Agenda and Objectives

Trane Engineers Newsletter Live Series

Air-Handling Systems, Energy, and IAQ

Air-handling systems are key elements for building comfort and air quality, but they use energy. How much energy? The answer depends upon system configuration and control approaches. This broadcast presents various design and control strategies that can help reduce energy use, along with some interesting new technologies for improving indoor air quality (IAQ).

By attending this event you will be able to:

1. Summarize the latest initiatives to reduce building energy use
2. Identify several air-handling system configurations and control strategies that reduce energy use
3. Identify the latest air cleaning approaches for improving IAQ

Agenda:

1) Latest initiatives to reduce building energy use (ASHRAE building labeling, etc.)
2) Choices
    a) Ventilation system type
    b) Energy-saving air handling unit (AHU) ideas that are common to all system types
3) System-specific energy-saving options
    a) Constant-volume air handlers
    b) VAV air-handling systems
4) Dedicated outdoor-air systems
    a) Describe dual wheel unit (enthalpy wheel)
    b) Deliver air “cold” rather than “neutral”
5) Overview of air cleaning
    a) Particulate filters
    b) Gaseous air cleaners
    c) Biologicals

Presenters

Trane Engineers Newsletter Live Series

Air-Handling Systems, Energy, and IAQ

(2009)

Art Hallstrom | Team Leader, Applied System Specialist | Trane

Art has more than 35 years of industry experience working with innovative systems and products. Currently he heads up a support team of system specialists to develop innovative solutions to challenging projects. Art has created over 30 applications manuals and articles on subjects like electronic noise cancellation, building pressurization, and static regain duct design. Art is a PE, ASHRAE Fellow and is serves on the ASHRAE Technical Council. He is a former Director of ASHRAE and a Past President of the ASHRAE College of Fellows. He is a retired U.S. Army LTC, a commercial pilot, an advanced SCUBA diver, and licensed sailboat skipper.

Dennis Stanke | staff application engineer | Trane

With a BSME from the University of Wisconsin, Dennis joined Trane in 1973, as a controls development engineer. He is now a Staff Applications Engineer specializing in airside systems including controls, ventilation, indoor air quality, and dehumidification. He has written numerous applications manuals and newsletters, has published many technical articles and columns, and has appeared in many Trane Engineers Newsletter Live broadcasts.

An ASHRAE Fellow, he is currently Chairman for SSPC62.1, the ASHRAE committee responsible for Standard 62.1, "Ventilation for Acceptable Indoor Air Quality," and he serves on the USGBC LEED Technical Advisory Group for Indoor Environmental Quality (the LEED EQ TAG).

John Murphy | senior applications engineer | Trane

John has been with Trane since 1993. His primary responsibility as an applications engineer is to aid design engineers and Trane sales personnel in the proper design and application of HVAC systems. As a LEED Accredited Professional, he has helped our customers and local offices on a wide range of LEED projects. His main areas of expertise include dehumidification, air-to-air energy recovery, psychrometry, ventilation, and ASHRAE Standards 15, 62.1, and 90.1.

John is the author of numerous Trane application manuals and Engineers Newsletters, and is a frequent presenter on Trane's Engineers Newsletter Live series of broadcasts. He also is a member of ASHRAE, has authored several articles for the ASHRAE Journal, and is a member of ASHRAE's "Moisture Management in Buildings" and "Mechanical Dehumidifiers" technical committees

Air-Handling Systems, Energy and IAQ

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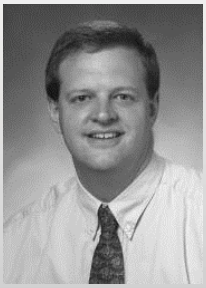
Air-Handling Systems, Energy and IAQ

Today's Topics

- Latest initiatives to reduce building energy use
- Energy-saving ideas for air-handling systems
  - Constant-volume air-handling units
  - VAV air-handling systems
- High-performance dedicated outdoor-air systems
- Overview of air-cleaning technologies

Today's Presenters

Art Hallstrom
Manager, Applied System Specialists



John Murphy
Applications Engineer

Dennis Stanke
Staff Applications Engineer

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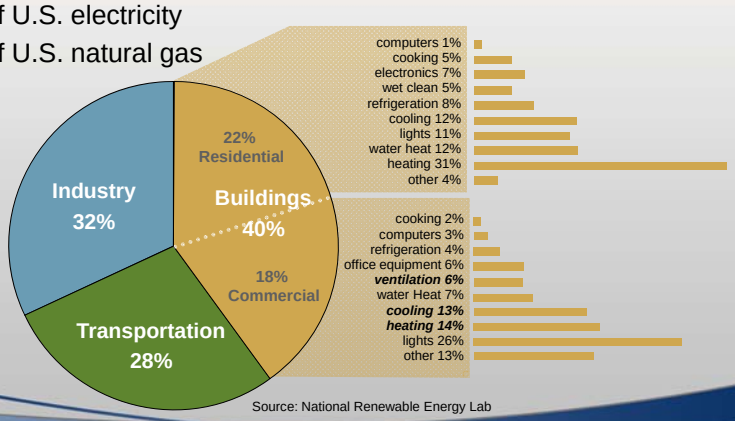
Why Buildings' Energy Use is Important

- Largest energy consumer in the U.S.
- 40% of primary energy consumption
- 72% of U.S. electricity
- 55% of U.S. natural gas



Source: National Renewable Energy Lab

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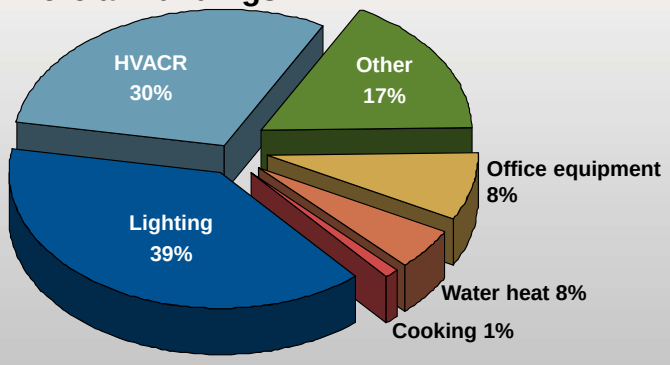
The Case for Sustainable Buildings

Average Energy Consumption in Commercial Buildings



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Air-Handling Systems, Energy and IAQ

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Latest Initiatives for Reducing Building Energy Use

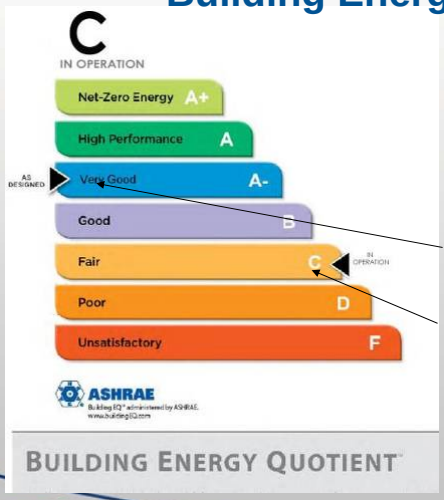
Balancing IAQ and Energy

- Building performance metrics
  - Energy, water use
  - Thermal comfort
  - IAQ
  - Lighting
  - Noise
- Building energy use
  - Energy Use Intensity (EUI) - kBtu/ft^2-yr
  - Every building has this metric

Building Energy Rating Methods

- Two groups
  - **Environmental and Energy**
    - LEED®
    - ASHRAE 189.1 and 189.2
  - **Energy Only**
    - EPA (DOE) (Energy Star®)
    - ASHRAE Building EQ™
    - State Standards (CA Title 24)
    - CIBSE (Chartered Institution of Building Services Engineers)

ASHRAE Building Energy Quotient™



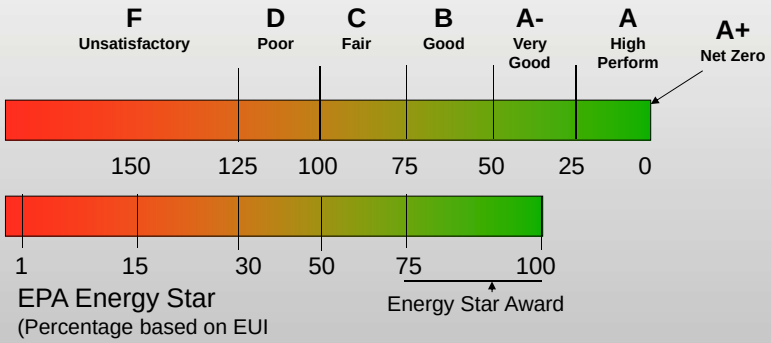
- Technically sound
- Developed with international input
- In pilot phase

