps allow access from virtually anywhere**
- **Wired or Air-Fi® Wireless unit to unit communication network and sensors**
- **Demand Management – energy demand limiting for the purposes of avoiding peak charges**
- **Asset Management – From BAS coordinate maintenance and repair tasks and tenant requests**
- **Data management and presentation - dashboards**

Air-Fi® Wireless Controls

Trane Air-Fi Wireless communication is an innovative, easy-to-install communication technology that provides highly secure and reliable network communication between zone sensors and mechanical equipment controllers.

The Air-Fi Wireless Communications Interface (WCI) enables wireless communications between system controls, unit controls, and wireless sensors for Trane® control products that use the BACnet® protocol. The WCI replaces the need for communications wire in all system applications.

The Air-Fi Wireless Communications Sensor (WCS) is compatible with any Trane controller that uses a WCI. The WCS provides the same functions as many currently available Trane wired sensors. No further software or hardware is necessary for site evaluation, installation, or maintenance.

Adherence to ANSI/ASHRAE® Standard 135 "*BACnet® A Data Communication Protocol For Building Automation and Control Network*", enables secure and reliable wireless monitoring and control over commercial building systems. It also conforms to the IEEE® 802.15.4 standard, which ensures that your wireless BAS Communication system will reliably coexist with other wireless systems, including Bluetooth® and Wi-Fi.

Key Features

- **Eliminates wires between equipment controllers and zone sensors, and between equipment and system controllers, allowing for faster installation, increased location flexibility, and easier relocation**
- **Self-healing wireless mesh and extended signal range maximize reliability**
- **Supports open communication protocols through conformance with ASHRAE® Standard 135 (BACnet/ZigBee®)**
- **Up to four sensing functions in one zone sensor: temperature, humidity, occupancy, and CO_2**
- **15-year lifetime batteries**
- **Factory installed and pre-addressed products allow a faster network setup**
- **Easy installation annd relocation of sensors**
- **Highly secure network isolated from the internet, cellular and Bluetooth**

Optimized System Control Strategies

There are several system optimizations that can be easily implemented with Trane controls to reduce energy usage while continuing to maintain space comfort. Optimized control strategies, such as optimal start and stop, fan pressure optimization, discharge air temperature reset, and ventilation optimization, are prepackaged in the Tracer® system. Many of these optimized control strategies are implemented by simply "checking the box" to enable a strategy.

Discharge air temperature reset and fan pressure optimization can utilize ASHRAE's trim and respond logic found in ASHRAE® Guideline 36 "*High-Performance Sequences of Operation for HVAC Systems*."

Optimized Controls and ASHRAE® Guideline 36

The stated purpose of ASHRAE Guideline 36 "*High-Performance Sequences of Operation*" is: "to provide uniform sequences of operation for heating, ventilating, and air-conditioning (HVAC) systems that are intended to maximize HVAC system energy efficiency and performance, provide control stability, and allow for real-time fault detection and diagnostics. Some benefits include:

- Reduce engineering time
- Reduce programming and commissioning time
- Reduce energy consumption
- Reduce system downtime by including fault detection diagnostic algorithms

There are three key concepts in the guideline that may be unique. First, while most traditional control sequences do have optimization strategies, Guideline 36 is focused on using trim and respond. Trim and respond is a feedback loop control method used instead of the traditional proportional-integral-derivative (PID) loop control. It uses feedback from downstream equipment unit controls to determine what changes should be made to setpoints or system operation.

A properly functioning trim and respond loop will continuously adjust target setpoints. A good way to think about it: the system is trying to balance energy efficiency with comfort. When comfort is met, the loop will "trim" to a more energy-efficient setpoint until the loop receives feedback from devices indicating comfort is no longer being maintained. Then, based on that feedback, the system will "respond" until comfort is met. The cycle then repeats. Since the system is receiving requests from each zone, those experiencing mechanical or maintenance issues are easily identified. Trim and respond also adjusts the importance of individual zones and may be used for many different airside and waterside optimization strategies.

Second, the guideline prescribes rules for automated fault detection and diagnostics (FDD). This logic is expected to reside on equipment controllers and generate alarms when issues arise. Automated fault detection and diagnostics (AFDD) is a system for detecting and diagnosing equipment faults. The goal is to identify sensor or mechanical faults before they become an issue for proper system operation or impact energy efficiency. For example, there are 15 different diagnostics identified in the guideline that apply to air handlers. For each air handler operating mode such as economizer or mechanical cooling, different diagnostics are run to proactively identify issues. Some examples of those diagnostics are temperature drop across an inactive cooling coil, temperature rise across an inactive heating coil, or discharge static pressure too low when the fan is at full speed.

Lastly, hierarchical alarm suppression is a unique solution which suppresses alarms based on feedback from other equipment. As HVAC systems become larger and more complex, the number of potential nuisance alarms becomes a significant issue for building operators. The guideline addresses this issue by using hierarchical alarm suppression. Equipment is categorized as source or load. If the source has an alarm, the load alarms are suppressed. For example, if a fan fails at the air handling unit, all zones served by that air handler will have their alarms suppressed. This reduces the number of alarms generated and allows the building operator to focus on the most likely cause of the alarm.

Optimal Start/Stop

During hours when the building is expected to be unoccupied, the HVAC system is typically shut off and zone temperature is allowed to drift away from its occupied setpoint. The time at which the system starts back up again is usually scheduled early enough so that the zone temperature reaches its occupied setpoint prior to scheduled occupancy on the worst-case (coldest or warmest) morning of the year. As a result, on all other days the system starts earlier than needed.

The Tracer SC+ system controller uses a pre-engineered control strategy—called optimal start—which determines the length of time required to bring the zone from its current temperature to its occupied setpoint. Then it waits as long as possible before starting the system, so that the zone reaches its occupied setpoint just in time for scheduled occupancy. It even learns from its historical performance, and can compensate for the current outside temperature, to better predict this optimal starting time. This strategy reduces the number of system operating hours and saves energy.

A similar strategy—called optimal stop—uses the Tracer® SC+ system controller to determine how early the heating or cooling can be shut off for the zone, so that the temperature in that zone will drift no more than 2°F from its occupied setpoint by the end of the scheduled occupancy period. In this mode, only cooling and heating are shut off; the supply fan continues to operate, and the outdoor-air damper remains open to continue ventilating the building. This strategy further reduces the number of system operating hours, saving energy by allowing indoor temperatures to drift early.

Fan Pressure Optimization

In a multiple-zone VAV system with terminal heat, each VAV terminal unit modulates to vary airflow delivered to its zone, as the load in that zone changes. This causes the pressure inside the supply ductwork to change. The rooftop unit controller varies the speed of the supply fan to maintain static pressure in the ductwork at the desired setpoint.

The Tracer SC+ system controller uses a pre-engineered control strategy—called fan-pressure optimization—to minimize duct pressure and save fan energy. Each Symbio® 210 controller knows the current position of the damper in its VAV terminal. The system control panel continually polls all the VAV controllers, looking for the terminal unit with the most-open damper. Then it dynamically resets the duct static pressure setpoint as low as possible, until one damper is nearly wide open. This new setpoint is communicated to the rooftop, water-cooled self-contained unit or air handler controller, allowing the supply fan to deliver the required airflow at as low a static pressure possible.

This results in less fan energy use, lower sound levels, greater supply fan turndown, and a reduced risk of fan surge. Plus, the duct static pressure sensor can be installed anywhere in the supply duct, allowing for it to remain at the factory-installed location in the discharge of the rooftop unit.

Discharge Air Temperature Reset

In a multiple-zone VAV system with terminal heat, increasing the discharge air temperature (DAT) setpoint at part-load conditions can reduce cooling and reheat energy use, but increases fan energy and can result in elevated zone humidity levels. Therefore, DAT reset should be implemented so that it minimizes overall system energy use—considering the trade-off between compressor, reheat, and fan energy.

To balance these competing issues in a multiple zone VAV system, the Tracer SC+ system controller uses a pre-engineered control strategy that keeps the DAT setpoint cold when its warm outside, thereby taking advantage of the significant energy savings from unloading the fan and avoiding elevated zone humidity levels. Then the DAT setpoint is reset upward during mild and cold weather to enhance the benefit of the airside economizer (thus saving cooling energy) and minimize reheat energy use.

