Energy efficiency in building automation and control

Application guide for ventilation and air conditioning

Answers for infrastructure.

SIEMENS

Content

1 About this document

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1.5 Target readership

This guide is targeted at all persons dealing with the energy efficiency of building technical plants and who want to become familiar with the most important energy savings functions in the building automation and control system.

This includes engineers of HVAC plants or measuring and control technology, installers of building technical plants, plant operators in the area of heating and cooling supply systems and persons consulting and selling building automation and control systems.

This guide can serve as the basis for training in the area of energy efficiency as well as a reference book.

2 Energy efficiency fundamentals

2.1 Factors that influence energy consumption in buildings

The following six factors primarily impact the energy demand of a building[1]):

- Outdoor climate
- Building shell
- Building technology and energy technology
- Operation and maintenance of the building
- Building use and user behavior
- Interior room quality

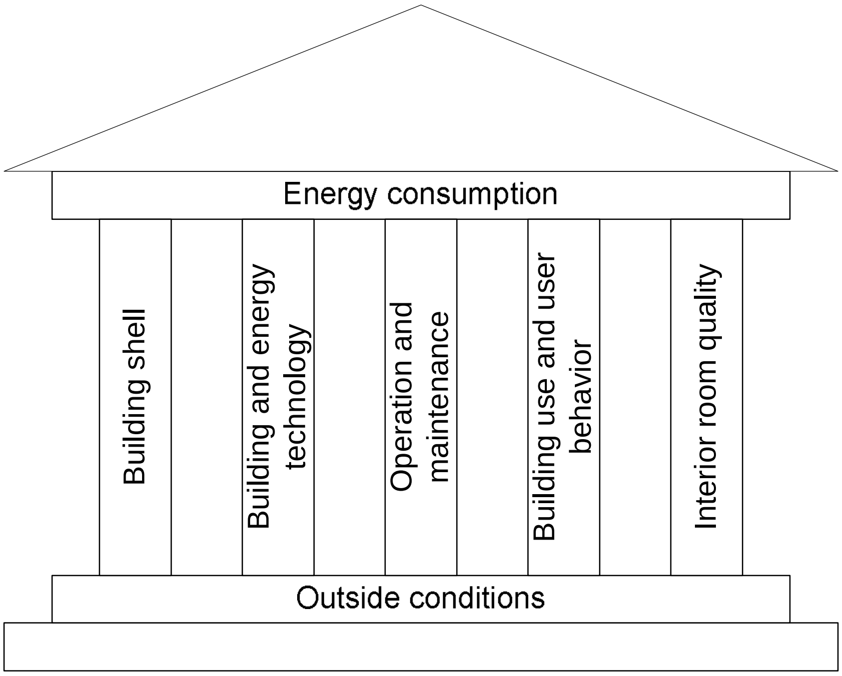


Fig. 1 Energy consumption of buildings

The building shell protects the building user from the elements. The exterior shell is considered and optimized as part of the planning for new buildings. This is to some extent not possible for existing buildings (historical or protected objects) or can only be achieved at considerable effort in terms of cost and time.
Energy is consumed and green house gases (CO_2) are emitted in the manufacture of construction materials. Increasing a building's insulation reduces energy consumption. Energy consumption to manufacture it increases, however, which in turn increase the amount of "gray energy". In other words, increased insulation only makes sense where the reduction in energy consumption is greater than the "gray energy" of the applied materials.

Building automation and control influences operation and use of building services plants thanks to clever control, monitoring and optimization functions and plays a decisive role in reducing a building's energy consumption. These measures can be implemented in the short term and are distinguished by short amortization periods.

[1]) according to Hiroshi Yoshino, Professor, Tohoku University, Sendai, Japan

2.2 Building automation and control as the basis for energy-optimized operation

The realization that careful engineering and implementation of building automation and control is the only way to achieve energy efficient building operation is increasingly gaining wider acceptance.

But it is primarily the task of building automation and control to determine whether energy is applied efficiently in the building for the following areas.

Building technology and energy technology
Control technology matched to the building services plants and with the appropriate energy savings functions make it possible to operate the plant in an energy efficient manner.

Service and maintenance
Building technology requires maintenance to operate efficiently over a number of years. With monitoring, alarm and optimization functions on building automation and control systems playing an important role.

Building use and user behavior
The building user requires the proper operating and display elements, e.g. easy-to-understand (intuitive) operator units in the room or heating and ventilation plant operation on the panel. Allowing the user or operator to undertake the correct actions during operation. Operation matched to a building's use must be carefully engineered and implemented.

User behavior plays a decisive role with regard to a building's energy consumption. Studies indicate that differences of up to 30% in consumption may occur for identically constructed buildings. A comparatively high level of consumption can occur, for example, if room temperatures are set too high or windows are left open for too long to air out rooms or, even worse, opened to lower the room temperature.

Interior room quality
Building technology is designed for certain room conditions including temperature, humidity, brightness, noise and air flow. Building automation and control is tasked with recording these variables and controlling the plants to ensure the conditions are met during occupancy at the lowest possible energy costs.

2.3 Term energy efficiency

Energy efficiency refers to the energy required to achieve a given usable effect. Technical measures can achieve greater energy efficiency, i.e. the energy required for the same use can be reduced to a fraction of the amount.
Energy efficiency also includes taking advantage of unused portions of energy conversion, such as using waste heat and energy recovery.

Networked control of proven building automation and control functions are given high priority to achieve and maintain a high level of energy efficiency; in addition to a high-quality exterior shell and modern plant technology.

The use of energy efficient functions in building automation and control has enormous potential when considering that some 40% of primary energy consumption worldwide goes into buildings. From that 85% are for room heating, hot water and room cooling.

The graph below from the "Analysis of Swiss energy consumption 2000 – 2006 by use" from the Federal Office of Energy (FOE) illustrates the importance of buildings.

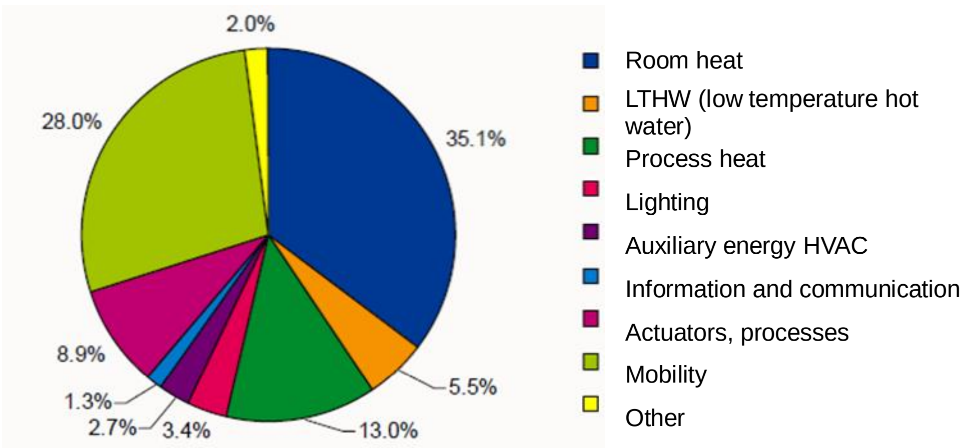
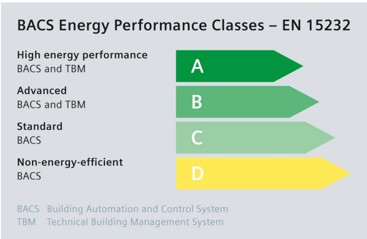


Fig. 2 Percentage of energy consumption by use (2006)

3 Energy efficiency in building automation and control

3.1 Directives, standards

In the EU, the introduction of the EPBD (Energy Performance Building Directive) set in place a key element in improving the energy efficiency of buildings. A series of EU standards have been issued based on this directive on designing, installing and inspecting heating, hot water, cooling, ventilation and air conditioning plants as well as lighting.
Moreover, the EuP Directive (Directive for Energy using Products) defines ecological criteria (energy consumption, emissions, recycling) for energy-operated products. This impacts components that generate, consume, monitor and measure energy. For HVAC plants, this includes boilers, heat pumps, chillers, pumps, fans, among others.



Standard EN 15232 "Energy Efficiency in Buildings – Influence of Building Automation and Control and Building Management" was introduced to take advantage of energy savings potential of control and building operation. [1, 2] The standard makes it possible to identify the savings potential from building automation and control and then to derive measures to improve energy efficiency. Energy consumption is classified into thermal and electrical parts. The following consumers are important in a building:

- Heating
- Domestic hot water
- Cooling
- Ventilation
- Lighting
- Auxiliary energy (for fans, pumps, etc.)

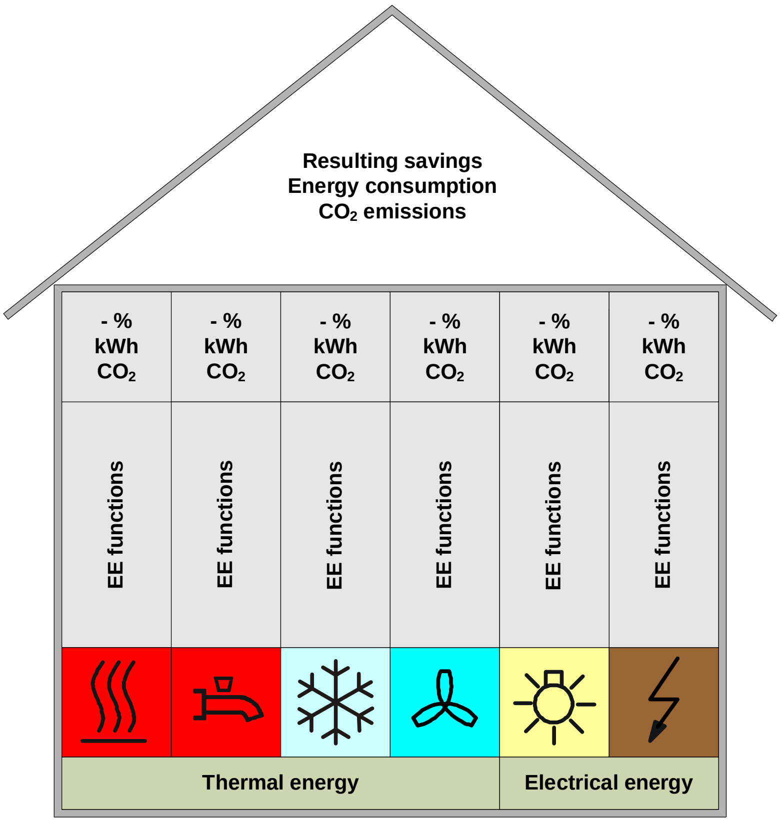


Fig. 3 Energy forms with consumer groups

As illustrated in Figure 3, energy efficiency (EE) functions can be used to achieve both thermal and electrical energy savings. Another consequence is a reduction in CO_2 emissions. All energy consumers must be considered and optimized to minimize overall building consumption.

eu.bac (**eu**ropean **b**uilding **a**utomation and **c**ontrols association) established a certification and testing process to ensure that the building automation and control products used meet high level quality and energy-efficiency criteria.
The EU evaluated and approved eu.bac certification.

Certifications for buildings with the labeling below are becoming increasingly more important for larger construction projects.

BREEAM: **Building Research Establishment's E**nvironmental **A**ssessment **M**ethod
http://www.breeam.org
Classification using a point system with four quality levels:
Pass, Good, Very Good, Excellent
Issuer: Licensed assessor.

LEED: **L**eadership in **E**nergy and **E**nvironmental **D**esign
http://www.usgbc.org
A classification system for energy and environmentally friendly engineering of buildings using a point system with four quality levels:
Certified, Silver, Gold, Platinum
Issuer: Green Building Certification Institute, USA.

DGNB: **D**eutsches **G**ütesiegel **N**achhaltiges **B**auen
(German seal of approval for sustainable construction)
http://www.dgnb.de
Certificate based on life-cycle principles for a building.
Using a point system for gold, silver and bronze.
Issuer: Deutsche Gesellschaft für nachhaltiges Bauen (German Society for Sustainable Construction).

HQE: **H**aute **Q**ualité **E**nvironnementable
http://www.assohqe.org
Distinguishes between three levels of building quality:
Base, Performant, Très performant
Issuer: Association pour la Haute Qualité Environnementable

CASBEE: **C**omprehensive **A**ssessment **S**ystem for **B**uilding **E**nvironmental **E**fficiency
http://www.ibec.or.jp/CASBEE/english/index.htm
Establishes "Building environmental efficiency" and considers in particular Japanese and Asian aspects:
C (poor), B, B+, A (excellent)
Issuer: Japan Sustainable Building Consortium.

GREEN STAR
http://www.gbca.org.au
Evaluation of building performance using stars:
Four stars: Best, five stars: Australian Excellence,
Six stars: World Leadership.
Issuer: Green Building Council of Australia.

3.2 Principles of energy-efficient operation

The following principles apply to operating building services plants – here in particular ventilation and air conditioning plants – in an energy-efficient manner:

- Demand-dependent distribution and preparation of air
  Supply air should be processed (heating, cooling, humidify, dehumidify) dependent on demand, only in the appropriate amount and demand (outside air ratio, temperature, humidity). The energy from extract air should be used for energy recovery.
- Minimize losses at air handling and in distribution networks.
- Correct balancing of air volume is required to be able to use the planned air volume under all operating conditions per room or zone.
- Networking energy-efficient individual control components into an energy-efficient system.
- Shut down all plants or parts thereof if no demand is pending.
- Adapt operating times to occupancy.
- Group and provide common supply to areas with the same use or similar behavior (building orientation with the corresponding solar radiation).
- Different room operating modes (Comfort, PreComfort, Economy, Protection) and their varying setpoints allow for operation adapted to various uses.
- Maintain room conditions such as temperature, humidity and air quality within comfort range during occupancy.
- Define an operating concept with information on room conditions, occupancy and operating times, etc.
- Demand-oriented energy transfer to achieve comfortable room conditions.
- For unintentional user interventions (e.g. ventilation losses from open windows), energy transfer is reduced and then only released again in case safety limits are breached.
- Take advantage of energy gains in the room (sun, internal loads, etc.).
- Realtime visualize energy consumption and report violations of tolerance values (e.g. in green, yellow and red).
- Visualize and report violations of defined tolerance levels for individual data points (e.g. physical variables, switch-on frequencies, switch-on period).
- Energy reporting, trend functions to follow-on analysis, etc.

3.3 Requirements for energy-efficient control

It is not enough to only use the best available components to achieve a high-level of energy efficiency in a building. The components must be matched as well - technically, but also in the way they are controlled. As a rule, a building automation and control system is needed to achieve optimum interaction. Consumption can still be too high even where the subsystems are optimally matched if the subsystems are not operated to actual demand; so for example, if the air conditioning plant is outside of occupancy or unused areas are continuously supplied with air.

The ventilation and air conditioning plants must meet the following requirements for energy-optimized operation:

- High-efficient components
  Fans, motors, energy recovery, etc.
- Optimum interplay of all components
  Energy-optimized design, installation, commissioning and acceptance are a must. In this regard, barely / correctly sized (over sizing should be consciously avoided) and balanced plants are quite important.
- Plant concept designed accordingly to use and actual user demand.
  Separate plants into consumers that permit energy-optimized operation (forming groups for rooms with similar operating time, equal temperature level, etc.)
- Define control concepts
  Equip for automated control including networking of all information carriers for demand control. Consider user behavior. Make the best use of free heat such as solar radiation and waste heat emitted by people and equipment. Avoid unnecessary cooling loads (solar radiation, lighting, waste heat from devices). Prevent loses through the integration and evaluation of corresponding messages (window contacts).
- Operation to actual use
  Continuous adaption of operation to changing demand.
  Regular checks, that all switches (hardware and software) are set to position „Auto“ (automatic). Only in reasonable cases may switches are in the position „Manual“.
- Use of proved and tested building automation functions, which have a high quality and allow project-specific adaptations.
- Technical services/operator
  Trained personnel only used to take care of plants and systems.

Building automation and control must meet the following requirements for energy-optimized operation:

- Decentralized functions, networked with superposed functions.
- Operation and monitoring (sufficient possibilities for user-friendly operation and monitoring).
- Log, process, monitor and visualize relevant data (physical and virtual data points).
- Etc.

