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Building Automation – Impact on energy efficiency

Application of EN 15232-1:2017

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1 Introduction

Target groups

This User’s Guide by Siemens Building Technologies (Siemens BT) is targeted at all participants in the planning phases for buidlings and, in particular, building automation and control.

1.1. Use, targets and benefits

The User’s Guide was written for building automation and control engineering and sales activities for both new and existing buildings.

European standard EN 15232-1:2017 on "Energy efficiency in buildings – Influence of Building Automation and Control and Building Management" and eu.bac (European Building Automation Controls Association) provide the basis for this work.

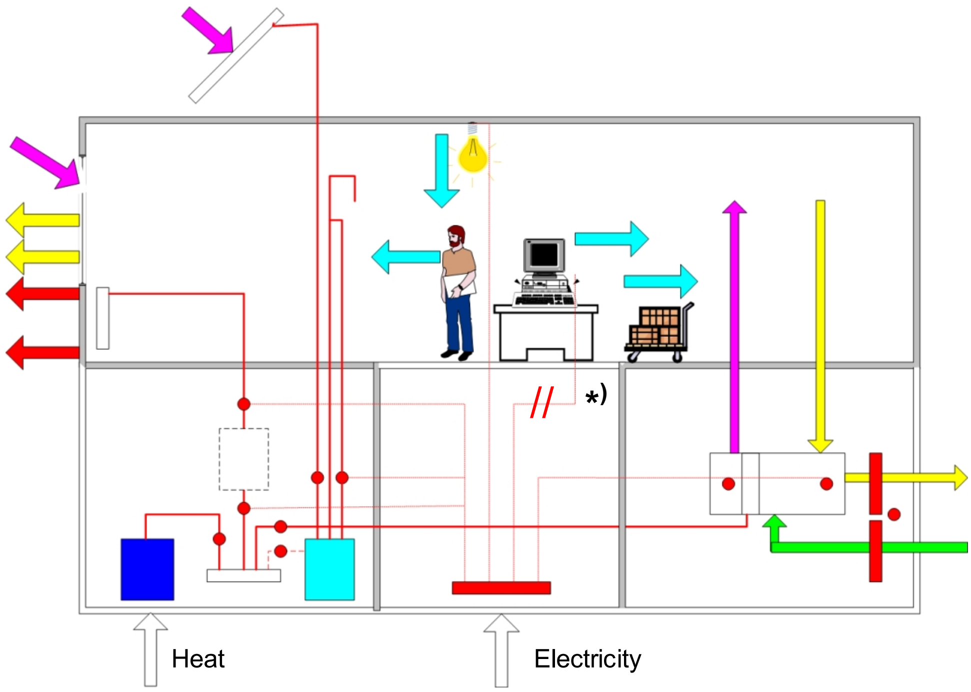
Building automation and control functions should be selected based on their impact on a building's efficiency. The purpose of the User’s Guide is to provide understanding on using building automation and control functions to promote higher energy efficiency in buildings as well as the methods involved. It further explains which building automation and control system functions by Siemens meet the requirements as per EN 15232.

The use of energy-efficient building automation and control functions saves building operating costs, preserves energy resources and lowers CO_2 emissions.

1.2. What constitutes energy efficiency?

The ratio of energy input to the calculated or estimated amounts of energy required to cover the various requirements relating to the standardized use of a building serves as the measure of energy efficiency. According to EU Directive "Energy Performance of Building Directive" (EPBD), the following thermal and electrical forms of energy are considered when determining the energy efficiency of a building:

- Heating
- DHW (domestic hot water)
- Cooling
- Ventilation
- Lighting
- Auxiliary energy



Source image: Prof. Dr. Ing. Rainer Hirschberg, FH Aachen, Deutschland
Example: Building without cooling

*) Note
Equipment of building users, such as PCs, printers, machines (excluding building elevators), etc., are not part of the electrical energy needs of a building for our purposes. The heat gains do, however, influence a building's thermal energy needs.

Building energy efficiency

Thermal and electrical energy (in the example: ⇧Heat and ⇧Electricity) should be kept to a minimum to achieve a high degree of energy efficiency.

The energy efficiency value for an individual building is determined by comparing it to reference values. It could, for example, be documented in an energy pass for the building.

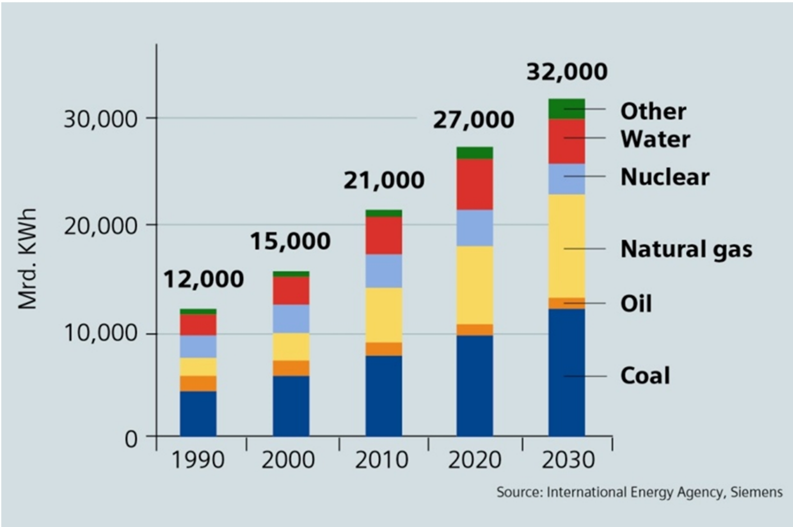
Executing regulations are assigned to the individual countries as per EN standard to determine the size of the reference values or how to calculate them.

2 Global situation: energy and climate

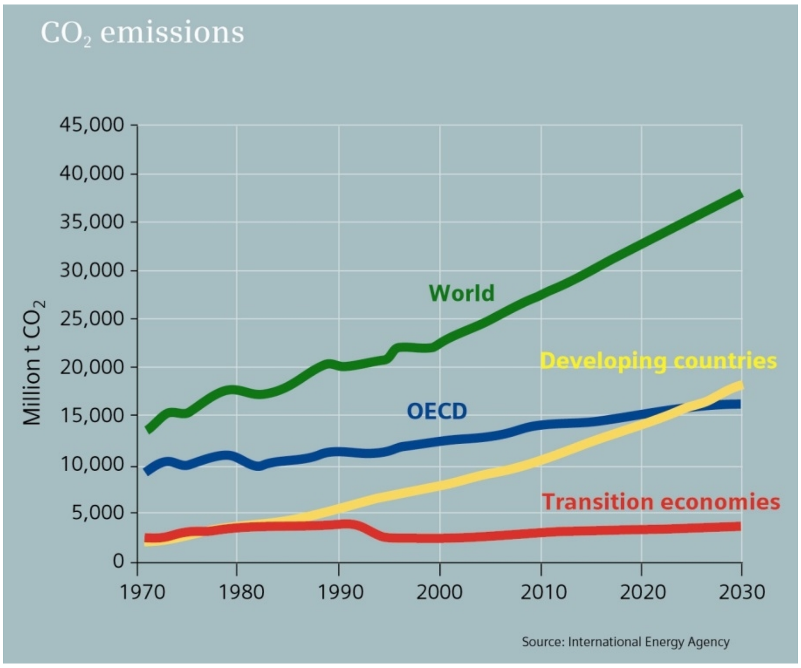
In this section, we discuss the global energy and climate situation as well as future perspectives on improving the situation.

2.1. CO_2-emissions and global climate

The global demand for energy has increased dramatically over the past decade and is likely to continue according to forecasts. Within the percentage of fossil fuels, oil is likely to stagnate or even decline in the future, while natural gas and coal are projected to increase significantly.



Global CO_2 emissions are developing in sync with the increased consumption of fossil fuels. They have strongly increased since 1970 and will continue to do so.



The impact of CO_2 emissions is already unmistakable: The average air temperature is continuously increasing over the long term; weather dynamics are increasing dramatically.

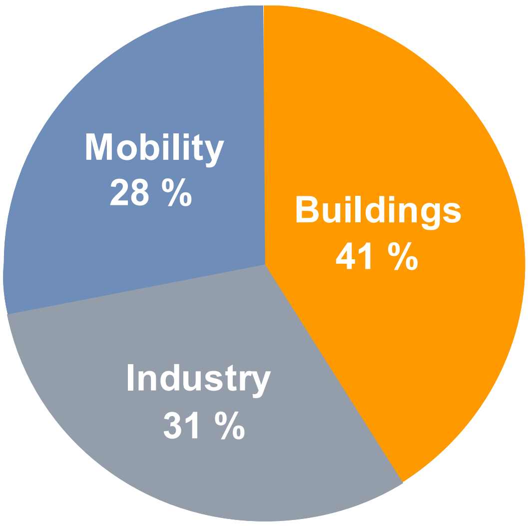
The consequences include an increase in storm winds and storms, damage to crops and forests, an increase in the sea level as well as mudslides, droughts and erosions – so for example, hurricane "Katrina" (New Orleans) or the continuously returning tornados in Oklahoma (USA):

Tornado in Oklahoma (Source: tagesschau.de)

The Climate Change Report 2007 by the United Nations is calling for global action.

2.2. Primary energy consumption in Europe

Buildings account for 41 % of primary energy consumption, of which 85 % is used for room heating and room cooling as well as 15 % for electrical energy (in particular for lighting).



2.3. Turning the tide – a long-term process

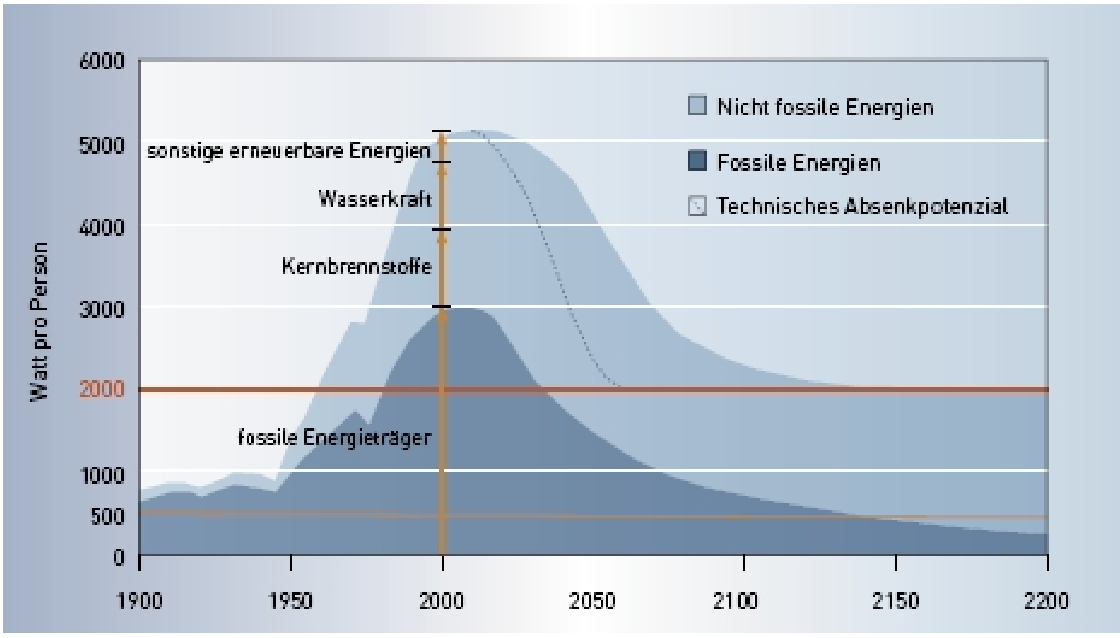
Europe has developed visions for a low-energy future and is intensely searching for ways to implement the visions:

Vision for the future

We want to find ways to continue enjoying our lives in reasonable comfort, but using less energy, and with fewer CO_2 and greenhouse emissions than today.

The scenario "Paths toward a 2,000 watt society" as part of Swiss energy policies pursues goals that are similar to current efforts at the EU level.

Statistics and vision "CO_2 in CH: The 2,000 watt society" published by "Novatlantis" illustrates that the path to a low-energy society is a long-term one.



Source: Novatlantis – Sustainability within the ETH

On the one hand, the chart illustrates the dramatic rise in energy use since the end of WWII (1945 through 2000). The short collapse in the increase is probably due to the oil crises (1973) and recession (1975). Nonetheless, the oil crises evidently did not change behavior.

Greenhouse gases roughly keep pace with the increase in fossil fuels – and as is well known, these have significantly increased too.

On the other hand, the right side of the chart outlines the vision for the future: The goal is a dramatic reduction in the consumption of fossil energy carriers as well as cutting overall energy usage to 2000 watts per person.

2.4. Reduce energy usage in buildings

Well-developed building construction standards are now available for low-energy houses that have proven themselves. The technology is ready to use – yet it is still going to take a number of decades before the technology is deployed throughout Europe.

New buildings

New buildings should only be built based on future-oriented low-energy standards and equipped with energy-saving building automation and control functions of BAC efficiency class A.

Current situation

Europe is developed – its building inventory cannot be transitioned to state-of-the-art energy-saving construction technology either in the short or medium-term. It is only possible over the long term with available construction capacity. And the required costs will certainly be enormous.

Some existing buildings cannot even be transitioned over the long term to state-of-the-art construction technology for cultural as well as historical reasons.

With regard to energy efficiency, we will still have to deal with a less-than-optimum building environment and do the best we can – for example, with the help of building automation and control.

Updating existing buildings

Various short-term measures can significantly improve the energy efficiency of existing building. Examples:

- Update using energy-saving building automation and control
- Position heating setpoint and cooling set at the far end of comfort levels
- Update mechanical ventilation with heat recovery
- Replace older boilers (often oversized, not very efficient)
- Lower the heat transmission losses on the building's exterior
- Replace existing windows
- Improve insulation of the rest of the exterior shell (walls, roof)
- Update older buildings to the "Minergie" standard for renovations
- etc.

Short term executable measures

You can achieve significant reductions in energy use and CO_2 emissions by further updating building automation and control functions in older and less energy-efficient buildings.

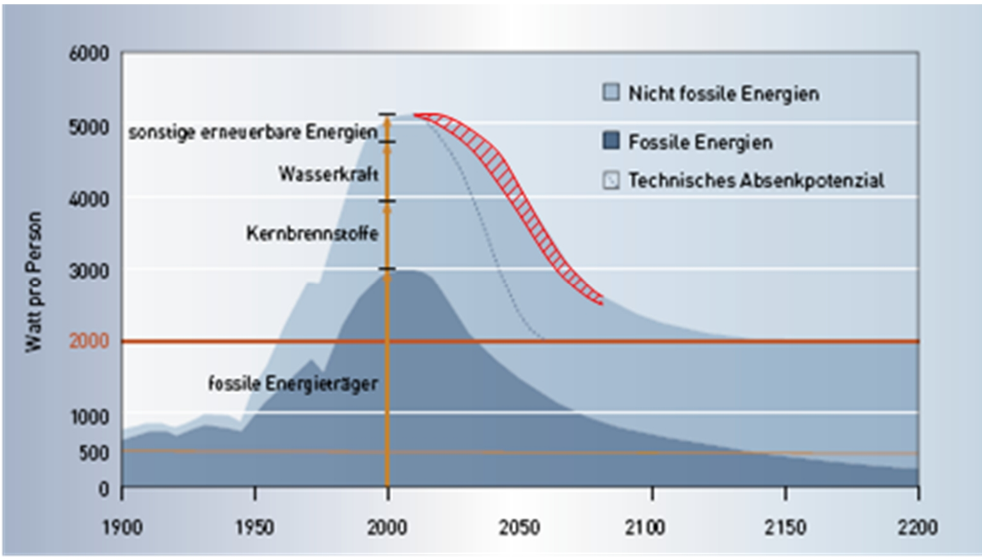
Goal of these measures

Existing buildings can be operated at significantly lower energy use after updating building automation and system functions that are optimally set and activated:

Cost savings from operational energy

Conserve the environment and existing energy resources

Guarantee reasonable comfort during occupancy



Source: Novatlantis – Sustainability within the ETH

Overall energy usage should be decreased by reducing the primary energy use for the building within the red intersecting region.

Energy saving potential with building automation and control

Building automation and control systems are the building’s brain. They integrate the information for all the building’s technology. They control the heating and cooling systems, ventilation and air conditioning plants, lighting, blinds as well as fire protection and security systems.

The building’s brain is thus the key for an effective check of energy use and all on-going operating costs.

Quote by Prof. Dr. Ing. Rainer Hirschberg, FH Aachen Germany

“Primary energy use for heat in buildings amounts to some 920 TWh (Terawatt hours) in Germany. Of which more than half (approx. 60%) comes from non-residential buildings where it makes sense to use building automation and control. A cautious estimate in business management (based on EN 15232) indicates that 20% can be saved by building automation and control, corresponding roughly to 110 TWh and a primary savings, extrapolated to overall consumption, of 12%, thus largely achieving the German government’s stated target by 2020.”

This finding certainly applies to a similar extent for other countries. Therefore the intelligent use of building automation and control can make a significant contribution to EU savings targets of 20% in 2020.

2.5. Siemens' contribution to energy savings

We are taking the initiative

Siemens feels an obligation to assist its customers in improving the energy efficiency of their buildings. As a consequence, Siemens is a member of a number of global initiatives.

An important part of the history of Siemens

Global achievements

- More than 100 years of experience with energy management systems and corresponding services
- Years of experience as an energy innovator – Siemens holds more than 6000 energy-related patents
- Implemented more than 2000 global energy projects since 1994
- Overall savings of ca. EUR 1.5 billion over a period of ten years
- CO_2 savings from all energy projects: Ca. 2.45 million tons of CO_2 annually
- 1,000,000 tons corresponds to 385,000 cars each driving 20,000 kilometers a year (at an average CO_2 emission of 130g/km)

eu.bac (European Building Automation and Controls Association) was established as the European platform representing the interest of home and building automation and control in the area of quality assurance. Siemens took the initiative and the members include renowned international manufacturers of products and systems in the home and building automation and control sector. These companies came together to document the control quality of their products through standardization, testing and certification. **Products and systems with eu.bac certification display a guaranteed state and quality assurance**.

Siemens is a partner of the GreenBuilding initiative by the European Commission, with a goal of implementing cost-effective, energy efficiency potential in buildings. As a signatory to this initiative, Siemens BT must ensure that its customers can achieve a minimum energy efficiency of at least 25% in their building infrastructures.

For some years Siemens has also been a member of LEED (Leadership in Energy and Environmental Design) – a US initiative similar to GreenBuildings. LEED continues as a recognized and respected certification, where independent third-parties certify that the building project in question is environmentally compatible and profitable and represents a healthy location for work and living.

Additional information can be found at the „U.S. Green Building Council ®" under: http://www.usgbc.org.

Headed by former US president Bill Clinton, the initiative cooperates with larger municipal governments and international companies to develop and implement various activities to reduce greenhouse gases. Specifically, the initiative informs large cities on measures available to optimize energy efficiency in buildings without loss of comfort for the residents and users. Here again, Siemens has taken the lead in conducting energy audits, building renovation and guaranteed savings from such projects.

German industry can make a number of contributions to climate protection and is therefore a problem solver. To underscore the German economy's commitment to climate protection, a number of leading business people came together under the auspices of the Association of German Industry on the initiative "Business for climate change"., With more than 40 companies (and Siemens being one of them), the initiative represents the entire spectrum and abilities of the productive economy in Germany.

In March 2017 the BDI has launched the initiative „Energy efficient buildings“ with a 10 point plan.

Point 4, „Efficiency-First-Approach and strengthening the focus on sustainability of the building energy efficiency“ focuses on building energy efficiency as an important part of the energy transition and for reaching the climate protection targets. As part of it, the life-cycle view on the building is strongly taken into account. Furthermore the quality insurance over the lifetime of the building with the help of automation, energy management systems and energy savings contracting are explicitly requested.

But above all, Siemens is concerned about making a contribution by providing various services to the customer so that we can solve the global problems of energy and climate. To this end, Siemens BT has prepared **comprehensive BAC and TBM functions** – **for new buildings** as well as **to update existing buildings**. In addition to that, Siemens BT even provides performance contracting.

3 Building automation and control system standards

This section discusses EU measures and goals with regard to energy and the environment, as well as the process and new standards intended to grasp and disarm the energy situation.

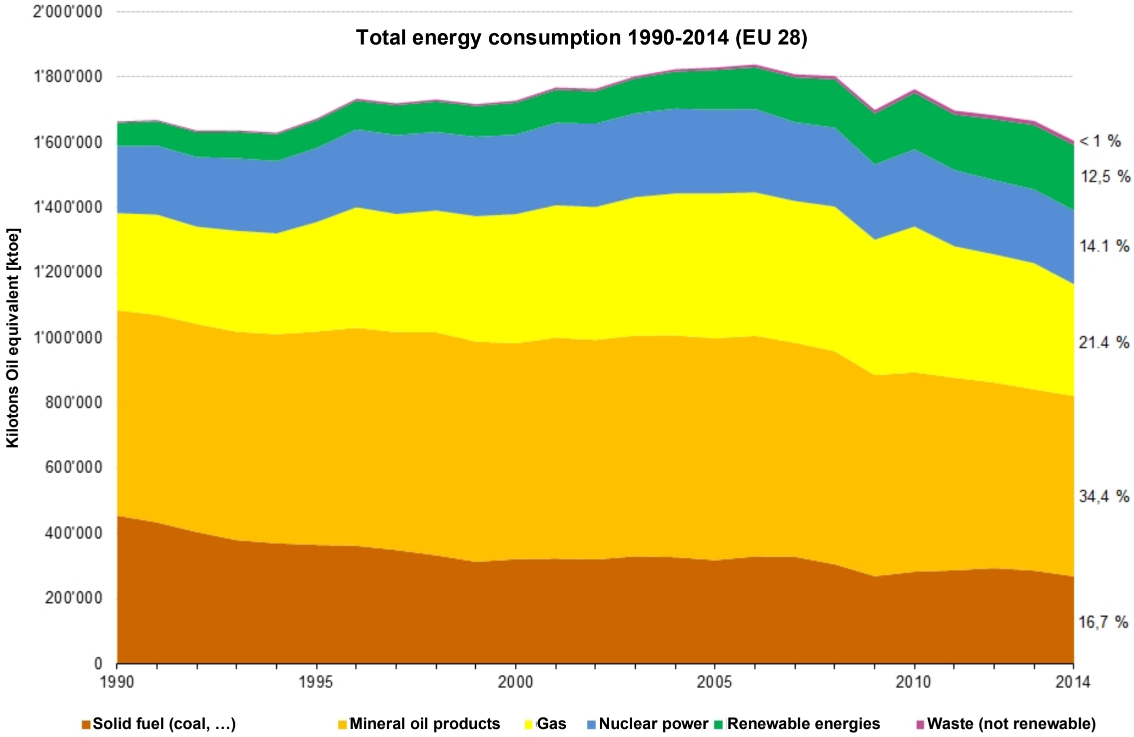
3.1. EU measures

Energy is a central concern of the EU

Dependency

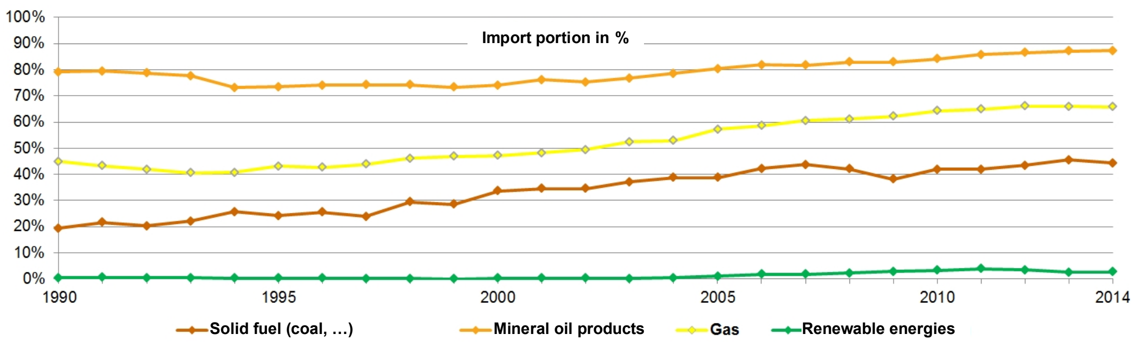
Without taking actions, dependency on foreign energy will climb to 70% by 2020/2030.

Example:



Total energy consumption Europe 1990 - 2014 EU-28 (Source: Eurostat 2016)

The percentage of renewable and non-renewable energy differs in other European countries, but the problem of dependency hardly varies at all.



Import portion in % for Europe 1990 - 2014 EU-28 (Source: Eurostat)

Environment

Energy production and consumption cause some 94% of CO_2 emissions.

Supply

Influence on energy supply is limited.

Price

Significant increase within a few short years, but subject to strong geopolitical changes.

Goal 2020: „20 20 20“

By 2020, the European Community (Commission energy and climate policy) wants to

- use 20% less energy versus the reference year of 1990
- emit 20% less greenhouse gases versus the reference year of 1990
- achieve 20% of overall energy consumption from renewable forms of energy

Accordingly to the „2015 Energy efficiency progress report“ of the EU the target is within reach. However the report mentions also, that additional efforts are required in the sectors buildings, transport and production to ensure that the goals can be really reached.

EU and domestic laws

EPBD   Energy Performance of Building Directive der EU

Motivation and content:

Increased energy efficiency constitutes an important part of the package of policies and measures needed to comply with the Kyoto Protocol and should appear in any policy package to meet further commitments, the EU issued a **Directive on Energy Performance of Buildings (EPBD)** in December 2002. Member states shall bring into force the laws, regulations and administrative provisions necessary to comply with this Directive at the latest on January 4, 2006.

"The objective of this Directive is to promote the improvement of the energy performance of buildings within the Community, taking into account outdoor climatic and local conditions, as well as indoor climate requirements and cost effectiveness.”

This Directive lays down requirements regarding:

(a) the general framework for a methodology of calculation of the integrated energy performance of buildings
(b) the application of minimum requirements on the energy performance of new buildings
(c) the application of minimum requirements on the energy performance of large existing buildings (> 1000 m^2) that are subject to major renovation
(d) Energy certification of buildings
(e) regular inspection of boilers and of air conditioning systems in buildings and in addition an assessment of the heating installation in which the boilers are more than 15 years old (Article 1 of EPBD)

Consequences of the EPBD

To meet the requirement for "methods to calculate the integrated overall energy efficiency of buildings" arising from the EPBD, the European Community tasked the **CEN (C**omité **E**uropéen de **N**ormalisation **–** European committee for standardization) to draft European Directives on the overall energy efficiency of buildings.

The **TC**s **(T**echnical **C**ommittee**)** at CEN developed various calculations and integrated them into an impressive number of European standards (**EN**)**.** The general relationships are described in the document prCEN / TR 15615 ("Declaration on the general relationship among various European standards and the EPBD – Umbrella document").This means that the impact of windows, building shell, technical building systems, and building automation functions can now be calculated.

The energy performance of a building is the amount of energy estimated or actually consumed to meet the different needs associated with a standardized use of the building, which may include:

- Heating EN 15316-1 and EN 15316-4
- Cooling EN 15243
- Domestic hot water EN 15316-3
- Ventilation EN 15241
- Lighting EN 15193
- Auxiliary energy

Initiative of the building automation industry

With regard to article 3 "Adoption of a methodology" the EPBD does not require any explicit methodology for building automation (refer to the Annex of the EPBD). For this reason, the building automation industry – with the specific support of Siemens experts applied to the appropriate EU and CEN committees to have building automation functions included in the calculation methodologies. In response, a standard for calculating the impact of building automation functions was drawn up by the CEN / TC247 (standardization of building automation and building management in residential and non-residential buildings) to supplement the standards for the building shell and the individual disciplines:

Building automation EN 15232

Title:
Energy performance of buildings -
Impact of Building Automation, Controls and Building Management

CEN / TC 247

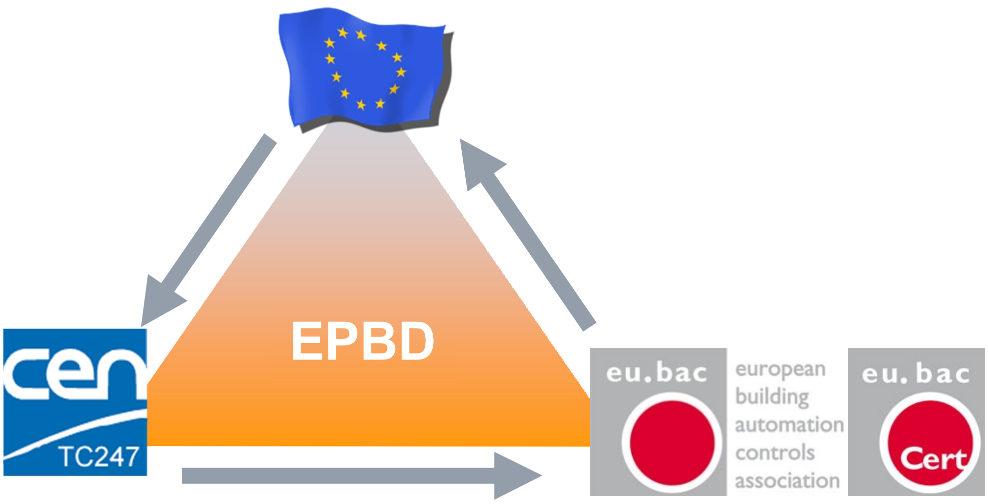
CEN / TC 247 develops European and international standards for building automation, controls and building management (BACS), for instance:

- Product standards for electronic control equipment in the field of HVAC applications (e.g. EN 15500)
  → Basis for product certification related to EPBD
- Standardization of BACS functions (EN ISO 16484-3)
  → Basis for the impact of BACS on energy efficiency
- Open data communication protocols for BACS (e.g. EN ISO 16484-5)
  → Prerequisite for integrated functions with BACS impact on energy efficiency
- Project specification and implementation (EN ISO 16484-1)
  → Prerequisite for project design and implementation and for the integration of other systems into the BACS
- Energy performance of BAC functions (EN 15232)
  Title: Energy performance of buildings – Impact of Building Automation, Controls and Building Management
  → Basis for the impact of BACS on the energy efficiency of buildings

Note:
BACS = Building Automation and Control System

Procedure

The EU mandated European CEN to standardize calculation methods to improve energy savings.



CEN - TC 247 prepared and approved

- **EN 15232** Impact of BACs functions on energy efficiency
- Product standards with energy performance criteria (e.g. EN 15500)

eu.bac prepared the certification procedure and test method and proposed this certification to the EU

CEN	European Committee for Standardization
EPBD	Energy Performance of Building Directive
eu.bac	european building automation and controls association
EN	European Norm
EU	European Union

3.2. The standard EN 15232

What is EN 15232?

