Building automation – impact on energy efficiency

Application per EN 15232:2012
eu.bac product certification

Answers for infrastructure.

SIEMENS

Contents

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 EN15232: 2012 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.

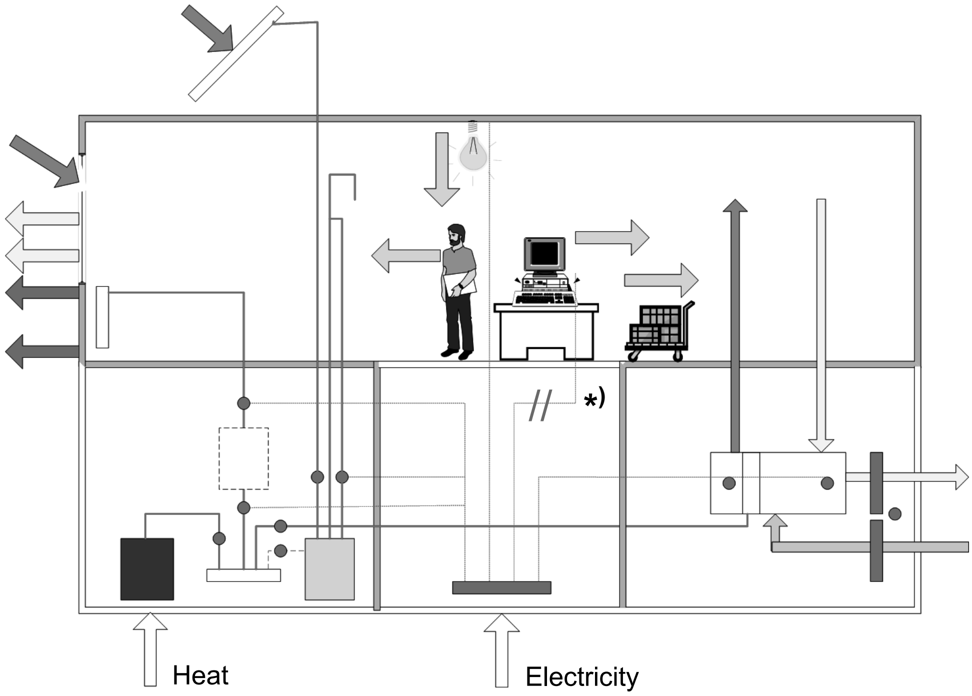
Building automation and control functions should be selected based on their impact on a building's efficiency. The purpose of the User's Guide is to provide understanding on using building automation and control functions to promote higher energy efficiency in buildings as well as the methods involved. 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; Germany
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.

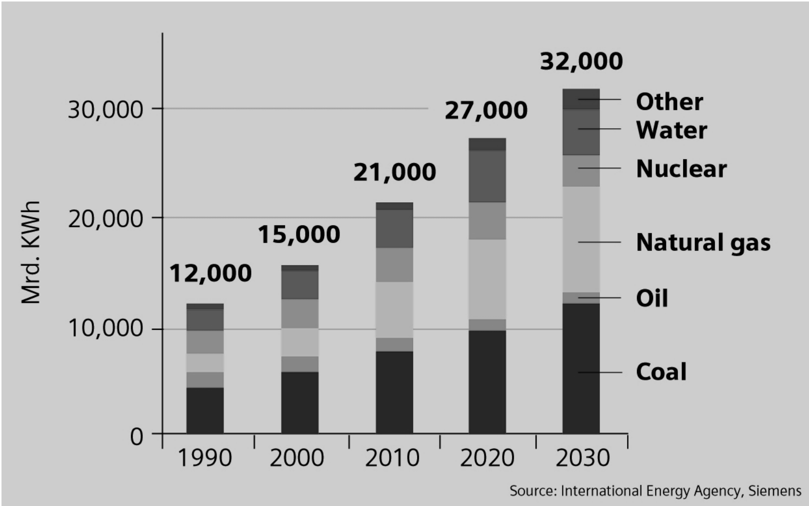
Executing regulations are assigned to the individual countries as per EN standard to determine the size of the reference values or how to calculate them.

2 Global situation: energy and climate

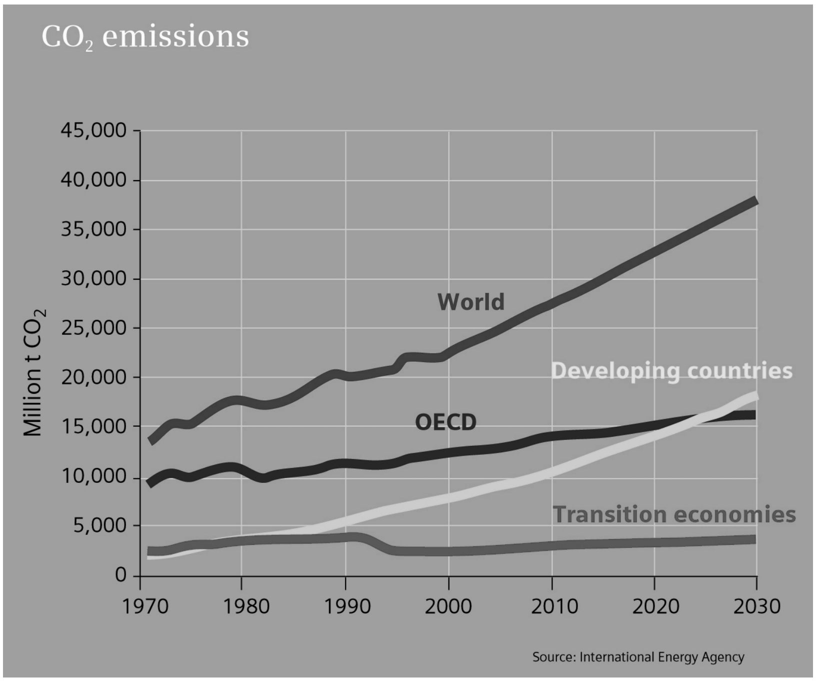
In this section, we discuss the global energy and climate situation as well as future perspectives on improving the situation.

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.



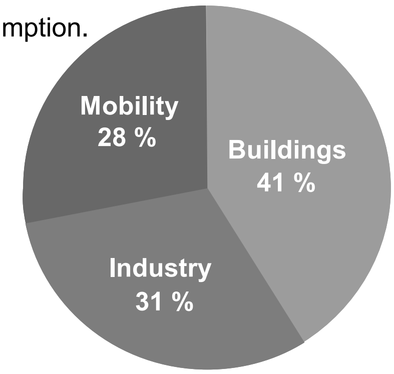
The impact of CO_2 emissions is already unmistakable: The average air temperature is continuously increasing over the long term; weather dynamics are increasing dramatically.

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):

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).



Overall, buildings account for 35% of primary energy use to achieve comfortable temperatures and 6% for electrical energy. That amounts to a significant portion.

2.3 Turning the tide – a long-term process

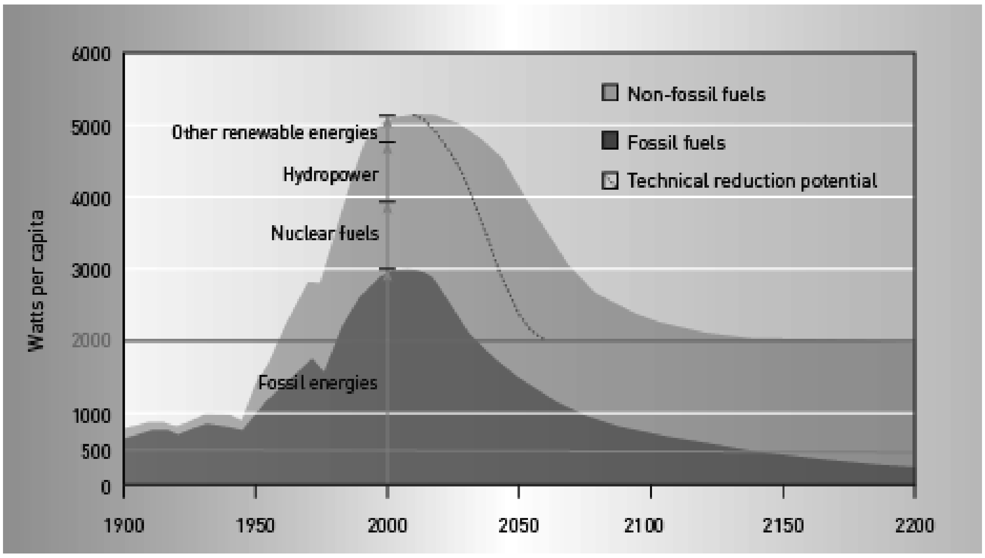
Europe has developed visions for a low-energy future and is intensely searching for ways to implement the visions:

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 2’000 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.

Update 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 buildings 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.

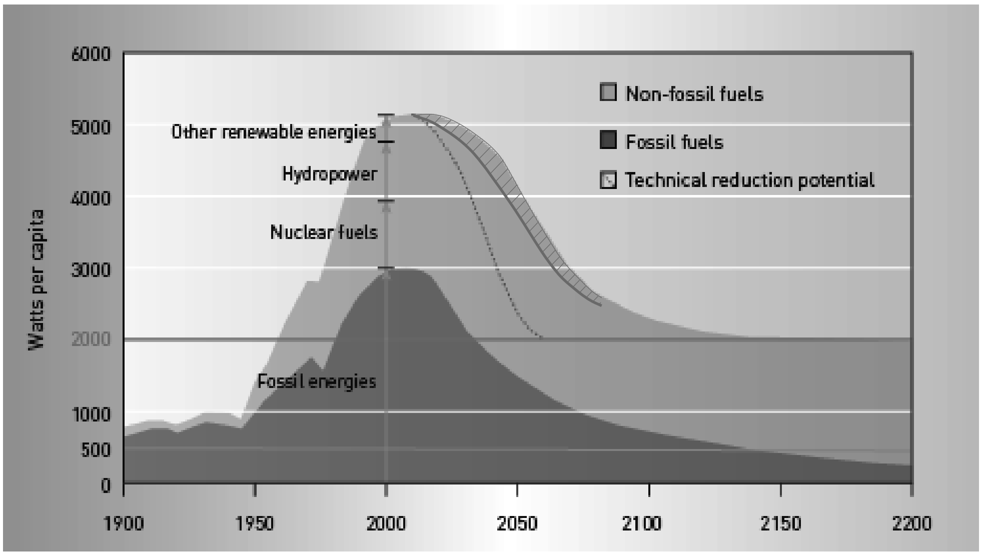
Short-term executable measures

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 ongoing 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 extend for other countries. So that 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 experience with energy management systems and corresponding services
- Years of experience as an energy innovator – Siemens holds more than 6'000 energy-related patents
- Implemented more than 1,900 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
- 700,000 tons corresponds to 805,000 cars each driving 20,000 kilometers a year

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**.

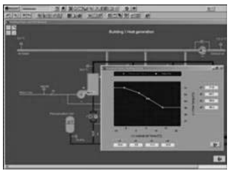
Siemens is a partner of the GreenBuilding initiative by the European Commission, with a goal of implementing cost-effective, energy efficiency potential in buildings. As a signatory to this initiative, Siemens BT must ensure that its customers can achieve a minimum energy efficiency of at least 25% in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

For the past five 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.

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.

Wirtschaft
für Klimaschutz
BDI initiativ

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, the initiative represents the entire spectrum and abilities of the productive economy in Germany.



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**. What's more, 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

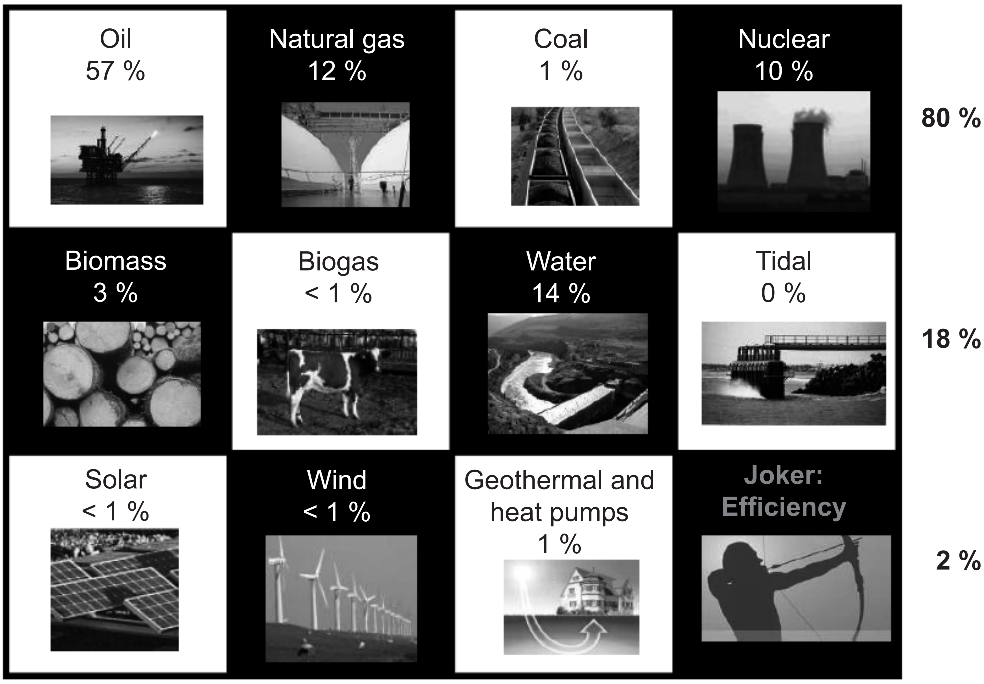
Dependency
Without taking actions, dependency on foreign energy will climb to 70% by 2020/2030.

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.

Example: Dependency

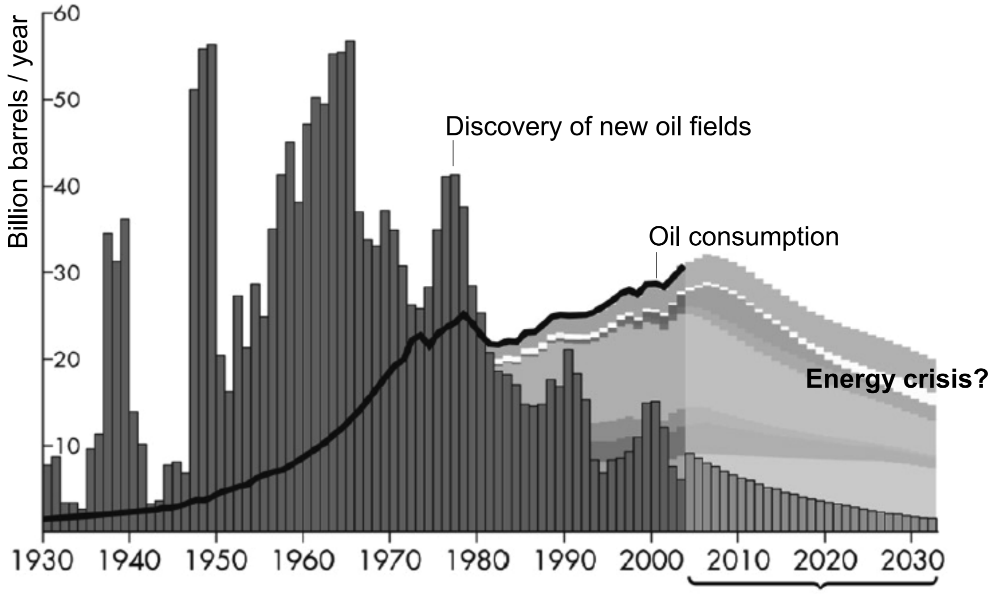


End energy consumption, Switzerland.
- Figures: BFE Overall energy statistics for 2006
- Chart: Zwölferspiel by Dr. Daniele Ganser, University of Basel. www.histsem.unibas.ch/peak-oil

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

Example: Supply and prices

The growing supply gap for oil



Forecast new discoveries

Source:
Association for the Study for Peak Oil (ASPO).
www.peakoil.ch

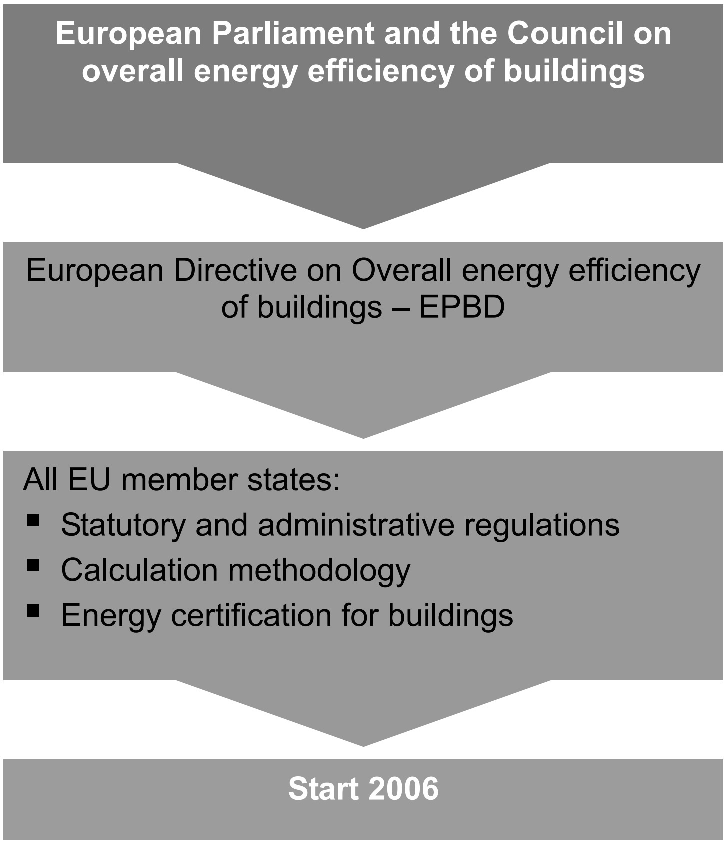
Supply is not secure, yet the price increase is ...

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

EU and domestic legislation



EPBD
Energy Performance of Building Directive

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 as regards:
(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**ommitée**)** 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 / TC247 develops European and international standards for building automation, controls and building management (BACS), for instance:

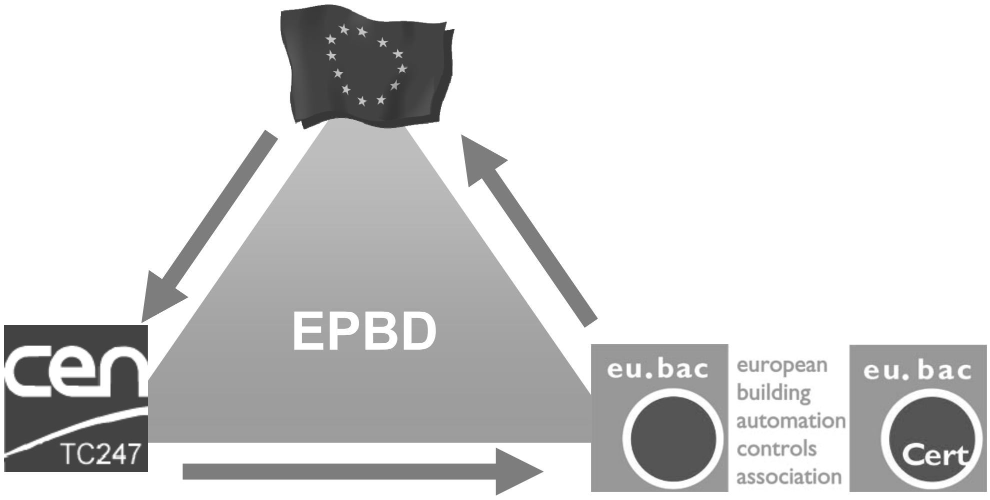
- Product standards for electronic control equipment in the field of HVAC applications (e.g. EN 15500)
  → Basis for product certification related to EPBD
- Standardization of BACS[1] functions (EN ISO 16484-3)
  → Basis for the impact of BACS on energy efficiency
- Open data communication protocols 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

---

[1] BACS = Building Automation and Control System

Procedure

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



CEN TC247 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 EN15232: "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 EN15232 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 EN15232: "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

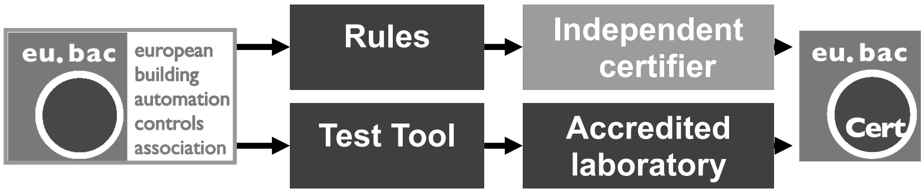
eu.bac Cert is a joint venture of eu.bac and various European certification bodies and test laboratories in conformity with the relevant provisions of the EN 45000 set of standards.

EU mandate for CEN to standardize calculation methods to improve energy efficiency

TC247: EN 15232 "Energy performance of buildings – Impact of Building Automation"

and

Product Standards
- Terminology
- Product data incl. energy performance criteria
- Test procedure



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.

3.4 Standardization benefits

Calculation standard

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.