Ventilation Optimization

Trane has two strategies built into the Tracer SC+ system controller to minimize ventilation energy usage: demand-controlled ventilation (DCV) and ventilation reset. As the number of people occupying a zone changes, the quantity of outdoor air required to properly ventilate that zone varies. DCV is a control strategy that dynamically resets outdoor airflow delivered to a zone based on this changing population, thereby reducing the energy needed to condition excess outdoor air. For a multiple-zone system, DCV control sequences—using either an occupancy sensor, time-of-day schedule, or CO_2 sensor—are pre-engineered in the Symbio® 210 VAV terminal unit controller and the Tracer® SC+ system controller. Ventilation reset continually calculates the correct outdoor airflow based upon the equations prescribed in ASHRAE® Standard 62.1. To do this, the Tracer® SC+ must periodically gather data from the VAV controllers.

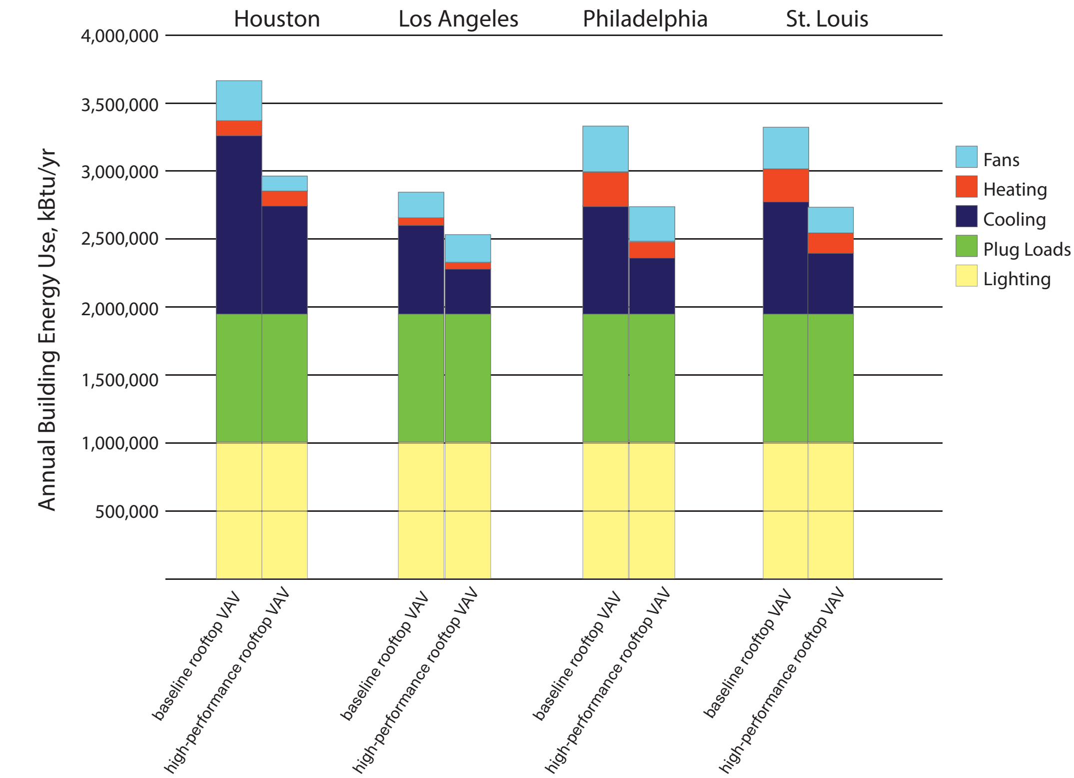
Additional information on optimization strategies

Trane Applications Engineering Manual - Rooftop VAV Systems (SYS-APM007*-EN) and Applications Engineering Manual - Chilled-Water VAV Systems (SYS-APM008*-EN).

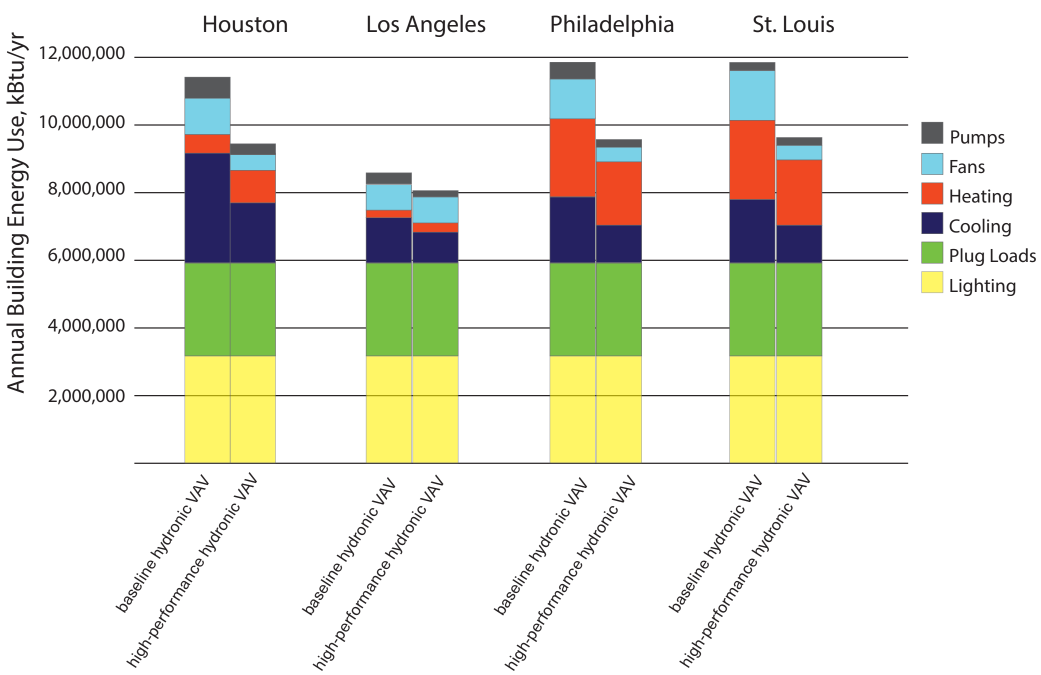
Energy Analysis

Energy simulation and analysis is useful to predict the energy consumption of a building, and select optimization strategies.

The Trane Air-Conditioning Economics (TRACE®) building energy analysis software was employed to model an 89,000 ft^2 office building. This analysis used a standard direct expansion VAV system as the baseline and compared it with an intelligent VAV system featuring energy recovery, variable speed equipment, and optimized controls. The findings showed that the intelligent VAV system outperformed the standard system, achieving annual energy savings of 20 to 30 percent.



A Hydronic VAV system was also modeled for a 268,500 ft^2 office building, revealing similar annual savings for the intelligent VAV system.



As with every system, Trane provides, supports, and encourages energy modeling during the system design phase. TRACE® 3D Plus software can be used to determine how an intelligent VAV system can help your building earn high performance designation, including earning LEED® points under EAc1. For more information, see "Resources from Trane" on page 44.

Application Considerations

Zoning

For multiple-zone Intelligent VAV systems with terminal heat, consideration should be given when grouping rooms or areas served by a single VAV terminal unit. The rooms/areas should have similar thermal load and population characteristics. For example, group rooms/areas on the same exposure to ensure similar envelope loads. Be careful grouping interior and exterior rooms/areas together in a single zone. Finally, rooms/areas that have unique thermal loads or operating profiles, such as server rooms, are best served by dedicated systems.

Component Sizing

A whole-building load design software program, like TRACE® 3D Plus, can be used to estimate the sizes of the various HVAC system components.

Rooftop unit. Single-zone two-speed and single-zone VAV work better with smaller rooftop unit sizes. As the size of the rooftop unit increases, the number of zones and the load diversity of those zones typically increase as well, which can lead to comfort issues—so a system with VAV terminals and terminal heat should be considered instead.

Air handling unit a**nd water-cooled self contained.** Multiple-zone VAV units can be selected to serve as many zones as needed for the application provided the coils can provide adequate part-load capacity. The maximum number of zones might be influenced by both unit capacity and budget. Unit capacity can depend on factors such as airflow, cooling, or heating needs. Budget considerations might take into account the control costs associated with having a larger number of smaller zones compared to a smaller number of larger zones.