A new European standard EN 15232: "Energy performance of buildings - Impact of Building Automation, Control and Building Management" is one of a set of CEN (Comité Européen de Normalisation, European Committee for Standardization) standards, which are developed within a standardization project sponsored by the EU. The aim of this project is to support the Directive of Energy Performance of Building (EPBD) to enhance energy performance of buildings in the member states of the EU. Standard EN 15232 specifies methods to assess the impact of Building Automation and Control System (BACS) and Technical Building Management (TBM) functions on the energy performance of buildings, and a method to define minimum requirements of these functions to be implemented in buildings of different complexities. Siemens Building Technologies was very much involved in the elaboration of this standard.

Building Automation and Control System (BACS) and Technical Building Management (TBM) have an impact on building energy performance from many aspects. BACS provides effective automation and control of heating, ventilation, cooling, hot water and lighting appliances etc., that increase operational and energy efficiencies. Complex and integrated energy saving functions and routines can be configured on the actual use of a building depending on real user needs to avoid unnecessary energy use and CO_2 emissions. Building Management (BM) especially TBM provides information for operation, maintenance and management of buildings especially for energy management – trending and alarming capabilities and detection of unnecessary energy use.

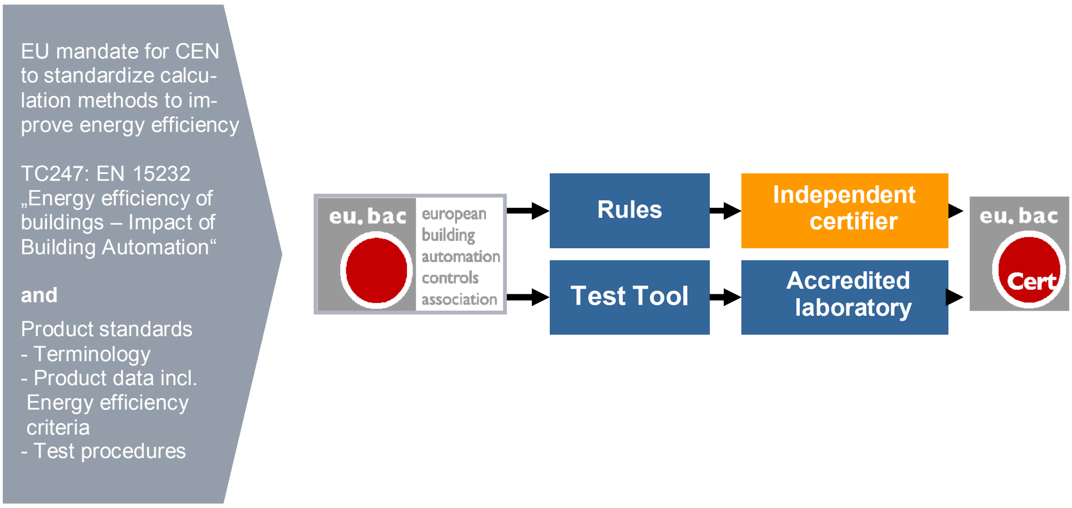
Content of EN 15232

Standard EN 15232: "Energy performance of buildings – Impact of Building Automation, Control and Building Management" provides guidance for taking BACS and TBM functions as far as possible into account in the relevant standards. This standard specifies

- a structured list of control, building automation and technical building management functions which have an impact on the energy performance of buildings
- a method to define minimum requirements regarding the control, building automation and technical building management functions to be implemented in buildings of different complexities,
- detailed methods to assess the impact of these functions on the energy performance of a given building. These methods enable to introduce the impact of these functions in the calculations of energy performance ratings and indicators calculated by the relevant standards,
- a simplified method to get a first estimation of the impact of these functions on the energy performance of typical buildings.

3.3. eu.bac Certification

eu.bac Cert is a joint venture of eu.bac and various European certification bodies and test laboratories in conformity with the relevant provisions of the EN 45000 set of standards.



eu.bac Cert guarantees users a high level of

- energy efficiency, and
- product and system quality

as defined in the corresponding EN/ISO standards and European Directives.

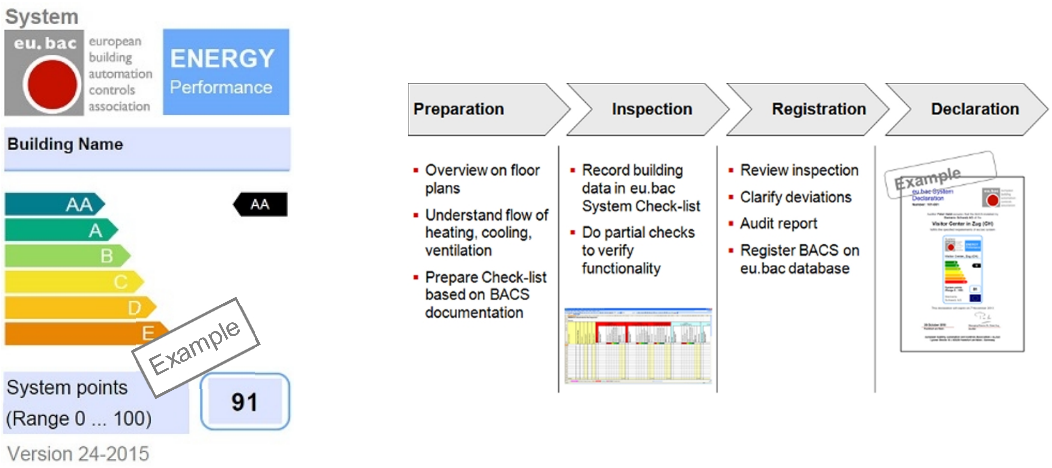
Some public organizations approve only eu.bac-certified products.

3.3.1. eu.bac System Certification

In addition to the product certification, eu.bac has developed and launched a systematic approach to assess and certify complete building automation system solutions in a building. This system certification is based on the EN 15232 classification of the building automation functions. In addition, this approach considers the distribution of the various technical building systems throughout the building and wheighs them accordingly.

Based on that an overall building automation classification is derived and labeled between F … AA. Furthermore areas of potential efficiency improvements are identified and can the be further pursued.

This eu.bac System Certification is carried out by certified auditors and a system assessment will be validated by a eu.bac control body, before the System Certificat is issued and the certified building gets added to a database of certified buildings.



eu.bac System Certificate example and process overview (Source: eubac.org)

3.4. Standardization benefits

Calculation standards

The EN 15232 standard clearly shows for the first time the huge potential energy savings that can be achieved in the operation of technical building systems. Consequently, all planners should apply the EN 15232 standard. Planners are generally familiar with energy requirements and are therefore able to provide construction owners with information on the benefits of building automation. Manufacturers of building automation facilities should also use the EN 15232 standard for assessment purposes when carrying out modernization work.

Product standards and certification

Product standards such as EN 15500 "Building automation for HVAC applications – electronic individual zone control equipment" define energy efficiency criteria that are verified and certified by eu.bac. Product users can therefore be sure that the promised characteristics and quality are indeed delivered.

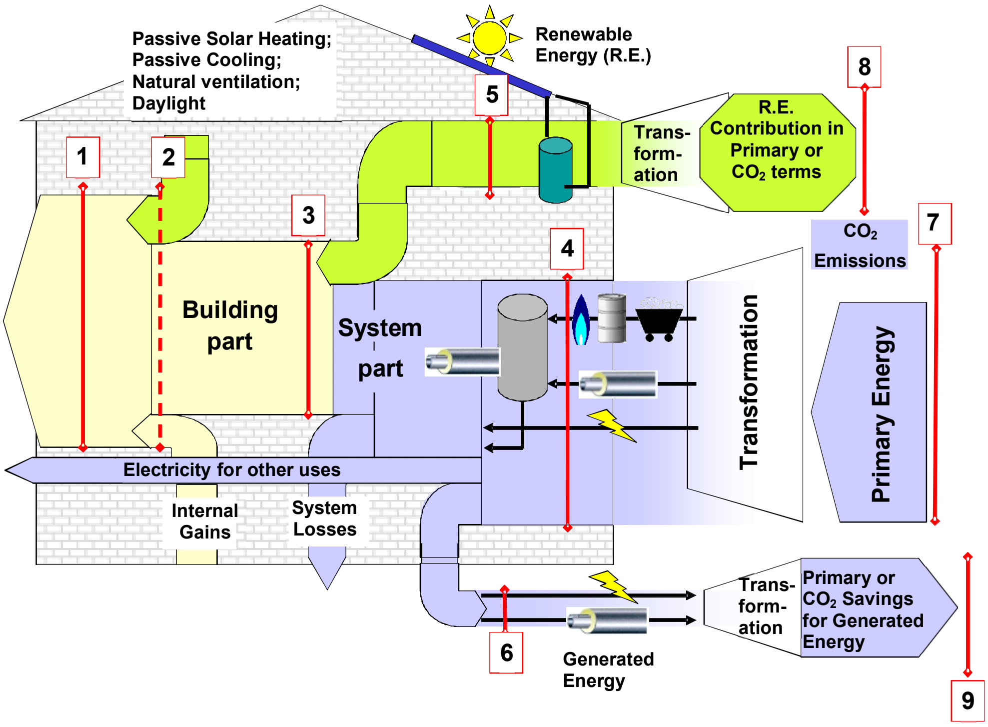
4 The EN 15232 standard in detail

EN 15232 makes it possible to qualify and quantify the benefits of building automation and control systems. The entire standard is based on building simulations using pre-defined building automation and control functions.

Parts of the standard can be used directly as a tool to qualify the energy efficiency of building automation and control projects. It is also planned to assign projects to one of the standard energy efficiency classes A, B, C or D.

Energy flow model

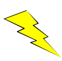
The energy needs of various building models with differing BAC and TBM functions are calculated with the help of simulations. Various energy flow models for the basis, e.g. Energy flow model for thermal conditioning of a building:



Source: PD CEN/TR 15615:2009

Title: Declaration on the general relationship between various European standards and the EPBD ("Umbrella document")

Symbols:



Electricity

Gas, Oil, Coal, bio mass etc.

Heat, refrigeration

Key:

[1] is the energy needed to fulfill the user's requirements for heating, lighting, cooling etc., according to levels that are specified for the purposes of the calculation

[2] are the "natural" energy gains – passive solar, ventilation cooling, daylight, etc. together with internal gains (occupants, lighting, electrical equipment, etc.)

[3] is the building's net energy use, obtained from [1] and [2] along with the characteristics of the building itself

[4] is the delivered energy, represented separately for each energy carrier, inclusive of auxiliary energy, used by heating, cooling, ventilation, hot water and lighting systems, taking into account renewable energy sources and co-generation. This may be expressed in energy units or in units of the energyware (kg, m³, kWh, etc.)

[5] is renewable energy produced on the building premises

[6] is generated energy, produced on the premises and exported to the market; this can include part of [5]

[7] represents the primary energy usage or the CO_2 emissions associated with the building

[8] represents the primary energy or emissions associated with on-site generation that is used on-site and so is not subtracted from [7]

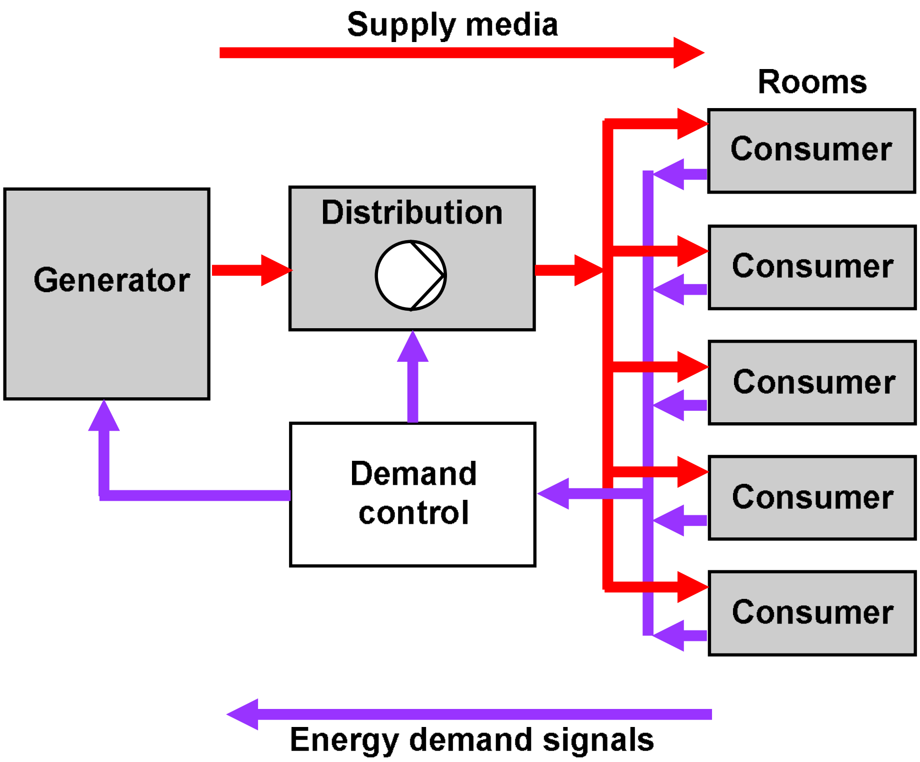
[9] represents the primary energy or CO_2 savings associated with exported energy, which is subtracted from [7]

The overall calculation process involves following the energy flows from the left to the right of the model above.

The model above is a schematic illustration and is not intended to cover all possibilities. For example, a ground-source heat pump uses both electricity and renewable energy from the ground. And electricity generated on-site by photovoltaics could be used within the building, it could be exported, or a combination of these. Renewable energy sources like biomass are included in [7], but are distinguished from non-renewable energy carriers by low CO_2 emissions. In the case of cooling, the direction of energy flow is from the building to the system.

Energy demand and supply model

The BAC functions according to EN 15232 are based on the energy demand and supply model for a building as shown below.

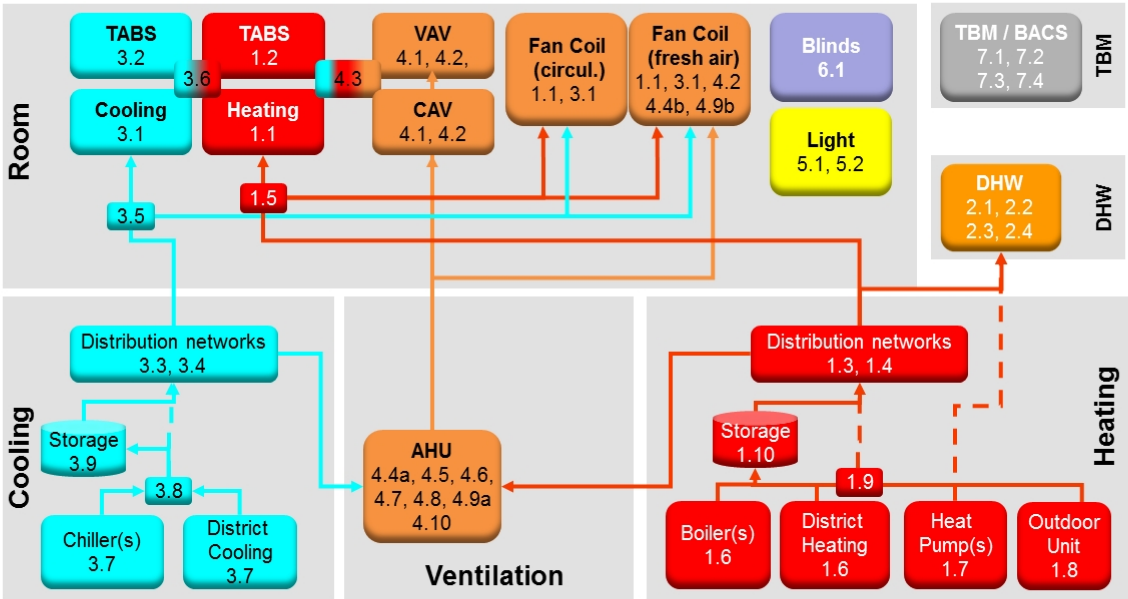


Rooms represent the source of energy demand. Suitable HVAC plants should ensure comfortable conditions in the rooms with regard to temperature, humidity, air quality and light as needed.

Supply media is supplied to the consumer according to energy demand allowing you to keep losses in distribution and generation to an absolute minimum.

The building automation and control functions described in sections 4.1 and 4.2 are aligned in accordance with the energy demand and supply model. The relevant energy efficiency functions are handled starting with the room via distribution up to generation.

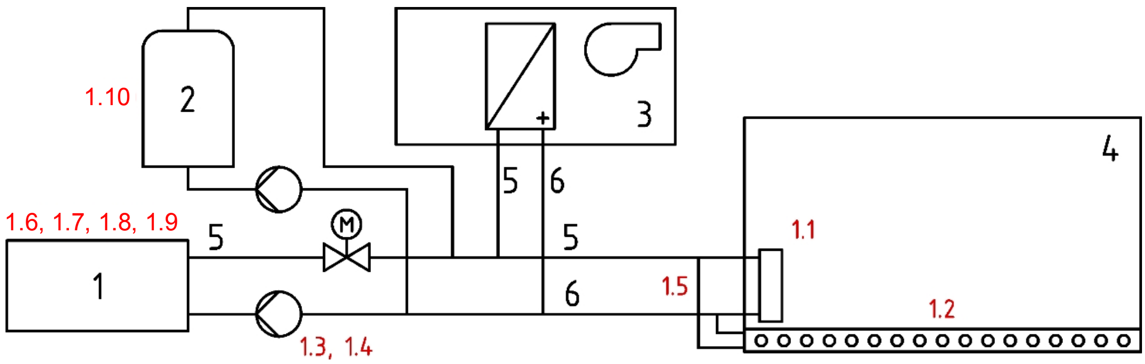
The following graphic show the cross-dependencies between functions in the room (e.g. Heating 1.1, Cooling 2.1) and functions of the distribution and generation for heating, cooling, ventilation and hot water (e.g. heat pump 1.7, ventilation plant 4.5). To complete the picture also functions of the Technical Building Management (TBM) and the Building Automation and Controls Systems (BACS) are shown. The numbering corresponds with the functions described in chapter 4.1 and the energy-efficiency classifications listed in chapter 4.2.



Source: eu.bac

The following Figures illustrate basic system designs for heating, domestic hot water, cooling, ventilation and air conditioning purposes. The numbers refer to the control functions summarized in Table 4. These basic elements can be combined to more or less complex systems that also account for local, regional or national specifics. The building automation and control functions defined in Table 4 are according to these basic system designs. Air side system control of HVAC shall be treated as ventilation and air-conditioning control, separately from heat generators, chillers, terminal units and water and refrigerant side controls.

Space heating system

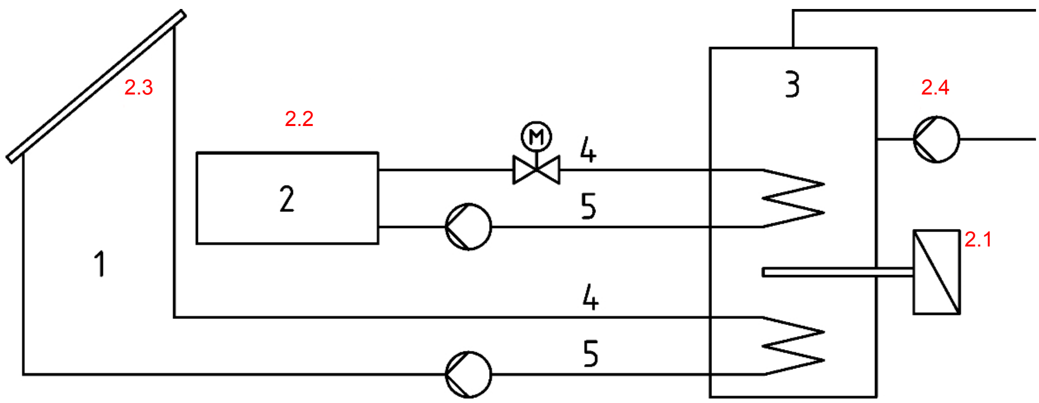


Key

1 heat generator
2 thermal energy storage
3 air handling unit
4 room
5 heating water supply
6 heating water return

NOTE The numbers 1.1 through 1.9 refer to the numbers in the tables in Chapter 4.

Domestic hot water heating system

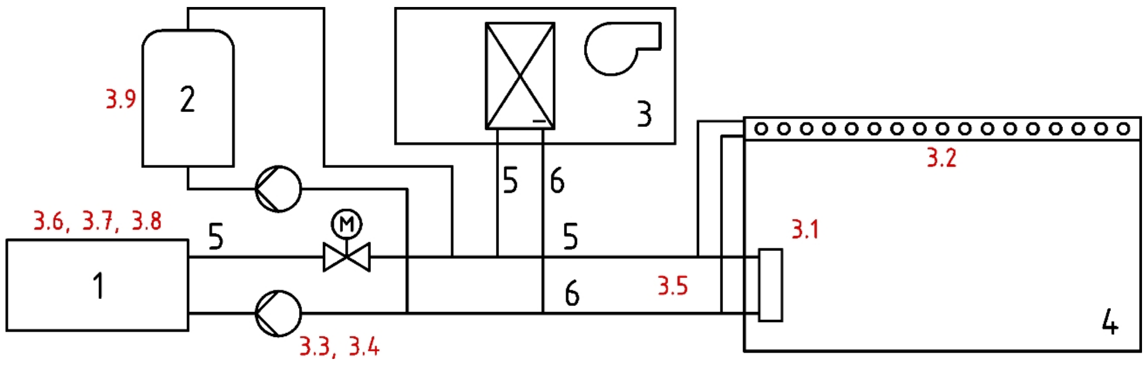


Key

1 solar collector
2 boiler/district heating heat pump
3 domestic hot water storage
4 heating water supply
5 heating water return

NOTE The numbers 2.1 through 2.4 refer to the numbers in the tables in Chapter 4.

Cooling system

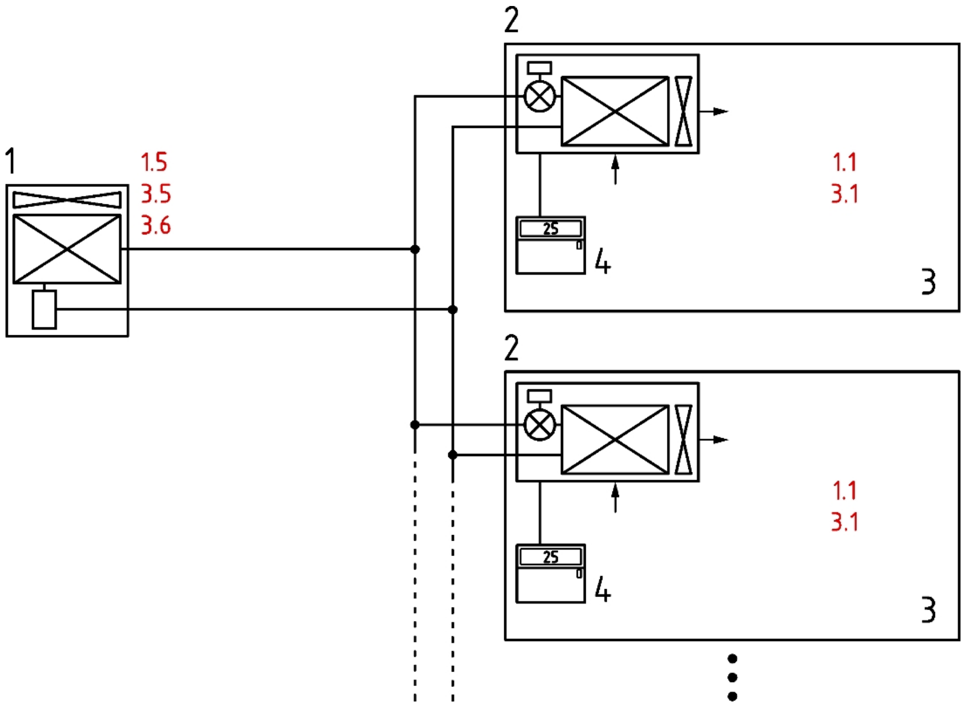


Key

1 solar collector
2 thermal energy storage
3 air handling unit
4 room
5 heating water
6 heating water return

NOTE The numbers 3.1 through 3.9 refer to the numbers in the tables in Chapter 4.

Split system/VRF (heating and/or cooling)

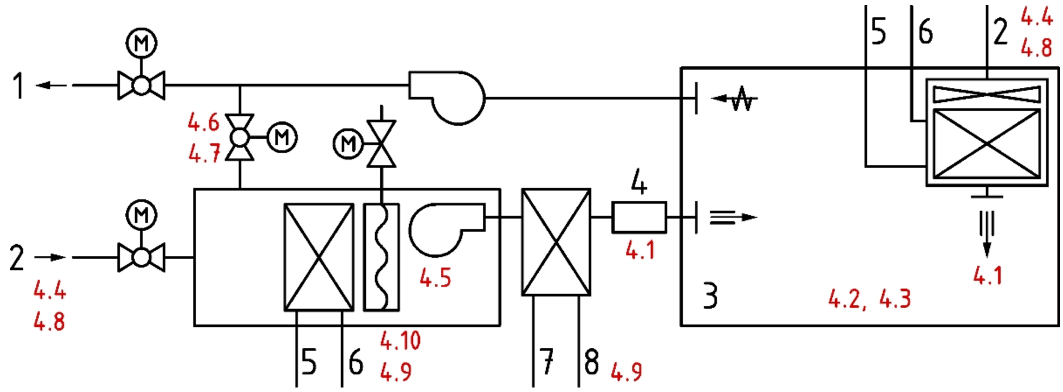


Key

1 outdoor unit
2 indoor unit
3 room 1
4 room 2

NOTE The numbers 1.1 through 3.6 refer to the numbers in the tables in Chapter 4.

Ventilation and air-conditioning System



Key

1 exhaust air
2 outside air
3 room
4 variable air volume
5 chilled water supply
6 chilled water return
7 heating water
8 heating water return

NOTE The numbers 4.1 through 4.10 refer to the numbers in the tables in Chapter 4.

4.1. List of relevant building automation and control functions

Energy efficiency-relevant functions and possible **processing functions** for building automation and control systems are the focus of EN 15232. They are listed in the left part of a multi-page table grouped by the different areas of use.

This list includes
• All functions and processing functions as per EN 15232-1:2017 • Justifications for energy savings by functions and processing functions as per EN 15232

The function list below has 5 columns:

Columns 1 through 3 correspond to the content of EN 15232-1:2017

- Column 1 Number of BACS and TBM functions
- Column 2 Field of use and the corresponding numbers for possible processing functions
- Column 3 Processing functions with detailed commentaries

Columns 4 and 5 are supplements by Siemens BT

- Column 4 Refers to interpretations by Siemens Building Technologies for the functions and processing functions as per EN 15232. (BT = remarks of Siemens BT)
- Column 5 Explains how the corresponding function saves energy

1	2	4	5

1	2		4	5
1	2	3	4	5

On the following pages are

- Right side: Tables from EN 15232 and reason for energy saving
- Left side: Remarks of Siemens BT

→ Continued on the next double page

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232-1:2017.

1) Plants required for "emission control" of thermal energy (e.g. radiators, chilled ceilings, VAV systems) may have different supply media (e.g. water, air, electricity). As a result, different BAC solutions may be possible for a processing function.

2) The Siemens interpretation gives full consideration to the processing function in the function list of EN 15232:
   - It includes thermostatic valves and electronic control equipment.
   - Non-communicating electronic control equipment may include a local scheduler, but experience suggests that they are often not correctly set
   - For „Cooling Control“ thermostatic valves are not utilized

3) Communication between a superposed centralized unit and electronic individual room controllers allow for centralized schedulers, monitoring of individual room controllers as well as centralized operation and monitoring.

4) Demand control (by use) = demand control based on occupancy information from a presence detector or a presence button with automatic reset after a set period. Control switches from PreComfort to Comfort or vice versa using this occupancy information (see EN 15500).

   Notes:
   - Air quality control is considered by "Ventilation and air conditioning control"
   - Occupancy information can influence "heating control", "cooling control" and "ventilation and air conditioning control"

Note:

Setpoints for heating and cooling should be configured so that the setpoint range is as wide as possible (with summer and winter compensation) to meet present use and comfort requirements.

<table>
<tr><td colspan="5">AUTOMATIC CONTROL</td></tr>
<tr><td>1</td><td colspan="2">HEATING CONTROL</td><td>BT</td><td>Reason for energy savings</td></tr>
<tr><td>1.1</td><td colspan="2">Emission control</td><td>1</td><td></td></tr>
<tr><td></td><td></td><td>The control system is installed at the emitter or room level, for case 1 one system can control several rooms.</td><td></td><td></td></tr>
<tr><td></td><td>0</td><td><u>No automatic control</u> of the room temperature</td><td></td><td>The highest supply output is continuously delivered to the heat emitters resulting in the supply of unnecessary thermal energy under part load conditions.</td></tr>
<tr><td></td><td>1</td><td><u>Central automatic control</u>
There is only central automatic control acting either on the distribution or on the generation. This can be achieved for example by an outside temperature controller conforming to EN 12098-1 or EN 12098-3; one system can control several rooms.</td><td></td><td>Supply output depending on the outside temperature for example (corresponding to the probable heat demand of the consumers). Energy losses under part load conditions are reduced, but no advantage can be taken of individual heat gains in the rooms.</td></tr>
<tr><td></td><td>2</td><td><u>Individual room control</u>
By thermostatic valves or electronic controller</td><td>2</td><td>Supply output based on room temperature (= controlled variable). It considers heat sources in the room as well (heat from solar radition, people, animals, technical equipment). The room can be kept comfortable with less energy.
Comment:
Electronic control equipments ensures higher energy efficiency than thermostatic valves (higher control accuracy, coordinated manipulated variable acts on all valves in the room).</td></tr>
<tr><td></td><td>3</td><td><u>Individual room control</u>
By thermostatic valves or electronic controller</td><td>3</td><td>Same reason as above. In addition:
Central ...
schedulers make it possible to reduce output during non-occupancy,
operating and monitoring functions further optimize plant operation.</td></tr>
<tr><td></td><td>3</td><td><u>Individual room control with communication</u>
As above, in addition:
For integrated plants the heat emission e.g. floor heating, wall heating, etc. the function 1.1.3 is assigned to the BA class A.</td><td>3</td><td>Same reason as above. With this a similar energy efficient operation can bie achieved for integrated plants for heat emission as with function 1.1.4</td></tr>
<tr><td></td><td>4</td><td><u>Individual room control with communication and occupancy detection:</u>
Between controllers and BACS; Demand control / occupancy detection (this function level is usually not applied to any slow reacting heat emission systems with relevant thermal mass, e.g. floor heating, wall heating).</td><td>4</td><td>Same reason as above. In addition:
Effective occupancy control results in additional energy savings in the room under part load conditions.
Demand-controlled energy provision (production of energy) results in minimum losses in provision and distribution.</td></tr>
</table>

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232-1:2017.

5) The following main features distinguish TABS from other heating and cooling systems:
   - TABS is a low-temperature heating/high temperature cooling system
   - TABS activates relatively large thermal storage

   These features permit energy-efficient operation in a number of cases

6) As a rule, there is only a single flow temperature setpoint per zone (heating and cooling – no setpoint range. This means: Frequently slight overheating or undercooling during transition periods (where heating and cooling are released).