3.4 Structure of ventilation and air conditioning plant

3.4.1 System overview

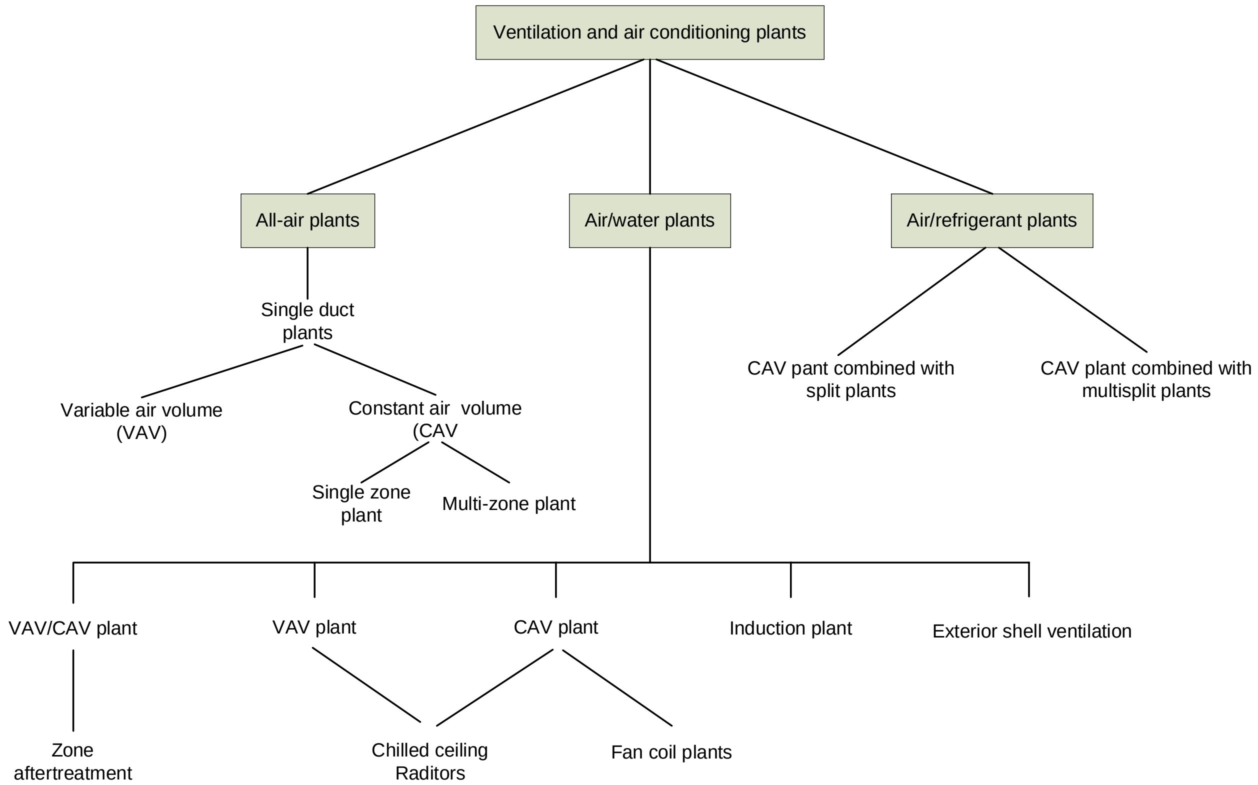
Air conditioning plants are essentially classified by the way in which the heating and cooling energy is delivered to the room, i.e. whether it is delivered via supply air only, or via the LTHW/CHW circuits only, or by a combination of both methods. The following system variants result from this distinction:

- All-air plants
- Air/water plants
- Air/refrigerant plants

It should be noted that to deliver the same heating and cooling output, significantly more energy is required in all-air plants than in water systems as well as considerably more space. For example, it requires approximately 0.5 kWh of electrical energy to transport 1 kWh of heating or cooling energy via air, i.e. 30 to 60% of annual operating costs for an AC plant go to the fans, whereas a pump requires on average 1 to 3% to transport energy via water.

VAV Variable air volume systems as one-room plant with variable air volume or as multi-room plant with VAV-boxes

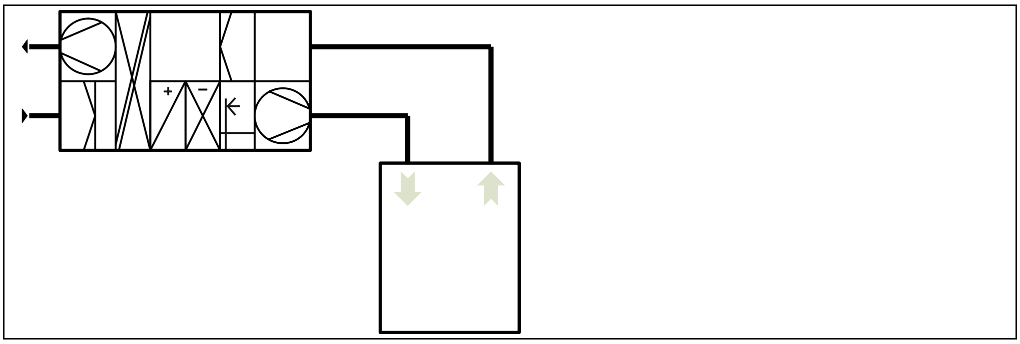
Fig. 4 System overview of ventilation and air conditioning plants



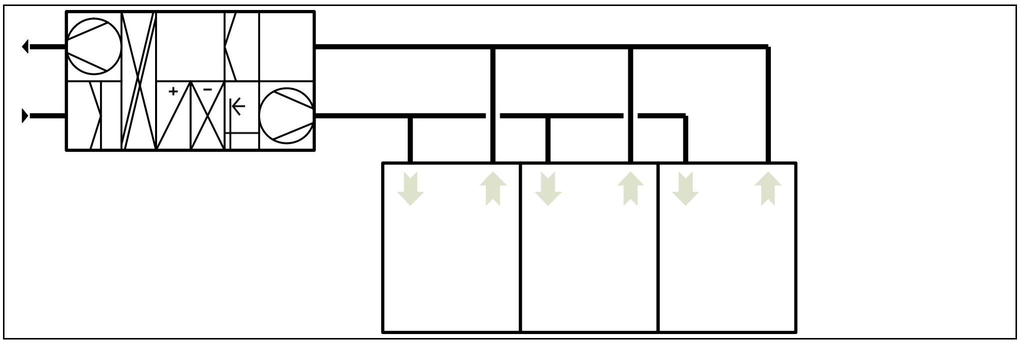
Note:
In the overview above, two-duct plants with heating and cooling air ducts are no longer listed, since they are only found today in existing systems.
The air-refrigerant plants, also referred to as VRF system (Variable Refrigerant Flow), are not further dealt with in this document.

Examples All-air plants

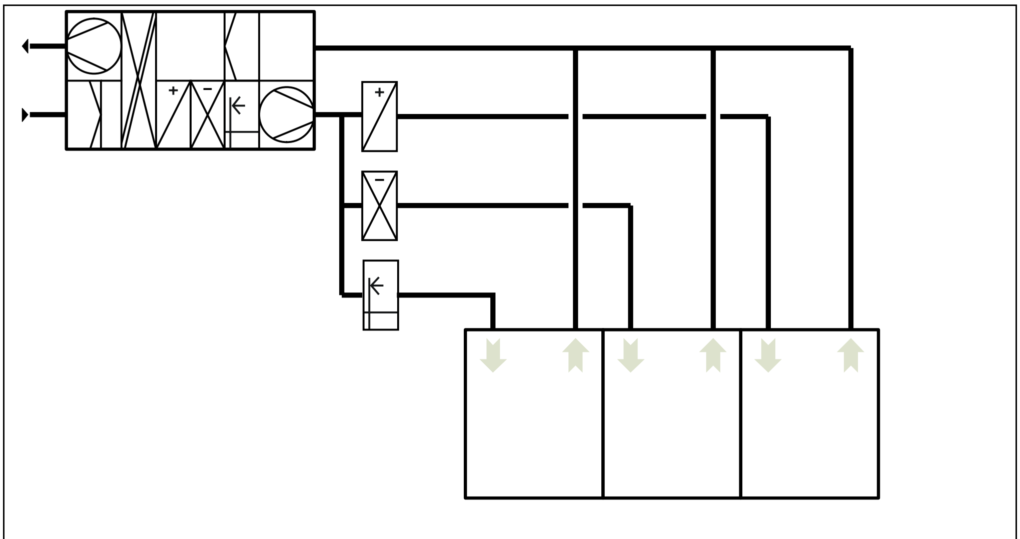
Single duct plant as one-room plant



Single duct plant without zone after treatment

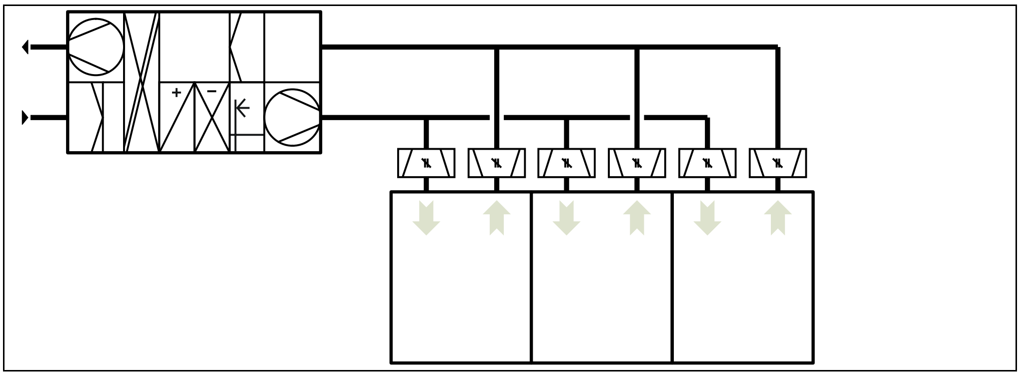


Single duct plant with zone after treatment Centralized at air handling unit



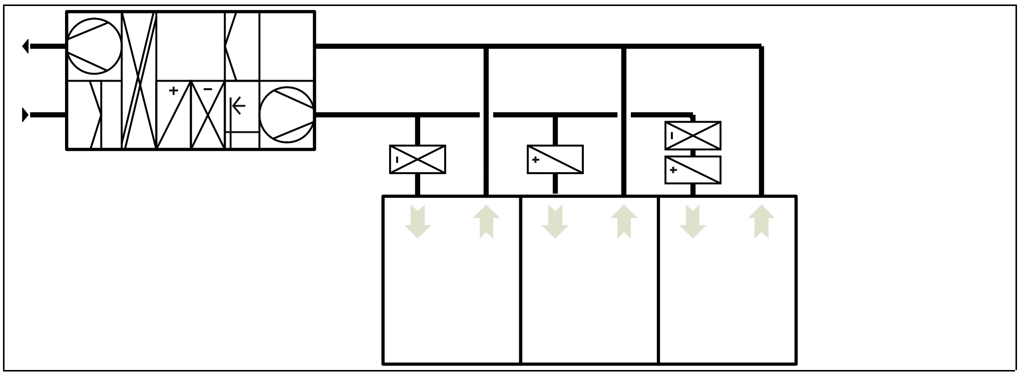
Presentation with three different types of zone after treatment

Plants with variable air volume (VAV)

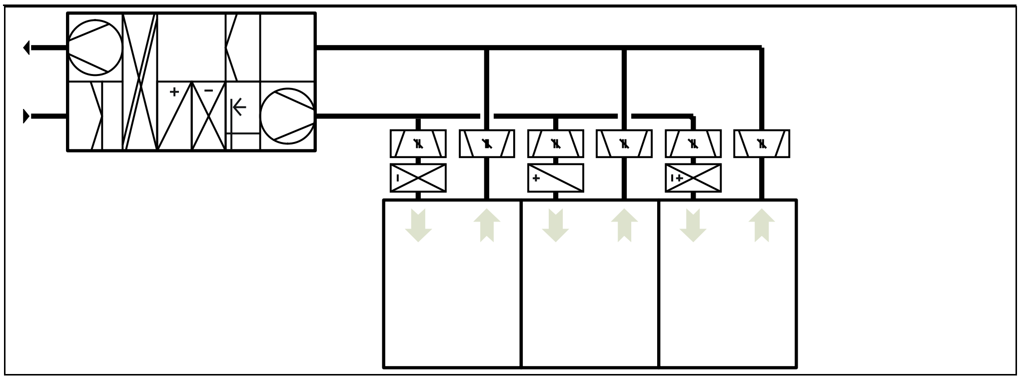


Examples air/water plants

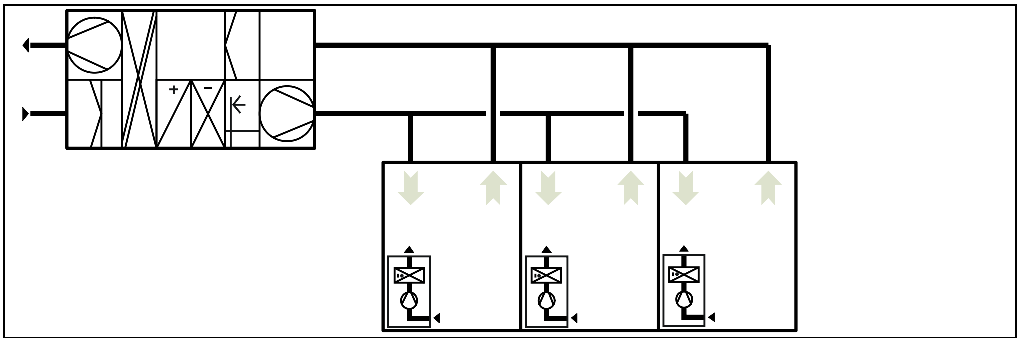
Single-duct plant with local reheaters/ recoolers



Plants with variable air volume (VAV) and local reheaters/recoolers

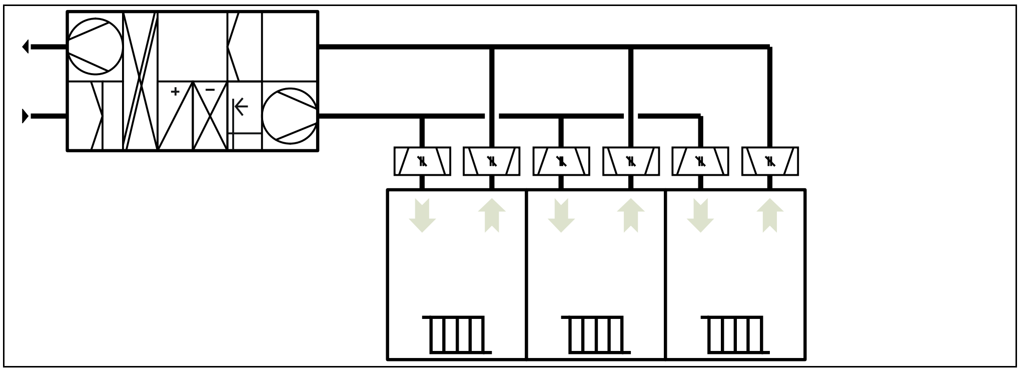


Plants with fan coils

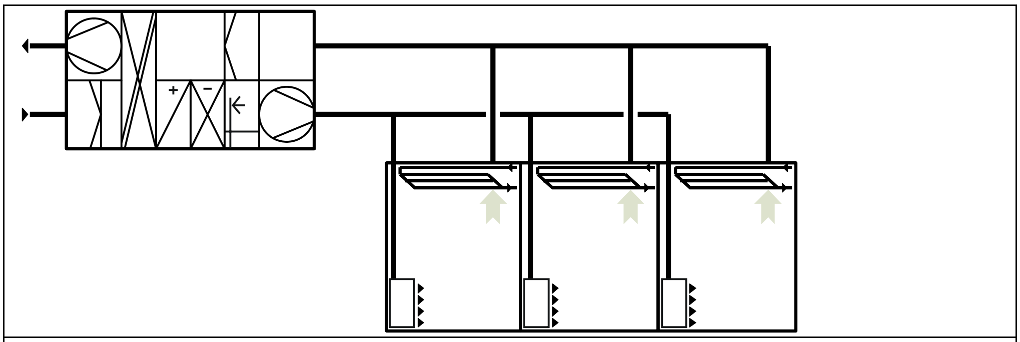


Variant: With primary air supply; outside air; with pure recirculated air mode

Plants with variable air volume (VAV) and local room heating

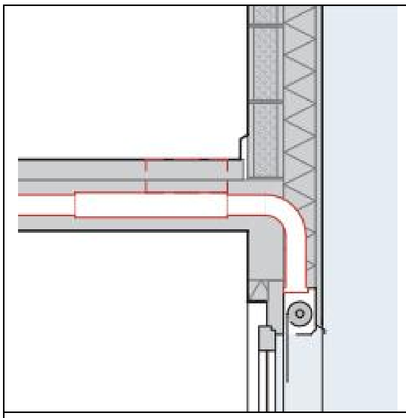


Displacement ventilation with chilled ceiling



Can either be used as CAV plant for hygienic ventilation or combined with VAV systems. Cooling can also occur via chilled beams or hybrid chilled ceilings.
When combined with TABS[2] as CAV plant without room temperature control.