As designed

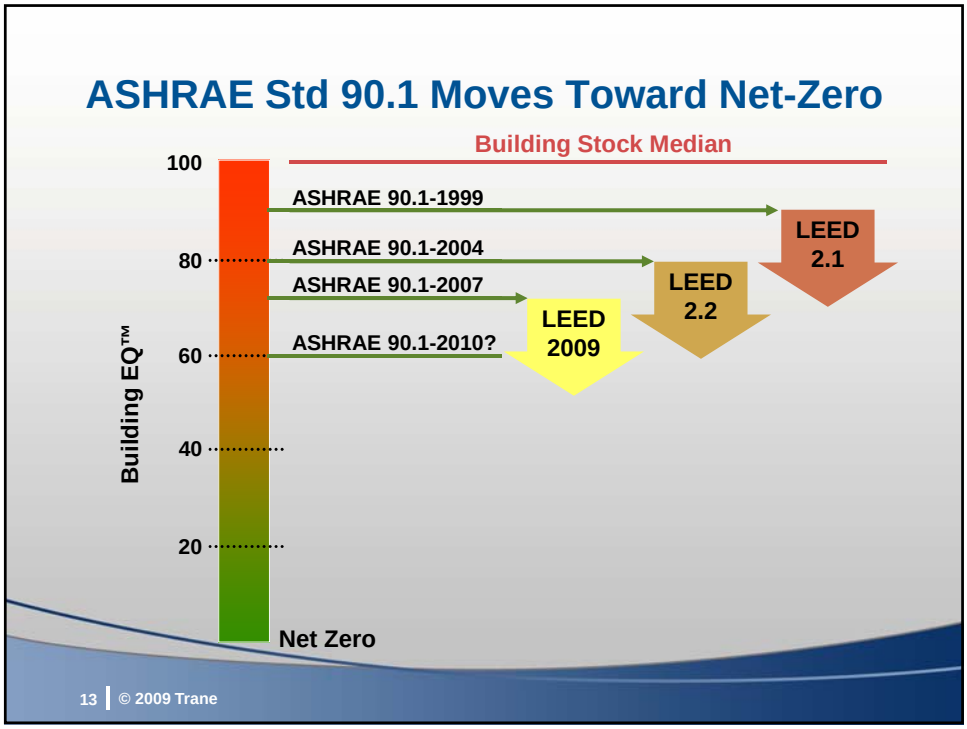
As operated

ASHRAE/EPA Label Comparison

ASHRAE Building EQ™
(Percentage based on ratio of $EUI_{building}/EUI_{median}$)



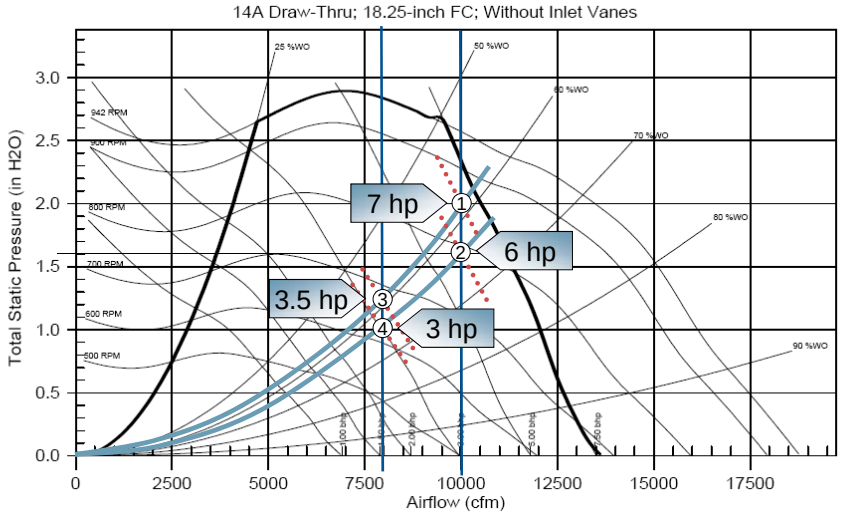
EPA Energy Star
(Percentage based on EUI distribution in actual building stock)



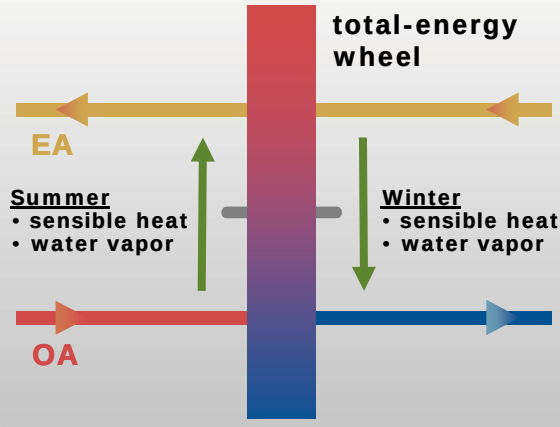
Energy-Saving Ideas Common to All System Types

- Reduce airside pressure loss
  - Less airflow (i.e., colder air)
  - Less resistance (bigger ducts, bigger ahu, right coils)
- Use high-efficiency fans (if you have a choice)
- Consider air-to-air energy recovery
- Use factory-supplied operating controls
  - To coordinate (e.g., reduce simultaneous heating/cooling)
  - To optimize (e.g., demand-controlled ventilation)

Unit size 14A (18.25-inch FC without inlet vanes)



Consider Air-to-Air Energy Recovery



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Employ Demand-Controlled Ventilation

- At design, minimum intake airflow (Vbz):
  - Vbz = Rp*Pz + Ra*Az
  - = 7.5*260 + 0.06*4000 = 2190 cfm
  - Qoa = about 4 tons
- At part load, if Pz = 130
  - Vbz = 7.5*130 + 0.6*4000 = 1215 cfm
  - Qoa = less than 2 tons
- Zone-level DCV
  - Saves energy at part load
  - Required by Std 90.1 (Section 6.4.3.9) for zones with more than 40 people/1000 ft^2

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Energy-Saving Strategies for Air-Handling Systems

- Reduce pressure loss
  - Less supply airflow
  - Less distribution systems pressure drop
- Recover total energy (both sensible and latent)
- Use controls to your advantage
  - Coordinate (eliminate simultaneous heating/cooling)
  - Optimize (for instance, demand controlled ventilation)

Air-Handling Systems, Energy and IAQ

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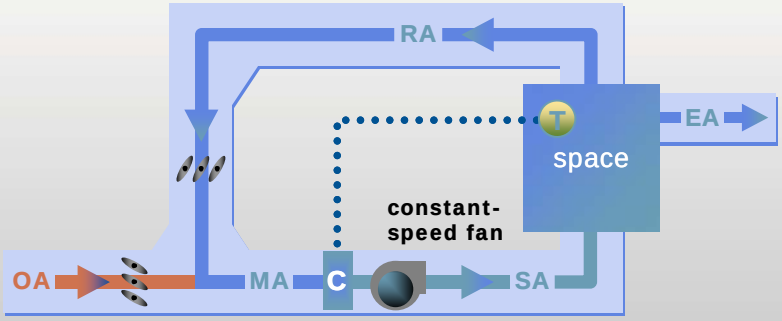
Energy Strategies for Single-Zone Systems

Ingersoll Rand

Energy-Saving Ideas For Specific System Types

- Constant-volume, air-handling units (single-zone)
- VAV air-handling systems (multiple-zone)
- Dedicated outdoor air systems (100% outdoor air)

constant volume (CV)
Basic System

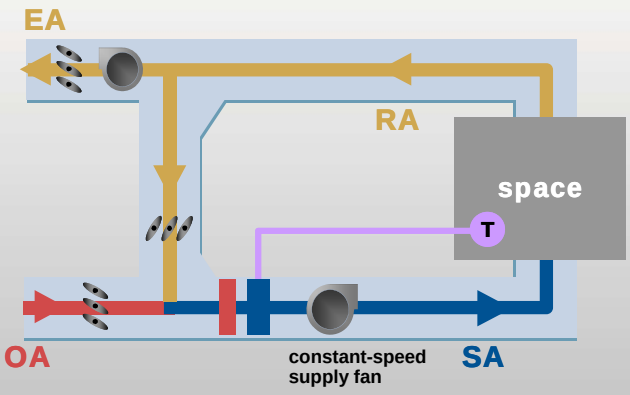


zone temperature determines AHU cooling capacity

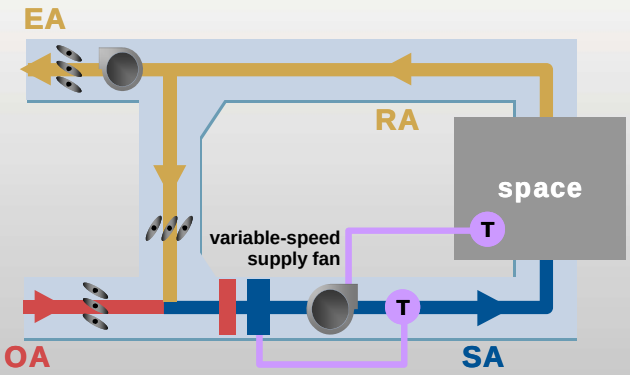
Energy-Saving Ideas For Constant-Volume Air-Handling Units

