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BSI Standards Publication

Energy performance of buildings — Impact of Building Automation, Controls and Building Management

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National foreword

This British Standard is the UK implementation of EN 15232:2012. It supersedes BS EN 15232:2007, which is withdrawn.

CEN correction notice 15 February 2012 provided a revised English language text, incorporating the following editorial corrections:

5.2 — Table 1
1 Heating Control
3.1 Emission Control
(modification to wording and layout)

5.4 — Table 2
1 Heating Control
3.1 Emission Control
(modification to wording and layout, addition of an extra row)

The UK participation in its preparation was entrusted to Technical Committee RHE/16, Performance requirements for control systems.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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English Version

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

Performance énergétique des bâtiments - Impact de l'automatisation, de la régulation et de la gestion technique

Energieeffizienz von Gebäuden - Einfluss von Gebäudeautomation und Gebäudemanagement

This European Standard was approved by CEN on 27 November 2011.

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Foreword

This document (EN 15232:2012) has been prepared by Technical Committee CEN/TC 247 “Building Automation, Controls and Building Management”, the secretariat of which is held by SNV.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by July 2012, and conflicting national standards shall be withdrawn at the latest by July 2012.

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Introduction

This European Standard was created to establish conventions and methods for estimation of the impact of building automation and control systems (BACS) and technical building management (TBM) on energy performance and energy use in buildings.

This European Standard also provides guidance for taking BACS and TBM functions as far as possible into account in the relevant standards prepared under the mandate M/343. Therefore, it is coordinated between CEN/TC 247 and CEN/TC 89, CEN/TC 156, CEN/TC 169 and CEN/TC 228 to support these TCs by strong cooperation in specifying how the impact of the BACS and TBM functions are taken into account in their standards. The results concerning BACS and TBM in the relevant standards are summarized in Clause 5.

This European Standard specifies a method to estimate energy saving factors which can be used in conjunction with energy assessment of buildings. This European Standard supplements a series of standards which are drafted to calculate the energy efficiency of technical building services, e.g. heating, cooling, ventilation, lighting systems. This European Standard takes into account the fact that with BACS and TBM the energy consumption of a building can be reduced.

This European Standard should be used for existing buildings and for design of new or renovated buildings.

1 Scope

This European Standard specifies:

— a structured list of Building Automation and Control System (BACS) and Technical Building Management (TBM) functions which have an impact on the energy performance of buildings;

— a method to define minimum requirements regarding BACS and TBM functions to be implemented in buildings of different complexities;

— a factor based method to get a first estimation of the impact of these functions on typical buildings;

— detailed methods to assess the impact of these functions on 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.

This European Standard is defined for:

— building owners, architects or engineers, defining the functions to be implemented for a given new building or for the renovation of an existing building;

— public authorities, defining minimum requirements for BACS and TBM functions for new buildings as well as for renovation, as defined in the relevant standard;

— public authorities, defining inspection procedures of technical systems as well as inspectors applying these procedures to check if the level of BACS and TBM functions implemented is appropriate;

— public authorities, defining calculation methods which take into account the impact of BACS and TBM functions on the energy performance of buildings as well as software developers implementing these calculation methods and designers using them;

— designers, checking that the impact of all BACS and TBM functions are taken into account when assessing the energy performance of a building.

NOTE The terms BAC (Building Automation and Control) and BACS (Building Automation and Control System) are equivalent in view of energy calculation and energy efficiency. In this case BACS will be used in the English version and BAC (German term: "GA Gebäudeautomation") in the German version.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 12098-1, *Controls for heating systems — Part 1: Outside temperature compensated control equipment for hot water heating systems*

EN 12098-2, *Controls for heating systems — Part 2: Optimum start-stop control equipment for hot water heating systems*

EN 12098-3, *Controls for heating systems — Part 3: Outside temperature compensated control equipment for electrical heating systems*

EN 12098-4, *Controls for heating systems — Part 4: Optimum start-stop control equipment for electrical systems*

EN 12098-5, *Controls for heating systems — Part 5: Start-stop schedulers for heating systems*

EN 13779, *Ventilation for non-residential buildings — Performance requirements for ventilation and room-conditioning systems*

EN 15193:2007, *Energy performance of buildings — Energy requirements for lighting*

EN 15217:2007, *Energy performance of buildings — Methods for expressing energy performance and for energy certification of buildings*

EN 15239, *Ventilation for buildings — Energy performance of buildings — Guidelines for inspection of ventilation systems*

EN 15240, *Ventilation for buildings — Energy performance of buildings — Guidelines for inspection of air-conditioning systems*

EN 15241:2007, *Ventilation for buildings — Calculation method for energy losses due to ventilation and infiltration in commercial buildings*

EN 15242:2007, *Ventilation for buildings — Calculation methods for the determination of air flow rates in buildings including infiltration*

EN 15243:2005, *Ventilation for buildings — Calculation of room temperatures and of load and energy for buildings with room conditioning systems*

EN 15255*, Energy performance of buildings — Sensible room cooling load calculation — General criteria and validation procedures*

EN 15316-1:2007, *Heating systems in buildings — Method for calculation of system energy requirements and system efficiencies — Part 1: General*

EN 15316-2-1:2007, *Heating systems in buildings — Method for calculation of system energy requirements and system efficiencies — Part 2-1: Space heating emission systems*

EN 15316-2-3:2007, *Heating systems in buildings — Method for calculation of system energy requirements and system efficiencies — Part 2-3: Space heating distribution systems*

EN 15316-3-2:2007, *Heating systems in buildings — Method for calculation of system energy requirements and system efficiencies — Part 3-2: Domestic hot water systems, distribution*

EN 15316-3-3:2007, *Heating systems in buildings — Method for calculation of system energy requirements and system efficiencies — Part 3-3: Domestic hot water systems, generation*

EN 15316-4-1, *Heating systems in buildings — Method for calculation of system energy requirements and system efficiencies — Part 4-1: Space heating generation systems (boilers)*

EN 15316-4-2, *Heating systems in buildings — Method for calculation of system energy requirements and system efficiencies — Part 4-2: Space heating generation systems, heat pump systems*

EN 15316-4-3, *Heating systems in buildings — Method for calculation of system energy requirements and system efficiencies — Part 4-3: Heat generation systems, thermal solar systems*

EN 15316-4-4, *Heating systems in buildings — Method for calculation of system energy requirements and system efficiencies — Part 4-4: Heat generation systems, building-integrated cogeneration systems*

EN 15316-4-5, *Heating systems in buildings — Method for calculation of system energy requirements and system efficiencies — Part 4-5: Space heating generation systems, the performance and quality of district heating and large volume systems*

EN 15316-4-6, *Heating systems in buildings — Method for calculation of system energy requirements and system efficiencies — Part 4-6: Heat generation systems, photovoltaic systems*

EN 15316-4-7, *Heating systems in buildings — Method for calculation of system energy requirements and system efficiencies - Part 4-7: Space heating generation systems, biomass combustion systems*

EN 15378, *Heating systems in buildings — Inspection of boilers and heating systems*

EN 15500:2008, *Control for heating, ventilating and air-conditioning applications — Electronic individual zone control equipment*

EN 15603:2008, *Energy performance of buildings - Overall energy use and definition of energy ratings*

EN 16001 2009, *Energy management systems — Requirements with guidance for use*

EN ISO 13790:2008, *Energy performance of buildings — Calculation of energy use for space heating and cooling (ISO 13790:2008)*

EN ISO 16484-3:2005, *Building automation and control systems (BACS) — Part 3: Functions (ISO 16484-3:2005)*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

NOTE 1 The terms and definitions listed in this standard but defined by other relevant ISO/IEC International Standards and/or European Standards are repeated below for convenience in most cases.

NOTE 2 Other language versions may contain an alphabetical index in national annexes.

3.1
auxiliary energy
electrical energy used by heating, cooling and/or domestic water systems to transform and transport the delivered energy into the useful energy

NOTE 1 This includes energy for fans, pumps, electronics etc., but not the energy that is transformed. Pilot flames are considered as part of the energy use by the system.

NOTE 2 In EN ISO 9488 the energy used for pumps and valves is called "parasitic energy".

[CEN/TR 15615]

3.2
building automation and controls
BAC
description for products, software, and engineering services for automatic controls, monitoring and optimization, human intervention and management to achieve energy – efficient, economical and safe operation of building services equipment

NOTE The trade designation and the industry branch are also referred to as building automation and/or building control.

[EN ISO 16484-2:2004]

3.3
building automation and control systems
BACS
comprising all products and engineering services for automatic controls (including interlocks), monitoring,

optimization, for operation, human intervention and management to achieve energy – efficient, economical and safe operation of building services

NOTE 1 The use of the word "control" does not imply that the system/device is restricted to control functions. Processing of data and information is possible.

NOTE 2 When a Building Control System, Building Management System or Building Energy Management System is in compliance with the requirements of the EN ISO 16484 standard series, it should be designated as a Building Automation and Control System (BACS).

[EN ISO 16484-2:2004]

3.4
building management
BM
totality of services involved in the management operation and monitoring of buildings (including plants and installations). Building management can be assigned as part of Facility Management

[CEN/TS 15379:2006]

3.5
building management system
BMS
cf. building automation and control system

NOTE 1 Building services is divided in technical, infrastuctural and financial building services and energy management is part of technical building management.

NOTE 2 Building energy management system is part of a BMS.

NOTE 3 Building energy management system comprising data collection, logging, alarming, reporting, and analysis of energy usage etc. The system is designed to reduce the energy consumption, improve the utilization, increase the reliability, and predict the performance of the technical building systems, as well as optimize energy usage and reducing its cost.

[EN ISO 16484-2:2004]

3.6
delivered energy
total energy, expressed per energy ware, supplied to the building through the system boundary from the last market agent, to satisfy the uses taken into account (heating, cooling, ventilation, domestic hot water, lighting, appliances etc.)

NOTE 1 For active solar and wind energy systems the incident solar radiation on solar panels or the kinetic energy of wind is not part of the energy balance of the building. The losses resulting from the transformation of these renewable energy carriers into heat or electricity are also not taken into account. Only the energy delivered by the generation devices and the auxiliary energy needed to supply the energy from the source (e.g. solar panel) to the building are taken into account in the energy balance and hence in the delivered energy.

NOTE 2 Delivered energy can be calculated for defined energy uses or it can be measured.

[CEN/TR 15615]

3.7
energy carrier
substance or phenomenon that can be used to produce mechanical work or heat or to operate chemical or physical processes

NOTE The energy content of fuels is given by their gross calorific value.

[ISO 13600:1997]

3.8
energy need for heating or cooling
heat to be delivered to or extracted from a conditioned space to maintain the intended temperature conditions during a given period of time

3.9
energy use for space heating or cooling or domestic hot water
energy input to the heating, cooling or hot water system to satisfy the energy need for heating, cooling or hot water respectively. It is the sum of the energy needs and the non-recovered technical system thermal losses

NOTE The energy use for lighting is also considered in this European Standard.

[EN 15306]

3.10
energy efficiency
ratio between an output of performance, service, goods or energy, and an input of energy

NOTE 1 Both input and output need to be accurately defined in quantity and quality, and be measurable.

NOTE 2 Energy efficiency is commonly used with the meaning of "Optimum Energy Efficiency", namely: "to operate (an entity) with minimum energy consumption".

NOTE 3 Commonly used sense of energy efficiency is doing at least the same with less energy.

[CEN/CLC/TR 16103]

3.11
energy efficiency improvement
increase in energy efficiency as a result of technological, behavioural and/or economic changes

[CEN/CLC/TR 16103]

3.12
energy use
manner or kind of application of energy

EXAMPLE Lighting, ventilation, heating, processes, transport.

NOTE The quantity of the energy applied is expressed as energy consumption.

[CEN/CLC/TR 16103]

3.13
control function
BACS effect of programs and parameters

NOTE 1 Functions within a BACS are referred to as control functions, I/O, processing, optimization, management and operator functions. They are listed in the BACS FL (function list) for a specification of work.

NOTE 2 Function is a program unit that delivers exactly one data element, which can be a multiple value (i.e. an array or a structure). Functions can be an operand in a program. [IEC 61131-3:2003]

[EN ISO 16484-2:2004]

3.14
integrated building automation and control systems
BACS designed to be interoperable and with the ability to be connected to one or more specified 3rd party building automation and control devices/systems through open data communication network or interfaces performed by standardized methods, special services and permitted responsibilities for system integration

EXAMPLES Interoperability between 3rd party BACS devices/systems for HVAC, domestic hot water, lighting, electrical power distribution, energy metering, elevators and escalators, other plants, as well as systems for communications, access control, security, life safety etc.

3.15
integrated function
BACS effect of programs, shared data points and parameters for multi-discipline interrelationships between various building services and technologies

3.16
measured energy rating
energy rating based on measured amounts of delivered and exported energy

NOTE 1 The measured rating is the weighted sum of all energy carriers used by the building, as measured by meters or other means. It is a measure of the in-use performance of the building. This is particularly relevant to certification of actual energy performance.

NOTE 2 Also known as "operational rating".

3.17
technical building management
TBM
process(es) and services related to operation and management of buildings and technical building system through the interrelationships between the different disciplines and trades

NOTE The disciplines and trades comprise all technical building services for the purpose of optimized maintenance and energy consumption.

EXAMPLE Optimization of buildings through interrelationships ranging from heating, ventilation and air conditioning (HVAC) to lighting and day lighting to life safety and security to electric power systems and energy monitoring and metering; to its services, including communications and maintenance and to its management.

3.18
technical building system
technical equipment for heating, cooling, ventilation, domestic hot water, lighting and electricity production

NOTE A technical building system is composed of different subsystems.

[CEN/TR 15615]

3.19
set-point temperature of a conditioned zone
internal (minimum) temperature, as fixed by the control system in normal heating mode, or internal (maximum) temperature, as fixed by the control system in normal cooling mode

NOTE The corrected value of a temperature set point is used for the calculation of energy performance. It enables the impact of the accuracy of the control system on the energy performance to be taken into account.

[CEN/TR 15615]

4 Abbreviations and acronyms

For the purposes of this document, the following abbreviations and acronyms apply.

BAC **Building Automation and Control**

BACS **Building Automation and Control System**

BM **Building Management**

DHW **Domestic Hot Water**

EMS **Energy Management System**

HVAC **Heating, Ventilation and Air Conditioning**

TABS **Thermo-active Building Systems**

TBM **Technical Building Management**

5 Impact of BACS and TBM on the energy performance of buildings

5.1 General

Building Automation and Control Systems (BACS) provide effective control functions of heating, ventilating, cooling, hot water and lighting appliances etc., that lead to improve operational and energy efficiencies. Complex and integrated energy saving functions and routines can be configured based on the actual use of a building, depending on real user needs, to avoid unnecessary energy use and CO_2 emissions.

Technical Building Management (TBM) functions as part of Building Management (BM) provide information about operation, maintenance, services and management of buildings, especially for energy management – measurement, recording trending, and alarming capabilities and diagnosis of unnecessary energy use. Energy management provides requirements for documentation, controlling, monitoring, optimisation, determination and to support corrective action and preventive action to improve the energy performance of buildings.

The BACS functions described in Table 1 are based on the energy demand and supply model for a building in Figure 1.

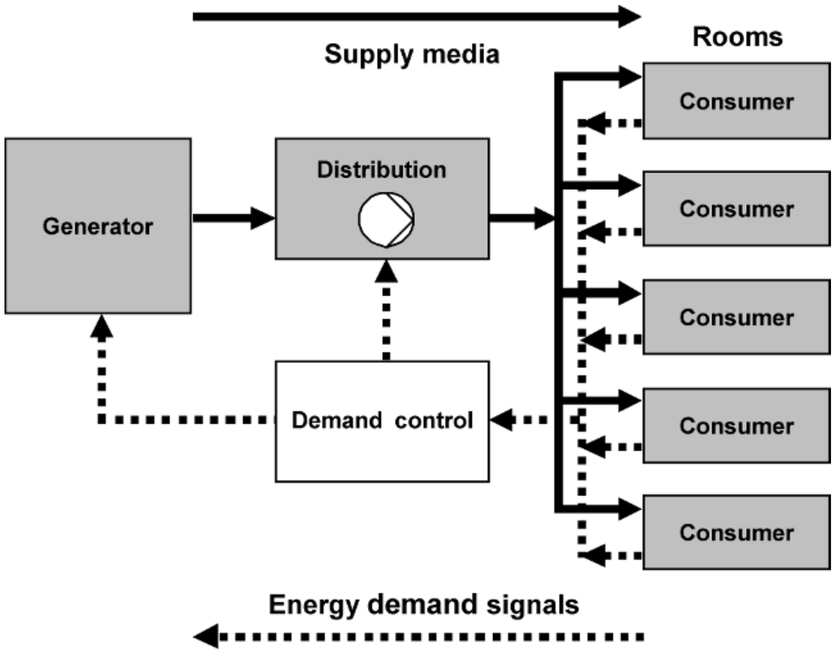


Figure 1 — Energy demand and supply model (Example: Heating plant)

Rooms represent the source of the energy demand. Suitable equipment should ensure comfortable conditions in the rooms with regard to temperature, humidity, air quality and light as needed and with due consideration of minimum or maximum requirements specified in local regulations..

Supply media is provided to the consumer according to energy demand keeping losses in distribution and generation to an absolute minimum.

The building automation and control functions described in Table 1 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 through generation.

5.2 BACS and TBM functions having an impact on the energy performance of buildings

The most common BACS and TBM functions having an impact on the energy performance of buildings have been described and summarized in Table 1.