7) A setpoint range is used here; one setpoint each can be preset separately for heating and cooling. This eliminates to some extent overheating or undercooling.

AUTOMATIC CONTROL				
1	**HEATING CONTROL**		**BT**	**Reason for energy savings**
1.2	Emission control of TABS (heating mode)		5	
	0	No automatic control of the room temperature		The highest supply output is continuously delivered to the TABS, resulting in the supply of unnecessary thermal energy under part load conditions.
	1	Central automatic control The central automatic control for a TABS zone (which comprises all rooms which get the same supply water temperature) typically is a supply water temperature control loop whose set-point is dependent on the filtered outside temperature, e.g. the average of the previous 24 hours.	6	Supply output is controlled depending on the outside temperature, for example (corresponding to the probable heat demand of the consumers). Energy losses under part load conditions are reduced, but no advantage can be taken of individual heat gains in the rooms.
	2	Advanced central automatic control This is a central automatic control of the TABS zone that is designed and tuned to achieve an optimal self-regulating of the room temperature within the required comfort range (specified by the room temperature heating set-point). “Optimal” means that the room temperatures of all rooms of the TABS zone remain during operation periods in the comfort range, to meet comfort requirements, but also is as low as possible to reduce the energy demand for heating.	7	Supply output is controlled depending on the outside temperature, for example (corresponding to the probable heat demand of the consumers). Taking advantage of self-regulating effects during operating times fulfills comfort requirements in all the rooms and reduces heat demand as much as possible. Different setpoints for heating and cooling (e.g. through the use of a setpoint range for the flow temperature) can prevent unnecessary overheating or undercooling. Additional energy can be saved by compensating for known heat gains in the building (e.g. by adjusting the flow temperatures over the weekend in office buildings – if there are no internal heat gains). Within a specified outside temperature range (transition period), the changeover between heating and cooling occurs (indirectly) based on heat gains in the building. This may enhance comfort and automate operation (no need for the operator to manually change over).
	3	Advanced central automatic control with intermittent operation and/or room temperature feedback control: a) Advanced central automatic control with intermittent operation. This is an advanced central automatic control according to 2) with the following supplement: The pump is switched off regularly to save electrical energy, either with a fast frequency - typically 6 hours on/off cycle time - or with a slow frequency, corresponding to 24 hours on/off cycle time. If the TABS is used for cooling, intermittent operation with 24 hours on/off cycle time can also be used to reject the heat to the outside air if the outside air is cold. b) Advanced central automatic control with room temperature feedback control. This is an advanced central automatic control according to 2) with the following supplement: The supply water temperature set-point is corrected by the output of a room temperature feedback controller, to adapt the set-point to non-predictable day-to-day variation of the heat gain. Since TABS react slowly, only day-to-day room temperature correction is applied, an instant correction cannot be achieved with TABS. The room temperature that is fed back is the temperature of a reference room or another temperature representative for the zone. c) Advanced central automatic control with intermittent operation and room temperature feedback control		Even more electricity can be saved through pump cycling operation. In addition, the on phases can be executed in some cases if energy efficiency can be gained or at times when energy is available at lower rates (e.g. cooling at night at low outside temperatures or at lower rates). Heat gains can be used to save energy through the use of room temperature control in a reference room by readjusting the flow temperature setpoint. Room temperature control automates the compensation of additional or missing heat gains and, if required corrects incorrectly set weather-compensated control in a restricted range.

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232-1:2017.

8) The pump is only released on demand.

   With proportional ∆p: Pump solutions with an external differential measurement (e.g. based on the effective load by the consumer) are more expensive overall. They do, however, allow for more precise pump control than pumps with integrated pressure control equipment. Furthermore, the risk of under-provisioning individual consumers is reduced.

AUTOMATIC CONTROL				
1		**HEATING CONTROL**	**BT**	**Reason for energy savings**
1.3		Control of distribution network hot water temperature (supply or return)		
		Similar function can be applied to the control of direct electric heating networks		
	0	No automatic control		The highest design temperature of all consumers is continuously provided in distribution, resulting in significant energy losses under part load conditions.
	1	Outside temperature-compensated control Actions generally lower the mean flow temperature		Distribution temperature is controlled depending on the outside (corresponding to the probable temperature demand of the consumers). This reduces energy losses under part load conditions.
	2	Demand-based control E.g. based on indoor temperature control variable; actions generally lower the mean flow temperature		Distribution temperature depending on the room temperature (controlled variable). It considers heat sources in the room as well (solar irradiance, people, animals, technical equipment). Keeps energy losses under part load conditions at an optimum (low).
1.4		Control of distribution pumps in networks		
		The controlled pumps can be installed at different levels in the network. Control is to reduce the auxiliary energy demand of the pumps.		
	0	No automatic control		No savings, since electrical power for the pump is drawn continuously.
	1	On / off control switch on and off automatically, pumps run with no control at maximum speed		Electrical power for the pump is drawn only as required – e.g. during occupancy periods or in protection mode (frost hazard).
	2	Multi-stage control Speed of pumps is controlled by a multi-step control		Operating at a lower speed reduces power consumption of multi-speed pumps.
	3	Variable speed pump control constant or variable Δp based on pump unit (internal) estimations	8	a) With *constant* Δp: Pressure differential does not increase at decreasing load when maintaining a constant pressure differential across the pump. The pump speed is reduced under part load conditions, which lowers power consumption. b) With *variable* Δp: Pressure differential across the pump drops as the load decreases. This provides additional reductions in speed and electrical power under part load conditions.
	4	Variable speed pump control variable Δ*p* following an external demand signal, e.g. hydraulic requirement, Δ*T*, energy optimization		With variable Δp following an external demand signal, the pump speed is reduced under part load conditions as much as possible whilst ensuring, that the consumer with the largest demand is still satisfied at any given operational situation, i.e. no underprovisioning of certain consumers. This lowers power consumption maximally.

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232-1:2017.

9) The Coefficient of Performance (COP) and the Seasonal Energy Efficiency Ratio (SEER) of heat pump plants are positively influenced on the one hand by lower flow water temperatures, while also benefiting from a small temperature differential between evaporator and condenser.

AUTOMATIC CONTROL				
1	**HEATING CONTROL**		**BT**	**Reason for energy savings**
1.5	Intermittent control of emission and/or distribution			
		One controller can control different rooms/zones having same occupancy patterns		
	0	No automatic control		No savings, since emission and/or distribution are permanently in operation.
	1	Automatic control with fixed time program To lower the operation time		Savings in emission and/or distribution outside the nominal operating hours.
	2	Automatic control with optimum start/stop To lower the operation time		Additional savings in emission and/or distribution by continuously optimizing the plant operating hours to the occupancy times.
	3	Automatic control with demand evaluation To lower the operation time		The operating time for emission and/or distribution is determined based on consumer demand. This can be accomplished via the operating mode (Comfort, PreComfort, Economy, Protection).
1.6	Generator control for combustion and district heating			
		The goal consists generally in minimizing the generator operation temperature		
	0	Constant temperature control		The generator continuously provides the highest design temperature of all consumers, resulting in significant energy losses under part load conditions.
	1	Variable temperature control depending on outdoor temperature		Generation temperature is controlled depending on the outside temperature (corresponding to the probable temperature demand of the consumers), considerably reducing energy losses.
	2	Variable temperature control depending on the load: E.g. depending on supply water temperature		Generation temperature is controlled depending on the effective heat demand of the consumers, keeping energy losses at the generator to an optimum (low).
1.7	Heat generator control (heat pump)			
		The goal consists generally in minimizing the heat generator operation temperature and by this in maximizing the heat generator efficiency	9	
	0	Constant temperature control		Generation temperature is controlled depending on the outside temperature (corresponding to the probable temperature demand of the consumers), thus increasing the COP.
	1	Variable temperature control depending on outside temperature		Generation temperature is controlled depending on the effective temperature demand of the consumers, keeping the COP at an optimum (high).
	2	Variable temperature control depending on the load: E.g. depending on supply water temperature setpoint		Priority control adapts current generation output (with priority to renewable forms of energy) to current load in an energy-efficient manner.

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232-1:2017.

No specific remarks here.

AUTOMATIC CONTROL				
1	**HEATING CONTROL**		**BT**	**Reason for energy savings**
1.8	Heat generator control (outdoor unit)			
		The goal consists generally in maximizing the heat generator efficiency		
	0	On/Off-control of heat generator		The delivered heat from the heat generator can only roughly be adjusted to the needs of the consumers. The adjustment mainly happens by changing the switching frequency. This results in reduced efficiency of the heat generator.
	1	Multi-stage control of heat generator capacity depending on the load or demand (e.g. on/off of several compressors)		The delivered heat can be better adjusted to the needs of the consumers by swichting of several stages. By that the efficiency of the heat generator is improved.
	2	Variable control of heat generator capacity depending on the load or demand (e.g. hot gas bypass, inverter frequency control)		By variably controlling the heat generator based on load or demand the heat can be always be produced optimally and the efficiency of the heat generator will be maximized.
1.9	Sequencing of different heat generators			
		This control function only applies to a system with a set of different heat generator sizes or types including Renewable Energy Sources		
	0	Priorities only based on running time		Based on that the running times can be distributed amongst the different heat generators as desired.
	1	Control according to fixed priority list: e.g. heat pump prior to hot water boiler		With this, more efficient heat generators can be run with priority. This has a positive effect on the annual performance factor (APF).
	2	Control according to dynamic priority list (based on current efficiency and capacity of generators) e.g. solar, geothermal heat, cogeneration plant, fossil fuels)		By considering actual efficiency and operating situations it is possible to run the most appropriate combination. This further increases the annual performance factor (APF).
	3	Control according to dynamic priority list (based on predicted and current load, efficiency and capacity of generators)		By considering actual efficiency and operating situations and by predicting the expected future operating situation with the corresponding efficiency factors the various heat generators can by operated optimally in the long run.
1.10	Control of Thermal Energy Storage (TES) charging			
		The TES is part of the heating system.		
	0	Continuous storage operation		This is mainly to ensure supply in case a heat generator fails. By continuously storing heat there is also a continuous loss of heat from the storage tank.
	1	2-sensor charging of storage		The two storage sensors provide an indication about the charging of the storage tank. With this information switching heat generators can be operated with fewer switching cycles and due to that will run more efficiently. The thermal storage losses will be reduced.
	2	Load prediction based storage operation		Based on consumer demand predictions there will only be as much charging of the storage as needed. This allows for optimal operation of the heat generator and reduces the thermal storage losses maximally.

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232-1:2017.

1) As a rule, DHW heating with storage tank is considered since considerable energy losses may arise for improper solutions. Instantaneous flow heaters close to the consumers are normally operated based on demand and have limited automation functions.

2) A defined charging time can minimize the period of time a higher production temperature is required for the hot water charge.

AUTOMATIC CONTROL			
2	**DOMESTIC HOT WATER SUPPLY CONTROL**	**BT**	**Reason for energy savings**
	Term: *Function* ***Charging time release:*** *Storage charging time release by time switch program* ***Multi-sensor storage management:*** *Demand-oriented storage management using two or more temperature sensors* ***Heat generation:*** *Boilers (fired with different types of fuels), heat pump, solar power, district heating, CHP.* ***Demand-oriented supply:*** *Information exchange to supply according storage temperature demand* ***Return temperature control:*** *Charging pump control for return temperature reduction* ***Solar storage charge:*** *Control of charging pump on / off to maximum DHW storage temperature during supply of free solar energy. Solar collector supplies the first priority energy.* ***Supplementary storage charge:*** *Release of supplementary control from heat generation with storage charging time release by time switch program to nominal DHW storage temperature or when going below the reduced DHW storage temperature. Heat generation supplies the second priority energy.*	1	
2.1	Control of DHW storage temperature with integrated electric heating or electric heat pump		
	0 Automatic control on/off		Control is affected via a thermostat.
	1 Automatic control on/off and scheduled charging enable		Release of the charging time results in energy savings (losses in the DHW storage tank) by defining the charging duration and preventing frequent charging. If the DHW temperature drops below a certain reduced level, recharging takes place even without a time-based release.
	2 Automatic control on/off and scheduled charging enable and multi-sensor storage management		Multi sensors allow for dividing the DHW storage tank into various zones ensuring better adaptation to usage. This reduces heat losses in the storage tank.
2.2	Control of DHW storage temperature using heating water generation		
	0 Automatic control on/off		Control is affected via thermostat.
	1 Automatic control on/off and scheduled charging enable	2	Release of the charging time enable results in energy savings (losses in storage tank) by defining the charging duration and preventing frequent charging. If the DHW temperature drops below a certain reduced level, recharging takes place even without a time-based release.
	2 Automatic control on/off, scheduled charging enable and demand-based supply temperature control or multi-sensor storage management		Demand-controlled supply temperature reduces heat losses in generation and distribution. The supply temperature can be matched to the DHW storage tank temperature and increased as needed. Spreading the load over time (e.g. heating circuits) lowers the maximum output for generation: Generation can be operated in an optimum part load range.

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232-1:2017.

3) The hot water circulation pipe from the storage tank to the consumer loses a lot of energy when continuously operating. The storage tank temperature drops due to the continuous energy losses. Frequent recharging is required to cover the losses.

<table>
<tr><th colspan="5">AUTOMATIC CONTROL</th></tr>
<tr><th>2</th><th colspan="2">DOMESTIC HOT WATER SUPPLY CONTROL</th><th>BT</th><th>Reason for energy savings</th></tr>
<tr><td>2.3</td><td colspan="2">Control of DHW storage charging with solar collector and supplementary heat generation</td><td></td><td>DHW storage tank with two integrated heat exchangers.</td></tr>
<tr><td></td><td>0</td><td><u>Manual control</u></td><td></td><td>Control is affected via thermostat. The generator must be preselected:</td></tr>
<tr><td></td><td>1</td><td><u>Automatic control of solar storage charge (Prio. 1) and supplementary storage charge (Prio. 2)</u></td><td></td><td>The solar collector can recharge any amount of freely available energy up to the maximum DHW storage tank temperature so that the maximum possible share of solar energy is used. Heat generation only supplements the required energy amount to ensure a sufficient DHW temperature at any time.</td></tr>
<tr><td></td><td>2</td><td><u>Automatic control of solar storage charge (Prio. 1) and supplementary storage charge (Prio.2) and demand based supply temperature control or multi-sensor storage management</u></td><td></td><td>Solar storage tank charging has the highest priority.
The remaining, required coverage is provided by the heat generator via demand-controlled supply temperatures thus reducing heat losses in generation and distribution. Multi sensors allow for dividing the DHW storage tank into various zones, ensuring better adaptation to usage. This reduces heat losses in the storage tank.</td></tr>
<tr><td>2.4</td><td colspan="2">Control of DHW circulation pump</td><td></td><td></td></tr>
<tr><td></td><td>0</td><td><u>No control, continuous operation</u></td><td>3</td><td>Hot water circulates, leading to unnecessary heat losses which have an impact on overall efficiency of DHW heating.</td></tr>
<tr><td></td><td>1</td><td><u>With time program</u></td><td></td><td>Heat losses in hot water circulation are limited to primary occupancy periods.</td></tr>
</table>

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232-1:2017.

1) The Plants required for "emission control" of thermal energy, such as fan coils, chilled ceilings or VAV systems may have different supply media (e.g. water, air). As a result, different BAC solutions may be possible for a processing function.

2) The Siemens interpretation gives full consideration to the processing function in the function list of EN 15232:
   - It includes thermostatic valves and electronic control equipment.
   - Non-communicating electronic control equipment may include a local scheduler. But experience suggests that they are often not correctly set.
   - Thermostatic valves are not used for "cooling control".

3) Communication between a superposed centralized unit and electronic individual room controllers allows for centralized schedulers, monitoring of individual room controllers as well as centralized operation and monitoring.

4) Demand control (by use) = demand control based on occupancy information from a presence detector or a presence button with automatic reset after a set period. Control switches from Pre-Comfort to Comfort or the other way around using this occupancy information (see EN 15500).

Note:

- Air quality control is considered in "Ventilation and air conditioning control".
- Occupancy information can influence "heating control", "cooling control" and "ventilation and air conditioning control".

AUTOMATIC CONTROL				
3	**COOLING CONTROL**		**BT**	**Reason for energy savings**
3.1	Emission control		1	
		The control function is applied to the emitter (cooling panel, fan-coil unit or indoor unit) at room level; for type 1 one function can control several rooms		
	0	No automatic control of the room temperature		The highest supply output is continuously delivered to the heat exchangers, resulting in the supply of unnecessary thermal energy under part load conditions.
	1	Central automatic control There is only central automatic control acting either on the distribution or on the generation. This can be achieved for example by an outside temperature controller conforming to EN 12098-1 or EN 12098-3		Supply output is controlled depending on the outside temperature, for example (corresponding to the probable heat demand of the consumers). Energy losses under part load conditions are reduced, but no advantage can be taken of individual heat gains in the rooms.
	2	Individual room control By thermostatic valves or electronic controller	2	Supply output depending on the room temperature (= controlled variable). It considers heat gains in the room as well (solar radiation, people, animals, technical equipment). Room comfort can be maintained to satisfy individual needs.
	3	Individual room control with communication Between controllers and BACS (e.g. scheduler, room temperature setpoint)	3	Same reason as above. In addition: Central... • schedulers make it possible to reduce output during non-occupancy • operating and monitoring functions further optimize operation
	3	Individual room control with communication Same as above, in addition: In case of slow reacting cool emission systems, e.g. cooling ceiling, etc. function 3.1.3 is allocated to BAC class A.	3	Same reason as above. With that a similarly energy-efficient operation for integrated, slow reacting emission systems can be achieved as with function 3.1.4
	4	Individual room control with communication and occupancy detection Between controllers and BACS; Demand control/occupancy detection (this function level is usually not applied to any slow reacting cool emission systems with relevant thermal mass, e.g. floor cooling)	4	Same reason as above. In addition: • Effective occupancy control results in additional energy savings in the room under part load conditions. • Demand-controlled energy provisioning (energy production) results in minimum losses from provision and distribution.

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232-1:2017.

5) The following main features distinguish TABS from other heating and cooling systems:
   - TABS is a low-temperature heating/high temperature cooling system
   - TABS activates relatively large thermal storage

   These features permit energy-efficient operation in a number of cases

6) As a rule, there is only a single flow temperature setpoint per zone (heating and cooling – no setpoint range. This means: Frequently slight overheating or undercooling during transition periods (where heating and cooling are released).

7) A setpoint range is used here; one setpoint each can be preset separately for heating and cooling. This eliminates to some extent overheating or undercooling.

AUTOMATIC CONTROL				
3	**COOLING CONTROL**		**BT**	**Reason for energy savings**
3.2	Emission control for TABS (cooling mode)		5	
	0	No automatic control of the room temperature		The highest supply output is continuously delivered to the TABS, resulting in the emission of unnecessary cooling energy under part load conditions.
	1	Central automatic control The central automatic control for a TABS zone (which comprises all rooms which get the same supply water temperature) typically is a supply water temperature control loop whose set-point is dependent on the filtered outside temperature, e.g. the average of the previous 24 hours.	6	Supply output is controlled depending on the outside temperature, for example (corresponding to the probable heat demand of the consumers). Energy losses under part load conditions are reduced, but no advantage can be taken of individual heat gains in the rooms.
	2	Advanced central automatic control: This is an automatic control of the TABS zone that fulfils the following conditions: This is a central automatic control of the TABS zone that is designed and tuned to achieve an optimal self-regulating of the room temperature within the required comfort range (specified by the room temperature cooling set-point). "Optimal" means that the room temperatures of all rooms of the TABS zone remain during operation periods in the comfort range, to meet comfort requirements, but also is as high as possible to reduce the energy demand for cooling.	7	Supply output is controlled depending on the outdoor temperature (corresponding to the probable heat demand of the consumers). Taking advantage of self-regulating effects during operating times fulfills comfort requirements in all the rooms and reduces refrigeration demand as much as possible. Using different setpoints for heating and cooling (e.g. through the use of a setpoint range for the flow temperature) can prevent unnecessary overheating or undercooling. Additional energy can be saved by compensating for known heat gains in the building (e.g. by adjusting the flow temperatures over the weekend in office buildings – if there are no internal heat gains). Within a specified outside temperature range (transition period), the changeover between heating and cooling occurs (indirectly) based on heat gains in the building. This may enhance comfort and automate operation (no need for the operator to manually change over).
	3	Advanced central automatic control with intermittent operation and/or room temperature feedback control: a) Advanced central automatic control with intermittent operation. This is an advanced central automatic control according to 2) with the following supplement: The pump is switched off regularly to save electrical energy, either with a fast frequency - typically 6 hours on/off cycle time - or with a slow frequency, corresponding to 24 hours on/off cycle time. If the TABS is used for cooling, intermittent operation with 24 hours on/off cycle time can also be used to reject the heat to the outside air if the outside air is cold. b) Advanced central automatic control with room temperature feedback control. This is an advanced central automatic control according to 2 with the following supplement: The supply water temperature set-point is corrected by the output of a room temperature feedback controller, to adapt the set-point to non-predictable day-to-day variation of the heat gain. Since TABS react slowly, only day-to-day room temperature correction is applied, an instant correction cannot be achieved with TABS. c) Advanced central automatic control with intermittent operation and room temperature feedback control.		Even more electricity can be saved through the pump cycling. In addition, the switch-on phases can be executed in some cases if energy efficiency can be gained or at times when energy is available at lower rates (e.g. cooling at night at lower outside temperatures or at lower electricity rates). Heat gains can be used to save energy through the use of room temperature control in a reference room by readjusting the flow temperature setpoint. Room temperature control automates the compensation of additional or missing heat gains if required corrects incorrectly set weather-compensated control in a restricted range.

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232-1:2017.

8) The pump is only released on demand.

With proportional Δp: Pump solutions with an external differential measurement (e.g. based on the effective load by the consumer) are more expensive overall. They do, however, allow for more precise pump control than pumps with integrated pressure control equipment. Furthermore, the risk of under-provisioning individual consumers is reduced.

AUTOMATIC CONTROL				
3	**COOLING CONTROL**		**BT**	**Grund der Energieeinsparung**
3.3	Control of distribution network cold water temperature (supply or return)			
		Similar function can be applied to the control of direct electric cooling (e.g. compact cooling units, split units) for individual rooms		
	0	Constant temperature control		A constant, low design temperature of all consumers is continuously provided in distribution, resulting in significant energy losses under part load conditions.
	1	Outside temperature compensated control Action generally raise the mean flow temperature		Distribution temperature is controlled depending on the outside temperature (corresponding to the probable temperature demand of the consumers), considerably reducing energy losses.
	2	Demand based control E.g. Indoor temperature control variable; Actions generally raise the mean flow temperature.		Distribution temperature depends on the room temperature (controlled variable). It considers heat gains in the room as well (solar irradiance, people, animals, technical equipment). Keeps energy losses under part load conditions to an optimum (low)
	3			
3.4	Control of distribution pumps in hydraulic networks			
		The controlled pumps can be installed at different levels in the network		
	0	No automatic control		No savings, since electrical power for the pump is drawn continuously.
	1	On off control To reduce the auxiliary energy demand of the pumps		Electrical power for the pump is drawn only as required – e.g. during occupancy or in protection mode (overheating hazard).
	2	Multi-stage control To reduce the auxiliary energy demand of the pumps		Operation at a lower speed reduces the power consumption of multi-speed pumps.
	3	Variable speed pump control constant or variable Δp based on pump unit (internal) estimations to reduce the auxiliary energy demand of the pumps	8	a) With constant Δp: Pressure differential does not increase at decreasing load when maintaining a constant pressure differential across the pump. The pump speed is reduced under part load conditions, which lowers the electrical power. b) With variable Δp: Pressure differential across the pump drops as the load decreases. This provides additional reductions in speed and electrical power under part load conditions.
	4	Variable speed pump control variable Δp following an external demand signal, e.g. hydraulic requirements, ΔT, energy optimization to reduce the auxiliary energy demand of the pumps		With variable Δp following an external demand signal, the pump speed is reduced under part load conditions as much as possible whilst ensuring, that the consumer with the largest demand is still satisfied at any given operational situation, i.e. no underprovisioning of certain consumers. This lowers power consumption maximally.

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232-1:2017.

9) In buildings with air conditioning systems is this an important function regarding energy savings. The possibility to cool and heat a room at the same time depends on the system setup and the automation functions. Depending on the system setup, a complete interlock can be achieved with a simple automation function, or a complex automation function might be required.

AUTOMATIC CONTROL				
3	**COOLING CONTROL**		**BT**	**Reason for energy savings**
3.5	Intermittent control of emission and /or distribution			
		One controller can control different rooms/zones having same occupancy patterns		
	0	No automatic control		No savings, since emission and/or distribution are permanently in operation.
	1	Automatic control with fixed time program To lower the operation time		Savings in emission and/or distribution outside the nominal operating hours.
	2	Automatic control with optimum start/stop To lower the operation time		Additional savings in emission and/or distribution by continuously optimizing the plant operating hours to the occupancy times.
	3	Automatic control with demand evaluation To lower the operation time		The operating time for emission and/or distribution is determined based on consumer demand. This can be accomplished via the operating mode (Comfort, PreComfort, Economy, Protection).
3.6	Interlock between heating and cooling control of emission and/or distribution		9	
		To avoid at the same time heating and cooling in the same room depends on the system principle(e.g. cooling panel/heat emitter, TABS/ventilation, several indoor units)		
	0	No interlock: the two systems are controlled independently and can provide simultaneously heating and cooling		Simultaneous heating and cooling possible. The energy provided in addition is wasted.
	1	Partial interlock (dependent of the HVAC system) The control function is set up in order to minimize the possibility of simultaneous heating and cooling. This is generally done by defining a sliding set point for the supply temperature of the centrally controlled system.		Generation/distribution in HVAC system: The outside temperature-dependent generation setpoints for heating and cooling can prevent – to some extent – that room temperature controllers used in connection with terminal units reheat in the summer or recool in the winter. The more apart the setpoints of all individual room controllers for heating and cooling (large neutral zones), the more efficiently provisioning can be locked.
	2	Total interlock The control function enables to warranty that there will be no simultaneous heating and cooling.		Emission in the room: A complete lock (e.g. a room temperature sequence controller) prevents any energy absorption in the individual room. Generation/distribution in HVAC system: The demand-dependent setpoints for heating and cooling from the rooms can prevent that the room temperature controllers used in connection with terminal units reheat in the summer or recool in the winter. The more apart the setpoints of all individual room controllers for heating and cooling (large neutral zones), the more efficiently provisioning can be locked.

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232-1:2017.

No special remarks here.

AUTOMATIC CONTROL				
3		**COOLING CONTROL**	**BT**	**Reason for energy savings**
3.7		Different chillers selection control		
		The goal consists generally in maximizing the chiller water temperature		
	0	Constant temperature control		With that a low chilled water temperature will always be provided independent from the demand. This results in an unnecessarily high energy consumption at the chiller(s).
	1	Variable temperature control depending on outside temperature		With that the seasonally varying outside air temperature is taken into consideration which leads to higher chilled water temperatures when appropriate. This results in reduced energy consumption at the chiller(s).
	2	Variable temperature control depending on the load: This includes control according to room temperature		With that the actual demand will be considerd. This leads to a reasonably adjusted chilled water temperature and by that to a substantial reduction of the energy consumption.
3.8		Sequencing of different chillers (chilled water generators)		
		This control function only applies to a system with a set of different chiller sizes or chilled water generator types including Free Cooling and/or Renewable Energy Sources		
	0	Priorities only based on running time		With that run times can be distributed as desired amongst the various chillers.
	1	Fixed sequencing based on loads only: E.g. depending on the generators characteristics, e.g. absorption chiller vs. centrifugal chiller		With that the different chillers can be operated based on various load situations. This leads to a certain improvement of the annual performance factors.
	2	Priorities based on generator efficiency and characteristics: The generator operational control is set individually to available generators so that they operate with an overall high degree of efficiency (e.g. outside air, river water, geothermic heat, refrigeration machines)		By considering actual efficiency and operating situations the correspondingly fitting combination can be operated which leads to improved annual performance factors.
	3	Load prediction based sequencing: The sequence is based on e.g. COP and available power of a device and the predicted required power.		By considering actual efficiency and operating situations and by predicting the expected future consumption the various chillers can be run long term in an optimal way.

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232-1:2017.

No special remarks here.

AUTOMATIC CONTROL				
3	**COOLING CONTROL**		**BT**	**Reason for energy savings**
3.9	Control of Thermal Energy Storage (TES) charging			
		The TES is part of the cooling/chilled water system.		
	0	Continuous storage operation		This is mainly to ensure supply in case of a chiller failure. By continuously storing chilled water there is also a continuous loss (by absorbing heat from the surroundings) at the storage tank.
	1	Time-scheduled storage operation		The two storage sensors provide an indication about the charging of the storage tank. With this information switching chiller can be operated with fewer switching cycles and due to that will run more efficiently. The thermal storage losses will be reduced.
	2	Load prediction based storage operation		Based on consumer demand predictions there will only be as much charging of the storage as needed. This allows for optimal operation of the chiller(s) and reduces the thermal storage losses maximally.

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232-1:2017.

1) Here only air renewal in the room is considered.

Note:
For the room temperature control the parts “Heating control” and “Cooling control” of the EN 15232 are to be considered.

2) Here only the approach how the room temperature is controlled via the supplied air flow and the supply air temperature is of importance.

AUTOMATIC CONTROL				
4	**VENTILATION AND AIR CONDITIONING CONTROL**		**BT**	**Reason for energy savings**
	This section is for building energy systems that bring air into the building: both ventilation and air conditioning systems. Heating and Cooling of air requires additional heating and cooling devices. Control functions related to heating/cooling systems are defined in sections 1 and 3 resp.			
4.1	Supply air flow control at the room level (e.g. fan on/off)		1	By reducing the air flow energy for the air conditioning and the distribution can be saved.
	0	No automatic control: The system runs constantly (e.g. manual controlled switch)		There will always be a constant (high) air flow to the room even though this is not necessary from a comfort perspective (e.g. air quality). With manual switching such plants are often switched off too late or not at all – as experience shows. This leads to an unnecessary high energy consumption at the air handling unit and also for air transportation.
	1	Time control: The system runs according to a given time schedule		There will always be a constant (high) air flow to the room, but based on a time schedule. Whether ventilation is only done as required from a comfort perspective with this approach depends on the quality of the time schedule and the possibilty to make adaptations to it. As experience shows this approach often also leads to unnecessary ventilation. This then results in an unnecessary high energy consumption at the air handling unit and also for air transportation.
	2	Occupancy detection: The system runs dependent on the occupancy (light switch, infrared sensors etc.)		By utilizing presence detection a room will only be ventilated if it is used. With that the disadvantages of a predefinded time schedule are eliminated and the energy consumption at the air handling unit and for transportation will be reduced. The air flow however is still constant (high).
4.2	Room air temperature control by the ventilation system (all-air systems; combination with static systems as cooling ceiling, radiators, etc.)		2	
		Room air temperature depends on air flow (4.1, 4.5) as well as supply air temperature (4.9). This control function is related to a closed loop controller for the room air temperature acting on the air flow or supply air temperature. It can work with or without an additional static heating system (radiators etc.). Minimum air flow rates are maintained.		
	0	On-off control: Fixed air flow rate and fixed supply air temperature at the room level; Room temperature setpoints are set individually.		With that the room temperature can only be influenced minimally by ventilation. The room temperature will fluctuate accordingly due to the on/off control. With that too much heating/cooling power will be brought to the room and the energy for transportation will be consistently high.
	1	Continuous control: Either air flow rate or supply air temperature at the room level can be varied continuously ; Room temperature setpoints are set individually		The air flow or the supply air temperature will be adjusted by the room temperature control. When adjusting the air flow, a reasonable supply air temperature (4.9) must operating at the superior level. When controlling the supply air temperature at the room level the air flow is constant. This leads to a correspondingly high transportation energy.
	2	Optimized control: Minimum energy demand by optimized control. Both air flow rate as well as supply air temperature at the room level are controlled dependent on heating/cooling load.		With that the minimally required air flow can be provided as long as possible. Only if it is no longer feasible to provide sufficient heating/cooling power to the room with this air flow will it be increased. By that the energy consumption for air transportaton and also for air conditioning will be optimized.