- Change to single-zone VAV control
- Use a dual-path AHU configuration (split dehumidification unit, SDU)
- Add a series Type III desiccant wheel for low dew point applications

Single-Zone, Constant-Volume System



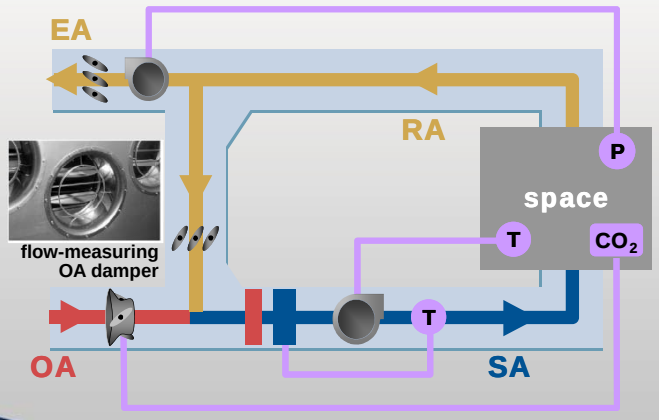
Single-Zone VAV System



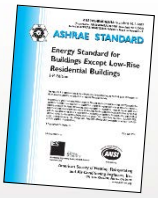
single-zone VAV
Benefits

- Lower operating cost by reducing fan speed at part load
- Reduced sound levels at part load
- Improved dehumidification since the system continues to supply cool, dry air at part load
- *Typical applications:* larger zones with variable occupancy (gymnasiums, cafeterias, lecture halls, auditoriums, churches, arenas)

Single-Zone VAV System



Change for ASHRAE 90.1-2010

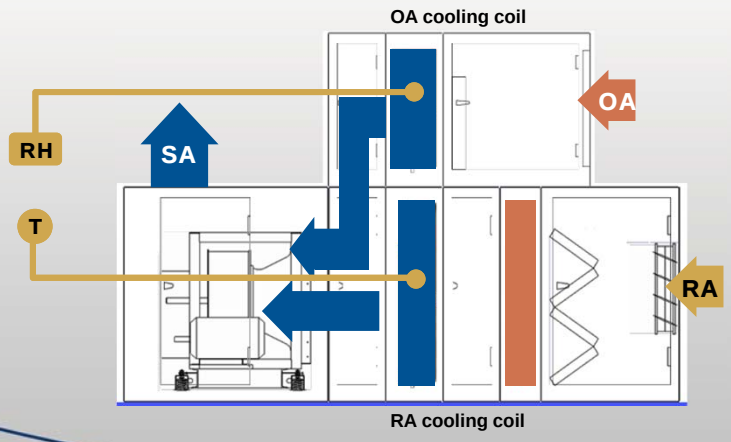


- **6.4.3.10 Single Zone VAV Control**
  - **Effective January 1, 2010**, air-handling and fan-coil units with **chilled-water cooling coils** and supply fans with motors greater than or equal to **5 hp** shall have their supply fans controlled by two-speed motors or **variable-speed drives**.
  - At cooling demands less than or equal to 50%, the supply fan controls shall be able to reduce the airflow to no greater than the larger of the following:
    1. One half of the full fan speed, or
    2. The volume of outdoor air required to meet the ventilation requirements of Standard 62.1.

Energy-Saving Ideas For Constant-Volume Air-Handling Units

- Change to single-zone VAV control
- Use a dual-path AHU configuration (split dehumidification unit, SDU)
- Add a series Type III desiccant wheel for low dew point applications

Split Dehumidification Unit (SDU)



split dehumidification unit

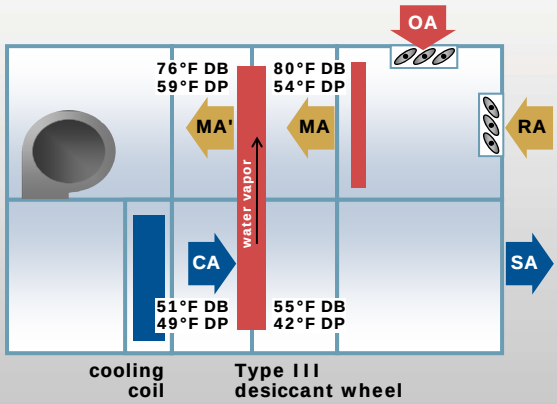
Benefits

- Improved dehumidification performance
- Smaller footprint since bottom coil module is sized for recirculated air only (not mixed air)
  - or keep same footprint and reduce fan power
- *Typical applications:* larger zones in non-arid climates

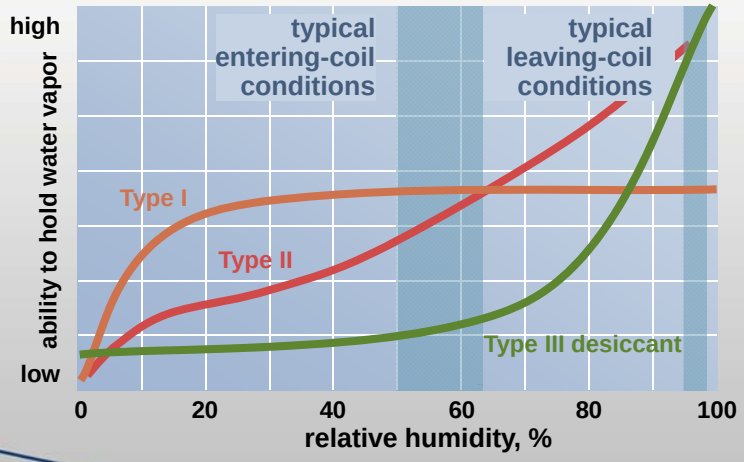
Energy-Saving Ideas For Constant-Volume Air-Handling Units

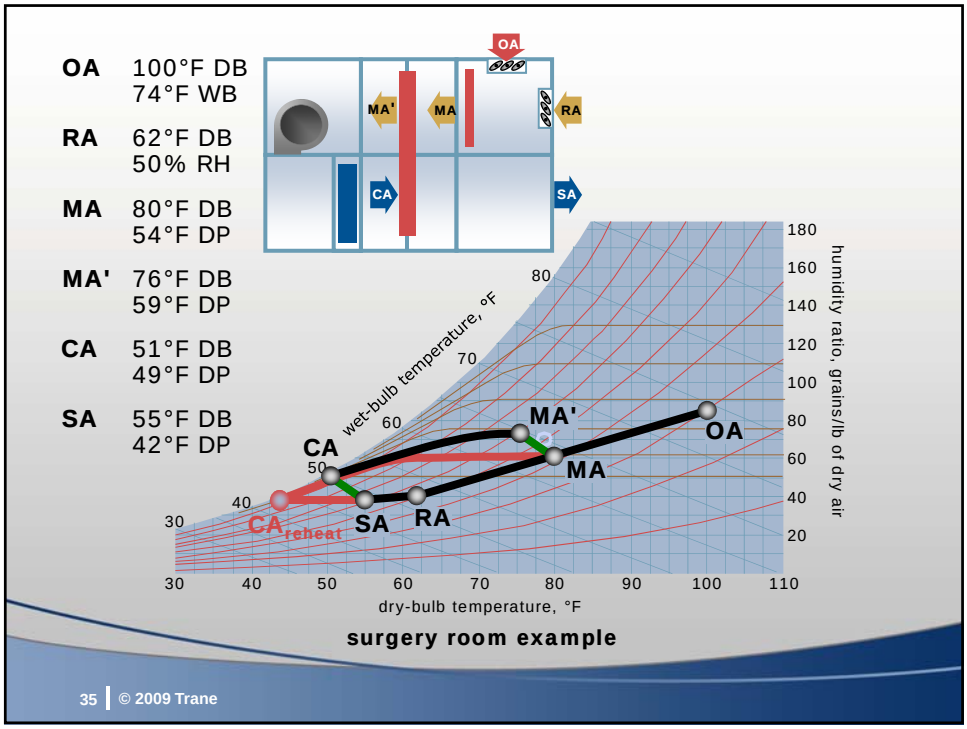
- Change to single-zone VAV control
- Use a dual-path AHU configuration (split dehumidification unit, SDU)
- Add a series Type III desiccant wheel for low dew point applications