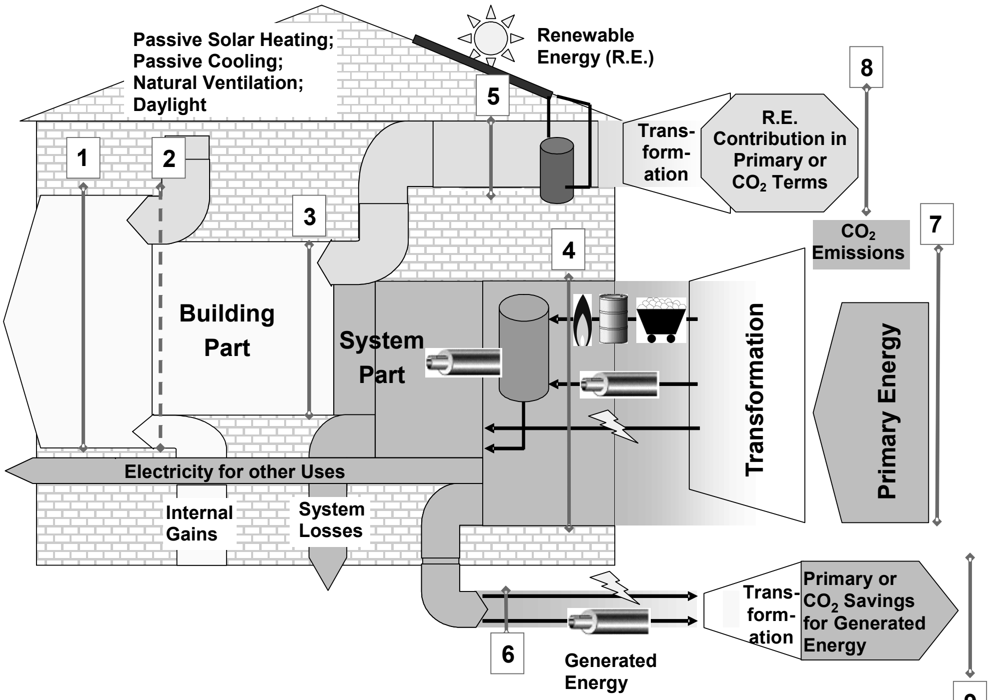
4 The EN 15232 standard in detail

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.

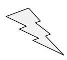
Energy flow model

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: prCEN/TR 15615:2007
Title: Declaration on the general relationship between various European standards and the EPBD ("Umbrella document")

Symbols:

 Electricity

 Natural gas, oil, coal, biomass, 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

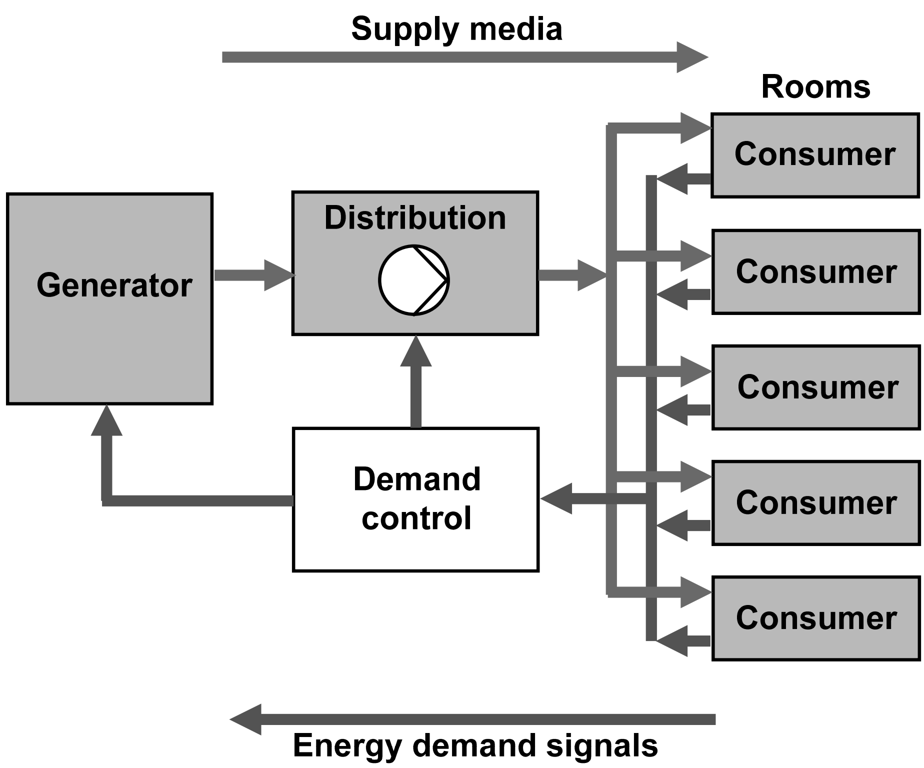
[4] is the delivered energy, represented separately for each energy carrier, inclusive of auxiliary energy, used by heating, cooling, ventilation, hot water and lighting systems, taking into account renewable energy sources and co-generation. This may be expressed in energy units or in units of the energy-ware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

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 15232:2012
- 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 15232:2012
- 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 15232:2012.

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

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.

AUTOMATIC CONTROL				
1	**HEATING CONTROL**		**BT**	**Reason for energy savings**
1.1	Emission control		1	
		The control system is installed at the emitter or room level, for case 1 one system can control several rooms		
	0	No automatic control of the room temperature		The highest supply output is continuously delivered to the heat emitters 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 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 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).
	3	Individual room control with communication Between controllers and BACS (e.g. scheduler)	3	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.
	4	Individual room control with communication and presence control Between controllers and BACS; Demand/Presence control performed by occupancy	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 provision (production of energy) results in minimum losses in provision and distribution.

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232:2012.

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 for TABS		5	
	0	<u>No automatic control</u> 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	<u>Central automatic control</u> 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 dependant 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	<u>Advanced central automatic control</u> This is an automatic control of the TABS zone that fulfills the following conditions: – If the TABS is used only for heating: The central automatic control 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. – If the TABS is used for heating and cooling: The central automatic control is designed and tuned to achieve an optimal self-regulating of the room temperature within the required comfort range (specified by room temperature heating and cooling setpoints). "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 uses as far as possible the full range to reduce the energy demand for heating and cooling. – If the TABS is used for heating and cooling: the automatic switching between heating and cooling is not done only dependent on the outside temperature, but also taking at least indirectly the heat gains (internal and solar) into account.	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	<u>Advanced central automatic control with intermittent operation and/or room temperature feedback control:</u> 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		a) 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). b) 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 15232:2012.

8. The pump is only released for 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				
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 Action 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; actions generally lead to a decrease of the flow rate		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		
	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 periods or in protection mode (frost hazard).
	2	Multi-stage control To reduce the auxiliary energy demand of the pumps		Operating at a lower speed reduces power consumption of multi-speed pumps.
	3	Variable speed pump control With constant or variable Δp and with demand evaluation 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 power consumption. b) With *proportional* Δp: Pressure differential across the pump drops as the load decreases. This provides additional reductions in speed and electrical power under part load conditions.
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 reduce the indoor temperature and the operation time		Savings in emission and/or distribution outside the nominal operating hours.
	2	Automatic control with optimum start/stop To reduce the indoor temperature and 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 reduce the indoor temperature and the operation time		The operating time and/or the temperature setpoint for emission and/or distribution is determined based on consumer demand. This can be accomplished via the operating mode (Comfort, PreComfort, Economy, Protection).

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232:2012.

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 temperatures, while also benefiting from a small temperature differential between evaporator and condenser.

10. This Siemens interpretation gives full consideration to the processing function in the function list from EN 15232: Switching on generators with the same rated output is accomplished based solely on load (no additional prioritization).

AUTOMATIC CONTROL				
1	**HEATING CONTROL**		**BT**	**Reason for energy savings**
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	Generator control for heat pumps			
		The goal consists generally in minimizing the generator operation temperature	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 outdoor 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		Priority control adapts current generation output (with priority to renewable forms of energy) to current load in an energy-efficient manner.
1.8	Sequencing of different generators			Priority control adapts current generation output (with priority to renewable forms of energy) to current load in an energy efficient manner.
	0	Priorities only based on running time		
	1	Priorities only based on loads	10	Only the generators for covering the current load are in operation.
	2	Priorities based on loads and demand of the generator capacities		At increasing output stages of all generators (e.g. 1 : 2 : 4, etc.) a) adaptation of the current generator output to load can be more precise, b) the large generators operate in a more efficient partial load range
	3	Priorities based on generator efficiency The generator operational control is set individually to available generators so that they operate with an overall high degree of efficiency (e.g. solar, geothermic heat, cogeneration plant, fossil fuels)		The generator operational control is set individually to available generators so that they operate with an overall high degree of efficiency or using the cheapest energy form (e.g. solar, geothermic heat, cogeneration plant, fossil fuels).

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232:2012.

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 effected via a thermostat.
	1	Automatic control on/off and charging time release		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 charging time release 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 heat generation		
	0	Automatic control on/off		Control is effected via thermostat.
	1	Automatic control on/off and charging time release	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, charging time release and demand-oriented supply 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.
	3	Automatic control on/off, charging time release, demand-oriented supply or return temperature control 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. Lower return temperature can be achieved through a reduction in the supply volume. These are required for condensing boilers, heat pumps, and district heating substations and save energy.

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232:2012.

3. The heating heat generation operated over the course of a year at a higher load level and effectiveness by reducing the operating time and uses less energy accordingly.

4. The electric heating assumes storage charge output the heating period. The charge time enable should be set to a timeframe where no peak loads occur and lower electricity rates are available.

AUTOMATIC CONTROL				
2	**DOMESTIC HOT WATER SUPPLY CONTROL**		**BT**	**Reason for energy savings**
2.3	Control of DHW storage temperature, varying seasonally: with heat generation or integrated electric heating			
	0	Manual selected control with charging pump on/off or electric heating		Control is effected via thermostat. The generator must be preselected:
	1	Automatic selected control with charging pump on/off or electric heating and charging time release	3	Generator is shut down automatically during non-heating periods and electric heating is released. Just the opposite during heating periods. This increase the level of use for the heat generator. If the DHW temperature drops below a certain reduced level, recharging takes place even without a time-based release.
	2	Automatic selected control with charging pump on/off or electric heating, charging time release and demand-oriented supply or multi-sensor storage management	4	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 and efficiency.
	3	Automatic selected control with heat generation, demand-oriented supply and return temperature control or electric heating, charging time release 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. Lower return temperatures can be achieved through a reduction in the supply volume. This is required for condensing boilers, heat pumps, and district heating substations and saves energy.

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232:2012.

5. 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.

AUTOMATIC CONTROL				
2	**DOMESTIC HOT WATER SUPPLY CONTROL**		**BT**	**Reason for energy savings**
2.4	Control of DHW storage temperature with solar collector and heat generation			DHW storage tank with two integrated heat ex-changers.
	0	Manual selected control of solar energy or heat generation		Control is effected via thermostat. The generator must be preselected:
	1	Automatic control of solar storage charge (Prio. 1) and sup-plementary storage charge		The solar collector can recharge any amount of freely available energy up to the maximum DHW storage tank temperature so that the maximum pos-sible share of solar energy is used. Heat generation only supplements the required energy amount to ensure a sufficient DHW temperature at any time.
	2	Automatic control of solar storage charge (Prio. 1) and sup-plementary storage charge and demand-oriented supply or multi-sensor storage management		Solar storage tank charging has the highest priority. The remaining, required coverage is provided by the heat generator via demand-controlled supply tem-peratures thus reducing heat losses in generation and distribution. Multi sensors allow for dividing the DHW storage tank into various zones, ensuring bet-ter adaptation to usage. This reduces heat losses in the storage tank.
	3	Automatic control of solar storage charge (Prio. 1) and sup-plementary storage charge, demand-oriented supply, return temperature control and multi-sensor storage management		Solar storage tank charging has the highest priority. The remaining, required coverage is provided by the heat generator via demand-controlled supply tem-peratures, thus reducing heat losses in generation and distribution. Lower return temperature can be achieved through a reduction in the supply volume flow. This is required for condensing boilers, heat pumps, and district heating substations and saves energy. Storage tank management optimized to use only heats storage tank zones required for the re-spective demand. This reduces heat losses in the storage tank.
2.5	Control of DHW circulation pump			
		Continuous operation, time switch program controlled or de-mand-oriented on/off		
	0	Without time switch program	5	Hot water circulates, leading to unnecessary heat losses which have an impact on overall efficiency of DHW heating.
	1	With time switch program		Heat losses in hot water circulation are limited to primary occupancy periods.
	2	Demand-oriented control Demand-dependent on water usage (e.g. open/close tap)		Heat losses in hot water circulation are limited to current occupancy periods. Use can be determined using consumption measurement or acquiring the circulation temperature. The windshield washer function (periodic pump run, measuring circulation temperature, deciding on whether a pump run is needed) can also be used to determine use.

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232:2012.

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). 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 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 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".

AUTOMATIC CONTROL				
3		**COOLING CONTROL**	**BT**	**Reason for energy savings**
3.1		Emission control	1	
		The control system is installed at the emitter or room level, for case 1 one system can control several rooms		
	0	No automatic control Providing 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 to BACS (e.g. scheduler)	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
	4	Individual room control with communication and presence control Between controllers and BACS; Demand / Presence control performed by occupancy	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 15232:2012.

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 a relatively large thermal storage capacity.
   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, so that it often overheats or undercools somewhat 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 activities. This eliminates to some extent overheating or undercooling.

AUTOMATIC CONTROL				
3		**COOLING CONTROL**	**BT**	**Reason for energy savings**
3.2		Emission control for TABS	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 dependant 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: – If the TABS is used only for cooling: The central automatic control 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. – If the TABS is used for heating and cooling: The central automatic control is designed and tuned to achieve an optimal self-regulating of the room temperature within the required comfort range (specified by room temperature heating and cooling set-points). "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 uses as far as possible the full range to reduce the energy demand for heating and cooling. – If the TABS is used for heating and cooling: the automatic switching between heating and cooling is not done only dependent on the outside temperature, but also taking at least indirectly the heat gains (internal and solar) into account.	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) 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) 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. Advanced central automatic control with intermittent operation and room temperature feedback control		a) 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). b) 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 15232:2012.

8. Comparable functions can be used for controlling networks for electrical direct cooling (e.g. compact cooling units or split units for individual rooms)

9. The pump is only enabled for demand.

   With proportional Δp: Pump solutions with an external pressure 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**	**Reason for energy savings**
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	8	
	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 increase 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; Actions leads generally to a decrease of the flow rate		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)
3.4	Control of distribution pumps in 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 With variable Δp and with demand evaluation to reduce the auxiliary energy demand of the pumps	9	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 *proportional* Δp: Pressure differential across the pump drops as the load decreases. This provides additional reductions in speed and electrical power under part load conditions.
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 raise the indoor temperature and to lower the operation time		Savings in emission and/or distribution outside the nominal operating hours.
	2	Automatic control with optimum start/stop To raise the indoor temperature and 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 raise the indoor temperature and to lower the operation time		The operating time and/or the temperature setpoint for emission and/or distribution is determined based on consumer demand. This can be accomplished via the operating mode (Comfort, PreComfort, Economy, Protection).

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232:2012.

10. For air conditioned buildings this function is one of the most important regarding energy savings. The possibility to provide simultaneously heating and cooling in the same room depends on the system principle and the control functions. Depending on the system principle a full interlock can be achieved with a very simple control function or can request a complex integrated control function.

11. This Siemens interpretation gives full consideration to the processing function in the function list of EN 15232: Switching on generators with the same nominal output is accomplished based solely on load (no additional prioritization)

AUTOMATIC CONTROL				
3		**COOLING CONTROL**	**BT**	**Reason for energy savings**
3.6		Interlock between heating and cooling control of emission and/or distribution	10	
		To avoid at the same time heating and cooling in the same room depends on the system principle		
	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 (dependant 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.
3.7		Different generator control		
		The goal consists generally in minimizing the generator operation temperature		
	0	Constant temperature control		The generator continuously provides the lowest 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: This includes control according to room temperature		Generation temperature is controlled by the effective temperature demand of the consumers. Keeps energy losses at the generator to an optimum (low).
3.8		Sequencing of different generators		Priority control adapts momentary generation output (with priority to renewable energies) to current load in an energy efficient manner.
	0	Priorities only based on running time		
	1	Priorities only based on loads	11	Only the generators required for the current load are switched on.
	2	Priorities based on loads and demand Depending on the generator capacities		At increasing output stages of all generators (e.g. 1 : 2 : 4, etc.) , … • adaptation of the current generator output to load can be more precise, • the larger generators operate in a more efficient partial load range.
	3	Priorities based on generator efficiency The generator operational control is set individually to available generators so that they operate with an overall high degree of efficiency (e.g. outdoor air, river water, geothermic heat, refrigeration machines)		Generator operational control is set individually to available generators, enabling them to operate with an overall high level of efficiency or the most favorably priced form of energy (e.g. solar, geothermic energy, cogeneration plant, fossil fuels).

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232:2012.

1. This deals exclusively with air renewal in the room.
   Note: As per EN 15232, the parts "Heating control" and "Cooling control" apply for **room** temperature control

2. This function affects the air flow in a single room system (e.g. movie theater, lecture hall) or in the reference room of a multi-room system without room automation.
   This function affects the air flow of each room automation as part of a multi-room system. For that, supply air pressure control in the air handling unit is required (refer to Processing function 4.2 per interpretation 3).

3. Processing functions 0 until 2 affect the air flow in the air handling unit as part of a multi-room system without room automation. These are, however, already contained in the function per interpretation 2. Processing function 3 was planned as air flow provisioning for a multi-room system with room automation.

4. Control of exhaust air side icing protection of heat recovery (heat exchanger).

AUTOMATIC CONTROL				
4		**VENTILATION AND AIR CONDITIONING CONTROL**	**BT**	**Reason for energy savings**
4.1		Air flow control at the room level	1 2	Reduction of the air flow saves energy for air handling and distribution.
	0	No automatic control The system runs constantly (e.g. manual controlled switch)		Air flow for the maximum load in the room is used up continuously, resulting in greater energy losses under part load conditions in the room and during non-occupancy.
	1	Time control The system runs according to a given time schedule		Air flow for the maximum load in the room is used up during nominal occupancy times, resulting in significant energy losses under part load conditions in the room.
	2	Presence control The system runs dependent on the presence (light switch, infrared sensors etc.)		Air flow for the maximum load in the room is only used up during current occupancy times. Energy losses under part load conditions in the room are reduced to actual occupancy.
	3	Demand control The system is controlled by sensors measuring the number of people or indoor air parameters or adapted criteria (e.g. CO2, mixed gas or VOC sensors). The used parameters shall be adapted to the kind of activity in the space.		Air flow in the room controlled by an air quality sensor, for example, ensuring air quality at lower energy for air handling and distribution.
4.2		Air flow or pressure control at the air handler level	3	Reduction of air flow saves energy for air handling and distribution.
	0	No automatic control Continuously supplies of air flow for a maximum load of all rooms		Air handling unit continuously supplies air flow for a maximum load of all rooms, resulting in unnecessary energy expenses under part load conditions and during non-occupancy.
	1	On off time control Continuously supplies of air flow for a maximum load of all rooms during nominal occupancy time		Air handling unit supplies air flow for a maximum load of all connected rooms during nominal occupancy times, still resulting in significant energy losses under part load conditions.
	2	Multi-stage control To reduce the auxiliary energy demand of the fan		Operation at a lower speed reduces the electrical consumption of multi-speed fan motor.
	3	Automatic flow or pressure control With or without pressure reset, with or without demand evaluation: Load depending supplies of air flow for the demand off all connected rooms.		Air flow adapts to demand of all connected consumers. Under part load conditions, electrical power is reduced at the fan in the air handling unit,
4.3		Heat recovery exhaust air side icing protection control	4	
	0	Without defrost control There is no specific action during cold period		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 defrost control During cold period a control loop enables to warranty that the air temperature leaving the heat exchanger is not too low to avoid frosting		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 15232:2012.

5. Control of heat recovery in the centralized air handling unit.

6. Cooling and ventilation with a portion provided by passive energy (renewable and free, may however require auxiliary energy, e.g. electrical energy for pumps). This reduces the percentage of active energy (that has to be paid for)

AUTOMATIC CONTROL				
4		**VENTILATION AND AIR CONDITIONING CONTROL**	**BT**	**Reason for energy savings**
4.4	Heat recovery control (prevention of overheating)		5	
	0	Without overheating control There is no specific action during hot or mild periods		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		Temperature sequence control at heat recovery prevents unnecessary recooling of the supply air.
4.5	Free mechanical cooling		6	
	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 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		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 15232:2012.

7. If the ventilation system serves only one room and is controlled to the indoor temperature of that room, use "7.4 Heating and cooling control", even if the control acts on the supply temperature. In the other cases, the types of available controls must be differentiated.

   Exercise care when using this type of temperature control, unless the system is designed to prevent simultaneous heating and cooling.

8. An air washer that has a humidification efficiency of at least 95%, i.e. one that can almost achieve the saturation of the escaping air is required for dew point control. If the temperature of this nearly saturated air is also controlled, its water vapor content is fixed. Therefore, the required effort in terms of control equipment is relatively small. This solution is appropriate in applications where the air that has been cooled to the dew point is largely reheated by internal heat sources in the conditioned space. If this is not the case, direct humidity control is – for energy efficiency reasons – preferable for conventional air conditioning systems.

9. In the case of water spray humidification, a humidification efficiency that is considerably lower than that of the dewpoint air washer suffices. This means that a lower priced device can be used accordingly. It is, however, important for the humidifier to be controlled within a sufficiently large output range.

AUTOMATIC CONTROL				
4		**VENTILATION AND AIR CONDITIONING CONTROL**	**BT**	**Reason for energy savings**
4.6		Supply air temperature control	7	
	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 dependant 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
4.7		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	8	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 constant value	9	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 15232:2012.

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. Manual On/Dimmed (Off) and Manual On/Auto Off 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.