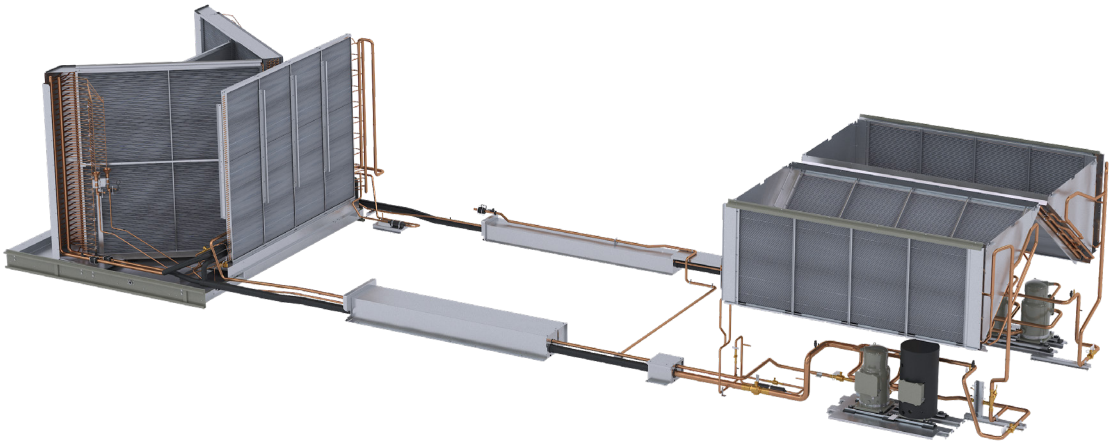
Oversizing rooftop, water-cooled self contained units and air handling units can create control issues leading to poor temperature and humidity control.

Water-cooled self contained unit. Multiple-zone VAV systems with self-contained units can be selected to match the cooling load capacity. An adequate water supply with good quality will prevent issues like scaling and corrosion.

VAV terminal units. It's important to correctly select the VAV terminal unit size for each zone to be properly controlled. The terminal unit should have adequate capacity to meet the cooling and heating needs of the zone, yet not be oversized. Oversized VAV terminals can lead to airflow control, operation, and acoustic problems. Therefore, select the smallest size that meets the maximum airflow requirement of the zone, and avoid sizes where the maximum (design) airflow is less than half of the factory-designed nominal flow (page 19).

Consult the "Selection Procedure" detailed in either the VariTrane® Round Inlet/Round Outlet product catalog (VAV-PRC016*-EN) or the VariTrane Single-Duct Units product catalog (VAV-PRC011*-EN) for more information..

Rooftop Unit Dehumidification



Multiple-zone Intelligent VAV systems typically do a good job of limiting indoor humidity levels over a wide range of indoor loads, because the rooftop unit supplies cool—and, therefore, dry—air at part-load conditions while varying supply airflow during cooling mode. To ensure adequate dehumidification:

- Avoid using discharge-air-temperature reset during humid weather. Warmer discharge air means less dehumidification at the cooling coil and higher humidity levels in the zone.
- Consider equipping the VAV terminal units with a heater. This allows the rooftop unit to continue dehumidifying the air to a lower discharge-air temperature setpoint (and, therefore, a lower dew point) when it's humid outside, and the terminal heat can be used to reheat this cool air, if necessary, to avoid overcooling the zone.
- Increase the flow of dry conditioned air to the zone. Temporarily increase the supply of dry supply air by forcing the VAV damper open. This will increase the flow of dry conditioned air from the rooftop unit. As a result, the rooftop fan will increase it's operating speed. To prevent over-cooling the zone, that VAV terminal unit may activate its reheat coil.

Trane IntelliPak® rooftop units can be equipped with modulating hot gas reheat (HGRH) for improved part-load dehumidification. If zone humidity exceeds the desired limit, a valve diverts hot gas leaving the compressor through a reheat coil located downstream of the evaporator (cooling coil). The compressor continues to operate, dehumidifying the air, while the hot gas reheat valve modulates to warm this dehumidifier just enough to avoid overcooling the zone.

The Symbio® 800 controller can be configured to activate hot gas reheat based on either zone dew point temperature or zone relative humidity level and can be activated in either occupied or unoccupied mode. This allows the system monitor space relative humidity or space dew point temperature. The newest versions of ASHRAE® Standard 62.1 now require space humidity be monitored and controlled using dew point temperature.

For comfort applications, hot gas reheat is typically not needed in a multiple-zone VAV system, since the rooftop unit is already dehumidifying the air to a low dew point, even at part-load conditions. If the humidity level in a zone were ever to rise higher than desired, the discharge-air temperature setpoint could be temporarily lowered to increase dehumidification. Alternatively, IntelliPak rooftop units can be equipped with modulating hot gas reheat. In a multiple-zone VAV system, the controller will increase compressor capacity to further dehumidify the air and modulate the hot gas reheat valve to maintain the discharge-air temperature at its cooling setpoint. For example, during cooling mode, the unit may discharge air at 55°F. During dehumidification mode, the leaving-evaporator temperature setpoint may be reset downward from 55°F to 50°F. Modulating hot gas reheat then reheats the cool, dehumidified air from 50°F to 55°F. VAV terminal unit heaters may then be used to provide additional zone reheat to maintain temperature.

Selection of Heat

Trane systems are available with a choice of heating options to best meet the needs of the project.

Rooftop Unit Heat

IntelliPak® rooftop units can be equipped with either a staged electric heater, a staged gas heater, or a modulating gas heater. Additionally, rooftop units can use a modulating hot water coil or steam coil.

Multiple-zone Intelligent VAV systems with terminal heat: For applications where the mixed-air temperature is not expected to drop below 45°F during occupied hours, consider upsizing the heaters in the VAV terminal units such that the heater in the rooftop unit does not need to operate during occupied mode. In this case, the rooftop unit might not be equipped with a heater, or it might be equipped with staged heat (or heat pump) that is used only for morning warm-up mode and daytime warm-up.

For applications where the mixed-air temperature is expected to drop well below 45°F during occupied hours, consider equipping the rooftop unit with a modulating gas heater, an SCR electric heater, or a hot-water coil with modulating control valve. This will enable the use of "supply-air tempering" to avoid too cold of air being delivered down the ductwork during these conditions.

For rooftop units equipped with **staged heat**, the heater operates in the following modes:

1. Morning warm-up mode: When the Tracer® SC+ system controller determines warm-up is required, it commands the dampers in all VAV terminal units to their maximum heating airflow setpoints. The supply fan in the rooftop unit ramps up to full speed and its heater stages until the zone temperatures rise back up to their occupied heating setpoints.

2. Daytime warm-up mode: During cold weather, the mixed-air temperature decreases. When the heater in the rooftop unit is off, this cool air is supplied down the duct. If the heaters in the VAV terminal units are not sized large enough to adequately warm this air, the temperature in one or more zones may drop below its heating setpoint. If this occurs, the Tracer SC+ can initiate a "daytime warm-up" mode during which it commands the dampers in all VAV terminal units to their maximum heating airflow setpoints, the supply fan ramps up to full speed, and the heater in the rooftop unit is staged on. Once the zones are warmed back above their heating setpoints, the heater in the rooftop unit turns off, the supply fan ramps back down and modulates to maintain the current duct static pressure setpoint, and the VAV dampers are allowed to return to normal operation.

For rooftop units equipped with **modulating heat**, the heater operates in the following modes:

1. Morning warm-up mode: When the Tracer SC+ determines warm-up is required, it commands the dampers in all VAV terminal units to their maximum heating airflow setpoints. The supply fan in the rooftop unit ramps up to full speed and its heater turns on and modulates until the zone temperatures rise back up to their occupied heating setpoints.

2. Supply-air tempering (occupied mode): During cold weather, if the mixed-air temperature drops below the desired discharge-air temperature setpoint, the heater in the rooftop unit turns on and modulates to maintain the current discharge-air temperature setpoint, while the supply fan modulates to maintain the current duct static pressure setpoint.

For projects where the VAV terminal units are equipped with hot-water coils, consider equipping the rooftop unit with a hot-water coil also—or having it field-installed in the supply ductwork, just after the air discharges from the rooftop unit—since the building is going to have a hot-water system anyway. In this case, if sub-freezing outdoor air is expected to enter the rooftop unit, it is recommended that the hot-water system include some means of freeze protection, such as glycol.

Water-Cooled Self-Contained Unit Heat

Trane Water Cooled Self-Contained Unit units can be equipped with a variety of heating coil options, staged or modulating SCR electric heat, hot water, and steam heat.