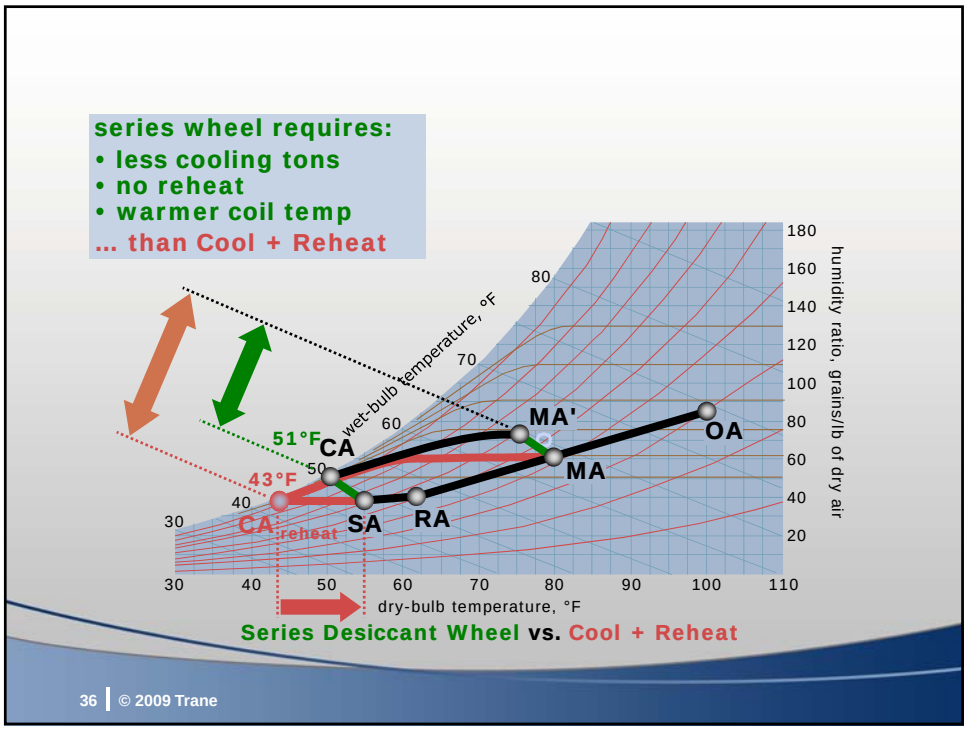
Series Type III Desiccant Wheel



series Type III desiccant wheel
How It Works







series Type III desiccant wheel

Benefits

- Extends the application of mechanical (vapor-compression) cooling equipment
  - Lowers achievable dew point by 5°F to 10°F
- Uses less energy than cooling plus reheat
  - Less cooling tons, no reheat, warmer coil temperature
- Does not require a separate exhaust airstream
  - It is NOT exhaust-air energy recovery
- *Typical applications:* zones that require lower dew points (surgery rooms, supermarkets, laboratories, pharmacies, libraries, museums, archive storage)

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Air-Handling Systems, Energy and IAQ

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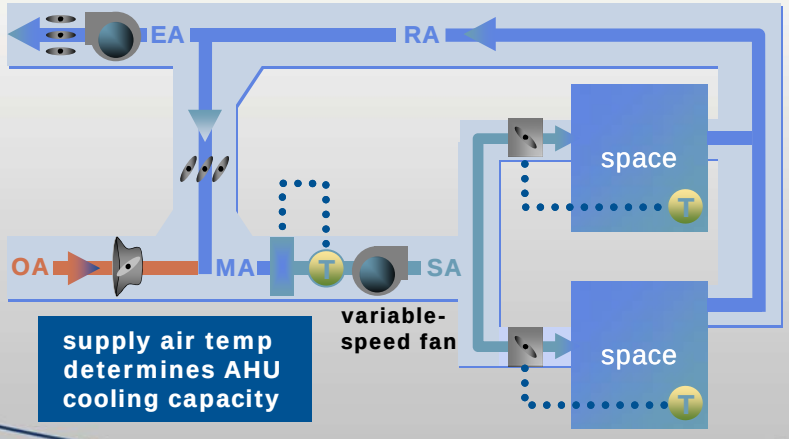
Energy Strategies for VAV Multiple-Zone Systems

Ingersoll Rand

Energy-Saving Ideas Specific to System Types

- Constant-volume air-handling units (single-zone)
- VAV air-handling systems (multiple-zone)
- Dedicated outdoor air systems (100% outdoor air)

Multiple-Zone VAV



Optimized VAV System Controls

- Optimal start/stop
- Time-of-day scheduling
- Fan-pressure optimization
- Supply-air-temperature reset
- Ventilation optimization
  - Demand-controlled ventilation at zone level
  - Ventilation reset at system level (and TRAQ dampers)
- Return fan control
- Building pressure control

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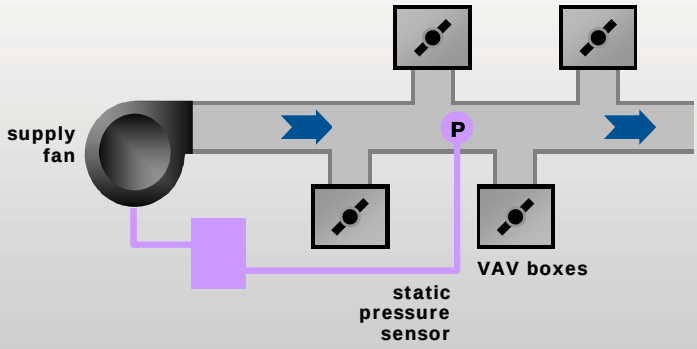
Traditional VAV Fan Control



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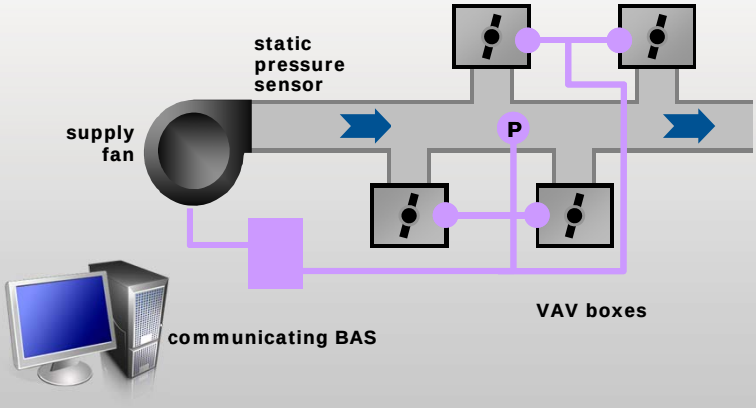
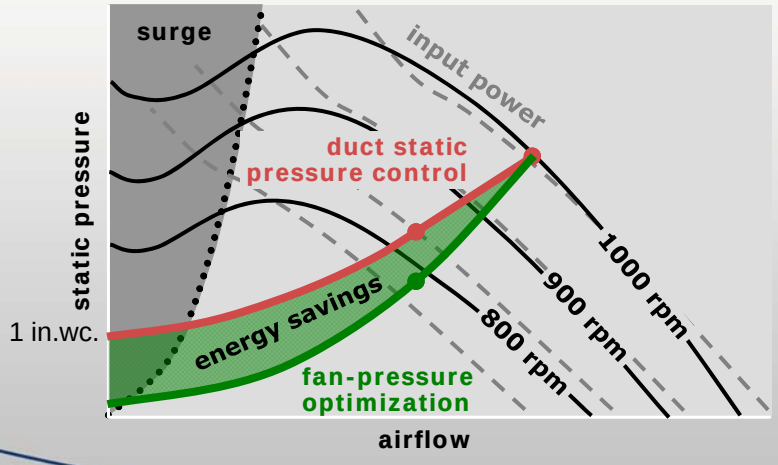
Fan-Pressure Optimization

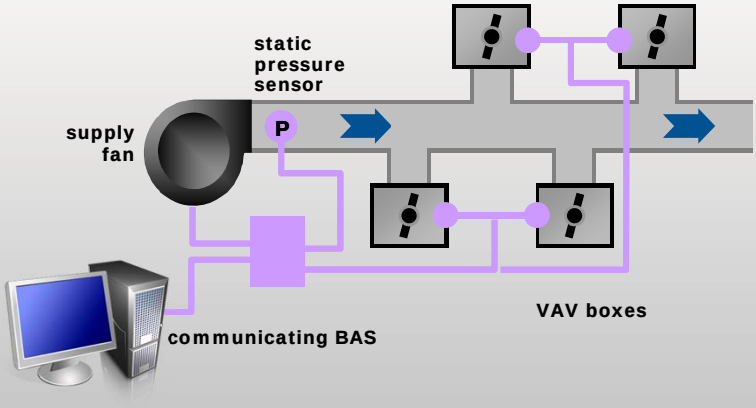


fan-pressure optimization

Part-Load Energy Savings



Fan-Pressure Optimization



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fan-pressure optimization

Benefits

- Part-load energy savings
- Lower sound levels
- Better zone control
- Less duct leakage
- Reduced risk of fan surge
- Factory-installation and -commissioning of duct pressure sensor
- Operator feedback to "tune the system"