Distributed supply air unit



With two-pipe connection (heating/cooling) and centralized extract.
Facade units or ventilation boxes

[2] Thermally-activated building systems

3.4.2 Distribution structures

Single room plants
For restaurants, kitchens, shops, auditoriums, etc.
All-air systems or displacement ventilation via chilled ceilings, chilled beams, or hybrid chilled ceiling, in the event that air-side cooling does not suffice.

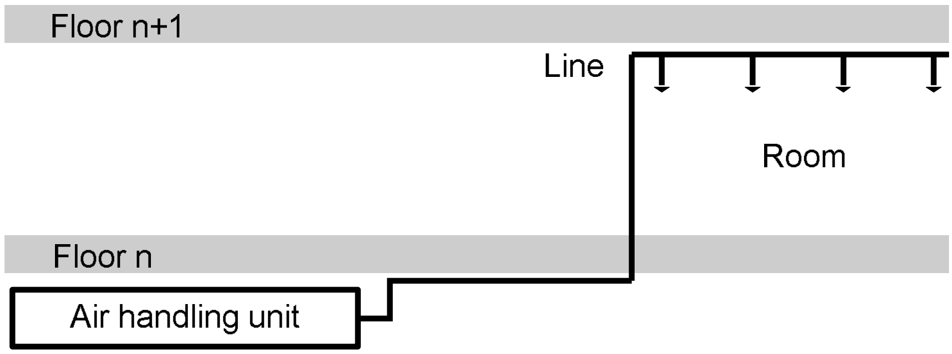


Fig. 5 Distribution structure for single room plant

Multi-room plants
For training rooms, meeting rooms, offices, labs, etc.

- All-air plants with variable air volume (VAV) and zones for constant air volume (CAV) as base ventilation.
- Air/water plants with VAV and radiators, with displacement ventilation and chilled ceiling or
  zone after treatment with local reheaters/recoolers

Mechanical air dampers (or constant volume controller) to balance the air volume and motorized dampers for demand-controlled (presence) air supply of areas are a must for energy-efficient overall functionality.
For hotels, offices

- As primary ventilation plant for rooms with fan coils

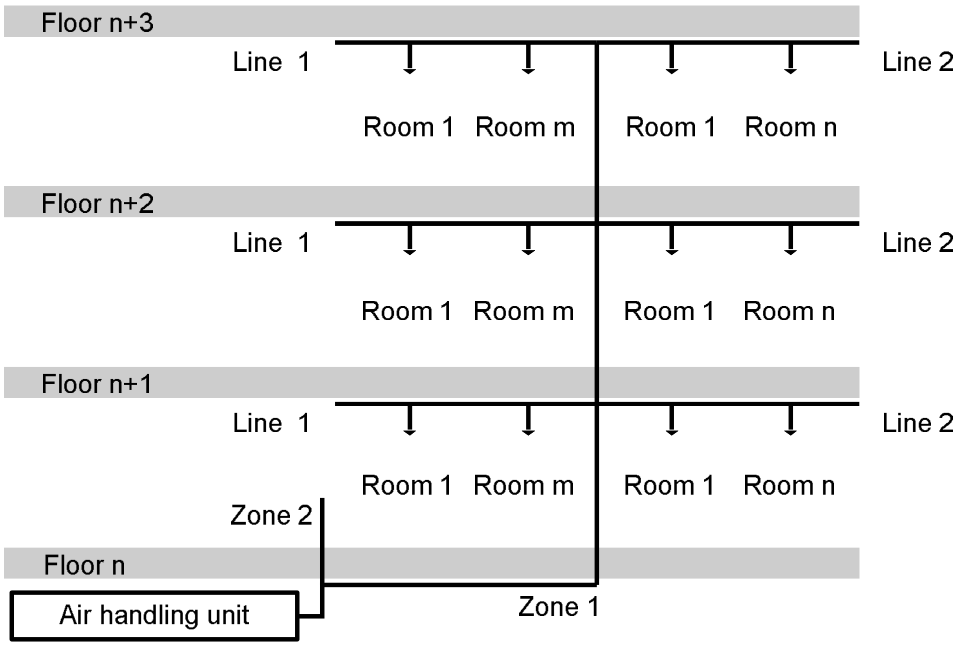


Fig. 6 Distribution structure for multi-room plant

3.5 Demand control

3.5.1 Model for demand and supply

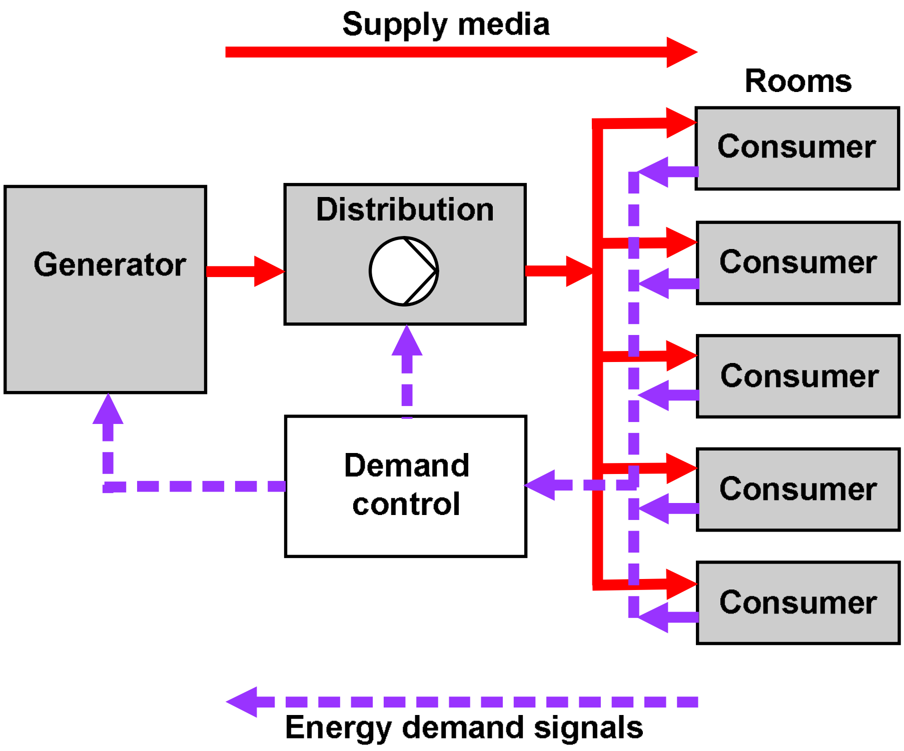


Fig. 7 Energy demand and supply model [1]

The room is the source of demand (e.g. air volume, heating and cooling demand). Suitable building services plants and matched control ensure demand-controlled, comfortable conditions in the rooms with regard to temperature, humidity, air quality and lighting.
Operating times for the partial plants can be optimized when supply media (air, heating, cooling) is provided based on consumer demand which in turn minimizes losses in distribution and generation.

Energy-efficient building automation and control functions are distinguished by optimized, individual energy-savings components from consumer to generation using networked control. Matching the components guarantees that building automation and building technology components are integrated into one energy-efficient overall system.

3.6 Function overview ventilation / air conditioning

3.6.1 General

The superposed, generally applicable functions to operate plants in an energy-efficient manner:

- Scheduler
- Operating modes and setpoints.

3.6.2 Ventilation and air conditioning functions

Room level:

- Air volume control
- Temperature control:
  - Supply air temperature control
  - Room or extract air temperature control
  - Room or extract-supply air temperature cascade control
- Air humidity control
- Air quality control
- Integrated individual room control with information exchange on distribution and/or generation.
  - Record occupancy with presence detectors
  - Window contact to limit energy loss in room.
  - Close the blinds.
  - Compensation for the influence of interior sources of heat (people, lighting, machines)
  - Demand signals for air volume, temperature, air humidity, and air quality

Distribution:

- Air volume control
- Static pressure control in air ducts
- Control of zone after treatment
  - Heating
  - Cooling
  - Humidification and dehumidification
- Ventilation systems with VAV
- Displacement ventilation control

Air handling unit:

- Control air volume or pressure
  - Multi-stage control
  - Automatic air volume or pressure control
- Heat recovery control with icing protection on the extract air side
- Heat recovery control (overheating protection)
- Control of free machine cooling
- Supply air temperature control
- Air humidity control
- Sequence control of temperature and humidity
- Air quality control
- Filter supervision for variable air flow
- Monitoring of energy recovery

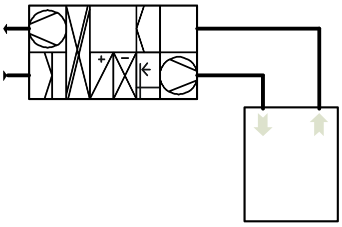
Special functions:

- h,x control Economizer tx2
- AirOptiControl

3.6.3 Energy efficiency functions and air conditioning systems

The following section outlines variables that influence the energy efficiency of the various air conditioning systems. The functions are briefly described for the room, distribution, and air handling units that can significantly influence a plant's energy efficiency [4].

All-air plants



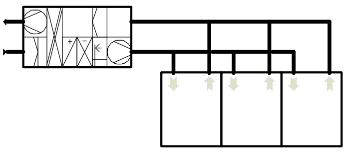
Single duct as single room plant

Room influences:

- Temperature – measured in the room or in extract air. Control room or extract air temperature compensated by outside air temperature
- Air humidity – measured in the room or in extract air. Use the setpoint in a range (summer-/winter adaptation) in the annual curve and not a constant value
- Air quality – measured in the room or extract air changes the required outside air volume flow
- Presence – determines the plant operating mode (Comfort, Precomfort, Economy)

Air handling unit:

- Speed dependent air volume – determines electricity consumption and influences the thermal energy consumption
- Energy recovery (ER) functions – minimize thermal energy consumption
- Free machine cooling – reduces the use of active cooling by taking advantage of cooler outside air
- Control of room or extract air-supply air temperature cascade
- Control of supply air humidity – relative or absolute
- Sequence control of air handling components (ER, air dampers, heating, cooling coils) guarantee high control accuracy at minimum energy consumption
- Filter supervision with differential pressure sensors in variable air volume
- h,x control Economizer tx2
- AirOptiControl



Single duct as multi-room plant without zone after treatment

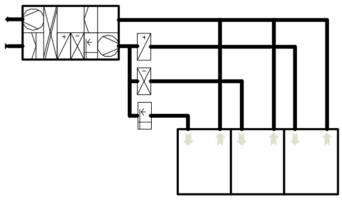
Room influences:

- Temperature varies due to internal loads and can therefore be characterized as non-controlled
- Presence (if a damper is available per zone)

Air handling unit:

- Air volume – can be variable if zone dampers available
- Energy recovery (ER) functions – minimize thermal energy consumption
- Free machine cooling – reduces the use of active cooling by taking advantage of cooler outside air
- Control of supply air temperature compensated for outside air temperature, Control by reference room temperature (min., max. or average) possible, but leads to unsatisfactory results
- Control of supply air humidity – relative or absolute
- Sequence control of air handling components (ER, air dampers, heating, cooling coils) guarantee high control accuracy at minimum energy consumption
- Filter supervision with differential pressure sensors in variable air volumes

Single duct plant with zone after treatment, centralized at the air handling unit



The zone corresponds to one room.

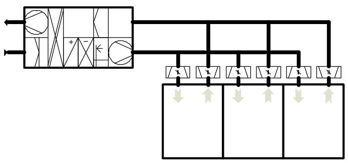
Influences:

- Temperature – measured in the given room or in extract air. Controls the room or extract air temperature compensated by outside air temperature, transmits positioning signals to centralized after treatment components.
- Air humidity – measured in the room or in extract air, if humidifier exists per zone.
- Air quality cannot be guaranteed.
- Presence can be used if motorized dampers exists for each zone and determines the plant operating mode (Comfort, Precomfort, Economy) for the zone

Air handling unit:

- Variable air volume if dampers are available for each room, control using differential pressure sensors after the air handling unit
- Energy recovery (ER) functions – minimize thermal energy consumption
- Free machine cooling – reduces the use of active cooling by taking advantage of cooler outside air
- Control supply air temperature, control by zone room temperatures
- Control supply air humidity – to absolute value or minimum value of relative humidity, if zone humidification is available
- Sequence control of air handling components (ER, air dampers, heating, cooling coils) guarantee high control accuracy at minimum energy consumption
- Filter supervision with differential pressure sensors in variable air volumes

Plant with variable air volume (VAV)



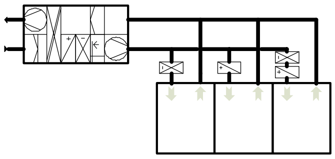
Room influences:

- Temperature – measured in the room or in extract air. Controls the room or extract air temperature compensated by outside air temperature.
- Air quality – measured in the room or extract air (CO_2 and or VOC content) changes the required outside air volume flow
- Record presence to open/close VAV dampers

Air handling unit:

- Variable air flow, controlled by VAV damper position or differential pressure sensors
- Energy recovery (ER) functions – minimize thermal energy consumption
- Free machine cooling – reduces the use of active cooling by taking advantage of cooler outside air
- Control supply air temperature, controlled by room temperatures
- Control of supply air humidity – relative or absolute
- Sequence control of air handling components (ER, air dampers, heating, cooling coils) guarantee high control accuracy at minimum energy consumption
- Filter supervision with differential pressure sensors in variable air volumes
- AirOptiControl

Air/water plants



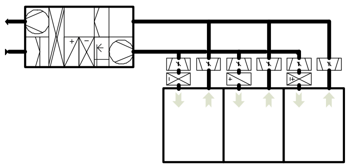
Single-duct plant using local reheaters/recoolers

Influences:

- Temperature – measured in the room or in extract air. Control room or extract air temperature compensated by outside air temperature
- Air quality cannot be guaranteed.
- Presence can be used if motorized dampers exists for each zone and determines the plant operating mode (Comfort, Precomfort, Economy) for the zone

Air handling unit:

- Variable air volume if dampers are available for each room, control using differential pressure sensors after the air handling unit
- Energy recovery (ER) functions – minimize thermal energy consumption
- Free machine cooling – reduces the use of active cooling by taking advantage of cooler outside air
- Control supply air temperature, control by zone room temperatures
- Control of supply air humidity – relative or absolute
- Sequence control of air handling components (ER, air dampers, heating, cooling coils) guarantee high control accuracy at minimum energy consumption
- Filter supervision with differential pressure sensors in variable air volumes



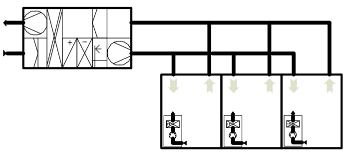
VAV plants with zone after treatment using local reheaters/recoolers

Room influences:

- Temperature – measured in the room or in extract air. Controls the room or extract air temperature compensated by outside air temperature
- Air quality – measured in the room or extract air (CO_2 and/or VOC content) changes the required outside air volume flow
- Record presence to open/close VAV dampers

Air handling unit:

- Variable air flow, controlled by VAV damper position or differential pressure sensors
- Energy recovery (ER) functions – minimize thermal energy consumption
- Free machine cooling – reduces the use of active cooling by taking advantage of cooler outside air
- Control supply air temperature, controlled by room temperatures
- Control of supply air humidity – relative or absolute
- Sequence control of air handling components (ER, air dampers, heating, cooling coils) guarantee high control accuracy at minimum energy consumption
- Filter supervision with differential pressure sensors in variable air volumes
- AirOptiControl



Plants with fan coils

Recirculated air operation (without air handling unit):

Air is renewed using window ventilation. Fan coils are used as heating or cooling system.