Multiple-zone Intelligent VAV systems with terminal heat: For applications where the mixed-air temperature is not expected to drop below 45°F during occupied hours, consider upsizing the heaters in the VAV terminal units such that the heater in the rooftop unit does not need to operate during occupied mode. In this case, the water-cooled self-contained unit might not be equipped with a heater, or it might be equipped with staged heat that is used only for morning warm-up mode and daytime warm-up.

For applications where the mixed-air temperature is expected to drop well below 45°F during occupied hours, consider equipping the water-cooled self-contained unit with an SCR electric heater, or a hot-water coil or steam coil with modulating control valve. This will enable the use of “supply-air tempering” to avoid too cold of air being delivered down the ductwork during these conditions.

Air Handling Unit Heat

Trane Performance Climate Changer AHU are typically equipped with a hydronic heating coil to maintain the desired discharge set point. Other heating coil alternatives include a modulating electric heater (SCR), a heat pump coil or steam coil.

Heat in the VAV Terminals

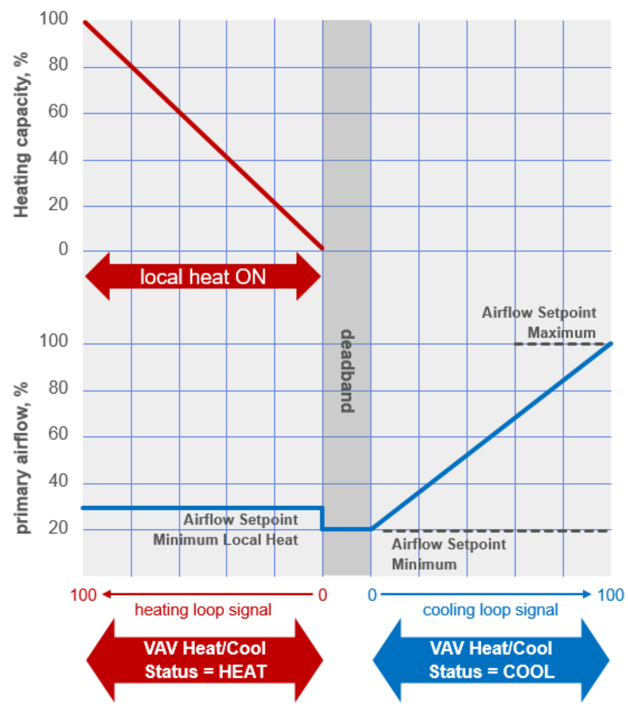
VariTrane® VAV terminal units can be equipped with either an electric heater—with staged or modulating SCR control—or a hot-water coil—with two-position or modulating valve control.

The table below compares the performance of an example VAV terminal unit, operating at this same design heating capacity, selected for a HWS temperature of only 105°F:

- In this example, either a three- or four-row coil is needed to provide the required heating capacity.
- Providing the same capacity with a lower HWS temperature requires a higher fluid flow rate, which affects the size of pipes, pumps, and valves, and can also increase pumping energy use.
- Increasing from three to four rows allows for a reduction in both fluid flowrate and fluid pressure drop, but results in a slightly higher airside pressure drop, which impacts fan energy use.
- Upsizing the VAV terminal unit—from an 8-in. to a 10-in. inlet in this example—is a way to further minimize the impact on both pumping and fan energy use. Note that in some cases, upsizing the inlet diameter (diameter of VAV damper) may require using a higher minimum airflow setting to ensure proper controllability at the lowest airflows.

VAV terminal unit control sequence with staged electric or two-position hot water heat

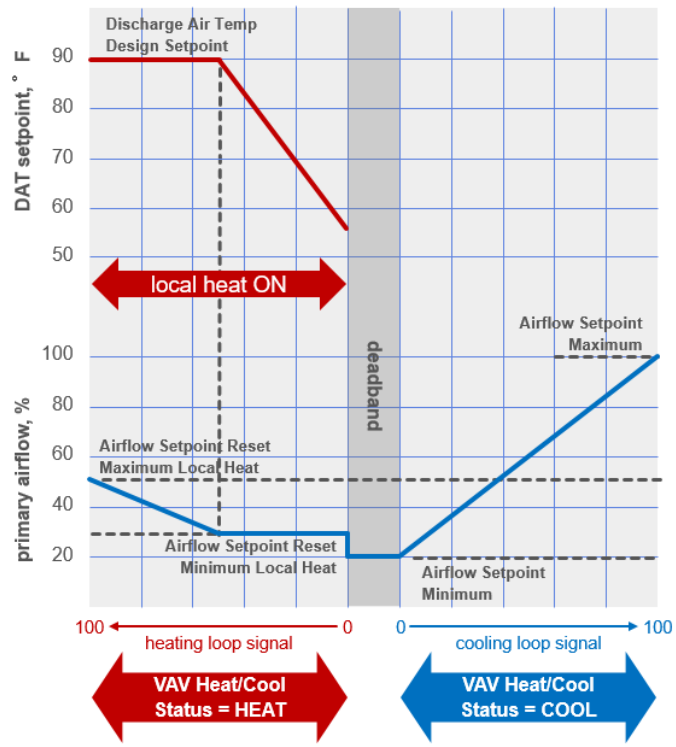
The chart depicts the control sequence for a VAV terminal unit equipped with either **staged electric** or **two-position hot-water heat.** If the zone requires cooling (VAV Heat/Cool Status = COOL), the VAV damper modulates airflow between maximum and minimum primary airflow setpoints, as required to maintain zone temperature at its cooling setpoint. When primary airflow has reached its minimum airflow setpoint, and the zone temperature has cooled to its heating setpoint, local heat is activated to avoid overcooling the zone (VAV Heat/Cool Status = HEAT). The VAV damper opens to its minimum local heating airflow setpoint and the controller stages the electric heater on and off (or cycles the hot-water valve open and closed), as required to maintain zone temperature at its heating setpoint.



Hot-water supply temperature	180°F	140°F	105°F	105°F	105°F	105°F
Coil rows	1	2	3	4	3	4
Inlet (VAV damper) diameter, in.	8	8	8	8	10	10
Coil heating capacity, Btu/h	10,600	10,600	10,600	10,600	10,600	10,600
Entering fluid temperature, °F	180	140	105	105	105	105
Leaving fluid temperature, °F	132	118	98	93	91	85
Fluid flow rate, gpm	0.44	0.95	3.27	1.71	1.52	1.05
Fluid pressure drop, ft. H_2O	0.66	0.10	1.13	0.45	0.70	0.51
Airside pressure drop at design cooling airflow, in. H_2O	0.23	0.43	0.63	0.83	0.31	0.41
Airside pressure drop at maximum heating airflow, in. H_2O	0.06	0.11	0.16	0.21	0.08	0.10

Note: Assumes airside pressure drop changes with the square of the airflow reduction—design cooling airflow = 650 cfm, minimum airflow = 130 cfm (165 cfm for 10-in. inlet diameter), maximum heating airflow = 325 cfm—using the "dual maximums" control sequence required by Section 6.5.2.1 of ASHRAE® Standard 90.1.

VAV terminal unit control sequence with SCR electric or modulating hot-water heat (i.e., “dual max sequence”)



The chart depicts the control sequence for a VAV terminal unit equipped with either modulating **SCR (silicon controlled rectifier) electric** or **modulating hot-water heat** and a discharge-air temperature (DAT) sensor. If the zone requires cooling (VAV Heat/Cool Status = COOL), the VAV damper modulates airflow between maximum and minimum primary airflow setpoints, as required to maintain zone temperature at its cooling setpoint. When primary airflow has reached its minimum airflow setpoint, and the zone temperature has reached its heating setpoint, local heat is activated to avoid overcooling the zone (VAV Heat/Cool Status = HEAT). The VAV damper opens to its minimum local heating airflow setpoint and the controller resets the DAT setpoint upward, as required to maintain zone temperature at its heating setpoint. The SCR electric heater (or hot-water valve) then modulates to maintain the current DAT setpoint. If the DAT reaches the DAT design setpoint, and the zone requires more heat, the VAV damper modulates between minimum and maximum local heating airflow setpoints as required to maintain zone temperature at its heating setpoint, while the SCR electric heater (or hot-water valve) continues to modulate to maintain the current DAT design setpoint.

Selection of SCR electric or modulating hot-water heat is recommended to enable use of the “dual max” control sequence. This improves comfort by minimizing thermal stratification when delivering warm air through overhead diffusers.