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**
5.1		Occupancy control		Reducing lighting to occupancy times or current needs in room areas saves energy.
	0	Manual on/off switch The luminary is switched on and off with a manual switch in the room		In residential buildings Users can turn the lighting on and off as needed. This saves lighting energy. In non-residential buildings Lighting is mostly on. Reason: Many users do not turn off lighting during breaks or at the end of the work.
	1	Manual on/off switch + additional sweeping extinction signal The luminary is switched on and off with a manual switch in the room. In addition, an automatic signal automatically switches off the luminary at least once a day, typically in the evening to avoid needless operation during the night	1	Ensures that lights are turned off in non-residential buildings as well (e.g. in the evening or on weekends).
	2	Automatic detection **Auto On / Dimmed Off:** The control system switches the luminary (ies) automatically on whenever there is presence in the illuminated area, and automatically switches them to a state with reduced light output (of no more than 20% of the normal 'on state') no later than 5 min after the last presence in the illuminated area. In addition, no later than 5 min after the last presence in the room as a whole is detected, the luminary(ies) is automatically and fully switched off **Auto On / Auto Off**: The control system switches the luminary(ies) automatically on whenever there is presence in the illuminated area, and automatically switches them entirely off no later than 5 min after the last presence is detected in the illuminated area **Manual On / Dimmed**: The luminary(ies) can only be switched on by means of a manual switch in (or very close to) the area illuminated by the luminary(ies), and, if not switched off manually, is/are automatically switched to a state with reduced light output (of no more than 20% of the normal 'on state') by the automatic control system no later than 5 min after the last presence in the illuminated area. In addition, no later than 5 min after the last presence in the room as a whole is detected, the luminary(ies) are automatically and fully switched off **Manual On / Auto Off:** The luminary(ies) can only be switched on by means of a manual switch in (or very close to) the area illuminated by the luminary(ies), and, if not switched off manually, is automatically and entirely switched off by the automatic control system no later than 5 min after the last presence is detected in the illuminated area	2	Auto On/Dimmed Off 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. Auto On/Auto Off 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. Manual On/Dimmed Lighting of each area … • can only be switched on manually, • 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. Manual On/Auto Off Lighting of each area … • can only be switched on manually, • 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.
5.2		Daylight control		Artificial lighting can be reduced as the incoming daylight increases, thus saving energy.
	0	Manual There is no automatic control to take daylight into account		Lighting is manually increased when daytime light is too weak. Lighting is not always manually reduced, however, when daytime light is more than sufficient (suboptimal).
	1	Automatic An automatic system takes daylight into account in relation to automatisms described in 5.1.	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 15232:2012.

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 15232:2012.

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**
	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. These set points are often modified by the users. 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	Detecting faults of home and building systems and providing support to the diagnosis of these faults	1	First, errors as well as ongoing deviations from the specifications must be recognized and displayed. Only then will it be possible to initiate counter-measures to resume energy-efficient operation. Examples of possible errors: • Operating mode select switch permanently set to "ON" • Party switch continuously active • Scheduler permanently overridden • Setpoint or actual value outside the normal range for a long period of time
7.2	Reporting information regarding energy consumption, indoor conditions and possibilities for improvement	2	The following BM system functions support analysis and evaluation of plant operations: • Calculate weather-adjusted annual energy consumption, as well as additional weather-adjusted key variables • Compare object’s operating data and the plant’s against standard values, class values, etc. • Ability to efficiently report deviations

Technical home and building management functions: Extract from EN 15232

A.10.1 General

These functions are especially useful to achieve the following requirements of energy performance in buildings directive:

- Establishing an energy performance certificate;
- Boiler inspection;
- Air conditioning system inspection.

A.10.2 Monitoring

Detecting faults of building and technical systems and providing support to the diagnostics of these faults

Specific monitoring functions shall be set up to enable to detect quickly the following faults:

a) Improper operation schedules
This is especially necessary in buildings which are not permanently occupied, such as offices and schools.
The monitoring function shall include at the minimum a graph or an indicator highlighting the time where fans are on, the cooling system is running, the heating system is in normal mode, lighting is on.

b) Improper setpoints
Specific monitoring functions shall be set up to facilitate quick detection of incorrect room temperature setpoints.
The monitoring function shall include a graph or an indicator, making it possible to have a global view of the different of room temperature setpoints for heating and cooling.

c) Simultaneous heating and cooling
If the system can lead to simultaneous heating and cooling monitoring functions shall be set to check that simultaneous heating and cooling is avoided or minimized.
Fast switching between heating and cooling shall also be detected.

d) Priority to generator(s) having the best energy performance
When several generation systems with different energy performance are used to do the same function (e.g. heat pump and backup, solar system and backup) a monitoring function shall be set to verify that the systems having the best energy performance are used before the others.

A.10.3 Reporting

Reporting information regarding energy consumption, indoor conditions and possibilities for improvement.
Reports with information about energy consumption and indoor conditions shall be produced.

These reports can include:

a) Energy certificate for the building

b) The monitoring function which shall be used to obtain a measured rating as defined in EN 15603:2008, clause 7.

   Online monitoring functions make it possible to obtain a rating fully in conformity with the requirements of EN 15603:2008. Measurements of the meters can be done for an exact year according to 7.2. If a sufficient number of meters are installed the measurements can be made for each energy carrier. Energy used for other purposes than heating, cooling, ventilation, hot water or lighting can be measured separately according to 7.3. Measurement of the outside temperature facilitates readjustments of the outdoor climate as defined in 7.4.

   The rating can be used to prepare an energy performance certificate designed according to EN 15217;

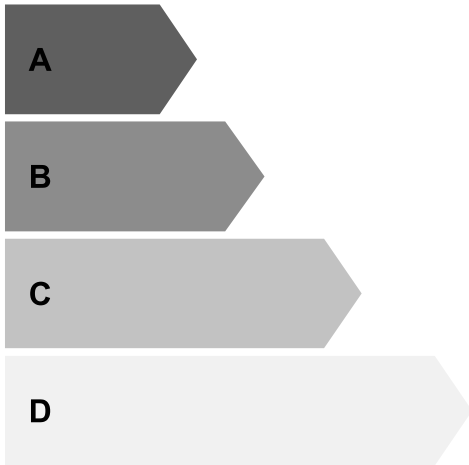
c) Assessing the impact of the improvement of building and energy systems
   This assessment can be made according to EN 15603:2008 by using a validated building calculation model as defined in clause 9.
   The monitoring functions make it possible to take into account the current climatic data, indoor temperature, internal heat gains, hot water use and lighting patterns, according to EN 15603:2008, 9.2 and 9.3;

d) Energy monitoring
   The TBM monitoring function can be used to prepare and display the energy monitoring graphs as defined in EN 15603:2008, Annex H;

e) Room temperature and indoor air quality monitoring
   The monitoring function can be used to provide reports about air or room operative temperatures in the rooms as well as indoor air quality. For buildings which are not permanently occupied these functions shall differentiate between occupied and non-occupied buildings. For buildings which are heated and cooled the report shall differentiate between cooling and heating periods.
   The reports shall include the actual value as well as reference values such as setpoints for example.

4.2 Building automation and control 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 15232:2012

- 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 columns 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 15232:2012.

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 proportional Δp: Pump solutions with an external pressure 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 for individual consumers is reduced.

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.

1.8 1. This Siemens interpretation gives full consideration to by the processing function in the function list of EN 15232: Switching on generators with the same nominal output is accomplished based solely on load (no additional prioritization).

			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 system is installed at the emitter or room level, for case 1 one system can control several rooms								
	0	No automatic control								
	1	Central automatic control								
	2	Individual room control								
	3	Individual room control with communication								
	4	Individual room control with communication and presence control								
1.2	Emission control for TABS									
	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								
1.5	Intermittent control of emission and/or distribution									
		One controller can control different rooms/zone 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	Generator control for combustion and district heating									
	0	Constant temperature control								
	1	Variable temperature control depending on outdoor temperature								
	2	Variable temperature control depending on the load								
1.7	Generator control for heat pump									
	0	Constant temperature control								
	1	Variable temperature control depending on outdoor temperature								
	2	Variable temperature control depending on the load or demand								
1.8	Sequencing of different generators									
	0	Priorities only based on running times								
	1	Priorities only based on loads								
	2	Priorities based on loads and demand								
	3	Priorities based on generator efficiency								

Remarks of Siemens

This section outlines how Siemens interprets the functions and processing functions according to EN 15232:2012.

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.

2.3 1. Due to the reduced operating time, the generator for space heating is operated over the course of the year at a higher load level and greater efficiency, thus lowering energy consumption.

2. Electric heating ensures DHW storage tank charging outside the heating period. Release of the charging time should be set to a timeframe where no peak loads occur and lower electricity rates are available.

2.5 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.

			Definition of classes							
			Residential				**Non residential**			
			D	**C**	**B**	**A**	**D**	**C**	**B**	**A**
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 charging time release								
	2	Automatic control on/off and charging time release and multi-sensor storage Management								
2.2	Control of DHW storage temperature using heat generation									
	0	Automatic control on/off								
	1	Automatic control on/off and charging time release								
	2	Automatic control on/off, charging time release and demand-oriented supply or multi-sensor storage management								
	3	Automatic control on/off, charging time release, demand-oriented supply or return temperature control and multi-sensor storage management								
2.3	Control of DHW storage temperature, varying seasonally: with heat generation or integrated electric heating									
	0	Manual selected control with charging pump on/off or electric heating								
	1	Automatic selected control with charging pump on/off or electric heating and charging time release								
	2	Automatic selected control with charging pump on/off or electric heating, charging time release and demand-oriented supply or multi-sensor storage management								
	3	Automatic selected control with heat generation, demand-oriented supply and return temperature control or electric heating, charging time release and multi-sensor storage management								
2.4	Control of DHW storage temperature with solar collector and heat generation									
	0	Manual selected control of solar energy or heat generation								
	1	Automatic control of solar storage charge (Prio. 1) and supplementary storage charge								
	2	Automatic control of solar storage charge (Prio. 1) and supplementary storage charge and demand-oriented supply or multi-sensor storage management								
	3	Automatic control of solar storage charge (Prio. 1) and supplementary storage charge, demand-oriented supply and return temperature control and multi-sensor storage management								
2.5	Control of DHW circulation pump									
	Continuous operation, time switch program controlled or demand-oriented on off									
	0	Without time switch program								
	1	With time switch program								
	2	Demand-oriented control								

Remarks of Siemens

This section outlines how Siemens interprets these functions and processing functions according to EN 15232:2012.

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.

3.3 Comparable functions can be used to control networks for electrical direct cooling (e.g. compact cooling units or split units for individual rooms).

3.4 3. The pump is only released for demand.
With proportional Δp: Pump solutions with an external pressure differential measurement (e.g. based of 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 for individual consumers is reduced.

3.8 1. This Siemens interpretation gives full consideration to the processing function in the function list of EN 15232: Switching on generators with the same nominal output is accomplished based solely on load (no additional prioritization).

			Definition of classes							
			Residential				**Non residential**			
			D	**C**	**B**	**A**	**D**	**C**	**B**	**A**
3	**COOLING CONTROL**									
3.1	Emission control									
		The control system is installed at the emitter or room level, for case 1 one system can control several rooms								
	0	No automatic control								
	1	Central automatic control								
	2	Individual room control								
	3	Individual room control with communication								
	4	Individual room control with communication and presence control								
3.2	Emission control for TABS									
	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 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								
	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								
3.5	Intermittent control of emission and/or distribution									
		One controller can control different rooms/zone 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 (dependant of the HVAC system)								
	2	Total interlock								
3.7	Different generator control for cooling									
	The goal consists generally in minimising the generator operation temperature									
	0	Constant temperature control								
	1	Variable temperature control depending on outdoor temperature								
	2	Variable temperature control depending on the load								
3.8	Sequencing of different generators									
	0	Priorities only based on running times								
	1	Priorities only based on loads								
	2	Priorities based on loads and demand								
	3	Priorities based on generator efficiency								

Remarks of Siemens

This section outlines how Siemens interprets these functions and processing functions according to EN 15232:2012.

4.1 This deals exclusively with air renewal in the room.
Note:
As per EN 15232, the parts "Heating control" and "Cooling control" apply to **room** temperature control.

4.1 This function affects the air flow in a single room system (e.g. movie theater or lecture hall) or in the reference room of a multi-room system without room automation.
This function affects the air flow of each room automation as part of a multi-room system. For that, supply air pressure control in the air handling unit is required (refer to Processing function 3 per interpretation 4.2).

4.2 Processing functions 0 to 2 affect the air flow in the air handling unit as part of a multi-room system without room automation. These are, however, already contained in the function as per interpretation 4.1.

Processing function 3 was planned as air flow provisioning for a multi-room system with room automation.

4.3 Control of exhaust air side icing protection of heat recovery (heat exchanger).

4.4 Control of heat recovery in the central air handling unit.

4.5 Cooling and ventilation with a portion provided by passive energy (renewable and free, may however require auxiliary energy, e.g. electrical energy for pumps). This reduces the percentage of active energy (that has to be paid for).

4.6 If the air system serves only one room and is controlled according to indoor temperature of this room one should use "Heating and cooling control" even if the control acts on the supply temperature. In the other cases one shoud differentiate at least the available types of control.
This temperature control shall be considered with particular attention if the system principle does not prevent simultaneous heating and cooling.

4.7

1. The prerequisite for dew point control is an air washer that has a humidification efficiency of at least 95 %, i.e. one that can almost achieve the saturation of the escaping air. If the temperature of this practically saturated air is also controlled, its water vapor content is fixed. Therefore, the required effort in terms of control equipment is relatively small. This solution is appropriate in applications where the air that has been cooled to the dew point is largely reheated by internal heat sources in the conditioned space. If this is not the case, direct humidity control is – for energy efficiency reasons – preferable in conventional air conditioning systems

2. In the case of water spray humidification, humidification efficiency that is considerably lower than that of the dewpoint air washer is sufficient. This means that a correspondingly lower priced device can be used. It is, however, important that the humidifier is controllable within a sufficiently large output range.

			Definition of classes							
			Residential				**Non residential**			
			D	**C**	**B**	**A**	**D**	**C**	**B**	**A**
4	**VENTILATION AND AIR CONDITIONING CONTROL**									
4.1	Air flow control at the room level									
	0	No automatic control								
	1	Time control								
	2	Presence control								
	3	Demand control								
4.2	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								
4.3	Heat recovery exhaust air side icing protection control									
	0	Without defrost control								
	1	With defrost control								
4.4	Heat recovery control (prevention of overheating)									
	0	Without overheating control								
	1	With overheating control								
4.5	Free mechanical cooling									
	0	No automatic control								
	1	Night cooling								
	2	Free cooling								
	3	H,x- directed control								
4.6	Supply air temperature control									
	0	No automatic control								
	1	Constant set point								
	2	Variable set point with outdoor temperature compensation								
	3	Variable set point with load dependant compensation								
4.7	Humidity control									
	0	No automatic control								
	1	Dewpoint control								
	2	Direct humidity control								

Remarks of Siemens

This section outlines how Siemens interprets these functions and processing functions according to EN 15232:2012.

5.1

1. When using schedule-driven turn-off of lighting, a warning function allows overriding the turn-off signal by the user.
   In case of switchable lights these are flashed on/off and turned off after a certain time, unless a room user activated the override function.
   In case of dimmable lights, these are dimmed to a preset warning level and turned off after a certain time, unless a room user activated the override function.

2. Manual On/Dimmed (Off) and Manual On/Auto Off provide the highest energy savings as lights are typically turned on manually by the user at lower light levels than required for occupancy detectors automatically turning lights on.

5.2

1. 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 very simply integrates with automated blind control.

6

Reasons for blind control:
- Reduction of external light can prevent blinding room users
- Reduction of heat radiation in the room can save cooling energy
- Allowing heat radiation in the room can save heating energy
- Closed blinds can 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 gains and at the same time allows using indirect and diffuse sun light 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.

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

7.2 Recording energy consumption and operational data provides the foundation:
- to evaluate the building, plants as well as their operation,
- for issuing an energy pass,
- to recognize potential improvements and plan measures.

			Definition of classes							
			Residential				Non-residential			
			D	C	B	A	D	C	B	A
5	**LIGHTING CONTROL**									
5.1	Occupancy control									
	0	Manual on/off switch								
	1	Manual on/off switch + additional sweeping extinction signal								
	2	Automatic detection								
5.2	Daylight control									
	0	Manual								
	1	Automatic								
6	**BLIND CONTROL**									
	0	Manual operation								
	1	Motorized operation with manual control								
	2	Motorized operation with automatic control								
	3	Combined light/blind/HVAC control								
7	**TECHNICAL HOME AND BUILDING MANAGEMENT**									
7.1	Detecting faults of home and building systems and providing support to the diagnosis of these faults									
	0	No								
	1	Yes								
7.2	Reporting information regarding energy consumption, indoor conditions and possibilities for improvement									
	0	No								
	1	Yes								

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.

Procedure

1. Functions relevant to the project are checked off "✓ " in column 1.
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 "✗ " in column 1 (in the example: red).

B

				Definition of classes							
				Residential				Non-residential			
				D	C	B	A	D	C	B	A
	4	VENTILATION AND AIR CONDITIONING CONTROL									
✓	4.1	Air flow control at the room level									
		0	No automatic control								
		1	Time control								
✗		2	Presence control								
		3	Demand control								
✓	4.2	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								
✓	4.3	Heat recovery exhaust air side icing protection control									
		0	Without defrost control								
✗		1	With defrost control								
✓	4.4	Heat recovery control (prevention of overheating)									
		0	Without overheating control								
✗		1	With overheating control								
✓	4.5	Free mechanical cooling									
		0	No automatic control								
		1	Night cooling								
✗		2	Free cooling								
		3	H,x- directed control								
✓	4.6	Supply air temperature control									
		0	No automatic control								
		1	Constant set point								
✗		2	Variable set point with outdoor temperature compensation								
		3	Variable set point with load dependant compensation								
	4.7	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 "✗ ".

Function 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.

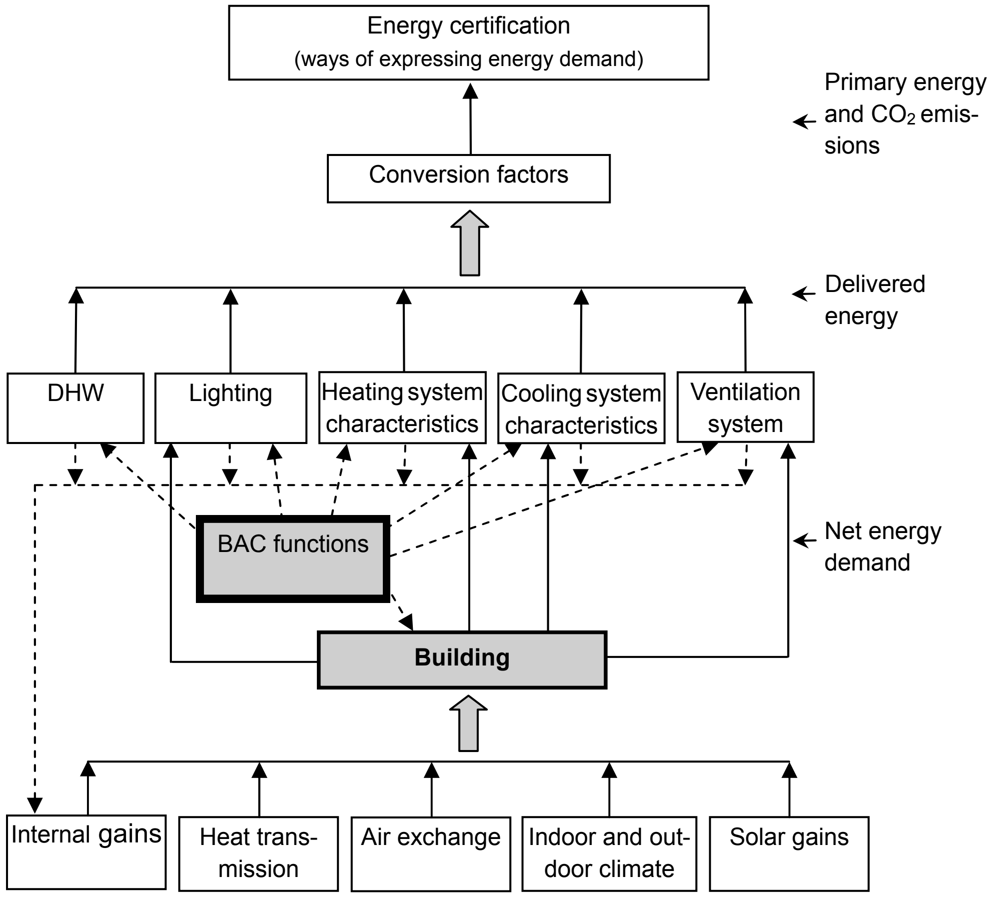
- If a specific function is required to be in a specific BACS efficiency class, there is no need for it to be strictly required throughout the building. If the designer can give good reasons that the application of a function does not bring a benefit in a specific case it can be ignored. For example if the designer can show that the heating load of a set of rooms is only dependant 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:

Function		Standard
Automatic control		
HEATING , COOLING CONTROL, DHW		
	Emission control	EN 15316-2-1:2007, 7.2, 7.3, EN 15243:2007, 14.3.2.1 and Annex G EN 15316-2-1:2007, 6.5.1 EN ISO 13790
	Control of distribution network water temperature	EN 15316-2-3:2007, EN 15243:2007
	Control of distribution pump	EN 15316-2-3:2007
	Intermittent control of emission and/or distribution.	EN ISO 13790:2008, 13.1 EN 15316-2-3:2007, EN 15243:2007
	Interlock between heating and cooling control of emission and/or distribution	EN 15243:2007
	Generation control and sequencing of generators	EN 15316-4-1 to -6 (-see 7.4.6) EN 15243:2007
VENTILATION AND AIR CONDITIONING CONTROL		
	Air flow control at the room level	EN 15242, EN 13779
	Air flow control at the air handler level	EN 15241
	Heat exchanger defrost and overheating control	EN 15241
	Free mechanical cooling	EN ISO 13790
	Supply temperature control	EN 15241
	Humidity control	EN 15241
LIGHTING CONTROL		EN 15193
	Combined light/blind/HVAC control (also mentioned below)	None
BLIND CONTROL		EN ISO 13790
Home automation/Building automation and controls		
Centralized adapting of the home and building automation system to users needs: e.g. time schedule, set points etc.		None
Centralized optimizing of the home and building automation system: e.g. tuning controllers, set points etc.		None
Technical building management with energy efficiency functions		
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		EN 15603:2008