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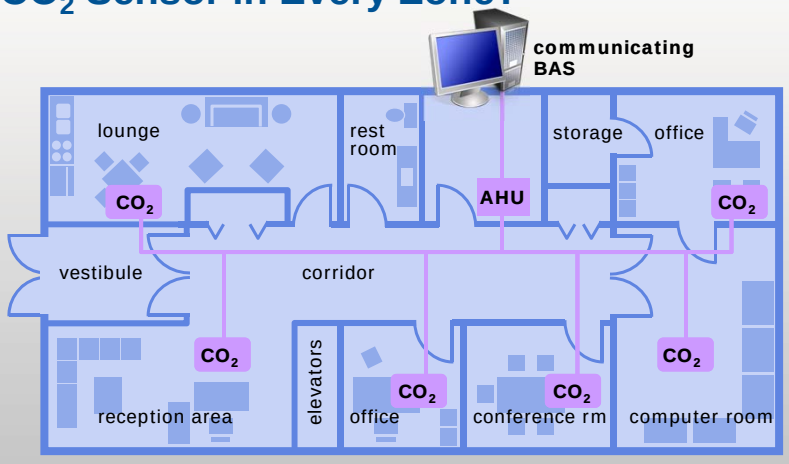
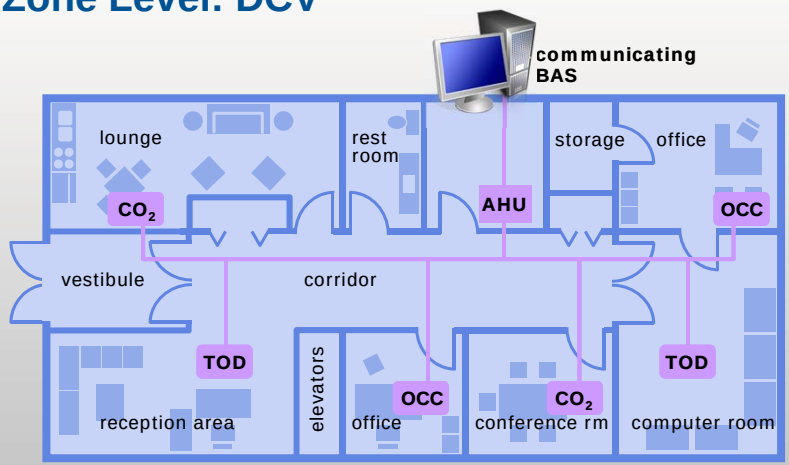
demand-controlled ventilation

CO_2 Sensor in Every Zone?



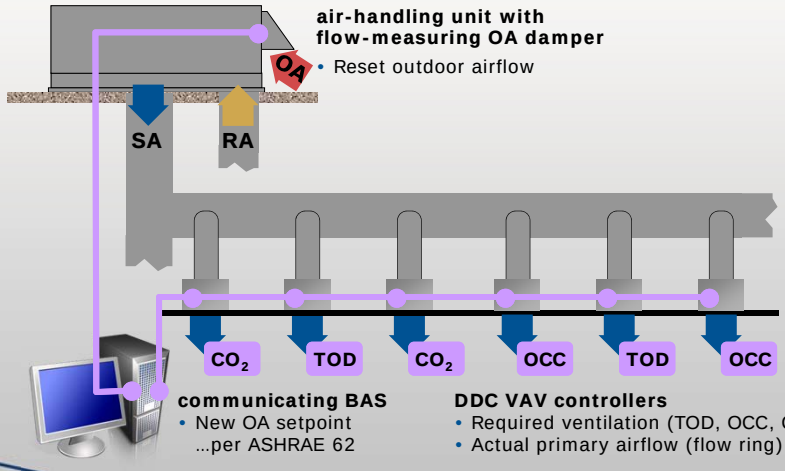
ventilation optimization

Zone Level: DCV



ventilation optimization

System Level: Ventilation Reset



ventilation optimization

Benefits

- Saves energy during partial occupancy
- Lower installed cost, less maintenance, and more reliable than installing a CO_2 sensor in every zone
  - Use zone-level DCV approaches where they best fit (CO_2 sensor, occupancy sensor, time-of-day schedule)
  - Combine with ventilation reset at the system level
- Earn LEED EQc1: Outdoor Air Delivery Monitoring

Example TRACE® 700 Analysis

Optimized VAV system controls

- Optimal start
- Fan-pressure optimization
- SA temperature reset
- Ventilation optimization
  - DCV at zone level
  - Ventilation reset at system level

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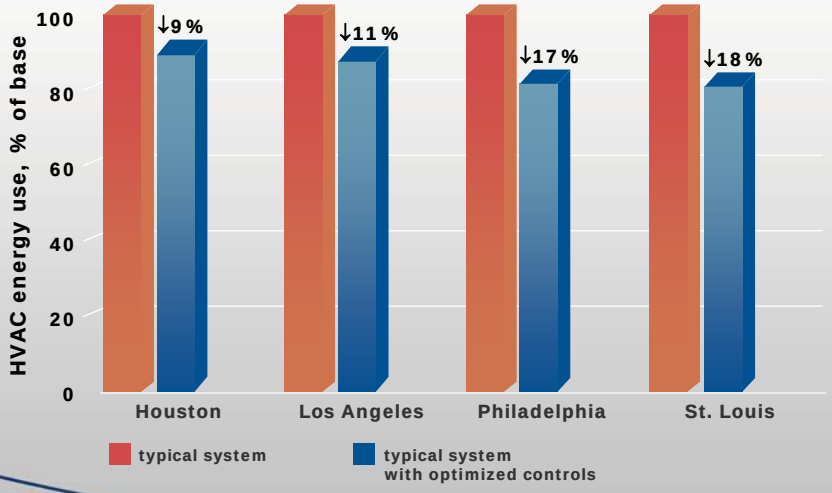
VAV system

Energy Savings Via Optimized Controls



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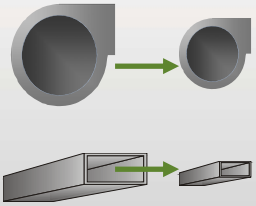
Lower Supply-Air Temperature

- Benefits
  - Reduces supply airflow
    - Less supply fan energy
    - Smaller fans, air handlers, VAV terminals, and ductwork
  - Lowers indoor humidity levels
- Drawbacks
  - Increases reheat energy
  - Fewer hours when economizer provides all necessary cooling (compressors shut off)



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lower supply-air temperature

Maximize Energy Savings

- Use supply-air temperature reset
  - Maximizes benefit of airside economizer
  - Reduces reheat energy use
- Raise space setpoint by 1°F or 2°F
  - Further reduces airflow and fan energy use
- Keep same size ductwork
  - Further reduces fan energy use
  - Allows SAT reset in systems that serve zones with near-constant cooling loads
  - Capable of delivering more airflow if loads increase in the future

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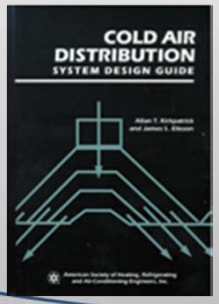
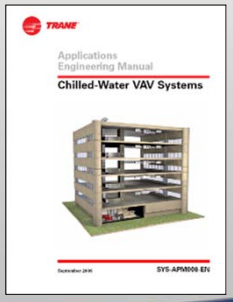
lower supply-air temperature

Challenges

- Minimize comfort problems due to “dumping”
- Avoid condensation on air distribution system components

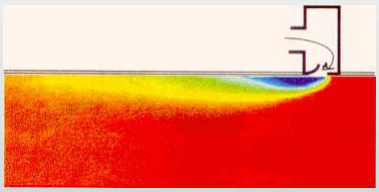




lower supply-air temperature

Minimizing Comfort Problems (Dumping)

- Use linear slot diffusers…



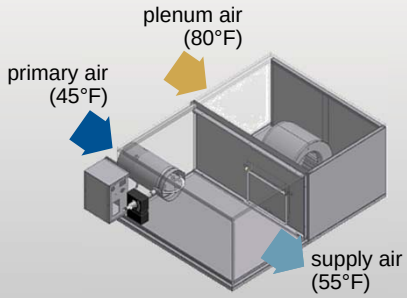
linear slot diffuser

conventional concentric diffuser

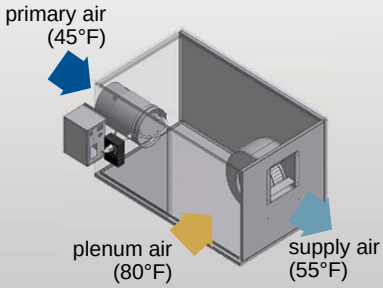
lower supply-air temperature

Minimizing Comfort Problems (Dumping)

…or use fan-powered VAV terminals as “air blenders”



parallel fan-powered VAV terminal



series fan-powered VAV terminal

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lower supply-air temperature

Avoiding Condensation

- Properly insulate and vapor-seal ductwork, VAV terminals, and supply-air diffusers
- Use an open ceiling plenum return, if possible
- Maintain positive building pressure to minimize infiltration of humid outdoor air
- Monitor indoor humidity during unoccupied periods and prevent it from rising too high
- During startup, slowly ramp down the supply-air temperature to pull down indoor humidity
- Use linear slot diffusers to increase air motion