Ventilation Control

For some zones, delivering a fixed (constant) quantity of outdoor air may be desired. For other zones, demand-controlled ventilation (DCV) may be desired. DCV is a control strategy that dynamically adjusts the ventilation airflow delivered to a zone based on the changing population in that zone, thereby reducing the energy needed to condition excess outdoor air. See "Ventilation Optimization" on page 24. Within the air handler or rooftop, an outdoor air damper is used to control and regulate the flow of outdoor air for ventilation.

It is common to utilize one of two methods to control the outdoor air damper:

1. Vary the position of the outdoor air damper in proportion to the change in supply airflow, which is determined by the variable speed supply fan.

2. Utilize a flow-measuring device to directly measure and control the outdoor airflow, such as Trane's Traq™ damper.

Utilize occupied standby for energy savings

A sensor, such as a motion detector, can be used to detect the presence of people in a zone and communicate this information forward to a system controller. When the sensor detects that the zone is unoccupied, the controller can change the operating mode to "occupied standby." This mode resets the outdoor air flow to zero or less-than-design (based upon the requirements of ASHRAE® Standard 62.1). Next, the minimum volume of conditioned air flowing to the zone can be reset, as the space is empty and likely experiencing reduced load. Additionally, the space setpoint temperature can be reset to reduce cooling or heating energy usage and space lights can be dimmed or turned off.

When occupancy is detected, normal space operation is resumed with ventilation, typical temperature setpoints, and lighting levels.

Example of occupied standby mode

Lights	Occupied mode	Occupied standby mode
Zone Cooling Setpoint	75°F	77°F
Outdoor Airflow Required	310 cfm	0 cfm*
Minimum Primary Airflow Setting	450 cfm	225 cfm

* ASHRAE® Standard 62.1 permits some zone types to use occupied standby and reset ventilation to 0 cfm provided the ventilation can be immediately reset when occupancy is detected. Check the standard for applicable zone types.

Air Cleaning and Filtration

There are a variety of different air cleaning and filtration technologies available to reduce particulate and pathogen spread. Trane provides numerous filtration and air cleaning solutions detailed in the IAQ portfolio table on page 34.

Rooftop units, water-cooled self-contained units, and air handlers can be shipped with different filter types of varying MERV ratings. Some models include options for pre-filters to initially clean the supply air upstream of system coils and fans, and downstream or final filters which are used to clean the air before discharge into the supply air system.

Additionally, Trane offers three other air cleaning technologies:

- **Dry-hydrogen Peroxide (DHP)**. Room- and duct-mounted devices that are designed to produce molecular hydrogen peroxide using a photocatalytic reaction. The hydrogen peroxide molecules oxidize a microbe's cell membrane and disrupt its chemical structure to inactivate the pathogen. This technology if often coupled with filtration because DHP does not capture particulates.
- **Photocatalytic oxidation (PCO).** Ultraviolet light shines on a catalyst to produce highly reactive hydroxyl radicals. The cells of microbiological organisms that contact these hydroxyl radicals are destroyed through a process called lysis (destruction of the cell by rupturing its membrane or cell wall). Biological organisms also create low levels of volatile organic compounds (VOCs), which typically cause odors. Some PCO technologies can be used to remove VOCs from the air stream. VOCs are adsorbed onto the surface of the catalyst. Ideally, this process oxidizes all the organic compounds into carbon dioxide (CO_2) and water (H_2O). Trane offers an air cleaning system which combines high efficiency filtration and photocatalytic oxidation.
- **Ultraviolet Germicidal Irradiation (UVGI).** Ultraviolet energy can be used to inactivate microorganisms by damaging their DNA or RNA. In applications where sufficient residence times exist, such as on stationary surfaces, it is possible and often practical to deliver a "killing" dose of ultraviolet energy to the organism.

For additional information on pathogens and air cleaning technologies, see the Trane Applications Engineering Manual "*Air Cleaning Systems*" (APP-APM002*-EN).

IAQ Portfolio

The following table shows Trane's IAQ portfolio, including filtration options and cleaning technologies available per product.

	Filtration					Synexis Dry Hydrogen Peroxide	Trane Catalytic Air Cleaning System (TCACS)	Ultraviolet Germicidal Irradiation (UVGI)
	2-inch	4-inch	Other filters	12-inch cartridge	HEPA			
IntelliPak I	S	S	18-19 inch/30-inch bag	S	CT	CT	CT	CT
IntelliPak II	S	S	18-19 inch/30-inch bag	S	CT	CT	CT	CT
IntelliPak III	S	S	MERV-14 - CT	S		CT	CT	CT
Catalog Air Handling Units	S	S				S		
Semi-Custom Air Handling Units	S	S	18-19 inch/30-inch bag	S	S	S	S	S
Custom Air Handling Units	S	S	18-19 inch/30-inch bag	S	S	S	S	S
S = standard option from the factory CT = Contact your Trane sales representative								

Airside Economizing

An airside economizer is a common energy-saving control strategy that uses outdoor air as a source of “free” cooling whenever possible. When the outdoor air temperature is cool enough, the air handler or rooftop unit uses it to offset as much of the cooling load as possible.

When the outdoor air dry-bulb temperature is less than the unit discharge air temperature, such as 55°F, the unit controller modulates the outdoor air and return air dampers to discharge air at the desired setpoint temperature—a mode called modulating economizer control. Because the outdoor air is cool enough, the rooftop refrigeration system is off or air handler cooling coil valve is closed—no mechanical cooling is needed. The outdoor air damper can modulate between the minimum position needed to provide ventilation and wide open.

When the outdoor air dry-bulb temperature rises above the current discharge air temperature setpoint, the system requires more cooling capacity than can be simply provided by the outdoor air. The outdoor air damper remains wide open with return-air dampers closed, but the unit controller uses mechanical cooling to provide the balance of the cooling capacity needed to achieve the desired discharge air temperature. This “integrated economizer” mode utilizes the cool ambient air and refrigeration or chilled water to offset the cooling load.

Additional information on economizer control

For more information on the various methods of controlling airside economizers, and their impact in Intelligent VAV systems, refer to “*Chilled Water VAV Systems*” or “*Rooftop VAV Systems*” Applications Engineering Manuals (SYS-APM008*-EN and SYS-APM007*-EN, respectively), the Trane Engineers Newsletter Live broadcast titled “*Delivering Performance from Airside Economizers*” (APP-CMC058-EN) and the Trane *Engineers Newsletters* titled “Airside Economizers” (ADM-APN020-EN) and “Airside Economizers and ASHRAE® Standard 90.1-2013” (ADM-APN052-EN).

Airside economizing is suspended when the outdoor air conditions reach the high-limit shutoff. There are numerous high-limit shutoff strategies, but the most common are: fixed dry-bulb control, fixed enthalpy control, or differential enthalpy control.

- **Fixed dry-bulb control** uses a sensor to measure the dry-bulb temperature of the outdoor air then compares this temperature to a pre-determined high-limit shutoff setting. Whenever the outdoor air temperature is above the limit, airside economizing is disabled.
- **Differential dry-bulb control** uses sensors to compare the outdoor dry-bulb temperature to the return air dry-bulb temperature. When the outdoor air temperature is greater than the return air temperature, airside economizing is disabled.
- **Fixed enthalpy control** uses sensors to measure the dry-bulb temperature and relative humidity of the outdoor air. The controller then calculates the outdoor air enthalpy and compares to a predetermined high-limit shutoff setting. Whenever the outdoor air temperature is above the limit, airside economizing is disabled.
- **Differential/comparative enthalpy control** uses sensors to measure the dry-bulb temperature and humidity of both the outdoor air and return air streams. The controller calculates the enthalpy of both air streams and uses the lower-enthalpy air to satisfy the cooling load. The economizer is disabled when the outdoor air enthalpy is higher than the return air enthalpy.

When a system is utilizing chiller heat recovery for air hander or VAV heat, it may be advised to suspend the airside economizing in order to maximize the chiller heat recovery capacity.