Room influences:

- Temperature control in room or based on return air temperature
- Presence – determines the plant operating mode (Comfort, Precomfort, Economy)

With local connection for outside air (without air handling plant):

Room influences:

- Temperature control in room or based on return air temperature
- Presence – determines the plant operating mode (Comfort, Precomfort, Economy)

- Outside air ratio is primarily used as a constant value. The damper is closed at lower outside air temperatures. The control must affect the outside air damper if controlled by air quality

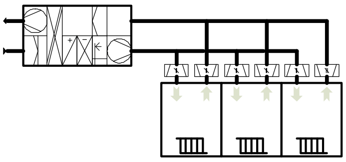
With primary air supply through air handling unit:

Room influences:

- Temperature control in room or based on return air temperature
- Air quality cannot be guaranteed.
- Presence – determines the plant operating mode (Comfort, Precomfort, Economy)

Air handling unit:

- Constant air volume or using multi-stage fans
- Energy recovery (ER) functions – minimize thermal energy consumption
- Free machine cooling – reduces the use of active cooling by taking advantage of cooler outside air
- Control supply air temperature – controlled by room temperatures
- Control of supply air humidity – relative or absolute
- Sequence control of air handling components (ER, air dampers, heating, cooling coils) guarantee high control accuracy at minimum energy consumption
- Filter supervision with differential pressure detectors



Plants with variable air volume (VAV) and local heating

Room influences:

- Temperature – measured in the room or in extract air. Control room or extract air temperature compensated by outside air temperature
- Air quality – measured in the room or extract air (CO_2 and/or VOC content) changes the required outside air volume flow
- Record presence to open/close VAV dampers
- Local heating integrated in sequence control

Air handling unit:

- Variable air flow – controlled by VAV damper position or differential pressure sensors
- Energy recovery (ER) functions – minimize thermal energy consumption
- Free machine cooling – reduces the use of active cooling by taking advantage of cooler outside air
- Control supply air temperature – controlled by room temperatures
- Control of supply air humidity – relative or as absolute value
- Sequence control of air handling components (ER, air dampers, heating, cooling coils) guarantee high control accuracy at minimum energy consumption
- Filter supervision with differential pressure sensors in variable air volumes
- AirOptiControl

Remark

If measured values (temperature, humidity, air quality) are acquired in the room, additional energy savings potential exists, since the plant can be switched off within the comfort setpoint field. For sensors in the extract air duct, the plant must be operating or switched on cyclically to measure correct values.

3.7 General functions

3.7.1 Scheduler

Target

The function is intended to
- Minimize operating times for plants and components and thereby lower energy consumption.

Use

The function can be used in a number of applications to switch building technical plants.

Principle of operation

A scheduler offers functions associated with well-known time switches with the following extensions:
- Weekly program for seven days
  for repetitive events
  multiple entries for various days and time windows possible
- Exception day program
  for entries with date and time.
- Calendar
  for data, week and/or date range entries, e.g. vacation.
- Switching various outputs including
  single and multi-state plants
  Setpoints
  operating modes, etc.

Resolution (the smallest switching value) for the scheduler is generally one minute. Time sync and summer/winter changeover is ensured within networked controllers with system functions.

The example below illustrates a two-stage output with weekly schedule that includes various exceptions.

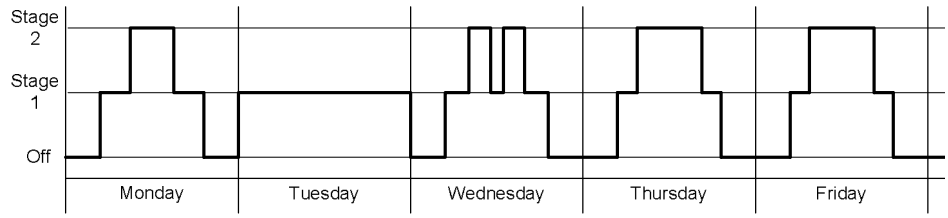


Fig. 8 Example for a weekly scheduler

BAC efficiency class as per EN 15232

Enables class C

Prerequisites

Entry of all scheduler entries matched to occupancy.

Product range

Synco, Desigo

3.7.2 Operating modes and setpoints

Target

The function is intended to
- Easily adapt setpoints and operating modes to the user's individual needs,
- Simplify scheduler entries.

Use

The function can be used as operational support in conjunction with plant states with the appropriate setpoints.

Principle of operation

Operator intervention, automation facility or the process determines the operating mode. Operating modes have various states and associated setpoints. The following states are available for room control:
- Comfort
  The operating mode for an occupied room. The room state is within the comfort range with regard to temperature, humidity, air quality and movement as well as brightness and blinding.
- PreComfort
  Is an energy-savings operating mode for a room. The room state quickly achieves the comfort range when switching to operating mode Comfort. Control operates using setpoints in PreComfort operation that may deviate from Comfort setpoints. A presence detector/key is normally used for changing over from PreComfort to Comfort, but may also take place using the scheduler.
- Economy
  Is an energy-saving operating mode for the room where Comfort mode is not required for longer periods. Control operates using setpoints in Economy mode that may deviate from PreComfort and Comfort setpoints. A scheduler is normally use for the changeover to Economy mode.
- Protection mode
  Is an operating mode where a plant is switched on for cool down, frost and overheat protection of a building and its facilities. An event message from a window contact or condensation monitor or scheduler may be used to changeover to Protection mode.

The following terms are typically used for hot water heating:
- Normal operation
  In conjunction with the normal temperature setpoint for the hot water.
- Reduced operation
  In conjunction with the reduced temperature setpoint for hot water.
- Protection mode
  In conjunction with the setpoint for the shut down plant. Only protection functions (e.g. frost protection) remain enabled.

BAC efficiency class as per EN 15232

Not mentioned.

Prerequisites

- The neutral zone between heating and cooling must be as large as possible.
- Select different setpoints for operating modes Comfort, PreComfort, and Economy to take advantage of achievable energy savings.

Product range

Synco, Desigo

3.8 Ventilation and air conditioning functions at the room level

3.8.1 Air volume control

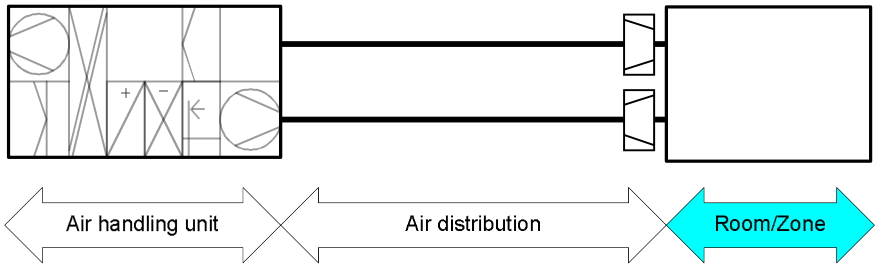
Target

The function is intended to
- Save energy by reducing the air volume – while maintaining comfort conditions in the room – for air handling and distribution.

Use

Employ this function to rooms or zones where air volume can be reduced through changes in occupancy (number of people in the room) or changing thermal loads.
- Systems with variable air volume (VAV), fan coils with primary air supply: Open/close air dampers per room or zone adapt the air volume based on "time" or "occupancy".
- Variable air volume (VAV) systems: Modulating control alters the air volume per room based on "demand"
- Used in individual room plants including lecture halls, restaurants, convention halls, conference rooms, theaters, cinemas, shopping malls, etc.

Effect



Principle of operation and energy savings

Air supply to the room or zone is reduced using open/close air dampers. This can be "time based" or "occupancy based".
For time-based operation, air flow for the maximum load in the room is used up during the nominal occupancy times. This results in greater energy losses at partial load in the room and during non-occupancy
For occupancy-based operation, air flow for the maximum load in the room is used up during actual occupancy times. Energy loses at partial load in room are reduced to actual occupancy.
For Variable Air Volume (VAV) systems, the air volume is continuously changed between the minimum and nominal air volume. A room-supply air cascade control is used as the first temperature for temperature, and supply and extract air for air quality control (CO_2, VOC) [5] is used for the second sequence for air volume. This balances out changing load ratios.
The air volume is thus "demand-dependent" control; this guarantees the air quality using less energy for air handling and distribution.
The function reduces energy consumption for transporting air, and, in addition, energy consumption for heat, cooling, humidification and dehumidification depending on plant constellation.

BAC efficiency class as per EN 15232

Scheduled control:	Enables class C
Occupancy-based control:	Enables class B
Demand-dependent control:	Enables class A

Prerequisites

The function can only be used in air systems where the air volume can be throttled.

Product range

Synco, Desigo

3.8.2 Temperature control

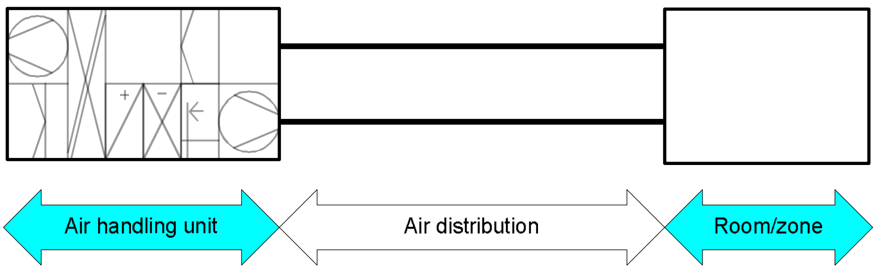
Target

This function handles the supply air for rooms or building zones so that
- The room temperatures in the impacted areas are within the comfort range and can be guaranteed at the lowest possible energy consumption.

Use

The function can be used for all types of air handling units.

Effect



Principle of operation

The room temperature should be held constant to the applicable setpoint in the given operating mode (e.g. Comfort) – regardless of internal heat sources (people, devices, lighting) and external heat sources (solar radiation). This occurs, depending on the plant type, via constant or variable air volume or using auxiliary heat (e.g. base load heating) or cooling plant components (e.g. chilled ceilings).
Control the temperature in the room or in the zone by…
- Supply air temperature control,
- Room/extract air temperature control,
- Room or extract-supply air temperature cascade control

Supply air temperature control:
The temperature sensor is installed in the supply air duct and the controller compares this measured value with the supply air setpoint. A constant room temperature can result if there is little or no heat gain in the room. The supply air temperature should be controlled by outside air temperature to better adapt as needed. The room temperature can on longer be guaranteed for larger or irregularly recurring loads. Supply air temperature control can be used where the air handling unit is primarily used for air renewal and room temperature control is secured using a separate control circuit (e.g. base load heating).

Room/extract air temperature control
The supply air temperature is adapted to changing loads via a room temperature control circuit and maintains a constant room temperature. A supply air temperature limitation ensures, at high internal loads, that incoming supply air is not too cold, preventing drafts in this manner. Temperature changes are measured by room temperature control and can be quickly eliminated.
Extract air temperature control has the same task in principle as the room temperature control, with the temperature sensor located in the extract air duct. The temperature sensor installed in the extract air duct measures only air temperature, whereas the room temperature sensor also measures the radiation ratio and better fulfills comfort requirements in this regard. The extract air temperature control is preferred where the proper placement of a room sensor is difficult or the radiation ratio can be disregarded.

Room or extract-supply air temperature cascade control:
Cascade control consists of a lead and sequential control circuit. The lead controller uses the room sensor to measure the temperature. For a setpoint deviation, the room temperature, the lead controller adjusts the setpoint for the supply air temperature by this control difference and the set cascade influence. The sequential controller measures the supply air temperature, compares it with the new setpoint and adjusts the heating or cooling valve position until the demanded supply air temperature is achieved.

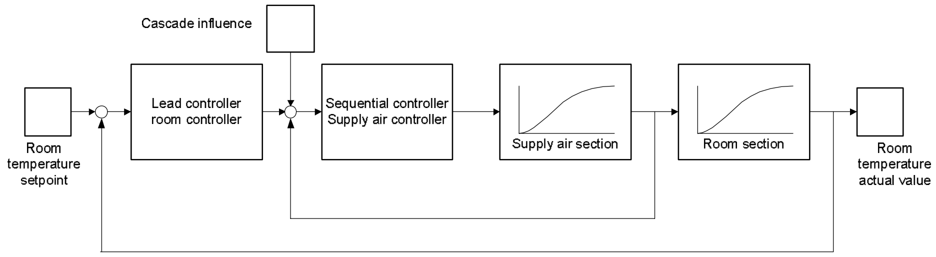


Fig. 9 Diagram cascade control

The function reduces energy use. It lowers…
- Thermal energy use for heat and cooling, since control deviation is very small thanks to precise control of internal loads in the room.
- A room/extract air temperature control, supplemented by cascade control, is preferred over supply air temperature control since the room temperature setpoint can be precisely maintained.

BAC efficiency class as per EN 15232	Constant setpoint:	Enables class C
	Variable setpoint modification independent of Outside air temperature:	Enables class B
	Variable setpoint with modification based on load:	Enables class A

Prerequisites

For a single-room plant, cascade control (room/extract) provides solid control results. For a multi-room plant, you must ensure that the individual rooms are independent of one another and control different internal loads and thus are able to guarantee the room setpoint.

Product range

Synco, Desigo

3.8.3 Air humidity control

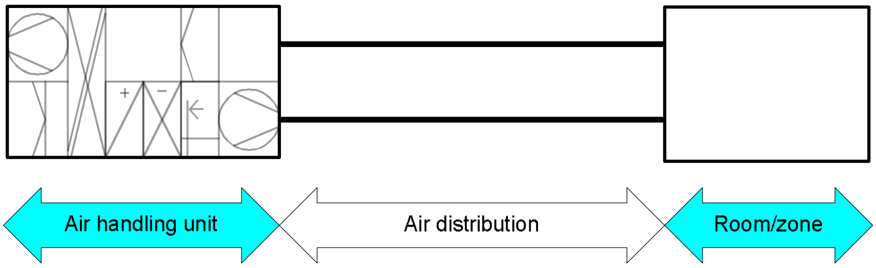
Target

The goal of this function is to process the air for air conditioned rooms independent of the state of outside air and the processes in the room, so that…
- Relative humidity remains constant or within the preset limits,
- Energy expense for humidification and dehumidification is minimized.

Use

The function can be employed as follows:
- Room or extract air control
- Room supply air humidity or extract-supply air humidity cascade control

Effect



Principle of operation

Humidity in the room can be controlled to absolute or relative values. These values can be measured in the room or in the extract air. If an air conditioning plant is supposed to maintain room temperature and room humidity as precisely as possible, this is only possible through the use of one temperature and humidity control circuit each in the room (or in the extract air) to be air conditioned.

Humidity control can occur in simple plants through the use of room hygrostats (two-point control). This type of control only meets modest needs since swings to relative room humidity are unavoidable due to on/off control. An improvement is achieved using room humidity control without supply air humidity sensors to humidify and dehumidify room air.
Cascade control is required for both humidity as well as temperature to achieve more precise control results. The lead control circuit (room or extract air) measures humidity and as soon as a setpoint deviation occurs, the setpoint for the sequential controller is modified depending on supply air humidity, room setpoint specification and cascade influence.

An additional control circuit is required to achieve the desired room temperature and relative room humidity that once again controls to the required inlet temperature via the reheating valve and cooled air.

The function reduces energy use. It lowers
- Energy consumption for humidification and dehumidification as well as thermal energy use for heating and cooling, since the control deviation is very small thanks to precise control.

BAC efficiency class as per EN 15232

Evaluated at the air handling unit level.

Prerequisites

Direct humidity control is preferred over dew point control to minimize energy consumption at precise control results.

Product range

Synco, Desigo

3.8.4 Air quality control

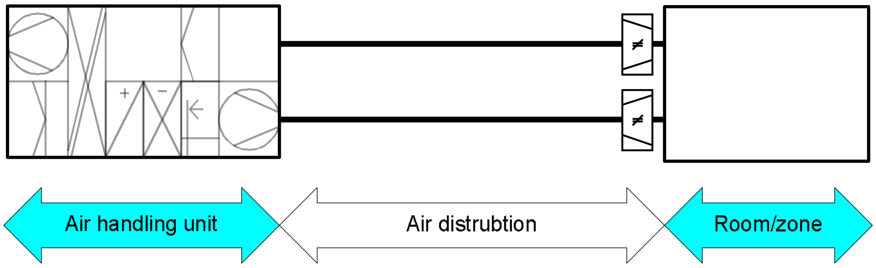
Target

The function is intended to
- Control room air quality to improve comfort and minimize energy consumption
- Demand the lowest possible air volume in the room to minimize energy consumption for air handling and distribution.

Use

The function should be used in plants where air volume can be reduced due to changing personnel occupancy:
- Single-room plants for lecture halls, restaurants, convention halls, conference rooms, theaters, cinemas, shopping malls, etc.
- Variable air volume (VAV) systems for individual rooms:
  Modulating control alters the air volume per room based on "demand"

Effect



Principle of operation

Room air quality is influenced by demand-controlled transport of outside air. The CO_2 content of the room can be a good indicator for the room air load caused by humans as long as there is no smoking or other sources of contamination. The VOC* measurement should be used if smells such as tobacco smoke or fumes from materials (furniture, carpets, paint, etc.) exist. Both values should be measured if neither the one or the other source dominates. This sensor measures the CO_2/VOC concentration, evaluates it internally and processes this into a ventilation demand signal. This is the result of a maximum selection from the CO_2 measurement and the filtered VOC sensing signals.
Air quality can be measured in both the room as well as in the extract air duct. Differing control strategies can be used depending on how the air handling unit is equipped. See section 3.10.8.