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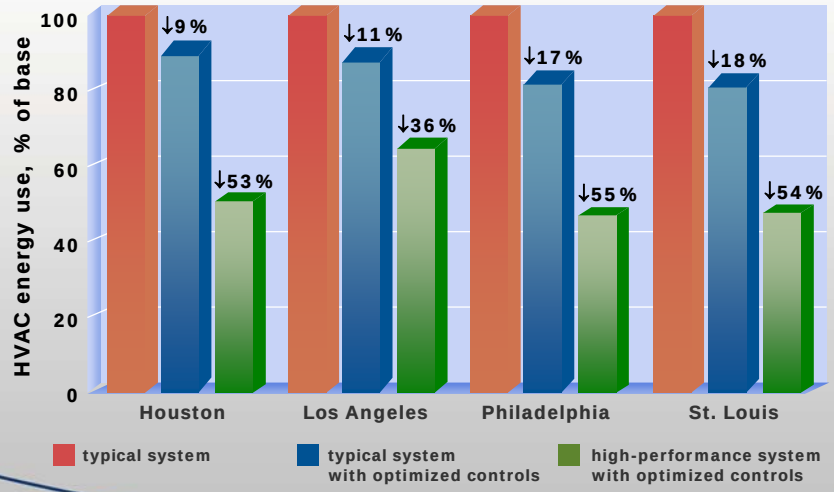
High-Performance CHW-VAV System



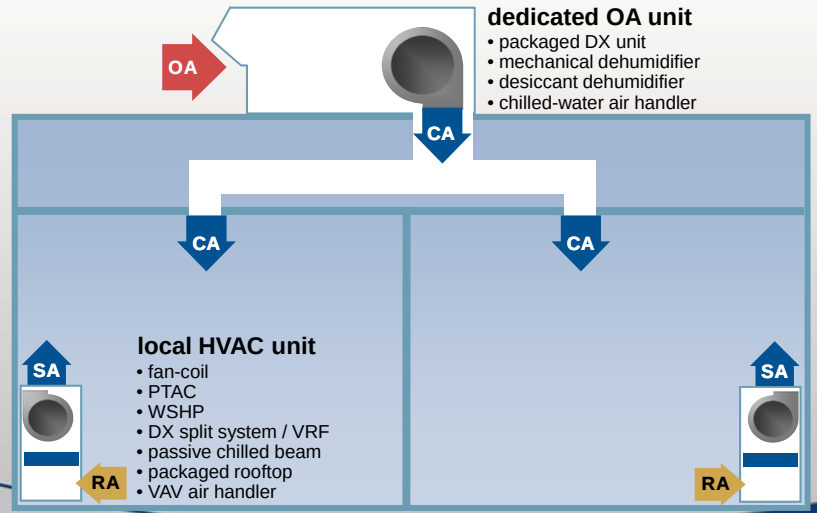
High-Performance CHW-VAV System

- Cold-air distribution (48°F supply-air temperature) with same size ducts
- Fan-pressure optimization, supply-air-temperature reset, ventilation optimization, and optimal start control strategies
- Parallel fan-powered VAV terminal units serving the perimeter zones
- Airside economizer with fixed enthalpy control (fixed dry-bulb control in LA)
- High-efficiency, direct-drive plenum fans in VAV air-handling units
- Total-energy wheel to precondition the entering outdoor air (not in LA)
- Low-flow condenser-water (15°F ΔT) and chilled-water (14°F ΔT) distribution systems
- High-efficiency, water-cooled centrifugal chillers (5.96 COP, or 7.33 COP for Los Angeles)
  - For a centrifugal chiller operating at these water temperatures and flow rates, which differ from ARI standard rating conditions, the minimum efficiency required by ASHRAE 90.1-2007 is 5.11 COP (5.90 COP for Los Angeles).
- Chiller-tower optimization control strategy

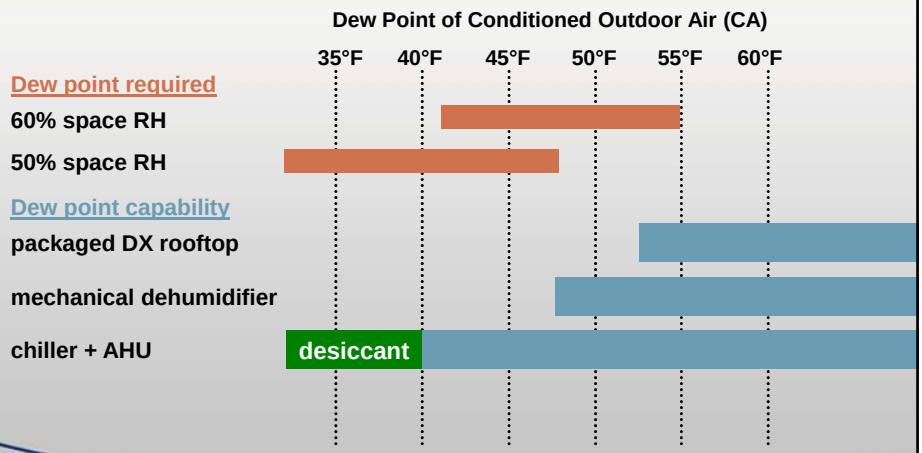
Energy-Saving Ideas Specific to System Types

- Constant-volume air-handling units
- VAV air-handling systems
- 100% outdoor air systems

Dedicated OA System (DOAS)



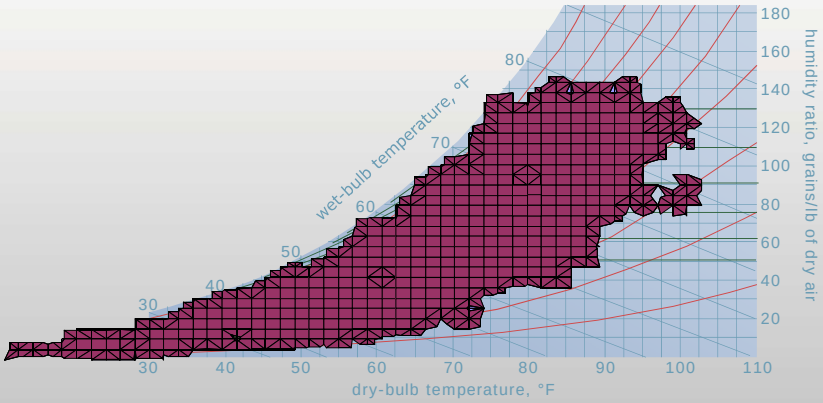
Dedicated OA Unit Choices



Benefits of Chilled-Water DOAS

- Can achieve lower dew points
- Wider operating envelope

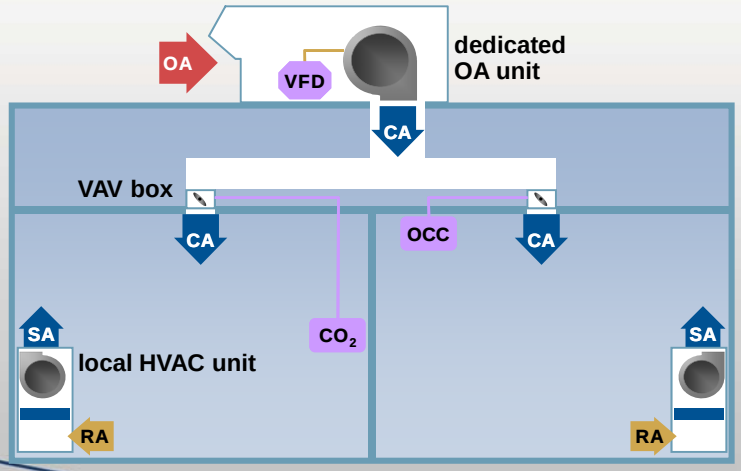
dedicated OA unit
Wide Operating Envelope



Nashville, Tennessee
(Monday – Friday, 6 AM – 6 PM)

dedicated OA system

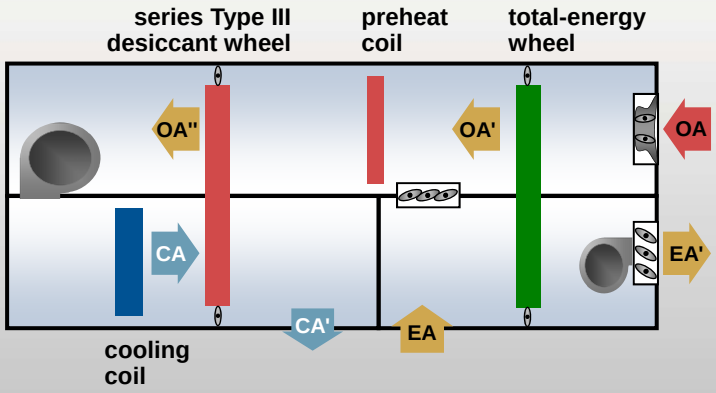
Demand-Controlled Ventilation



Benefits of Chilled-Water DOAS

- Can achieve lower dew points
- Wider operating envelope
  - Especially when using variable airflow
  - DX equipment often requires hot gas bypass (energy waste)
- Greater flexibility and efficiency
  - Fans, air cleaning, energy recovery, desiccant wheel, airflow measurement, ice storage
- Certified performance
  - ARI, UL, ETL
  - No ARI certification for DX dedicated OA units (EER's typically not published)
- Reduced refrigerant charge