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232-1:2017.

3) With that it will be prevented that two control loops attempt to control the same control value. This means e.g. the room heating is set to bring the room temperature to 15 °C, the supply air temperature will then be provided depending on the room temperature in order to maintain the desired room temperature. With that internal heat gains (e.g. from people, devices, lighting, …) can be considered or compensated.

4) By taking air quality indicators (CO_2, VOC/mixed gas) into account the rooms will always be provided with the minimally required outside air flows. Because of this only this outside air flow must be conditioned. This keeps the energy consumption low.

AUTOMATIC CONTROL				
4		**VENTILATION AND AIR CONDITIONING CONTROL**	**BT**	**Reason for energy savings**
4.3		Coordination of room air temperature control by ventilation and by static system		
		Interaction of the different systems has to be coordinated.		
	0	Interaction is not coordinated: E.g. closed loop controllers are dedicated to each system to maintain the room air temperature independently.		Without coordination there is a risk of having independent control loops working against each other and inner and external heat gains cannot be taken into account. This leads to unnecessary energy consumption and at times to uncomfortable room temperatures.
	1	Interaction is coordinated: I.e. only one system is controlled by a closed loop controller for the room air temperature and the other system conditions the room only to that extent that allows the closed loop controller to benefit from internal and external heat gains.	3	With that the various system parts work in a coordinated way with each other to always provide a comfortable room temperature. The energy consumption will be kept low with this approach.
4.4		Outside air flow control		
		This control function is applied to ventilation systems that allow varying the OA ratio or flow respectively.		
	0	Fixed OA ratio/OA flow: The system runs according to a given OA ratio, e.g. modified manually.		Often there is an unnecessarily hight outside air flow to the plant that will be conditioned. Experience shows that outside air rates that have been set too high will not be reset which leads to a constantly high energy consumption for the conditioning of the outside air.
	1	Staged (low/high) OA ratio/OA flow: Depending on a given time schedule		The outside air rate will be adjusted in stages (e.g. a time schedule reduces the outside air rate over lunch, late in the afternoon, …). With that the energy consumption for the conditioning of the outside air will be reduced accordingly. Whether this provides an appropriate outside air rate from an occupancy perspective depends on the quality of the time schedule and its flexibility for adjustments.
	2	Staged (low/high) OA ratio/OA flow: Depending on the occupancy, e.g. light switch, infrared sensors etc.		With presence detection there will only be a high outside air rate if the rooms are occupied. With that the disadvantages of a preefined time schedule are eliminated and the energy consumption for the air conditioning will be somewhat reduced. The outside air rate often is still too high compared to the demand.
	3	Variable control: The system is controlled by sensors which detect the number of people or indoor air parameters or adapted criteria (e.g. CO_2, mixed gas or VOC sensors). The used parameters shall be adapted to the kind of activity in the space.	4	There will always be only as much outside air brought to the plant and conditioned as necessary. This leads to the minimally required energy consumption for the conditioning from an outside air flow perspective.

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232-1:2017.

5) By switching stages the speed n of the fans and with that the air flow $\dot{V}$ will be changed. With that the power consumption of the fans changes too. For that, the following proportional (or affinity) laws apply:

   $$\frac{n_1}{n_2} = \frac{\dot{V}_1}{\dot{V}_2} \text{ und } \frac{P_1}{P_2} = \left(\frac{\dot{V}_1}{\dot{V}_2}\right)^3 \text{ resp. } \frac{P_1}{P_2} = \left(\frac{n_1}{n_2}\right)^3$$

   Example:
   At half the speed, the air flow is reduced to its half (1/2) * also and the power consumption goes down to an eighth (1/8) *.

   Note:
   * This applies under ideal (loss-free) conditions only. For practical purposes the fan vendor's documentation should be consulted. The reduction of the power consumption e.g. at half the air flow is substantial based on experience and disproportionately high (e.g. 60 %)

6) This type of control is widely used. It provides for adjusting the air flow to the demand of the rooms. However there is no direct connection between the controllers in the room and the air flow control at the air handling unit. Changes from the rooms will be transmitted via the duct work and will affect the air pressure (e.g. VAV-controllers close → pressure at the sensor increases). The pressure control can react to that and adjust the air flow at the fan based on that e.g. with a variable speed drive (VSD). Based on experience the set point for the supplied air pressure is often set too high (be on the safe side, poorly balanced air duct work). This leads to continuously and disproportionally high energy consumption for the air transportation (see proportional laws under 2).

7) This control approach requires individual control of the air flow at room level based on temperature and/or air quality (4.2, 2 and 4.4, 3). This functionality can be easily implemented in the Siemens Desigo building automation system using the standard solution "AirOptiControl". Applying this solution required communicating room- and VAV-controller that provide the necessary demand information.

8) When cooling the extract air for heat recovery purposes the humidity contained in the air can condensate. At low temperatures this condensate can freeze at the heat exchanger surface. Because of this the free cross-section for the air flow through the heat exchanger can be partially or completely closed off.
   Fans with variable speed drives (VSD) react to an increasing resistance at the heat exchanger with increasing the fan speed in order to still provide the required air flow. This leads to increased power consumption.
   If fans with constant speed are used, then, with the increasing resistance, the air flow on the extract side of the heat exchanger will be reduced in case of icing. With the power consumption remaining about the same, an undesirable over-pressure situation in the ventilation system occurs. This should be avoided.
   Not all heat recovery constructions are similarly prone to icing. With rotating heat exchangers this risk occurs only at very low outside air temperatures. For details on this the manufacturer's documentation should be consulted.

9) This protection function reduces the capacity of the heat recovery system (e.g. via bypass damper for plate exchangers, diverting valve in a CVS-System). The reduced capacity must be compensated with the following air heating coil in the air handling unit.

AUTOMATISCHE REGELUNG				
4		**VENTILATION AND AIR CONDITIONING CONTROL**	**BT**	**Grund der Energieeinsparung**
4.5		Air flow or pressure control at the air handler level		
	0	No automatic control: Continuously supplies of air flow for a maximum load of all rooms.		When the air handling unit is in operation, always the maximally required air flow will be conditioned and transported. This leads to a correspondingly high energy consumption for conditioning and transporation. The air handling unit can also be in operation even if it is not required.
	1	On off time control: Continuously supplies of air flow for a maximum load of all rooms during nominal occupancy time.		The air handling unit will be operated during nominal occupancy times and always the maximum air flow will be conditioned and transported which leads to a correspondingly high energy consumption for conditioning and transportation.
	2	Multi-stage control: To reduce the auxiliary energy demand of the fan	5	As in 1), but with the air flow adjusted in stages (e.g. time schedule reduces the operating stage over lunch, in late afternoon, …). Operating the fan on a reduced stage will lead to correspondingly reduced power consumption for conditioning and disproportionately high reduction of power consumption for transportation (see proportional laws).
	3	Automatic flow or pressure control without pressure reset: Load dependent supplies of air flow for the demand of all connected rooms.	6	As in 1), but in addition the supply pressure will be controlled to a fixed setpoint by modulating the fan speed. If the air flow situation in the rooms change, the pressure in the duct work and the pressure control react to it and the air flow will be adjusted accordingly. This leads to a reduction of the energy consumption for conditioning and transportation. The pressure setpoint will be set accordingly to the most critical situation which leads to an unnecessary high supply pressure at part load operation.
	4	Automatic flow or pressure control with pressure reset: Load dependent supplies of air flow for the demand of all connected rooms (for variable air volume systems with VFD).	7	As in 3), but in addition the supply pressure setpoint will be adjusted based on demand. With that for all supplied rooms it is ensured, that only as much air as required will be conditioned and will be delivered with the minimally required pressure. By gathering the demands, the room with the currently highest demand will be satisfied at all times. This reduces the energy consumption for conditioning and transportation maximally.
4.6		Heat recovery control (icing protection)	8	
		This control function is to avoid icing of the heat exchanger.		
	0	Without icing protection control: There is no specific action to avoid icing of the heat exchanger.		As soon as exhaust air humidity ices up in the heat exchanger (the air spaces fill with ice), the power of the exhaust air fan must be increased to ensure air flow in the room.
	1	With icing protection control: A control loop enables to warranty that the exhaust air temperature leaving the heat exchanger is not too low to avoid frosting.	9	The power of the exhaust air fan need not be increased with icing protection limitation control.

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232-1:2017.

10) This is often the case in plants where separate (independent) control loops are utilized for the heat recovery and the pre-heating and heating coils.

11) This is today’s typical solution that utilizes heating/cooling sequences of the temperature control loop appropriately. By sequencing of the different devices such as heat recovery unit, heating coil and cooling coil they will be properly interlocked.

12) Cooling and ventilation with a portion of passive energy (renewable and at no cost can still require some energy, e.g. electrical energy for supply pumps). With that the portion of active energy (with costs) can be reduced.

AUTOMATIC CONTROL				
4	**VENTILATION AND AIR CONDITIONING CONTROL**		**BT**	**Reason for energy savings**
4.7	Heat recovery control (prevention of overheating)			
		This control function is to avoid overheating at the heat recovery unit.		
	0	Without overheating control There is no specific action to avoid overheating	10	Heat recovery is always on 100% and can overheat the supply air flow, requiring additional energy for cooling.
	1	With overheating control During periods where the effect of the heat exchanger will no more be positive a control loop between "stops" and "modulates" or bypass the heat exchanger.	11	Temperature sequence control at heat recovery prevents unnecessary recooling of the supply air.
4.8	Free mechanical cooling			
	0	No automatic control		Supply air is always mechanically cooled as required using active energy
	1	Night cooling The amount of outdoor air is set to its maximum during the unoccupied period provided: 1) the room temperature is above the set point for the comfort period. 2) the difference between the room temperature and the outdoor temperature is above a given limit. If free night cooling will be realized by automatically opening windows there is no air flow control.		Night cooling (passive cooling): During the night, heat stored in the building mass is removed by cool outdoor air until the lower limit of the comfort range is reached, reducing the use of active cooling energy during the daytime.
	2	Free cooling Both the amount of outdoor air and recirculation air are modulated during all periods of time to minimize the amount of mechanical cooling. Calculation is performed on the basis of temperatures	12	Reduces energy demand on active cooling of supply air: Maximum Economy Changeover (MECH): Heat recovery is opened whenever the exhaust air temperature is lower than the outside temperature. Production of chilled water with outside air: (from supply air via cooling coils and coolant directly to cooling tower). Has priority (favorably priced energy) as long as the outside temperature suffices for cooling.
	3	H,x- directed control The amount of outdoor air and recirculation air are modulated during all periods of time to minimize the amount of mechanical cooling. Calculation is performed on the basis of temperatures and humidity (enthalpy).		Maximum Economy Changeover (MECH): Heat recovery is opened whenever exhaust air enthalpy is lower than outdoor air enthalpy, reducing energy demand on active cooling of supply air.

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232-1:2017.

No special remarks here.

AUTOMATIC CONTROL				
4		**VENTILATION AND AIR CONDITIONING CONTROL**	**BT**	**Reason for energy savings**
4.9		Supply air temperature control at the AHU level		
		There might be several supply air temperatures in an air conditioning system: the supply air temperature at the outlet of the AHU, the supply air temperature at the outlet of central re-heaters as well as supply air temperature at the room level (terminal re-heat boxes). This control function is about how to determine the supply air temperature setpoint (in case there is one) at the air handler level not how to control the temperature (e.g. control of heat emission at the water-to–air HX).		
	0	No automatic control No control loop enables to act on the supply air temperature.		The supply air temperature is provided continuously depending on the maximum load. The highest supply air output is continuously delivered to the rooms or provided for re-treatment, resulting in unnecessary energy losses under part load conditions.
	1	Constant set point A control loop enables to control the supply air temperature, The set point is constant and can only be modified by a manual action.		The supply air temperature is set manually. The air is supplied to the rooms or provided for re-treatment. Temperature is increased manually as needed, but then often not reduced to correct levels. Behavior is suboptimum.
	2	Variable set point with outdoor temperature compensation A control loop enables to control the supply air temperature. The set point is a simple function of the outdoor temperature (e.g. linear function).		Supply air temperature is controlled depending on the outside temperature (corresponding to the probable demand of the individual rooms). Individual load of all individual rooms is not, however, considered. As a result, there is no way to influence how many individual room temperature controllers reheat in the summer or recool in the winter.
	3	Variable set point with load dependent compensation A control loop enables to control the supply air temperature. The set point is defined as a function of the loads in the room. This can normally only be achieved with an integrated control system enabling to collect the temperatures or actuator position in the different rooms.		Single room plant with cascading control: Supply air temperature is controlled depending on the load in the single room plant or reference room plant. Multi-room plant with room automation: The supply air temperature is controlled depending on 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. Notes on both solutions: • Energy demand placed on the HVAC plant drops as the load decreases • The more apart the setpoints of all room controllers for heating and cooling (large neutral zones), the smaller the energy demand placed on the HVAC plant

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232-1:2017.

13) Precondition for dew point control is an air humidifier (air washer) with a humidification efficiency of at least 95 %, by that practically reaching a fully saturated air condition. By controlling to the temperature of this saturated air the humidity content is also fixed. The required control infrastructure for it is relatively small. This solution is only suitable in cases where the air that has been cooled down to the dew point will be reheated in the room by internal (excessive) heat. If this is not the case, a direct humidity control should be implemented in air conditioning systems for efficiency reasons.

14) With spray humidification much lower humidification efficiency than for a dew point humidifier is sufficient. Therefore a less costly device can be utilized. Important is that this device can be controlled within a sufficiently large range.

AUTOMATIC CONTROL				
4		**VENTILATION AND AIR CONDITIONING CONTROL**	**BT**	**Grund der Energieeinsparung**
4.10		Humidity control		
		The control of the air humidity may include humidification and / or dehumidification. Controllers may be applied as "humidity limitation control" or "constant control".		
	0	No automatic control No control loop enables to act on the air humidity.		The humidity of the central supply air is not affected.
	1	Dewpoint control Supply air or room air humidity expresses the Dewpoint temperature and reheat of the supply air to bring the relative humidity to setpoint.	13	Control to the dewpoint requires additional energy to ensure the required inlet temperature.
	2	Direct humidity control Supply air or room air humidity; a control loop enables the supply air or room air humidity at a given setpoint. The setpoint is either fixed and predefined by the user or a fluctuating optimal value at a minimum energy but within min/max limits of room air condition.	14	Only cooled, humidified, and reheated to the extent required, resulting in lower energy consumption.

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232-1:2017.

1) A warning function overrides the turn-off signal by the user when using a scheduler to turn off lighting.
   For switchable lights, they are flashed on/off and turned off after a grace period unless overridden by a user.
   For dimmable lights, they are dimmed to a preset warning level and turned off after a grace period unless overridden by a user.

2) They provide the highest energy savings as lights are typically manually turned on by the user at lower light levels than is required for occupancy detectors that automatically turn lights on.

AUTOMATIC CONTROL				
5		**LIGHTING CONTROL**	**BT**	**Reason for energy savings**
5.1		Occupancy control		Reducing lighting to occupancy times or current needs in room areas saves energy.
	0	<u>Manual on/off switch</u> The luminaire is switched on and off with a manual switch in the room		<u>In residential buildings</u> Users can turn the lighting on and off as needed. This saves lighting energy. <u>In non-residential buildings</u> Lighting is mostly on. Reason: Many users do not turn off lighting during breaks or at the end of the work.
	1	<u>Manual on/off switch + additional sweeping extinction signal</u> The luminaire is switched on and off with a manual switch in the room. In addition, an automatic signal automatically switches off the luminaire at least once a day, typically in the evening to avoid needless operation during the night		Ensures that lights are turned off <u>in non-residential buildings</u> as well (e.g. in the evening or on weekends).
	2	<u>Automatic detection</u> **Auto On / Dimmed Off:** Auto On/Dimmed Off: The control system switches the luminaire(s) automatically on whenever the illuminated area is occupied, and automatically switches them to a state with reduced light output (of no more than 30 % of the normal 'on state') no later than 10 min after the last occupancy in the illuminated area. In addition, no later than 20 min after the last occupancy in the room as a whole is detected, the luminaire(s) is automatically and fully switched off **Auto On / Auto Off**: The control system switches the luminaire(s) automatically on whenever the illuminated area is occupied, and automatically switches them entirely off no later than 10 min after the last occupancy is detected in the illuminated area	1	<u>Auto On/Dimmed Off</u> Current occupancy is recorded in each area, in large rooms, hallways, etc. Then, automatic lighting control … 1. turns on lighting in an area at the start of occupancy, 2. reduces lighting to a maximum of 20% in the area at the end of occupancy, 3. turns off lighting in the room 5 minutes after the end of occupancy. <u>Auto On/Auto Off</u> Actual occupancy times of each room or room area are recorded. Then, automatic lighting control turns on lighting in a room or area at the start of occupancy and turns it off after a maximum of 5 minutes after the end of occupancy.
	3	<u>Automatic detection</u> **Manual On / Partial Auto On /Dimmed Off**: The luminaire(s) can only be switched on by means of a manual switch or automatically by occupancy detection sensor located in (or very close to) the area illuminated by the luminaire(s), and, if not switched off manually, is/are automatically switched to a state with reduced light output (of no more than 30 % of the normal 'on state') no later than 10 min after the last occupancy in the illuminated area. In addition, no later than 20 min after the last occupancy in the room as a whole is detected, the luminaires are automatically and fully switched off **Manual On / Partial Auto On /Auto Off:** The luminaire(s) can only be switched on by means of a manual switch or automatically by occupancy detection sensor located in (or very close to) the area illuminated by the luminaire(s), and, if not switched off manually, is automatically and entirely switched off by the automatic control system no later than 20 min after the last occupancy is detected in the illuminated area	2	<u>Manual On/ Partial Auto On /Dimmed Off</u> Lighting of each area … • can <u>only</u> be switched on manually, • *to be added* • can be dimmed and switched off manually. Actual occupancy times of each area are recorded in the room. Then, automatic lighting control … • reduces lighting to a maximum of 20% in the area at the end of occupancy, • turns off lighting in the room 5 minutes after the end of occupancy. <u>Manual On /Partial Auto On /Auto Off</u> Lighting of each area … • can <u>only</u> be switched on manually, • *to be added* • can be manually switched off. Actual occupancy times of each area are recorded in the room. Then, automatic lighting control turns off the lighting 5 minutes after the end of occupancy in the area.

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232-1:2017.

3) Daylight harvesting based on closed-loop automatic light-level control in combination with presence detection (modes: Manual On/Dimmed (Off) or Manual On/Auto Off) using a sensor in the room is a simple way to integrate automated blinds control.

AUTOMATIC CONTROL				
5	**LIGHTING CONTROL**		**BT**	**Reason for energy savings**
5.2	Light level / Daylight control (daylight harvesting)			Artificial lighting can be reduced as the incoming daylight increases, thus saving energy.
	0	Manual central Luminaires are controlled centrally; there is no manual switch in the room/zone.		Luminaires will be manually adjusted from a central point when the day light level becomes too low. However, the luminaires often will not be reduced when the day light is at a sufficient level (sub optimal).
	1	Manual Luminaires can be switched off with a manual switch in the room.		As in 0), but in addition the luminaires can be switched off manually in each room (increased local interaction possibilities). However, also with this setup, the luminaires often will not be turned off when the day light is at a sufficient level (sub optimal).
	2	Automatic switching The luminaires are automatically switched off when more than enough daylight is present to fully provide minimum illuminance required and switched on when there is not enough daylight.		With a sufficient day light level the luminaires will be switched off which eliminates the disadvantages of 0) and 1). Automatically switching on guarantees sufficient lighting.
	3	Automatic dimming The luminaires are dimmed down and finally fully switched off when daylight is available. The luminaires will be switched on again and dimmed up if the amount of daylight is decreasing.	3	Automatically supplemented lighting to the incoming daylight always ensures that there is sufficient lighting at minimum energy.

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232-1:2017.

1) Reasons for blind control:
   - Reduces external light can prevent blinding room users.
   - Reduces heat radiation in the room saves cooling energy.
   - Allowing heat radiation in the room saves heating energy.
   - Closed blinds reduce heat loss in the room.

2) Using shadow-edge tracking or sun-tracking individually or in combination provides solar protection from direct solar irradiance resulting in lower heat gain and at the same time uses indirect and diffuse sunlight for daylight harvesting in combination with automatic light level control (see 5.2-1).

3) The key component is a presence detector with three control channels for HVAC, lighting and solar protection. Coordination between lighting and solar protection control is achieved via the light level in the room. Coordination between solar protection control and HVAC is achieved via the room temperature.

AUTOMATIC CONTROL				
6	**BLIND CONTROL**		**BT**	**Reason for energy savings**
		There are two different motivations for blind control: solar protection to avoid overheating and to avoid glaring	1	
	0	Manual operation Mostly used only for manual shadowing, energy saving depends only on the user behavior		Usually, manual interventions are only made for glare protection. Energy savings are highly dependent on user behavior.
	1	Motorized operation with manual control Mostly used only for easiest manual (motor supported) shadowing, energy saving depends only on the user behavior		Motorized support only eases manual intervention and is mostly only done for glare protection. Energy savings are highly dependent on user behavior.
	2	Motorized operation with automatic control Automatic controlled dimming to reduce cooling energy	2	Motorized support is required for automatic control. The focus of automatic control functions is in the support of solar protection, reducing the heat input such that cooling energy can be saved. Manual operation by the user must be possible at all times, allowing the user to achieve glare protection independent of automatic solar protection control for energy savings.
	3	Combined light/blind/HVAC control To optimize energy use for HVAC, blind and lighting for occupied and non-occupied rooms	3	This processing function considers all the reasons to meet the needs of the use and energy-optimized (prioritized consideration for occupied and non-occupied rooms).

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232-1:2017.

No special remarks here.

AUTOMATIC CONTROL				
7	**TECHNICAL HOME AND BUILDING MANAGEMENT**		**BT**	**Reason for energy savings**
	The Technical Home and Building Management enables to adapt easily the operation to the user needs. *One shall check at regular intervals that the operation schedules of heating, cooling, ventilation and lighting is well adapted to the actual used schedules and that the set points are also adapted to the needs.* - *Attention shall be paid to the tuning of all controllers this includes set points as well as control parameters such as PI controller coefficients.* - *Heating and cooling set points of the room controllers shall be checked at regular intervals. The users often modify these set points. A centralized system enables to detect and correct extreme values of set points due to misunderstanding of users.* - *If the Interlock between heating and cooling control of emission and/or distribution is only a partial interlock. The set point shall be regularly modified to minimize the simultaneous use of heating and cooling.* - *Alarming and monitoring functions will support the adaptation of the operation to user needs and the optimization of the tuning of the different controllers. This will be achieved by providing easy tools to detect abnormal operation (alarming functions) and by providing easy way to log and plot information (monitoring functions).*			
7.1	Setpoint management			
		Management, set back and adaptation of BAC setpoints according to the room/zone operating modes		This part is about management of setpoints. The better they can be controlled, reset … and the more this can be done from a central location, the better.
	0	Manual setting room by room individually		In order to set/reset the setpoints an operator would have to do this room by room. Since this is rather cumbersome, most often it will not be done. This then leads to unnecessary high energy consumption due to inappropriate setpoint settings that remain for a long time.
	1	Adaptation from distributed/decentralized plant rooms only		The setpoints can be adjusted from a plant room that is located away from the supplied rooms. In order to set/reset the setpoints an operator would have to go to the respective plant room, which is still cumbersome and therefore quite often will not be done as required. This then leads to unnecessary high energy consumption due to inappropriate setpoint settings that remain for a certain time.
	2	Adaptation from a central room (e.g. work station, web operation; room operating units are excluded)		Here setpoints can be adjusted from a central location that is close(r) to the various rooms (e.g. one possibility on each floor …). For this it is required that the local setpoint adjustments are not with fixed hardware positions. With that it is more likely that setpoints will get adjusted/reset, which reduces the energy consumption somewhat.
	3	Adaptation from a central room (e.g. work station, web operation; room operating units are excluded) with frequent set back of user inputs		As in 2) but with automated resetting (e.g. daily, at lunch, at the end of the working day …) of user adjusted setpoints to specified values. This ensures frequent operation at specified setpoints which in turn reduces the energy consumption.

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232-1:2017.

1) Errors, deviations, etc., are automatically determined and reported, making it possible to eliminate less-than-efficient operation as early as possible.

2) Recording energy consumption and operational data provides the foundation for…
   - evaluating the building, plants as well as their operation,
   - issuing an energy pass,
   - recognizing potential improvements and plan measures.

AUTOMATIC CONTROL				
7		**TECHNICAL HOME AND BUILDING MANAGEMENT**	**BT**	**Reason for energy savings**
7.2		Manual setting room by room individually		
		Adaptation of system/plant operating hours according to given time schedule and/or calendar		
	0	Manual setting (plant enabling)		Often such plants are turned on at a reasonable time, but often are operating for unnecessarily long time, because they are not switched off based on demand. This results in unnecessary high energy consumption.
	1	Individual setting following a predefined schedule including fixed preconditioning phases		With a predefined time schedule the situation regarding switching off (see 0) will be improved. The fixed time definitions and the fixed preconditioning phases however lead to the plant being in operation even though it would not (yet) be necessary from a demand perspective.
	2	Individual setting following a predefined time schedule; adaptation from a central room (e.g. work station, web operation; room operating units are excluded); variable preconditioning phases		With this a better adjustment to the demand situation will be achieved and the plant mostly will only be in operation if it is required.
7.3		Detecting faults of technical building systems and providing support to the diagnosis of these faults	1	
	0	No central indication of detected faults and alarms		Faults and alarms very often are detected too late or not at all which leads to an unnecessary high energy consumptions until they are detected/fixed.
	1	With central indication of detected faults and alarms		With this faults and alarms will be indicated at a central location. The diagnosis depends on the capabilities/availabilities of the technical personnel. This often leads to delays in fixing them and with that to unnecessary high energy consumption until the fault situation gets fixed.
	2	With central indication of detected faults and alarms including diagnosing functions		With this faults and alarms will be indicated at a central location and the technical personnel have diagnostic functions available for quickly fixing them. This helps to respond early and focused and prevent unnecessary high energy consumption.
7.4		Reporting information regarding energy consumption, indoor conditions	2	
	0	Indication of actual values only (e.g. temperatures, meter values)		The information is available but without reasonable tools very often nothing happens based on it. Due to that increases in energy consumption are not detected (early on).
	1	Trending functions and consumption determination		Consumption data and trend information allow for early detection of changes. Whether it is possible to prevent increases in energy consumption based on this information depends on the capabilities and the availabilities of the technical personnel.
	2	Analyzing, performance evaluation, benchmarking of indoor environment and energy		With analysis and evaluation functions and the benchmarking of the indoor environment and energy consumption it is possible to prevent increasing energy consumption early on and with a focused effort.

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232-1:2017.

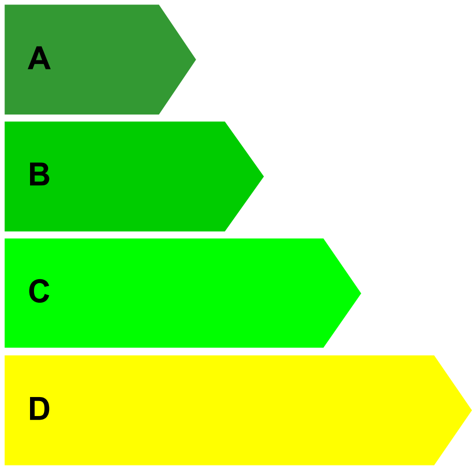
3) Local energy sources and energy production provide for a reduction of energy consumption from the net and therefore contribute to the reduction of superordinate produced energy (power plants) and with that contribute to the energy transition.

4) Heat recovery and heat shifting reduce the consumption of primary energy. With corresponding intermediate storage the waste heat utilization can be maximized.

AUTOMATIC CONTROL				
7	**TECHNICAL HOME AND BUILDING MANAGEMENT**		**BT**	**Reason for energy savings**
7.5	Local energy production and renewable energy		3	
		Managing local renewable energy sources and other local energy productions as CHP		
	0	Uncontrolled generation depending on the fluctuating availability of RES and or run time of CHP; overproduction will be fed into the grid		With that not all possibilities of local energy production and of renewable energy sources are utilized which leads to a corresponding energy consumption from the grid.
	1	Coordination of local RES and CHP with regard to local energy demand profile including energy storage management; Optimization of own consumption		With that the renewable energy sources and the local energy production will be extensively utilized and time gaps between production and utilization will be optimized regarding the energy consumption.
7.6	Heat recovery and heat shifting		4	
		Using of waste heat recovery on the building level and heat shifting		
	0	Instantaneous use of waste heat or heat shifting		Waste heat utilization and heat shifting is only done when is directly possible. With that a certain utilization potential is not realized.
	1	Managed use of waste heat or heat shifting (including charging/discharging TES)		With this time gaps between utilization and availability of waste heat will be taken into account which increases and optimizes the utilization of waste heat and heat shifting.
7.7	Smart grid integration			
		Interactions between building and any smart grid including demand side management		
	0	No harmonization between grid and building energy systems; building is operated independently from the grid load		This represents today's typical situation, therefore the „standard" classification.
	1	Building energy systems are managed and operated depending on grid load; demand side management is used for load shifting		The coordination of the building's energy systems with the grid load (smart-grid) is often driven by economical aspects, but can lead to improved energy efficiency. If the impact on energy efficiency is very small, the function can be excluded accordingly to the 5%-rule (see FprCEN/TR 15232-2).

4.2. BAC efficiency classes

EN 15232 defines four different BAC efficiency classes (A, B, C, D) For building automation and control systems:



Class	Energy efficiency
A	Corresponds to high energy performance BACS and TBM • Networked room automation with automatic demand control • Scheduled maintenance • Energy monitoring • Sustainable energy optimization
B	Corresponds to advanced BACS and some specific TBM functions • Networked room automation without automatic demand control • Energy monitoring
C	Corresponds to standard BACS • Networked building automation of primary plants • No electronic room automation, thermostatic valves for radiators • No energy monitoring
D	Corresponds to non-energy efficient BACS. Buildings with such systems shall be retrofitted. New buildings shall not be equipped with such systems • Without networked building automation functions • No electronic room automation • No energy monitoring

All processing functions in EN 15232 are assigned to one of the four classes for residential and non-residential buildings.