The function reduces energy use. It lowers…
- Electricity consumption to transport air,
- Heating energy consumption,
- Cooling energy consumption,
- Humidification and dehumidification energy consumption.

BAC efficiency class as per EN 15232

Demand-dependent control: Enables class A

Prerequisites

The function can only be used in air systems where the air volume can be changed while operating based on changing personnel occupancy.

Product range

Synco, Desigo

* volatile organic compounds

3.8.5 Individual room control with demand control

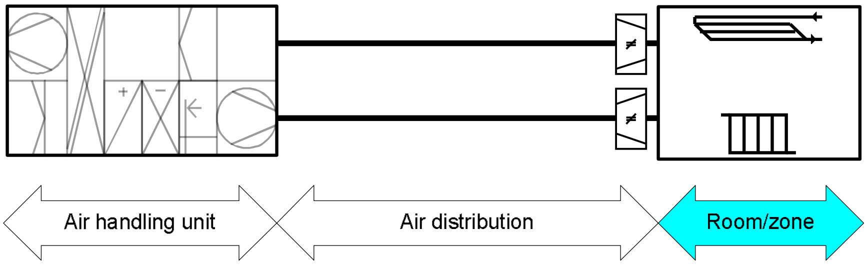
Target

The function is intended to
- Maintain the desired temperature, air humidity, and air quality in the room,
- Have user influenced room conditions,
- Form demand (air volume, heat, cooling) and transmit it for further processing,
- Evaluate window contacts to limit energy loss in the room,
- Allow scheduled preconditioning (PreComfort) of the room,
- Compensate for external influences.

Use

The function can be used to control …
- Ventilation and air conditioning plants that allow for individual room control in its system features. These are:
  - Single-room plants for lecture halls, restaurants, conference rooms, theaters, cinemas, etc.
  - System with variable air volume (VAV)
  - VAV plants with air aftertreatment (heat, cooling, humidification) or with radiators and/or chilled ceilings in the room
  - Fan-coil plants with outside air dampers or featuring primary air supply (air quality cannot be controlled for recirculated air operation)

Effect



Principle of operation

Individual room control includes the control of the room temperature, air quality, and humidity (if demanded) as well as exchanges information to the air handling unit and heat and cooling generation.
The temperature sensor measures the room temperature actual value, compares it to the setpoint and is heated or cooled in sequence control at minimum air volume. The room temperature controllers specify for the VAV controllers the desired air volume in the form of a modulating setpoint between the minimum and maximum value.
The load for room air is measured via a suitable sensor (CO_2/VOC) and the controller determines the volume flow from the setpoint/actual value deviation. The greater demand from temperature and air quality control provides the resulting setpoint for air volume control.

The individual room controller processes all user interventions (setpoint, operating state) and the information from the room (temperature, humidity, air quality, room occupancy with presence detector, window contact, dew point sensor, disruptions) and determines demand. The demand information is transmitted to heat and cooling generation and air handling for further processing. It is used there to determine which plant components must be switched on and the level for temperature, air volume, and outside air ratio.

The components room sensor, air quality sensor, presence detector, room unit (with setpoint readjustment and display as applicable), window contact, differential pressure sensor and control elements for heating, cooling, and VAV dampers are normally wired to individual room control.

A scheduler is available for each controller or room group for time-controlled operation of a room or zone using temperatures and air quality dependent on occupancy, such as…

- Preconditioning (PreComfort mode) prior to room occupancy,
- Setpoint offset for absences (holidays, exception days).

Using individual room control improves control quality in the rooms, since it generally does not indicate any control deviations as is the case with traditional thermostats. This allows you to maintain more precise desired temperatures and more efficiently control out heat gains.
The function minimizes energy use. It permits…

- Different temperatures in separate rooms,
- Occupancy and time-controlled curves for desired room temperature,
- Maintaining optimum air quality,
- Compensation for the influence of exterior sources of heat (sun),
- Compensation for the influence of interior sources of heat (people, lighting, machine),
- Summer compensation of room temperature setpoints,
- Close blinds to reduce incoming, radiated heat,
- A demand-controlled curve of the room air temperature,
- A demand-controlled air volume.

BAC efficiency class as per EN 15232

Enables class C

Prerequisites

- All rooms are equipped with individual room control and connected via a network
- Available functions are correctly commissioned and scheduler entries are continuously adapted to occupancy.
- Demand control must evaluate the relevant controller information and control supply temperature and air volume as well as operating times for distribution and generation components.

Product range

Synco, Desigo

3.8.6 Demand signal ventilation/heat/cooling

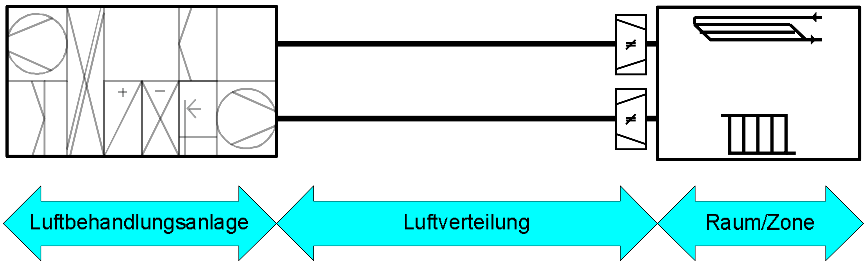
Target

The function is intended to
- Provide the air handling unit by room/zone demand with the lowest possible air volume using the demanded outside air ratio,
- Handling supply air temperature in an energy optimized manner,
- Control components for air handling plant through the evaluation of room or zone temperature, humidity, and air volume (e.g. damper positions),
- Control heating/cooling distribution and generation components by evaluating consumer valve settings,
- Generate and distribute heat/cooling quantity and temperature level by room/zone demand.

Use

The function can be used to control …
- Supply air temperature and quality,
- Supply air and extract air volume,
- Heating and cooling circuits as well as heat and cooling generators.

Effect



Principle of operation

The relevant information on all rooms belonging to an air handling unit are collected. The values may consist of VAV damper settings, air quality measured values, valve settings, room temperatures or operating states. The demand signals from multiple sources are gathered, evaluated and mapped to resulting demand signals for the following variables:
- Supply air temperature and humidity,
- Supply air and extract air volume
- Outside air volume
- Flow temperatures and flow volumes for heating and cooling circuits

Fans and additional components in the air handling unit as well as valves and pumps for heating and cooling are controlled based on these demand signals and determines the demand signals for heating and cooling generation.

The function reduces energy use. It lowers…
– Electricity consumption for fans and recirculating pumps,
– Consumption of thermal energy for air handling,
– Energy loss in the piping network.

BAC efficiency class as per EN 15232

Enables class C

Prerequisites

Room controllers must be connected via network with the controllers for primary plants (ventilation, heat, cooling) and provide the necessary information.

Product range

Synco, Desigo

3.9 Ventilation and air conditioning functions in distribution

3.9.1 Air volume control

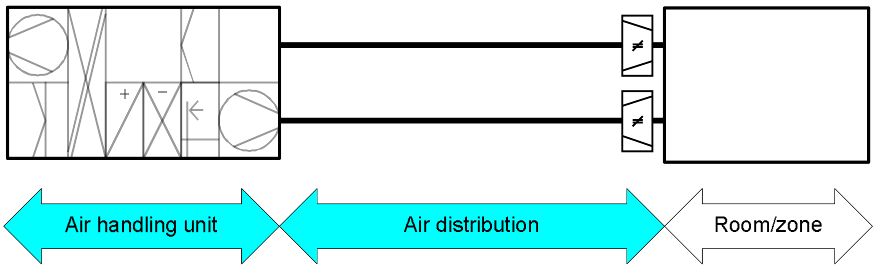
Target

The function is intended to
- Adapt demand to fan pressure in a branched duct network with VAV controllers and with it to minimize electrical energy consumption.

Use

The function can be used in plants where air volume varies due to changing occupancy or varying thermal loads:
- Variable air volume (VAV) systems:
  Modulating control alters the air volume based on "demand"

Effect



Principle of operation

To prevent too high a differential pressure in the VAV boxes, thus destroying energy, the setpoints for the room temperature controllers serve as a reference variable for supply air volume.

Demand control by the building automation and control system, selects the largest volume positioning signal from all connected individual room controllers and transmits it as the actual value to the controller for the supply air fan volume flow. This compares the actual value with the setpoint, formed from ca. 90 % of the positioning range of the room temperature controller. The supply air fan speed is reduced if the present positioning signal drops below the setpoint. This drops the pressure in the supply air duct and the room temperature controller must increase its volume flow positioning signal until the resulting variable once again corresponds to the setpoint for the supply air volume controller. This prevents the supply air fan from generating unnecessarily high pressure, inefficiently using electricity. The extract air can change in sync with the supply air fan speed if the supply air and extract air duct network have approximately the same pressure drop characteristic curve. You must plan for extract air volume control by the supply air volume if this is not the case.

The function reduces energy use. It lowers…
- Electricity consumption to transport air
- As well as consumption of thermal energy for air handling,

BAC efficiency class as per EN 15232

Automatic pressure control: Enables class A

Prerequisites

The prerequisite for this control concept is communication between the individual room controller via a bus and the building automation and control system.

Product range

Synco, Desigo

3.9.2 Static pressure control in air ducts

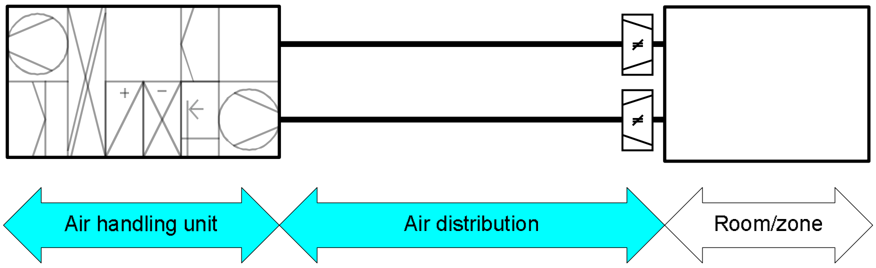
Target

The function is intended to
- Take advantage for energy savings by reducing the air volume, throttled or shut down in a branched duct network, in partial sections. The savings can be found on the one hand in electricity consumption, while also in the consumption for heating and cooling.

Use

The function can be used in plants where air volume is reduced due to changing occupancy or varying thermal loads:
- Constant air volume systems (CVS), systems with fan coils and primary air supply: Open/close air dampers per room or zone adapt the air volume based on "time" or "occupancy".
- Variable air volume (VAV) systems: Modulating control alters the air volume based on "demand".

Effect



Principle of operation

The static pressure increases in the duct network if the air dampers of the rooms/zones close due to reduced demand. This increase in pressure is prevented by controlling the impacted distribution duct. The motor's power consumption and energy consumption increases if no control is planned.
For automatic control, the setpoint is determined with, for example, a minimum selection, and the fan speed in the air handling unit changes. This control significantly reduces electricity consumption.

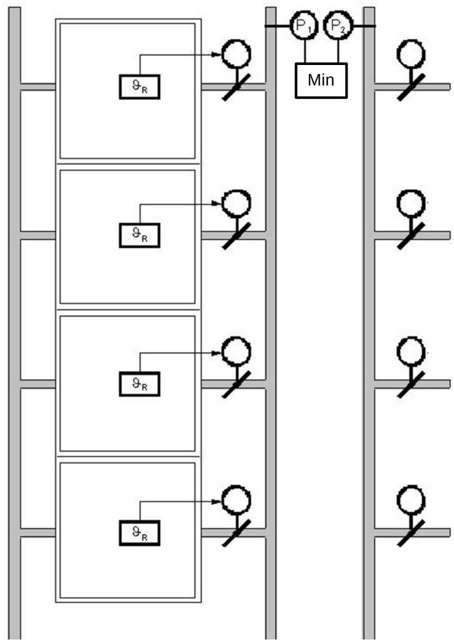


Fig. 10 Static pressure control in duct network

The function reduces energy use. It lowers…
- Electricity consumption to transport air
- As well as consumption of thermal energy for air handling,

BAC efficiency class as per EN 15232

Automatic pressure control: Enables class A

Prerequisites

Special care must be taken for the placement of the pressure sensor in the duct. It should be installed in a location where 50 to 70% of the impacted duct resistance can be measured (at peak load air volume).
The extract air volume control is optimally controlled after the supply air volume. The speed of the extract air fan can be operated in sync with the supply air if the extract air duct network has roughly the same pressure drop characteristic curve.

Product range

Synco, Desigo

3.9.3 Control with zone aftertreatment

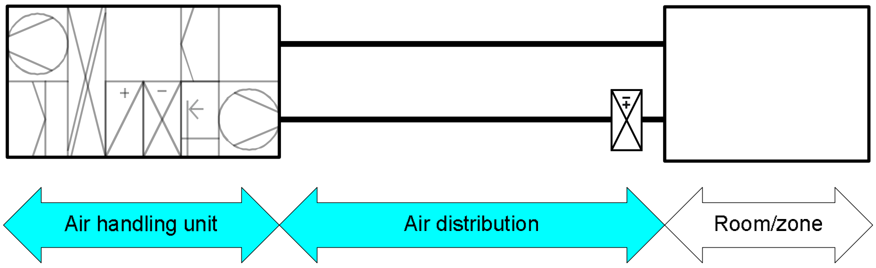
Target

The function is intended to
- Maintain the desired conditions via zone aftertreatment such as heating and cooling coils, humidifiers and dehumidifiers in the rooms.

Use

The function can be used to control …
- Reheat, recool, re-dehumidify, and rehumidify.
- Aftertreatment can take place after the air handling unit or in the vicinity of the rooms/zones.

Effect



Principle of operation

Differing use and occupancy in the individual rooms or zones requires individual adaption of heat, cooling, and humidification transfer. The air pretreated in the air handling unit is aftertreated for each zone as per the demanded room air state.
For aftertreatment in the vicinity of the zones, the control signals of the room or zone controllers directly control the actuators for the aftertreatment components (heating, cooling, dehumidifiers, humidifiers) in accordance with individual demand. Cascade controls (see Sec. 3.8.2) are used to achieve solid control accuracy. For centralized aftertreatment, the positioning signals of the individual rooms or zones must be routed to the control panel for the air handling unit.
To avoid wasting energy, it is important that the required supply air temperatures in the individual zones do not differ greatly.
The setpoints for supply air temperature and humidity of the air handling unit are the result of the evaluation of all supplied rooms/zones. The following criteria must be observed:
- Summer/winter mode or room with heating or cooling demand
- Availability and generation of energy (is heating energy available for cooling (eventually from energy recovery))
- Use of maximum or minimum values
- Influence of summer compensation
- Curve or range of setpoints for individual aftertreatment

The function minimizes energy use. It lowers…
- Consumption of heating and cooling energy,
- Energy consumption for the production of humidity.

BAC efficiency class as per EN 15232

Not mentioned

Prerequisites

Demand control must evaluate the relevant controller information and coordinate the supply temperature and humidity at the air handling units and aftertreatment.

Product range

Synco, Desigo

3.9.4 Ventilation systems with VAV and local reheaters and recoolers

Target

The function is intended to

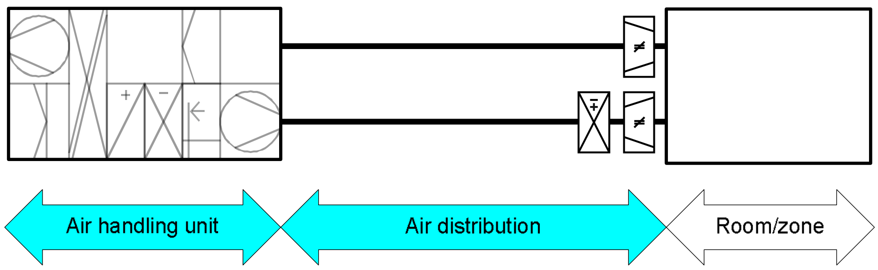
- For a variable air volume (VAV) system combined with zone aftertreatment, maintain the desired room conditions at the lowest possible energy consumption.

Use

The function can be used to control …

- Temperature and room air quality.
- Auxiliary and cooling load can be provided by aftertreatment with reheating/recooling or, room side with radiators and chilled ceilings.