Waterside Economizing

A waterside economizer is a common energy-saving control strategy that uses cooling tower water as a source of "free" cooling whenever possible. When the outdoor air temperature is cool enough to produce cool cooling tower water, the water-cooled self-contained unit uses it to offset as much of the cooling load as possible. When the cooling tower water temperature is 7 degrees less than the unit return air temperature, the unit controller modulates waterside economizer valve to reduce the amount of mechanical refrigeration needed to cool the return air to setpoint. If the cooling tower water is cool enough, the self-contained unit's refrigeration system is switched off and no mechanical cooling is needed. When the cooling tower water temperature rises above the current discharge air temperature setpoint, the system requires more cooling capacity than can be simply provided by the waterside economizer the unit controller uses mechanical cooling to provide the balance of the cooling capacity needed to achieve the desired discharge air temperature. This "integrated waterside economizer" mode utilizes the cooling tower water and the unit's refrigeration system to offset the cooling load.

Waterside Economizer Operation

The waterside economizer uses cooling tower water, whenever its temperature is 5 degrees lower than the return air temperature dry bulb temperature to offset all or part of the system load. To take advantage of the potential cooling effect of the cooling tower water, it is conducted through a coil that is placed in the return air stream ahead of the DX evaporator coil.

Similar to the airside economizer, the water side economizer option reduces the evaporator load, bringing about compressor energy savings. In addition, during waterside economizer operation the coincident lowering condensing temperatures contribute to more efficient compressor operation.

Advantages:

- Reduces compressor energy.
- Humidification is not required.
- No large outside air duct or wall penetration.
- Mechanical room can be located in the center of the building.
- Simplified control
- Building pressurization control is simpler.
- Separate economizer piping is not required.

The waterside economizer function are controlled by a three-way diverting valve, high limit control, leavening air temperature control and a compressor low limit control.

To take advantage of the potential cooling effect made available by low temperature tower water, the economizer coils is placed in the return air stream ahead of the evaporator.   Its capacity is controlled on an on-off basis from the cooling tower water loop supply. Once the supply tower temperature has been reduced to a point that it can offset load, this energizes the 3-way free-cooling valve. This places the valve in the straight-through position, directing the full flow of cooling tower water through the economizer coil and then to the condenser.

If the cooling load can be satisfied by the economizer alone, no mechanical refrigeration is used. However, if additional capacity is required, the Symbio controller will energize the stages of mechanical cooling needed to maintain the discharge air setpoint temperature.

If, or when, the entering tower water temperature falls to a point that can result in low suction pressure and possible coil frosting, the contracts of the compressor low limit control close.

If the leaving air temperature controls monitor the temperature of the unit discharge air it will modulate the free-cooling valve to maintain discharge air temperature setpoint.

Conversely, a rising cooling tower water loop temperature will cause the compressor low limit control to open and again maintain the discharge air temperature setpoint.

Building Pressure Control

System supply fan speed is typically determined based upon the building load and ventilation requirements. Modern systems utilize variable speed supply fan control to provide an adequate amount of supply air to offset zone loads and maintain ventilation while using the least amount of energy. As conditions allow, systems utilize demand-controlled ventilation (“Ventilation Control” on page 32) to reduce the quantity of outdoor air being used for ventilation. And when the weather conditions are favorable, the system utilizes airside economizing (“Airside Economizing” on page 35) to further reduce energy usage. As a result, the amount of outdoor air entering the system may vary from day to day and hour to hour.

Rooftop units or air handlers must be designed with a relief system that can be used to maintain building pressure as the amount of outdoor air varies throughout operation.

Building Pressure Control without an Exhaust Fan

If the unit is ordered without a factory installed relief or return fan, any needed building pressure control must be achieved by field-provided building exhaust or by using a building barometric relief assembly. Relief dampers must be properly sized and carefully oriented to ensure proper operation, even during windy conditions.

Building Pressure Control with a Relief Fan and StatiTrac™ Control System

To maintain building pressure, systems are often equipped with an optional relief fan that is designed to remove 0 to 100 percent of the supply airflow while maintaining space building pressure. If the unit is ordered with StatiTrac control system, a variable speed relief fan motor or modulating exhaust discharge damper (with a single speed relief fan) is used to maintain the desired space (building) pressure.

StatiTrac compensates for potential building pressure imbalance brought about by fluctuating fresh air intake volumes, wind, stack effect or remote exhaust systems such as restroom, lab, or kitchen exhaust turning on and off. Once the fresh air damper has opened to the exhaust enable setpoint, StatiTrac modulates the exhaust damper or relief fan variable speed drive to maintain the building pressure within “deadband” (space pressure setpoint plus or minus half of the space pressure deadband).

Acoustics

Background sound levels in occupied buildings can have a very large impact on occupant satisfaction. Some space types, such as school classrooms, have unique noise requirements to ensure the background level is not too high and impairs student learning. Within an HVAC system, there can be many different sound-generating components such as compressors and fans. Additionally, air passing through duct systems and terminal units can both attenuate and regenerate sound.

Rooftop units have several sound-producing components such as supply air fans, return or relief fans, compressors, and condenser fans. Since the rooftop is typically installed outside, the sound from these components can be attenuated to ensure proper background sound.

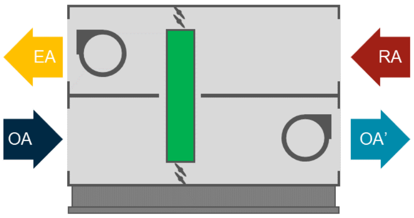
Air handling units typically have supply and return/relief fan sound sources. These sound sources can be managed with proper ductwork selection, sizing, and attenuation.

Both rooftop units and air handling units can be located far away from critical sound locations.

Variable air volume systems will utilize VAV boxes to modulate the flow of conditioned air to the occupied space. These units are the typically installed near the occupied space. Trane VAV boxes are among the quietest within the industry. Additionally, Trane provides robust acoustical sound data to support analyses via software, like Trane’s TAP™ acoustical analysis program.

Air-to-Air Energy Recovery

Air-to-air energy recovery refers to the transfer of sensible heat or sensible and latent heat (moisture) between air streams. The most common application is to recover energy from the system exhaust air stream and precondition the outdoor air introduced for ventilation.



Benefits of Outdoor Air Preconditioning with Air-to-Air Energy Recovery

- Reduces cooling, dehumidification, heating, and humidification energy
- Allows downsizing of cooling, dehumidification, heating, and humidification equipment
- Can be used as part of a decarbonization strategy to augment electrified heating

The Importance of Proper Control

In many climates, an airside economizer can provide the benefits of "free" cooling for much of the year. While the economizer operates, air-to-air energy recovery offers no additional benefit. In fact, unless it is turned off, the energy-recovery device increases the cooling load by transferring heat from the exhaust air stream. To accommodate economizer operation when the energy-recovery device is idle, bypass dampers allow full economizer airflow without significantly increasing the airside pressure drop.

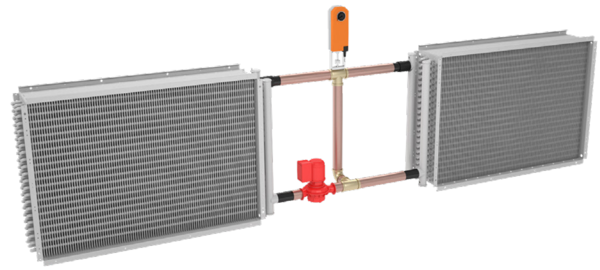
Preventing Frost. Any air-to-air energy-recovery device that preconditions outdoor air is subject to frost buildup during very cold weather. If the surface temperature of the device falls below the dew point of the exhaust air, water vapor will condense on the exhaust side of the device. If the exhaust-side surface temperature falls below 32°F, this water freezes, eventually blocking airflow. One of the benefits of total energy recovery over sensible-only energy recovery is that frost forms at a much colder outdoor temperature, which may even eliminate the need for frost prevention.

Typical approaches to frost prevention:

- Modulate an outdoor air bypass damper to reduce the heat transfer capacity of the energy recovery device
- Preheat either the outdoor air or the exhaust air before it enters the device, for applications with extremely cold outdoor air and higher indoor humidity levels during cold weather

Available Air-to-Air Energy Recovery Technologies

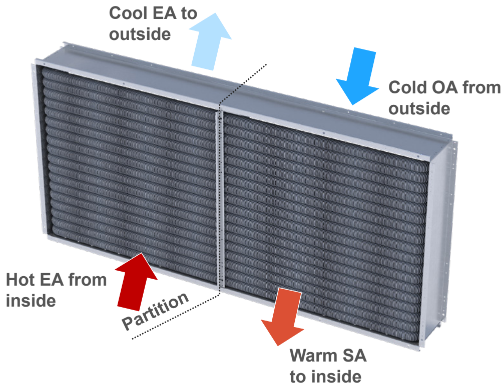
Coil Loop



Coil loops, sometimes called coil run-around loops, have two or more finned tube coils that are piped together in a closed loop. A fluid is circulated by a pump between the coils to transfer sensible heat from one air stream to another. The fluid is often water mixed with a freeze inhibitor like glycol.