Function classification list

The function classification list below contains 11 columns:

Columns 1 to 11 correspond to the content of EN 15232-1:2017

- Column 1 Number of BACS and TBM functions
- Column 2 Field of use and the corresponding numbers for possible processing functions
- Column 3 Processing functions for evaluation
- In columns 4 to 7
  Each processing function is assigned a BAC energy efficiency class for residential buildings. The gray rows should be interpreted from the left as columns in the corresponding class.
  Example for class B:

D	C	B	A

- In column 8 to 11
  Each processing function is assigned a BAC energy efficiency class for non-residential buildings.

1	2		4								
1	2		4								
1	2	3	4	5	6	7	8	9	10	11	

On the following pages are

- Right side: Tables of EN 15232
- Left side: Remarks of Siemens

→ Continued on the next double-page

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232-1:2017.

1.1

Plants and installations required for "emission control" of thermal energy, such as radiators, chilled ceilings or VAV systems, may use different supply media (e.g. water, air, electricity). As a result, different BAC solutions may be possible for a processing function.

2 The Siemens interpretation gives full consideration to the processing function in the function list of EN 15232:

- It includes thermostatic valves and electronic control equipment.
- Non-communicating electronic control equipment may include a local scheduler, but experience suggests that they are often not correctly set.
- Thermostatic valves are not used for "cooling control".

3 Communication between a superposed central unit and electronic individual room controllers allow for central schedulers, monitoring of individual room controllers as well as centralized operation and monitoring.

4 Demand control (by use) = demand control based on occupancy information from a presence detector or a presence button with automatic reset after a set period. Control switches from Pre-Comfort to Comfort or the other way around using this occupancy information (see EN 15500).

Notes:

- Air quality control is considered in "Ventilation and air conditioning control"
- Occupancy information can influence "heating control", "cooling control" and "ventilation and air conditioning control"

1.2

1 As a rule, there is only a single flow temperature setpoint per zone (heating and cooling – no setpoint range, so that it often overheats or undercools somewhat during transition periods (where heating and cooling are released).

2 A setpoint range is used here. One setpoint each can be preset separately for heating and cooling. This eliminates to some extent over- or underheating.

1.4

3 The pump is only enabled for demand.
With *constant* Δp: Pressure differential does not increase at decreasing load when maintaining a constant pressure differential across the pump. The pump speed is reduced under part load conditions, which lowers power consumption.
With *variable* Δp: Pressure differential across the pump drops as the load decreases. This provides additional reductions in speed and electrical power under part load conditions.

4 With *variable* Δp following an external demand signal, the pump speed is reduced under part load conditions as much as possible whilst ensuring, that the consumer with the largest demand is still satisfied at any given operational situation, i.e. no underprovisioning of certain consumers. This lowers power consumption maximally.

1.7

The Coefficient of Performance (COP) and the Seasonal Energy Efficiency Ration (SEER) of heat pump plants is positively influenced on the one hand by lower flow temperature, while also benefiting from a small temperature differential of evaporator and condenser.

			Definition of classes							
			Residential				**Non residential**			
			D	**C**	**B**	**A**	**D**	**C**	**B**	**A**
AUTOMATIC CONTROL										
1	**HEATING CONTROL**									
1.1	Emission control									
		The control function is applied to the heat emitter (radiators, underfloor heating, fan-coil unit, indoor unit) at room level; for type 1 one function can control several rooms								
	0	No automatic control								
	1	Central automatic control								
	2	Individual room control								
	3	Individual room control with communication				a				a
	4	Individual room control with communication and occupancy detection (not applied to slow reacting heating emission systems, e.g. floor heating)								
	a	In case of slow reacting heat (and cool) emission systems, e.g. floor heating, wall heating, etc. functions 1.1.3 (and 3.1.3) are allocated to BAC class A.								
1.2	Emission control for TABS (heating mode)									
	0	No automatic control								
	1	Central automatic control								
	2	Advanced central automatic control								
	3	Advanced central automatic control with intermittent operation and/or room temperature feedback control								
1.3	Control of distribution network hot water temperature (supply or return)									
		Similar function can be applied to the control of direct electric heating networks								
	0	No automatic control								
	1	Outside temperature compensated control								
	2	Demand based control								
1.4	Control of distribution pumps in networks									
		The controlled pumps can be installed at different levels in the network								
	0	No automatic control								
	1	On off control								
	2	Multi-Stage control								
	3	Variable speed pump control (pump unit (internal) estimations)								
	4	Variable speed pump control (external demand signal)								
1.5	Intermittent control of emission and/or distribution									
		One controller can control different rooms/zones having same occupancy patterns								
	0	No automatic control								
	1	Automatic control with fixed time program								
	2	Automatic control with optimum start/stop								
	3	Automatic control with demand evaluation								
1.6	Heat generator control (combustion and district heating)									
	0	Constant temperature control								
	1	Variable temperature control depending on outside temperature								
	2	Variable temperature control depending on the load								
1.7	Heat generator control (heat pump)									
	0	Constant temperature control								
	1	Variable temperature control depending on outside temperature								
	2	Variable temperature control depending on the load								

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232-1:2017.

1.8

1 With several capacity stages, the heat production can be provided according to the demand to a certain degree.

2 With variable control the produced heat can always be provided according to the demand.

1.9

0 Setting priorities based on run times has the focus of a controlled usage (e.g. evenly). The influence on the energy consumption is very minimal.

1 With that the production is according to demand, however without considering producer features.

2 With that the most efficient producer for a specific operational situation is utilized.

3 With predictive determined load situations the optimal producer (producer combination) for a specific load situation will be selected early on.

1.10

0 With continuous storage unnecessarily high storage losses occur.

1 Producers will be operated demand based accordingly to the storage loading situation.

2 The storages will be predictively loaded only as much as in the future required. This minimizes storage losses and utilizes the producers the best way.

			Definition of classes							
			Residential				Non residential			
			D	C	B	A	D	C	B	A
AUTOMATIC CONTROL										
1	**HEATING CONTROL**									
1.8	Heat generator control (outdoor unit)									
	0	On/Off-control of heat generator								
	1	Multi-stage control of heat generator								
	2	Variable control of heat generator								
1.9	Sequencing of different heat generators									
	0	Priorities only based on running times								
	1	Priorities only based on loads								
	2	Priorities based on generator efficiency and characteristics								
	3	Load prediction based sequencing								
1.10	Control of Thermal Energy Storage (TES) operation									
	0	Continuous storage operation								
	1	2-sensor charging of storage								
	2	Load prediction based storage operation								

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232-1:2017.

2

As a rule, DHW heating with storage tank is considered since considerable energy losses may arise for improper solutions. Instantaneous water heaters close to the consumers are normally operated based on demand and have limited automation functions.

2.2

1 A defined charging time can minimize the amount of time a higher generation temperature is required for DHW charging.

2 In addition to 1) the storage will only be loaded as much as required.

2.3

1 Here the solar energy will be utilized with priority whenever possible. The additionally required heat will be provided by the producer.

2 In addition to 1) the producer will operate based on demand with the minimally required temperature resp. only as long as the storage demand requires.

2.4

0 The hot water circulation pipe from the storage tank to the consumer loses considerable amounts of energy when operating continuously. The storage tank temperature drops due to the continuous energy losses. Frequent recharging is required to cover the losses.

1 The circulation is operating when reasonable for the building. With the losses will be reduced and there is limited unnecessary warm water circulation.

			Definition of classes							
			Residential				Non residential			
			D	C	B	A	D	C	B	A
AUTOMATIC CONTROL										
2	**DOMESTIC HOT WATER SUPPLY CONTROL**									
2.1	Control of DHW storage temperature with integrated electric heating or electric heat pump									
	0	Automatic control on/off	■				■			
	1	Automatic control on/off and scheduled charging enable	■	■			■	■		
	2	Automatic control on/off and scheduled charging enable and multi-sensor storage management	■	■	■	■	■	■	■	■
2.2	Control of DHW storage charging using heat generation									
	0	Automatic control on/off	■				■			
	1	Automatic control on/off and scheduled charging enable	■	■			■	■		
	2	Automatic control on/off, scheduled charging enable, demand-oriented supply or multi-sensor storage management	■	■	■	■	■	■	■	■
2.3	Control of DHW storage charging with solar collector and supplementary heat generation									
	0	Manual selected control	■				■			
	1	Automatic control of solar storage charge (Prio. 1) and supplementary storage charge (Prio. 2)	■	■			■	■		
	2	Automatic control of solar storage charge (Prio. 1) and supplementary storage charge (Prio. 2) plus-demand based supply temperature control or multi-sensor storage management	■	■	■		■	■	■	
2.4	Control of DHW circulation pump									
	0	No control, continuous operation	■				■			
	1	With time program	■	■	■		■	■	■	

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232-1:2017.

3.1

Plants required for "emission control" of thermal energy such as fan coils, chilled ceilings or VAV systems, may have different supply media (e.g. water, air, electricity). As a result, different BAC solutions may be possible for a processing function.

1 The Siemens interpretation gives full consideration to by the processing function in the function list of EN 15232: It includes thermostatic valves and electronic control equipment.

- Non-communicating electronic control equipment may include a local scheduler, but experience suggests that they are often not correctly set.
- Thermostatic valves are not used for "cooling control".

3 Communication between a superposed central unit and electronic individual room controllers allow for central schedulers, monitoring of individual room controllers as well as centralized operation and monitoring.

4 Demand control (by use) = demand control based on occupancy information from a presence detector or a presence button with automatic reset after a set period. Control switches from Pre-Comfort to Comfort or the other way around using this occupancy information (see EN 15500).

Notes:

- Air quality control is considered in "Ventilation and air conditioning control"
- Occupancy information can influence "heating control", "cooling control" and "ventilation and air conditioning control"

3.2

1 As a rule, there is only a single flow temperature setpoint per zone (heating and cooling – no setpoint range, so that it often overheats or undercools somewhat during transition periods (where heating and cooling are released).

2 A setpoint range is used here; one setpoint each can be preset separately for heating and cooling activities. This eliminates to some extent overheating or underheating.

3.4

3 The pump is only enabled for demand.
With *constant* Δp: Pressure differential does not increase at decreasing load when maintaining a constant pressure differential across the pump. The pump speed is reduced under part load conditions, which lowers power consumption.
With *variable* Δp: Pressure differential across the pump drops as the load decreases. This provides additional reductions in speed and electrical power under part load conditions.

4 With *variable* Δp following an external demand signal, the pump speed is reduced under part load conditions as much as possible whilst ensuring, that the consumer with the largest demand is still satisfied at any given operational situation, i.e. no underprovisioning of certain consumers. This lowers power consumption maximally.

			Definition of classes							
			Residential				**Non residential**			
			D	**C**	**B**	**A**	**D**	**C**	**B**	**A**
AUTOMATIC CONTROL										
3	**COOLING CONTROL**									
3.1	Emission control									
		The control function is applied to the emitter (cooling panel, fan-coil unit or indoor unit) at room level; for type 1 one function can control several rooms								
	0	No automatic control								
	1	Central automatic control								
	2	Individual room control								
	3	Individual room control with communication				a				a
	4	Individual room control with communication and occupancy detection (not applied to slow reacting cooling emission systems, e.g. floor cooling)								
	a	In case of slow reacting (heat and) cool emission systems, e.g. floor heating, wall heating, etc. functions (1.1.3 and) 3.1.3 are allocated to BAC class A.								
3.2	Emission control for TABS (cooling mode)									
	0	No automatic control								
	1	Central automatic control								
	2	Advanced central automatic control								
	3	Advanced central automatic control with intermittent operation and/or room temperature feedback control								
3.3	Control of distribution network chilled water temperature (supply or return)									
		Similar function can be applied to the control of direct electric cooling (e.g. compact cooling units, split units) for individual rooms								
	0	Constant temperature control								
	1	Outside temperature compensated control								
	2	Demand based control								
3.4	Control of distribution pumps in networks									
		The controlled pumps can be installed at different levels in the network								
	0	No automatic control								
	1	On off control								
	2	Multi-Stage control								
	3	Variable speed pump control (pump unit (internal) estimations)								
	4	Variable speed pump control (external demand signal)								
3.5	Intermittent control of emission and/or distribution									
		One controller can control different rooms/zones having same occupancy patterns								
	0	No automatic control								
	1	Automatic control with fixed time program								
	2	Automatic control with optimum start/stop								
	3	Automatic control with demand evaluation								
3.6	Interlock between heating and cooling control of emission and/or distribution									
	0	No interlock								
	1	Partial interlock (dependent on the HVAC system)								
	2	Total interlock								
3.7	Different chillers selection control for cooling									
		The goal consists generally in maximizing the chiller operation temperature								
	0	Constant temperature control								
	1	Variable temperature control depending on outside temperature								
	2	Variable temperature control depending on the load								

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232-1:2017.

3.8

0 Setting priorities based on run times has the focus of a controlled usage (e.g. evenly). The influence on the energy consumption is very minimal.

1 With that the production is according to demand, however without considering producer features.

2 With that the most efficient producer for a specific operational situation is utilized.

3 With predictive determined load situations the optimal producer (producer combination) for a specific load situation will be selected early on.

3.9

0 With continuous storage unnecessarily high storage losses occur.

1 Producers will be operated demand based accordingly to the storage loading situation.

2 The storages will be predictively loaded only as much as in the future required. This minimizes storage losses and utilizes the producers the best way.

			Definition of classes							
			Residential				Non residential			
			D	C	B	A	D	C	B	A
AUTOMATIC CONTROL										
3	**COOLING CONTROL**									
3.8	Sequencing of different chillers									
	0	Priorities only based on running times								
	1	Priorities only based on loads								
	2	Priorities based on generator efficiency and characteristics								
	3	Load prediction based sequencing								
3.9	Control of Thermal Energy Storage (TES) operation									
	0	Continuous storage operation								
	1	Time-scheduled storage operation								
	2	Load prediction based storage operation								

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232-1:2017.

4.1

Here only air renewal in the room is considered.
Note: For the room temperature control the parts “Heating control” and “Cooling control” of the EN 15232 are to be considered.

4.3

1 With that it will be prevented that two control loops attempt to control the same control value. This means e.g. the room heating is set to bring the room temperature to 15 °C, the supply air temperature will then be provided depending on the room temperature in order to maintain the desired room temperature. With that internal heat gains (e.g. from people, devices, lighting, …) can be considered or compensated.

4.4

3 By taking air quality indicators (CO_2, VOC/mixed gas) into account the rooms will always be provided with the minimally required outside air flows. Because of this only this outside air flow must be conditioned. This keeps the energy consumption low.

4.5

2 By switching stages the speed n of the fans and with that the air flow $\dot{V}$ will be changed. With that the power consumption of the fans changes too. For that, the following proportional (or affinity) laws apply:

$$\frac{n_1}{n_2} = \frac{\dot{V}_1}{\dot{V}_2} \text{ und } \frac{P_1}{P_2} = \left(\frac{\dot{V}_1}{\dot{V}_2}\right)^3 \text{ resp. } \frac{P_1}{P_2} = \left(\frac{n_1}{n_2}\right)^3$$

Example:
At half the speed, the air flow is reduced to its half (1/2) * also and the power consumption goes down to an eighth (1/8) *.

Note:
* This applies under ideal (loss-free) conditions only. For practical purposes the fan vendor’s documentation should be consulted. The reduction of the power consumption e.g. at half the air flow is substantial based on experience and disproportionately high (e.g. 60 %)

3 This type of control is widely used. It provides for adjusting the air flow to the demand of the rooms. However there is no direct connection between the controllers in the room and the air flow control at the air handling unit. Changes from the rooms will be transmitted via the duct work and will affect the air pressure (e.g. VAV-controllers close → pressure at the sensor increases). The pressure control can react to that and adjust the air flow at the fan based on that e.g. with a variable speed drive (VSD). Based on experience the set point for the supplied air pressure is often set too high (be on the safe side, poorly balanced air duct work). This leads to continuously and disproportionally high energy consumption for the air transportation (see proportional laws under 2).

4 This control approach requires individual control of the air flow at room level based on temperature and/or air quality (4.2, 2 and 4.4, 3). This functionality can be easily implemented in the Siemens Desigo building automation system using the standard solution “AirOptiControl”. Applying this solution required communicating room- and VAV-controller that provide the necessary demand information.

			Definition of classes							
			Residential				Non residential			
			D	C	B	A	D	C	B	A
AUTOMATIC CONTROL										
4	**VENTILATION AND AIR CONDITIONING CONTROL**									
4.1	Supply air flow control at the room level									
	0	No automatic control	■				■			
	1	Time control	■	■	■		■	■	■	
	2	Occupancy detection	■	■	■	■	■	■	■	■
4.2	Room air temp. control (all-air systems)									
	0	on-off control	■				■			
	1	variable control	■	■			■	■		
	2	Demand control	■	■	■	■	■	■	■	■
4.3	Room air temp. control (Combined air-water systems)									
	0	No coordination	■				■			
	1	Coordination	■	■	■	■	■	■	■	■
4.4	Outside air (OA) flow control									
	0	Fixed OA ratio/OA flow	■	■			■			
	1	Staged (low/high) OA ratio/OA flow (time schedule)	■	■	■		■	■		
	2	Staged (low/high) OA ratio/OA flow (occupancy)	■	■	■		■	■	■	
	3	Variable control	■	■	■	■	■	■	■	■
4.5	Air flow or pressure control at the air handler level									
	0	No automatic control	■				■			
	1	On off time control	■	■			■	■		
	2	Multi-stage control	■	■	■		■	■	■	
	3	Automatic flow or pressure control (without reset)	■	■	■	■	■	■	■	■
	4	Automatic flow or pressure control (with reset)	■	■	■	■	■	■	■	■

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232-1:2017.

4.6

1 When cooling the extract air for heat recovery purposes the humidity contained in the air can condensate. At low temperatures this condensate can freeze at the heat exchanger surface. Because of this the free cross-section for the air flow through the heat exchanger can be partially or completely closed off.
Fans with variable speed drives (VSD) react to an increasing resistance at the heat exchanger with increasing the fan speed in order to still provide the required air flow. This leads to increased power consumption.
If fans with constant speed are used, then, with the increasing resistance, the air flow on the extract side of the heat exchanger will be reduced in case of icing. With the power consumption remaining about the same, an undesirable over-pressure situation in the ventilation system occurs. This should be avoided.
Not all heat recovery constructions are similarly prone to icing. With rotating heat exchangers this risk occurs only at very low outside air temperatures. For details on this the manufacturer's documentation should be consulted.

This protection function reduces the capacity of the heat recovery system (e.g. via bypass damper for plate exchangers, diverting valve in a CVS-System). The reduced capacity must be compensated with the following air heating coil in the air handling unit.

4.7

0 This is often the case in plants where separate (independent) control loops are utilized for the heat recovery and the pre-heating and heating coils.

1 This is today's typical solution that utilizes heating/cooling sequences of the temperature control loop appropriately. By sequencing of the different devices such as heat recovery unit, heating coil and cooling coil they will be properly interlocked.

4.8

2 Cooling and ventilation with a portion of passive energy (renewable and at no cost can still require some energy, e.g. electrical energy for supply pumps). With that the portion of active energy (with costs) can be reduced.

4.10

1 Precondition for dew point control is an air humidifier (air washer) with a humidification efficiency of at least 95 %, by that practically reaching a fully saturated air condition. By controlling to the temperature of this saturated air the humidity content is also fixed. The required control infrastructure for it is relatively small. This solution is only suitable in cases where the air that has been cooled down to the dew point will be reheated in the room by internal (excessive) heat. If this is not the case, a direct humidity control should be implemented in air conditioning systems for efficiency reasons.

2 With spray humidification much lower humidification efficiency than for a dew point humidifier is sufficient. Therefore a less costly device can be utilized. Important is that this device can be controlled within a sufficiently large range.

			Definition of classes							
			Residential				Non residential			
			D	C	B	A	D	C	B	A
AUTOMATIC CONTROL										
4	**VENTILATION AND AIR CONDITIONING CONTROL**									
4.6	Heat recovery control: icing protection									
	0	Without icing protection	■				■			
	1	With icing protection	■	■	■	■	■	■	■	■
4.7	Heat recovery control: prevention of overheating									
	0	Without overheating control	■				■			
	1	With overheating control	■	■	■	■	■	■	■	■
4.8	Free mechanical cooling									
	0	No automatic control	■				■			
	1	Night cooling	■	■			■	■		
	2	Free cooling	■	■	■		■	■	■	
	3	H,x- directed control	■	■	■	■	■	■	■	■
4.9	Supply air temperature control									
	0	No automatic control	■				■			
	1	Constant set point	■	■			■	■		
	2	Variable set point with outside temperature compensation	■	■	■		■	■	■	
	3	Variable set point with load dependent compensation	■	■	■	■	■	■	■	■
4.10	Humidity control									
	0	No automatic control	■				■			
	1	Dewpoint control	■	■			■	■		
	2	Direct humidity control	■	■	■	■	■	■	■	■

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232-1:2017.

5.1

2 A warning function overrides the turn-off signal by the user when using a scheduler to turn off lighting.
For switchable lights, they are flashed on/off and turned off after a grace period unless overridden by a user.
For dimmable lights, they are dimmed to a preset warning level and turned off after a grace period unless overridden by a user.

3 They provide the highest energy savings as lights are typically manually turned on by the user at lower light levels than is required for occupancy detectors that automatically turn lights on.

5.2

3 Daylight harvesting based on closed-loop automatic light-level control in combination with presence detection (modes: Manual On/Dimmed (Off) or Manual On/Auto Off) using a sensor in the room is a simple way to integrate automated blinds control.

6

Reasons for blind control:
- Reduces external light can prevent blinding room users.
- Reduces heat radiation in the room saves cooling energy.
- Allowing heat radiation in the room saves heating energy.
- Closed blinds reduce heat loss in the room.

2 Using shadow-edge tracking or sun-tracking individually or in combination provides solar protection from direct solar irradiance resulting in lower heat gain and at the same time uses indirect and diffuse sunlight for daylight harvesting in combination with automatic light level control (see 5.2-1).

3 The key component is a presence detector with three control channels for HVAC, lighting and solar protection. Coordination between lighting and solar protection control is achieved via the light level in the room. Coordination between solar protection control and HVAC is achieved via the room temperature.

			Definition of classes							
			Residential				Non residential			
			D	C	B	A	D	C	B	A
AUTOMATIC CONTROL										
5	**LIGHTING CONTROL**									
5.1	Occupancy control									
	0	Manual on/off switch								
	1	Manual on/off switch + additional sweeping extinction signal								
	2	Automatic detection (auto on)								
	3	Automatic detection (manual on)								
5.2	Light level / Daylight control									
	0	Manual (central)								
	1	Manual (per room/zone)								
	2	Automatic switching								
	3	Automatic dimming								
6	**BLIND CONTROL**									
	0	Manual operation								
	1	Motorized operation with manual control								
	2	Motorized operation with automatic control								
	3	Combined light/blind/HVAC control								

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232-1:2017.

7.3

1 Errors, deviations, etc., are automatically determined and reported, making it possible to eliminate less-than-efficient operation as early as possible.

7.4

Recording energy consumption and operational data provides the foundation for…
- evaluating the building, plants as well as their operation,
- issuing an energy pass,
- recognizing potential improvements and plan measures.

7.5

Local energy sources and energy production provide for a reduction of energy consumption from the net and therefore contribute to the reduction of superordinate produced energy (power plants) and with that contribute to the energy transition.

7.6

Heat recovery and heat shifting reduce the consumption of primary energy. With corresponding intermediate storage the waste heat utilization can be maximized.

			Definition of classes							
			Residential				Non residential			
			D	C	B	A	D	C	B	A
AUTOMATIC CONTROL										
7	**TECHNICAL HOME AND BUILDING MANAGEMENT**									
7.1	Setpoint management									
	0	Manual setting room by room individually								
	1	Adaptation from distributed/decentralized plant rooms only								
	2	Adaptation from a central room								
	3	Adaptation from a central room with frequent set back of user inputs								
7.2	Runtime management									
	0	Manual setting (plant enabling)								
	1	Individual setting following a predefined time schedule including fixed preconditioning phases								
	2	Individual setting following a predefined time schedule; adaptation from a central room; variable preconditioning phases								
7.3	Detecting faults of technical building systems and providing support to the diagnosis of these faults									
	0	No central indication of detected faults and alarms								
	1	With central indication of detected faults and alarms								
	2	With central indication of detected faults and alarms/diagnosing functions								
7.4	Reporting information regarding energy consumption, indoor conditions									
	0	Indication of actual values only (e.g. temperatures, meter values)								
	1	Trending functions and consumption determination								
	2	Analyzing, performance evaluation, benchmarking								
7.5	Local energy production and renewable energies									
	0	Uncontrolled generation depending on the fluctuating availability of RES and or run time of CHP; overproduction will be fed into the grid								
	1	Coordination of local RES and CHP with regard to local energy demand profile including energy storage management; Optimization of own consumption								
7.6	Waste heat recovery and heat shifting									
	0	Instantaneous use of waste heat or heat shifting								
	1	Managed use of waste heat or heat shifting (including charging/discharging TES)								
7.7	Smart Grid integration									
	0	No harmonization between grid and building energy systems; building is operated independently from the grid load								
	1	Building energy systems are managed and operated depending on grid load; demand side management is used for load shifting								

4.2.1. Procedure for meeting an efficiency class for BACS projects

Example: Single room store

The building contains an open single room store that is air conditioned using a central air handling unit. Heating and cooling take place on the air side using heat exchangers (water-air).

Requirement: BAC class B

Approach

1. Relevant functions (e.g. 4.1) to the project are being marked in column 1 e.g. by coloring the cell.
2. Draw a line on the right-hand side for the required BAC class.
3. Select a processing function for each relevant function and the classification column (at a minimum) must reach the required class. It is marked by an "**X**" in column 1.

			Definition of classes							
			Residential				Non residential			
			D	C	B	A	D	C	B	A
AUTOMATIC CONTROL										
4	**VENTILATION AND AIR CONDITIONING CONTROL**									
4.1	Supply air flow control at the room level									
	0	No automatic control								
X	1	Time control								
	2	Occupancy detection								
4.2	Room air temp. control (all-air systems)									
	0	on-off control								
	1	variable control								
X	2	Demand control								
4.3	Room air temp. control (Combined air-water systems)									
	0	No coordination								
	1	Coordination								
4.4	Outside air (OA) flow control									
	0	Fixed OA ratio/OA flow								
	1	Staged (low/high) OA ratio/OA flow (time schedule)								
X	2	Staged (low/high) OA ratio/OA flow (occupancy)								
	3	Variable control								
4.5	Air flow or pressure control at the air handler level									
	0	No automatic control								
	1	On off time control								
X	2	Multi-stage control								
	3	Automatic flow or pressure control (without reset)								
	4	Automatic flow or pressure control (with reset)								
4.6	Heat recovery control: icing protection									
	0	Without icing protection								
X	1	With icing protection								
4.7	Heat recovery control: prevention of overheating									
	0	Without overheating control								
X	1	With overheating control								
4.8	Free mechanical cooling									
	0	No automatic control								
	1	Night cooling								
X	2	Free cooling								
	3	H,x- directed control								

			Definition of classes							
			Residential				Non residential			
			D	C	B	A	D	C	B	A
AUTOMATIC CONTROL										
4	**VENTILATION AND AIR CONDITIONING CONTROL**									
4.9	Supply air temperature control									
	0	No automatic control								
	1	Constant set point								
X	2	Variable set point with outside temperature compensation								
	3	Variable set point with load dependent compensation								
4.10	Humidity control									
	0	No automatic control								
	1	Dewpoint control								
	2	Direct humidity control								

Result

To meet energy efficiency class B, the BAC must be equipped with processing functions marked with “x” in the left column.

Functions with main impact on EE

Following the BACS and TBM function which have the main impact on energy consumption of a building:

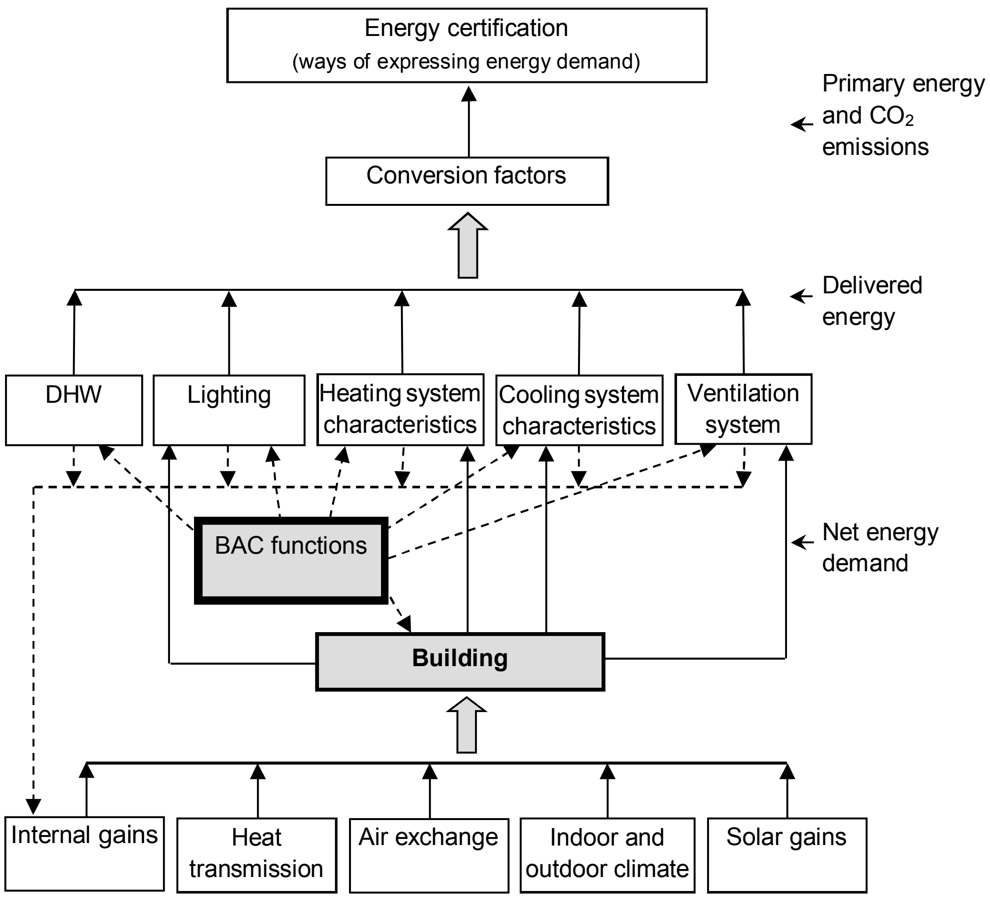
- BACS and TBM functions with the purpose to control or monitor a plant or section of a plant which is not installed in the building do not have to be considered when determining the class even if they are shaded for that class. For example, to be in class B for a building with no cooling system no individual room control with communication is required for emission control of cooling systems.
- If a specific function is required to be in a specific BACS efficiency class, there is no need for it to be strictly required throughout the building. If the designer can give good reasons that the application of a function does not bring a benefit in a specific case it can be ignored. For example if the designer can show that the heating load of a set of rooms is only dependent on the outside temperature and can be compensated with one central controller, no individual room control by thermostatic valves or electronic controllers is required to be in class C.
- Not all BACS and TBM functions in the table of section 4.2 are applicable to all types of building services. Therefore, BACS and TBM functions which have no substantial impact (<5%) within the kind of energy use for heating, cooling, ventilation, DHW or lighting do not have to be classified.