Effect



Principle of operation

VAV plants can be used as both heating as well as cooling systems. If room energy demand exists in the room, the room temperature is first controlled – at a minimum air volume – with the help of air aftertreatment
(heating coils, cooling coils) or with radiators or chilled ceilings. The supply air volume is increased only after this no longer suffices. A minimum amount of outside air must normally be added VAV plants as well for hygienic reasons. As a result, a minimum limitation acts on the positioning signal for the volume flow controller.

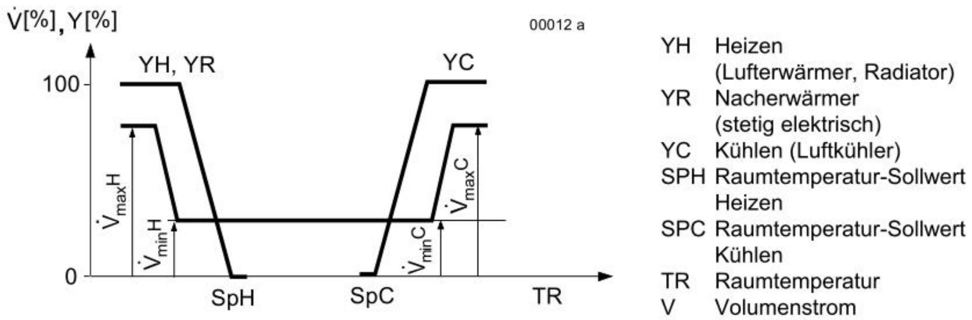


Fig. 11 Sequence diagram

There is no need to divide the building into zones, because the supply air volume flow rate can be individually matched in each room to load. Cascade control can achieve a stable room temperature. Room temperature control acting directly on the volume flow actuators, only works on open/close operation – due to the inertia of the room control path – which would result in large variations to room temperature.

The setpoints for supply air temperature of the air handling unit is the result of the evaluation of all supplied rooms/zones. The adjustment occurs using the same criteria as described in the previous section.
The function minimizes energy use. It lowers…

- Heating energy consumption,
- Cooling energy consumption.

BAC efficiency class as per EN 15232	Enables class A
Prerequisites	• Demand control must evaluate the relevant controller information and coordinate the supply temperature at the air handling units and aftertreatment.
Product range	Synco, Desigo

Principle of operation displacement ventilation

Displacement ventilation can largely satisfy the ever more stringent demands placed on ventilation plants regarding drafts, heat, and room air quality. Cooling load is generally assumed by chilled ceilings, heating load from static heat surfaces.

When using pure displacement ventilation in the comfort range, the lower temperature for supply air must be limited versus the room temperature in general by approximately 2 to 3 K. As a result only relatively small cooling loads can be dissipated. A combination of displacement ventilation and chilled ceilings are often used if greater cooling loads need to be dissipated. The displacement ventilation is used here to renew the air in the room, the chilled ceilings dissipate the cooling load. This satisfies a high level of comfort requirements.

The displacement ventilation is controlled to a constant supply air temperature. It can provide to some extent minimum cooling output to the room as well (winter, for internal heat gains). The chilled ceiling is controlled via the room temperature controller in sequence to the room heating.

Air quality is controlled via variable air volume with the necessary outside air ratio provided to a room. This can be accomplished in single room plants by measuring air quality in the room or extract air. The speed of the supply air fan is changed at the corresponding setpoint deviation, adapting the air volume. For multiple single-rooms, a VAV plant with air quality control guarantees this function (see Sec. 3.9.1/3.9.4).

When using chilled ceilings, the temperature of the chilled ceilings or lines, and thus chilled water, must be above the dew point in the room, otherwise condensation will occur.

You can monitor the dew point in various ways:

- Control cooling water flow temperature by outside air temperature
- Local dew point monitoring in the room (on/off)
- Centralized control of cooling water flow temperature using a critical room
- Local control of cooling water flow temperature by room state

Prerequisites

Displacement ventilation is especially suitable for rooms where loads do not fluctuate widely, or in areas where air quality is of particular importance (e.g. in manufacturing, sports halls, hotels, theaters, schools and restaurants).

3.10 Ventilation and air conditioning functions at the air handling unit level

3.10.1 Air volume control

Target

The function is intended to

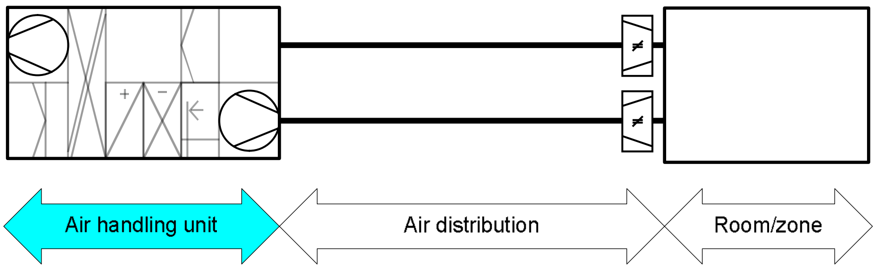
- Reduce air volume to lessen energy consumption for air handling and distribution and achieve energy savings for heating and cooling and electrical auxiliary energy.
  In a branched duct network, where sections are throttled or shut down, the operating plant cannot be impacted. Pressure must be controlled to a specified setpoint.

Use

The function can be used in plants where air volume is reduced due to changing occupancy or varying thermal loads:

- Constant air volume systems (CVS), systems with fan coils and primary air supply: Open/close air dampers per room or zone adapt the air volume based on "time" or "occupancy".
- Variable air volume (VAV) systems:
  Modulating control alters the air volume based on "demand"

Effect



Principle of operation

Differential pressure increases in the duct network (Fig. 12: Curve 1) if the air dampers to the rooms/zones close based on the reduced demand and the air volume decreases. If no automatic control is planned, the motor output – despite reduced volumetric capacity – remains the same or increase slightly.
With automatic control, the change in volume flow is measured using pressure filters as an absolute value or as differential pressure to the environment. Maintaining this pressure over the air handling unit at a constant level significantly reduces electricity use (Fig. 12: Curve).

Savings are increased by installing the pressure sensor at the plant's "minus point" since this lowers plant pressure, fan speed and thus fan output even more.
The "minus point" for the plant is the point at which a minimum pressure differential is required to supply the consumer(s) with the necessary air volume.

The "AirOptiControl" function controls fan pressure based on the VAV damper positions, permitting a return to the vicinity of the plant characteristic curve (Fig.12) and thus further reducing power consumption.

Power consumption can also be reduced using multi-stage fan control. The air volume flow cannot however be as precisely adapted to demand as is the case for modulating control.

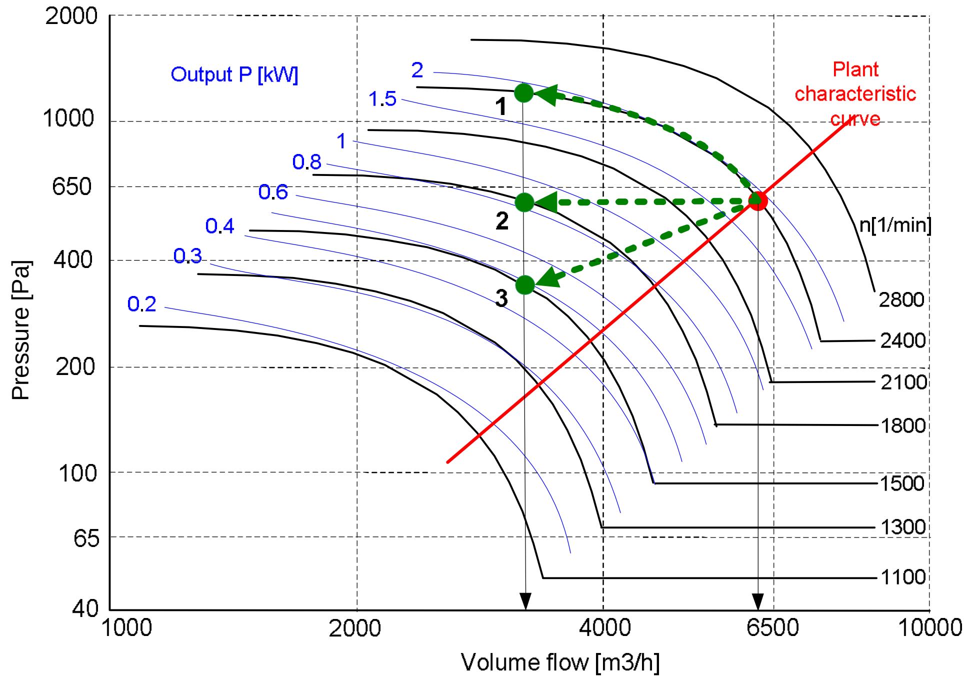


Fig. 12 Fan and plant characteristic curve featuring various control variants

BAC efficiency class as per EN 15232

Scheduled on/off control:	Enables class C
Multi-stage control:	Enables class B
Automatic pressure control:	Enables class A

Prerequisites

The function can only be used in air systems where the air volume is variable during operation.

Product range

Synco, Desigo

3.10.2 Heat recovery control with icing protection on the extract air side

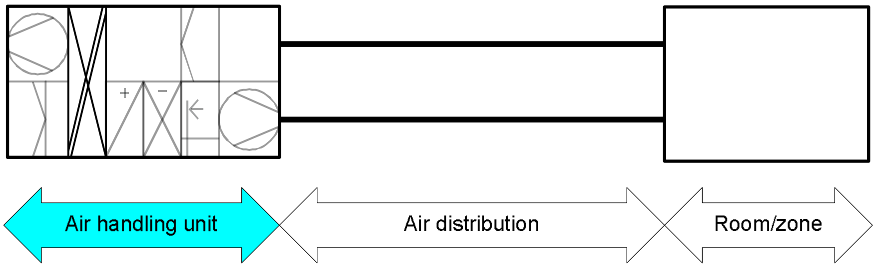
Target

The function is intended to
- Keep humidity in the extract air at the heat exchanger from **not** freezing at lower outside air temperatures, filling the air spaces with ice. The pressure loss increases with icing and the output of the extract air fan is increased to ensure air volume flow to the room.

Use

The function should be used in plants where hot extract air is transferred to outside air from the rooms via a heat exchanger when dropping below the frost limits:
- Air handling plants with:
  - Plate exchangers
  - Rotary heat exchanger
  - Coil heat exchanger

Effect



Principle of operation

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The use of a heat exchanger can result in significant savings in ventilation and air conditioning plants.
Water is separated on the heat recovery surface when the dew point is breeched if the energy from the warm and humid extract air is outputted to the colder outside air to preheat the supply air.
Ice begins to form as of a surface temperature of 0 °C.

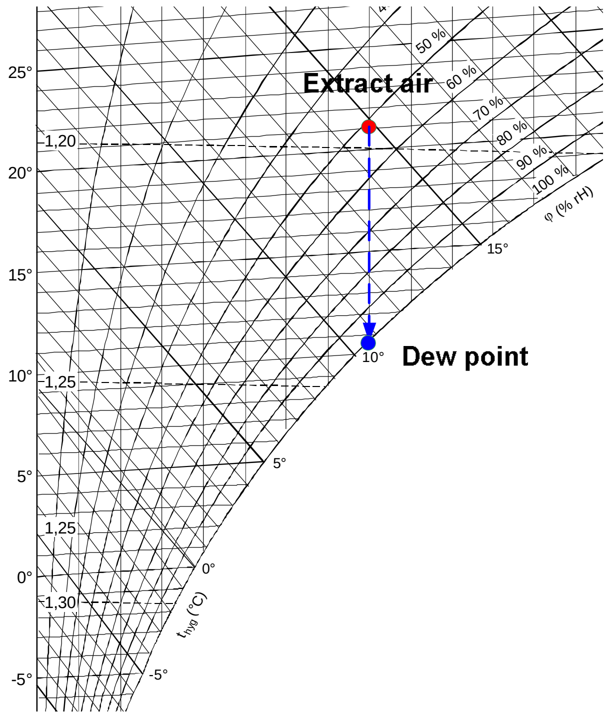


Fig. 13 h-x diagram for air

To prevent the ice from forming, a control circuit ensures that the temperature exiting the heat exchanger as exhaust air, is high enough high to prevent the formation of frost.

The control circuit takes over the actual value from the measurement of the exhaust air temperature, compares it to the setpoint and outputs the manipulated variable as follows, depending no heat recovery unit:
- Plate exchanger: Adjust bypass damper
- Rotary exchanger: Influence the speed
- Coil heat exchangers: Control value in the circuit

The function reduces energy use. It lowers…
- Consumption of electricity by preventing unnecessary pressure loss that increases fan output,
- The consumption of thermal energy, since no icing occurs on the heat recovery surface.

BAC efficiency class as per EN 15232

Enables class A

Prerequisites

The function only makes sense for installed heat recovery systems where the frost limits are breeched.

Product range

Synco, Desigo

3.10.3 Overheating control for heat recovery

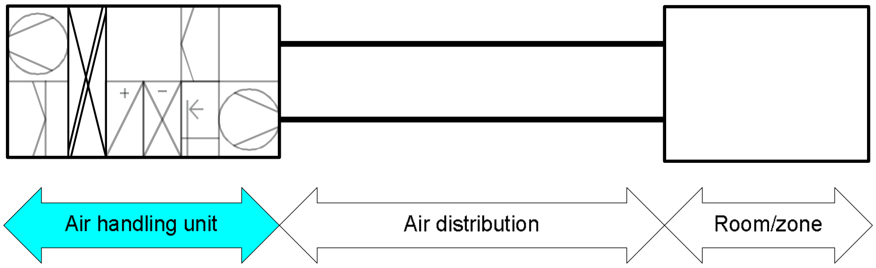
Target

The function is intended to
- The transfer output for heat recovery is reduced if the supply air setpoint cannot be achieved in this sequence.

Use

The function should be used in plants with heat recovery, where there is a risk of overheating caused by the transference of all the heat recovery output to the supply air flow:
- Air handling plants with:
  - Plate exchangers
  - Rotary heat exchanger
  - Coil heat exchanger

Effect



Principle of operation

The use of a heat exchanger can result in significant savings in ventilation and air conditioning plants.
Heat recovery installed without overheating control can overheat at full transfer output of the supply air volume flow. This can be prevented by integrating the heat exchanger in the supply air sequence control. The heat recovery forms the first sequence (see Sec. 3.10.7) to achieve the demanded supply air temperature setpoint. The control circuit reduces the transfer output for heat recovery if the necessary supply air temperature is achieved at a manipulated variable of 100% to prevent overheating of the supply air temperature. As a result, the temperature sequence control prevents unnecessary recooling of the supply air.

The function reduces energy use. It lowers
- Consumption of thermal energy since no unnecessary recooling occurs.

BAC efficiency class as per EN 15232

Enables class A

Prerequisites

The function should be integrated in the control sequence for installed heat recovery systems.

Product range

Synco, Desigo

3.10.4 Control for free machine cooling

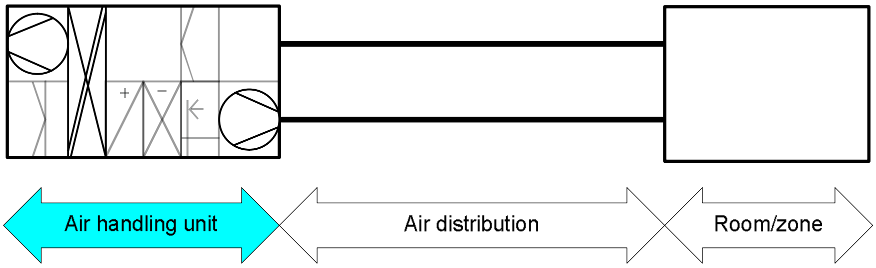
Target

The function is intended to
- Take advantage of passive energy, reducing the ratio of active energy.

Use

The function can be used in plants without a cooler to take advantage of passive cooling. In plants with active cooling, this function help reduce the expense for cooling energy as much as possible.

Effect



Principle of operation

With the **night cooling** function, at night, heat stored in the building mass is cooled to the lower limit of the comfort field using cooler outside air.
The amount of outside air is set to the highest value when the room is not occupied, provided that 1) the room temperature is above the setpoint for the comfort periods and 2) the difference between the room temperature and outside air temperature is above a specified limit value. The free nighttime cooling is primarily achieved by running the extract air fan. The entering of cooler outside air can take place via the supply air duct network, by automatically opening windows or planned inlets.

Free cooling reduces energy demand on active cooling of supply air. The amount of outside air and the recirculating air or energy transferred by heat recovery, is modulated throughout the entire period to keep the scope of machine cooling as low as possible. Control is based on temperatures or additionally by including humidity via enthalpy.
You can reduce the extract air temperature and optimize cooling effect by installing air humidifiers (water evaporators) in the extract air.