In the cooling season, hot outdoor air enters the building for ventilation. The air passes through a coil with fluid circulating through it. As a result, the outdoor air is cooled. This warm fluid is circulated to the other coil in the exhaust air stream where the heat is absorbed by the exhaust air, as it leaves the building. In the heating season, warm exhaust air heats the fluid in the coil. This fluid is circulated to the coil in the ventilation air stream and the outdoor air is heated.

Heat Pipe



A heat pipe is like a coil loop but not quite as flexible. The typical configuration requires the airflows to be side-by-side, as shown here. Each assembly contains multiple heat pipes. Each is an independent sealed tube filled with a heat-transfer fluid—often refrigerant. A partition divides the heat pipe into separate "evaporator" and "condenser" sections.

To control heat recovery, units may include bypass dampers to route air around the heat pipe or valves to restrict the flow of refrigerant.

Fixed Membrane

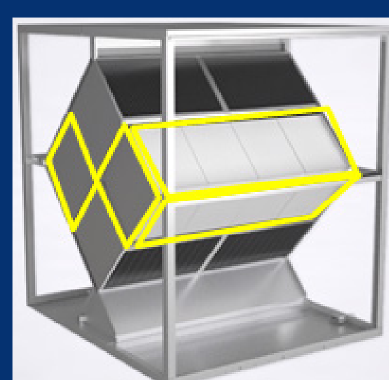
A variation of the fixed plate heat exchanger is the membrane exchanger. Instead of aluminum plates, a vapor permeable membrane can be used to exchange sensible heat and water vapor. Fixed membrane heat exchangers generally have higher air pressure drops and cannot withstand large air volumes so they may be manufactured in combination with fixed plate heat exchangers (see "Trane Sensible Assisted Membrane (SAM)" sidebar below).

Fixed Plate

Fixed plate heat exchangers use a series of plates with internal separators to create independent, separate airflow channels. There are a variety of materials used, but aluminum is the most common. The plates and separators are stacked with sealed alternate edges to prevent cross leakage. These exchangers can be made to withstand large pressure differentials. Fixed plate heat exchangers can be designed to handle higher temperatures and have an optional corrosion protection coating.

Trane Sensible Assisted Membrane (SAM)

Trane has developed a patented air-to-air energy recovery application called Sensible Assisted Membrane (SAM) which combines a fixed plate and fixed membrane heat exchanger into a single assembly. This allows the unit to provide sensible and latent energy recovery in air handling applications allowing greater size and scale as compared to membrane exchangers which increases the airflow range.



Total Energy Wheel

Rotary heat exchangers, commonly called heat recovery wheels, are designed to rotate between two airstreams. Some wheels are designed for sensible heat transfer only. However, most models are designed to transfer sensible and latent heat. Wheels in this latter category are sometimes called total energy wheels or enthalpy wheels.

The wheel rotates between 20 and 60 revolutions per minute between the exhaust and outdoor air streams. As the wheel rotates between air streams, sensible heat is transferred to the material from the hot air stream and released in the cold air stream. Similarly, latent heat is transferred as the desiccant adsorbs water vapor from the airstream with higher humidity and desorbs in the airstream with lower humidity. This means colder air is heated and drier air is humidified.

Comparing Air-to-Air Energy Recovery Technologies

The table on properties of air-to-air energy recovery technologies (below) summarizes the energy transfer capabilities, typical effectiveness values, air pressure drop values, and cross leakage for common air-to-air energy recovery technologies.

Properties of Air-to-Air Energy Recovery Technologies

	Energy transfer		Typical effectiveness		Typical air pressure drop (1) (in. w.g.)	Cross leakage
	Sensible	Latent	Sensible	Latent		
Coil loop	✓		50 - 55%		0.5 - 0.9	None
Heat pipe	✓		35 - 45%		0.5 - 1.0	Minimal
Fixed plate heat exchanger	✓		60 - 70%		0.4 - 0.8	Minimal
Membrane	✓	✓	65 - 70%	35 - 55%	0.7 - 1.3	Minimal
Sensible-Assisted membrane (SAM)	✓	✓	70 - 77%	25 - 55%	0.5 - 1.5	Minimal
Sensible heat wheel	✓		65 - 72%		0.5 - 1.0	Some
Total energy wheel	✓	✓	65 - 72%	60 - 70%	1.0 - 1.5	Some

(1) Typical air pressure drop per side

Note: This table represents the range how these technologies are often applied in commercial HVAC systems and do not represent full range or what may or may not be possible.

Air-to-Air Energy Recovery Options

	Coil loop	Heat pipe	Fixed plate	Fixed membrane	Total energy wheel
IntelliPak I	CT	CT	CT	CT	CT
IntelliPak II	CT	CT	CT	CT	S
IntelliPak III	CT	CT	CT	CT	CT
Catalog air handling units	S				
Semi-custom air handling units	S	CT	S	S	S
Custom air handling units	S	S	S	S	S

S = Standard option from the factory
CT = Contact your Trane sales representative

Cold-Air VAV Systems

Many choices in the design of an HVAC system are "predetermined" by experience. System design engineers repeatedly choose to supply 55°F (13°C) supply air because they know it has worked in the past. The supply airflows that result from this choice directly impact the size (and cost) of fans, VAV terminal units, diffusers, and ductwork. The size of fan motors is also affected, which extends the cost impact to the electrical distribution system.

Cold-air VAV systems typically deliver supply air at a temperature of 45°F to 52°F (7°C to 11°C). The appeal of cold-air distribution lies in the reduction in the airflow required to offset the sensible cooling loads in the zones. As the example in the Conventional versus Cold-Air VAV Systems table below suggests, lowering the supply-air temperature from 55°F (13°C) to 52°F (11°C) can reduce the supply-air volume by 17 percent.

Reducing supply airflow can trigger a series of related benefits:

- Smaller supply fan (and return or relief fan, if equipped)
- Smaller vertical air shafts, which can increase usable (or rentable) floor space
- Smaller VAV terminals, which ease tight installations, are less expensive, and may be quieter
- Smaller ductwork, which requires less sheet metal, simplifies installation, and leaves more space above the ceiling for other services
- Shorter floor-to-floor height (attributable to smaller ductwork) may reduce the cost of glass and steel in a multi-story building
- Smaller supply fans (and return or relief fans, if equipped) reduce the cost of the electrical distribution system and lowers operating costs (it may also reduce fan-generated noise)
- Potential for lower space humidity levels due to the delivery of colder (and, therefore, drier) air

For further energy savings, consider keeping the same size ductwork (not downsizing for installed cost savings). This also improves the ability of the system to respond to possible future increases in load, since the system will be capable of handling an increased airflow rate if needed. The lower relative humidity in a cold-air system often allows the zone dry-bulb temperature to be slightly warmer than in a conventional system, while still achieving an equivalent sensation of comfort.

Concerns that design engineers have about cold-air distribution typically focus on the following three issues:

1. Effects of delivering cold air into the zone on occupant comfort
2. Impact on overall system energy consumption
3. Avoiding condensation on components of the air distribution system

The first two challenges are overcome by selecting high-aspiration diffusers and/or fan-powered VAV terminals as air blenders, plenum returns, properly sealed and insulated components, and fully integrated system controls. Whole building energy analysis quantifies the energy impact of operating a cold-air system, including the impact on airside economizer operation, cooling and heating plants, and fan-powered VAV terminals when present.

Conventional versus Cold-Air VAV Systems

	Conventional VAV System	Cold-air VAV System
Supply-air temperature	55°F (13°C)	52°F (11°C)
Zone setpoint	75°F (24°C)	76°F (24.5°C)
T (T_{zone} - T_{SA})	20°F (11°C)	24°F (13.5°C)
Supply airflow per ton (kW) of zone sensible cooling load	553 cfm/ton (0.074 m^3/s/kW)	460 cfm/ton (0.060 m^3/s/kW)

Chilled Water or Direct Expansion?