Dual-Wheel Dedicated OA Unit



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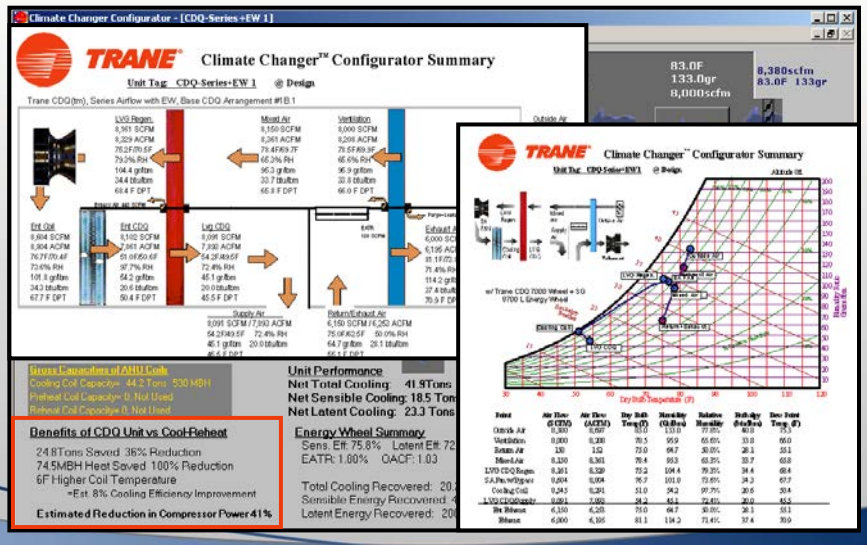
Trane Climate Changer™ Configurator



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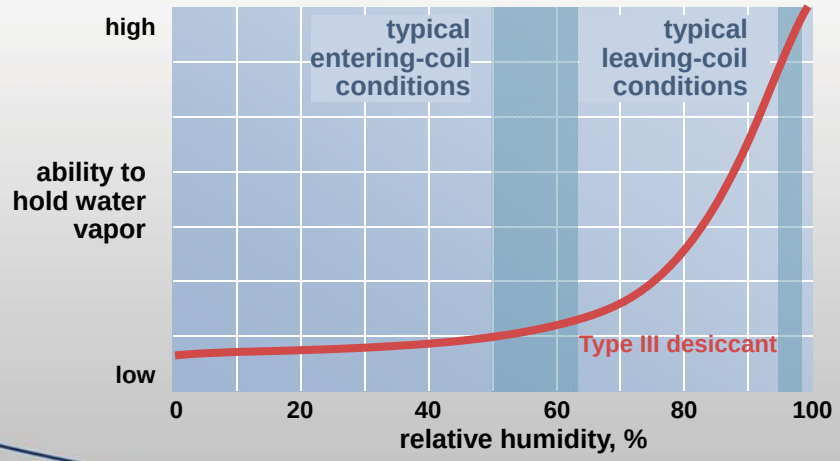
How It Works



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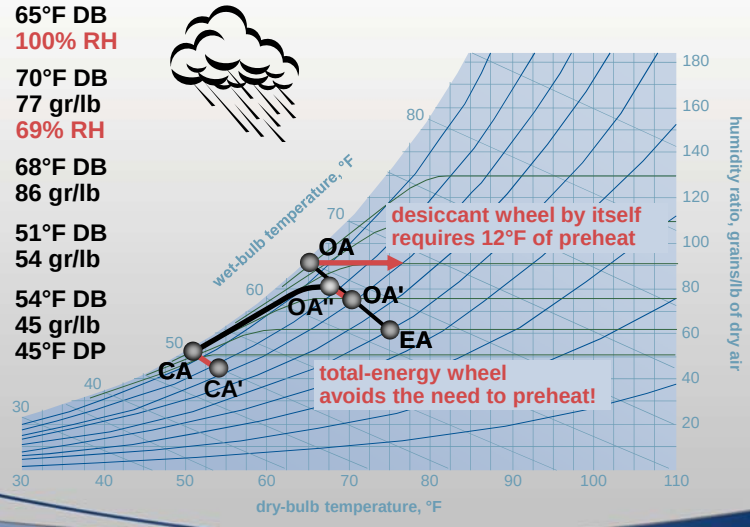
Example: Mild Rainy Day

OA	65°F DB 100% RH
OA'	70°F DB 77 gr/lb 69% RH
OA"	68°F DB 86 gr/lb
CA	51°F DB 54 gr/lb
CA'	54°F DB 45 gr/lb 45°F DP



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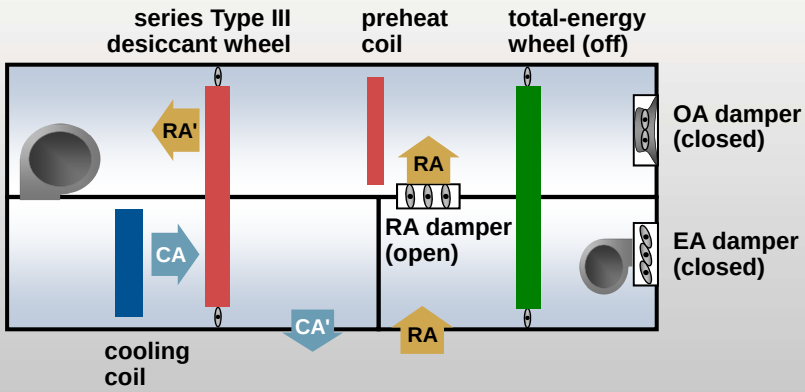
Dual-Wheel Dedicated OA Unit

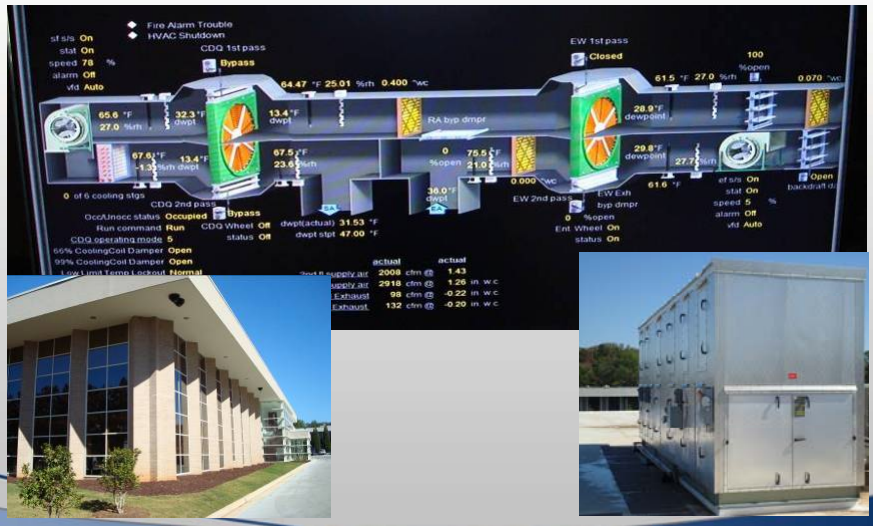
Series Type III desiccant wheel → **Makes the cooling coil a better dehumidifier** (exchanges sensible capacity for more latent capacity)

Total-energy wheel → **Avoids the need to add preheat for regeneration** (minimizes overall energy use, provides year-round energy savings)

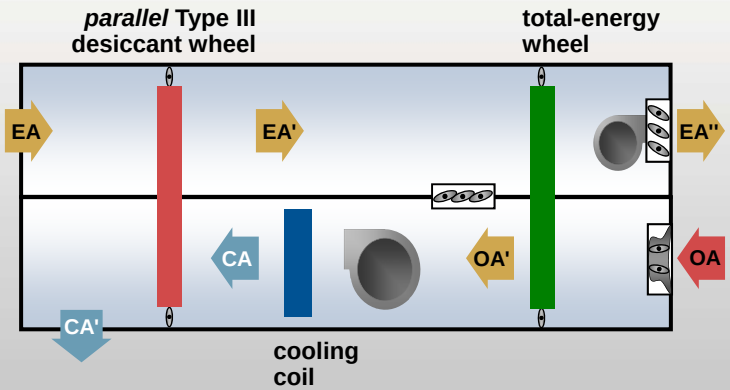
After-Hours Humidity Control



ASHRAE HQ Renovation (Atlanta)



dual-wheel dedicated OA unit
Alternate Configuration



Why Do We Need Air Cleaning?