Maximum Economy changeover (MECH):
Heat recovery is opened as long as the exhaust air temperature or enthalpy is lower than the outside air.

Generation of chilled water with outside air:
(from cooling towers, circumventing the cooling machine via the cooling coils to supply air)
Outside air has priority to the extent the outside air temperature suffices for cooling.

h,x control reduces energy demand even more for active cooling of the supply air compared to free cooling since energy gains are increased by additional exchange of humidity (enthalpy). The amount of outside air volume flow and the recirculating air or energy transferred by energy recovery, is modulated throughout the entire period to keep the scope of machine cooling as low as possible.
The function reduces energy use. It lowers…
- For night cooling, the use of active cooling energy during the day, if fan load is minimized,
- For free cooling, for daytime operation as well, the use of active cooling energy that takes advantage of energy recovery from the extract air.

BAC efficiency class as per EN 15232	Night cooling mode: Free cooling: h,x control	Enables class C Enables class B Enables class A

Prerequisites

For night cooling, cool outside air must get to the room at low air resistance to minimize energy consumption for the fan.

Product range

Synco, Desigo

3.10.5 Supply air temperature control

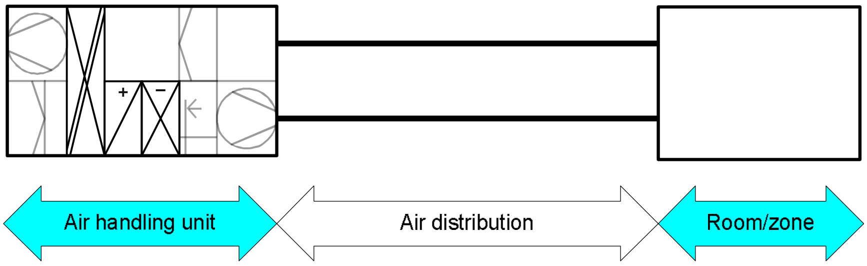
Target

This function handles the supply air for rooms or building zones so that…
- The room temperatures in the impacted areas are within the comfort range, or
- Comfort criteria can be guarantee through retreatment (heating/cooling).

Use

The function can be used where ventilation plants are primarily used to renew the air:
- For kitchens, restaurants or gyms
- For rooms with base load heating controlled by room temperature
- For rooms with controllable reheaters, recoolers, or fan coils

Effect



Principle of operation

The supply air temperature is transported to the air handling unit with the available given elements in a sequence control to the demanded setpoint. They can be influenced as follows:
- The setpoint is constant and is changed by hand.
  Supply air temperature output is supplied to the rooms or provided to air aftertreatment. The temperature is changed manually as needed, but then often not reduced to proper levels.
- The setpoint is a simple function of outside air temperature.
  Supply air temperature is outside temperature-dependent (as per probable demand of individual rooms). The individual load for all individual rooms is not, however, included. As a result, there is no way to influence how many individual room temperature controllers reheat in the summer or recool in the winter.
- The setpoint is defined as a function of the loads in the room.
  For individual room plants, load-based control of the supply air temperature can be implemented using cascade control.
  For a multi-room plant with room automation and control, the supply air temperature is supplied by the largest individual load of all individual rooms. This reduces the number of individual room temperature controllers that reheat in the summer or recool in the winter.
  The setpoint for the room temperature cannot be guaranteed for a multi-room plant without aftertreatment controlled by room automation. Setpoint compensation based on a selection (max./min.) from multiple rooms also results in unsatisfactory results

Cascade control consists of a lead and sequential control circuit.
The lead controller uses the room sensor to measure the temperature. For a setpoint deviation, the room temperature, the lead controller adjusts the setpoint for the supply air temperature accordingly by this control difference and the set cascade influence. The sequential controller measures the supply air temperature, compares it with the new setpoint and adjusts the heating or cooling valve position until the demanded supply air temperature is achieved.

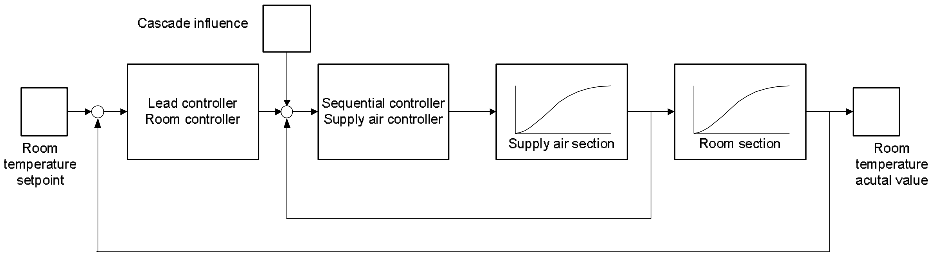


Fig. 14 Diagram cascade control

The function reduces energy use. It lowers

- Thermal energy use for heat and cooling, since control deviation is very small thanks to precise control of internal loads in the room.

BAC efficiency class as per EN 15232	Constant setpoint:	Enables class C
	Variable setpoint modification independent of Outside air temperature:	Enables class B
	Variable setpoint with modification based on load:	Enables class A

Prerequisites

For a single-room plant, cascade control (room/extract) provides solid control results. For multi-room plant, you must ensure that the individual rooms are independent of one another, that control different internal loads and thus able to guarantee the room setpoint.

Product range

Synco, Desigo

3.10.6 Supply air humidity control

Target

The goal of this function is to process the air for air conditioned rooms independent of the state of outside air and the processes in the room, so that…

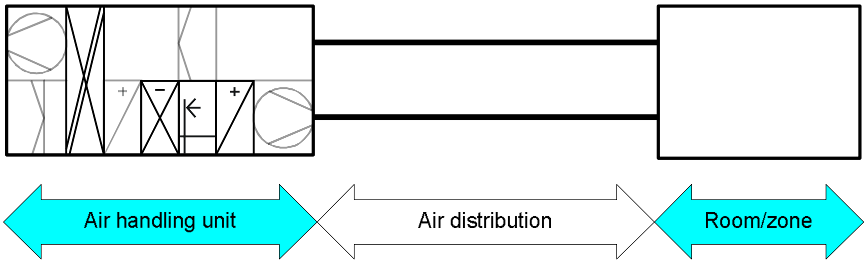
- Relative humidity remains constant or within preset limits and energy expense is minimized for humidification and dehumidification.

Use

The function can be employed as follows:

- Indirect humidity control via the dew point temperature for the desired room air state or via the water vapor content of the supply air
- Direct humidity control using a relative humidity sensor in room in question

Effect



Principle of operation

An air washer with humidification efficiency of at least 95%, i.e. practically achieving saturation of the out flowing air, is required for dew point control. The water vapor content of the temperature is fixed if used to control nearly saturated air. The dew point temperature controller with dew point temperature sensor by humidifier ensures that the setpoint of the dew point temperature is maintained at the various air states. The preheating or cooling valve is operated for a deviation of the dew point temperature from the entered setpoint. An additional control circuit is required to achieve the desired room temperature and relative room humidity that once again controls to the required inlet temperature via the reheating valve and cooled air.

The direct, modulating controllable humidification maintains a constant relative room humidity (and room temperature) at any outside air state, for setpoint compensation of the room temperature, for interior sources of heat, for extraneous humidity in the room or loss of humidity.

If an air conditioning plant is supposed to maintain room temperature and relative room humidity as precisely as possible, this is only possible through the use of one temperature and humidity control circuit each in the room (or in the extract air) to be air conditioned. The positioning signals for the room temperature controller act in sequence on the heating and cooling valve and the humidification valve for the humidity controller. Local priority control between the room temperature and the humidity controller output acts on the valve to dehumidify.
The cooling coils have a double function of cooling and dehumidifying. Which is why they must be placed prior the reheater and dehumidifier. Depending on operating state, it must be capable of cooling, humidifying or dehumidifying, and reheated.

The following humidifiers are primarily used to humidify:

- Controllable air washer
- Controllable steam humidification

Both offer the opportunity to control humidity by absolute or relative humidity.

The function reduces energy use. It lowers…

- Cooling energy consumption for direct humidity control and prevents unneeded operating states since it is only cooled as much as needed,
- Energy consumption for direct humidity control compared to dew point control massively, since it is only cooled, humidified and reheated when necessary.

BAC efficiency class as per EN 15232	Dew point control:	Enables class C
	Direct humidity control:	Enables class A

Prerequisites

- Dew point control should no longer used in general since it requires additional energy.
- For mist humidification, the efficiency can be considerably lower as the level of efficiency for a dew point air washer. It is important, however, that the humidifier be controlled within a sufficiently large output range

Product range

Synco, Desigo

3.10.7 Sequence control for temperature, humidity

Target

The goal of this function is to process the air for air conditioned rooms independent of the state of outside air and including the processes in the room, so that…

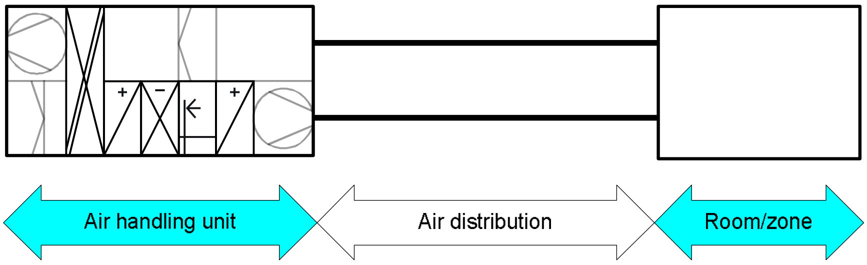
- Energy expense is minimized for air handling for heating and cooling as well as humidification and dehumidification.

Use

The function can be employed as follows:

- Preheating control
- Supply air temperature control
- Humidification control (humidification/dehumidification)

Effect



Principle of operation

The sequence is a "series" of various controllers with the goal of higher control accuracy at minimized energy consumption.
A control sequence is composed of various elements depending on the control tasks to be resolved. Sequence control ensures that a follow-on controller is only switched when the prior controller has provided its maximum output.
Heating and cooling sequences are separated by a neutral zone. The greater the range between the heating and cooling setpoints, the lower the energy demand for the HVAC plant.
Sequence controls can be used to control temperature, humidity, and combinations thereof.

In the example below, the supply air temperature for a ventilation plant is controlled in the heating sequence using the elements heat recovery (Y1), reheater (Y4) and preheater (Y2) and the cooling sequence with the cooler (Y3).
The heat recovery unit can be used in dependency of the temperature or enthalpy difference between outside air and extract both as cooling (Y1 dotted line) as well as heating element.

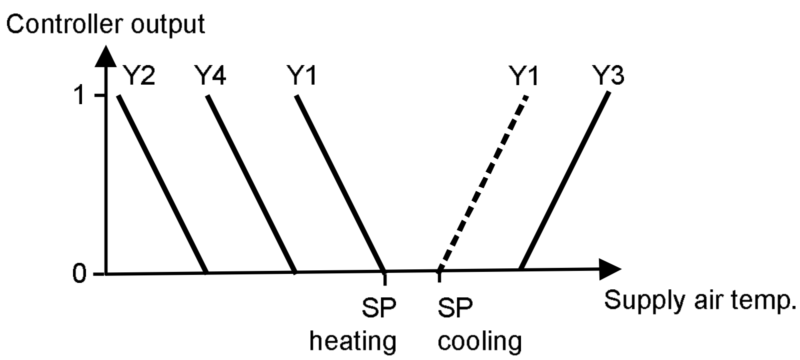


Fig. 15 Function diagram sequence control supply air temperature

The function reduces energy use. It lowers…
- Heating energy consumption,
- Cooling energy consumption,
- Energy consumption for the production of humidity.

BAC efficiency class as per EN 15232	Not explicitly mentioned.
Prerequisites	You should integrate the controllers in a sequence if more than one controller is used to control a variable (temperature or humidity). Energy-optimized operation is not guaranteed when used as individual controllers.
Product range	Synco, Desigo

3.10.8 Air quality control

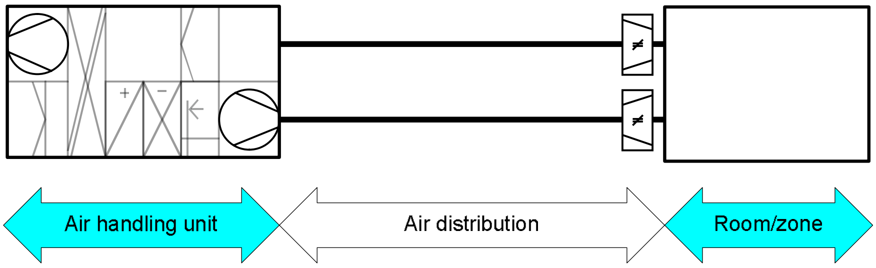
Target

The function is intended to
- Control the air handling plant according to room air quality to improve comfort and minimize energy consumption
  A reduction in air volume flow reduces energy consumption for air handling and distribution. This achieves energy savings for heating and cooling and electricity consumption is lowered.

Use

The function can be used in plants where air volume can be reduced due to changing personnel occupancy:
- Single-room plants for lecture halls, restaurants, convention halls, conference rooms, theaters, cinemas, shopping malls, etc.
- Variable air volume (VAV) systems:
  Modulating control alters the air volume based on "demand"

Effect



Principle of operation

The air quality sensor determines room air quality. Sensors available to this end include CO_2 and/or VOC* sensors. The CO_2 content of the room can be a good indicator for the room air load caused by humans as long as there is no smoking or other sources of contamination. The VOC measurement should be used if smells such as tobacco smoke or fumes from materials (furniture, carpets, paint, etc.) or other smells exist. Both values should be measured if neither the one or the other source dominates. This sensor records the CO_2/VOC concentration, evaluates it internally and processes this into a ventilation demand signal. This is the result of a maximum selection from the CO_2 measurement and the filtered VOC sensing signals. Room air quality is influenced by demand-control transport of outside air.

Differing control strategies can be used depending on how the air handling unit is equipped. These are:

a) Plants with 2-stage fans and direct mixing with recirculating air:
   The outside air damper opens continuously from a minimum position if air quality deteriorates. The 2nd fan stage is switched on only after the air damper is fully opened. The ratio of outside air should be limited on the upside for low outside air temperatures
b) Outside air plant heat recovery and 2-stage fans:
   Switches from the 1st to the 2nd fan stage if the air quality deteriorates.
c) Outside air plant heat recovery and speed-controlled fans:
   Fan speed is increased if the air quality deteriorates.

Compared to control strategy "c", strategies "a" and "b" on the second fan stage, generally transports more air than would otherwise be required to maintain good air quality. As a result, for these strategies, thermal energy consumption for heating and cooling as well as consumption of electrical energy for drive output of the fan motor is higher. For control strategy "c", the air volume can be continuously adapted to the demanded air quality.

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* volatile organic compounds

The function reduces energy use. It lowers…

- Electricity consumption to transport air,
- Heating energy consumption,
- Cooling energy consumption,
- Humidification and dehumidification energy consumption.

BAC efficiency class as per EN 15232	Demand-dependent control:	Enables class A
Prerequisites	The function can only be used in air systems where the air volume can be changed while operating based on changing personnel occupancy.	
Product range	Synco, Desigo	

3.10.9 Air filter monitoring

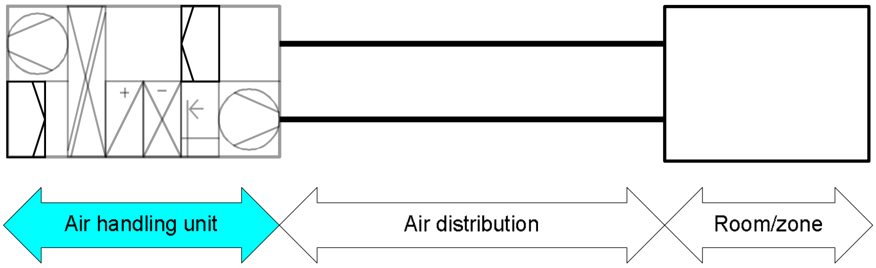
Target

The function is intended to
- Avoid consumption of unneeded energy for increased contamination,
- Monitor the air filter so that room air quality remains clean, parts of plants are protected, and the duct network is less dirty.