4.3. Calculating the impact of BACS and TBM on a building's energy efficiency

4.3.1. Introduction

Calculation diagram for a building

Before going into detail on energy efficiency calculations, we will outline the sequence of the individual calculation steps in the diagram below. The illustration shows that the calculation starts with the consumers (handover in room) and ends with primary energy, that is, in the opposite direction as the supply flow.



Source: prCEN/TR 15615:2007

Declaration on the general relationship between various European standards and the EPBD ("Umbrella Document").

Applied standards

The automation functions set forth in section 4.1 must be considered for applications for the standards defined in the table below:

Automatic control		
Function		**Norm**
HEATING, COOLING CONTROL, DHW		
	Emission control	FprEN 15316–2:2016, 7.2, 7.3, EN 15243:2007, 14.3.2.1 and Annex G FprEN 15316–2:2016, 6.5.1 FprEN ISO 52016-1:2016
	Control of distribution network water temperature	FprEN 15316–2:2016 EN 16798-09
	Control of distribution pump	FprEN 15316–3:2016 EN 16798-09
	Intermittent control of emission and/or distribution.	FprEN ISO 52016-1:2016 FprEN 15316–3:2016 EN 15243
	Interlock between heating and cooling control of emission and/or distribution	EN 15243
	Generation control and sequencing of generators	FprEN 15316–4-1 to –6 (see 7.4.6) EN 16798-09 EN 16798-13 EN 16947-1
	Thermal energy storage control	EN 15316 EN 16798-15
VENTILATION AND AIR CONDITIONING CONTROL		
	Air flow control at the room level	FprEN 16798–7:2016 EN 13779
	Air flow or pressure control at the air handler level	EN 16798-5-1
	Heat exchanger defrost and overheating control	EN 16798-5-1
	Free mechanical cooling	EN 16798-13
	Supply temperature control	EN 16798-5-1
	Humidity control	EN 16798-5-1
LIGHTING CONTROL		FprEN 15193–1:2016
	Combined light/blind/HVAC control (also mentioned below)	None
BLIND CONTROL		FprEN ISO 52016-1:2016

Technical building management with energy efficiency functions	
Function	**Norm**
Setpoint management	FprEN 16947:2016
Run time management	FprEN 16947:2016
Local energy production and renewable energies	FprEN 16947:2016
Waste heat recovery and heat shifting	FprEN 16947:2016
Smart Grid integration	FprEN 16947:2016
Detecting faults of building and technical systems and providing support to the diagnosis of these faults	None
Reporting information regarding energy consumption, indoor conditions and possibilities for improvement	FprEN ISO 52000-1:2016

Calculation procedure per EN 15232

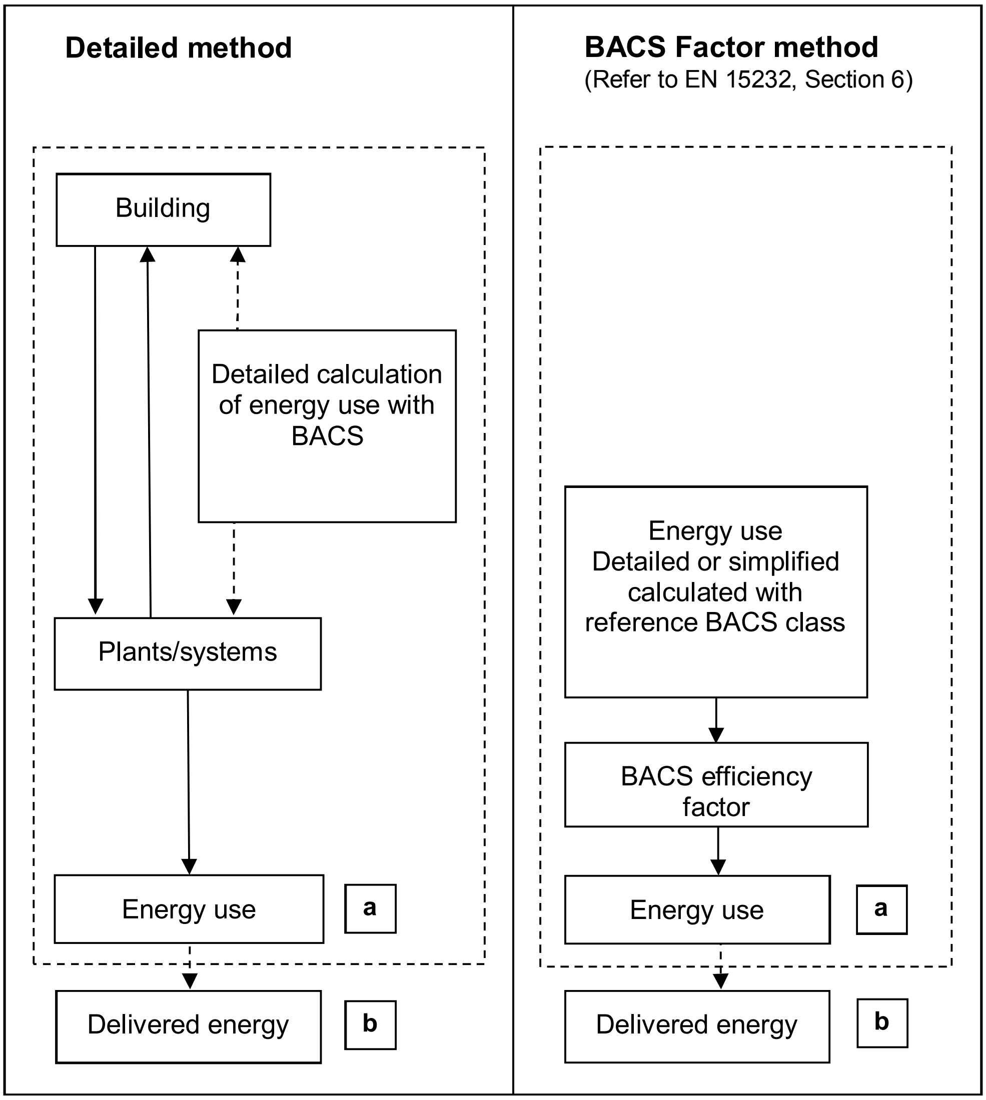
The basis for energy demand calculations in buildings are…

- the "Energy flow diagram for a building" presented earlier,
- procedures as per standards for the corresponding partial installations of building and HVAC partial plants.

The building type corresponding to the occupancy profile is considered when calculating energy demand. The building's exterior shell is subjected to defined outside weather patterns.

You can determine the impact of BAC functions on the energy efficiency of a building by comparing two energy demand calculations for a building using various building automation functions.

The calculation of the impact of the building automation and control and building management functions on the energy efficiency of a building can be accomplished using either a detailed method or the BACS factor method. The following figure illustrates how to use the different approaches.



Differences between the detailed and BACS factor method in EN 15232 (the arrows only serve to point out the calculation process and do not represent the energy flow and/or mass flow)

Key:

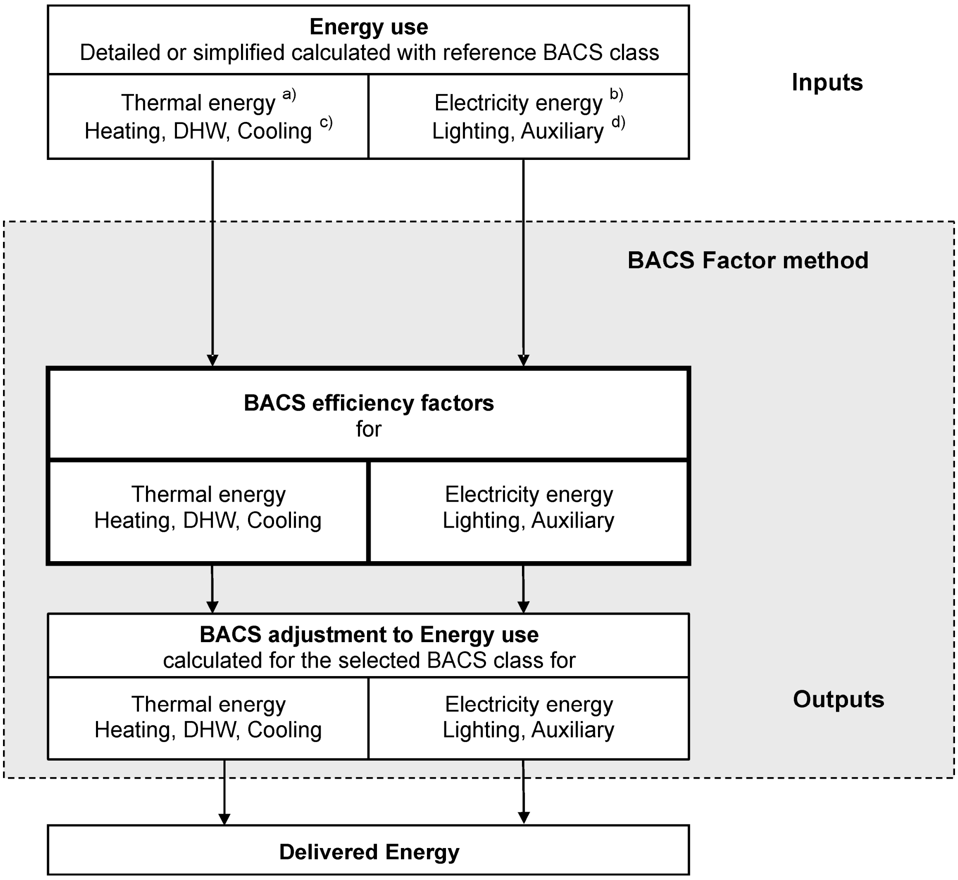
a Energy use for heating, cooling, ventilation, DHW or lighting

b Delivered energy is the total energy, expressed per energy carrier (natural gas, oil, electricity, etc.). [CEN/TR 15615, Figure 2]

4.3.2. Factor-based calculation procedure of the BACS impact on the energy performance of buildings (BACS factor method)

General

The BACS factor method described here has been established to allow a simple calculation of the impact of building automation, control and management functions on the building's energy performance. The following figure illustrates how to use this approach.



Remarks

Arrows (( ) illustrate only the calculation process and do not represent energy and/or mass flows
1) Delivered energy is the total energy, expressed per energy carrier (gas, oil, electricity etc.)
a) Thermal energy = overall energy use for heating, DHW, cooling, and ventilation
b) Electricity energy = overall energy use for auxiliary equipment and lighting
c) Specific energy use for heating, DHW or cooling
d) Specific energy use for auxiliary equipment or lighting

The BAC factor method gives a rough estimation of the impact of BACS and TBM functions on thermal and electric energy demand of the building according to the efficiency classes A, B, C and D. The BACS factor method is specially appropriated to the early design stage of a building because there is no special information needed about any specific control and automation function just the recent (if it is an existing building) or reference building automation class and the classification of the building as expected or predefined.

Simplified calculation method

The BACS efficiency factors were obtained by performing dynamic pre-calculations for different building types. Thereby each building type is characterized by a significant user profile of occupancy and internal heat gains due to people and equipment, respectively. The BAC efficiency classes A, B, C and D were represented by different levels of control accuracy and control quality.

BACS efficiency factors

The impact of BACS functions from an energy class on a building's energy demand is established with the aid of BACS efficiency factors. **The BACS efficiency factor for all building models is in the reference class C = 1** (energy demand = 100 %):

BAC efficiency factor = energy demand $BAC_{planned\ class}$ / energy demand $BAC_{Class\ C}$

BACS efficiency factors for all building models are published in the table from EN 15232.

Energy savings from BACS functions

Energy demand for BACS efficiency class C must be known (calculated using the detailed calculation method, measures or possibly estimated) to establish energy savings from BACS functions for a BACS efficiency class:

Energy demand $BAC_{planned\ class}$ = energy demand $BAC_{class\ C}$ * BAC efficiency $factor_{planned\ class.}$

Savings = 100 * energy demand $BAC_{class\ C}$ (1 – BAC efficiency $factor_{planned\ class}$) [%]

Benefits and limits of the simplified method

The simplified method allows you to determine the impact of BACS and TBM on the energy efficiency of a number of buildings to a satisfactory degree without costly calculations.

As a rule, BACS efficiency factors can be used on two basic types:

- **Relative to unknown energy demand in class C**
  BACS efficiency factors are scalable. You determine the energy demand for a building in a given energy efficiency class in relationship to the energy demand of a building in energy efficiency class C.

  This allows for a sufficiently accurate determination of **energy savings in [%]** versus class C

- **Relative to known energy consumption in class C**
  When annual absolute energy demand for a building in class C is known (e.g. energy consumption was recorded or measured over three years of operation, or the planner calculated or possibly estimated the energy demand), you can easily and sufficiently determine the absolute **energy savings (**e.g. in [kWh]) for a building in a certain energy efficiency class in relationship to a building in energy efficiency class C.

  You can also calculate savings from energy costs and the payback period for updating BAC by applying current costs per [kWh].

Application of the simplified method is limited to BAC efficiency classes A, B, C and D. A more finely graded classification of the BAC functions is not possible using this method.

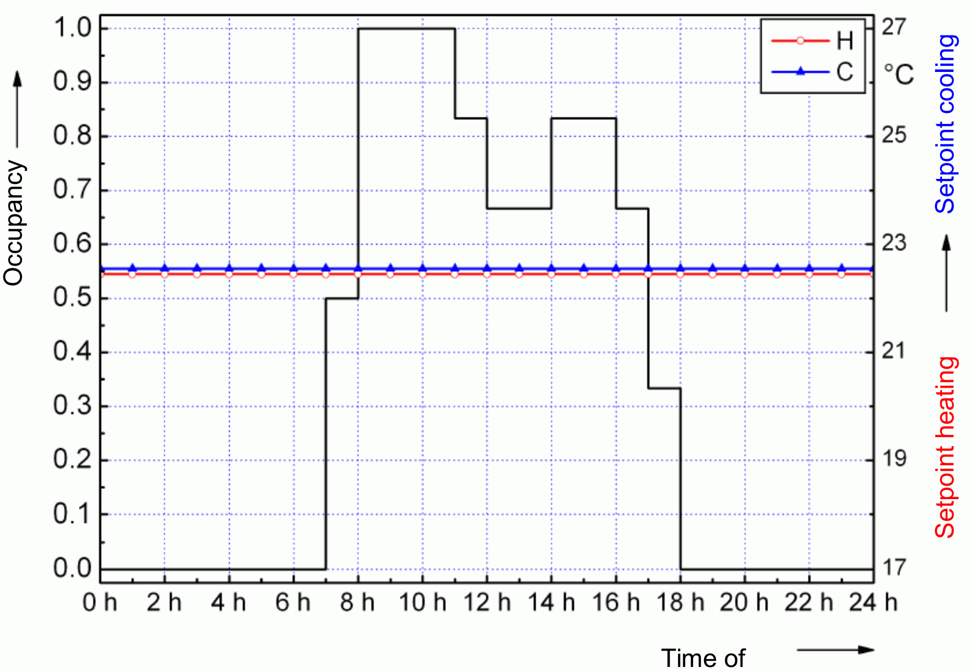
4.3.3. Savings potential of various profiles for the different building types

Savings potential varies depending on the building type. The reason is found in the profiles forming the basis for EN 15232:

- **Operation** (heating, cooling, ventilation,.. in efficiency classes A, B, C, D)
- **User** (occupancy varies depending on building type)

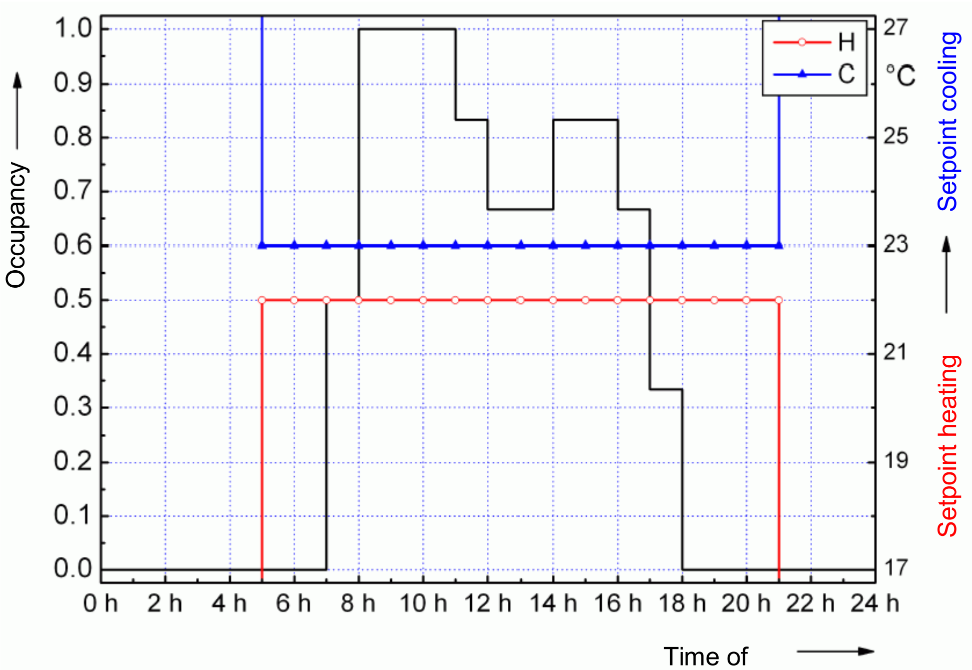
Operation profiles in an office building

BAC efficiency class D



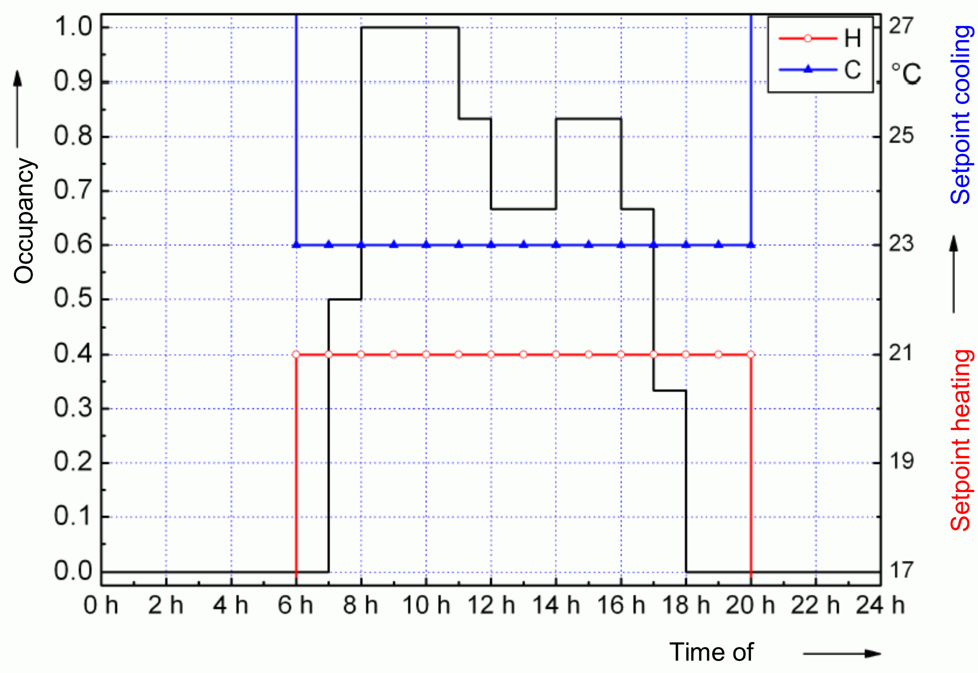
Efficiency class D represents a less beneficial case versus class C. Both temperature setpoints (for heating and cooling) have the same value. In other words, there is no energy dead band. The HVAC plant is operated 24 hours a day, although occupancy is only 11 hours.

BAC efficiency class C (reference class)



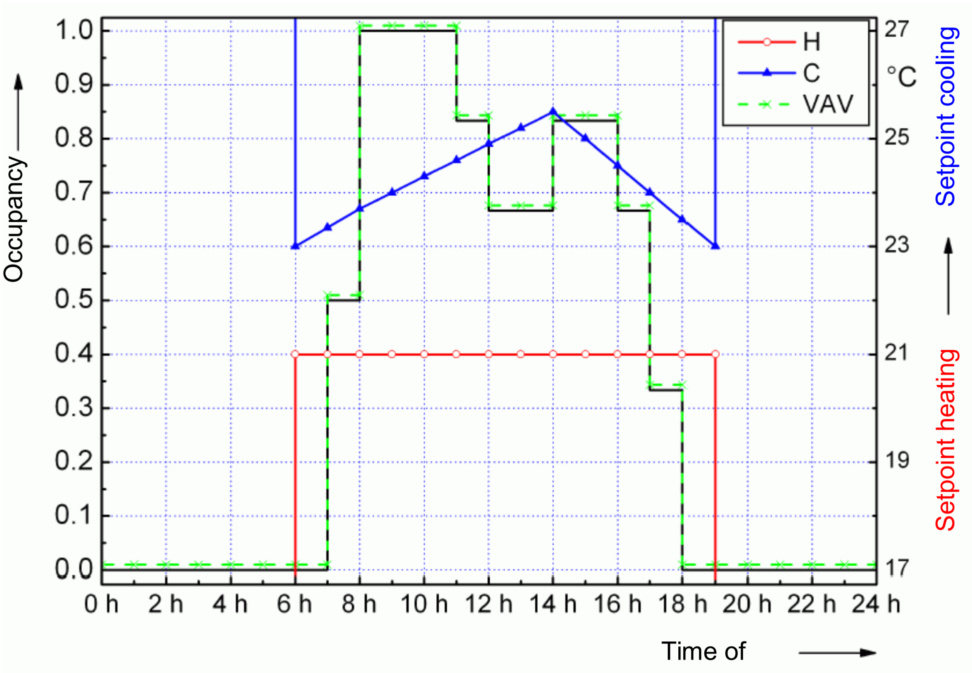
In efficiency class C, the difference the temperature setpoints for heating and cooling is very small at ca. 1 K (minimum dead energy band). Operation of the HVAC plant starts two hours prior to occupancy and ends three hours after the end of the occupancy period.

BAC efficiency class B



Efficiency class B applies better adapted operating times by optimizing switching on/off periods. The current temperature setpoints for heating and cooling are monitored by superposed functions, resulting in a dead energy band that is greater than the one for efficiency class C.

BAC efficiency class A



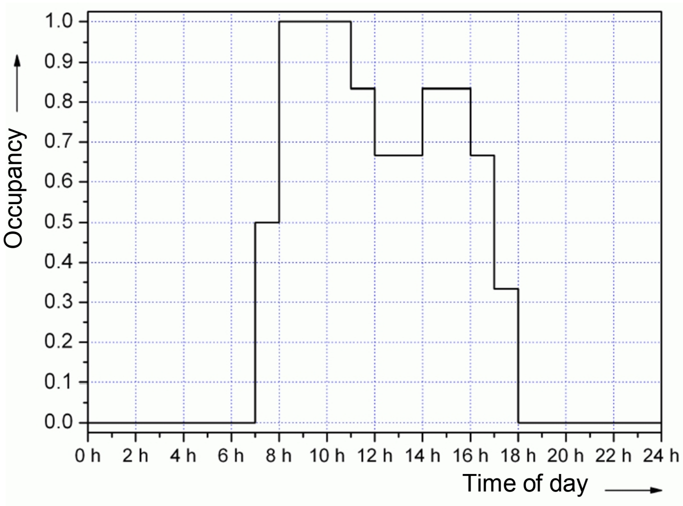
Efficiency class A provides additional energy efficiency by applying advanced BAC and TBM functions as well as adaptive setpoint adjustments for cooling or demand-controlled air flows.

Findings from the four operation profiles

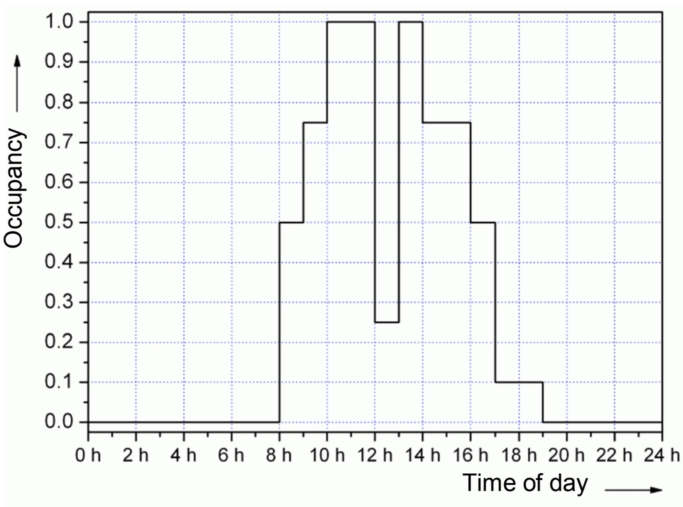
You can achieve significant improvements in BAC energy efficiency using presence-controlled plant operation, controlling air flow, as well as controlling setpoints for heating and cooling (must be as large an energy dead band as possible!).

User profiles for non-residential buildings

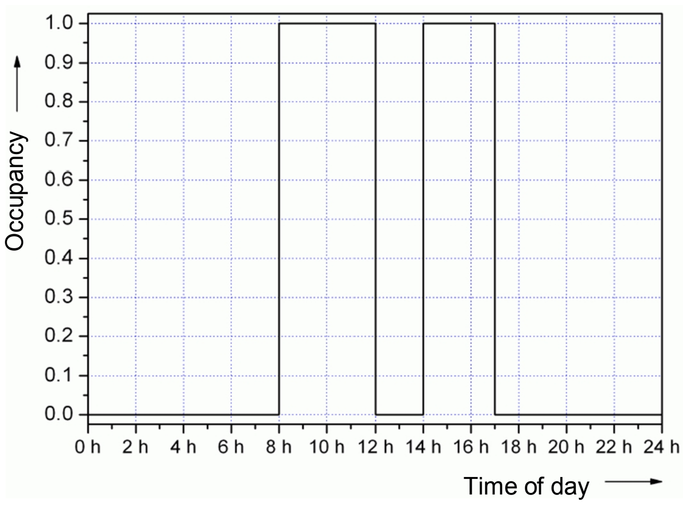
Office buildings



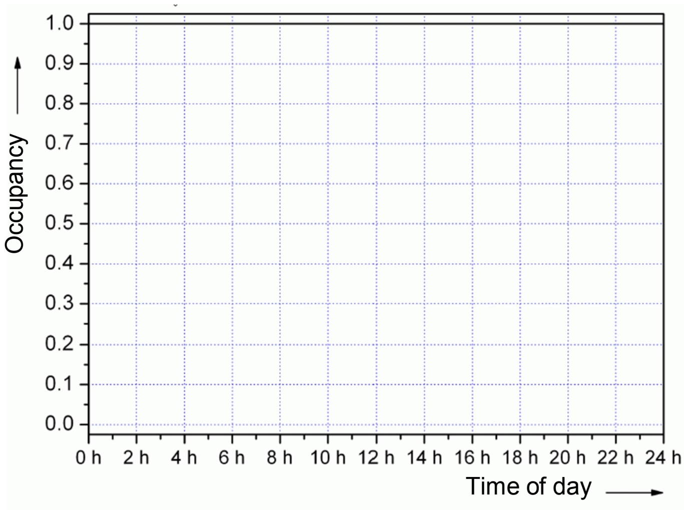
Lecture hall



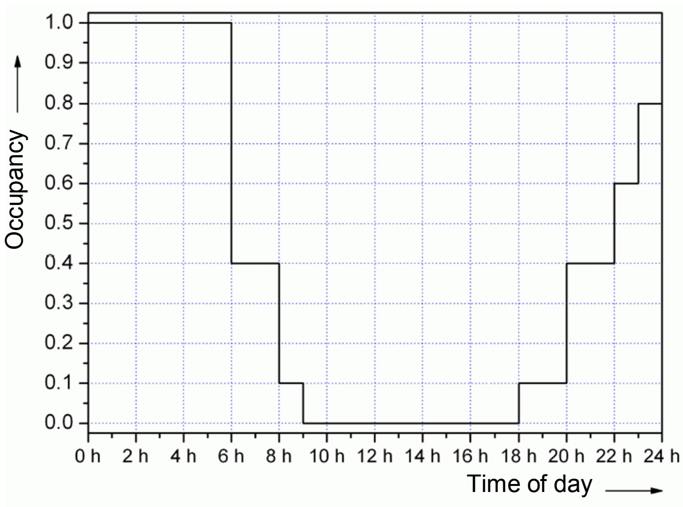
School



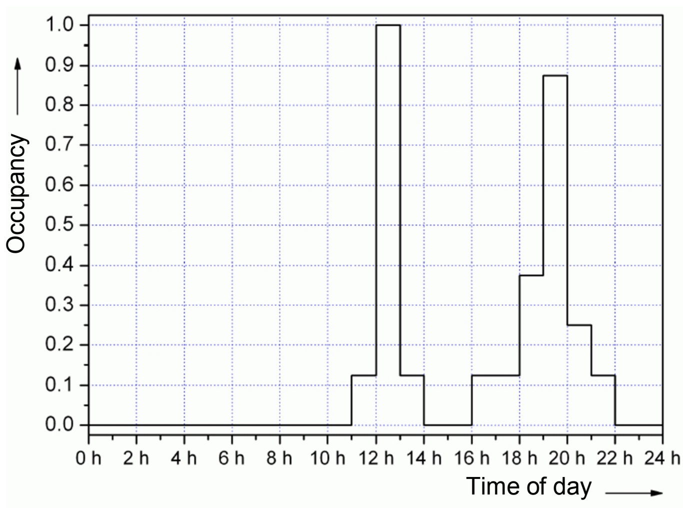
Hospital



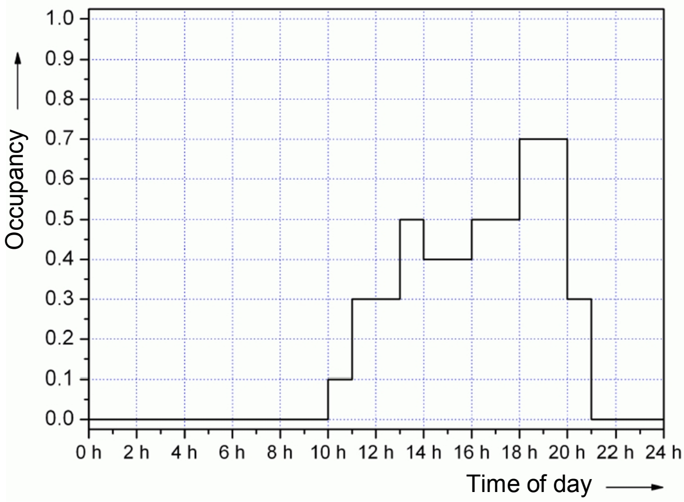
Hotel



Restaurant



Wholesale and retail



Findings from user profiles for non-residential buildings

The occupancy in the user profiles vary greatly among the different types of uses for non-residential buildings. And the BAC efficiency factors as per EN 15232 clearly illustrate the point:

- Large energy savings can be achieved in lecture halls, wholesale and retail stores
- Rather large energy savings are also possible in hotels, restaurants, office buildings and schools
- Potential energy savings are rather small in hospitals since they generally operate 24 hours a day

4.4. Overall BACS efficiency factors

You learned the following from the previous section:

- The origins of BACS efficiency factors
- All BACS efficiency factors for energy efficiency class C are 1
- All BACS efficiency factors are tied to efficiency classes A, B, C or D

In this User's Guide we generally use the term BACS efficiency factors (it is the same as BACS energy efficiency factors) in place of the more detailed term "BACS and TBM efficiency factors".