Calculation procedure per EN 15232

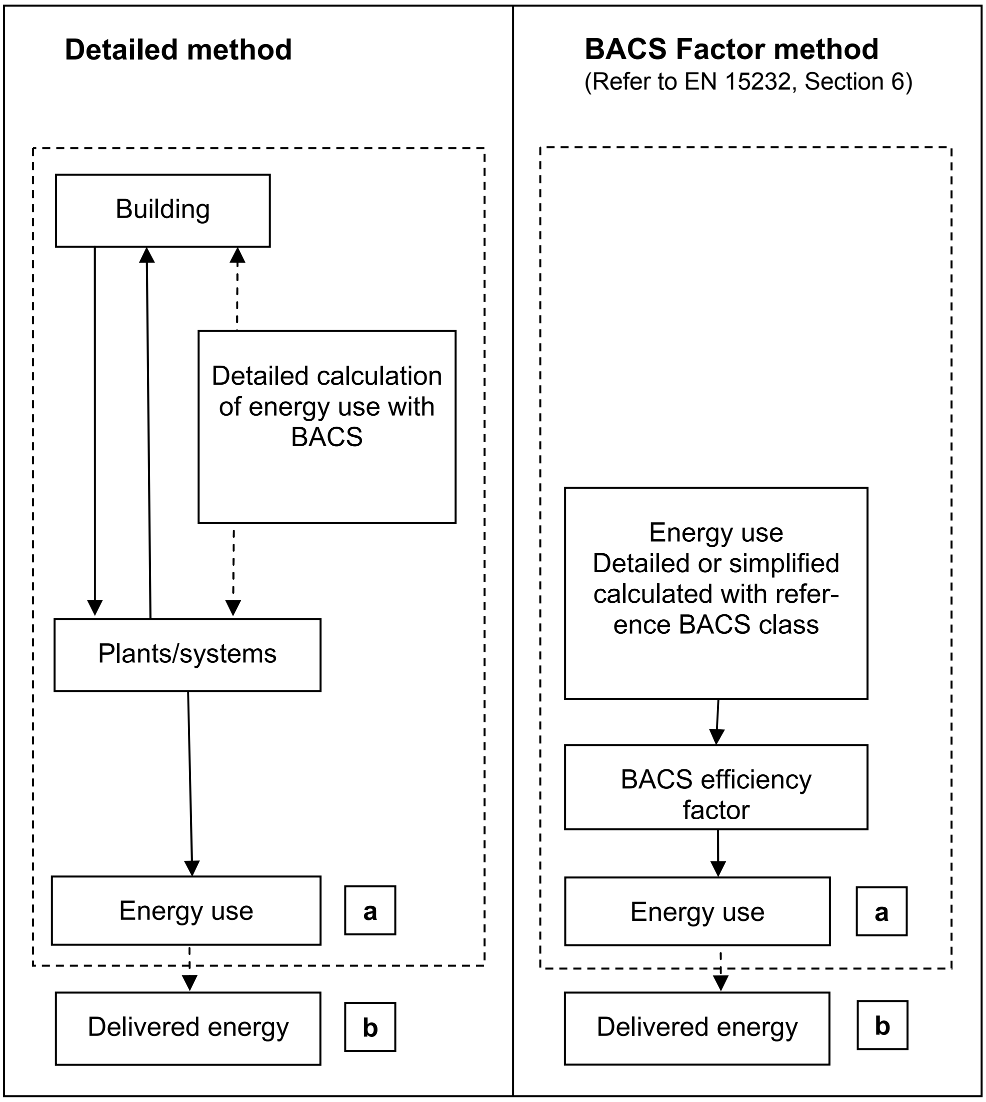
The basis for energy demand calculations in buildings are…

- 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:

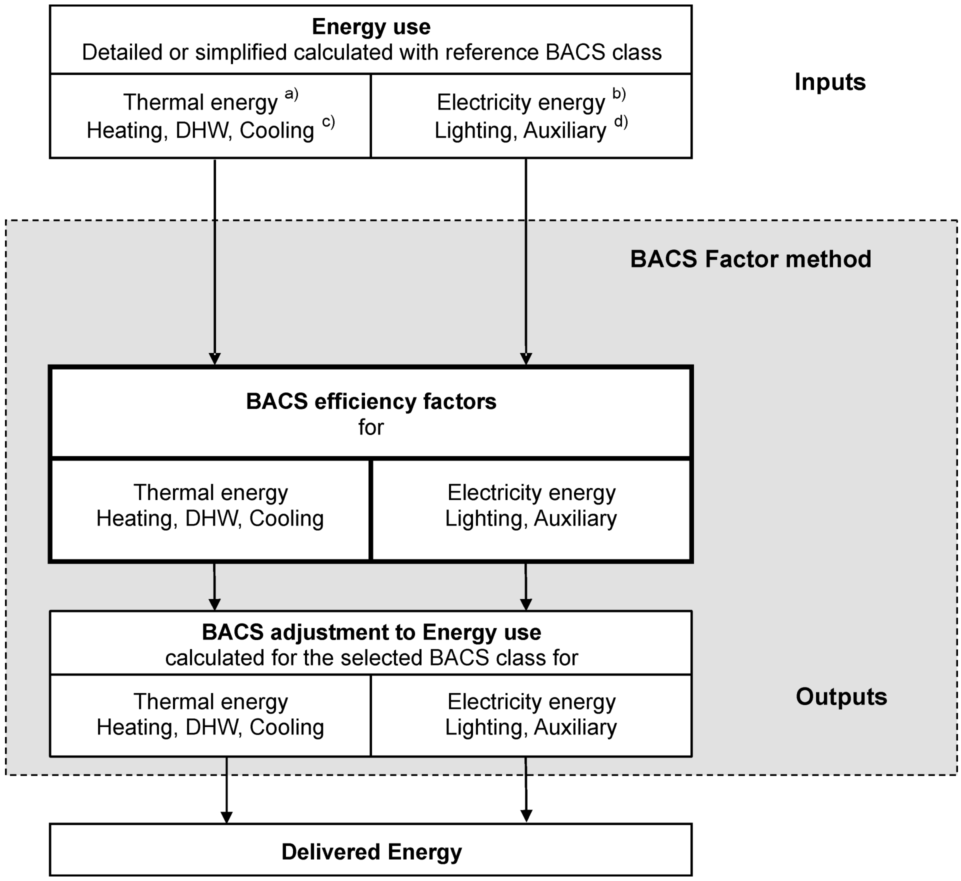
a Energy use for heating, cooling, ventilation, DHW or lighting

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 2 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.

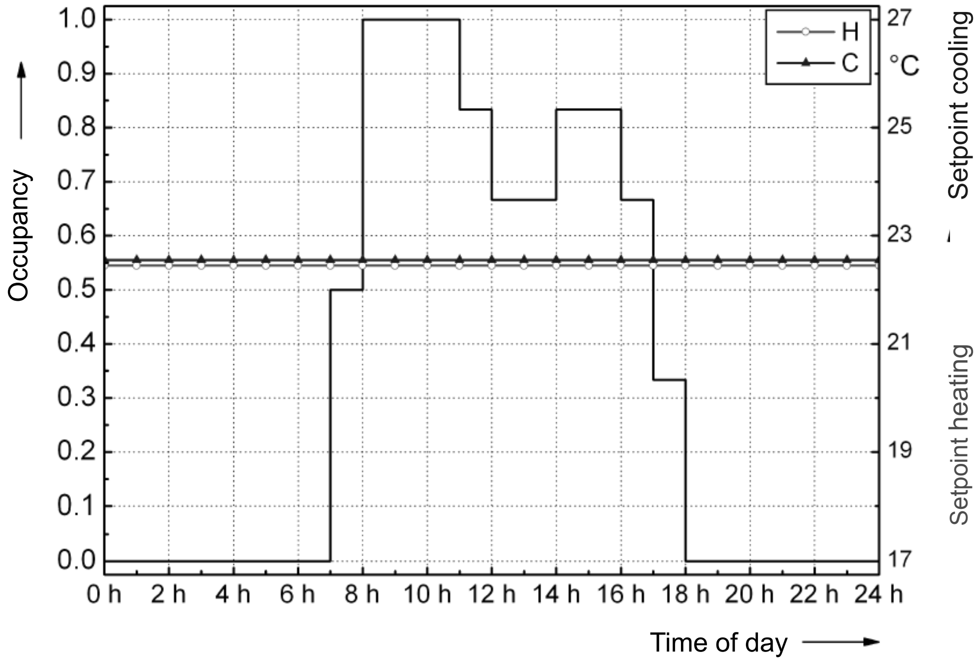
4.3.3 Savings potential of various profiles for the different building types

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)

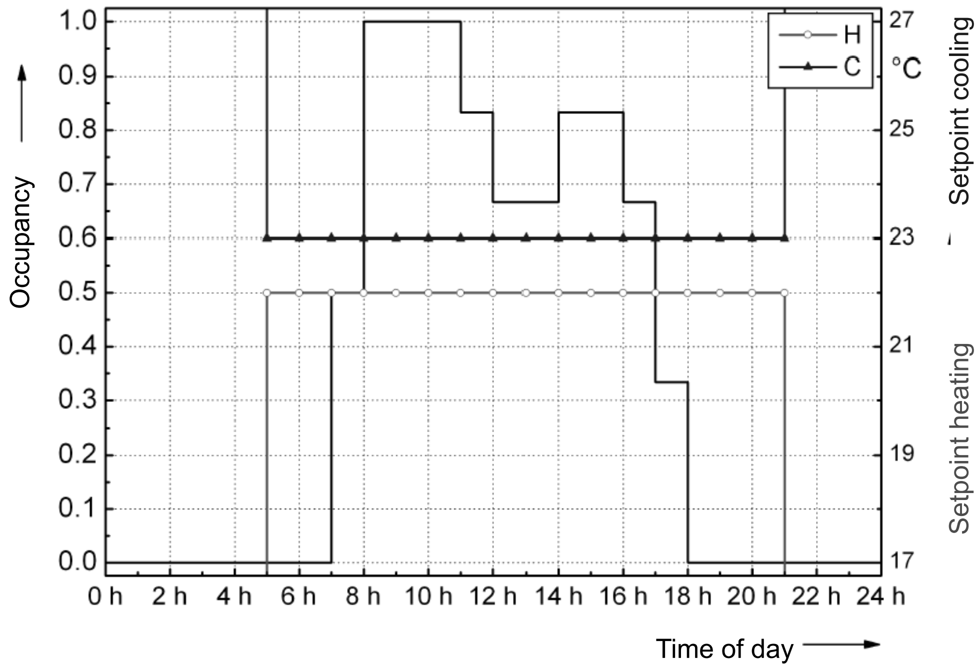
Operation profiles in an office building

BAC efficiency class D



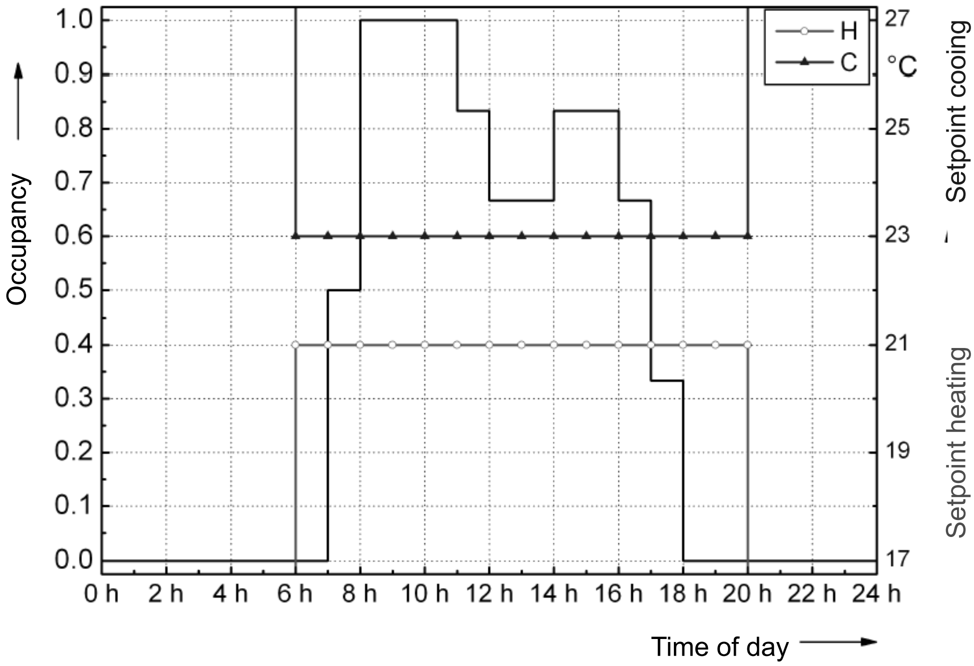
Efficiency class D represents a less beneficial case versus class C. Both temperature setpoints (for heating and cooling) have the same value. In other words, there is no energy dead band. The HVAC plant is operated 24 hours a day, although occupancy is only 11 hours.

BAC efficiency class C (reference class)



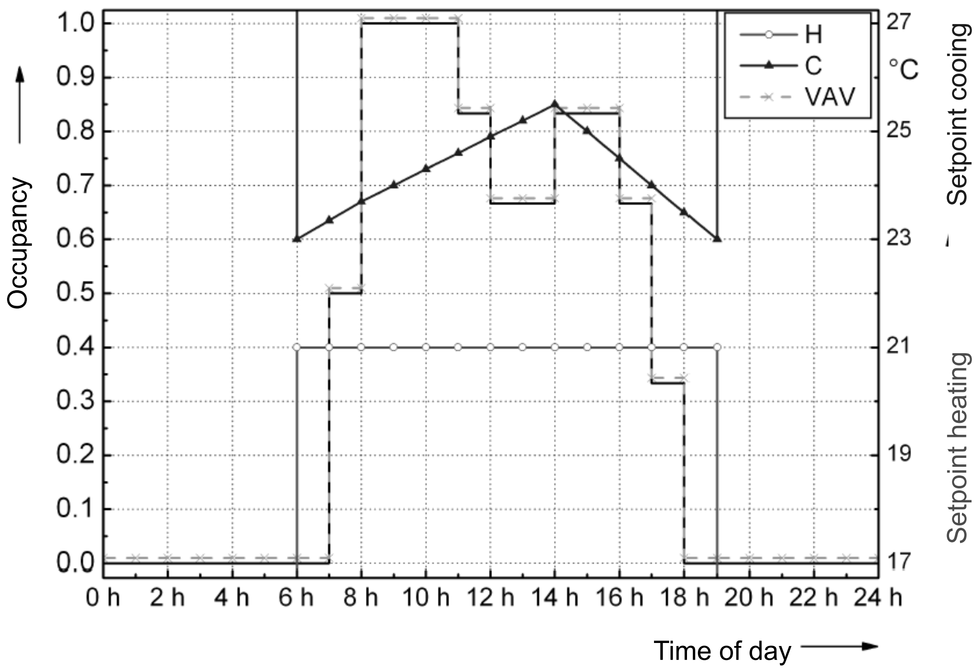
In efficiency class C, the difference the temperature setpoints for heating and cooling is very small at ca. 1 K (minimum dead energy band). Operation of the HVAC plant starts two hours prior to occupancy and ends three hours after the end of the occupancy period.

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

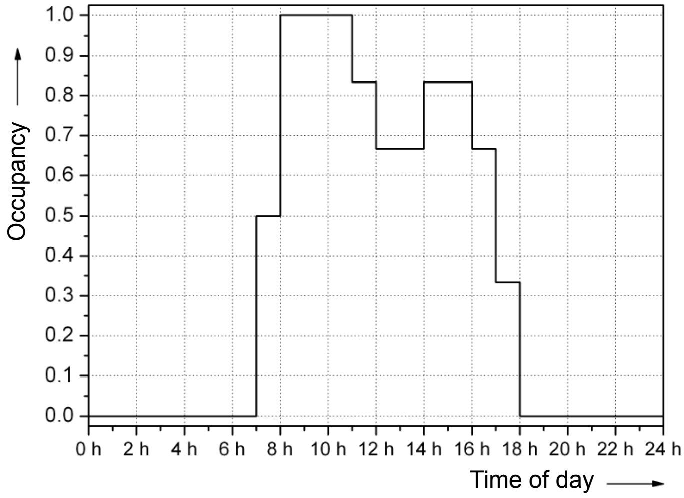


Efficiency class A provides additional energy efficiency by applying advanced BAC and TBM functions as well as adaptive setpoint adjustments for cooling or demand-controlled air flows.

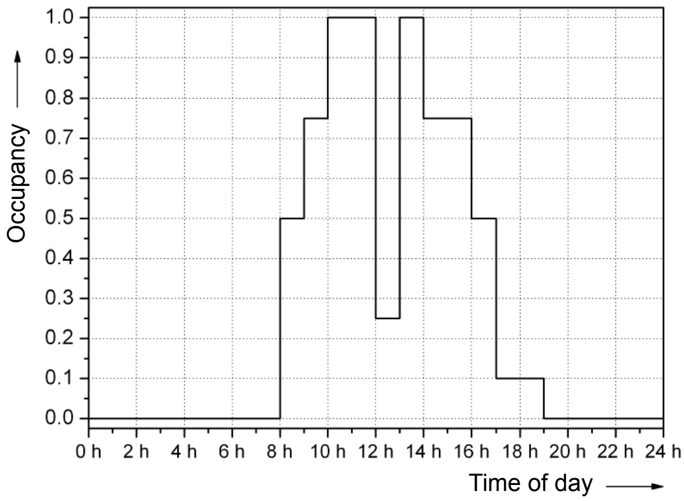
Findings from the four operation profiles
You can achieve significant improvements in BAC energy efficiency using presence-controlled plant operation, controlling air flow, as well as controlling setpoints for heating and cooling (must be as large an energy dead band as possible!).

User profiles for non-residential buildings

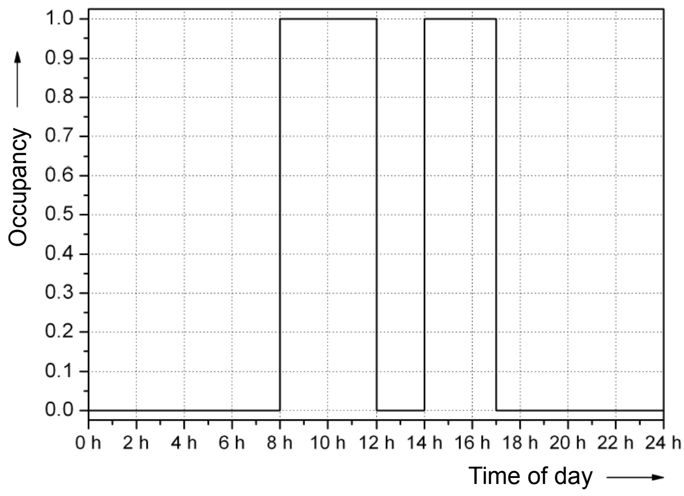
Office buildings



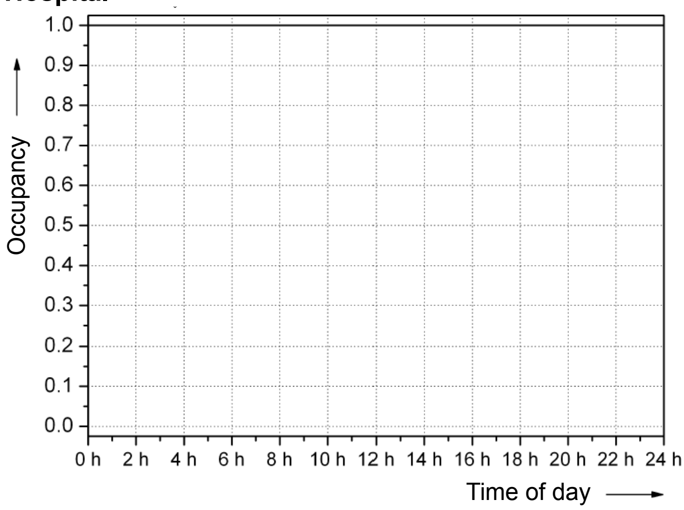
Lecture hall



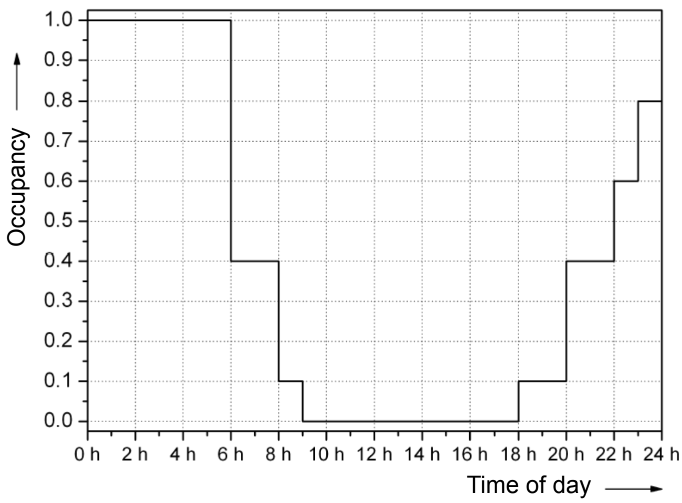
School



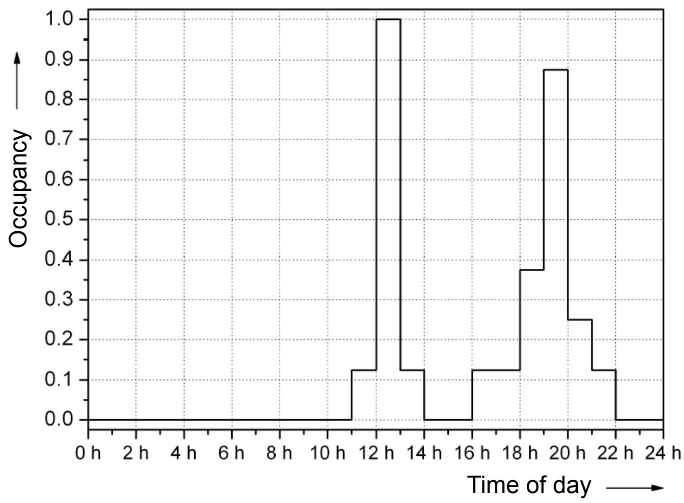
Hospital



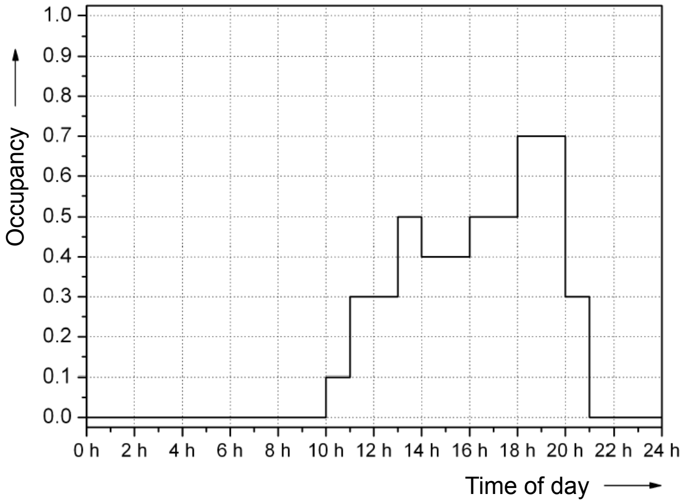
Hotel



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**			
	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**			
	D	**C**	**B**	**A**
	Non energy efficient	**Standard (reference)**	Advanced energy efficiency	High energy efficiency
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**			
	D	**C**	**B**	**A**
	Non energy efficient	**Standard (reference)**	Advanced energy efficiency	High energy efficiency
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**			
	D	**C**	**B**	**A**
	Non energy efficient	**Standard (reference)**	Advanced energy efficiency	High energy efficiency
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**			
	D	**C**	**B**	**A**
	Not energy efficient	**Standard (Reference)**	Increased energy efficiency	High energy efficiency
Offices	1.51	1	0.80	0.70
Lecture halls		Operation profile		
Educational facilities (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
[a] The values are highly dependent on heating/cooling demand for ventilation				