When deciding between a direct-expansion (DX) system and a chilled-water system for an Intelligent VAV system application, several factors should be considered.

Installed Cost:

DX Systems: Often have a lower installed cost for smaller buildings. They eliminate the need for chilled-water pumps, control valves, piping, and related accessories. Packaged DX equipment generally requires less field labor and materials to install, and many control functions can be integrated into the same piece of control hardware, reducing design, installation, and commissioning time.

Chilled-Water Systems: May have a higher initial installed cost due to the need for additional components like pumps and piping.

Life-Cycle Cost:

DX Systems: Do not have the added energy use of pumps, but their compressors may be less efficient than those in chilled-water systems.

Chilled-Water Systems: The larger compressor on the water chiller is often more efficient. A comprehensive energy analysis is recommended to estimate life-cycle cost differences. Software tools like TRACE® 3D Plus can assist in this analysis.

Design Flexibility:

DX Systems: Using packaged components can reduce initial costs but may limit design flexibility, making it difficult to meet certain system requirements.

Chilled-Water Systems: Offer more flexibility in design with more sustainable solutions, but may come with higher initial costs.

Space Requirements:

DX Systems: Ideal for applications with limited indoor space. Many DX systems are packaged and use air-cooled condensers, allowing them to be located on the roof, in small equipment rooms, or within the perimeter wall of the building.

Chilled-Water Systems: Typically require indoor equipment rooms for chillers and pumps, which can reduce usable or rentable floor space. Air-cooled chilled-water systems require less indoor space but still need room for the evaporator and/or pumps.

Services to maintain an Intelligent VAV system

Connected Services

Building connectivity enables optimization of facilities from a data-informed, streamlined perspective.

Trane's Connected Building Services are innovative, technology-driven solutions that leverage the power of automation, the IoT, data analytics, machine learning and more to transform how systems interact with each other and people.

At the equipment level, Symbio® unit controllers enable remote connectivity to monitor, analyze and enhance equipment performance. Symbio unit controllers integrate seamlessly and securely with Tracer or non-Trane building automation systems, leveraging secure remote connectivity with open standard communication protocols (BACnet, Modbus® and LonTalk®) and optional Air-Fi® wireless technology for simplified equipment monitoring and management.

Once the equipment is connected, a Connected Mechanical Service Agreement allows digital equipment inspections to leverage continuous data collection and our digital analytics to identify unfavorable operating trends and diagnostics that can erode equipment performance resulting in increased operating costs.

At the system level, Tracer SC+ system controller serves as the central coordinator for all individual devices on a Building Automation System (BAS). With Connected Building Services, the complete building performance is taken into consideration. Through performance charts, dashboards and inspection there is more transparency identifying potential problems and fixing them remote or onsite.

Trane Autonomous Control is an AI-driven service for Trane controls. Working 24/7, the technology constantly observes and analyzes your multi-site buildings for opportunities, and it performs the improvement without the need for human intervention. This cloud-hosted service analyzes predictive factors and complex variables to leverage every opportunity to conserve energy while maintaining comfortable and productive spaces. To see how Trane Autonomous Control powered by BrainBox AI® can optimize your building systems even more, visit Trane.com or contact your Trane account manager.

R'newal®

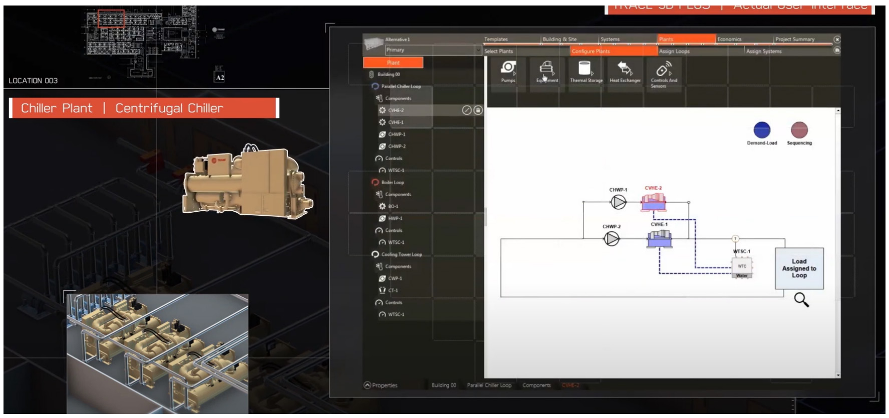
Reliable and efficient Heating, Ventilating and Air Conditioning (HVAC) equipment is essential to daily business operation. From enhancing productivity to ensuring occupant comfort, there are many reasons to keep your chiller up and running. However, with all mechanical equipment, deterioration occurs with time and usage. The key is to know when to take proactive steps to renew your equipment, maintaining reliable operation and minimizing financial risk. Trane's R'newal® service program can help you do just that.

R'newal is a planned service program that proactively replaces critical elements of your HVAC system, effectively restoring compressor function and reliability to like-new performance. We're so confident it will perform like new that we back applicable components with a limited factory warranty for up to 5 years.

Reach out to Trane to learn about other service programs that can help keep your unit running efficiently for its entire life.

Trane has a variety of resources available to help design, select, and configure Intelligent VAV systems. These include simulation software for component sizing and energy simulation, equipment selection tools, configuration tools, and programming tools for controls.

TRACE® 3D Plus Design and Analysis Software



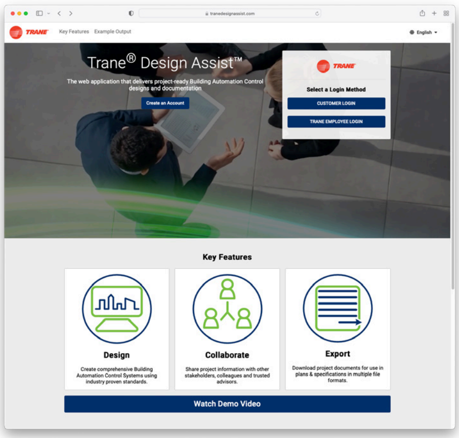
For over 50 years, Trane has developed the TRACE family to provide best-in-class simulation, including component sizing and energy/economic simulation. TRACE can be used to size individual coils to determine air handler or rooftop unit sizing, VAV box sizing, reheat coil sizing, and fan sizing. Then, the software can be used to simulate the as-designed building over a prescribed period to determine energy consumption and cost of operation.

TRACE 3D Plus Supports

- 3D graphical interface for easy building creation
- Comprehensive energy modeling and economic analysis
- Support for the latest high-performance system control optimizations
- Automated code and standard compliance wizards
- Support for up to 20 alternatives to facilitate easy system and control comparison
- Supports carbon calculations, renewable energy, and associated cost savings

For more information, including a free demonstration download, visit www.trane.com/trace3dplus.

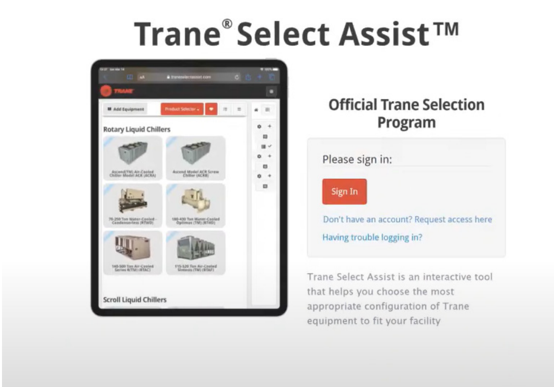
Trane® Design Assist™



Trane Design Assist offers the ability to create high performing building automation system designs and documentation using a web-based canvas. Users create scalable designs on a digital canvas within the tool, giving self-service access to comprehensive documentation like overall project layouts, flow diagrams, sequence of operations, points list, and project guide specifications. It supports multiple HVAC applications such as AHUs, cooling plants, heating plants, dedicated outdoor air systems, chiller-heater systems, VAV, VRF, terminal systems, and more. Plus, it provides options for greater levels of customization if needed to meet specific project needs. Available in English, Spanish, French Canadian, and Portuguese.

Explore at www.tranedesignassist.com.

Trane® Select Assist™



Trane's product selection program, Trane Select Assist, provides a web-based flexible tool that can be used on a PC, tablet, or smartphone. The selection program guides users through the process of configuring Trane equipment to meet or exceed the project specifications. When selections have been run and identified, it is easy to simply share the selection file with your Trane account manager.

Explore at www.traneselectassist.com.

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