The BACS and TBM efficiency factors published in EN 15232 were calculated based on the energy demand results of a large number of simulations. The following was considered as part of each simulation:

- The occupancy profile per building type was pursuant to EN 15217
- One energy efficiency class
- All BAC and TBM functions listed in EN 15232 for this energy efficiency class

The impact of the various BAC and TBM functions on a building's energy efficiency was determined after comparing annual energy consumption for a **representative building model** for the different BAC and TBM functionalities.

The simplified method allows you to determine the impact of BAC and TBM on the energy efficiency of **residential** and various **non-residential buildings** to a satisfactory degree without costly calculations.

The following tables, taken from EN 15232, are aids to determine the impact of BACS and TBM on the energy efficiency for building projects.

4.4.1. Overall BACS efficiency factors for thermal energy

The BACS efficiency factors for thermal energy (heating, DHW and cooling) are classified based on building type and efficiency class to which the BACS/TBM is related to. Factors for efficiency class C are set at 1, since this class represents the standard case for a BACS and TBM system. Application of efficiency class B or A always results in lower BAC efficiency factors, i.e. it improves a building's energy efficiency.

Non-residential building types	**BACS efficiency factors thermal $f_{BAC,th}$**			
	D	**C**	**B**	**A**
	Non energy efficient	**Standard (reference)**	Advanced energy efficiency	High energy performance
Offices	1.51	1	0.80	0.70
Lecture halls	1.24	1	0.75	0.5 [a]
Educational buildings (schools)	1.20	1	0.88	0.80
Hospitals	1.31	1	0.91	0.86
Hotels	1.31	1	0.85	0.68
Restaurants	1.23	1	0.77	0.68
Wholesale and retail buildings	1.56	1	0.73	0.6 [a]
Other types: • Sport facilities • Storage • Industrial facilities • etc.		1		

[a] The values are highly dependent on heating/cooling demand for ventilation

Residential building types	**BACS efficiency factors thermal $f_{BAC,th}$**			
	D	**C**	**B**	**A**
	Non energy efficient	**Standard (reference)**	Advanced energy efficiency	High energy performance
• Single family dwellings • Multi family houses • Apartment houses • Other residential or residential-like buildings	1.10	1	0.88	0.81

4.4.2. Overall BACS efficiency factors for electrical energy

According to EN 15232, electric energy in this context means lighting energy and electric energy required for auxiliary equipment. The BACS efficiency factors in following table for electric energy (but not electric energy for the equipment) are classified depending on the building type and the efficiency class of the BACS and TBM system.

The factors for efficiency class C are defined to be 1 as this class represents a standard functionality of BACS and TBM system. The use of efficiency classes B or A always leads to lower BACS efficiency factors, i.e. an improvement of building performance.

Non-residential building types	**BACS efficiency factors electrical $f_{BAC,el}$**			
	D	**C**	**B**	**A**
	Non energy efficient	**Standard (reference)**	Advanced energy efficiency	High energy performance
Offices	1.10	1	0.93	0.87
Lecture halls	1.06	1	0.94	0.89
Educational buildings (schools)	1.07	1	0.93	0.86
Hospitals	1.05	1	0.98	0.96
Hotels	1.07	1	0.95	0.90
Restaurants	1.04	1	0.96	0.92
Wholesale and retail buildings	1.08	1	0.95	0.91
Other types: • Sport facilities • Storage • Industrial facilities • etc.		1		

Residential building types	**BACS efficiency factors electrical $f_{BAC,el}$**			
	D	**C**	**B**	**A**
	Non energy efficient	**Standard (reference)**	Advanced energy efficiency	High energy performance
• Single family dwellings • Multi family houses • Apartment houses • Other residential or residential-like buildings	1.08	1	0.93	0.92

4.4.3. Reflection of the profile on BACS efficiency factors

Operation and user profile impact BACS efficiency factors differently. Their impacts on BACS efficiency is shown in the following table: Thermal for non-residential buildings:

Non-residential building types	BACS efficiency factors thermal $f_{BAC,th}$			
	D	C	B	A
	Non energy efficient	**Standard (reference)**	Advanced energy efficiency	High energy performance
Offices	1.51	1	0.80	0.70
Lecture halls	1.24	**Operation profile**	0.75	0.5 [a]
Educational buildings (schools)	1.20	1	0.88	0.80
Hospitals	1.31	1	0.91	0.86
Hotels	1.31	1	0.85	0.68
Restaurants	1.23	1	0.77	0.68
Wholesale and retail buildings	1.56	1	0.73	0.6 [a]

User profile

[a] The values are highly dependent on heating/cooling demand for ventilation

4.4.4. Sample calculation for an office building

Application of the BACS efficiency factors when calculating the impact of BACS and TBM on overall energy efficiency of a medium-sized office building (length 70 m, width 16 m, 5 floors). **BACS efficiency class C** is used as the reference. Improvements to energy efficiency by **changing to BACS efficiency class B** are calculated.

Description	No.	Calcu-lation	Unit	Heating	Cooling	Ventila-tion	Lighting
Thermal energy							
Energy demand	1		$\frac{kWh}{m^2 \cdot a}$	100	80		
Plant losses Reference case	2		$\frac{kWh}{m^2 \cdot a}$	22	28		
Energy expense for Reference class C	3	Σ 1+2	$\frac{kWh}{m^2 \cdot a}$	**122**	**108**		
BACS factor thermal Reference class C	4			1	1		
BACS factor thermal Actual case (Class B)	5			0.80	0.80		
Energy expense Actual case class B	6	$3 \cdot \frac{5}{4}$	$\frac{kWh}{m^2 \cdot a}$	**98**	**86**		
The expense of thermal energy must be distributed among various energy carrier to complete the calculation.							
Electrical energy							
Auxiliary energy class C	7a		$\frac{kWh}{m^2 \cdot a}$	**5**	**20**	**21**	
Lighting energy	7b						**34**
BACS factor electrical Reference class C	8			1	1	1	1
BACS factor electrical Actual case (class B)	9			0.93	0.93	0.93	0.93
Auxiliary energy Actual case (class B)	10	$7 \cdot \frac{9}{8}$	$\frac{kWh}{m^2 \cdot a}$	**4.6**	**18.6**	**19.5**	**31.6**

Results

After transforming the office building by updating BACS functions from the BACS efficiency class C to class B, energy consumption per BACS efficiency factors published in EN 15232 were reduced as follows:

- Heating energy **98 kWh/m² · a** instead of 122 Reduction to 80 %
- Cooling energy **86 kWh/m² · a** instead of 108 Reduction to 80 %
- Electrical energy **74 kWh/m² · a** instead of 80 Reduction to 93 %

These improvements in energy efficiency lead to annual energy savings of 291,200 kWh for the entire building (5,600 m²).

4.5. Detailed BACS efficiency factors

Four sets of BACS efficiency factors for heating, cooling, DHW and electrical energy were extracted from the results of the energy performance calculations. They are available for the assessment of:

- Thermal energy for space heating and cooling
- Thermal energy for DHW heating
- Electric energy for ventilation, lighting and auxiliary equipment

The energy input to the building energy systems (energy use) accounts for building energy demand, total thermal losses of the systems as well as auxiliary energy required to operate the systems. Each of the energy systems installed in a building shall be assessed with the right BACS factor taking into account the correlations given in the following table.

Energy use	Energy need	System losses	Aux. Energy	BACS factor
Heating	Q_{NH}	$Q_{H,loss}$	-	$f_{BAC,H}$
	-	-	$W_{h,aux}$	$f_{BAC,el,aux}$
Cooling	Q_{NC}	$Q_{C,loss}$	-	$f_{BAC,C}$
	-	-	$W_{c,aux}$	$f_{BAC,el,aux}$
Ventilation	-	-	$W_{V,\ aux}$	$f_{BAC,el,aux}$
Lighting	-	-	W_{L}	$f_{BAC,el,L}$
DHW	Q_{DHW}	-	-	$f_{BAC,DHW}$

4.5.1. Detailed BACS efficiency factors for heating and cooling

Non-residential building types	Detailed BACS efficiency factors $f_{BAC,H}$ and $f_{BAC,C}$							
	D		C		B		A	
	Non energy efficient		**Standard (reference)**		Advanced energy efficiency		High energy performance	
	$f_{BAC,H}$	$f_{BAC,C}$	$f_{BAC,H}$	$f_{BAC,C}$	$f_{BAC,H}$	$f_{BAC,C}$	$f_{BAC,H}$	$f_{BAC,C}$
Offices	1.44	1.57	1	1	0.79	0.80	0.70	0.57
Lecture halls	1.22	1.32	1	1	0.73	0.94	0.3 [a]	0.64
Educational buildings (schools)	1.20	–	1	1	0.88	–	0.80	–
Hospitals	1.31	–	1	1	0.91	–	0.86	–
Hotels	1.17	1.76	1	1	0.85	0.79	0.61	0.76
Restaurants	1.21	1.39	1	1	0.76	0.94	0.69	0.6
Wholesale and retail buildings	1.56	1.59	1	1	0.71	0.85	0.46[a]	0.55
Other types: • Sport facilities • Storage • Industrial facilities • etc.	–	–	1	1	–	–	–	–
[a] The values are highly dependent on heating/cooling demand for ventilation								

Residential building types	Detailed BACS efficiency factors $f_{BAC,H}$ and $f_{BAC,C}$							
	D		C		B		A	
	Non energy efficient		**Standard (reference)**		Advanced energy efficiency		High energy performance	
	$f_{BAC,H}$	$f_{BAC,C}$	$f_{BAC,H}$	$f_{BAC,C}$	$f_{BAC,H}$	$f_{BAC,C}$	$f_{BAC,H}$	$f_{BAC,C}$
• Single family dwellings • Multi family houses • Apartment houses • Other residential or residential-like buildings	1.09	–	1	–	0.88	–	0.81	–

4.5.2. Detailed BACS efficiency factor for DHW

The BAC efficiency factors for DHW systems are calculated based on the following conditions:

- Operation timer; the time when the DHW storage tank is charged and maintained at the setpoint temperature
- Mean DHW storage tank temperature

Detailed factors are accounting for the BAC impact on energy performance of DHW systems by covering DHW as a single functionality.

Non-residential building types	**Detailed BACS efficiency factors $f_{BAC,DHW}$**			
	D	**C**	**B**	**A**
	Non energy efficient	**Standard (reference)**	Advanced energy efficiency	High energy performance
Offices	1.11	1.00	0.90	0.80
Lecture halls				
Educational buildings (schools)				
Hospitals				
Hotels				
Restaurants				
Wholesale and retail buildings				
Other types: • Sport facilities • Storage • Industrial facilities • etc.				

Residential building types	**Detailed BACS efficiency factors $f_{BAC,DHW}$**			
	D	**C**	**B**	**A**
	Non energy efficient	**Standard (reference)**	Advanced energy efficiency	High energy performance
• Single family dwellings • Multi family houses • Apartment houses • Other residential or residential-like buildings	1.11	1.00	0.90	0.80

4.5.3. Detailed BACS efficiency factor for lighting and auxiliary energy

Factors for non-residential building types are available as detailed factors accounting for different BAC impacts on energy performance of electricity for lighting and auxiliary energy.

Non-residential building types	**Detailed BACS efficiency factors $f_{BAC,el,L}$ and $f_{BAC,el,aux}$**							
	D		**C**		**B**		**A**	
	Non energy efficient		**Standard (reference)**		Advanced energy efficiency		High energy performance	
	$f_{BAC,el,L}$	$f_{BAC,el,aux}$	$f_{BAC,el,L}$	$f_{BAC,el,aux}$	$f_{BAC,el,L}$	$f_{BAC,el,aux}$	$f_{BAC,el,L}$	$f_{BAC,el,aux}$
Offices	1.1	1.15	1	1	0.85	0.86	0.72	0.72
Lecture halls	1.1	1.11	1	1	0.88	0.88	0.76	0.78
Educational buildings (schools)	1.1	1.12	1	1	0.88	0.87	0.76	0.74
Hospitals	1.2	1.1	1	1	1	0.98	1	0.96
Hotels	1.1	1.12	1	1	0.88	0.89	0.76	0.78
Restaurants	1.1	1.09	1	1	1	0.96	1	0.92
Wholesale and retail buildings	1.1	1.13	1	1	1	0.95	1	0.91
Other types: • Sport facilities • Storage • Industrial facilities • etc.	–	–	1	1	–	–	–	–

4.6. Guideline for using BACS for EMS

This chapter explains how to apply and use BACS (Building Automation and Control System including TBM (Technical Building Management) for an EMS (Energy Management System) in buildings.

EMS as specified by EN ISO 50001 is intended to improve energy performance by managing energy use systematically. EN ISO 50001 sets forth the requirements for continual improvement in the form of more efficient and sustainable energy use for production/process, transportation and buildings.

The use of BACS encourages different levels and functions of the organization by implementing the EMS in buildings and simplifying and significantly improving the continual EMS process in buildings.

The following table outlines BACS options, requirements and functions to support implementation and processing of EMS in buildings.

No.	EMS requirements according to EN ISO 50001:2011	BACS for EMS in buildings
1	**4 Energy management system requirements**	
1.1	**4.1 General requirements**	
	The organization shall: a) establish, document, implement, maintain and improve an EnMS in accordance with the requirements of ISO 50001; b) define and document the scope and boundaries of its EMS; c) determine how it will meet the requirements of ISO 50001 in order to achieve continual improvement of its energy performance and of its EnMS.	The organization shall: Take existing or planned BACS while establishing an EMS. Include existing BACS processes/documentation and esp. monitoring/reporting. Determine the general task to be performed BACS to support the EnMS regarding continual improvement energy performance of Buildings.
2.2	**4.2 Management responsibility**	
2.2.1	**4.2.1 Top-Management**	
	Top management shall demonstrate its commitment to support the EnMS and to continually improve its effectiveness by: a) defining, establishing, implementing and maintaining an energy policy; b) appointing a management representative and approving the formation of an energy management team; c) providing the resources needed to establish, implement, maintain and improve the EnMS and the resulting energy performance; NOTE Resources include human resources, specialized skills, technology and financial resources. d) identifying the scope and boundaries to be addressed by the EnMS; e) communicating the importance of energy management to those in the organization; ensuring that energy objectives and targets are established; g) ensuring that EnPIs are appropriate to the organization; f) ensuring that energy objectives and targets are established; h) considering energy performance in long-term planning; i) ensuring that results are measured and reported at determined intervals; j) conducting management reviews.	Top management should generally note and consider the following when implementing an energy management system (EMS): BAC impact on energy efficiency of buildings is defined in EN 15232. Application of BACS as the appropriate automatic tool to simplify, maintain and improve the energy management process to achieve improved energy performance of and reduce energy consumption in buildings
2.2.2	**4.2.2 Management representative**	
	Top management shall appoint a management representative(s) with appropriate skills and competence, who irrespective of other responsibilities, has the responsibility and authority to:	A BACS executive shall be appointed who has the responsibilities to:

No.	EMS requirements according to EN ISO 50001:2011	BACS for EMS in buildings
	a) ensure the EnMS is established, implemented, maintained, and continually improved in accordance with ISO 50001; b) identify person(s), authorized by an appropriate level of management, to work with the management representative in support of energy management activities; c) report to top management on energy performance; d) report to top management on the performance of the EnMS; e) ensure that the planning of energy management activities is designed to support the organization's energy policy; f) define and communicate responsibilities and authorities in order to facilitate effective energy management; g) determine criteria and methods needed to ensure that both the operation and control of the EMS are effective; h) promote awareness of the energy policy and objective at all levels of the organization.	
2.3	**4.3 Energy policy**	
	The energy policy shall state the organization's commitment to achieving energy performance improvement. Top management shall define the energy policy and ensure that it: a) is appropriate to the nature and scale of the organization's energy use and consumption; b) includes a commitment to continual improvement in energy performance; c) includes a commitment to ensure the availability of information and of necessary resources to achieve objectives and targets; d) includes a commitment to comply with applicable legal requirements and other requirements to which the organization subscribes to its related energy use, consumption and efficiency; e) provides the framework setting and reviewing energy objectives and targets; f) supports the purchase of energy-efficient products and services, and design for energy performance improvement; g) is documented and communicated at all levels within the organization; h) is regularly reviewed, and updated as necessary.	As part of an energy policy, top management tasks the organization as a whole to maintain and improve energy performance of buildings (existing buildings, modernized, new construction): Mandatory and specific BAC energy efficiency class (according to EN 15232) for implementation and compliance. Deploy energy-efficient and certified products only as BACS components. Use BACS as a tool for EMS and the documentation and information system supporting the organization. BACS operational processes (e.g. like default heating setpoints) shall support a fast and documented way of implementation measures identified in the on-going EMS activities.

No.	EMS requirements according to EN ISO 50001:2011	BACS for EMS in buildings
2.4	**4.4 Energy Planning**	
2.4.1	**4.4.1 General**	
	The organization shall conduct and document an energy planning process. Energy planning shall be consistent with the energy policy and shall lead to activities that continually improve energy performance. Energy planning shall involve a review of the organization's activities that can affect energy performance. NOTE 1 A concept diagram illustrating energy planning is shown in ISO 50001, Figure A.2. NOTE 2 In other regional or national standards, concepts such as identification and review of energy aspects or the concept of energy profile, are included in the concept of energy review.	The organization should consider the BACS options that identify and review energy aspects for EMS in buildings, such as: Specify and use BACS logs (data) on energy consumption including all parameters that impacting energy and review energy-relevant aspects in buildings. Specify data (available in BACS) to be recorded, stored and delivered, e.g.: Delivered energy (oil, natural gas, electricity etc.). Energy use for heating, air conditioning, lighting, etc. Parameters that impact energy use (occupancy, operating hours, climate conditions, building space usage data, user profiles, etc.) Uses of BACS data assignment for 3.3.1 a), b), c), d) and e) shall be determined.
2.4.2	**4.4.2 Legal and other requirement**	
	The organization shall identify, implement, and have access to the applicable legal requirements and other requirements to which the organization subscribes related to its energy use, consumption and efficiency. The organization shall determine how these requirements apply to its energy use, consumption and efficiency and shall ensure that these legal requirements and other requirements to which subscribes are considered in establishing, implementing and maintaining the EnMS. Legal requirements and other requirements shall be reviewed at defined intervals.	The organization should review whether BACS can be used to support the legal obligations and other requirements with regarding to EMS within buildings e.g.: Compile legally mandated records on energy consumption, room conditions, etc. Determine whether e.g. space usage profiles are within local privacy regulations and act accordingly.
2.4.3	**4.4.3 Energy review**	
	The organization shall develop, record, and maintain energy review. The methodology and criteria used to develop the energy review shall be documented. To develop energy review, the organization shall: a) analyse energy use and consumption based on measurement and other data, i.e. - identify current energy sources; - evaluate past and present energy use and consumption; b) based on the energy use and consumption, identify the areas of significant energy use, i.e. - identify the facilities, equipment, systems, processes and personnel working for, or on behalf of, the organization that significantly affect energy use and consumption;	BACS resources shall assist is compiling data and determination of consumptions in the desired detail. Depending on the depth of a BACS implementation these data might be around and would need to be tailored towards the measures. BACS can support and determine status of consumption(s) against given budgets.

No.	EMS requirements according to EN ISO 50001:2011	BACS for EMS in buildings
	- identify other relevant variables affecting significant energy uses; - determine the current energy performance of facilities, equipment, systems and processes related to identified significant energy uses; - estimate future energy use and consumption; c) identify, prioritize record opportunities for improving energy performance. NOTE Opportunities can relate to potential sources of energy, use of renewable energy, or other alternative energy sources, such as waste energy. The energy review shall be updated at defined intervals, as well as in response to major changes in facilities, equipment, systems, or processes.	
2.4.4	**4.4.4 Energy baseline**	
	The organization shall establish an energy baseline(s) using the information in the initial energy review, considering a data period suitable to the organization's energy use and consumption. Changes in energy performance shall be measured against the energy baseline(s). Adjustments to the baseline(s) shall be made in the case of one of the following: - EnPIs no longer reflect organizational energy use and consumption, or - there have been major changes to the process, operational patterns, or energy systems, or - according to a predetermined method. The energy baseline(s) shall be maintained and recorded.	BACS gathers the necessary data (monitoring function) in order to build baselines. BACS might need to normalize data according to given parameters (e.g. heating degree days). BACS might determine performance indicators that adapt to the actual usage in order to take automatically actual usage of space into account.
2.4.5	**4.4.5 Energy performance indicators**	
	The organization shall identify EnPIs appropriate for monitoring and measuring energy performance. The methodology for determining and updating the EnPIs shall be recorded and regularly reviewed. EnPIs shall be reviewed and compared to the energy baseline as appropriate.	BACS might determine performance indicators that adapt to the actual usage in order to take automatically actual usage of space into account.
2.4.6	**4.4.6 Energy objectives, energy targets and energy management action plans**	
	The organization shall establish, implement and maintain documented energy objectives and targets at the relevant functions, levels, processes or facilities within the organization. Time frames shall be established for achievement of the objectives and targets. The objectives and targets shall be consistent with the energy policy. Targets shall be consistent with the objectives.	The organization determines BACS objectives, targets and program that are consistent with the energy policy and the significant energy aspects of buildings, e.g.: Energy saving targets to be achieved by applying BACS. Apply BACS as tool support the EMS in achieving and maintaining its strategic and operative aims.

No.	EMS requirements according to EN ISO 50001:2011	BACS for EMS in buildings
	When establishing and reviewing objectives and targets, an organization shall take into account legal requirements and other requirements, significant energy uses and opportunities to improve energy performance, as identified in the energy review. It shall also consider its financial, operational and business conditions, technological options and the views of interested parties. The organization shall establish, implement and maintain action plans for achieving its objectives and targets. The action plans shall include: - designation of responsibility; - the means and time frame by which individual targets are to be achieved; - a statement of the method by which an improvement in energy performance shall be verified; - a statement of the method of verifying the results. The action plans shall be documented, and updated at defined intervals.	Apply BACS measuring criteria of the energy targets so that progress towards improved energy efficiency of buildings can be measured. Upgrade and adapt BACS as part of reconstruction, modernization, change in use, etc. On-going upgrade to BACS configuration and sequence programming to reflect organizational changes (e.g. changing operation times, use times, occupancy, room conditions, etc.). Continuously adjust and optimize BACS functions and control sequences to improve energy performance etc. Review building performance on a continuous basis.
3	**4.5 Implementation and operation**	
3.1	**4.5.1 General**	
	The organization shall use the action plans and other outputs resulting from the planning process for implementation and operations.	The organization determines functions, tasks, roles, responsibilities, and priorities for using BACS to improve energy performance of buildings as part of EMS, including: Technology, functions, resources and priorities of BACS applications. The resources, roles, authority and responsibility of the personnel at all BACS organizational levels. The BACS applications to support reporting building performance to top management for review, etc.
3.2	**4.5.2 Competence, training and awareness**	
	The organization shall ensure that any person(s) working for or on its behalf, related to significant energy uses, are competent on the basis of appropriate education, training, skills or experience. The organization shall identify training needs associated with the control of its significant energy uses and the operation of its EnMS. It shall provide training or take other actions to meet these needs. Appropriate records shall be maintained. The organization shall ensure that any person(s) working for or on its behalf are aware of:	The organization ensures and verifies appropriate level of training and advanced education of employees responsible for BACS as well as ensuring they remain up-to-date. Specifically, this means personnel are informed on the latest BACS functionality, operation and energy saving options. It shall provide training or take other actions to meet these needs. Appropriate records shall be maintained. BACS-specific requirements for awareness, knowledge, understanding, skills, e.g.: Energy saving functions and program

No.	EMS requirements according to EN ISO 50001:2011	BACS for EMS in buildings
	a) the importance of conformity with the energy policy, procedures and with the requirements of the EMS; b) their roles, responsibilities and authorities in achieving the requirements of the EMS; c) the benefits of improved energy performance; d) the impact, actual or potential, with respect to energy use and consumption, of their activities and how their activities and behaviour contribute to the achievement of energy objectives and targets, and the potential consequences of departure from specified procedures.	Operation and maintenance procedures Adjustment and optimization procedures. Continuous performance reviews Etc. The appropriate balance of education, training, experience, etc. to archive and maintain the BACS-specific requirements and its further development concerning awareness, knowledge, understanding and skills. Review of BACS training program to guarantee that the persons responsible for BACS have the necessary competence for its tasks to support EMS and to improve the energy efficiency in buildings.
3.3	**4.5.3 Communication**	
	The organization shall communicate internally with regard to its energy performance and EMS, such as appropriate to the size of the organization. The organization shall establish and implement a process by which any person working for, or on behalf of, the organization can make comments or suggest improvements to the EMS. The organization shall decide whether to communicate externally about its energy policy, EMS and energy performance, and shall document its decision. If the decision is to communicate externally, the organization shall establish and implement a method for this external communication.	The organization considers BACS options to achieve and maintain EMS communication requirements for buildings. As a consequence, the organization specifies: Whether to communicate the relevant data on energy performance aspects, costs, savings etc. for buildings. Preparation of data (anonymization, standardizing, benchmarking). Rules governing the flow of information of the relevant data at all levels within the internal organization. Rules governing the flow of relevant information to external person, organization, etc. if the decision is made to communicate externally.
3.4	**5.4.4 Documentation**	
3.4.1	**5.4.4.1 Documentation requirements**	
	The organization shall establish, implement and maintain information, in paper, electronic or any other medium, to describe the core elements of the EMS and their interaction. The EMS documentation shall include: a) the scope and boundaries of the EMS; b) the energy policy; c) the energy objectives, targets, and action plans; d) the documents, including records, required by this International Standard; e) other documents determined by the organization to be necessary. NOTE The degree of documentation can vary for different organizations for the following reasons: - the scale of the organization and type of activities;	The organization considers BACS support options to achieve and maintain the documentation requirements of EMS for buildings. As a consequence, the organization specifies: Development of BACS as the building's documentation system for EMS. Automated logging, archiving, storage, protection, and proof of all relevant, building operational data. Energy performance data (e.g.: key performance indicators – KPI; energy performance indicators - EPI = kWh/ m2, etc.), Evaluation period, frequency of measurements, plausibility check, reproducibility, replacement value, change management.

No.	EMS requirements according to EN ISO 50001:2011	BACS for EMS in buildings
	- the complexity of the processes and their interactions; - the competence of personnel.	
3.4.2	**5.4.4.2 Control of documents**	
	Documents required by this International Standard and the EMS shall be controlled. This includes technical documentation where appropriate. The organization shall establish, implement and maintain procedure(s) to: a) approve documents for adequacy prior to issue; b) periodically review and update documents as necessary; c) ensure that changes and the current revision status of documents are identified; d) ensure that relevant versions of applicable documents are available at points of use; e) ensure that documents remain legible and readily identifiable; f) ensure documents of external origin determined by the organization to be necessary for the planning and operation of the EMS are identified and their distribution controlled; g) prevent the unintended use of obsolete documents, and suitably identify those to be retained for any purpose.	The organization considers and identifies BACS options to support the control of EMS documentation for buildings. As a consequence, the organization determines logging and distribution of all EMS specifications and documented proof for the buildings: Documents are available in electronic form. Status of the document is clearly marked (e.g. current versions, no longer applicable, etc.). Develop the most expedient manner of making documents available to employees with a need to know about.
3.4.3	**4.5.5 Operational control**	
	The organization shall identify and plan those operations and maintenance activities which are related to its significant energy uses and that are consistent with its energy policy, objectives, targets and action plans, in order to ensure that they are carried out under specified conditions, by means of the following: a) establishing and setting criteria for the effective operation and maintenance of significant energy uses, where their absence could lead to a significant deviation from effective energy performance; b) operating and maintaining facilities, processes, systems and equipment, in accordance with operational criteria; c) appropriate communication of the operational controls to personnel working for, or on behalf of, the organization. NOTE When planning for contingency or emergency situations or potential disasters, including procuring equipment, an organization may choose to include energy performance in determining how it will react to these situations.	The organization considers supporting BACS options to achieve and maintain operational control requirements of the EMS. As a consequence, the organization specifies energy objectives and targets for buildings: Maintenance criteria (e.g. intervals, operating hours etc.) under the BACS maintenance. Building plants, installations, equipment, etc., are continuously adapted and optimized to meet current operational and organizational profiles, needs and demands. A commitment to implement and purchase (new procurement or replacement) only energy efficient BACS equipment and certified products, to the extent available. BACS procedures to record and analyse changes in energy consumption (before/after), modernization, etc. of buildings and/or building installation, plans, equipment etc. BACS communications with regard to building operation, maintenance, etc.