- Removes contaminants
- Why?
  - To keep buildings and equipment cleaner
  - To meet standards and codes
  - To obtain LEED® points
  - To make indoor spaces better

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What Are We Trying To Remove?

- From ASHRAE Handbook of Fundamentals
  - Particulate matter
    - Solids (dust, fumes, bioaerosols)
    - Liquids (mist and fog)
    - Bioaerosols include: pollen, mold spores, bacteria, viruses
  - Gases
    - Organic (VOC)
    - Non-Organic (carbon dioxide, carbon monoxide, ozone)

Air Cleaning Options

- Particulate filters
  - Impingement (MERV ratings)
  - Electronic
- Gaseous air cleaners
  - Adsorbents (e.g., activated carbon)
  - Photocatalytic oxidation
- Bioaerosols
  - Ultraviolet light (UVc)
  - Photocatalytic oxidation

Particulate Filters

Type of Particle Diameter	Settling Time
Human hair	5 seconds
Observable dust in air	>10 seconds
Bacteria	1 to 5 minutes
Viruses	10 days

Note: Spores, bacteria, and virus sizes are for the typical complete unit. When entrained in the air, they may be smaller (fragments) or larger (attached to debris)

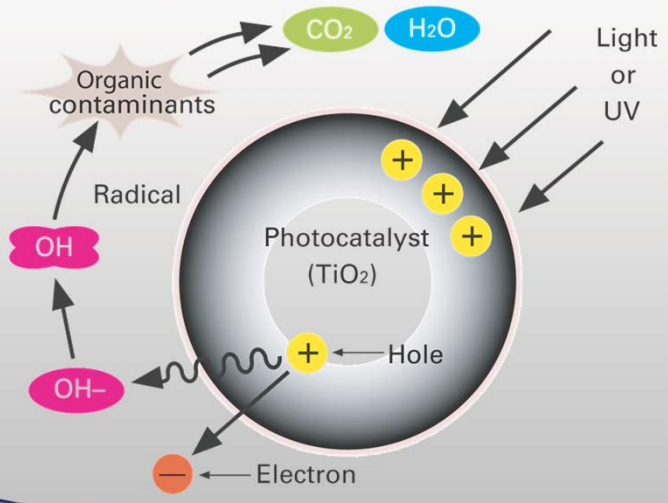
Source: ASHRAE Handbook 2009

Catalytic Air Cleaning System

MERV 13 filter followed by Catalytic Air Cleaner (shown)

- Six inches deep
- Very low pressure drop – 0.03 in. wc.
- Media life: ~ 15 years,
- UV Bulbs ~ 15 months
- No measureable ozone

Photo-catalysis



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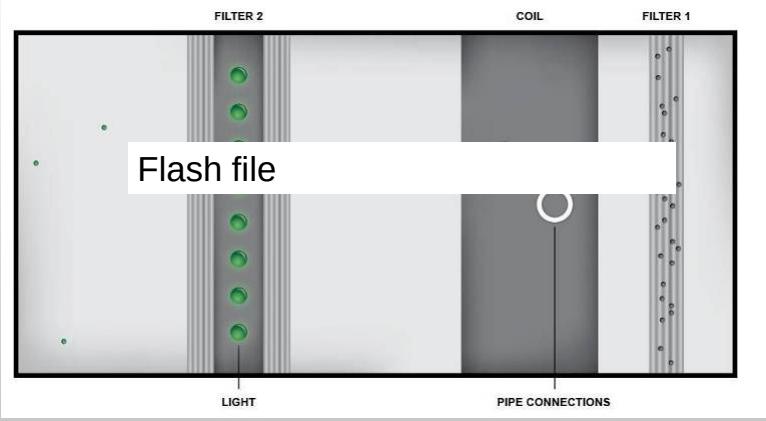
Flash file



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Catalytic air cleaning effectiveness
Depends on energy distribution

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In Summary….

- Air cleaning is a complex issue but getting easier to understand and control
- Best to know the contaminants of concern and where they are coming from
- Have a goal in mind
- Consider all available technologies
- Understand the maintenance requirements
- Evaluate from an effectiveness and “total cost of ownership” perspective

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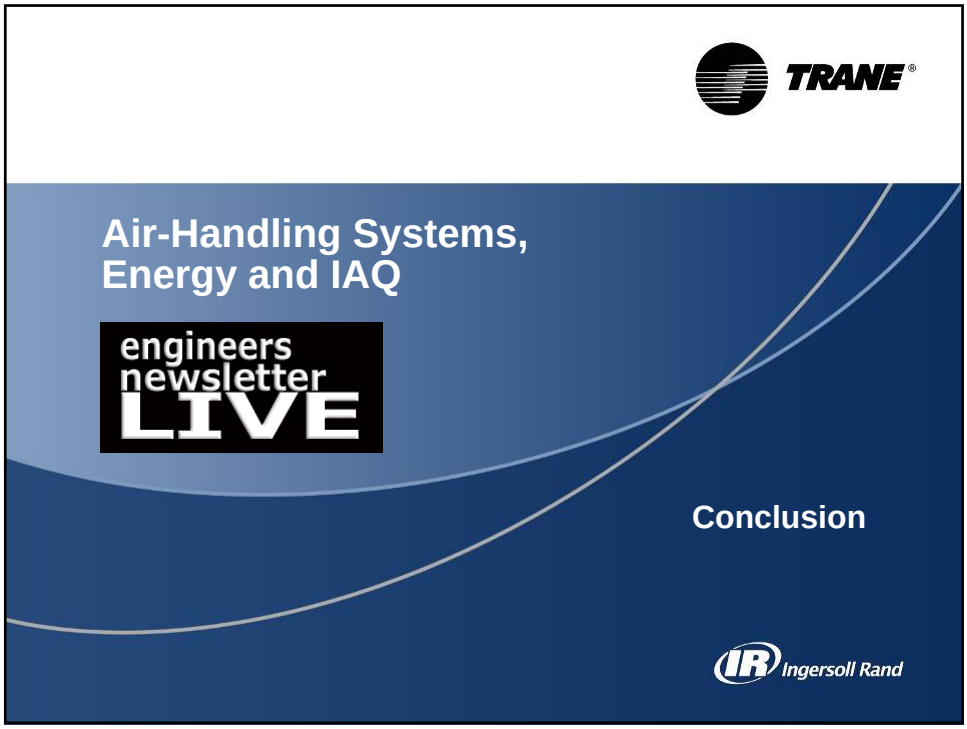

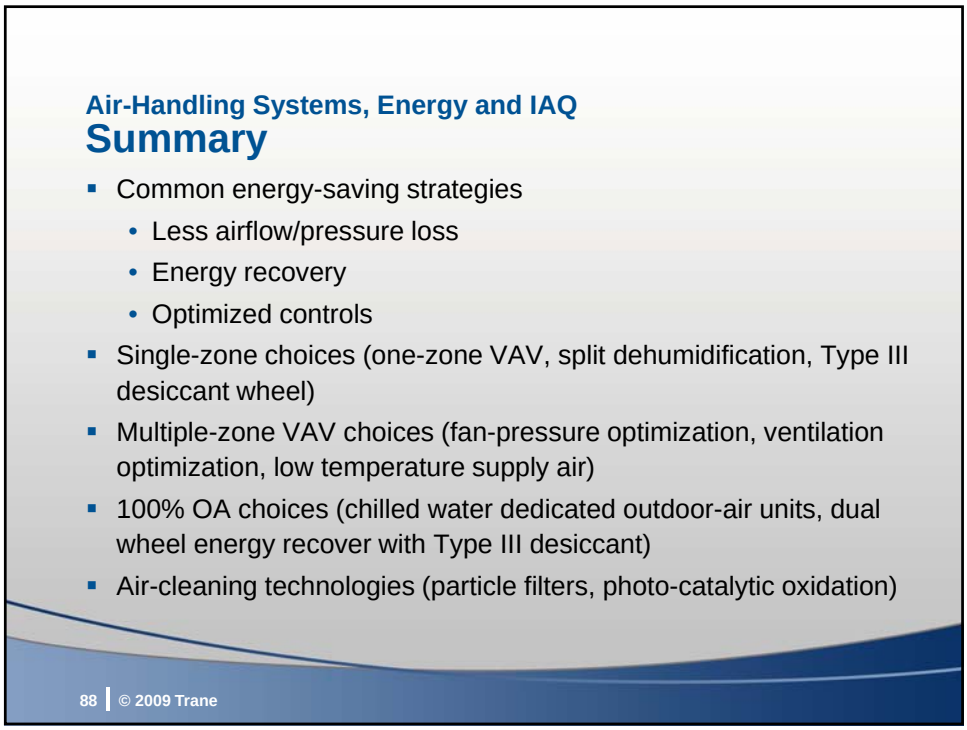

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