User profile

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.	Calcul-ation	Unit	Heating	Cooling	Ventila-tion	Lighting
Thermal energy							
Energy demand	1		$\frac{kWh}{m^2 \cdot a}$	100	100		
Plant losses Reference case	2		$\frac{kWh}{m^2 \cdot a}$	33	28		
Energy expense for reference class C	3	$\sum 1 + 2$	$\frac{kWh}{m^2 \cdot a}$	133	128		
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	$3 \times \frac{5}{4}$	$\frac{kWh}{m^2 \cdot a}$	106	102		
The expense of thermal energy must be distributed among various energy carrier to complete the calculation.							
Electrical energy							
Auxiliary energy class C	7a		$\frac{kWh}{m^2 \cdot a}$	14	12	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	$7 \times \frac{9}{8}$	$\frac{kWh}{m^2 \cdot a}$	13	11	20	32

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 **106 kWh/m^2 • a** instead of 133 Reduction to 80 %
- Cooling energy **102 kWh/m^2 • a** instead of 128 Reduction to 80 %
- Electrical energy **76 kWh/m^2 • a** instead of 81 Reduction to 93 %

These improvements in energy efficiency lead to annual energy savings of 324,800 kWh for the entire building (5,600 m^2).

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	Auxiliary energy	BAC factor
Heating	Q_{NH}	$Q_{H,loss}$	-	$f_{BACS,h}$
	-	-	$W_{h,aux}$	$f_{BACS,el-au}$
Cooling	Q_{NC}	$Q_{C,loss}$	-	$f_{BACS,c}$
	-	-	$W_{c,aux}$	$f_{BACS,el-au}$
Ventilation	-	-	$W_{V,\ aux}$	$f_{BACS,el-au}$
Lighting	-	-	W_{light}	$f_{BACS,el-li}$
DHW	Q_{DHW}	-	-	$f_{BACS,DHW}$

4.5.1 Detailed BACS efficiency factors for heating and cooling

Non-residential building types	Detailed BACS efficiency factors							
	D		C		B		A	
	Non energy efficient		**Standard (reference)**		Advanced energy efficiency		High energy efficiency	
	$f_{BACS,h}$	$f_{BACS,c}$	$f_{BACS,h}$	$f_{BACS,c}$	$f_{BACS,h}$	$f_{BACS,c}$	$f_{BACS,h}$	$f_{BACS,c}$
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							
	D		C		B		A	
	Non energy efficient		**Standard (reference)**		Advanced energy efficiency		High energy efficiency	
	$f_{BACS,h}$	$f_{BACS,c}$	$f_{BACS,h}$	$f_{BACS,c}$	$f_{BACS,h}$	$f_{BACS,c}$	$f_{BACS,h}$	$f_{BACS,c}$
• 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 BAC 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**			
	D	**C**	**B**	**A**
	Non energy efficient	**Standard (reference)**	Advanced energy efficiency	High energy efficiency
	$f_{BACS,DHW}$	$f_{BACS,DHW}$	$f_{BACS,DHW}$	$f_{BACS,DHW}$
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**			
	D	**C**	**B**	**A**
	Non energy efficient	**Standard (reference)**	Advanced energy efficiency	High energy efficiency
	$f_{BACS,DHW}$	$f_{BACS,DHW}$	$f_{BACS,DHW}$	$f_{BACS,DHW}$
• 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 BAC 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**							
	D		**C**		**B**		**A**	
	Non energy efficient		**Standard (reference)**		Advanced efficiency		High energy efficiency	
	$f_{BACel\text{-}li}$	$f_{BACel\text{-}au}$	$f_{BACel\text{-}li}$	$f_{BACel\text{-}au}$	$f_{BACel\text{-}li}$	$f_{BACel\text{-}au}$	$f_{BACel\text{-}li}$	$f_{BACel\text{-}au}$
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 16001 is intended to improve energy performance by managing energy use systematically. EN 16001 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.

Remark:
In the appendix of EN 15232:2012 are parts of the standard EN 16001 „Energy management systems – Requirements with guidance for use“ listed. This standard EN 16001:2009 is now transferred with small adjustments in the standard EN ISO 50001:2011.

No.	EMS requirements according EN 16001	BACS for EMS in building
E 1	**3.1 General requirements**	
E 1.1	The organization shall: a) establish, document, implement and maintain an energy management system in accordance with the requirements of this standard; b) define and document the scope and the boundaries of its energy management system; c) determine and document how it will meet the requirements of this standard in order to achieve continual improvement of its energy efficiency.	Top management should generally note and consider the following when implementing an energy management system (EMS): – BACS impact on energy efficiency of buildings per to EN 15232. – Application of BACS as the appropriate tool to simplify, maintain and improve the energy management process to achieve improved energy performance of and reduce energy consumption in buildings.
E 2	**3.2 Energy policy**	
	Top management shall establish, implement and maintain an energy policy for the organization. This energy policy shall state the organization's commitment for achieving improved energy performance. Top management shall ensure that the energy policy: a) defines the scope and boundaries of the energy management system; b) is appropriate to the nature and scale of, and impact on, the organization's energy use; c) includes a commitment to continual improvement in energy efficiency; d) includes a commitment to ensure the availability of information and of all necessary resources to achieve objectives and targets; e) provides the framework for setting and reviewing energy objectives and targets; f) includes a commitment to comply with all applicable requirements relating to its energy aspects, whether legally required or agreed to by the organization; g) is documented, implemented, maintained and communicated to all persons working for and on behalf of the organization; h) is regularly reviewed and updated; i) is available to the public.	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 BACS energy efficiency class (according to EN15232) for implementation and compliance. Deploy only energy-efficient, certified products as BACS components. Use BACS as a tool for EMS and as the documentation and information system in support of the organization.
E 3	**3.3 Planning**	
E 3.1	**3.3.1 Identification and review of energy aspects** The organization shall conduct an initial review of its energy aspects. The review of energy aspects shall be updated at predefined intervals. These reviews shall prioritize significant energy aspects for further analysis. These reviews of energy aspects shall include the following: a) past and present energy consumption and energy factors based on measurement and other data;	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 BACS data to be recorded, stored and delivered, e.g.:

	b) identification of areas of significant energy consumption, in particular of significant changes in energy use during the last period; c) an estimate of the expected energy consumption during the following period; d) identification of all persons working for and on behalf of the organization whose actions may lead to significant changes in energy consumption; e) identification and prioritization of opportunities for improving energy efficiency. The organization shall maintain a register of opportunities for saving energy. Each review shall be documented.	Delivered energy (oil, natural gas, electricity etc.). Energy use for heating, air conditioning, lighting, etc. Parameters that impact energy use (occupancy, operating hours, outdoor climate, user profiles, etc.) Uses of BACS data assignment for 3.3.1 a), b), c), d) and e) must be determined.
E 3.2	**3.3.2 Legal obligations and other requirements** The organization shall: - identify and have access to the applicable legal requirements and other requirements to which the organization subscribes related to its energy aspects, - determine how these requirements apply to its energy aspects. The organization shall ensure that these legal obligations and other requirements to which the organization subscribes are taken into account in the energy management system.	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.
E 3.3	**3.3.3 Energy objectives, targets and program(s)** The organization shall establish, implement and maintain documented energy objectives and targets, at the relevant functions and levels within the organization. The objectives and targets shall be consistent with the energy policy, including the commitments to improvements in energy efficiency and to comply with applicable legal obligations and other requirements to which the organization subscribes. The organization shall set specific targets for those controllable parameters that have a significant impact on energy efficiency. The energy objectives and target(s) shall be measurable and documented, and a time frame set for achievement. When establishing targets, the organization shall consider the significant energy aspects identified in the review as well as its technological options, its financial, operational and business conditions, legal requirements and the views of interested parties. The organization shall establish and maintain energy management programs which shall include: a) designation of responsibility; b) the means and time frame by which individual targets are to be achieved. The energy objectives, targets and program(s) shall be documented and be updated at pre-determined intervals.	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. 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. Ongoing upgrade to BACS program to reflect organizational changes (e.g. changing operation times, use times, occupancy, room conditions, etc.). Continuously adjust and optimize BACS functions and program for energy saving, etc. Review building performance on a continuous basis.

E 4	3.4 Implementation and operation	
E 4.1	**3.4.1 Resources, roles, responsibility and authority** Top management shall ensure the availability of resources essential to establish, implement, maintain and improve the energy management system. Resources include human resources, specialized skills, technology and financial resources. Roles, responsibilities and authorities shall be defined, documented and communicated in order to facilitate effective energy management. The organization's top management shall designate a management representative who, irrespective of other responsibilities, shall have defined roles, responsibility and authority for: a) ensuring that an energy management system is established, implemented and maintained in accordance with this standard; b) reporting on the performance of the energy management system to top management for their review, with recommendations for improvement.	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.
E 4.2	**3.4.2 Awareness, training and competence** The person designated in 3.4.1 shall be appropriately competent and qualified in energy and energy efficiency improvements. The organization shall ensure that its employees and all persons working on its behalf are aware of: a) the organization's energy policy and energy management programs; b) the energy management system requirements, including the activities of the organization to control energy use and improve energy performance; c) the impact, actual or potential, with respect to energy consumption, of their activities and how their activities and behavior contribute to the achievement of energy objectives and targets; d) their roles and responsibilities in achieving the requirements of the energy management system; e) the benefits of improved energy efficiency. Personnel performing tasks which can cause significant impacts on energy consumption shall be competent on the basis of appropriate education, training and/or experience. It is the responsibility of the organization to ensure that such personnel are and remain competent. The organization shall identify training needs associated with the control of its significant energy aspects and the operation of its energy management system. The organization shall also ensure that each level of management is informed and appropriately trained in the field of energy management in order to be able to	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. As a consequence, the organization identifies and determines: BACS-specific requirements for awareness, knowledge, understanding, skills, e.g.: Energy saving functions and program 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.

	establish pertinent objectives and targets and choose appropriate energy management tools and methodologies.	
E 4.3	**3.4.3 Communication** The organization shall communicate internally with regard to its energy performance and the energy management system. This shall ensure that all persons working for and on behalf of the organization can take an active part in the energy management and the improvement of the energy performance. The organization shall decide whether to communicate externally about its energy management system and energy performance. If the decision is to communicate externally, the organization shall establish, implement and document an external communication plan.	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.
E 4.4	**3.4.4 Energy management system documentation** The organization shall establish, implement and maintain information, in paper or electronic form, to: a) describe the core elements of the energy management system and their interaction; b) identify the location of related documentation including technical documentation.	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.
E 4.5	**3.4.5 Control of documents** The organization shall control records and other documents required by this standard to ensure that: a) they are traceable and can be located; b) they are periodically reviewed and revised as necessary; c) the current versions are available at all relevant locations; d) the documents are kept and maintained in such a way that they are easily accessible and protected against damage, loss or destruction; their retention time shall be established and documented; e) obsolete documents are retained for legal and/or knowledge preservation purposes and suitably identified, or removed as appropriate.	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. The document's originator is identifiable. The 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.

E 4.6	**3.4.6 Operational control** The organization shall identify and plan those operations that are associated with the significant energy aspects and ensure consistency with its energy policy, energy objectives and energy targets. This includes: a) preventing situations that could lead to deviation from the energy policy, energy objectives and energy targets, b) setting criteria for operation and maintenance of installations, equipment buildings and facilities, c) energy considerations in the acquisition and purchase of equipment, raw materials and services; when purchasing energy consuming equipment having a significant impact on the total energy consumption, the organization should inform suppliers that purchasing is partly evaluated on the basis of energy efficiency, d) evaluation of energy consumption when considering the design, change or restoration of all assets which have the potential to significantly affect energy consumption, including buildings, e) appropriate communication in this regard to personnel, and people acting on behalf of the organization and other relevant parties.	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 analyze 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.
E 5	**3.5 Checking**	
E 5.1	**3.5.1 Monitoring and measurement** The organization shall establish and describe the energy management program. An energy metering plan shall be defined and implemented. At defined intervals, the organization shall monitor, measure and record significant energy consumption and associated energy factors. The organization shall ensure that the accuracy and repeatability of monitoring and measuring equipment used is appropriate to the task. Associated records shall be maintained. The organization shall, in each practicable instance, establish the relationships between energy consumption and its associated energy factors and shall, at defined intervals, assess actual versus expected energy consumption. The organization shall maintain records of all significant accidental deviations from expected energy consumption, including causes and remedies. Relationships between energy consumption and energy factors shall be reviewed at defined intervals and revised if necessary. The organization shall wherever possible compare their energy performance indicators against similar organizations or situations, externally and internally.	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, 30, or 60 minutes, 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.: Ongoing 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).
E 5.2	**3.5.2 Evaluation of compliance** Consistent with its commitment to compliance, the organization shall periodically evaluate compliance with legal obligations and other requirements to which the organization subscribes that are relevant to the scope of this standard. The organization shall keep records of the results of the periodic evaluations.	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.
E 5.3	**3.5.3 Nonconformity, corrective action and preventive action** The organization shall identify and manage non-conformance, initiating corrective and preventive action in a suitable manner within a specified time limit. The organization shall retain all relevant documentation in accordance with legal and/or documented time frames. NOTE It is left to the organization to decide how action is to be taken on non-conformance, including criteria for determining when non-conformance is of such a nature that action is required.	The organization considers BACS options to achieve and maintain the nonconformity, corrective action and preventive requirements of the EMS for buildings and specifies: Automate BACS applications: monitor, analyze 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.
E 5.4	**3.5.4 Control of records** The organization shall establish, implement and maintain records as necessary to demonstrate conformity to the requirements of the energy management system and of this standard. The records shall demonstrate the performance achieved and the effectiveness of the energy management system. The organization shall define the necessary controls needed for record management. Records shall be and remain legible, identifiable and	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;

	traceable to the relevant activity, product or service for the established retention period.	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.
E 5.5	**3.5.5 Internal audit of the energy management system** At planned intervals, the organization shall carry out management system audits to ensure that the energy management system: a) conforms to the energy policy, objectives, targets and energy management program, and all other requirements of this standard; b) is compliant with relevant legal obligations and other requirements to which the organization subscribes; c) is effectively implemented and maintained. An audit schedule shall be planned, taking into consideration the significance of the parts of the management system to be audited, as well as the results of previous audits. The selection of auditors and conduct of audits shall ensure objectivity and the impartiality of the audit process. The management responsible for the area being audited shall ensure that actions are taken without undue delay to eliminate detected nonconformities and their causes. Follow-up activities shall include the verification of the actions taken and the reporting of verification results. Audits of the energy management system are carried out by, or at the request of, the organization itself, for internal purposes and may be the basis for a self declaration of conformance to this standard. Audit results shall be documented 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.

E 6	3.6 Review of the energy management system by top management	
E 6.1	**3.6.1 General** Top management shall review the organization's energy management system at planned intervals to ensure continuing suitability, adequacy and effectiveness. Records of management reviews shall be maintained.	The organization reviews how BACS can support top management review of the EMS for buildings.
E 6.2	**3.6.2 Inputs to management review** Inputs to the management review shall include: a) follow-up actions from previous management reviews; b) review of energy aspects and the energy policy; c) evaluation of legal compliance and changes in legal obligations and other requirement to which the organization subscribes; d) the extent to which the energy objectives and targets have been met; e) energy management system audit results; f) status of corrective and preventive actions; g) the overall energy performance of the organization; h) projected energy consumption 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.
E 6.3	**3.6.3 Outputs from management review** Outputs from the management review shall include any decisions or actions related to: a) the improvement in the energy performance of the organization since the last review; b) changes to the energy policy; c) changes to objectives, targets or other elements of the energy management system, consistent with the organization's commitment to continual improvement; d) 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)

Objectives

- To establish a European quality assurance system for building automation and control components 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.

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.

The first devices certified were a few individual room controllers in 2007. Various applications (e.g. hot water radiated heat, chilled ceilings) are following in phases. 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:

- License
- Test Report Summary

License

The license 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. 20705) and a reference to the expiration date, or the deadline for retesting.


LICENCE

Number: 20705

eu.bac european building automation controls association

Siemens Schweiz AG

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

Desigo RXC21.1

for the application(s)

Fan Coil Unit System

based on the certification rules of eu.bac
and the Certificate 02002

This licence will expire on 29 October 2012

eu.bac Cert

020705

29 October 2007
Frankfurt am Main

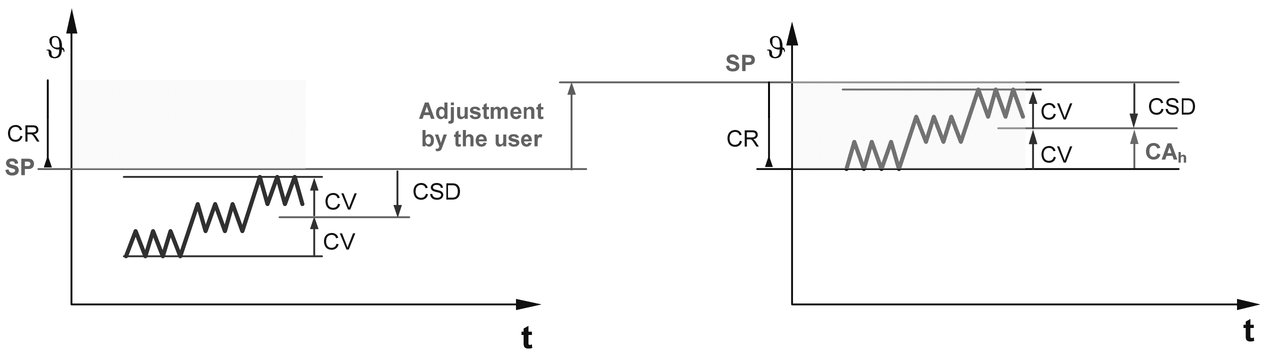
Managing Director Winfried Brandt
eu.bac

european building automation and controls Association - eu.bac
Lyoner Straße 18 - 60528 Frankfurt am Main - Germany

Requirements for issuing a license 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



ϑ	Room temperature
CR	Comfort range
SP	Setpoint
CV	Control variation
CSD	Control to setpoint deviation
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

eu.bac Cert

Product Information	
Licence Number:	020705
Licensee:	Siemens Schweiz AG
Product Family and Model Number	Desigo RXC21.1
Test Specifications	
Tested Application:	Fan coil unit system 4 pipes
Temperature Sensor:	
- Type:	NTC 10 Kohms
- Time Constant:	8 min
Actuator:	
- Type:	Motoric
Valve	
- Characteristic:	Exponential
Test Result	
Temperature Control Accuracy CA	Heating mode 0,2 K Cooling mode 0,1 K

31 March 2008
Frankfurt am Main

Managing Director Winfried Brandt
eu.bac

european building automation and controls Association - eu.bac
Lyoner Straße 18 - 60528 Frankfurt am Main - Germany

5.2 Customer benefits resulting from eu.bac Cert

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

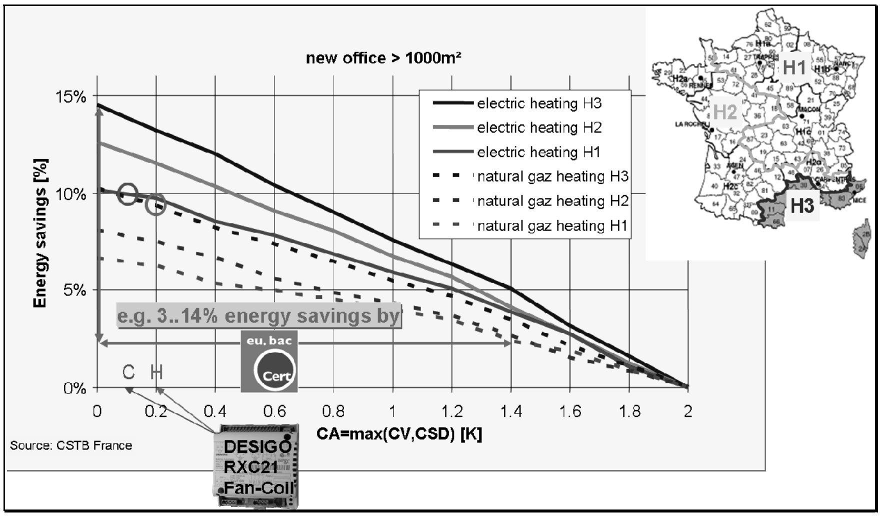
- energy efficiency and
- product quality

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 chart below illustrates how much energy (in %) a controller with control accuracy of 0.2 K saves versus a controller with control accuracy of 1.4 K. Please note the following:
Eu.bac has reduced the required minimum control accuracy in EN15500 from 2 K to 1.4 K.