Table 1 — BACS and TBM functions having an impact on the energy performance of buildings

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 of the room temperature
	1	Central automatic control: There is only central automatic control acting either on the distribution or on the generation. This can be achieved for example by an outside temperature controller conforming to EN 12098-1 or EN 12098-3
	2	Individual room control: By thermostatic valves or electronic controller
	3	Individual room control with communication: Between controllers and BACS (e.g. scheduler)
	4	Individual room control with communication and presence control: Between controllers and BACS; Demand / Presence control performed by occupancy
1.2	Emission control for TABS	
	0	No automatic control of the room temperature
	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.
	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 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 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.
	3	Advanced central automatic control with intermittent operation and/or room temperature feedback control: a) Advanced central automatic control with intermittent operation. This is an advanced central automatic control according to 2) with the following supplement: The pump is switched off regularly to save electrical energy, either with a fast frequency - typically 6 hours on/off cycle time - or with a slow frequency, corresponding to 24 hours on/off cycle time. If the TABS is used for cooling, intermittent operation with 24 hours on/off cycle time can also be used to reject the heat to the outside air if the outside air is cold. b) Advanced central automatic control with room temperature feedback control. This is an advanced central automatic control according to 2) with the following supplement: The supply water temperature set-point is corrected by the output of a room temperature feedback controller, to adapt the set-point to non-predictable day-to-day variation of the heat gain. Since TABS react slowly, only day-to-day room temperature correction is applied, an instant correction cannot be achieved with TABS. The room temperature that is fed back is the temperature of a reference room or another temperature representative for the zone. c) Advanced central automatic control with intermittent operation and room temperature feedback control
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: Action lower the mean flow temperature
	2	Demand based control: E.g. based on indoor temperature; Actions leads generally to a decrease of the flow rate
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: To reduce the auxiliary energy demand of the pumps
	2	Multi-Stage control: To reduce the auxiliary energy demand of the pumps
	3	Variable speed pump control: With constant or variable Δp and with demand evaluation to reduce the auxiliary energy demand of the pumps

Table 1 (*continued*)

1.5	Intermittent control of emission and/or distribution	
		One controller can control different rooms/zones having same occupancy patterns
	0	No automatic control
	1	Automatic control with fixed time program: To reduce the indoor temperature and the operation time
	2	Automatic control with optimum start/stop: To reduce the indoor temperature and the operation time
	3	Automatic control with demand evaluation: To reduce the indoor temperature and the operation time
1.6;	Different generator control for combustion and district heating	
		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: E.g. depending on supply water temperature
1.7	Generator control for heat pumps	
		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: E.g. depending on supply water temperature
1.8	Sequencing of different generators	
	0	Priorities only based on running time
	1	Priorities only based on loads
	2	Priorities based on loads and demand of the generator capacities
	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)

Table 1 (*continued*)

2	**DOMESTIC HOT WATER SUPPLY CONTROL**	
	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.*	
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, 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: Demand dependent on water usage (e.g. open/close tap)

Table 1 (*continued*)

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: Providing the room temperature
	1	Central automatic control: There is only central automatic control acting either on the distribution or on the generation. This can be achieved for example by an outside temperature controller conforming to EN 12098-1 or EN 12098-3
	2	Individual room control: By thermostatic valves or electronic controller
	3	Individual room control with communication: Between controllers and BACS (e.g. scheduler)
	4	Individual room control with communication and presence control: Between controllers and BACS; Demand / Presence control performed by occupancy
3.2	Emission control for TABS for cooling	
	0	No automatic control: Of the room temperature
	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.
	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.
	3	Advanced central automatic control with intermittent operation and/or room temperature feedback control: a) Advanced central automatic control with intermittent operation. This is an advanced central automatic control according to 2 with the following supplement: The pump is switched off regularly to save electrical energy, either with a fast frequency - typically 6 hours on/off cycle time - or with a slow frequency, corresponding to 24 hours on/off cycle time. If the TABS is used for cooling, intermittent operation with 24 hours on/off cycle time can also be used to reject the heat to the outside air if the outside air is cold. b) Advanced central automatic control with room temperature feedback control. This is an advanced central automatic control according to 2 with the following supplement: The supply water temperature set-point is corrected by the output of a room temperature feedback controller, to adapt the set-point to non-predictable day-to-day variation of the heat gain. Since TABS react slowly, only day-to-day room temperature correction is applied, an instant correction cannot be achieved with TABS. The room temperature that is fed back is the temperature of a reference room or another temperature representative for the zone. c) Advanced central automatic control with intermittent operation and room temperature feedback control
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: Action increase the mean flow temperature
	2	Demand based control: E.g. Indoor temperature; Actions generally lead to an increase of the flow rate

Table 1 (*continued*)

3.4	Control of distribution pumps networks	
		The controlled pumps can be installed at different levels in the network
	0	No automatic control
	1	On off control: To reduce the auxiliary energy demand of the pumps
	2	Multi-Stage control: To reduce the auxiliary energy demand of the pumps
	3	Variable speed pump control: With variable ∆p and with demand evaluation to reduce the auxiliary energy demand of the pumps
3.5	Intermittent control of emission and/or distribution	
		One controller can control different rooms/zones having same occupancy patterns
	0	No automatic control
	1	Automatic control with fixed time program: To raise the indoor temperature and to lower the operation time
	2	Automatic control with optimum start/stop: To raise the indoor temperature and to lower the operation time
	3	Automatic control with demand evaluation: To raise the indoor temperature and to lower the operation time
3.6	Interlock between heating and cooling control of emission and/or distribution	
		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
	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
	2	Total interlock: The control function enables to warranty that there will be no simultaneous heating and cooling.
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: This includes control according to room temperature
3.8	Sequencing of different generators	
	0	Priorities only based on running time
	1	Priorities only based on loads
	2	Priorities based on loads and demand: Depending on the generator capacities
	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)

Table 1 (*continued*)

4	**VENTILATION AND AIR CONDITIONING CONTROL**	
4.1	Air flow control at the room level	
	0	No automatic control: The system runs constantly (e.g. manual controlled switch)
	1	Time control: The system runs according to a given time schedule
	2	Presence control: The system runs dependent on the presence (light switch, infrared sensors etc.)
	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.
4.2	Air flow or pressure control at the air handler level	
	0	No automatic control: Continuously supplies of air flow for a maximum load of all rooms
	1	On off time control: Continuously supplies of air flow for a maximum load of all rooms during nominal occupancy time
	2	Multi-stage control: To reduce the auxiliary energy demand of the fan
	3	Automatic flow or pressure control: With or without pressure reset, with or without demand evaluation: Load depending supply of air flow for the demand off all connected rooms.
4.3	Heat recovery exhaust air side icing protection control	
	0	Without defrost control: There is no specific action during cold period
	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
4.4	Heat recovery control (prevention of overheating)	
	0	Without overheating control: There is no specific action during hot or mild periods;
	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
4.5	Free mechanical cooling	
	0	No automatic control
	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 realised by automatically opening windows there is no air flow control
	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
	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).
4.6	Supply air temperature control	
	0	No automatic control: No control loop enables to act on the supply air temperature;
	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
	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)
	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

Table 1 (*continued*)

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
	1	Dewpoint control: Supply air or room air humidity expresses the Dewpoint temperature and reheat of the supply air
	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
5	**LIGHTING CONTROL**	
5.1	Occupancy control	
	0	Manual on/off switch: The luminary is switched on and off with a manual switch in the room
	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
	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(s), 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(s) 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
5.2	Daylight control	
	0	Manual: There is no automatic control to take daylight into account
	1	Automatic: An automatic system takes daylight into account in relation to automatisms described in 5.1.
6	**BLIND CONTROL**	
	There are two different motivations for blind control: solar protection to avoid overheating and to avoid glaring	
	0	Manual operation: Mostly used only for manual shadowing, energy saving depends only on the user behaviour
	1	Motorized operation with manual control: Mostly used only for easiest manual (motor supported) shadowing, energy saving depends only on the user behaviour
	2	Motorized operation with automatic control: Automatic controlled dimming to reduce cooling energy
	3	Combined light/blind/HVAC control: To optimize energy use for HVAC, blind and lighting for occupied and non-occupied rooms

Table 1 (*concluded*)

7	**TECHNICAL HOME AND BUILDING MANAGEMENT**
	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 centralised 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 minimise 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
7.2	Reporting information regarding energy consumption, indoor conditions and possibilities for improvement

5.3 BACS Efficiency Class

Four different BACS efficiency classes (A, B, C, D) of functions are defined both for non-residential and residential buildings.

- Class D corresponds to non-energy efficient BACS. Building with such systems shall be retrofitted. New buildings shall not be built with such systems.
- Class C corresponds to standard BACS.
- Class B corresponds to advanced BACS and some specific TBM functions.
- Class A corresponds to high-energy performance BACS and TBM.

One is in class D: If the minimum functions to be in class C are not implemented.

To be in class C: Minimum functions defined in Table 3 shall be implemented.

To be in class B: Building automation function plus some specific functions defined in Table 1 shall be implemented in addition to class C. Room controllers shall be able to communicate with a building automation system.

To be in class A: Technical building management function plus some specific functions defined in Table 1 shall be implemented in addition to class B. Room controllers shall be able for demand controlled HVAC (e.g. adaptive set point based on sensing of occupancy, air quality, etc.) including additional integrated functions for multi-discipline interrelationships between HVAC and various building services (e.g. electricity, lighting, solar shading, etc.)

NOTE In addition, the hydraulic system should be properly balanced.

5.4 BACS and TBM functions assigned to the BACS efficiency classes

BACS and TBM functions described and summarised in 5.2, Table 1 are assigned to the BACS efficiency classes as defined in 5.3 depending on their use in residential or non-residential buildings. The Functions assignment to the BACS efficiency classes are listed in Table 2.

Table 1 and Table 2 should be applied in the following way by:

a) building owners, architects or engineers defining the building automation and controls (BACS) and technical building management (TBM) functions to be implemented for a given new building or for the renovation of an existing building:

   1) they can put an X in front of each of the functions they want to be implemented. They will use the shaded boxes as a help tool to determine in which class A, B, C, D the function they have specified is located. To achieve for example category B the X shall all be put in a shaded box for category B;

   2) it will be a simplified alternative – especially for specification at an early stage of a project – to specify only the classes of function A, B, C, D;

b) public authorities defining minimum requirements for BACS and TBM functions for new buildings as well as for renovations as defined in EN 15217:2005, D.3:

   1) they can define the minimum class to be achieved. Unless differently specified this class is C;

c) public authorities defining inspection procedures of technical systems as well as inspectors applying these procedures to check if the level of BACS and TBM functions implemented is appropriate:

   1) public authorities can request the use of the table to inspect the BACS in place;

   2) inspectors can put an X in front of each of the BACS functions which is implemented;

   3) they will then be able to determine the class A, B, C, D of functions already implemented. To be in a given class all the X shall correspond to shaded boxes for this class;

d) public authorities defining calculation methods which take into account the impact of BACS and TBM functions on the energy performance of buildings, as well as software developers implementing these calculation methods and designers using them:

   1) public authorities can request that the impact of the BACS and TBM functions defined in Table 1 is taken into account;

   2) software developers can develop software user interfaces enabling to input the list of BACS and TBM functions which are implemented according to Table 1. They can provide a simplified input mode based on the class of functions A, B, C, and D according to Table 2.

e) designers checking that the impact of all BACS and TBM functions is taken into account when assessing the energy performance of a building:

   1) designers will only have to input either the class of functions (A, B, C, D) or the detailed list of functions in the software enabling assessment of the energy performance of a building.

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 part 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, it is not required that it is strictly required everywhere in 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 outdoor 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 Table 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.

Table 2 — Function list and assignment to BACS efficiency classes

			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/zones having same occupancy patterns								
	0	No automatic control	■				■			
	1	Automatic control with fixed time program	■	■			■	■		
	2	Automatic control with optimum start/stop	■	■	■		■	■	■	
	3	Automatic control with demand evaluation	■	■	■	■	■	■	■	■
1.6	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 pumps									
	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 time	■				■			
	1	Priorities only based on loads	■	■			■	■		
	2	Priorities based on loads and demand	■	■	■		■	■	■	
	3	Priorities based on generator efficiency	■	■	■	■	■	■	■	■

Table 2 (*continued*)

			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								

Table 2 (*continued*)

			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 for cooling									
	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/zones having same occupancy patterns								
	0	No automatic control								
	1	Automatic control with fixed time program								
	2	Automatic control with optimum start/stop								
	3	Automatic control with demand evaluation								
3.6	Interlock between heating and cooling control of emission and/or distribution									
	0	No interlock								
	1	Partial interlock (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								

Table 2 (*continued*)

			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	■	■	■	■	■	■	■	■

Table 2 (*continued*)

			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								

5.5 Reference list of BACS functions

A reference list of BACS functions to reach is defined in Table 3. That table defines the minimum requirements of BACS and TBM functions according to BACS efficiency class C of Table 2.

Unless differently specified this list shall be used for the following:

— to specify the minimum functions to be implemented for a project;

— to define the BACS function to take into account for the calculation of energy consumption of a building when the BACS functions are not defined in detail.

— to calculate the energy use for the reference case in step 1 of the BACS efficiency factor method (first box in Figure 2 in Clause 6).

Unless differently specified by public authorities the minimum level of functions to be implemented corresponds to the functions defined in Table 3. Public authorities wishing to modify the reference list or minimum requirements respectively shall adapt this table for the reference class C.

Table 3 — Reference list of BACS functions for class C

			Residential	Non residential
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		
	1	Central automatic control		
1.2	Emission control for TABS			
	1	Central automatic 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		
	1	Outside temperature compensated control		
1.4	Control of distribution pumps in networks			
		The controlled pumps can be installed at different levels in the network		
	1	On off control		
1.5	Intermittent control of emission and/or distribution			
		One controller can control different rooms/zones having same occupancy patterns		
	1	Automatic control with fixed time program		
1.6	Generator control for combustion and district heating			
	1	Variable temperature control depending on outdoor temperature		
1.7	Generator control for heat pumps			
	1	Variable temperature control depending on outdoor temperature		
1.8	Sequencing of different generators			
	1	Priorities only based on loads		

Table 3 (*continued*)

			Residential	Non residential
2	**DOMESTIC HOT WATER SUPPLY CONTROL**			
2.1	Control of DHW storage temperature with integrated electric heating or electric heat pump			
	1	Automatic control on / off and charging time release		
2.2	Control of DHW storage temperature using heat generation			
	1	Automatic control on / off and charging time release		
2.3	Control of DHW storage temperature, varying seasonally: with heat generation or integrated electric heating			
	1	Automatic selected control with charging pump on / off or electric heating. With charging time release		
2.4	Control of DHW storage temperature with solar collector and heat generation			
	1	Automatic control of solar storage charge (Prio. 1) and supplementary storage charge		
2.5	Control of DHW circulation pump			
	Continuous operation, time switch program controlled or demand-oriented on / off			
	1	With time switch program		
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		
	1	Central automatic control		
3.2	Emission control for TABS			
	1	Central automatic 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		
	1	Outside temperature compensated control		
3.4	Control of distribution pumps in networks			
		The controlled pumps can be installed at different levels in the network		
	1	On off control		
3.5	Intermittent control of emission and/or distribution			
		One controller can control different rooms/zones having same occupancy patterns		
	1	Automatic control with fixed time program		
3.6	Interlock between heating and cooling control of emission and/or distribution			
	1	Partial interlock (dependant of the HVAC system)		
3.7	Different Generator control for cooling			
	The goal consists generally in minimising the generator operation temperature			
	1	Variable temperature control depending on outdoor temperature		
3.8	Sequencing of different generators			
	1	Priorities only based on loads		

Table 3 (*continued*)

			Residential	Non residential
4	**VENTILATION AND AIR CONDITIONING CONTROL**			
4.1	Air flow control at the room level			
	1	Time control		
4.2	Air flow or pressure control at the air handler level			
	1	On off time control		
4.3	Heat recovery exhaust air side icing protection control			
	1	With defrost control		
4.4	Heat recovery control (prevention of overheating)			
	1	With overheating control		
4.5	Free mechanical cooling			
	1	Night cooling		
4.6	Supply air Temperature control			
	1	Constant set point		
4.7	Humidity control			
	1	Dewpoint control		
5	**LIGHTING CONTROL**			
5.1	Occupancy control			
	0	Manual on/off switch		
	1	Manual on/off switch + additional sweeping extinction signal		
5.2	Daylight control			
	0	Manual		
6	**BLIND CONTROL**			
	1	Motorized operation with manual control		
	2	Motorized operation with automatic 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		

5.6 Applying BACS for EMS and maintaining BACS energy efficiency

5.6.1 GENERAL

Once a BACS is installed two main questions arise, in view of EN 15232:

1) How can a BACS support an Energy Management System (EMS) for the building part?

2) Which related activities have to be provided to maintain and to improve the impact of BACS/TBM on the energy efficiency in buildings and to upgrade its current system class?

5.6.2 Applying BACS for EMS

EMS as specified by EN 16001 is intended to improve energy performance by managing energy use systematically. EN 16001 sets the requirements for continual improvement of more efficient and sustainable energy use for production/process, transportation and buildings.

The use of BACS/TBM systems encourages different levels and functions of organization to implement an EMS in buildings and simplifies and significantly improves the continuous EMS process for buildings.

A good approach is described in Annexe E. This Annex explains in detail how to apply and use BACS/TBMS for an EMS for buildings.

Table E.1 outlines BACS/TBMS requirements, options and functions used to support implementation and processing of the different stages of EN 16001 concerning EMS in buildings.

Annexe E also shows that a dedicated skilled BACS/TBMS team has to be dedicated to the project.

5.6.3 Maintaining BACS energy efficiency

The experience from real projects show that an installed BACS will deviate dramatically from desired sustainable optimisation and expected energy efficiency over time due to lack of services.

The required BACS services on the project site to keep the functionality and the objectives of a System Class (D), C, B, A. have to be provided.

The actions required to upgrade from one system class to another and its related services, e.g. from D->C->B->A have to be specified.

Remark: An upgrade from one class to a higher system class could also be considered (e.g. from D to C, C to B, B to A, etc.).

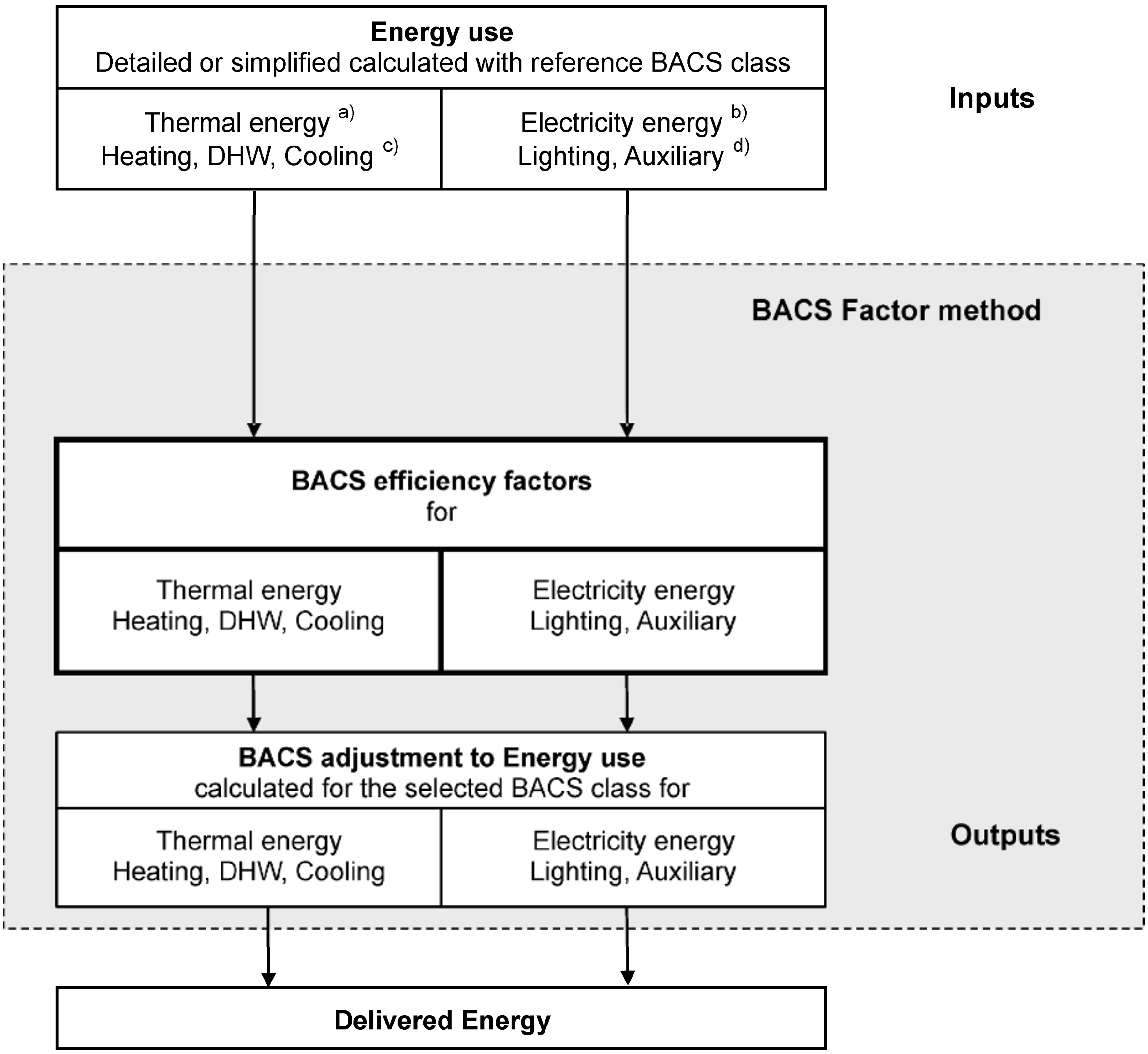
The required services for continuous improvement of the BACS impact concerning efficient and sustainable energy use in buildings are described in Annex F.