Use

The function can be used for all types of air handling plants.
- In CAV plants, a filter detector displays a maintenance message
- In VAV plants, using a differential pressure sensor dependent on the volume flow for contamination

Effect



Principle of operation

Various monitoring strategies should be used depending on whether the plant is operated using constant or variable air volume. These are:

a) Filter detector for constant air volume (CAV):
The pressure differential increases at constant volume flow as the filter contamination increases and forms a measure for determining the degree of contamination. A filter detector can monitor this. On a multi-stage plant, the fan must be operated at the highest stage at least once a week for the function to operate correctly

b) Pressure differential sensor with adaption to air volume (VAV):
In plants with variable air volume, the air volume control maintains a constant level of air volume by increasing the fan speed as the filter becomes increasingly contaminated. So that the plant is operating at a speed that is too high when the filter is contaminated and consumes too much energy. The degree of contamination should be measured using a differential pressure filter to maintain effective filter monitoring at reduced volume flow. The limit setpoint must be controlled based on the volume flow or air velocity (see law of proportionality [3]).

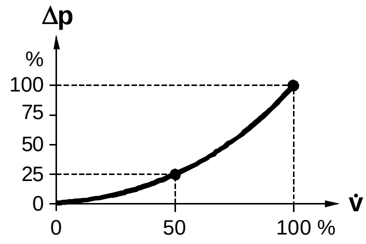


Fig. 16 Filter supervision at variable air volume using a differential pressure sensor

The function reduces energy use. It lowers
- Electricity consumption to transport air.

BAC efficiency class as per EN 15232

Not explicitly mentioned.

Product range

Synco, Desigo

3.10.10 Monitoring of energy recovery

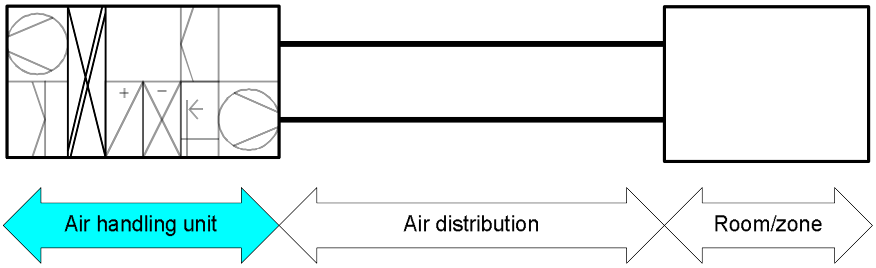
Target

The function is intended to
- Monitor the efficiency of energy recovery and generate a message when the adjustable limit value is breeched.

Use

The function can be used for all types of air handling plants that
- Have energy recovery with plate exchangers, rotary heat exchangers, or run around coil system.

Effect



Principle of operation

The effectiveness, or more correctly, heat recovery or humidity recovery ratio is used as a ratio of the actual achieved temperature or enthalpy change to the outside air for theoretical purposes. The designation degree of change or transfer is also common.
Measurements occur in the outside air and extract air after heat recovery in the supply air duct or, as an alternative, in the exhaust air duct. The function calculates with these input values the present degree of transfer of energy recovery. The calculated value is available after achieving a stable operating state.

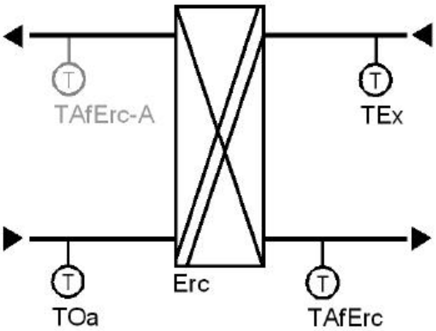


Fig. 17 Sequence diagram ERC

The lower limit value of the degree of transfer can be determined in consultation with the energy recovery system. An message is triggered if the limit value is breeched after an adjustable delay.

The function reduces energy use. It lowers
- Thermal loss for less than optimum, operating energy recovery.

BAC efficiency class as per EN 15232

Not explicitly mentioned.

Prerequisites

Air humidity must be measured in addition to the temperature to calculate the degree of enthalpy change.
For unequal air volumes (various air volumes in the supply and extract air) and for phase conversions (vaporization in the case of condensation) must use degree of change of enthalpy, as this would otherwise result in false results.

Product range

Synco, Desigo

3.10.11 H,x controlled economizer tx2

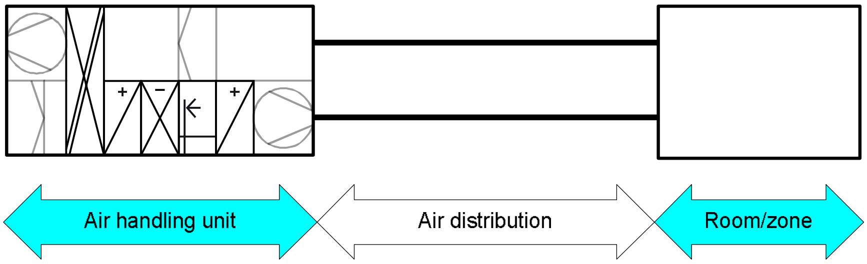
Target

The function is intended to
- Control air conditioning plants in an energy-optimized manner by conditioning the air supplied to the rooms using the most favorable type of energy. Siemens Economizer tx2 optimizes the room state within the setpoint field resulting in optimum setpoint specifications for the ventilation plant [6].

Use

The function can be used for air conditioning plants, whereby the following equipment is required:
- Plate heat exchanger, rotating ERC, or mixed air dampers
- Hot water heating coil
- Chilled water cooling coil
- Steam humidifier, washer, spray humidifier

Effect



Principle of operation

The Economizer tx2 corresponds to h,x-controlled temperature and humidity control. The tx2-strategy controls the heat recovery system so that the air handling process is cost-optimized considering predominant air states and specific energy costs of air handling aggregates. Daraus ergeben sich folgende Hauptfunktionen:
- Comfort area as a setpoint
- tx2 control
- Weighted processes
- ERC strategy

Comfort area as a setpoint:
Optimal working environment conditions exist not just at a specific setpoint for room temperature and room humidity, but within a particular range.
The greater the comfort area, the greater the energy savings potential.

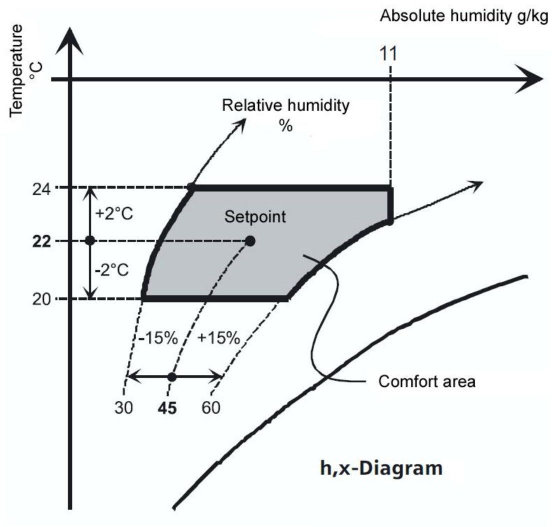


Fig. 18 Comfort area in the h,x diagram

tx2 control:
The comfort area determines the room air setpoint for temperature and humidity based on the present room air state and the defined comfort area. The comfort area is not actively controlled. The temperature and humidity controller are used as room air supply sequence cascade controllers. The reference controller calculates the reference variable for supply air from the room-side control deviation. The supply air controllers calculate the positioning signals for heating, cooling, humidification and dehumidification from supply air-side control deviations.

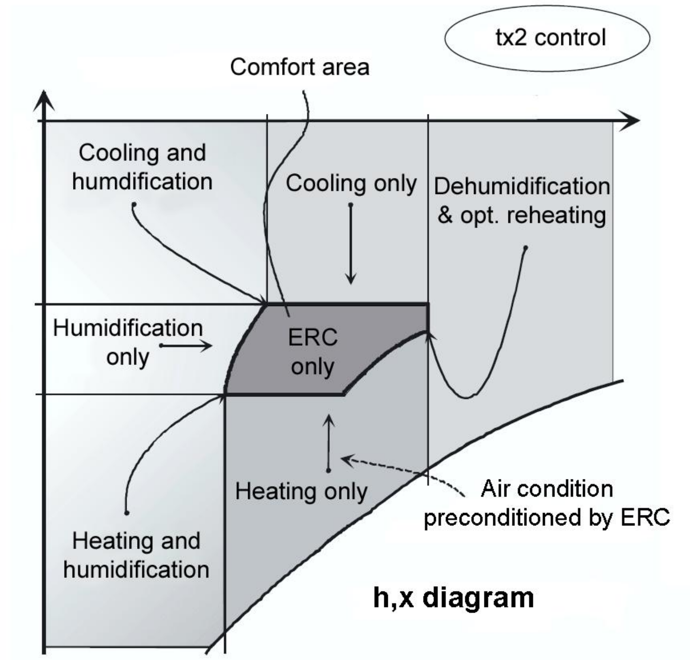


Fig. 19 Possible state changes in the h,x diagram for the comfort area

Weighted processes:
Relative weightings are used to optimize ERC. They result from the energy provisioning processes for heating, cooling, humidification, and dehumidification. The weighting factors can be used to optimize energy costs, energy consumption, CO_2 emissions and can be individually set for each plant.

ERC strategy:
The position signals are converted into demand signals for the ERC strategy and weighted. The tx2-algorithm then calculates the positioning signal for heat recovery from the weighted demand signals so that the mixed air or air state after ERC continues to be conditioned by the follow-on air handling aggregates at minimum energy expense and costs.
Energy recovery is controlled so that the sum of all weighted demand signals for heating, cooling, humidification, and dehumidification is minimized.

Comprehensive building simulations indicated that the Economizer tx2 can typically save between 5 and 10% of annual consumption compared to conventional air conditioning control. Savings of up to 40% are possible depending on room use and outside air conditions.

BAC efficiency class as per EN 15232	Not explicitly mentioned.
Product range	Desigo

3.10.12 AirOptiControl

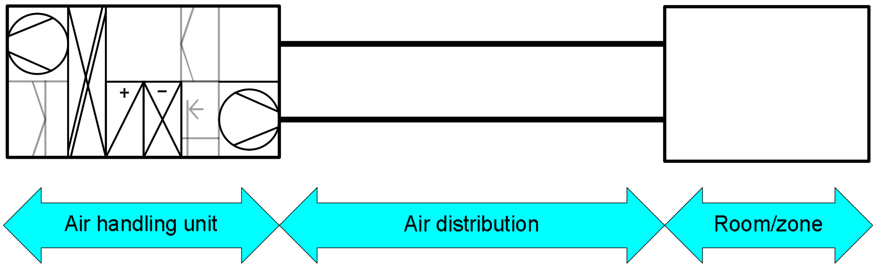
Target

The Siemens AirOptiControl function is intended to
- Optimize air volume flow, lower energy consumption and provide in this manner an excellent foundation for highly efficient operation of ventilation and air conditioning plants for rooms. At the same time, comfort control ensures that limit values are maintained for temperature, humidity and air quality. [7]

Use

The function can be employed in air handling units as follows:
- Variable room air volume flow in VAV systems,
- Air quality control and presence detection in the room,
- Variable speed controlled supply and extract air fans,
- Base load heating in the room with radiators.

Effect



Principle of operation

AirOptiControl minimizes the air volume flow required by the rooms to ventilation and air condition using the following coordination functions:
- Temperature coordination: Supply air temperature is controlled dependent on room temperature demand
- Air quality coordination: The recirculating dampers are controlled dependent on room air quality demand

And then supplies only air to the room if they where there is demand and optimizes the transportation energy required using the following coordination functions:
- Volume flow coordination: Controls speed of supply and extract air fans dependent on room air volume flow demand
- Energy efficiency control: The VAV dampers and plant are shut down when there is no volume flow demand

Demand-dependent control of fans, volume flow coordination
"Volume flow coordination" refers to the control of supply air and extract air fan speed dependent on air volume flow demand in the individual rooms. The fan speed is controlled in the function of the VAV damper positions or air volume flow control deviation so that at least one VAV damper is open as wide as possible. This destroys less pressure via the VAV dampers and keeps transportation energy to a minimum for the air volume flow as demanded by the room.

Energy efficiency control and energy efficiency optimization:
VAV dampers and air handling plant are switched on and off in an energy efficient manner dependent on room temperature, room humidity and room air quality. The VAV dampers in the room are closed when the room control variables temperature, air quality and optional humidity achieve the switch off setpoints within the applicable comfort setpoint range. The air handling unit is switched off if the VAV dampers are closed for all rooms. The plant is switched on again as soon as a room control variable violates the corresponding comfort setpoint range.

Energy efficiency optimization increases, available only for single-room plants, a plant's thermal output is increased to optimize operating time and thus lower drive

energy for the fan. Output from the air handling unit is optimized by influencing the room temperature setpoints and the outside air portion. There are three optimization types available maximum heating, maximum cooling and maximum air renewal.
While operating, the system attempts to achieve the comfort setpoint range more quickly and reduce fan runtime even more by using increased thermal output or increased outside air portion.

Demand-controlled control of mixed air dampers, air quality coordination:
Um diese Funktion zu nutzen, muss die Luftbehandlungsanlage mit Mischluftklappen zur Umluftbemischung ausgerüstet sein.
"Air quality coordination" refers to control of the outside air portion dependent on room air quality demand in the individual rooms. The mixed air dampers are controlled in the function of control deviation to room air quality so that the outside air portion is increased for air quality demand in the room. This keeps air volume flow demand to a minimum in the rooms.

Demand-dependent control of supply air temperature, temperature coordination:
"Temperature coordination" refers to control of the supply air temperature dependent on room air quality demand in the individual rooms. The supply air temperature is controlled in the function of control deviation of room temperature so that the supply air temperature is increased or lowered for temperature demand in the room before the air volume flow must be increased in the room to maintain the temperature. This keeps air volume flow demand to a minimum in the rooms.

Radiator control and demand-dependent control of heating group:
Radiator control in the room is an integral part of the AirOptiControl application to integrate room temperature control and coordination with the heating group. At first glance, this seems irrelevant, but in practice, the radiators are often controlled autonomously to room demand without coordination with the heating group.

Comprehensive trials on real plants under lab conditions and building simulations consistently indicate energy savings in the neighborhood of 50 %.
Detailed results are described in the application data sheet [7].

The function reduces energy use. It lowers…
- Electricity consumption to transport air,
- Heating energy consumption,
- Cooling energy consumption,
- Humidification and dehumidification energy consumption.

BAC efficiency class as per EN 15232	Exceeds class A.
Product range	Desigo

Index

Sources and index of figures

Source index

[1] European Standard 15232:2012; Energy performance of buildings – Impact of Building Automation, Controls and Building Management

[2] Building automation – impact on energy energy efficiency
Application per EN 15232:2012, eu.bac product certification;
Brochure – Siemens Building Technologies; Order-no.: 0-92189-en

[3] Introduction to building technology
Brochure – Siemens Building Technologies; Order-no.: 0-91916-en

[4] Control of ventilation and air-conditioning plants;
Brochure – Siemens Building Technologies; Order-no.:0-91912-en

[5] Demand-controlled ventilation - Control strategy and application for energy-efficient operation
Brochure – Siemens Building Technologies; Order-no.:0-91966-en

[6] h,x-controlled economiser tx2; Application data sheet – Siemens Building Technologies Order-no.:CM110745en-TX2

[7] Energy efficient application AirOptiControl; Application data sheet – Siemens Building Technologies Order-no.:CM110745en

Index of figures

Abbreviations and terms

BACS	Building Automation and Controls System
CAV	Constant air volume systems
Desigo	Siemens Building automation system For large and complex buildings
EE	Energy Efficiency
EN 15232	European standard „Energy Efficiency in Buildings – Influence of Building Automation and Control and Building Management“
ERC	Energy recovery
Fan coil	Fan coil with 2- or 4-pipe system for heating and cooling
HVAC	Heating, ventilation and air conditioning
h,x-diagram	Mollier h,x-diagram for determination of air-condition-changes
LEED	Leadership in Energy and Environmental Design Certification system for sustainable buildings
Synco	Siemens Building automation system For larger buildings and basic to advanced tasks
TABS	Thermally-activated building systems
TBM	Technical Building Management System
VAV	Variable air volume systems as one-room plant with variable air volume or as multi-room plant with VAV-boxes
VRF	Variable Refrigerant Flow
VOC	Volatile organic compounds

More technical brochures

Energy efficiency in building automation

0-92189-en	Application per EN 15232:2012
BT_0002_EN	Applications guide for heating and cooling supply

HCAV basics

Order no.	Title
0-91899-en	The psychrometric chart
0-91910-en	Measuring technology
0-91911-en	Control of heating plants
0-91912-en	Control of ventilation and air conditioning plants
0-91913-en	Control technology
0-91914-en	Cooling technology
0-91915-en	Heat recovery in the cooling
0-91917-en	Hydraulics in building systems
0-91918-en	Modulating capacity control in the cooling cycle
0-92166-en	Demand-controlled ventilation

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