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

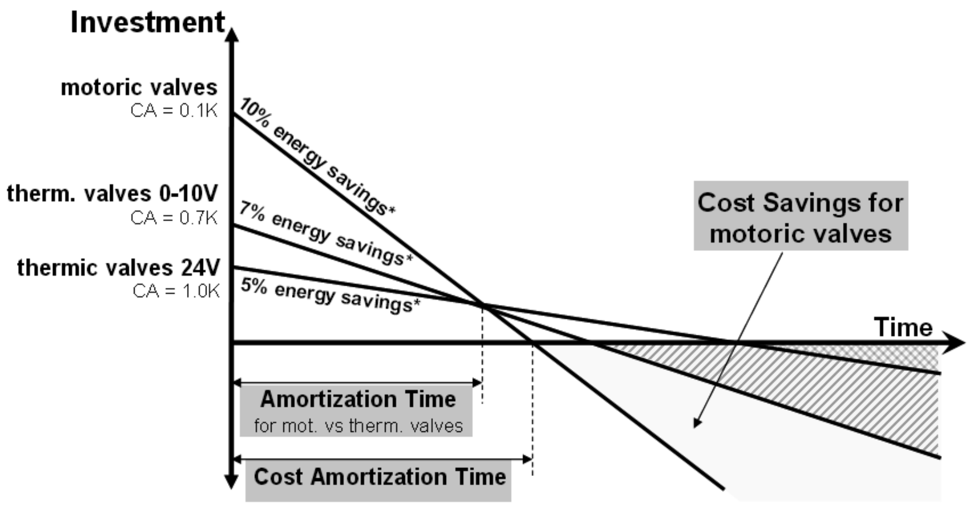
Siemens individual room controllers achieved very solid values. For example, for Desigo RXC21/fan coil with actuators for heating 0.2 K and cooling 0.1 K.

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, we achieve different levels of control accuracy 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. 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



Comparison with the previous chart, curve "Natural gas heating H3" (Southern France)

The following table outlines the payback for a DESIGO RX control circuit with electromotoric actuators compared to thermal (AC 24V) actuators.

		Energy savings	Reduction in energy costs			Amortization		
			Heating oil	Natural gas	Elec-tricity	Heating oil	Natural gas	Elec-tricity
		kWh per annum	EUR	EUR	EUR	Years	Years	Years
Old building	Large office, 3 fan coil	1,000	80	60	90	3.1	4.2	2.7
	Large office, 1 fan coil	1,000	80	60	90	1.0	1.3	0.9
	Small office, 1 fan coil	300	24	18	27	3.4	4.7	3.0
Average building	Large office, 3 fan coil	500	40	30	45	6.6	9.4	5.8
	Large office, 1 fan coil	500	40	30	45	2.0	2.7	1.8
	Small office, 1 fan coil	150	12	9	14	7.5	10.7	6.6
New building	Large office, 3 fan coil	250	20	15	23	15.9	24.5	13.6
	Large office, 1 fan coil	250	20	15	23	4.2	5.8	3.7
	Small office, 1 fan coil	75	6	5	7	18.5	29.2	15.7

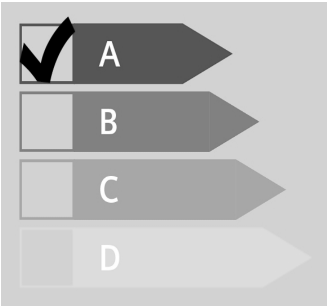
Amortization m = Additional investment I / annual return R
Annual return R = annual energy cost savings minus interest on additional investment
Annual additional interest costs = 1/2 the additional investment * calculatory interest rate

Conditions fort the table above:

Office space [m^2]:	Large office 100, small office 30
Energy characteristics heating [kWh/m^2]:	Old 200, average 100, new 50
Energy price [€/kWh]:	Oil 0.08, natural gas 0.06: electricity 0.09
Energy saving:	5% (electromotoric vs. thermal actuator)
Basic for calculation:	5%
Additional investment:	Large office, 3 fan coils, 6 actuators Large office, 1 fan coil, 2 actuators Small office, 1 fan coil, 2 actuators

6 Energy efficiency from Siemens

6.1 Products and systems



Siemens BT offers building automation and control systems and products, that achieve a high degree of energy efficiency conforming to EN 15232 or guarantees certified quality as per eu.bac Cert.
The Siemens building or home automation systems (Desigo, Synco, Synco living) meet the requirements for energy efficiency class A as per EN 15232.

6.1.1 Desigo

6.1.1.1 Desigo Insight

Display the complex simply
Workflows on the user interface for a building automation and control system are highly complex: Easy-to-understand graphical displays are in demand. This also includes simple, plausible operation: Desigo Insight presents the complex simply.

Flexible alarm management
Desigo Insight provides centralized recording, processing and evaluation of alarms for all integrated systems. The powerful alarm routing allows for operational alarm forwarding via SMS, fax, email or pager, regardless of where your operator is located and whether someone is actually sitting at the management station.

Economical
Desigo integrates energy consumption meters from the various building services plants. The building automation and control system continuously registers the appropriate data. This allows you to compare consumption values with target values (budgeted).

Targeted optimization
Fully integrated, historic and real-time data processing allows for quick and targeted optimization of the plants. Powerful supplemental programs are available to operators requiring additional archiving and evaluation functions.

Costs under control
Uniform operation appropriate to the user increases the transparency and reduces maintenance costs of all the electrical and mechanical installations in the building and allows for employment of less qualified personnel. Even inexperienced personnel know what to do.

Proven concept
Desigo Insight can be employed in any size building. Starting with small systems of just a few data points, the offering ranges to solutions for large building complexes with several thousand data points. Whether office or industrial buildings, hotel or hospital, Desigo Insight has the right solution.

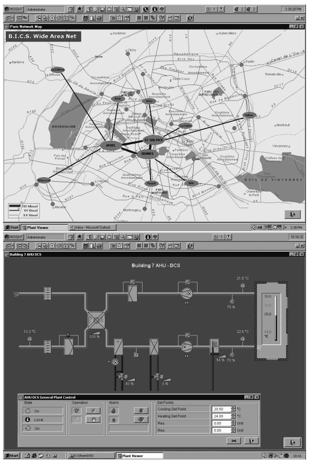
Simple integration
The consistent and targeted use of standard technologies and integrated SCADA software (Supervisory Control And Data Acquisition) ensure that third-party systems can also be connected to Desigo Insight via BACnet, OPC or the web – straightforwardly and at affordable prices. This allows for homogenous operation of all electrical and mechanical installations in the building.

Open interfaces
Various standard interfaces mean that customized applications such as facility management or service or maintenance management can be integrated into Desigo at the lowest possible cost. Even more simplification: Data from Desigo Insight can be moved to MS Office with drag and drop and then used there for additional evaluations.

Standardized technology
The Desigo Insight management station is based on a broad spectrum of standard technologies including ActiveX, DCOM, OLE and MS SQL-Server. As a result, it can be used on a PC without a problem and quickly finds its place in modern office environments.

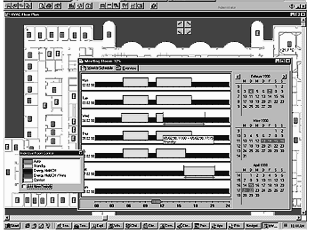
Reports provide and overview
Report templates to record alarm and fault states, for logbook entries and plant states. Reports can also be created to meet individual need and started based on events.

Highlights
- Flexible alarm management
- Targeted optimization for greater economic feasibility
- A system for any size of building
- Standardized technologies and open interfaces for simple integration
- Individual or predefined reports provide an overview

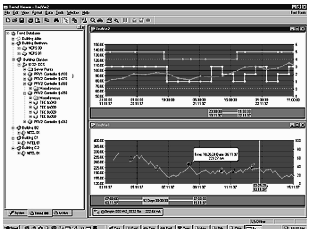


Plant Viewer
Graphics from practical experience make it possible to quickly monitor and operate the system in a targeted manner.

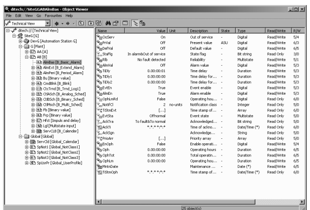
Alarm Viewer
Detailed alarm overview of multiple buildings. The user can go directly to the corresponding plant graphic to quickly find and eliminate faults.



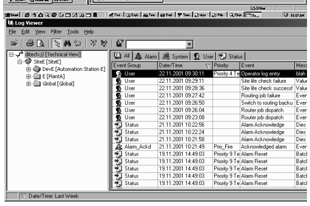
Time Scheduler
Centralized programming of all scheduled building service functions including individual room control. Easy graphical operation of weekly, holiday and exception programs.



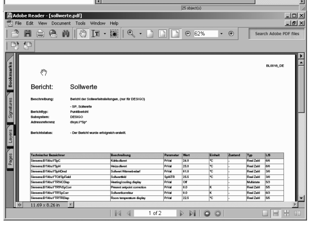
Trend Viewer
Historical and real-time data processing allows for fast and targeted operational optimization.



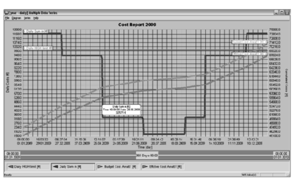
Object Viewer
Allows fast access to all objects and parameters in the system and building services plants.



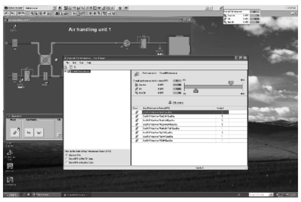
Log Viewer
All events (alarms, system messages and user activities, etc.) are recorded in chronological order and can be displayed at any time for additional analysis.



Report Viewer
Offers reports to analyze plant operations as well as for evaluation and documentation.



Energy report
The wizard-supported application deliver statistical analyses of energy-related data:
- Energy consumption
- Energy costs
- Consolidated energy costs
- CO_2 emissions
- Yearly heating report corrected with degree days



Eco monitoring
Offers a continuous monitoring of process and consumption values.
- Identification of energy-savings potential
- Evaluations, analysis, report
- Timely intervention possible before higher energy

6.1.1.2 Desigo PX

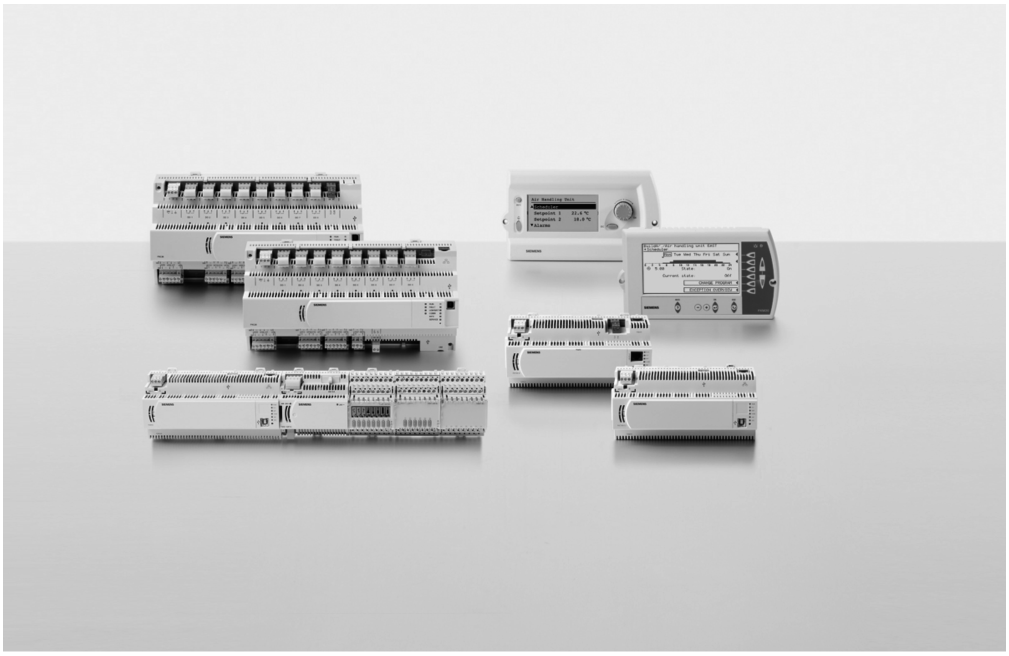
The Desigo PX building automation and control system controls and monitors heating, ventilation, air conditioning and other building services plants. It is distinguished by its unique scalability of freely programmable automation stations, range of graded operator units as well as a high degree of system openness.

Employed universally thanks to modular system concept
Desigo PX can adapt to the requirements and needs at hand thanks to its modular system design. The DDC technology can even be used economically and at low cost in small HVAC plants. The investment is limited to the system components that are actually needed for both new construction and upgrading. Thanks to its innovative system design, Desigo PX can be extended at any time and in stages to a comprehensive building automation and control system.

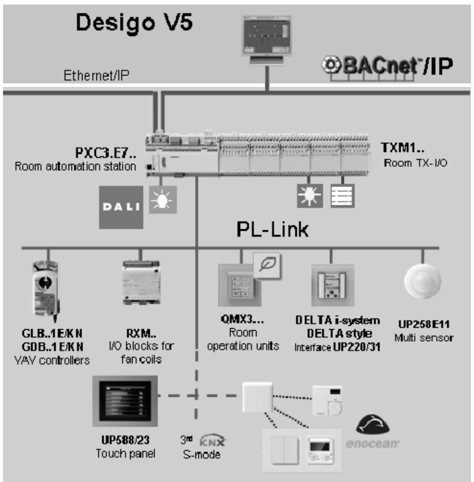
■ Family of automation stations
The PX automation stations are used to optimally control and monitor building services plants. They are supported by comprehensive system functions including alarming, scheduling programs and trend data storage.

■ Years of experience
Siemens is a global leader in building automation and control as well as HVAC control technology. Our development is based on expert knowledge and years of experience by our technicians. The result is a reliable and user-friendly system – Desigo.

Highlights
■ Employed universally thanks to module system design
■ BACnet communication for maximum openness
■ Operation as needed
■ Family of automation stations
■ Years of experience in building automation and control

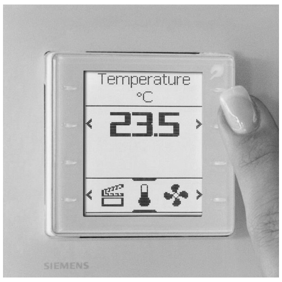


6.1.1.3 Desigo Total Room Automation



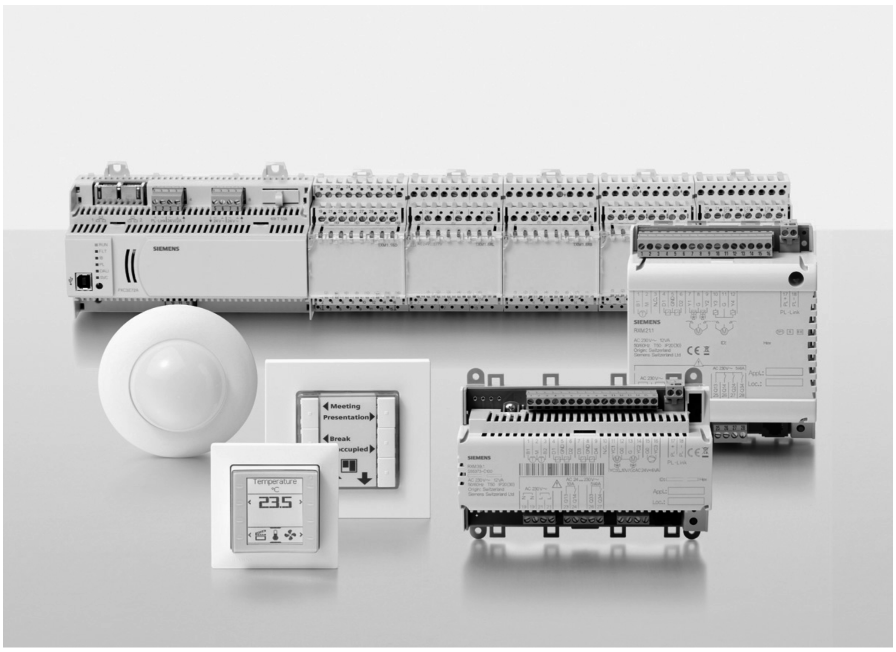
New energy savings directives, lower operating costs as well as even greater demand for comfort and design require increasingly improved interaction of the various electrical and mechanical installations.
The modular room automation stations PXC3 combine lighting, shading and HVAC into one comprehensive solution and connects via BACnet/IP directly with PX automation stations for the primary plants as well as Desigo Insight.
The periphery bus PL-Link connects field devices including the room operator units, push buttons, presence detectors or VAV controllers without engineering. Connecting application-specific modules (RXM..) for fan coils provides even greater flexibility.
PXC3 is the perfect solution in the room with its support of KNX, DALI and EnOcean devices. The costs of extending or changing room occupancy are an important factor in the life-cycle of a building. A flat system architecture and uniform tool for all building disciplines allows the operator to quickly and easily extend or change room use.

The Total Room Automation product range (TRA) is the first choice for buildings with higher demands on functionality and flexibility. TRA is used wherever multiple disciplines (HVAC, lighting, shading) are combined into a total solution. The product range is suited specifically for energy-optimized solutions (Class A as per EN15232) without loss of comfort.
The modular PXC3 room automation stations communicate on BACnet/IP, are freely programmable, flexible and provide integrated interfaces for PL-Link and DALI.



With Desigo TRA, the room user is actively involved in energy management thanks to the innovative operating and display concept. The energy efficiency function RoomOptiControl recognizes any unnecessary energy consumption and indicates it on the room operator unit by changing the color of the Green Leaf display; simply press the symbol to return room control to energy-optimized operation (without any loss of comfort).

The combination of the PXC3 room automation station with standard application "Fan Coil 01" is ready for eu.bac certification.



6.1.1.4 Desigo RXC/RXB/RXL

Desigo RX offers individual room comfort as needed in public buildings, office complexes, school and hotels. This economical and user-friendly system stands for flexible control no matter the type. Desigo RX can be used for both existing as well as new plants and guarantees optimum energy efficiency.

■ High degree of flexibility thanks to bus (LONWORKS®/KNX) technology
Desigo RX is easily integrated into building automation and control systems thanks to the use of bus technologies. This also results in lower installation and life-cycle costs, offers comprehensive extension opportunities and flexibility at a lower price and improves energy efficiency, since you are able to combine numerous electrical and mechanical installations.

■ Complete product line of room units
A comprehensive product range of room units is available to directly operate and monitor setpoints and actual values in individual rooms. Units for wireless communication and flush mounted room units round off the product range.

■ Flexible room use
Desigo RX controllers are also highly flexible with regard to engineering and commissioning. You can quickly and simply adapt to changes in occupancy plans or room assignment – without changing wiring and with no need to lay new cables.

■ Energy savings of up to 14%
Together with room units, Desigo RX controllers guarantee highly accurate room temperature control including optimum room conditions combined with energy savings. The eu.bac certificate confirms the exceptional control accuracy (CA) of the RX controllers, for example, a CA value of 0.1K for a fan coil. RX achieves BACS energy efficiency class A as per EN 15232. Setpoints for heating and cooling based on occupancy as well as intelligent algorithms and operating modes, etc., also contribute to reducing energy consumption to an absolute minimum.

eu.bac Cert

■ Large selection of standard applications
Desigo RX offers a broad range of standard applications for room automation, including, for example, for fan coils, radiators, chilled ceilings, VAV and integrated lighting and blinds applications.

■ Integration into the DESIGO building automation and control system
Desigo PX integrates RX controllers into the Desigo building automation and control system. This provides even more functions such as schedulers, trending, heating/cooling demand, centralized monitoring of setpoints and lots more. In other words, RX becomes an integral part of a modular and extendable, complete system that ensures economic viability for years to come.