Annex F describes the minimum activities of a commissioned BACS to ensure the maintainability of its current system class on the one hand and the procedure how to upgrade to a higher class at the request of the customer on the other hand.

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

6.1 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 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
a) Thermal Energy = overall Energy use for Heating, DHW and cooling, ventilation
b) Electricity Energy = overall Energy use for auxiliary and lighting
c) Specific energy use for heating, DHW or Cooling
d) Specific energy use for auxiliary or lighting
1) Delivered energy is the total energy, expressed per energy carrier (gas, oil, electricity etc.)

Figure 2 — BACS Factor method

The BACS 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 (defined in Clause 5). 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.

6.2 Description of BACS Factor method

This method gives the opportunity to simply evaluate the impact of BACS and TBM functions on building energy performance by using BACS efficiency factors. The factors are related to the annual energy use of a building including:

- thermal and auxiliary energy input to the space heating system, calculated according to EN 15316;
- thermal and auxiliary energy input to the cooling system, calculated according to EN 15255;
- thermal energy input to the domestic hot water system, calculated according to EN 15316;
- electric energy input to the lighting system, calculated according to EN 15193;
- electric energy input to the ventilation system, calculated according to EN 15241.

In principle, it will be possible to calculate the energy use of the building using any dedicated calculation algorithm, e.g. EPBD standards within Europe (as mentioned above), ISO-standards outside Europe or any national or regional code available. Anyhow, the calculation procedure used to estimate the energy input data of the BACS factor method will account for the specific building, its specific use, and specific climatic conditions as well the building is located at. Thus, BACS factors are independent on any of these specifics, e.g. climatic parameters.

The BACS efficiency factors were obtained by performing transient pre-calculations for different building types as mentioned in EN 15217. Thereby each building type is characterized by a significant user profile of occupancy and internal heat gains due to people and equipment, respectively. The BACS efficiency classes A, B, C and D as defined in Clause 4 were represented by different levels of control accuracy and control quality. The impact of different climate conditions on the BACS factors was treated as neglectable since the main impact of climatic conditions is on the energy input data which again are derived from preparatory energy performance calculations. Further background information about these pre-calculations as well as boundary conditions is given in Annex B.

Finally, four sets of BACS efficiency factors $f_{BACS,h}$, $f_{BACS,c}$, $f_{BACS,DHW}$ and $f_{BACS,e}$ were extracted from the results of the energy performance calculations. They are available for the assessment of:

- Thermal energy for space heating and cooling ($f_{BACS,h}$ $f_{BACS,c}$ according to Tables 9 and 10) and
- Thermal energy for domestic hot water generation ($f_{BACS,DHW}$ according to Tables 11 and 12) and
- Electric energy for ventilation, lighting and auxiliary devices ($f_{BACS,el}$ according to Table 13).

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 Table 6.

Table 4 — Relations between building energy systems and BACS efficiency factors

— Energy use	—	— Energy need — 1)	—	— System losses 2)	— Auxiliary energy — 3)	— BACS factor	—
Heating	— =	— Q_{NH}	— +	— $Q_{H,loss}$	—	— $f_{BACS,h}$	—
		—	— +	—	— $W_{h,aux}$	— $f_{BACS,el}$	—
— Cooling	— =	— Q_{NC}	— +	— $Q_{C,loss}$	—	— $f_{BACS,c}$	—
		—	— +	—	— $W_{c,aux}$	— $f_{BACS,el}$	—
— Ventilation	— =	—	—	—	— $W_{V,aux}$	— $f_{BACS,el}$	—
— Lighting	— =	—	—	—	— W_{light}	— $f_{BACS,el}$	The impact of lighting control should be evaluated separately with EN 15193.
— DHW	— =	— Q_{DHW}	—	—	—	— $f_{BACS,DHW}$	

— 1) Energy need for heating and cooling should both be calculated with EN ISO 13790.

— 2) System losses of a heating system should be estimated by using the EN 15316 series for different process areas whereas losses of a cooling system should be estimated by using EN 15255.

— 3) The auxiliary energy required by the systems should be calculated by using EN 15316 series (heating systems), EN 15241 (ventilation systems) and EN 15193 (lighting systems) respectively.

The whole calculation sequence of the BACS efficiency factor method is depicted in Figure 3. As to be seen one of the BACS efficiency classes as described in Table 1 shall be defined as a reference case first. Normally class C which corresponds to a state-of-the-art building automation and control system is set as reference case. For this reference case, the annual energy use of the building energy systems shall be calculated either in a detailed or a more simplified matter using an appropriate calculation method. The BACS factors then allow to easily asses the energy performance of a building operating with a building automation and control system different to that system defined as the reference case. Since the relevant efficiency factors have to be set in relation against each other also building energy performance is in relation to a reference case.

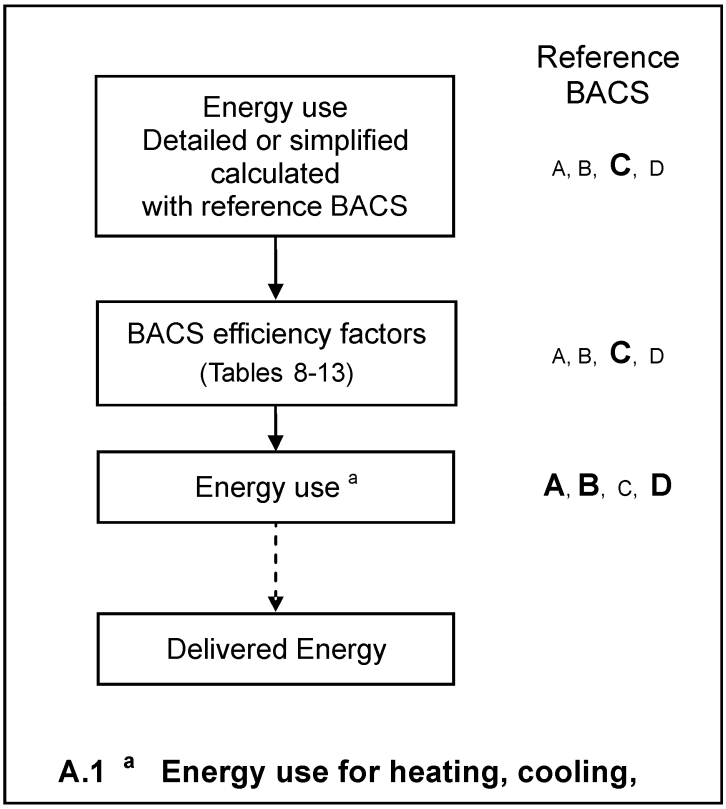


Figure 3 — Calculation sequence of BACS efficiency factor method

The BACS efficiency factors have to be used as illustrated in the following equations to calculate the BACS assessed energy inputs to the systems.

- Heating system

$$Q_{H,Tot,BAC} = \left(Q_{H,nd,B} + Q_{H,sys}\right) \times \frac{f_{BACS,h}}{f_{BACS,h,ref}} \tag{1}$$

$$W_{H,aux,BAC} = W_{H,aux} \times \frac{f_{BACS,el}}{f_{BACS,el,ref}} \tag{2}$$

- Cooling system

$$Q_{C,Tot,BAC} = \left(Q_{C,nd,B} + Q_{C,sys}\right) \times \frac{f_{BACS,c}}{f_{BACS,c,ref}} \tag{3}$$

$$W_{C,aux,BAC} = W_{C,aux} \times \frac{f_{BACS,el}}{f_{BACS,el,ref}} \tag{4}$$

- Ventilation system

$$W_{V,aux,BAC} = W_{V,aux} \times \frac{f_{BACS,el}}{f_{BACS,el,ref}} \tag{5}$$

– Lighting system

$$W_{L,BAC} = W_L \times \frac{f_{BACS,el}}{f_{BACS,el,ref}} \tag{6}$$

– DHW system

$$Q_{DHW,BAC} = Q_{DHW} \times \frac{f_{BACS,DHW}}{f_{BACS,DHW,ref}} \tag{7}$$

where

$Q_{H,Tot,BACS}$ is the total heating energy related to a BACS efficiency class;

$Q_{H,nd,B}$, $Q_{H,sys}$ are the heating energy needs of the building, energy losses of the heating system;

$Q_{C,Tot,BACS}$ is the total cooling energy related to a BACS efficiency class;

$Q_{C,nd,B}$, $Q_{C,sys}$ are the cooling energy needs of the building, energy losses of the cooling system;

$W_{H,aux,BACS}$, $W_{C,aux,BACS}$, are the electrical auxiliary energy for heating, cooling, ventilation

$W_{V,aux,BACS}$, $W_{L,BACS}$ and electrical energy for the lighting related to a BACS efficiency class;

$W_{H,aux}$, $W_{C,aux}$ are the electrical auxiliary energy for heating, cooling, ventilation

$W_{V,aux}$, W_L and electrical energy for the lighting;

$f_{BACS,h}$, $f_{BACS,c}$, $f_{BACS,el}$ are the BACs efficiency factors for thermal energy (heating and/or cooling) and for electric energy;

$f_{BACS,h,ref}$, $f_{BACS,c,ref}$, $f_{BACS,el,ref}$ are the BACs efficiency factors as before but for reference BACS.

6.3 Overall BACS efficiency factors for thermal energy $f_{BACS,th}$

The BACS efficiency factors in Table 5 and Table 6 for thermal energy (heating, DHW and cooling) are classified depending on the building type and the efficiency class the BACS/TBM system is related to. 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.

Table 5 — Overall BACS efficiency factors $f_{BACS,th}$– Non-residential buildings

Non-residential building types	**Overall BACS efficiency factors $f_{BACS,th}$**			
	D	**C (Reference)**	**B**	**A**
	Non energy efficient	**Standard**	Advanced	High energy performance
Offices	1,51	1	0,80	0,70
Lecture hall	1,24	1	0,75	0,5 [a]
Education 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 trade service buildings	1,56	1	0,73	0,6 [a]
Other types: - sport facilities - storage - industrial buildings - etc.		1		
[a] These values highly depend on heating / cooling demand for ventilation.				

Table 6 — Overall BACS efficiency factors $f_{BACS,th}$ – Residential buildings

Residential building types	**Overall BACS efficiency factors $f_{BACS\ th}$**			
	D	**C (Reference)**	**B**	**A**
	Non energy efficient	**Standard**	Advanced	High energy performance
Single family houses Apartment block Other residential buildings or similar residential buildings	1,10	1	0,88	0,81

6.4 Overall BACS efficiency factors for electric energy $f_{BACS,el}$

Electric energy in this context means lighting energy and electric energy required for auxiliary devices as defined in Table 4. The BACS efficiency factors in Table 7 and Table 8 for electric energy (i.e. lighting energy and electric energy required for auxiliary devices (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.

Table 7 — Overall BACS Efficiency factors $f_{BACS,el}$ – Non-residential buildings

Non-residential building types	**Overall BACS efficiency factors $f_{BACS,el}$**			
	D	**C (Reference)**	**B**	**A**
	Non energy efficient	**Standard**	Advanced	High energy performance
Offices	1,10	1	0,93	0,87
Lecture hall	1,06	1	0,94	0,89
Education 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 trade service buildings	1,08	1	0,95	0,91
Other types: - sport facilities - storage - industrial buildings - etc.		1		

Table 8 — Overall BACS efficiency factors $f_{BACS,el}$ – Residential buildings

Residential building types	**Overall BACS efficiency factors $f_{BACs,el}$**			
	D	**C (Reference)**	**B**	**A**
	Non energy efficient	**Standard**	Advanced	High energy performance
Single family houses Multi family houses Apartment block Other residential buildings or similar residential buildings	1,08	1	0,93	0,92

6.5 Detailed BACS efficiency factors for heating and cooling

Table 9 — Detailed BACS Efficiency factors $f_{BACS,H}$ and $f_{BACS,C}$ – Non-residential buildings

Non-residential building types	Detailed BACS efficiency factors $f_{BACS,H}$ and $f_{BACS,C}$							
	D		C (Reference)		B		A	
	Non energy efficient		**Standard**		Advanced		High energy performance	
	$f_{BACS,H}$	$f_{BACS,C}$	$f_{BACS,H}$	$f_{BACS,C}$	$f_{BACS,H}$	$f_{BACS,C}$	$f_{BACS,H}$	$f_{BACS,C}$
Offices	1,44	1,57	1	1	0,79	0,80	0,70	0,57
Lecture hall	1,22	1,32	1	1	0,73	0,94	0,3 [a]	0,64
Education 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 trade service buildings	1,56	1,59	1	1	0,71	0,85	0,46 [a]	0,55
Other types: - sport facilities - storage - industrial buildings - etc.			1	1				

[a] These values highly depend on heating / cooling demand for ventilation.

Table 10 — Detailed BACS efficiency factors $f_{BACS,H}$ and $f_{BACS,C}$ – Residential buildings

Residential building types	Detailed BACS efficiency factors $f_{BACS,H,C}$							
	D		C (Reference)		B		A	
	Non energy efficient		**Standard**		Advanced		High energy performance	
	$f_{BACS,H}$	$f_{BACS,C}$	$f_{BACS,H}$	$f_{BACS,C}$	$f_{BACS,H}$	$f_{BACS,C}$	$f_{BACS,H}$	$f_{BACS,C}$
Single family houses Apartment block Other residential buildings or similar residential buildings	1,09	-	1	-	0,88	-	0,81	-

6.6 Detailed BACS efficiency factors for DHW

The BACS efficiency factors for DHW systems are calculated based on the conditions described in B.4.

Detailed factors are accounting for the BACS impact on energy performance of DHW systems by covering DHW as a single functionality. The detailed factors for non-residential building types are available in (Table 11) or for residential building types in (Table 12).

Table 11 — Detailed BACS efficiency factors $f_{BACS,DHW}$ - Non-residential buildings

Non-residential building types	**Detailed BACS efficiency factors $f_{BACS, DHW}$**			
	D	**C (Reference)**	**B**	**A**
	Non energy efficient	**Standard**	Advanced	High energy performance
	$f_{BACS,DHW}$	$f_{BACS, DHW}$	$f_{BACS,DHW}$	$f_{BACS,DHW}$
Offices Lecture hall Education buildings (schools) Hospitals Hotels Restaurants Wholesale and retail trade service buildings Other types: – sport facilities – storage – industrial buildings – etc.	1,11	1,00	0,90	0,80

Table 12 — Detailed BACS efficiency factors $f_{BACS,DHW}$ – Residential buildings

Residential building types	**Detailed BACS efficiency factors $f_{BACS, DHW}$**			
	D	**C (Reference)**	**B**	**A**
	Non energy efficient	**Standard**	Advanced	High energy performance
	$f_{BACS,DHW}$	$f_{BACS\ DHW}$	$f_{BACS,DHW}$	$f_{BACS,DHW}$
Single family houses Apartment block Other residential buildings or similar residential buildings	1,11	1,00	0,90	0,80

6.7 Detailed BACS efficiency factors for lighting and auxiliary energy

Factors for non residential building types are available as detailed factors (Table 13) accounting for different BACS impacts on energy performance of electricity for lighting and auxiliary energy.

Table 13 — Detailed BACS Efficiency factors $f_{BACS,el-li}$ and $f_{BACS,el-au}$ – Non- residential buildings

Non-residential building types	Detailed BACS efficiency factors $f_{BACS, el-li}$ and $f_{BACS, el-au}$							
	D		C (Reference)		B		A	
	Non energy efficient		**Standard**		Advanced		High energy performance	
	$f_{BACS, el-li}$	$f_{BACS, el-au}$	$f_{BACS, el-li}$	$f_{BACS, el-au}$	$f_{BACS, el-li}$	$f_{BACS, el-au}$	$f_{BACS, el-li}$	$f_{BACS, el-au}$
Offices	1.1	1.15	1	1	0.85	0.86	0.72	0.72
Lecture hall	1.1	1.11	1	1	0.88	0.88	0.76	0.78
Education 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 trade service buildings	1.1	1.13	1	1	1	0.95	1	0.91
Other types: - sport facilities - storage - industrial buildings - etc.	-	-	1	1	-	-	-	-

6.8 Sample calculation with the BACS factor method

Table 14 gives an example on how to use the overall BACS efficiency factors for calculating impact of BACS/TBM on the total energy performance of an office building. The efficiency class C was chosen as reference BACS. The improvement of energy efficiency when changing to BACS efficiency class B will be calculated.

Table 14 — Example of using the overall BACS factors

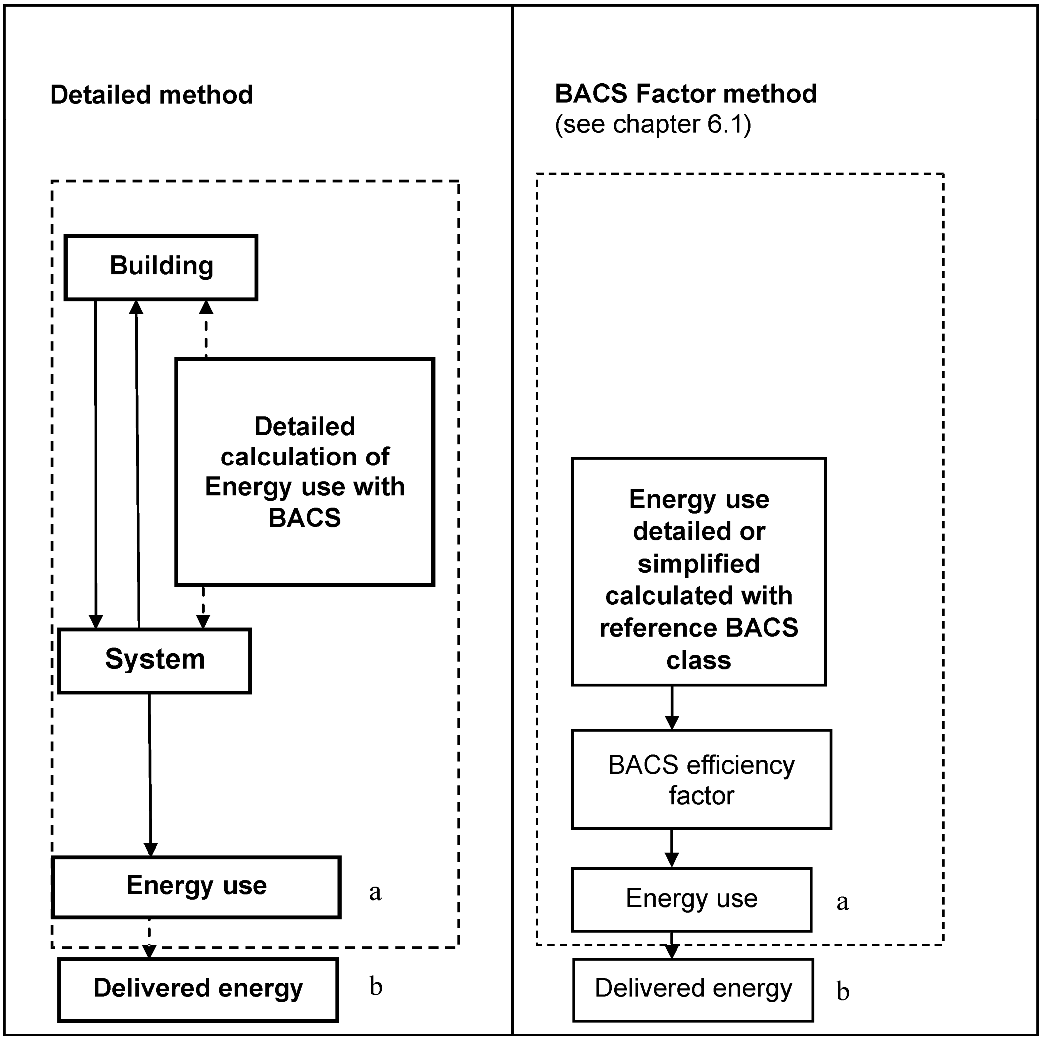
Description	No.	Calc.	Units	Heating	Cooling	Ventilation	Lighting
Energy need	1		kWh/ period	100	100		
System losses Reference Case	2		kWh/ period	33	28		
Thermal energy use Reference Case (Class C)	3	$\sum 1+2$	kWh/ period	133	128		
BACS factor $\mathbf{f_{BACS,th,ref}}$ Reference case (Class C)	4			1	1		
BACS factor $\mathbf{f_{BACS,th}}$ Actual case (Class B)	5			0,80	0,80		
Thermal Energy use Actual case (Class B)	6	$3\times\frac{5}{4}$	kWh/ period	106	102		
The thermal energy use needs to be split on to different energy carriers to finish the calculation process.							
Auxiliary energy	7a		kWh/ period	14	12	21	
Lighting energy	7b						34
BACS factor $\mathbf{f_{BACS,el, ref}}$ Reference case	8			1	1	1	1
BACS factor $\mathbf{f_{BAC,e}}$ Actual case	9			0,93	0,93	0,93	0,93
Auxiliary energy Actual case	10	$7\times\frac{9}{8}$	kWh/ period	13	11	20	32

Annex A
(normative)

Detailed calculation procedure of the BACS impact on the energy performance of buildings (Detailed method)

A.1 Introduction

The calculation of the impact of building automation, control and management functions on the building energy performance can also be done by a **detailed method**. The following Figure A.1 illustrates how to use the detailed method compared to the BACS Factor method.