No.	EMS requirements according to EN ISO 50001:2011	BACS for EMS in buildings
3.5	**4.5.6 Design**	
	The organization shall consider energy performance improvement opportunities and operational control in the design of new, modified and renovated equipment, systems and processes that can have a significant impact on its energy performance. The result of the energy performance evaluation shall be incorporated where appropriate into the specification, design and procurement activities of the relevant project(s). The result of the design activity shall be recorded.	
3.6	**4.5.7 Procurement of energy services, products, equipment and energy**	
	When procuring energy services, products and equipment that have, or can have, an impact on significant energy use, the organization shall inform suppliers that procurement is partly evaluated on the basis of energy performance. The organization shall establish and implement the criteria for assessing energy use, consumption and efficiency over the planned or expected operating lifetime when procuring energy using products, equipment and services which are expected to have a significant impact on the organization's energy performance. The organization shall define and document energy purchasing specifications, as applicable, for effective energy use. NOTE See Annex A for more information	
4	**4.6 Checking**	
4.1	**4.6.1 Monitoring, measurement and analysis**	
	The organization shall ensure that the key characteristics of its operations that determine energy performance are monitored, measured and analysed at planned intervals. Key characteristics shall include at minimum: a) significant energy uses and other outputs of the energy review; b) the relevant variables related to significant energy use; c) EnPIs; d) the effectiveness of the action plans in achieving objectives and targets; e) evaluation of actual versus expected energy consumption. The results from monitoring and measurement of the key characteristics shall be recorded.	The organization considers suitable, multiplex BACS options to achieve and maintain the measurement and monitoring requirements of the EMS within buildings and specifies: An appropriate energy metering plan for buildings based on BACS to include an energy data repository for storing all types of energy data. It should include data entered at equal intervals (e.g. measured values for every 15 min, 30 min, or 60 min, etc.) and meter readings and also energy-related factors (operating times, occupancy, etc.). BACS measuring principles including calibration to ensure accuracy, high availability and reproducibility of the energy data and records. BACS activities (more or less online and automated) for measurement and monitoring, e.g.:

No.	EMS requirements according to EN ISO 50001:2011	BACS for EMS in buildings
	An energy measurement plan, appropriate to the size and complexity of the organization and its monitoring and measurement equipment, shall be defined and implemented. NOTE Measurement can range from only utility meters for small organizations up to complete monitoring and measurement systems connected to a software application capable of consolidating data and deliver automatic analysis. It is up to the organization to determine the means and methods of measurement. The organization shall define and periodically review its measurement needs. The organization shall ensure that the equipment used in monitoring and measurement of key characteristics provides data which are accurate and repeatable. Records of calibration and other parameters shall be made.	On-going logging and monitoring of the significant energy use and affected energy factors. Summary of significant energy consumption in form of key figures. Compare actual and expected energy consumption, etc. Intervene when deviations from expected energy consumption occur. Log all significant deviations from expected energy consumption along with the reasons (if determined) as well as associated measures. BACS methods to standardize and anonymize data (for example, energy performance indicators etc.) and for benchmarking purposes (externally and internally).
4.2	**4.6.2 Evaluation of legal and other requirements**	
	At planned intervals, the organization shall evaluate compliance with legal requirements and other requirements to which it subscribes related to its energy use and consumption. Records of the results of the evaluations of compliance shall be maintained.	The organization reviews whether BACS is capable of supporting compliance evaluation requirements of EMS for building, e.g.: The organization monitors EMS compliance with legal obligations and other requirements. Maintain relevant BACS records to document compliance, to which the organization subscribes, relating to significant energy consumption.
4.3	**4.6.3 Internal audit of the EnMS**	
	The organization shall ensure that the EnMS: - conforms planned arrangements for energy management including the requirements of this International Standard; - conforms with the energy objectives and targets established; - is effectively implemented and maintained, and improves energy performance. An audit plan and schedule shall be developed taking into consideration the status and importance of the processes and areas to be audited as well as the results of previous audits. The selection of auditors and conduct of audits shall ensure objectivity and impartiality of the audit process. Records of the audit results shall be maintained and reported to top management.	The organization reviews how BACS can support internal audit requirements of EMS for buildings, e.g.: BACS provides effective and efficient energy management program, processes and systems: opportunities to continual improve the capability of processes and systems; data provisioning to apply effective and efficient statistical techniques; a suitable information technology platform to support audit activities.
4.4	**4.6.4 Nonconformities, correction, corrective action and preventive action**	
	The organization shall address actual and potential nonconformities by making corrections, and by taking corrective action and preventive action, including the following:	The organization considers BACS options to achieve and maintain the nonconformity, corrective action and preventive requirements of the EMS for buildings and specifies:

No.	EMS requirements according to EN ISO 50001:2011	BACS for EMS in buildings
	a) reviewing nonconformities or potential nonconformities; b) determining the causes of nonconformities or potential nonconformities; c) evaluating the need for action to ensure that nonconformities do not occur or recur; d) determining and implementing the appropriate action needed; e) maintaining records of corrective actions and preventive actions; f) reviewing the effectiveness of the corrective action or preventive action taken. Corrective actions and preventive actions shall be appropriate to the magnitude of the actual or potential problems and the energy performance consequences encountered. The organization shall ensure that any necessary changes are made to the EnMS	Automate BACS applications: monitor, analyse and signal non-conformance to energy saving targets, etc.; identify the cause of the non-conformance; Send appropriate action to correct the non-conformance; initiate action required to prevent recurrence of non-conformance; BACS applications that support: changing documented procedures as needed to ensure that they are consistent with new initiatives or actions; identifying responsible party for recording non-conformance and how it is recorded; ensuring that corrective and preventive action procedures are initiated; storing the relevant data in accordance with legal and/or documented time frames.
4.5	**4.6.5 Control of records**	
	The organization shall establish and maintain records, as necessary, to demonstrate conformity to the requirements of its EMS and of this International Standard, and the energy performance results achieved. The organization shall define and implement controls for the identification, retrieval and retention of records. Records shall be and shall remain legible, identifiable and traceable to the relevant activity.	The organization considers BACS options to achieve and maintain the control of records requirements of EMS for buildings and specifies: BACS electronic records of significant energy consumption, energy performance indicators; effectiveness of energy saving measures, before and after comparisons, etc. BACS electronic records of important messages (e.g. fault, operational status, maintenance, limit violation, etc.) of equipment with an energy impact; installation, plan, etc. BACS maintenance program with scheduled inspections and servicing of equipment with an energy impact; installation, plan etc. BACS requirements that ensure that the records are legible, identifiable, traceable and readily retrievable. The organization reviews how BAC can support internal audit requirements of EMS for buildings, e.g.: BACS provides effective and efficient energy management program, processes and systems: opportunities to continual improve the capability of processes and systems; data provisioning to apply effective and efficient statistical techniques; a suitable information technology platform to support audit activities.

No.	EMS requirements according to EN ISO 50001:2011	BACS for EMS in buildings
5	**4.7 Management review**	
5.1	**4.7.1 General**	
	At planned intervals, top management review the organization's EnMS to ensure its continuing suitability, adequacy and effectiveness. Records of management review shall be maintained	The organization reviews how BACS can support top management review of the EMS for buildings.
5.2	**4.7.2 Input to management review**	
	Inputs to the management review shall include: a) follow-up actions from earlier management reviews b) review of the energy policy; c) review of energy performance and related EnPIs; d) results of the evaluation of compliance with legal requirements and changes in legal and other requirements to which the organization subscribes; e) the extent to which the energy objectives and targets have been met; f) EMS audit results; g) the status of corrective actions and preventive actions; h) projected energy performance for the following period; i) recommendations for improvement	For inputs to management review: BACS provides inputs to review the EMS part for buildings as it relates to system abilities, compliance with energy policy and the achievement of energy targets. BACS provides an assistant to review overall energy performance of the building and other energy-related factors. Etc.
5.3	**4.7.3 Output from management review**	
	Outputs from the management review shall include any decisions or actions related to: a) changes in the energy performance of the organization; b) changes to the energy policy; c) changes to the EnPIs; d) changes to objectives, targets or other elements of the EMS, consistent with the organization's commitment to continual improvement; and allocation of resources.	Activities resulting on outputs from management review: Adjusting and enhancing of BACS and its organization on the building-related results of the management review.

5 eu.bac certification

5.1. Goal and purpose of eu.bac

EU Directives and national regulations require proof of energy consumption and energy efficiency of buildings, provided by testing and certification. The goal is to ensure an EU reduction in energy consumption of 20% by 2020.

Siemens launched an initiative with leading companies, active internationally in home and building automation and control, to establish the European Building Automation and Controls Association (eu.bac) in 2003. In the meantime, eu.bac members represent ca. 95% of the European market. (www.eubac.org)

eu.bac european building automation controls association

Objectives

- To establish a European quality assurance system for building automation and control components and for complete systems to significantly improve the energy efficiency of buildings.
- A legally binding set of regulations for performance contracting of buildings that rely on components and systems certified by eu.bac Cert.

5.2. eu.bac Product certification

A uniform, pan-European, valid certification is decisive for the EBPD to fully unleash its effectiveness to improve the energy efficiency of buildings. Numerous national certification systems could seriously jeopardize EBPD implementation. From this understanding, the European Association of Manufacturers of Building Automation and Control eu.bac, took the lead in certifying products.

The eu.bac certification process is based on European standards. It includes certification rules, accredited test labs to test the performance of products, factory inspections and approvals by recognized certification offices. eu.bac cooperates with European certification offices, Intertek (formerly, ASTA BEAB) in Great Britain, Centre Scientifique et Technique du Bâtiment (CSTB) in France and WSPCert in Germany. They are approved by the International Accreditation Forum (IAF) and work per EN 45011.

For product testing, eu.bac authorized recognized test labs such as BSRIA in England, CSTB-Lab in France and WSPLab in Germany.

Since 2007 a whole range of individual room controllers have been certified covering various applications (e.g. hot water radiated heat, chilled ceilings). In the works, are certifications for field devices such as temperature sensors, valves, actuators as well as outside air temperature controlled heating controllers. The current list of certified devices is available at www.eubaccert.eu.

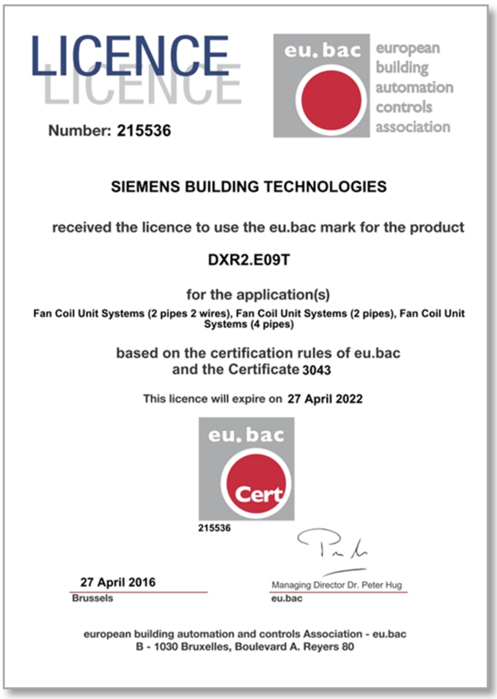
Certification documents

The following documents officially confirm the certification of products:

- Licence
- Test Report Summary

Licence

The licence confirms that the licensee (e.g. Siemens) is allowed to publish the eu.bac Cert symbol for the confirmed products and applications. Each certified product/application receives its own license number (e.g. 215536) and a reference to the expiration date, or the deadline for retesting.


LICENCE

Number: 215536

eu.bac european building automation controls association

SIEMENS BUILDING TECHNOLOGIES

received the licence to use the eu.bac mark for the product

DXR2.E09T

for the application(s)

Fan Coil Unit Systems (2 pipes 2 wires), Fan Coil Unit Systems (2 pipes), Fan Coil Unit Systems (4 pipes)

based on the certification rules of eu.bac
and the Certificate 3043

This licence will expire on 27 April 2022

eu.bac Cert

215536

27 April 2016
Brussels

Managing Director Dr. Peter Hug
eu.bac

european building automation and controls Association - eu.bac
B - 1030 Bruxelles, Boulevard A. Reyers 80

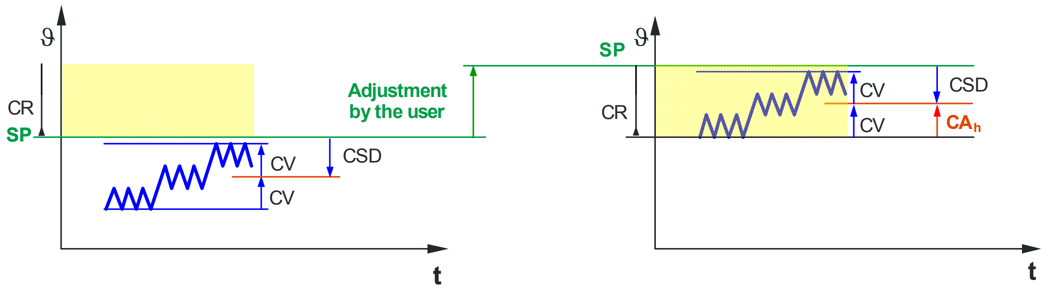
Requirements for issuing a licence from eu.bac Cert

1. eu.bac certification body must inspect the factory for:

- verification of quality management system (ISO EN 9001) of the manufacturing process for the product line in question
- testing of relevant aspects of the quality plan include testing facilities to ensure compliance of the product with the relevant EN standards

2. Product testing based on energy efficiency criteria according to EN standards:

- In the case of the individual room controller as per EN 15500: Accuracy of temperature control under three different loads



Product testing: Accuracy of the temperature control

ϑ	Room temperature	CV	Control variation
CR	Comfort range	CSD	Control to setpoint deviation
SP	Setpoint	CA_h	Control accuracy for heating

The user adjusts the deviation from the setpoint by shifting the setpoint. As a result, the average room temperature is by CV higher than requested by the user and with regard to energy consumption, the CV is part of the control accuracy CA_h.

Test result

The eu.bac-accredited test lab provides a test report on each license. The test information relevant to product use is compiled in the test report summary.

Since in the example for individual room controllers, the control circuit is tested (control accuracy), the report placed special emphasis on the important characteristics of field components. For example: the sensor element and its time constant for the temperature sensor and the type of actuator and its characteristic curve for the valve. Finally, the report documents the test results. In the case of the individual room controller, the measured values for heating and cooling are documented.


Test Report Summary

Product Information	
Licence Number:	215536
Licensee:	SIEMENS BUILDING TECHNOLOGIES
Product Identification	DXR2.E09T
Test Specifications	
Tested Application:	Fan Coil Unit Systems (4 pipes)
Temperature Sensor	
- Type:	Ni1000
- Time Constant:	16 Mins
Actuator Identification	SSB81
- Type:	Motorized: 3P
Valve Identification	VXP45.10-1
- Characteristic	2-way/3-way drive(23WV): equal percentage(EP)
AV Acronym	24Vac/MA/3P/23WV/EP
Fan Speed (For Fan Coil Applications)	
- Characteristic	variable speed fan
Test Result	
Temperature Control Accuracy C_A according EN 15500	Heating - 0.1 K Cooling - 0.1 K

27 April 2016
Brussels

Managing Director Dr. Peter Hug
eu.bac

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5.2.1. Customer benefits resulting from eu.bac Cert products

For the product user, eu.bac Cert guarantees a high-degree of

- energy efficiency and
- product quality

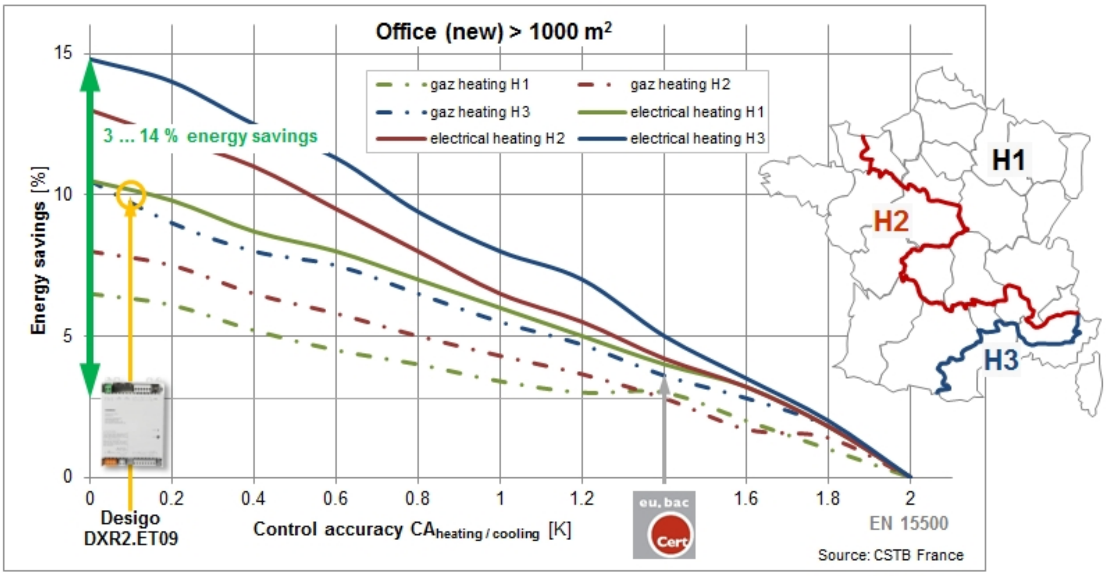
as set forth in the corresponding EN / ISO standards and European Directives. The energy efficiency of individual room controllers can be documented as follows:

Impact on energy savings

As mentioned earlier, the control accuracy of individual room controllers is measured and confirmed with a certificate. The control accuracy has a direct impact on the behavior of room users. The poorer the control accuracy, the more likely the user is to adjust the room setpoint as a result of poor comfort.

The graphic below illustrates how much energy (in %) a controller with control accuracy of 0.1 K saves versus a controller with control accuracy of 1.4 K (resp. 2 K).

Please note the following:
eu.bac has reduced the required minimum control accuracy in EN 15500 from 2 K to 1.4 K.



Source: „Centre Scientifique et Technique du Bâtiment (CSTB)", Frankreich

Siemens achieved very solid values with their certified single room controllers. For example with Desigo DXR2.E09T (for fan coils) with motoric actuators control accuracy for heating and cooling of 0.1 K was achieved.

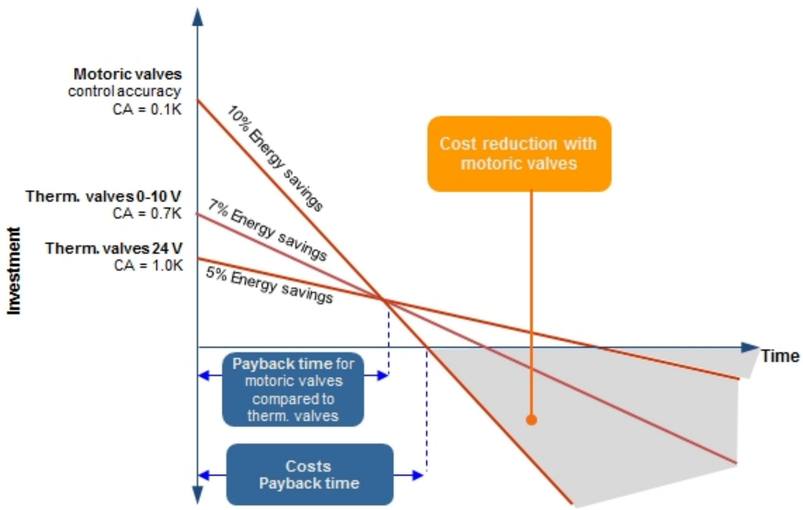
Impact of actuator on energy savings

It is well known that characteristics (time constants, adjustment response, characteristic curve, etc.) for field devices have a direct impact on control accuracy.

In other words, different levels of control accuracy can be achieved with the same individual room controllers and temperature sensors, but using different valve actuators (motor, thermal modulating, thermal on/off) and thus different energy savings can be realized. On the flip side, the variously equipped control circuits cause differences in the costs of the control circuit.

The chart below illustrates that a higher investment in motor driven valves makes sense versus thermally driven valves (in the comparison with the previous chart, curve "natural gas heating H3"/Southern France):

- The amortization period for the investment is shorter
- Then operating costs are lower as a result of larger energy savings
- And the impact on the environment declines in line with the energy savings



Cost reduction from utilizing motoric valves (see curve „ gaz heating H3“, Southern France above)

5.3. eu.bac System certification

5.3.1. System audit and labelling – eu.bac system

Context

The primary purpose of a building is the provision of space for working and living, a place of comfort and safety. BACS control according to design specification which must follow current facility requirements. Current facility requirements change during the life of the building influenced by factors such as change in use, operational priorities, technology development and regulatory requirements.

Questions to be answered:

- Is the BACS designed to support the energy efficiency goals of the building owner?
- In what content does your BACS contribute to energy efficiency of your building?
- Does the installed BACS control according to specification?
- How do the users interact with the BACS?
- Is the full potential of the installed BACS being used?

The eu.bac assessment method could help you find the answers to the above questions. Moreover, this methodology offers an *uncomplicated and effective* way to benchmark the BACS and to identify improvement potential without a detailed energy analysis. The outcome of this standardized assessment shows the gap between the actual functionality and the optimal control functions for the specific system. It clearly points out the improvement potential and prospective rating increase that could be achieved with better control strategies for each specific function and field of use.

5.3.2. eu.bac methodology

The eu.bac System Method will assure the users a level of performance of their systems, as defined in the EU directives and relevant EN standards. It rates the system efficiency and creates trust and transparency to the benefit of building owners and occupants.

EN 15232-1:2017 function classifications are the basis

The BACS evaluation is based on a points system and is normalised to a 0–100 scale. Using points provides a flexible and multi-value scale. Individual control functions are allocated different amounts of points depending on their relative importance for the BACS energy efficiency. As described above, the assignment of points directly relates to functions listed in the EN 15232-1:2017 standard (as described in this document in 4.1 “List of relevant building automation and control functions”).

1	Heating control		
1.1	Emission control	HEAT_EMIS_CTRL_DEF	M3–5
		The control function is applied to the heat emitter (radiators, underfloor heating, fan-coil unit, indoor unit) at room level; for type 1 one function can control several rooms	
	0	No automatic control of the room temperature	
	1	Central automatic control: There is only central automatic control acting either on the distribution or on the generation. This can be achieved for example by an outside temperature controller conforming to EN 12098-1 or EN 12098; one system can control several rooms	
	2	Individual room control: By thermostatic valves or electronic controller	
	3	Individual room control with communication: Between controllers and BACS (e.g. scheduler, room temperature setpoint)	
	4	Individual room control with communication and occupancy detection: Between controllers and BACS; Demand control/occupancy detection (this function level is usually not applied to any slow reacting heat emission systems with relevant thermal mass, e.g. floor heating, wall heating)	

Example of function classification list out of EN 15232-1:2017

Thus the relative importance of each of the applications (e.g. Emission Control application) is established, assigning them a multiplication factor to create an overall summary assessment that is relevant to the section in question of a typical building.

Weighting of different spaces and equipment of a building in the eu.bac assessment tool

A typical building contains rooms/spaces, several air-handling units (AHU), a central plant. These may have various pieces of equipment that are controlled through different control functions. In the eu.bac assessment tool each space, AHU, heating distribution network, heating plant, etc. is described in one row. To be able to make an accurate classification different weightings are applied to them. Weighting factors are given as a relative value to compare equipment of different sizes or spaces with different operating schedules. For technical building management (TBM), the area covered by the respective BACS is used in the calculation.

Different building types and related importance of BACS functionality

Moreover, the tool is capable to weigh up the applications differently for different types of buildings. The selection of building type is used to assign importance factors for all the different applications in the different sections. The weighting factors were modelled and tested in collaboration with the Technical University of Dresden.

The eu.bac method considers the following types of buildings:

- Office
- Education
- Hospital
- Hotel
- Retail
- Restaurant
- Data Centre
- Residential Building

The type of building determines the relative importance of BACS functionality for the following applications:

- Heating control;
- Domestic hot water control;
- Cooling control;
- Ventilation and air-conditioning control;
- Lighting control;
- Shading control;
- Technical building management.

In addition, the eu.bac method evaluates the use of Key Performance Indicators, certain extended functionality, and/or certified products that contribute to high energy performance.

The methodology could also be used in the simulation of concrete examples, i.e. to demonstrate the new, improved rating if the recommended installations and optimisations were implemented.

The eu.bac Technical Recommendations document describes the different functionality options for each application in more detail and advises how to check that functionality during the audit.

5.3.3. eu.bac label and classification system

eu.bac established the AA/A/B/C/D/E classification scheme for all eu.bac related product certifications as well as the eu.bac System certification with the AA rating being the best.

The eu.bac System Label assures the BACS has been assessed according to EN15232 and highlights the potential to control the building systems in the most energy-efficient way.

The eu.bac certificate and allocation of points to the corresponding levels is depicted below:

Level	Points
AA	85-100
A	75-84
B	65-74
C	55-64
D	45-54
E	0-44

Example: eu.bac system label

Based on the calculation methods described in EN 15232, conclusions can be drawn regarding the potential for energy savings. An improvement of 10 points corresponds to energy savings of approximately 5%. These values, of course, depend very much on the individual object to be evaluated and should be considered as reference values.

The eu.bac label sustains the energy-efficient control of building systems. The certificate is valid for 3 years. Subsequent recertification will be required in order to keep or improve the given rating. When KPIs have already been in use the recertification would focus only on identified deficiencies and on areas where modifications to the building or the BACS have occurred.

5.3.4. eu.bac system Key Performance Indicators (KPIs)

The eu.bac method includes continuous, automated evaluation of key performance indicators (KPIs) which prove that the building systems are controlled at their most sustainable energy-efficient level while maintaining indoor comfort closely related to building occupants' satisfaction, health and productivity. The KPIs are self-adapting to modifications in operational parameters, e.g. if the operator changes the temperature setpoint, the KPI using this value in the calculation will adapt automatically the allowed deviation within a defined range.

eu.bac System KPIs detect any deficiencies in the control of energy-consuming technical equipment in the building. A simple traffic light evaluation (green, yellow, red) allows first level diagnostic without consulting complicated trend curves.

Example KPI:

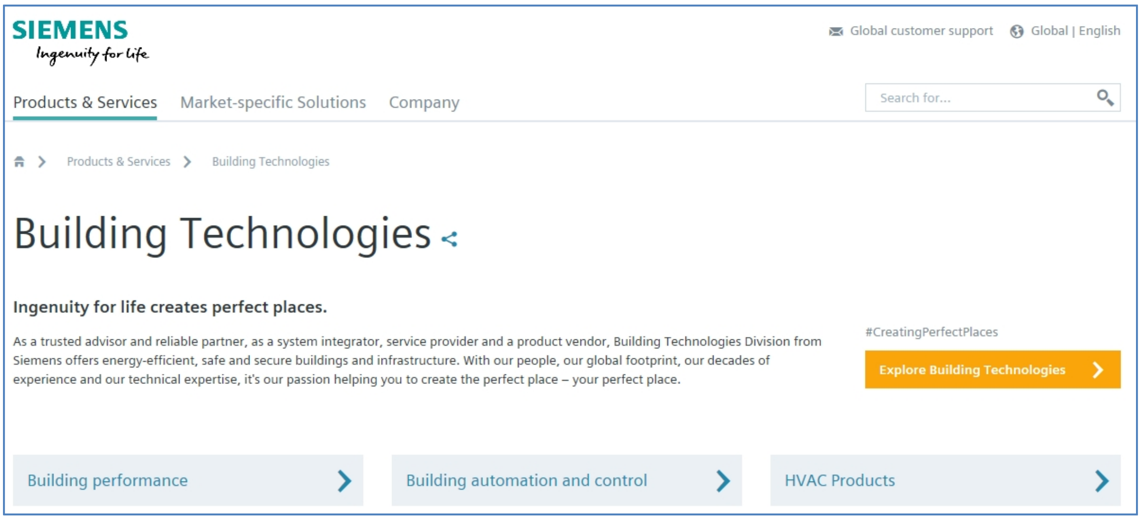
- Room / Zone air temperature (heating comfort supervision)
  - The goal of the KPI is to generate an alert when the room temperature rises during heat demand over the comfort zone.
  - Approach: Accumulation of time during a day in which the temperature is above the comfort band in relation to the accumulated usage time.
  - The valuation is as follows: If the comfort band is breached while more than 20% of the usage time red is displayed at 10% to 19% yellow, and less than 10% green.

The key performance indicators enable ongoing assessment of the performance of the building automation system and its components. With the help of these indicators, operators can detect and optimise settings that differ from actual requirements. For energy consultants, they also constitute a reliable data source and are the basis for energy optimisation. The basic principle here is: The greater the level of instrumentation and the finer the resolution, the more accurate the information, the more precise the control of the indoor environment; the more individual control the occupant has on his/her immediate environment.

6 Energy efficiency from Siemens

6.1. Building Automation solutions from Siemens

For up-to-date information on Siemens' wide range of Building automation systems, control products and field devices that support energy efficient operation of your buildings, please refer to the corresponding Siemens Internet sites.



https://www.siemens.com/global/en/home/products/buildings.html

6.1.1. Building automation and control Systems

Siemens provides a comprehensive range of building automation systems and HVAC products for every area of use like heating, ventilation, air conditioning, cooling application, and for every technical requirement. These building management systems are optimally matched so you profit not only from minimized installation and operating costs, but from a high level of security against failure as well.

https://www.siemens.com/global/en/home/products/buildings/automation.html

6.1.2. HVAC products to create perfect places

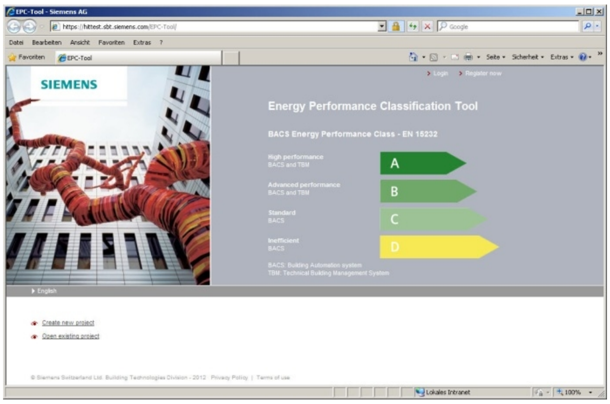
From valves and actuators to sensors and thermostats: All of Siemens products fulfill the highest quality standards. Energy efficiency, easy handling and long lifecycles are among the essential features of every single one of our products. And open communication standards like KNX and BACnet enhance compatibility and easily allow for seamless integration into building automation and control systems – this is how perfect places become a reality.

Our portfolio offers you all the products you need from just one source. You benefit from consistent installation processes and easy engineering for every single product. Plus, you'll receive support anywhere and anytime, with tools and apps designed to make your work as simple as possible – so you can focus on creating perfect places for your customers.

https://www.siemens.com/global/en/home/products/buildings/hvac.html

6.2. Energy Performance Classification (EPC) tool

The tool enables you to assess the BACS Energy Performance Classification of your building based on the standard EN15232.



This tool provides the following key functions:

- Acquisition of the actual state of an existing BACS and allocation of the controls to energy performance classes A to D
- Determination of the new state of BACS following modernization and allocation of the controls to energy performance classes A to D
- Potential savings are derived as per section 6 of EN 15232-1:2017 in…
  - liters
  - kWh
  - CO_2
- Determination of annual potential savings and indication in the respective currency
- Considerations on the potential profit of modernization
- Quick establishment of customized documentation

Extra functions:

The tool can be used either online or locally on a PC.

All standard web browsers are supported.

Operation and EN 15232 standard texts can be selected in different languages.

Evaluation of building automation and control:

- By means of overall or individual factors as per EN 15232-1:2017
- Using weighting based on experience made by Siemens

If no data on the consumption of the customer's building is available (both financial costs and energy usage (kWh, liters, m3, etc.)) the energy saving potentials in percent listed represent a useful basis. In addition, the required improvements can be outlined in the form of a catalog of measures.

When building technology creates perfect places –
that's Ingenuity for life.

Never too cold. Never too warm.
Always safe. Always secure.

With our knowledge and technology, our products, our solutions and our services, we turn places into perfect places.

We create perfect places for their users' needs – for every stage of life.

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