Highlights
- Versatile thanks to bus (LONWORKS/KNX) technology
- Comprehensive room unit product range
- Flexible room use
- Simple mounting and maintenance
- Energy efficiency certified by eu.bac
- Large selection of standard application

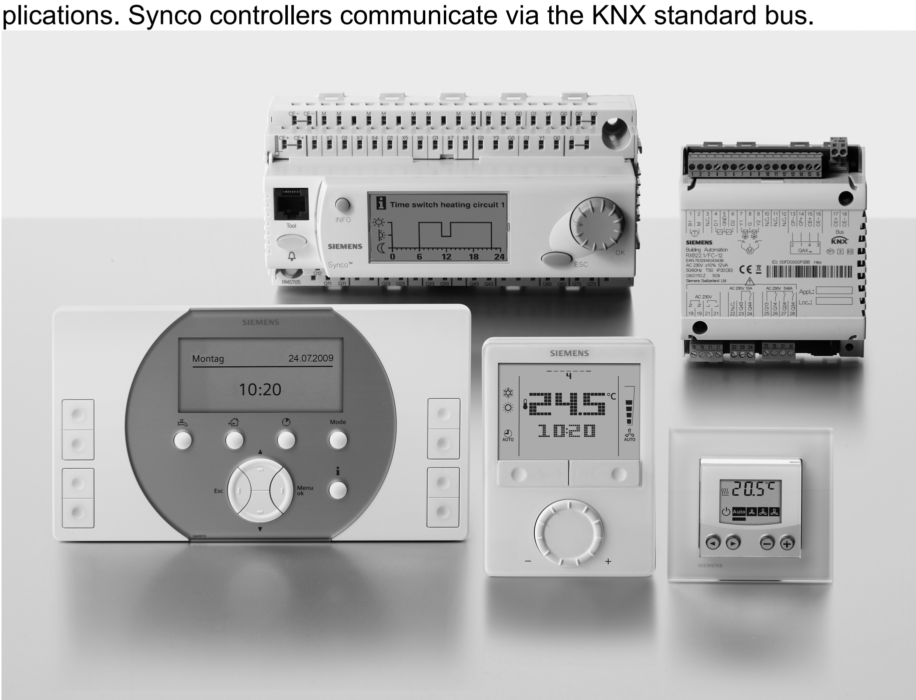
6.1.2 Synco – for enhanced comfort and energy efficiency

Buildings place different requirements on HVAC control systems depending on building size, life cycle, operating times, and comfort needs.
Synco™ can be matched to all these requirements: The standard controllers offer maximum energy efficiency plus reliability and represent a product range of modular design. This means that Synco enables you to plan a versatile, cost- and energy-efficient HVAC control system and to straightforwardly install and commission it – with no need for programming.

KNX The worldwide standard for building control

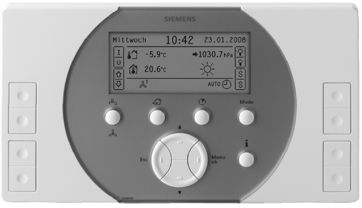
Energy savings thanks to intelligent building automation
Synco controllers exchange information on energy usage via KNX communication, thus making certain that the only plant components put into operation are those required for ensuring the desired comfort level: Heating boilers, refrigeration machines, pumps, and so on. The proven and programmed energy saving functions provided by all Synco controllers support energy-optimum operation of plant – both summer and winter.
Users and plant operators can greatly influence a building's energy consumption by shutting down plant during hours of non-occupancy, by setting adequate room temperatures, and by matching the time program to the current occupancy times. The straightforward operation of Synco controllers and room units supports the operator when making settings for energy-efficient operation of the entire HVAC plant.

Comprehensive product range
From basic temperature control to complete HVAC plant control – from heat or refrigeration generation control through distribution to individual room control: Synco offers a comprehensive range of standard controllers for all types of applications. Synco controllers communicate via the KNX standard bus.



Versatile and expandable for future use
Synco supports the entire life cycle of a building. Whether you change the usage of a building, in case of a staged construction or when you expand or modernize a plant – Synco is the ideal solution for you. Thanks to their modular concept and backward-compatible communication, the controllers can be expanded and adapted at any time. This means that the functionality of HVAC plants can grow depending on new requirements, and investments can be made in stages.

Straightforward operation and quick commissioning
Synco excels in high levels of user and service friendliness, owing to straightforward and efficient operation. Proven and preprogrammed applications and energy saving functions are integrated, enabling you to save time and costs in terms of planning, engineering, and commissioning. Furthermore, smooth and energy-efficient operation is ensured.

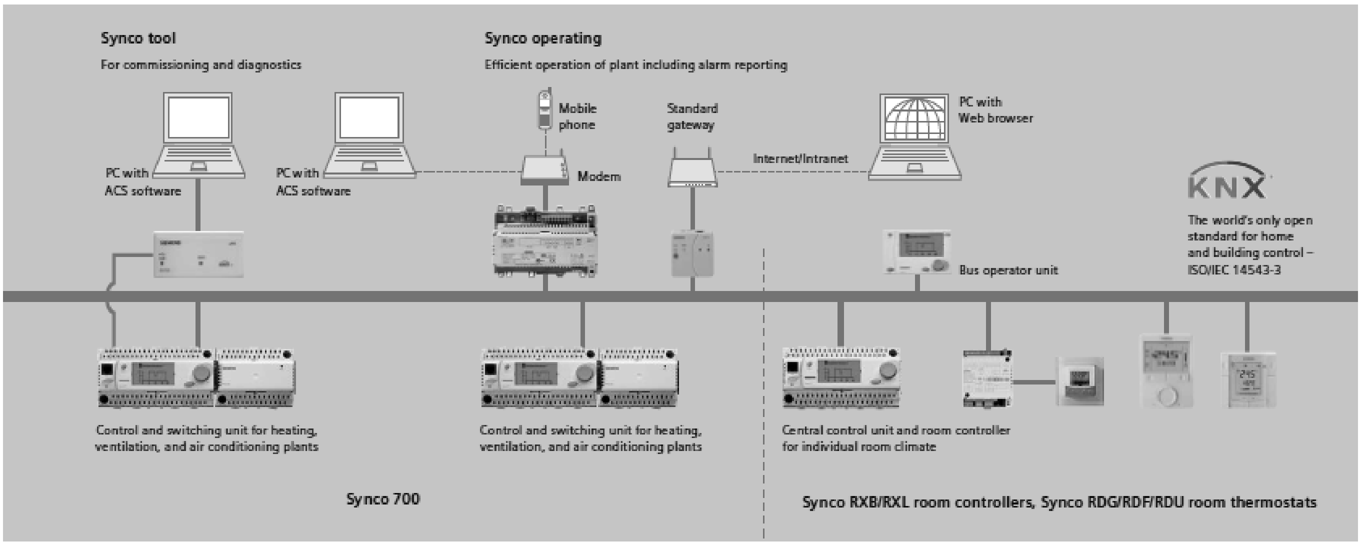


Synco living – more comfort at home
Synco living is specially tailored to the needs of private areas. The new automation system unites all functions such as heating, ventilation, lighting, blinds as well as security technology and is easy to operate. Proper room temperature and energy consumption are matched and brought to a reasonable relationship. This creates the decisive prerequisites for living and comfort in your home.

Efficient operation of plant with straightforward remote control
Thanks to Synco's web server, plant operation and monitoring can be effected from any PC at any time and from any location. An alarm system delivers fault status or maintenance messages in due time, also via SMS or e-mail, if required.

Simple concept for opening communication
With Synco, opening and starting communication is child's play: Simply interconnect the units, activate the bus power supply on the controller, and set the device address. All relevant settings can be made directly via local operation. This way, the units exchange information over the bus – information about energy demand, for example, room temperatures or time programs. In addition, the units ensure automatic coordination within the system.

Open data exchange via KNX standard bus, irrespective of supplier
The KNX standard bus facilitates interconnections of HVAC, lighting and blind control, for instance, irrespective of the supplier – for simultaneous control of the ventilation system and of lighting via presence detectors, for example



6.1.3 GAMMA – building control technology

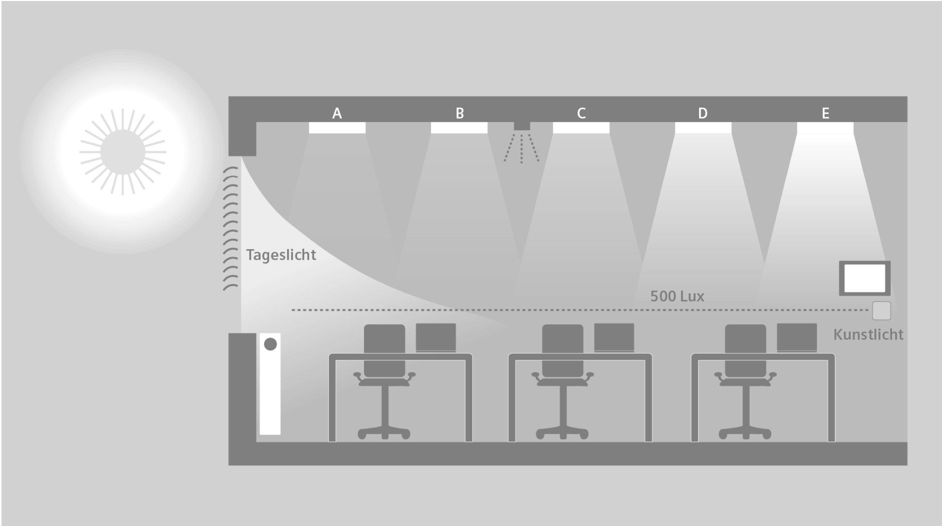
Energy-efficient building and room automation based on KNX
Increase safety and comfort in the building while saving energy: The intelligent GAMMA building control technology based on the global KNX standard makes it possible. GAMMA building control technology is based on the proven and worldwide KNX standard as per European standard EN 50090, international standard ISO/IEC 14543 and Chinese standard GB/Z 20965.
Buildings are energy-efficient using the proven GAMMA building control technology and can be quickly and inexpensively modified to meet individual user needs. Electrical installation for room climate, lighting, and shading can be implemented to save energy in a convenient and user-friendly manner.
The system can be extended with additional functionality thanks to the open and standardized KNX communications standard – securing your investment in the long term as well.

Lower energy costs with GAMMA building control technology
Comfort and saving energy are no longer contradictions. Whether lighting, shading, or room climate, Gamma building control technology's target control unifies intelligent functions; allowing savings of up to 44% on energy while continuing to enjoy comfort. Automated control of solar protection facilities contribute, among others, by allowing as much daylight in the room as possible through the use of shadow edge tracking and tracking of the position of the sun. Automated lighting control ensures that available daylight is used in an optimum manner.

Your benefit – economical operation
Innovative GAMMA building control technology provides ideal conditions for lower energy and operating costs. In other words, lower maintenance costs for building operators while maintaining the same level of comfort for the room user.

Set the lighting in a optimum and well thought out manner
Intelligent lighting control saves money while retaining the same level of visual comfort. For example, constant lighting control that takes advantage of daylight provides only the requisite amount of artificial light. Room control based on occupancy provides additional energy savings potential. The lighting automatically turns off if a room is not used. Presence detectors integrated in access control or a timer, provide the control. In hallways, lighting can be switched off outside of primary occupancy periods based on presence. During primary occupancy, the light is returned to an adjustable minimum level of brightness when no one is there. Automated control in all areas does not restrict a user's comfort. Manual control and adapting to individual needs is also possible as needed.

Your benefit – higher level of visual comfort at a lower energy demand
Centralized switching off of lighting as well as lighting control dependent on daylight and occupancy reduce energy demand.



Control room temperature by use
Heating and air conditioning costs represent a significant component of operating costs. GAMMA building control technology significantly reduces these expenses by heating, cooling, or ventilating rooms only when they are really in use. Room temperature can be controlled using presence detectors, by core occupancy times, room-related occupancy schedules or manually. Additional functions provide even greater savings – for example, lowering heating automatically to frost protection, reducing or switching off cooling and ventilation as long as a window is opened. The function "Centralized off" function can reduce heating, ventilation and air conditioning to provide protection at night for the entire building.
Your benefit – comfort as desired
Intuitive room operating units for lighting, shading, ventilation, heating and air conditioning – GAMMA *instabus* is oriented precisely to the user's desires.

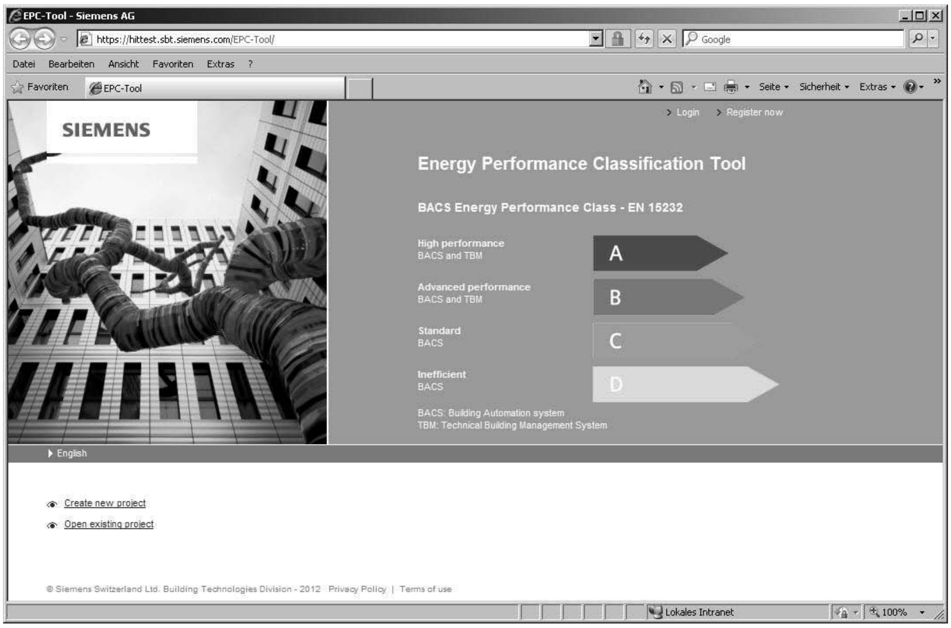
Manage your building with greater efficiency
The centralized visualization of GAMMA building control technology provides a current overall picture of all the functions in the building, enabling central operation. Building management can even extend to multiple buildings by integrating it to existing data networks (LAN and internet) or building control technology. Whether within a building complex, a city or even further away. Even distributed properties can be managed in an optimum and energy efficient manner thanks to up-to-date status information.
Your benefit – networking third-party systems made easy
No other provider has such a wide variety of solution offerings to connect GAMMA *instabus* with other systems in a building with the help of KNXnet/IP.

Your benefit – **remote control and access to all room functions**
Whether local or via remote access, room function can be controlled on site or via the internet.

6.2 Energy efficiency tools

6.2.1 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 15232:2012 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:

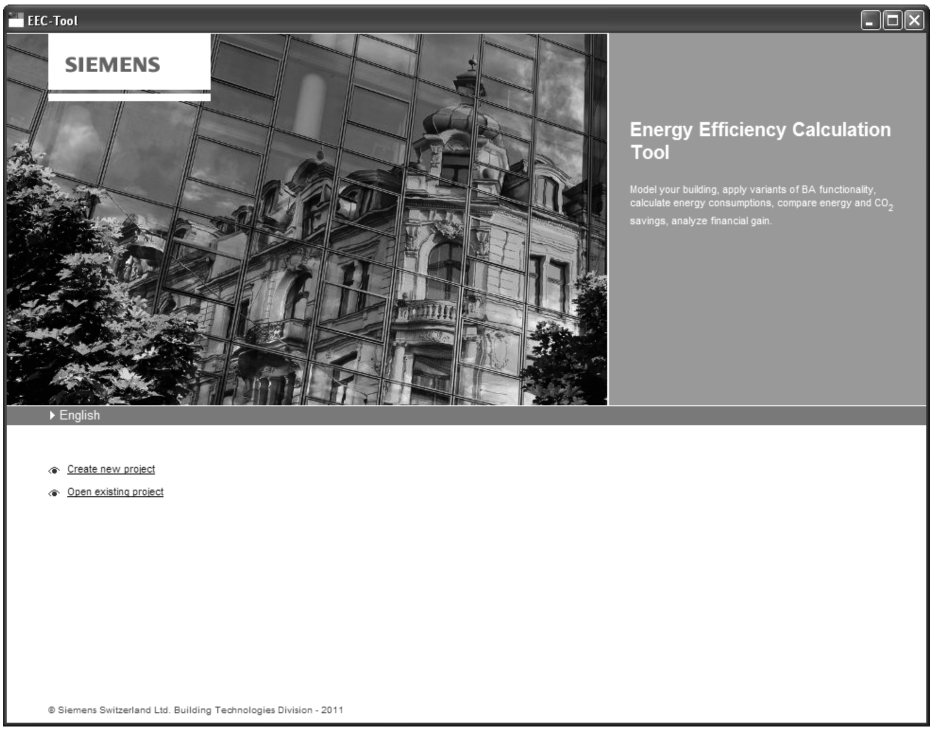
The tool can be used either online or locally on a PC.
All standard web browsers are supported.
Operation and EN 15232 standard texts can be selected in different languages.
Evaluation of building automation and control:

- By means of overall or individual factors as per EN 152323:2012
- Using weighting based on experience made by Siemens

If no data on the consumption of the customer's building are 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.

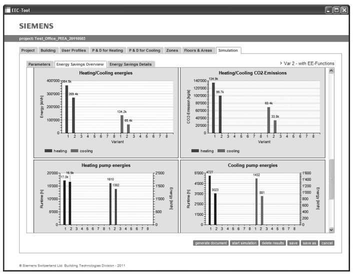
6.2.2 Energy Efficiency Calculation (EEC) tool

For a selected building with the HVAC plants, the tool calculates the potential energy savings and the CO_2 emission reductions made possible by BACS functions.



The EEC tool is a sales support tool serving the following main purposes:

- Showing customers potential energy savings resulting from various energy efficiency (EE) functions applied to their buildings and plants and comparison of the calculated energy cost savings with the required investments.
- Providing information on payback time information to customers.

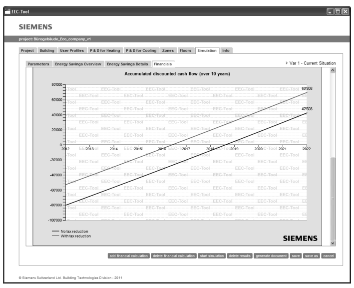


Energy savings calculations

The EEC tool uses a thermal building model and applies location specific building constructions and weather data (hourly values of temperature and solar radiation) as part of the energy simulation calculation.

When using the EEC tool, follow these steps:

- Create a simplified model of the building, its plants and internal loads.
- Apply the current BA functions, schedules and set-points to plants and the various zones of the building.
- Run the simulation calculation for an initial set up.
- Create additional variants of the plant and zone definitions with improved EE functions.
- Run the simulation calculation for these variants.
- Compare the calculated energy savings across the variants.
- Create reports on the energy savings for the customer.



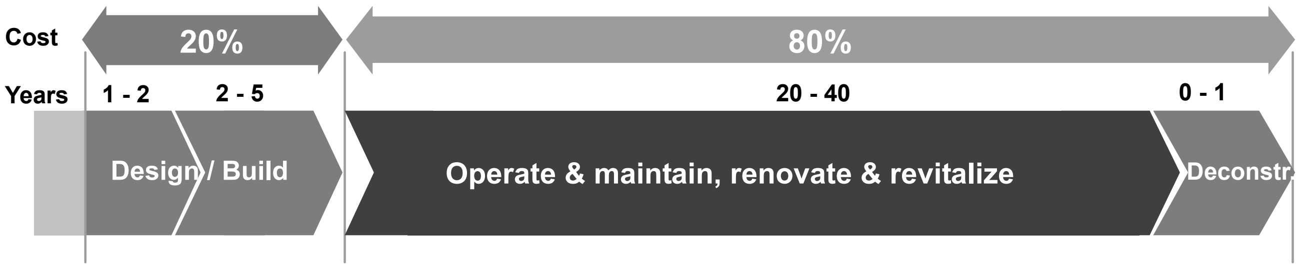
Financial calculations

- Estimate the required investments with the typical sales tools (outside of the EEC tool).
- Apply the calculated investments and use the financial part of the EEC tool to run payback time calculations.
- Create reports on the financial aspects for the customer.

6.3 Services

Siemens BT not only offers building automation and control systems and products, that achieve a high degree of energy efficiency as per EN 15232 or guarantees certified quality per eu.bac Cert.

Approximately 80% of the costs associated with a building occur during operation. Energy costs in particular make up the lion's share and offer tremendous potential for optimization. The economic operation may not, however, impact the comfort at work. The negative impact of uncomfortable customers and sick employees clearly exceed the cost of operating the building.

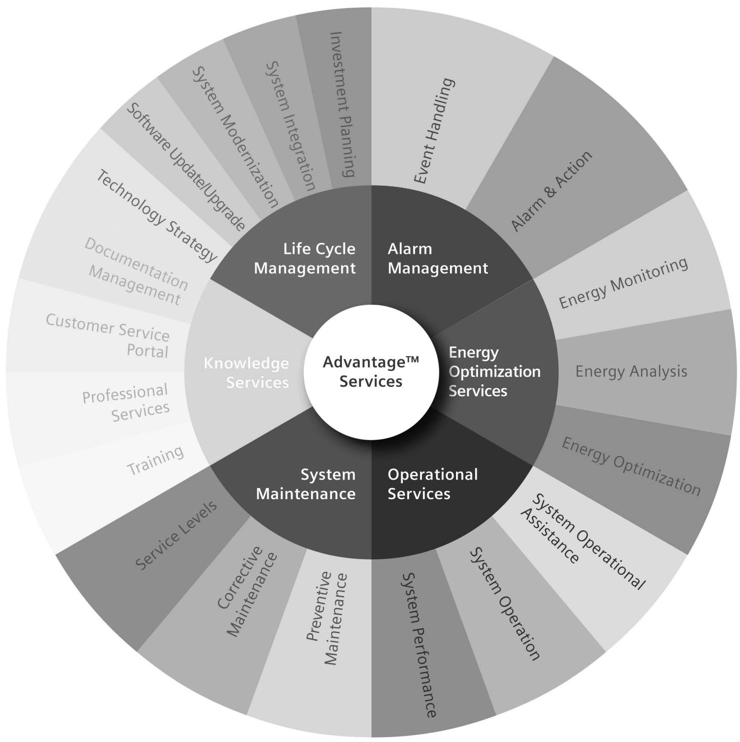


Siemens BT offers also comprehensive services to the market, aimed at…

- optimizing the energy efficiency of buildings in a sustainable manner,
- assessing existing, older building technology, re-engineering and upgrading it; the required investments can be financed from future energy savings.