Remark:

→) Arrows illustrate only the calculation process and do not represent energy and/or mass flows)

a) Energy use for heating, cooling, ventilation, domestic hot water or lighting

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

Figure A.1 — Detailed method in comparison with BACS Factor method

The detailed method should be used only when a sufficient knowledge about automation, control and management functions used for the building and the energy systems is available. The application of the detailed calculation procedure implies that all automation, control and management functions that have to be account for the operation of a building and its energy systems are known. Clause 7 gives a general survey of those functions and declares how to use them in the context of energy performance calculations.

This Annex A describes approaches to take into account the impact of BACS and TBM function in the assessment of energy performance indicators defined in EN 15217, EN 15603:2008 and connected standards.

It defines:

— in A.2 description of the main approaches used in these standards to take into account the impact of the BACS and TBM functions;

— In A.3 an overview of links between these standards and the BACS and TBM functions;

— In A.4 to A.10. a detailed description of the ways each BACS and TBM functions can be dealt with in connection with the relevant standards. Especially when the relevant standard does not describe explicitly how to deal with BACS and TBM function, this standard provides this explicit description.

A.2 General principles and main approaches of detailed calculation

A.2.1 General

The standards enabling to calculate the impact of BACS and TBM functions on energy consumption use different approaches to calculate this impact.

Five approaches are common to different standards:

— direct approach;

— operating mode approach;

— time approach;

— temperature approach;

— correction coefficient approach.

A.2.2 Direct approach

When the calculation of energy performance is performed using detailed simulation method or even hourly simulation method as described in EN ISO 13790:2008, it is possible to calculate directly the impact of a number of functions e.g. impact of intermittent heating, varying temperature between heating and cooling set points, movable solar shadings etc.

This approach is not relevant when monthly methods are used.

Even with detailed simulation method the direct approach can not be used when the impact of control leads to time variations which are quicker than the simulation time step.

In these cases the other approaches shall be used.

A.2.3 Operating mode approach

Automatic control enables to operate climate systems under different operating mode e.g. for ventilation system: occupied mode/unoccupied mode, for intermittent heating normal mode, no heating mode, set back mode, peak power mode.

The approach to calculate the impact of the automatic control on the energy consumption is to calculate the energy consumption sequentially for each operating mode. The total energy consumption is obtained by summing the energy consumption during each operating mode.

Each operating mode corresponds to a given state of the control system. The calculations are performed for each operating mode by considering the relevant state of the control system: e.g. fan on / fan off.

A.2.4 Time approach

— This approach can be used when the control system has a direct impact on the operating time of a device (e.g. control of a fan, a luminary).

— The energy consumption for a certain time period is given by Equation (A.1) which has the following shape:

$$E = P.t.F_c \tag{A.1}$$

where

E is the energy consumption for the time period;

P is the input power of the controlled system;

t is the duration of the time period;

F_c is a characteristic coefficient which represents the impact of the control system. It is the ratio between the time where the control switches the system on and the duration of the time period.

— By extension the time approach can be used if the control system modulates the operation of the system instead of switching it on and off. F_c represents in this case an equivalent operating time ratio.

A.2.5 Room temperature approach

— This approach can be used when the control system has a direct impact on the room temperature.

— It consists of taking into account in the calculation of the energy needs according to EN ISO 13790:2008 a corrected room temperature which takes into account the impact of the control system.

— The following impacts shall be taken into account:

  — emission control of heating and cooling;

  — intermittent control of emission and or distribution;

  — optimizing the operation by the tuning of the different controllers;

  — detecting faults of building and technical systems and providing support to the diagnosis of these faults;

  — the impact of the room controller;

— the impact of the intermittent heating controller;

— The calculation of the energy used is performed by Equation (A.2) which has the following shape:

$$E = L.\left(\left(\theta_{sp} + \Delta\theta_{c}\right) - \theta_{r}\right).t \qquad \text{(A.2)}$$

where

E is the energy demand or consumption of the time period;

L is a transfer coefficient;

θ_{sp} is the set point which shall be maintained by the control system;

$\Delta\theta_{c}$ represents the impact of the actual control system, it will be equal to 0 if the control system was perfect, and will be positive in case of heating and negative in case of cooling;

θ_{r} is a reference temperature e.g. the outdoor temperature;

t is the duration of the time period.

In this approach:

θ_{sp} depends on the control system type used. It can be constant or variable;

$\Delta\theta_{c}$ is a characteristic of the quality of the control system itself and of the controlled system. It can be defined by a product standard or a product certification provided this standard takes into account not only the controller but also the controlled system;

L enables the influence of the plant or of the building controlled to be taken into account;

θ_{r} enables the boundary conditions to be taken into account, such as for example the climate;

$\theta_{sp} + \Delta\theta_{c}$ is called the equivalent temperature set point.

A.2.6 Correction coefficient approach

This approach is used when the control system has a more complex impact such as for example a combined effect on time, temperature etc.

— The calculation of the energy demand or consumption is performed by Equation (A.3) which has the following shape:

$$E = E_{pc}.x_{c} \qquad \text{(A.3)}$$

where

E is the energy demand or consumption;

E_{pc} is the energy consumption in the reference case, e.g. if the system is controlled ideally, or if a BACS or TBM function is not present, or if the system is assumed to be controlled such that it is simple to calculate the energy performance;

x_{c} is the correction coefficient which represents the increase or decrease of energy consumption as compared to the energy consumption E_{pc} of the reference case.

The values of x_c depend on the control type but vary also with the climate, building type etc. Tables or formulae should be provided for example in national annexes to determine the impact of these parameters on x_c.

A.2.7 Equivalence between the different approaches

— The parameters of the operating mode approach, times approach (F_c) and of the temperature approach ($\Delta\theta_c$) can generally be determined from the description of the control system and of the user profile.

— The parameter of the correction coefficient approach x_c shall be determined by prior simulations. These simulations enable to define the tables or formulas giving the value of x_c in function of relevant parameters: building type, system type, user profile, climate etc.

A.3 Approach to take into account the different function in the calculation procedure

The control functions defined in Table A.1 shall be taken into account when applying the standards defined in Table 3.

Table A.1 — Overview

Function	Standard
Automatic control	
HEATING , COOLING CONTROL, DOMESTIC HOT WATER	
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 or pressure 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

A.4 Heating and cooling control

A.4.1 Emission control

One shall differentiate at least the types of room temperature control described in Table 1, 1.1 and 3.1

The impact of the control system type is taken into account by considering an equivalent internal temperature set point.

$$\theta_{ei} = \theta + \delta\theta \tag{A.6}$$

where

θ_{ei} is the equivalent internal temperature which takes into account control inaccuracies;

θ is the set point temperature of the conditioned zone;

$\delta\theta$ is the control accuracy which depends on the control and controlled systems.

The set point is increased by $\delta\theta$ for heating and decreased by $\delta\theta$ for cooling. $\delta\theta$ depends on the control system and on the emitter type.

This approach is described in:

— EN 15316-2-1:2007, 7.3 for heating systems;

— EN 15243:2007, 14.3.2 for air conditioning systems;

— EN ISO 13790:2008.

For electronic controllers $\delta\theta$ is equal to the "control accuracy" determined according to EN 15500:2008.

Values of the control accuracy are given in Table G1 of Annex G – Control Accuracy.

A.4.2 Emission control for TABS

One shall differentiate at least the types of room temperature control described in Table 1, 1.2 and 3.2:

The impact of the control system for heating and cooling is taken into account by simulation.

A.4.3 Control of distribution network water temperature

One shall differentiate at least the types of supply temperature control described in Table 1 1.3 and 3.3:

Two effects shall be taken into account when assessing the impact of the supply (and/or return) temperature control:

— The presence of an automatic control that lowered the mean flow temperature. This leads to a decrease of distribution losses. These losses shall be calculated according to EN 15316-2-3:2007, subclause 7.2.2, the temperature being calculated according to Clause 8.

— If there is no automatic control of the supply and/or return temperature the room controller actions leads generally to a decrease of the flow rate. This enables to reduce the auxiliary energy consumption. This shall be calculated according to EN 15316-2-3:2007, 6.3.2 through the correction coefficient for supply flow temperature control f_S defined in EN 15316-2-3:2007, 6.3.3.2.

NOTE This flow temperature control correction coefficient shows that the flow and the auxiliary energy consumption are lower if there is no temperature control. Indeed a reduction of the supply and/or return temperature in the heating case or an increase of it in the cooling case reduces the temperature difference between the supply and the return temperature, which requires a higher mass flow in order to supply the same flow of heat and/or cold (which is proportional to the product of the temperature difference and the mass flow) to the emitters.

A.4.4 Control of distribution pumps in networks

One shall differentiate at least the types of pump control described in Table 1, 1.4 and 3.4:

— The impact of pump control on auxiliary energy demand is taken into account according to EN 15316-2-3:2007, 6.3.4.1 through the correction coefficient for control f_R.

A.4.5 Intermittent control of emission and/or distribution

One shall differentiate at least the following types of intermittent control of emission and/or distribution:

0) no automatic control;

1) automatic intermittent control without optimum start in conformity with EN 12098-1 or EN 12098-3 or EN 12098-5 or EN ISO 16484-3;

2) automatic intermittent control with optimum starts in conformity with EN 12098-2 or EN 12098-4.

The impact of intermittent control of emission and/or distribution is split in two aspects:

— an impact on the energy needs of the building due to indoor temperature reduction;

— an impact on the energy use of the HVAC system due to lower operating times;

— impact on the energy needs of the building.

The impact of the intermittent occupation is calculated according to EN ISO 13790:2008. This approach takes into account the fraction of the number of hours in the week with a normal heating or cooling set point (e.g. 5 × 14/7/24), this fraction is defined by the coefficient $f_{H,hr}$ for heating and $f_{C,hr}$ for cooling.

The approach described in this standard does not differentiate the different types of controls.

In order to differentiate the different types of control the following procedure shall be applied:

In the Equations (48) and (49) of EN ISO 13790:2008 replace:

— $f_{N,H}$ by $f_{N,H,C} = f_{N,H} \cdot X$

— $f_{N,C}$ by $f_{N,C,C} = f_{N,C} \cdot X$

where X is given in the following Table A.2:

Table A.2 — Factor X

	X
No automatic control	0,5
Automatic intermittent control without optimum start	0,8
Automatic intermittent control with optimum start	1

— Impact on the energy use of the HVAC system.

The impact of the control system on the operating time of the HVAC system is calculated according to a reduction of the auxiliary energy demand for heat distribution calculated according to EN 15316-2-3:2007, 6.3.5.

One can in addition consider the impact of an optimum stop function. Nevertheless, no standard already enables to assess this impact.

A.4.6 Interlock between heating and cooling control of emission and/or distribution

For air conditioned buildings the function described in Table 1, 3.6 is one of the most important regarding energy savings.

The possibility to provide at the same time heating and cooling in the same room depends on the system principle and on 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. One shall differentiate at least:

0) no interlock

1) partial interlock

2) total interlock

A total interlock can be achieved in different ways:

— by the system principle which avoids any risk, for example;

— heating and cooling are generated by a reversible heat pump which can not provide heating and cooling at the same time;

— a single distribution network provides either heat or cool (e.g. 2 pipes fan coils with change over);

— by a single controller acting in sequence on heating and cooling. This is applicable to systems where heating and cooling can both be totally controlled at the room level, for example 4 pipes fan coils;

— system including a control of heating (respectively cooling) at the building level and a control of cooling (respectively heating) at the room level raised specific problems regarding interlock of heating and cooling. They include for example system composed of:

  — a central ventilation system serving different rooms with a preheating coil in the central air handling unit, and a central control of the supply air temperature;

- a cooling (or heating and cooling) device in each room with its local control.

In such systems one can reach the three levels of interlock:

- no interlock: the supply air temperature set point is fixed to a constant value;
- partial interlock: the supply air temperature set point varies with the outdoor temperature;
- total interlock: the supply air temperature set point is automatically reset depending on the cooling request in the different zones (this requests and integrated control system).
- Example of methods to calculate this impact through a correction factor approach is given in EN 15243:2007, E.1.2.4.

A.4.7 Generation control

The generation control depends on the generator type. Nevertheless, the goal consists generally in minimising the generator operating temperature. This enables limiting the thermal losses. For thermodynamic generators this also enables increasing the thermodynamic efficiency.

Three main types of temperature control are described in Table 1, 1.6; 1.7 and 3.7:

Details regarding specific systems are given in the following standards:

- combustion systems: EN 15316-4-1:2008;
- heat pump systems: EN 15316-4-2:2008;
- solar heating systems: EN 15316-4-3:2007;
- quality district heating systems: EN 15316-4-5:2007;
- other renewable systems: EN 15316-4-6:2007;
- biomass generation system: EN 15316-4-7:2009.

A.4.8 Sequencing of different generators

A.4.8.1 General

If different generators are available one can differentiate at least the types of sequence control described in Table 1, 1.8 and 3.8:

This is calculated according to EN 15316-4-1:2008, 5.3.3.

A.4.8.2 Boilers

The impact of the control system is calculated according to EN 15316-4-1:2008.

This standard includes three calculation methods: typology, case specific boiler efficiency method, boiler cycling method.

The “case specific boiler efficiency method” describes explicitly how to asses the impact of the control system.

This is dealt with in 5.3.9 running temperature of the generator and Annex H.

A.4.8.3 Biomass generation system

The impact of the generator control system is calculated according to EN 15316-1:2007, 7.3.4.1.

The method is similar to the "directive method" described in EN 15316-4-1:2008.

The generator operating temperature shall be calculated in the same way as in EN 15316-4-1:2008, 5.3.9, running temperature of the generator.

A.4.8.4 Quality district heating systems

The impact of the generator control system is calculated according to EN 15316-4-3:2008.

The losses are calculated in 6.3.5 "Thermal Loss". The loss depends on the mean temperature of the dwelling station.

This temperature depends on the mean water temperature of the secondary circuit of the dwelling station which shall be calculated in the same way as in EN 15316-4-1:2008, 5.3.9, running temperature of the generator.

A.4.8.5 Heat pump systems

The impact of the control system is calculated according to EN 15316-4-2:2010.

This standard includes 2 calculation methods: a simplified method based on system typology and a detailed case specific method.

The simplified methodology when existing is the subject of a national annex. It is developed by applying the detailed case specific method to cases representative of a national typology. The way to deal with control in this simplified methodology does then depend on the national annex.

The application of the detailed specific method takes into account the controller setting of the heat emission system. One shall at minimum differentiate the following control types of the distribution:

0) constant temperature control;

1) variable temperature depending of the outdoor temperature;

2) variable temperature depending on the load (this includes control according to room temperature).

From the type of control used, one can define the operating temperature in the calculation procedure.

A.4.8.6 Back up heater

The operation of back up heaters depends on the following values of outdoor temperature:

— a cut off temperature θ_{ltc}: below this temperature the heat pump is switched off and the back up operates alone;

— a balance temperature θ_{bp}: below this temperature the back up is started. This temperature is in all cases equal or higher than the cut off temperature.

The following mode shall be taken into account:

— alternate mode: the cut off temperature and the balance point are equal. At this temperature the heat pump is stopped and the back up operates alone;

— parallel mode: there is no cut off temperature. Below the balance temperature the back up is started and operates in parallel with the heat pump which operates at its full power;

— partly parallel mode: Above the balance temperature the heat pump operates alone. Between balance and cut off temperature, back up is and heat pump operates in parallel with the heat pump at its full power. Below the cut off temperature the back up operates alone.

A.4.8.7 Solar heating systems

The calculation method defined in EN 15316-4-3:2007, does not distinguish between different types of control systems in its normative part.

A.4.8.8 Cogeneration systems

The calculation method defined in EN 15316-4-3:2007, does not differentiate different types of control systems.

A.5 Domestic hot water control

Their full functions are explained in the Table 1, 2.1 – 2.5.

Any determined DHW storage temperature function of 2.1 - 2.4 may be additionally combined with a DHW circulation pump. Therefore, the function 2.5 will become relevant together with the determined function.

The calculation method defined in EN 15316-3-2:2007, for DHW distribution and EN 15316-3-3:2007, for DHW generation does not distinguish between different types of control systems in its normative part.

A.6 Ventilation control

A.6.1 Air flow control at the room level

One shall at least differentiate the types of local (room or zone) flow control described in Table 1, 4.1.

The type of control to use shall be specified according to EN 13779:2007.

The impact of the control type is calculated according to EN 15242:2007, 6.2.3 and 6.2.5. This impact is calculated by multiplying the air flow by two characteristic coefficient called C_{use} and C_{cont} in EN 15242.

The coefficient value depends on:

— the control type;

— the use profile of the building.

A.6.2 Air flow or pressure control at the air handler level

One shall differentiate at least the types of control described in Table 1, 4.2:

The impact of the control type is calculated according to EN 15242:2007, 6.2.3 through the C_{use} coefficient. This represents the fraction of time where the fan is on.

The impact of an automatic flow control on the energy consumption is highly dependant on the actuator used to modulate the flow (dampers, blade angles for axial fan, speed control). It is calculated according to EN 15241:2007, 6.3.4 through the C_{cont} coefficient. Nevertheless the impact of automatic air flow control with pressure reset is not dealt with in this European Standard.

A.6.3 Heat recovery plant control

The impact of the control system of a heat exchanger for heat recovery is calculated according to EN 15241:2007, 6.3.4.

When applying this standard one shall differentiate the following cases:

A.6.3.1 Heat recovery exhaust air side icing protection control (Defrosting)

One shall differentiate at least the types of control described in Table 1, 4.3:

The impact of defrosting control is considered in EN 15241:2007, 6.3.5.3.

A.6.3.2 Heat recovery control (Prevention of overheating)

One shall at least differentiate the types of hear recovery control described in Table 1, 4.4:

The impact to prevent air heating in a cooling period is considered in EN 15241:2007, 6.3.5.4.

A.6.4 Free mechanical cooling

This control function enables to use the cooler outdoor to cool down the buildings internal fabric and inside air.

One shall at least differentiate the types of free cooling described in Table 1, 4.5:

Night cooling is defined in EN ISO 16484-3:2005, 5.5.3.5.8. Its impact can be calculated according to EN 13790:2008, 5.2.

h,x- directed control is defined in EN ISO 16484-3:2005, 5.5.3.5.2.

The impact of the function shall be calculated by determining for each calculation period an equivalent air flow rate.

A.6.5 Supply air temperature control

If the air system serves only one room and is controlled according to indoor temperature of this room one shall use A.4 even if the control acts on the supply temperature.

In the other cases one shall differentiate at least the types of control described in Table 1, 4.6:

This temperature control shall be considered with a particular attention if the system principle does not prevent simultaneous heating and cooling. See A.4.6.

The impact of this supply temperature control shall be calculated according to EN 15241:2007, 6.3.7 and 6.3.8. To apply this standard it is necessary to define precisely the set point of the supply temperature: $T_{s,\ sp}$.

A.6.6 Air humidity

A.6.6.1 General

The control of the air humidity may include humidification and / or dehumidification. Controllers may be applied as “**humidity limitation control**” or “**constant humidity control**”.

“Humidity limitation control” keeps the air humidity in a large neutral zone. A control loop enables to avoid the supply air humidity to go over or below threshold values. It is used to assure the comfort for the room users or as a building protection to prevent the grow of damp inside the building envelope.

"Constant humidity control" keeps the air humidity in a small neutral zone. A control loop enables to keep the supply air humidity at a constant value. It is used e.g. in a manufacturing process room.

In general the required energy for humidity limitation control is much lower than for a constant humidity control.

NOTE As larger the neutral zone (h_{Max} - h_{Min}), as smaller the required energy to control the air humidity.

A.6.6.2 Humidity control

One shall at least differentiate at the following types of control described in Table 1, 4.6:

— The impact of the humidity control shall be calculated according to EN 15241:2007, 6.3.9.

A.7 Lighting control

One shall differentiate at least the types of control

a) occupancy control described in Table 1, 5.1;

b) daylight control described in Table 1, 5.2.

The impact of the control system can be performed according to EN 15193:2007. It is calculated by a time approach according to A.2.4. The time during which the light is on is obtained by multiplying the occupation time of the building by reduction coefficient according to Equations (7) and (8) of EN 15193:2007.

The coefficient F_D takes into account the impact of daylight. The coefficient F_O takes into account the impact of occupation.

The impact of daylight control is determined according to Annex C of EN 15193:2007.

The coefficient dealing with daylight control $F_{D,C,n}$ is given in Table C.9 of EN 15193:2007. Its values depend on:

— the control type manual /automatic;

— the level of daylight penetration in the building: weak/medium/strong.

This coefficient is combined with a second coefficient dealing with daylight supply to obtain the F_D the approach is described.

The impact of occupancy control is determined according to Annex D of EN 15316-1:2007.

First the coefficient F_{oc} which depends only on the control type is read in Table D.1 of EN 15316-1:2007.

This coefficient is then combined with the proportion of the time that the space is unoccupied to obtain F_o.

A.8 Blind control

There are two different motivations for blind control: solar protection to avoid overheating and to avoid glaring. One shall differentiate at least the control types described in Table 1, 6:

The impact of blind control on solar gains shall be taken into account according to EN ISO 13790:2008, 11.4.3 movable shading provisions.

The impact of blind control on thermal losses during night shall be taken into account according to EN ISO 13790:2008, 8.3.2 (effect of nocturnal insulation).

A.9 Home and building automation system

One shall differentiate at least the types of home and building automation system described in Table 1, 7 which include specific functions in addition to standard control functions.

The impact of specific functions of the energy efficiency of home and buildings shall be calculated by simulation.

A.10 Technical home and building management functions

A.10.1 General

These functions are especially useful to achieve the following requirements of the energy performance in buildings directive (EPBD 2009/01/EC):

— Article 7: Establishing an energy performance certificate;

— Article 8: Boiler inspection;

— Article 9: Air conditioning system inspection.

These functions are dealt with in the following standards:

— EN 15217, *Energy performance of buildings — Methods for expressing energy performance and for energy certification of buildings;*

— EN 15603:2008, *Energy performance of buildings — Overall energy use and definition of energy ratings;*

— EN 15378:2007, *Energy performance of buildings — Inspection of boilers and heating systems;*

— EN 15239, *Ventilation for buildings — Energy performance of buildings — Guidelines for inspection of ventilation systems;*

— EN 15240, *Ventilation for buildings — Energy performance of buildings — Guidelines for inspection of air-conditioning systems.*

A.10.2 Monitoring

Detecting faults of building and technical systems and providing support to the diagnosis 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, schools.

   The monitoring function shall include at the minimum a graph or an indicator highlighting the time where: Fans are on, cooling system is running, heating system is in normal mode, lighting is on.

b) Improper set points

Specific monitoring functions shall be set up to enable to detect quickly improper set points of room temperature.

The monitoring function shall include a graph or an indicator enabling to have a global view of the different set points of room temperature 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 having different energy performances are used to do the same function (e.g. heat pump and back up, solar system and back up) a monitoring function shall be set to verify that the systems having the best energy performances are used before the others.

A.10.3 Reporting

Information regarding energy consumption, indoor conditions and possibilities for improvement.

Report shall be set to report information regarding energy consumption and indoor conditions.

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.

Using the on line monitoring function enables to obtain a rating fully in conformity with 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 is installed the measurements can be done 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. The measurement of outdoor temperature enables to perform the correction for outdoor climate 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 improvement of building and energy systems

This assessment can be done according to EN 15603:2008 by using a validated building calculation model as defined in Clause 9.

Using the monitoring functions enables to take into account the actual values regarding climatic data, internal temperature, internal gains, hot water use, lighting use, 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 defined in EN 15603:2008, Annex H;

e) room temperature and indoor air quality monitoring

Monitoring function can be used to provide report regarding air or room operative temperature in the rooms as well as indoor air quality. For buildings which are not permanently occupied these functions shall differentiate occupied and non occupied buildings. For buildings which are heated and cooled the report shall differentiate cooling and heating periods.

The reports shall include the actual value as well as reference values such as set points for example.

A.10.4 Technical building management

Assessing the impact of home and building automation system and technical building management functions

The impact of functions described in 7.8 and 7.9 shall be performed in the following way:

- collect reference data regarding set points for heating and cooling and operating time;
- correct the reference data to take into account the difference between a building with BACS system and TBM functions and building without it according to Table A 3;
- calculate the energy consumption using the detailed method.

Table A.3 — Input data

	Without BACS and TBM functions **Class C**	**With BACS functions** **Class B**	**With BACS and TBM functions** **Class A**
Set point for heating	Add 1 K	Add 0,5 K	No correction
Set point for cooling	Subtract 1K	Subtract 0,5 K	No correction
Operating time	add 2 hours per day	add 1 hour per day	No correction

Annex B
(informative)

Determination of the BACS efficiency factors

B.1 Determination procedure

BACS efficiency factors were calculated based on the results delivered from a large set of simulation runs. These simulations have been conducted with the building energy simulation tool TRNSYS. The impact of different BACS and TBM functions on the energy performance of buildings was found by comparing the annual energy consumptions of a standardized room (EPBD 2006) for different BACS and TBM functionalities representing the BACS efficiency classes as defined in Clause 5.3. The functionalities were represented by:

- time of operation for the heating and/or cooling system;
- definition of temperature set points for heating/cooling (energy dead band). Temperature set points are defined in dependence on the BACS efficiency class as described in Table 6 to account for different control accuracies;
- definition of outside airflow characteristic (constant / variable).

The room used as a reference for these calculations can be described by the following properties:

- dimensions: 5 m × 4 m × 3 m;
- floor space: 20 m²;
- exterior wall: 15 m² (including windows of 8 m²);
  orientation: west
- U-Values: 0,34 W/m²/K (exterior wall);
  0,65 W/m²/K (internal wall);
  0,4 W/m²/K (floor / ceiling);
  1,4 W/m²/K (window, SHGC=0,58);
- thermal mass: medium C=50 Wh/(m²K).

Room temperatures in adjacent zones have been treated as identical so that there is an adiabatic boundary condition for internal walls.

Different user profiles have been applied to cover the most common building types as mentioned in EN 15217. The modelling approaches regarding user profiles as well as functionality of BACS efficiency classes are described in detail in 5.2.

Simulations have been performed for average weather conditions represented by TRY04 (reference station Würzburg, Germany,(Deutscher Wetterdienst DWD, Offenbach, www.dwd.de/Klima).

Space heating, cooling and air conditioning devices have been modelled as follows:

- Heating: operating hours and temperature set points as declared in Tables A.1 to A.7
- Cooling: operating hours and temperature set points as declared in Tables B.1 to B.7

— Air conditioning: operating hours and temperature set points as declared in Tables B.1 to B.7

The operating hours and set points are determining the energy need. The expenditure energy for the a discrete system is nearly independent from the absolute value of the energy need so that it is only necessary to calculate the factors depending on the different energy needs. Heat recovery systems are taking into account by calculating the energy need also.

The auxiliary energy is depending in most cases from the flow in pumps or fans while the energy for control systems is nearly constant. The auxiliary energy is therefore given by the relation between design flow and actual flow (i.e. demand oriented ventilation). Note that the auxiliary energy is the cube of this relation.

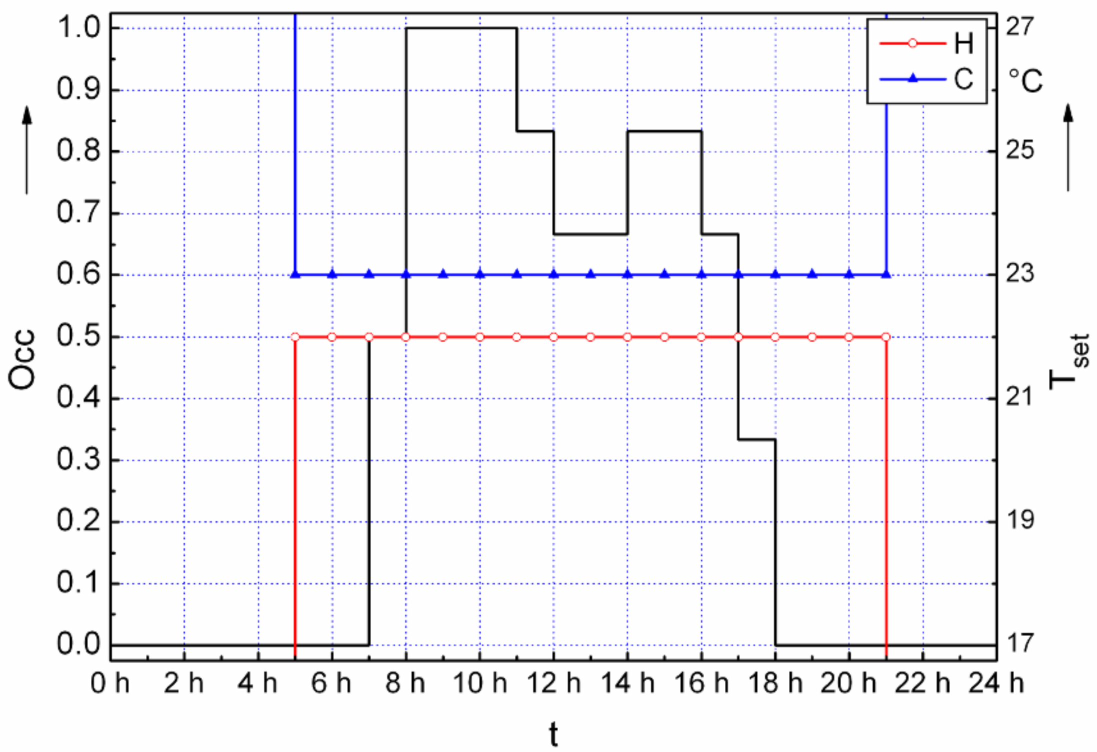
All calculations (simulations) are made with a single node room temperature model.

Energy required for artificial lighting was not taken into account when BACS efficiency factors were determined because the impact of lighting control is evaluated separately within EN 15193 this effect is not taken into account when BACS efficiency factors were determined for artificial lighting.

B.2 Detailed modelling approaches and user profiles

BACS efficiency class C was defined as a reference. That is why its boundary conditions are described first to clarify the differences to classes D, B, and A, respectively. The following figures exemplify the user profile of an office building. The user profiles of other buildings are described in B.3.

Efficiency class C (reference)



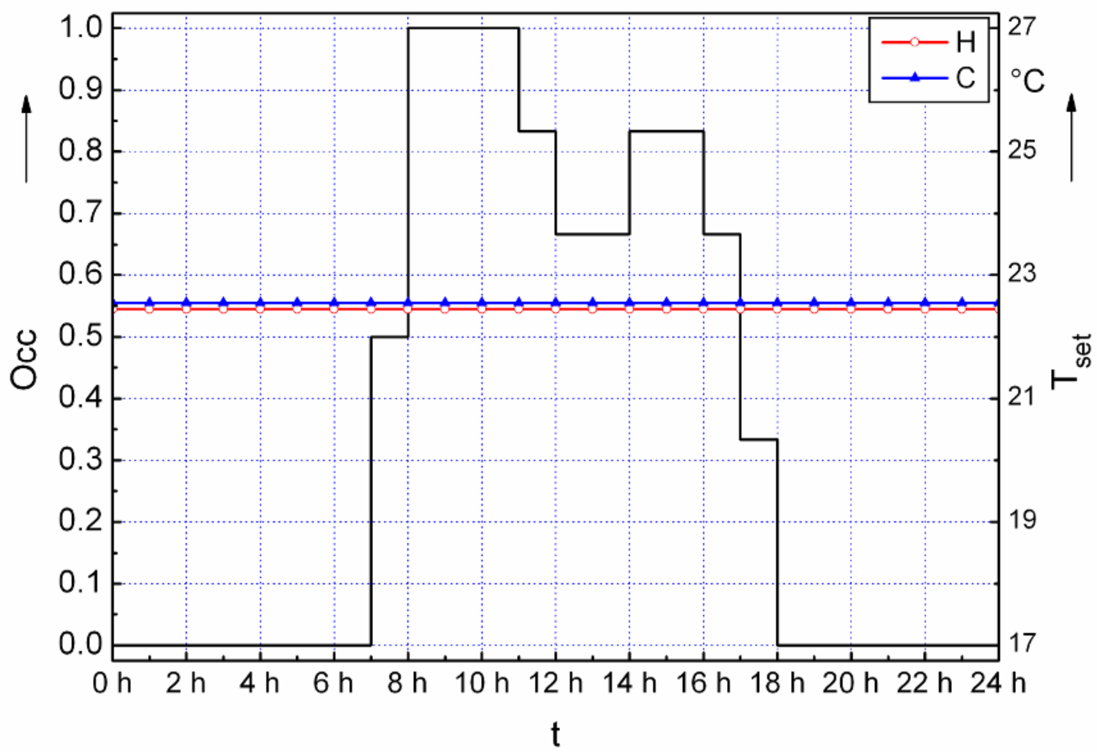
Key

Occ = standardised level of occupancy   t = time T_{set} = temperature set point

Figure B.1 — User profiles, temperatures and operation times for BACS efficiency class C; office

There is a small difference of about 1 K between heating and cooling temperature set point. The operation of the HVAC system starts two hours before occupancy and finishes three hours after occupied period is ended.

Efficiency class D



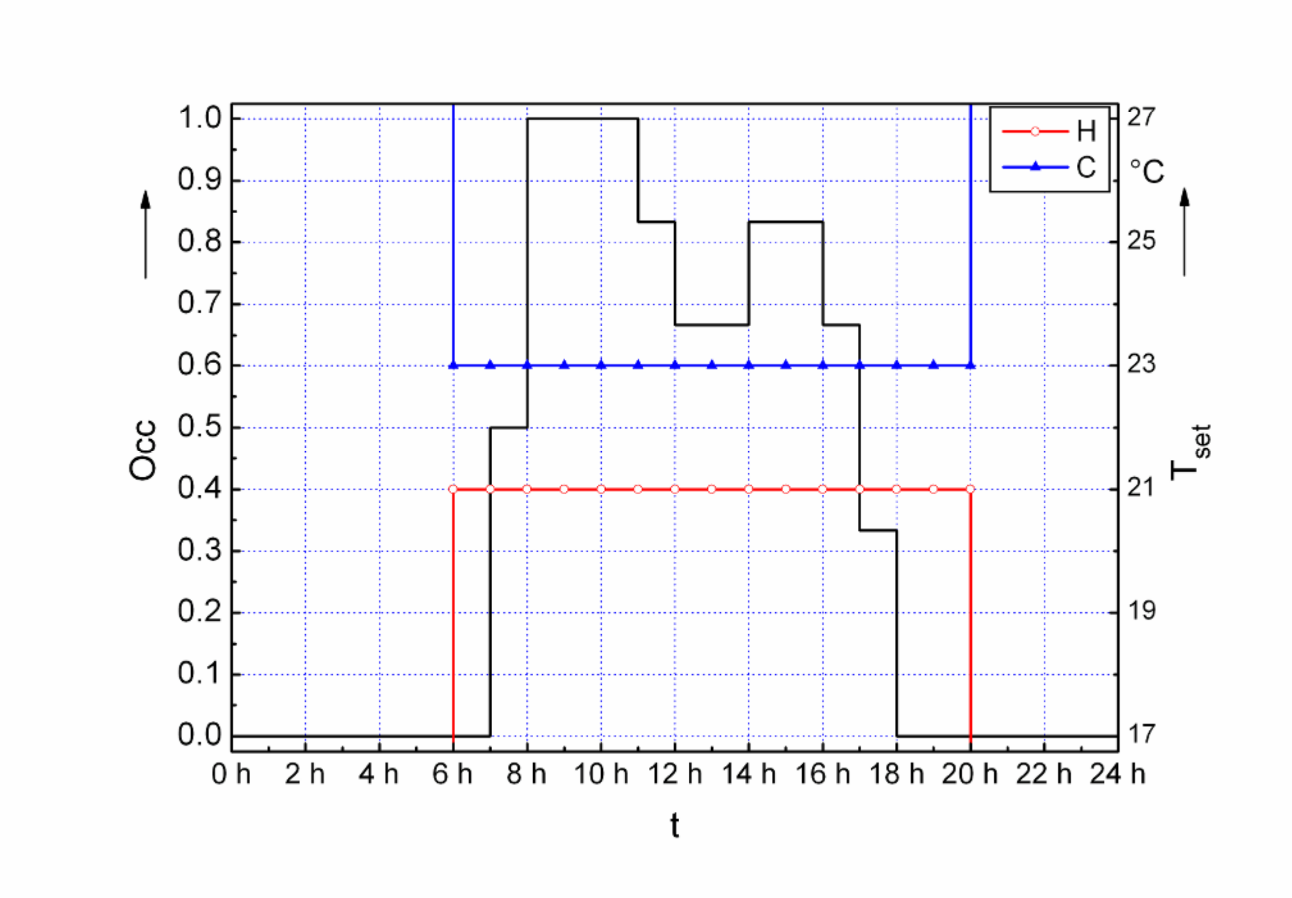
Key

Occ = level of occupancy t = time T_{set} = temperature set point

Figure B.2 — User profiles, temperatures and operation times for BACS efficiency class D; office

Efficiency class D represents a worse case than class C. For this reason, the temperature set points for heating and cooling are similar which is again related to no energy dead band. The HVAC operates with no interruption.