6.3.1 Minimize life-cycle costs of the building

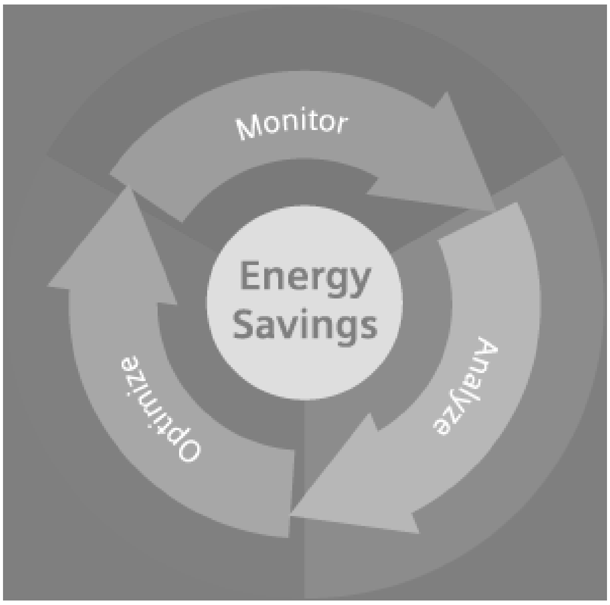
How do we ensure that your requirements will be met?
First, we listen to you. At Siemens, each customer is unique. The only way to ensure that will give due consideration to your needs is to listen and take the time to understand your building and your objectives.



Advantage™ Services is a comprehensive program offering, in addition to quality and reliability, flexibility to adapt solutions to meet your exact needs and requirements.

6.3.2 Continuous optimization

Our energy services pursue a simple yet proven concept:
In a first step we monitor (**monitoring**) the energy consumption of your building. We then evaluate the collected data and draft an optimization plant (**analysis**) and implement it (**optimization**). The achieved effect is then once again monitored to ensure the results. This energy optimization process allows you to save on energy consumption while keeping the impact on the environment to an absolute minimum.



Sustainable process
To ensure not only short-term savings, but rather guaranteed sustainable energy efficiency, the process should be maintained throughout the life cycle for your technical equipment in buildings (see chart below).

Energy monitoring
Energy consumption must first be measured to control and optimize energy consumption. Based on well thought out measurement concepts, the data is compressed and prepared into power reports on energy consumption, costs and emissions. The improved transparency and information quality makes it easy to make forward-looking management decisions.

Information from energy monitoring allows you to identify energy saving potential and forms the basis for your optimization plan. Continuous monitoring not only ensures that all the potential is tapped, but also documents the success of all implemented measures.

Energy analysis
Technologies and procedures for energy savings undergo continuous development. And Siemens has the technical expertise and experience to actively analyze your building. Together with powerful comparative figures and proven documented methodologies, the knowledge is implemented into concrete measures within your optimization plan.

Energy optimization
Your energy optimization plan is specially matched to meet your needs and requirements based on the results from energy monitoring and energy analysis. Successful implementation of the draft measures plays a key role in achieving the goals. To achieve the most benefits in the area of energy optimization, you can complete the offering with operational optimization measures as an option.

Your benefits

Cooperation with the Siemens team offers a tailored process to optimize the efficiency of your building with the following advantages:
- Reduce energy and operating costs
- Constant comfort level at work
- Increase reliability and efficiency of your technical equipment in buildings
- Extend the life of your technical equipment in your building
- Expand the competency of your operating personnel
- Ease sustainable management decisions thanks to greater transparency
- Lessen the impact on the environment

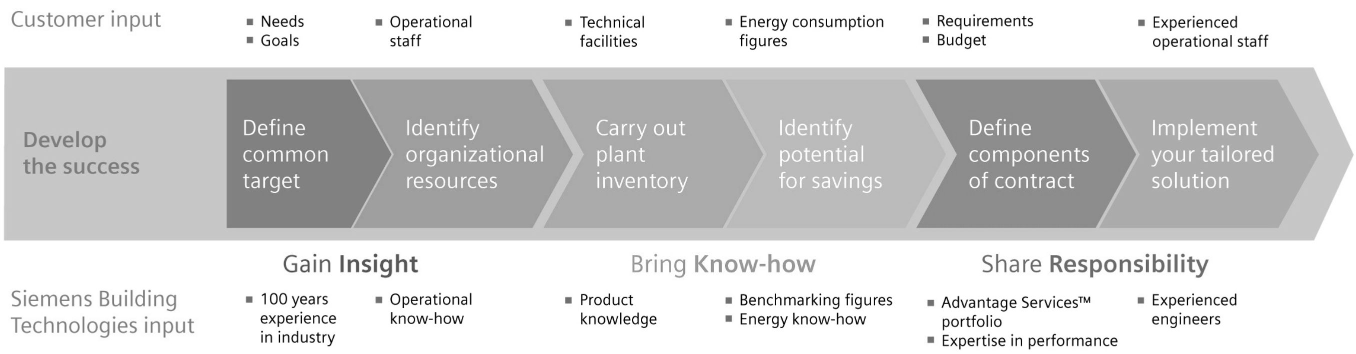
Implement and maintain – with us as your partner – a sustainable energy optimization process for your building.

Building Performance Optimization

Building Performance Optimization consists of three parts: Emergency and service control centers, energy services and operational service from the Advantage™ Services program by Siemens.

Phase 1

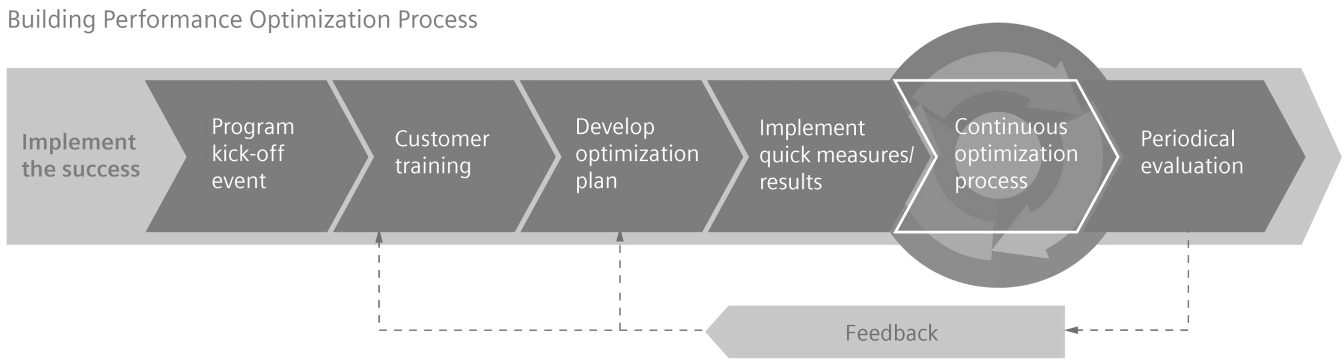
Develop success
We provide a short presentation on how to develop tailored solutions for you as a way to illustrate our customer orientation. You as well as Siemens are actively involved in the process "Gain insight, contribute know-how and share responsibility".



Phase 2

Implement success

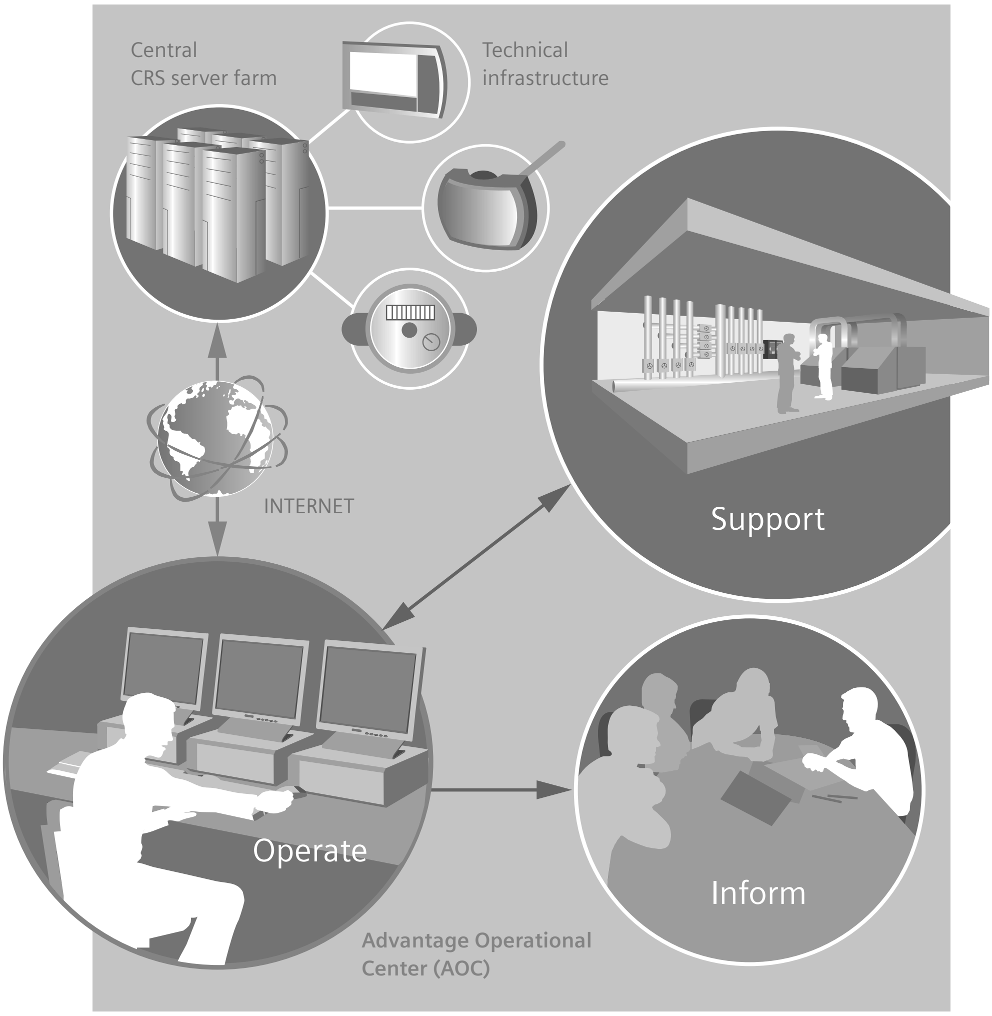
The following chart illustrates the systematic approach to implementing building performance optimization. In close cooperation with your personnel (workshop), we analyze your building and draft a tailored solution. Targeted training for your employees as well as implementing all measures that can be implemented on the spot are also important components of our optimization process. We then use continuous checks, supported by the Advantage Operation Center, to secure long-term optimization success and as well as improvements.



Advantage Operation Center

A remote connection via secured access to your building automation and control system creates a common data base and efficiently implements optimization measures.
It is possible to set up a secure remote connection to your building automation and control system from the Advantage Operation Center (AOC). This allows you to implement measures in a cost-optimized manner as well as ensure achieved savings success by monitoring important operating parameters (energy consumption, system messages, etc.). A refined reporting system, consisting, for example, of alarm statistics, consumption curves and logbook functions support the quality and speed of actions. Cooperation between your operating personnel and our engineers is founded on a common basis.
Optimization measures that cannot be implemented remotely are conducted on site by our service technicians or your operating personnel.

.



Take advantage of the benefits of the Advantage Operation Center:

- Short response times
- Access to highly qualified technicians
- Remote plant monitoring and optimization
- Cost-efficient execution
- On-going analysis of consumption data and events
- Internet access to energy data for the customer
- Powerful reports
- Documentation of services provided

6.3.3 Performance Contracting

What is Performance Contracting ?

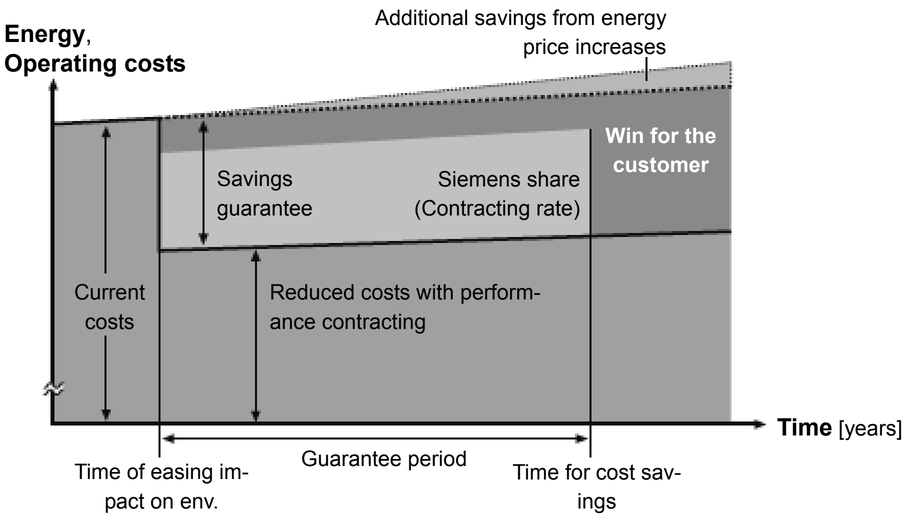
Concentration on what's important

Tap existing energy saving potential in your customer's building technology with targeted renovations and optimization, resulting in lower operating costs and increased values. The required investments pay for themselves from savings in energy and operating costs throughout the contract period. A savings guarantee ensures your customer's business success. Updating technical plants and guaranteeing functions during the term of the contract also increases operational security. And we make a valuable contribution to the environment together with our customers by saving energy.

A win-win situation for the building operator with performance contracting

- Added value through modernization
- Savings pay for investments
- Risk-free thanks to success guarantee
- Function guarantee during the contract period
- Sustainable quality assurance by energy management
- Secured financing

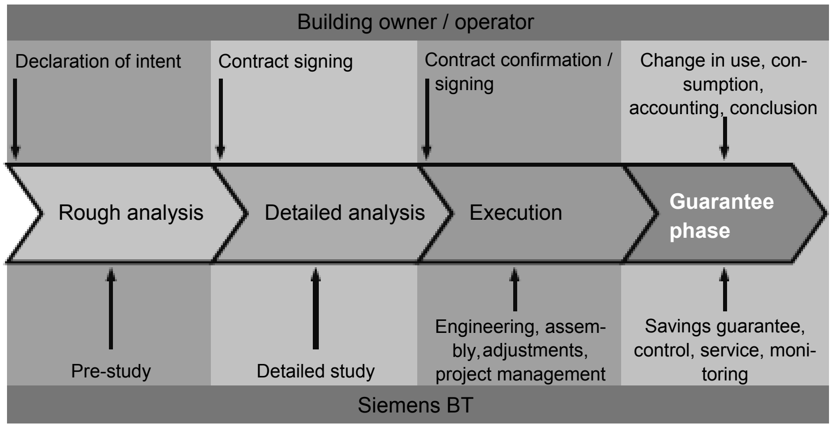
Financing model



From guarantee start to the end of the contract, guaranteed savings

- Finance all necessary savings measures
- Additional savings split among the parties
- Ensure that we take the risk of not achieving savings
- When the contract ends, you benefit 100% from the savings

Project workflow



Together with us, the customer defines the project workflow. After determining the suitable buildings, we estimate the savings potential in a pre-study. A detailed study clarifies the potential, determines measures and calculates the economic viability. After the performance contract is signed, we commence with planning, delivery and installation. Securing the efficiency guarantee begins as soon as the project is completed, in other words ensuring guaranteed savings. Regular reports on achieved savings are provided during this phase.

7 Information and documentation

We would naturally be pleased should you like to learn more above and beyond the scope of this User's Guide on the topic of energy efficiency.

We have provided some useful links on the internet as well as a list of documents for your continued contribution to our joint efforts to create energy efficient building technologies.

7.1 Internet links

European Commission/Energy	http://ec.europa.eu/energy/
EPBD	http://www.buildup.eu
eu.bac	http://www.eubac.org/
eu.bac Cert	http://www.eubaccert.eu/
International Energy Agency	http://www.iea.org/
CEN/TC247	http://www.cen.eu
ASHRAE publications about LEED	http://www.ashrae.org
Minergie	http://www.minergie.com/
U.S. Green Building Council	http://www.usgbc.org/
Siemens Building Technologies/Energy Efficiency	https://www.siemens.com/ee
Novatlantis – Nachhaltigkeit im ETH Bereich	http://www.novatlantis.ch/
Association for the Study for Peak Oil (ASPO)	www.peakoil.ch

7.2 Document index

7.2.1 Literature

EC, EPBD Directive:
- Deutsch
http://www.eco.public.lu/attributions/dg3/d_energie/energyefficient/info/directive_de.pdf
- English
http://www.eco.public.lu/attributions/dg3/d_energie/energyefficient/info/directive_en.pdf
- Français
http://www.eco.public.lu/attributions/dg3/d_energie/energyefficient/info/directive_fr.pdf

Report on climate change 2007 by the United Nations

7.3 Relevant standards

CEN

Declaration on the General Relationship between various European standards and the EPBD ("Umbrella Document").

prCEN/TR 15615 : 2007

Heating	EN 15316-1, EN 15316-4
Cooling	EN 15243
DHW	EN 15316-3
Ventilation	EN 15241
Lighting	EN 15193
Auxiliary energy	
Building automation and control	EN 15232

Product standard for electronic control devices in HVAC applications, e.g.

EN 15500, EN12098

Standardization for building automation and control systems:

EN ISO 16484-1	Building automation and control systems(BACS)/Part 1: Project specification and implementation
EN ISO 16484-2	Building automation and control systems(BACS)/Part 2: Hardware
EN ISO 16484-3	Building automation and control systems(BACS)/Part 3: Functions
EN ISO 16484-5	Building automation and control systems(BACS)/Part 5: Data Communication Protocol – BACnet
EN ISO 16484-6	Building automation and control systems(BACS)/Part 6: Data Communication Conformance Testing – BACnet

Standards for communication protocols:

EN ISO 16484-5 /-6	BACnet
EN 14908-1 .. -6	LonWorks
EN 50090 und EN 13321	KNX

EN 45000 standardization series for eu.bac Cert

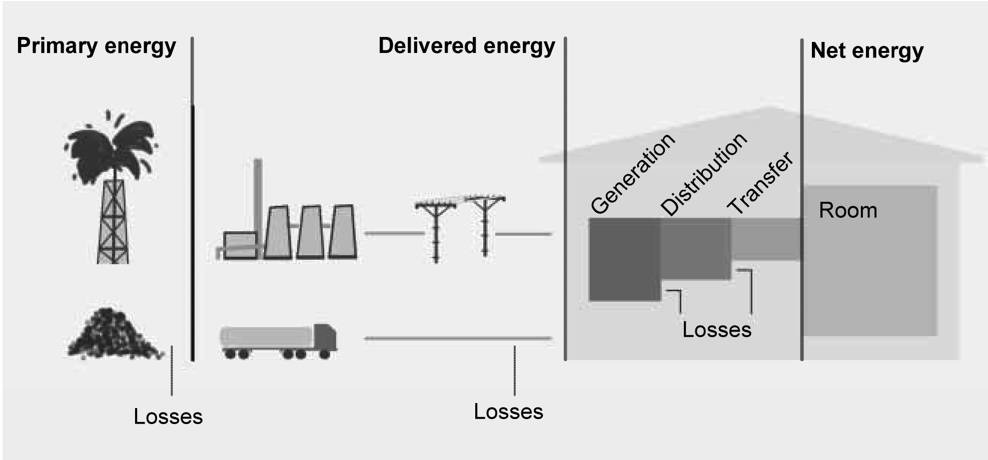
8 Abbreviations and terms

8.1 Abbreviations

BAC	**B**uilding **A**utomation and **C**ontrol
BACS	**B**uilding **A**utomation and **C**ontrol **S**ystem
CEN	**C**omitée **E**uropéen de **N**ormalisation - European committee for standardisation
EPBD	**E**nergy **P**erformance of **B**uilding **D**irective
EMPA	Formerly the **E**idgenössische **M**aterial**p**rüfungs**a**nstalt. Today: Interdisciplinary research and service institution for materials sciences and technological development within the ETH
EN	**E**uropean **N**orm (Standard)
ETH	**E**idgenössisch **T**echnische **H**ochschule Swiss Federal **I**nstitute of Technology (University)
eu.bac eu**.**bac Cert	**Eu**ropean **B**uilding **A**utomation and **C**ontrols association eu**.**bac certification procedure
EU	**E**uropean **U**nion
HR	**H**eat **R**ecovery
IEA	**I**nternational **E**nergy **A**gency
MINERGIE®	Construction standard(s) for low-energy buildings (currently in CH and FR): Higher quality of life, lower energy consumption
TABS	Thermally Active Building Structure
TBM	**T**echnical **B**uilding **M**anagment
TC	**T**echnical **C**ommitée

8.2 Terms

Primary energy



Compound	Solution or partial solution in the form of a software building block
Night cooling	Cooling the building at night to achieve a lower cooling load or lower room temperature for the next occupancy period, where cooling should cost as little as possible (free energy) and should be as efficient as possible
Night ventilation	Form of night cooling using outside air

Siemens Switzerland Ltd
Infrastructure & Cities Sector
Building Technologies Division
International Headquarters
Gubelstrasse 22
6301 Zug
Switzerland
Tel +41 41 724 24 24

Siemens Building Technologies
Infrastructure & Cities Sector
Brunel House
Sir William Siemens Square, Frimley
Camberley
Surrey, GU16 8QD
United Kingdom
Tel +44 1276 696000

Siemens Ltd
Infrastructure & Cities Sector
Building Technologies Division
22/F, Two Landmark East
100 How Ming Street, Kwun Tong
Kowloon, Hong Kong
Tel +852 2870 7888

Answers for infrastructure.
Our world is undergoing changes that force us to think in new ways: demographic change, urbanization, global warming and resource shortages. Maximum efficiency has top priority – and not only where energy is concerned. In addition, we need to increase comfort for the well-being of users. Also, our need for safety and security is constantly growing. For our customers, success is defined by how well they manage these challenges. Siemens has the answers.

"We are the preferred partner for energy-efficient, safe and secure buildings and infrastructure."

www.siemens.com/energyefficiency