Efficiency class B



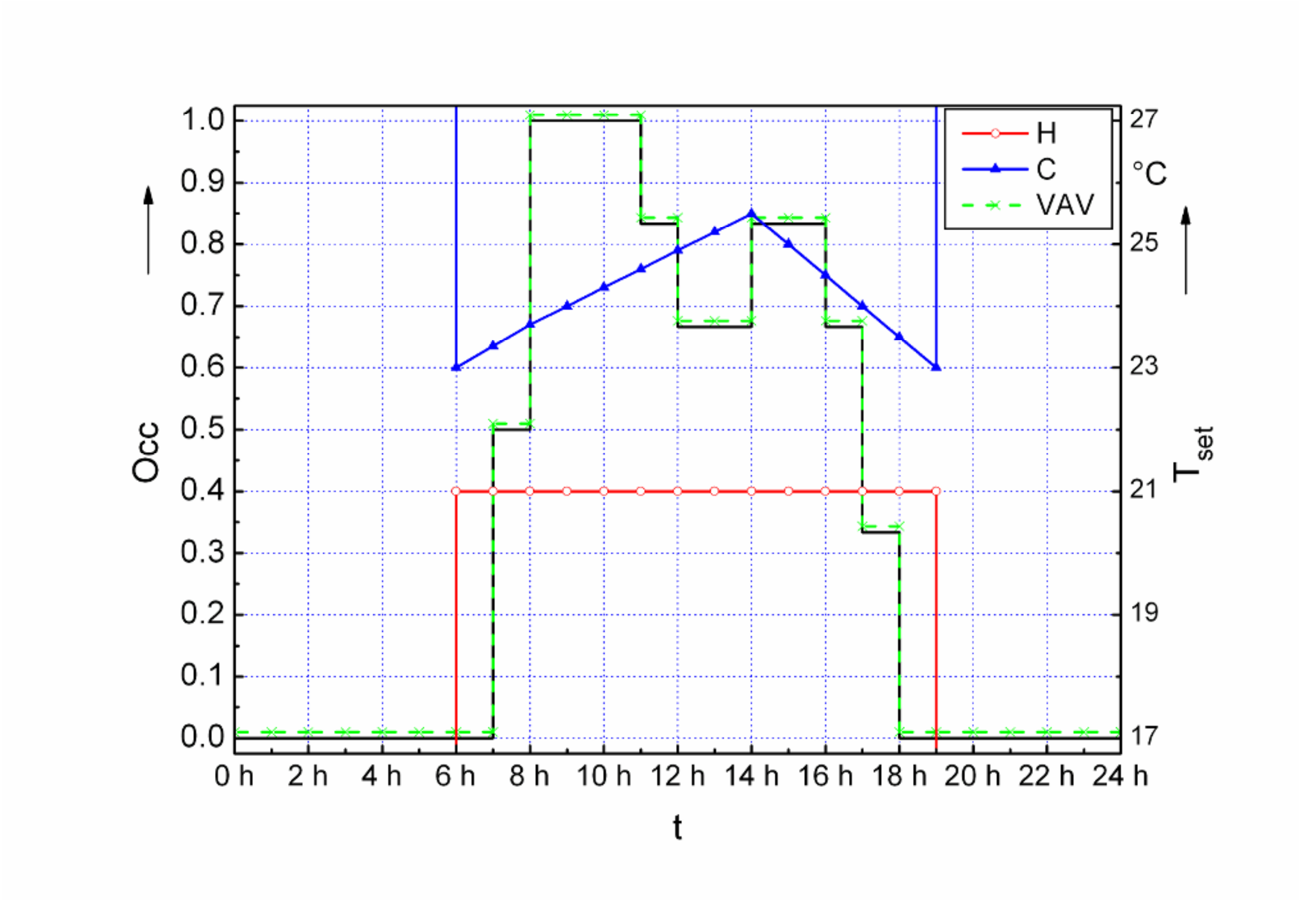
Key

Occ = level of occupancy   t = time T_{set} = temperature set point

Figure B.3 — User profiles, temperatures and operation times for BACS efficiency class B; office

Efficiency class B allows a better adaptation of operating time by optimizing start/stop times. The actual temperature set points for heating and cooling are under observation by a superior management system which leads to a bigger zero energy band than in efficiency class C.

Efficiency class A



Key

Occ = level of occupancy t = time T_{set} = temperature set point

Figure B.4 — User profiles, temperatures and operation times for BACS efficiency class A; office

Efficiency class A further improves energy performance by applying advanced BACS and TBM functions, e.g. adaptive cooling set points or ventilation air flows related to the presence of occupants.

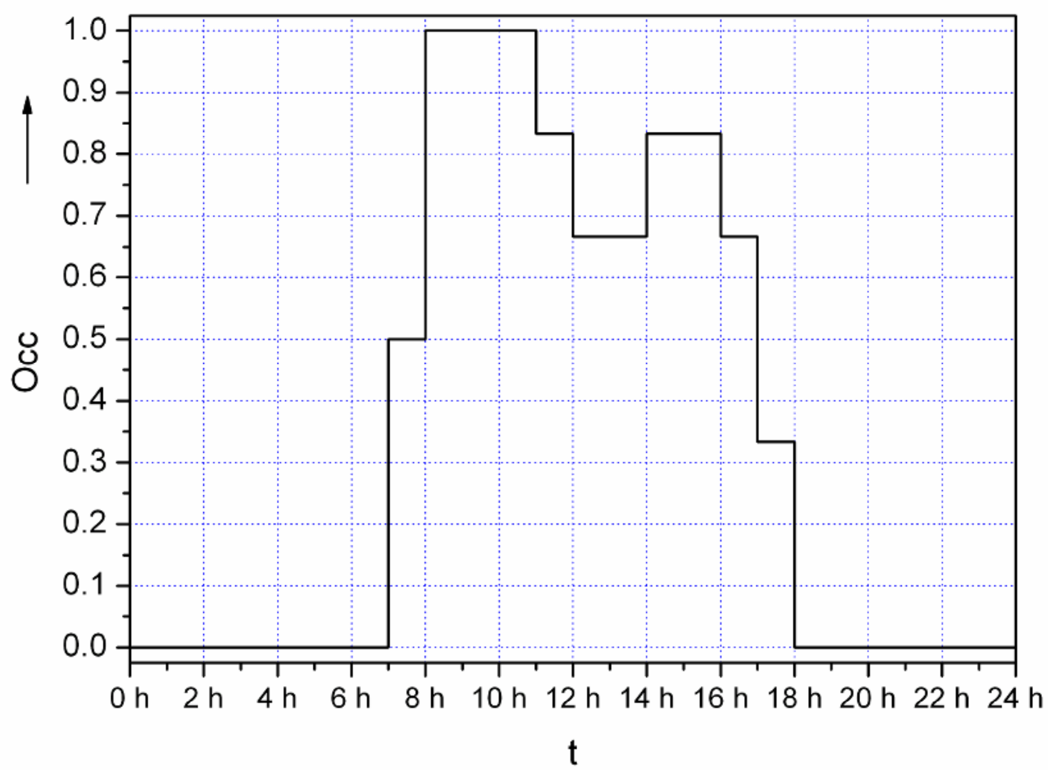
B.3 Boundary conditions

For each building type both the user profile and relevant boundary conditions are given in Tables B.1 to B.7. Boundary conditions include temperature set points for heating and cooling, operation time for heating, cooling, and lighting systems, number of persons (population density), internal thermal gains, ventilation air change, shading control, and number of workdays / weekends. Heat gains due to persons are between 70 and 100 W/person depending on room air temperature and is defined according to VDI 2078 [19]. Number of persons in a room can be calculated from required space given in the tables. Given heat gains (persons and equipment) are available during occupied period only.

Cooling set point temperature varies between 24°C and 27°C depending on ambient air temperature which represents an often used static comfort model for summer conditions.

The shading of BACS efficiency classes B and A depends on a threshold value for solar irradiation (200W/m² and 130 W/m² resp.) when shading controller starts his activity.

Office



Key

Occ = level of occupancy   t = time

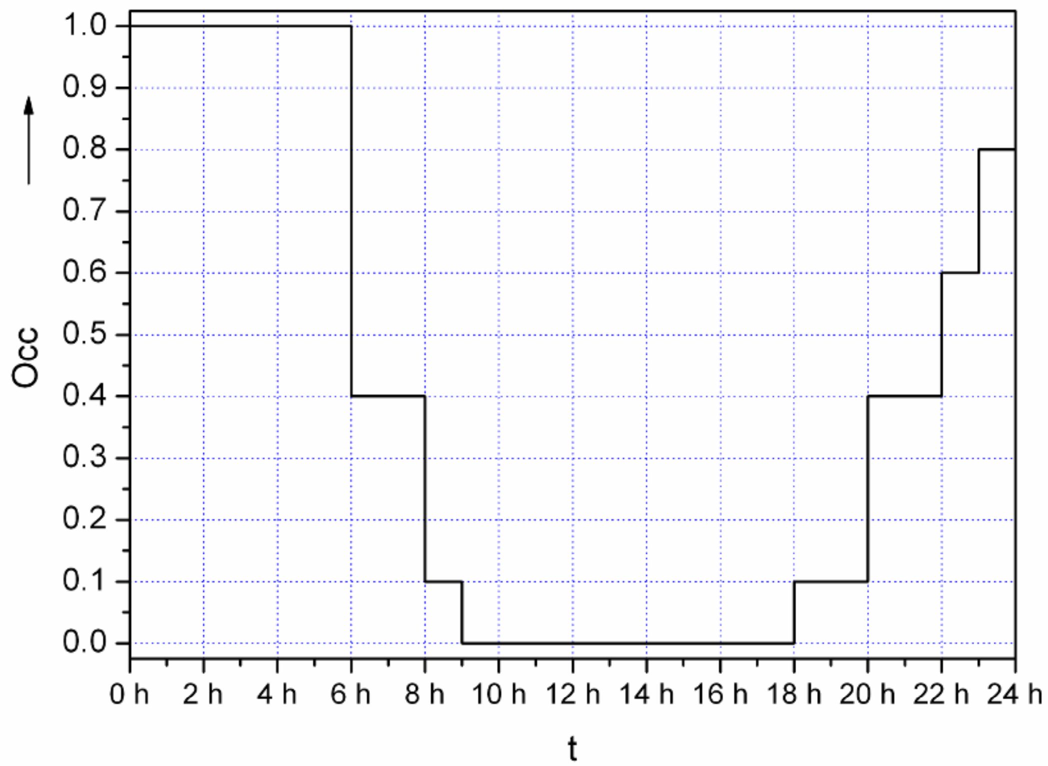
Figure B.5 — User profiles for an office

Table B.1 — Boundary conditions for BACS efficiency classes: office

(*for further explanations refer to B.3)

Office		BACS efficiency class			
		D	C	B	A
Heating	Temperature set point	22,5 °C	22 / 15 °C	21 / 15 °C	21 / 15 °C
	Operation time	00:00 - 24:00	05:00 - 21:00	06:00 - 20:00	06:00 - 19:00
Cooling	Temperature set point	22,5 °C	23 °C	23 °C	$T_C=f(T_{amb})$
	Operation time	00:00 - 24:00	05:00 - 21:00	06:00 - 20:00	06:00 - 19:00
Lighting	Power	13 W/m²	13 W/m²	13 W/m²	13 W/m²
	Operation time	07:00 - 18:00	07:00 - 18:00	07:00 - 18:00	07:00 - 18:00
Gains	Persons	13,3 m²/Pers.	13,3 m²/Pers.	13,3 m²/Pers.	13,3 m²/Pers.
	Equipment	10 W/m²	10 W/m²	10 W/m²	10 W/m²
Ventilation	Air change	0 / h	0 / h	0 / h	0 / h
Solar	Shading factor	0,3 manual	0,5 manual	0,7 (200 W/m²)*	0,7 (130 W/m²)*
User profile	Workday / weekend	5 / 2	5 / 2	5 / 2	5 / 2

Hotel



Key

Occ = level of occupancy t = time

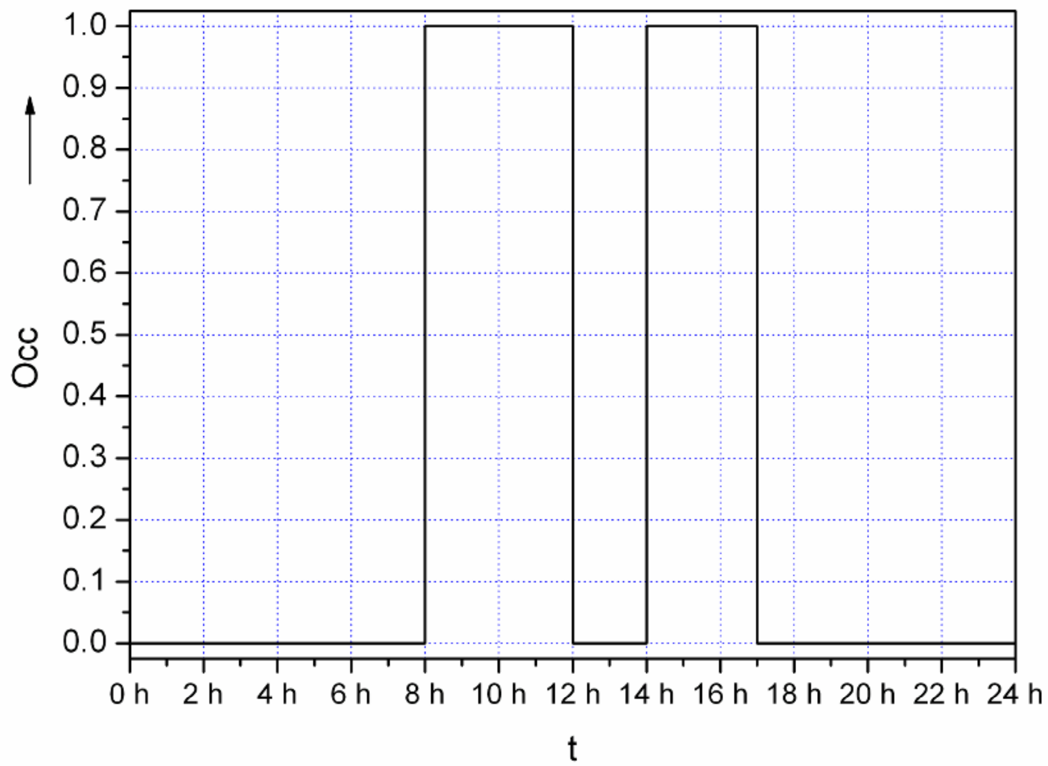
Figure B.6 — User profiles for a hotel

Table B.2 — Boundary conditions for BACS efficiency classes: hotel

(*for further explanations refer to B.3)

Hotel		BACS efficiency class			
		D	C	B	A
Heating	Temperature set point	22,5 °C	22 / 15 °C	21 / 15 °C	21 / 15 °C
	Operation time	00:00 - 24:00	00:00 - 11:00 / 16:00 - 24:00	00:00 - 10:00 / 17:00 - 24:00	00:00 - 09:00 / 18:00 - 24:00
Cooling	Temperature set point	22,5 °C	23 °C	23 °C	T_C=f(T_{amb})
	Operation time	00:00 - 24:00	14:00 - 10:00	06:00 - 20:00	17:00 - 09:00
Lighting	Power	10 W/m²	10 W/m²	10 W/m²	10 W/m²
	Operation time	18:00 - 08:00	18:00 - 08:00	16:00 - 10:00	18:00 - 08:00
Gains	Persons	10 m²/Pers.	10 m²/Pers.	10 m²/Pers.	10 m²/Pers.
	Equipment	4 W/m²	4 W/m²	4 W/m²	4 W/m²
Ventilation	Air change	1,3 / h	1,3 / h	1,3 / h	1,3 / h
Solar	Shading factor	0,3 manual	0,5 manual	0,7 (200 W/m²)*	0,7 (130 W/m²)*
User profile	Workday / weekend	7 / 0	7 / 0	7 / 0	7 / 0

Education, school



Key

Occ = level of occupancy t = time

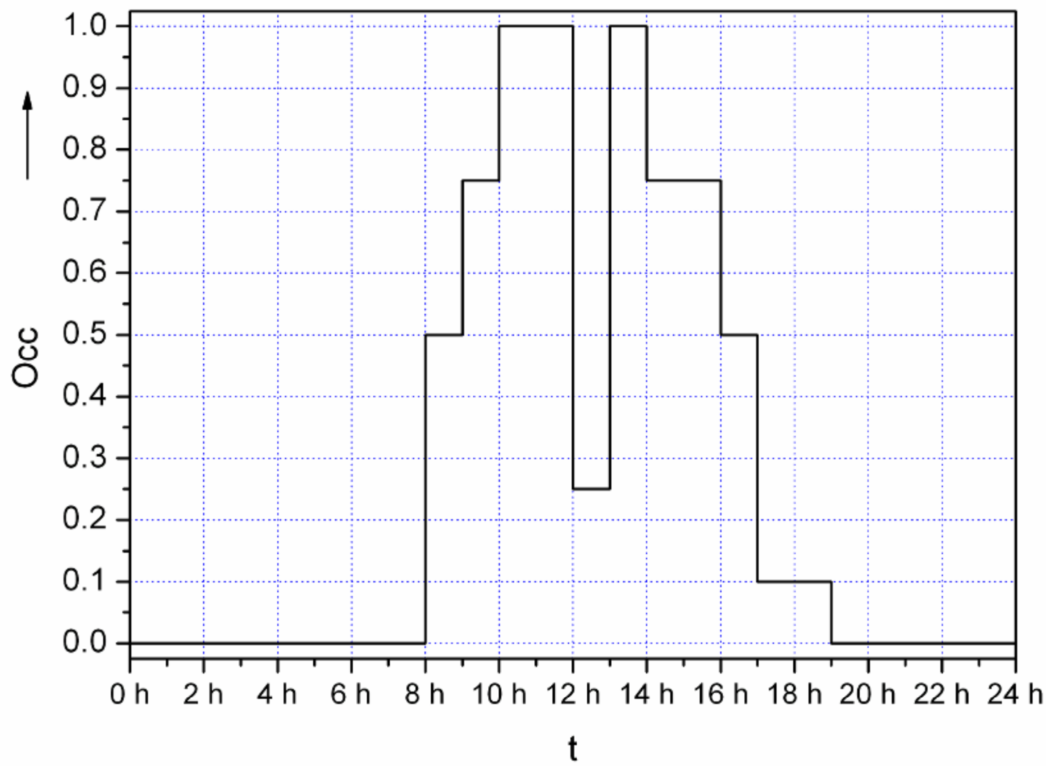
Figure B.7 — User profiles for a class room

Table B 3 — Boundary conditions for BACS efficiency classes: class room

(*for further explanations refer to B.3)

Education / school		BACS efficiency class			
		D	**C**	**B**	**A**
Heating	Temperature set point	22,5 °C	22 / 15 °C	21 / 15 °C	21 / 15 °C
	Operation time	00:00 - 24:00	06:00 - 19:00	06:30 - 17:30	07:00 - 12:00 / 13:30 - 17:30
Cooling	Temperature set point	-	-	-	-
	Operation time	-	-	-	-
Lighting	Power	13 W/m²	13 W/m²	13 W/m²	13 W/m²
	Operation time	07:00 - 18:00	07:00 - 18:00	07:00 - 18:00	07:00 - 18:00
Gains	Persons	3,3 m²/Pers.	3,3 m²/Pers.	3,3 m²/Pers.	3,3 m²/Pers.
	Equipment	4 W/m²	4 W/m²	4 W/m²	4 W/m²
Ventilation	Air change	0 / h	0 / h	0 / h	0 / h
Solar	Shading factor	0,3 manual	0,5 manual	0,7 (200 W/m²)*	0,7 (130 W/m²)*
User profile	Workday / weekend	5 / 2	5 / 2	5 / 2	5 / 2

Lecture hall



Key

Occ = level of occupancy t = time

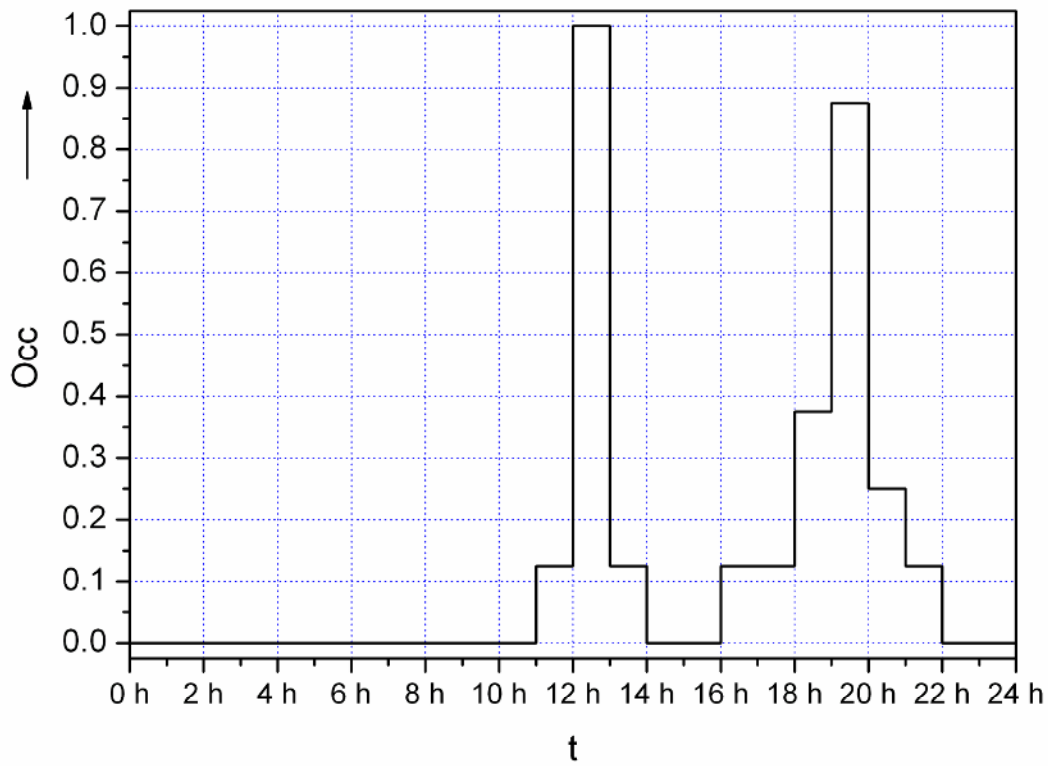
Figure B.8 — User profiles for a lecture hall

Table B.4 — Boundary conditions for BACS efficiency classes: lecture hall

(*for further explanations refer to B.3)

Lecture hall		BACS efficiency class			
		D	**C**	**B**	**A**
Heating	Temperature set point	22,5 °C	22 / 15 °C	21 / 15 °C	21 / 15 °C
	Operation time	05:00 - 22:00	06:00 - 21:00	07:00 - 20:00	08:00 - 19:00
Cooling	Temperature set point	22,5 °C	23 °C	23 °C	T_C=f(T_{amb})
	Operation time	05:00 - 22:00	06:00 - 21:00	07:00 - 20:00	07:00 - 20:00
Lighting	Power	25 W/m²	25 W/m²	25 W/m²	25 W/m²
	Operation time	07:00 - 20:00	07:00 - 20:00	07:00 - 20:00	07:00 - 20:00
Gains	Persons	1 m²/Pers.	1 m²/Pers.	1 m²/Pers.	1 m²/Pers.
	Equipment	4 W/m²	4 W/m²	4 W/m²	4 W/m²
Ventilation	Air change	10 / h	10 / h	10 / h	10 / h (presence control)
Solar	Shading factor	0,3 manual	0,5 manual	0,7 (200 W/m²)*	0,7 (130 W/m²)*
User profile	Workday / weekend	5 / 2	5 / 2	5 / 2	5 / 2

Restaurant



Key

Occ = level of occupancy t = time

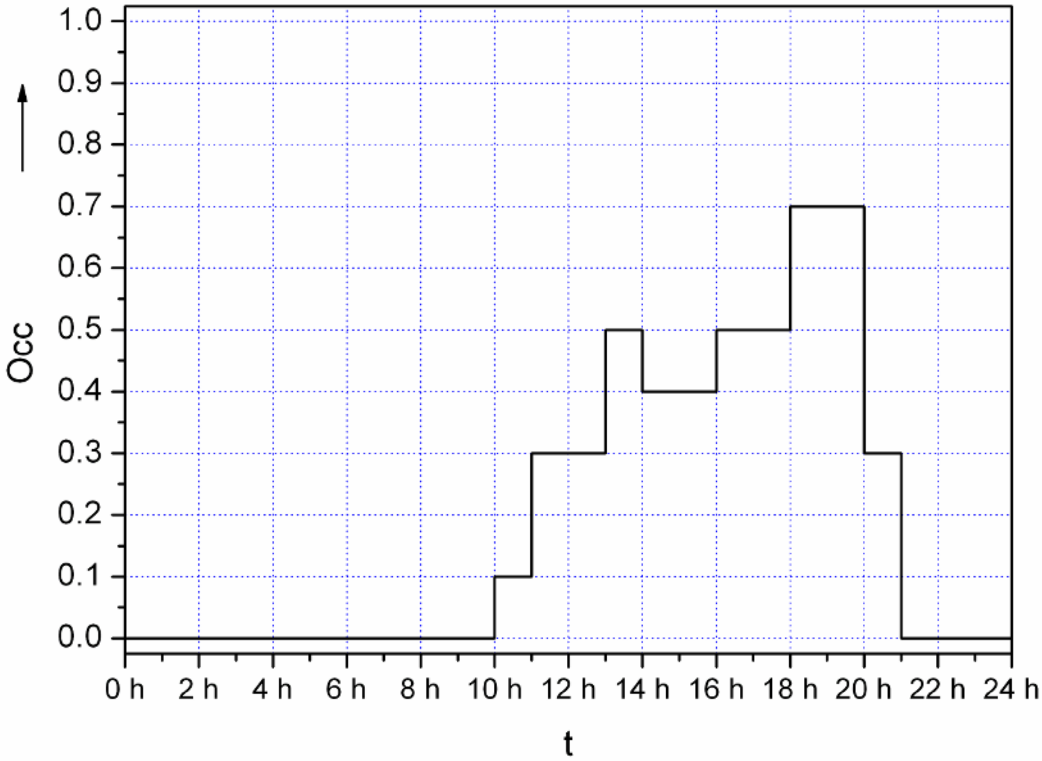
Figure B.9 — User profiles for a restaurant

Table B.5 — Boundary conditions for BACS efficiency classes: restaurant

(*for further explanations refer to B.3)

Restaurant		BACS efficiency class			
		D	**C**	**B**	**A**
Heating	Temperature set point	22,5 °C	22 / 15 °C	21 / 15 °C	21 / 15 °C
	Operation time	00:00 - 24:00	09:00 - 24:00	10:00 - 23:00	11:00 - 22:00
Cooling	Temperature set point	22,5 °C	23 °C	23 °C	$T_C=f(T_{amb})$
	Operation time	00:00 - 24:00	09:00 - 24:00	10:00 - 23:00	11:00 - 22:00
Lighting	Power	10 W/m²	10 W/m²	10 W/m²	10 W/m²
	Operation time	10:00 - 23:00	10:00 - 23:00	10:00 - 23:00	10:00 - 23:00
Gains	Persons	1 m²/Pers.	1 m²/Pers.	1 m²/Pers.	1 m²/Pers.
	Equipment	2 W/m²	2 W/m²	2 W/m²	2 W/m²
Ventilation	Air change	8,5 / h	8,5 / h	8,5 / h	8,5 / h (presence control)
Solar	Shading factor	0,3 manual	0,5 manual	0,7 (200 W/m²)*	0,7 (130 W/m²)*
User profile	Workday / weekend	7 / 0	7 / 0	7 / 0	7 / 0

Wholesale centre



Key

Occ = level of occupancy   t = time

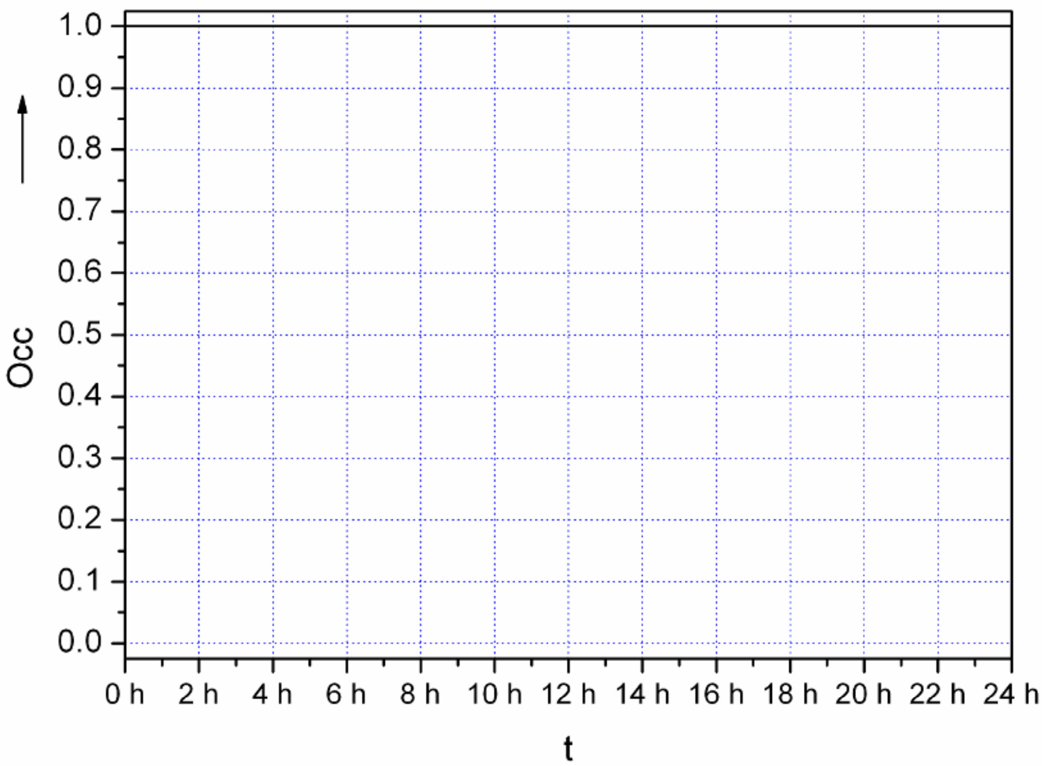
Figure B.10 — User profiles for a wholesale centre

Table B.6 — Boundary conditions for BACS efficiency classes: wholesale centre

(*for further explanations refer to B.3)

Wholesale		BACS efficiency class			
		D	**C**	**B**	**A**
Heating	Temperature set point	22,5 °C	22 / 15 °C	21 / 15 °C	21 / 15 °C
	Operation time	00:00 - 24:00	08:00 - 23:00	09:00 - 22:00	10:00 - 21:00
Cooling	Temperature set point	22,5 °C	23 °C	23 °C	T_C=f(T_{amb})
	Operation time	00:00 - 24:00	09:00 - 24:00	10:00 - 23:00	11:00 - 22:00
Lighting	Power	15 W/m²	15 W/m²	15 W/m²	15 W/m²
	Operation time	10:00 - 23:00	10:00 - 23:00	10:00 - 23:00	10:00 - 23:00
Gains	Persons	5 m²/Pers.	5 m²/Pers.	5 m²/Pers.	5 m²/Pers.
	Equipment	3,5 W/m²	3,5 W/m²	3,5 W/m²	3,5 W/m²
Ventilation	Air change	1,3 / h	1,3 / h	1,3 / h	1,3 / h (presence control)
Solar	Shading factor	0,3 manual	0,5 manual	0,7 (200 W/m²)*	0,7 (130 W/m²)*
User profile	Workday / weekend	6 / 1	6 / 1	6 / 1	6 / 1

Hospital



Key

Occ = level of occupancy t = time

Figure B.11 — User profiles for an hospital

Table B.7 — Boundary conditions for BACS efficiency classes: hospital

(*for further explanations refer to B.3)

Hospital		BACS efficiency class			
		D	C	B	A
Heating	Temperature set point	22,5 °C	22 / 15 °C	21 / 15 °C	21 / 15 °C
	Operation time	00:00 - 24:00	09:00 - 24:00	10:00 - 23:00	11:00 - 22:00
Cooling	Temperature set point	-	-	-	-
	Operation time	-	-	-	-
Lighting	Power	15 W/m²	15 W/m²	15 W/m²	15 W/m²
	Operation time	10:00 - 23:00	10:00 - 23:00	10:00 - 23:00	10:00 - 23:00
Gains	Persons	0,7 m²/Pers.	0,7 m²/Pers.	0,7 m²/Pers.	0,7 m²/Pers.
	Equipment	4 W/m²	4 W/m²	4 W/m²	4 W/m²
Ventilation	Air change	3,3 / h	3,3 / h	3,3 / h	3,3 / h (presence control)
Solar	Shading factor	0,3 manual	0,5 manual	0,7 (200 W/m²)*	0,7 (130 W/m²)*
User profile	Workday / weekend	7 / 0	7 / 0	7 / 0	7 / 0

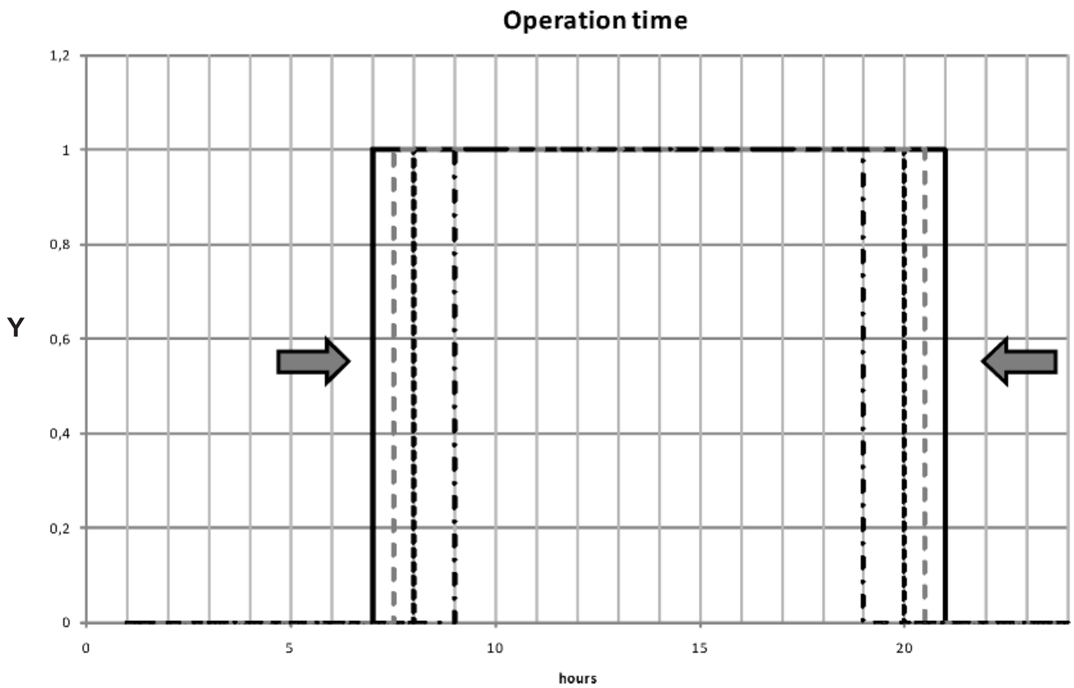
B.4 BACS efficiency classes - Domestic Hot Water (DHW)

The impact of BACS-systems on the energy performance of DHW-generation systems is based on

— operation timer; the time when the storage tank is loaded and hold at the set point temperature;

— mean DHW storage tank temperature.

The operation times for the different BACS efficiency classes are assumed as shown in Figure B.12



Key

Y = level of usage

hours = operating time in h

Class D ——— Class C .... Class B — — — Class A — · —

Figure B.12 — Operation time for DHW system for different BACS efficiency classes

The second impact on energy performance is coming from the mean storage tank temperature during operation. The mean temperatures for the different BACS efficiency classes are assumed as follows:

Table B.8 — Mean DHW storage tank temperature for BACS efficiency classes

BACS – Class	D	C	B	A
Storage tank temperature	48°C	47°C	46°C	45°C

B.5 Geographical influences of the BACS efficiency factors

All simulations in this standard to calculate BACS efficiency factors are based on the outdoor weather conditions of the City of Würzburg (Germany) and are taken from the corresponding TRY (Test-reference-year). In the TRY are values for the outside temperature, the solar radiation, the humidity and so on for each hour of a year. Test-reference-years are representing typical weather conditions without extremes.

Results from calculations with the used weather conditions can be transferred direct in other countries because of the mean part load of the heating demand.

Figure B.13 shows the different outdoor temperatures for cities in the south to north of Europe are shown over the whole year (8.760 hours/year). The cities are:

- Würzburg (Germany);
- Paris (France);
- Rom (Italy);
- Stockholm (Sweden);
- Madrid (Spain).

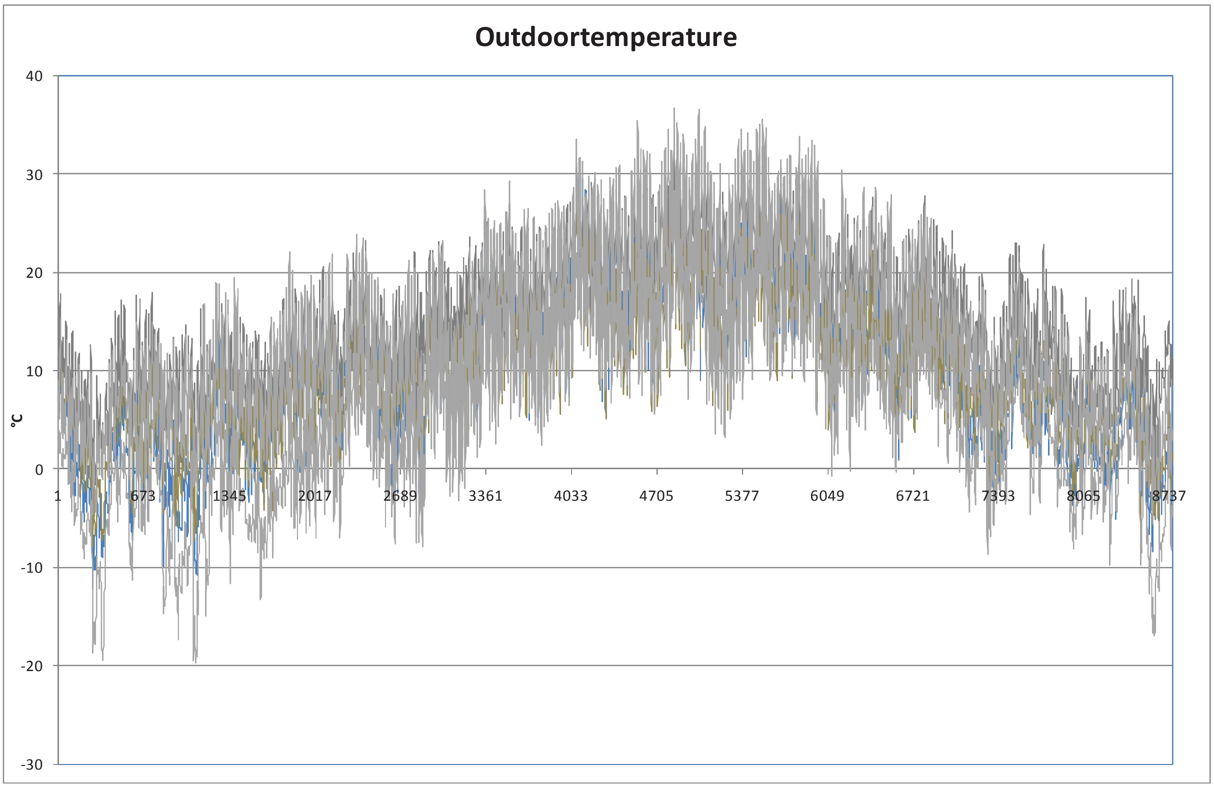


Figure B.13 — Outdoor temperatures for different cities in Europe

Based on the TRY for each City the heat load is calculated for the reference room used for the calculations in this standard.

By using the annual load duration curve (Figure B.14) of the same cities it is noticeable that the heating hours in the north are much more higher than in the south and that also the maximum heating load in the north is much higher than in the south but the shapes of the different curves are nearly the same.

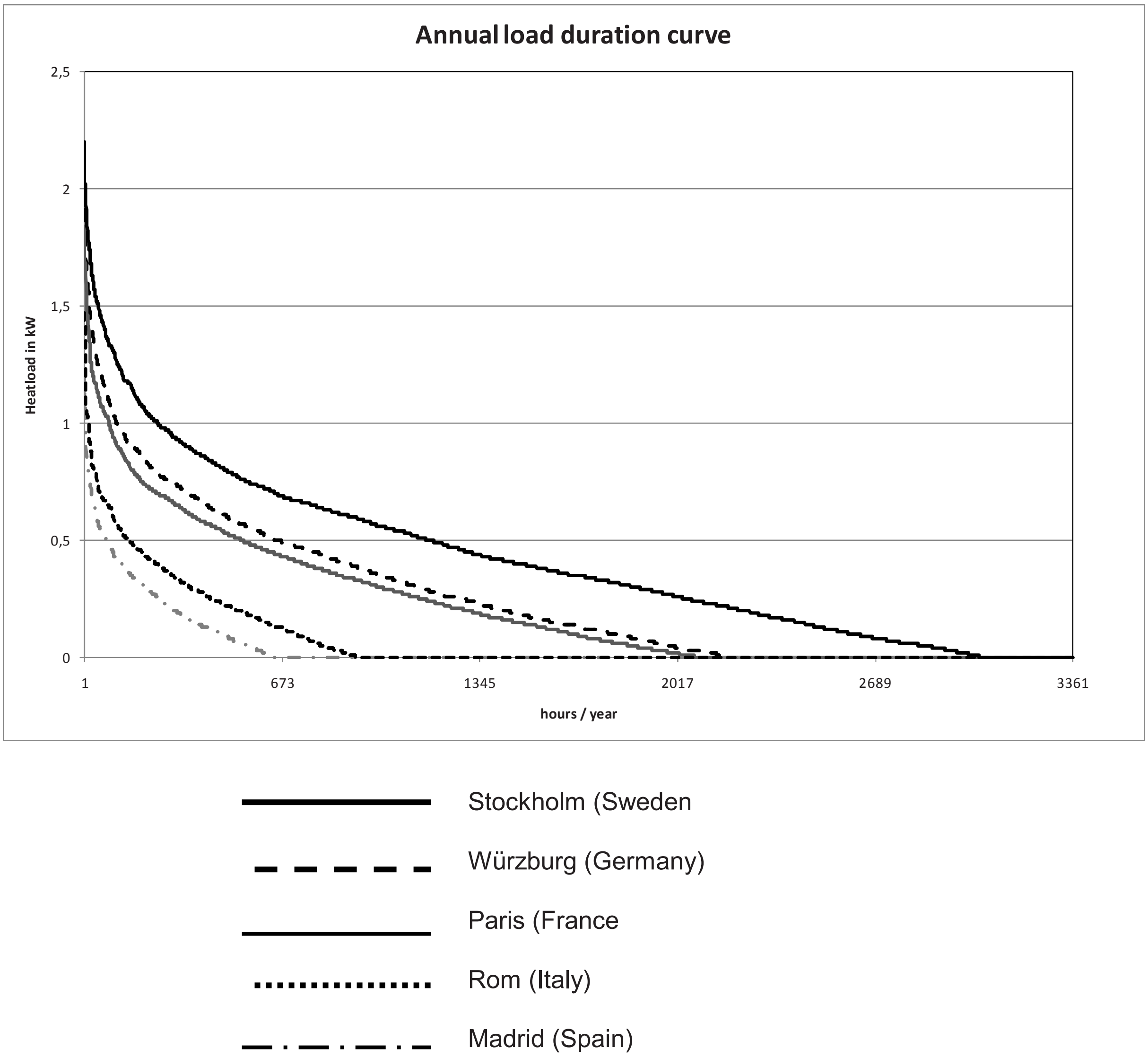


Figure B.14 — Annual load duration curves for different cities in Europe

The same result taking into account that the area below the annual duration curve represents the energy for heating it is possible to determine a mean part load:

$$\overline{\beta} = \frac{\int_0^{t_h} \dot{Q} \cdot dt}{\Phi \cdot t_h}$$

with Φ as maximum heat load and t_h as heating hours.

The calculation of the mean part load for each city is shown in Figure B.15.

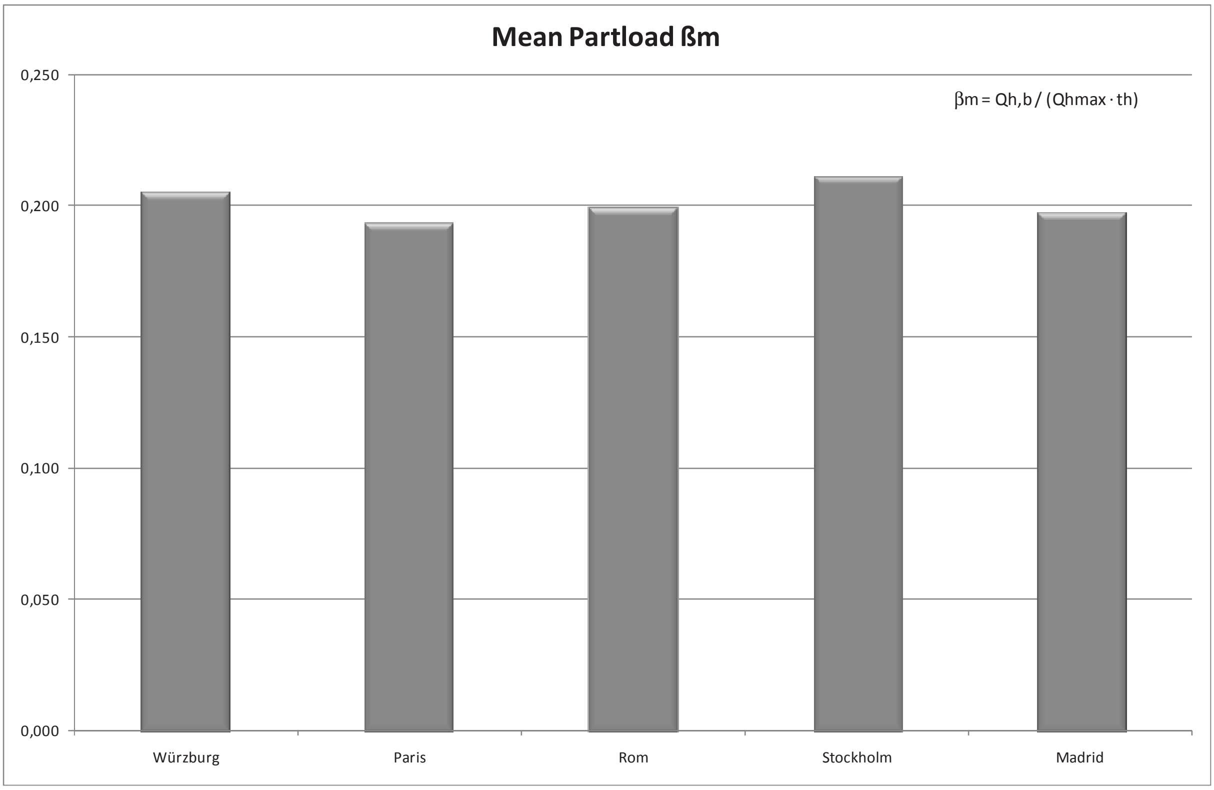


Figure B.15 — Mean part load for different cities in Europe

The very small differences between the different cities in Europe which are noticeable in Figure 3 are the evidence for using simulation results which are made with weather conditions of the middle of Europe over the whole Europe.

The use of simulation results is also valid for cooling because of the same fundamentals.

The expenditure energy factor e for heating or cooling systems in the sections Emission and Control, Distribution and Generation is depending on the mean part load of the energy demand, because the dynamic influence is in general a function of the mean part load.

B.6 Influence of the different user profiles of the BACS factors

The BACS factors in this standard are calculated with the user profiles which are listed in B.2.

For different user profiles (Figure B.16) a correction factor Ccorr can be calculated.

For the standard profile A (in Figure B.16 Office-Standard) a constant value Cuse, A (K = A) can be calculated

For the different user profile B (in Figure B.16 Office – new) a constant value Cuse,B (K = B) can be calculated in the same way.

The correction factor sets the constant value for a new profile in relation to the constant value of the standard profile.

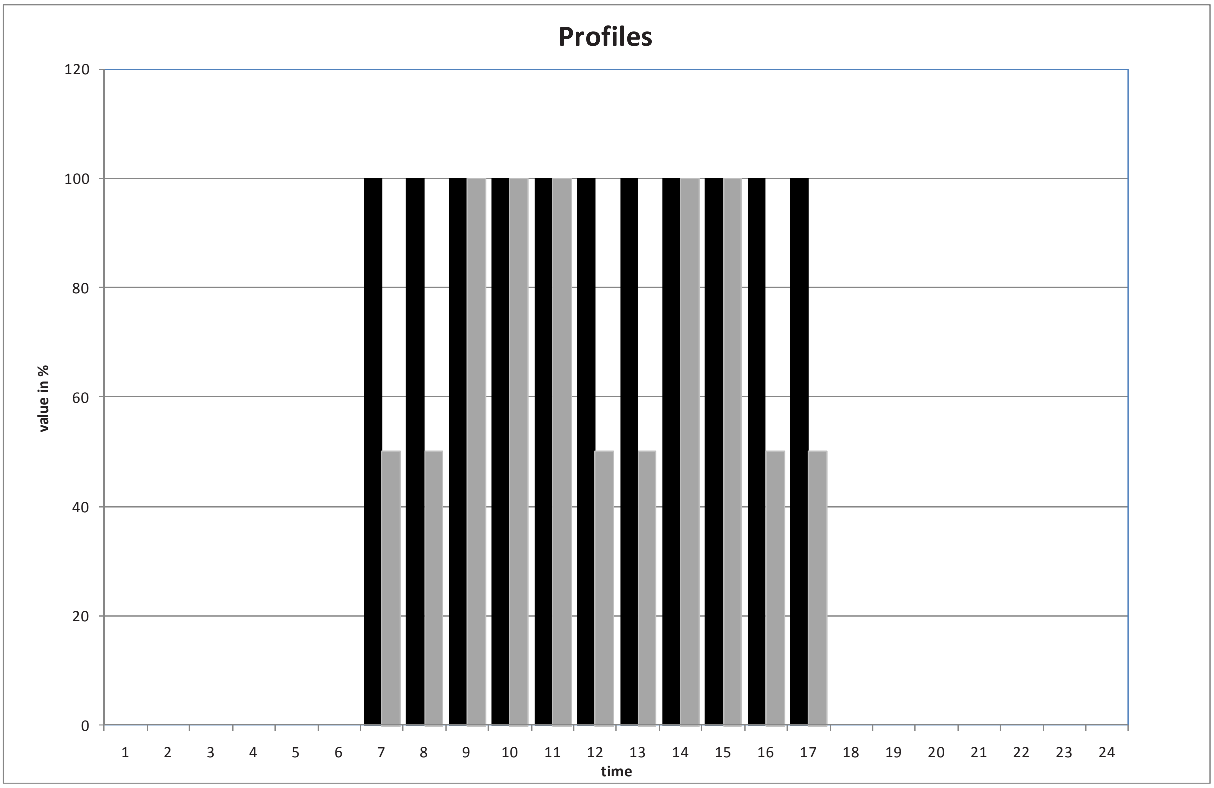


Figure B.16 — Different user profiles

The constant factor is to be calculated as:

$$C_{use,K} = \frac{\sum_{i=t_{use,s}}^{i=t_{use,e}} a_i}{t_{use,d}}$$

where

$t_{use,s}$ start of use;

$t_{use,e}$ end of use;

$t_{use,d}$ daily use;

a_i part of occupancy / gains in %.

Then the correction factor is to be calculated as:

$$C_{corr} = \frac{C_{use,A}}{C_{use,B}}$$

Annex C
(informative)

Examples of how to use the BACS function list of EN ISO 16484-3 to describe functions from this European Standard

C.1 General

BACS functions for project specification are described in EN ISO 16484-3; the documentation of complete plant functionality is documented by the BACS function list (BACS-FL) described in EN ISO 16484-3. The BACS-FL can also be used for the purposes of TBM functions. This Annex C shows the relation between EN ISO 16484-3 and this European Standard. Some few of the BACS or TBM functions considered in this European Standard correspond directly to functions defined in EN ISO 16484-3, i.e. to a column of the BACS function list. Examples are given in C.2. For many BACS or TBM functions however it is necessary to specify them by using one or several columns of the BACS function list in combination with a control schematic. See C.3 for examples.

C.2 Direct representation by a function defined in EN ISO 16484-3

C.2.1 Example 1 - Night cooling

Considered BACS and TBM Function in this Standard defined in 5.2, Table 1:

4	**VENTILATION AND AIR CONDITIONING CONTROL**	
4.5	Free mechanical cooling	
	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 realised by automatically opening windows there is no air flow control

Representation by using the BACS function list of EN ISO 16484-3:

— This function relates to function 6.7 "Night cooling" in the BACS function list.

C.2.2 Example 2 - h,x- directed control

Considered BACS or TBM Function in this European Standard defined in 5.2, Table 1:

4	**VENTILATION AND AIR CONDITIONING CONTROL**	
4.5	Free mechanical 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).

Representation by using the BACS function list of EN ISO 16484-3:

— This function relates to function 6.1 "h,x-directed control" in the BACS function list.

C.3 Representation by a combination of functions defined in EN ISO 16484-3

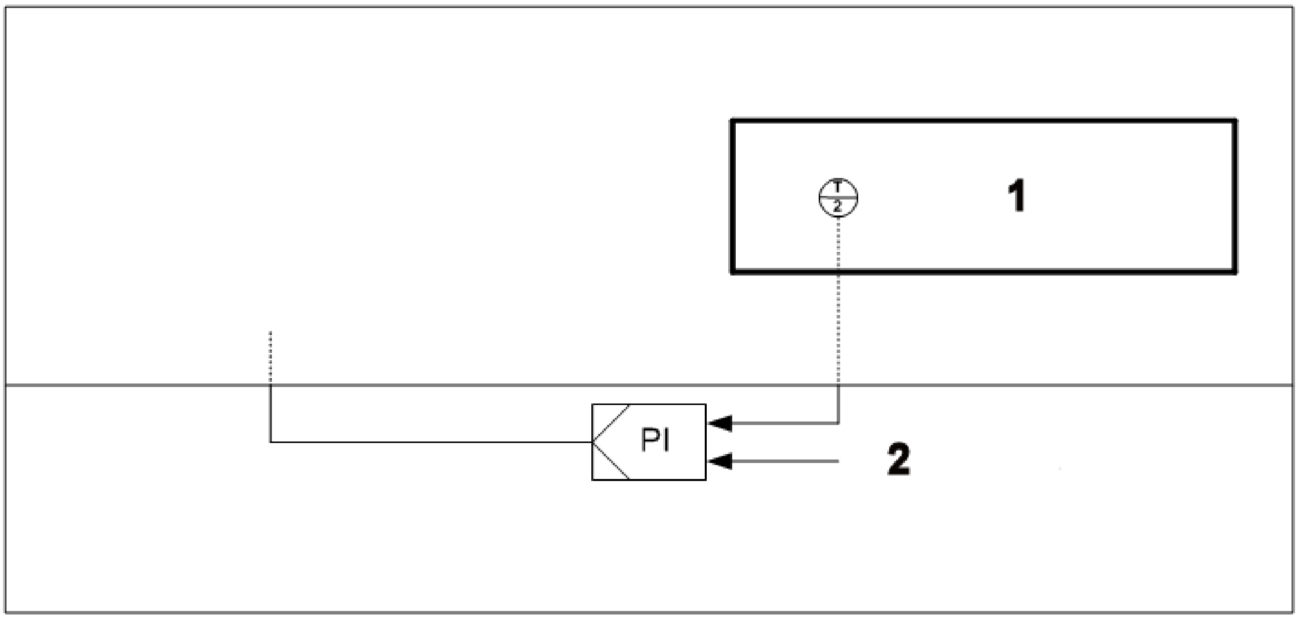
C.3.1 Example 3 - Individual room automatic control

Considered BACS and TBM Function in this Standard defined in 5.2, Table 1:

AUTOMATIC CONTROL		
1	**HEATING CONTROL**	
1.1	Emission control	
	2	Individual room control: By thermostatic valves or electronic controller

Representation by using the BACS function list of EN ISO 16484-3:

The function is described by one row of the EN ISO 16484-3 BACS function list and a control schematic, as shown in the following for the case of a PI controller. Analogously it can be represented for the case of a P controller. Any required controller output functions as e.g. proportional output stages for sequences have to be added (see Figure C.1 and Table C.1).



Key

1 room

2 set point room

Figure C.1 — Control schematic to example 3

Table C.1 — BACS function list - Example 3

EN ISO 16484-3

Annex A (normative)

BACS function list

1) Steady-state output, e.g.: 0,I,II=2 BO
Pulsed output, e.g.: 0,I,II=3 BO
Positioning outp. close-0-open=2 BO
Pulse width modulation output=1 BO

2) Active or passive

3) Only shared (networked) I/O data points from foreign systems for interoperable functions

4) Per input point address for a) collected, b) delayed or c) suppressed information

5) Per output point address

6) For cooling / heating use 2 x on / off conversions

7) Per input point address

8) E.g. device, schedule, life safety, loop, file (see EN ISO 16484-5)

9) If required, indicate whether applies to client devices "A" or server devices "B" (see BIBBs)

Row No.	Type of service (trade):	I/O functions										Processing functions																																Management functions				Operator functions				Remarks
		Physical					Shared 3), 9)					Monitoring						Interlocks					Closed loop control								Calculation / Optimization																					
	Plant	Binary output switching/positioning1)	Analog output positioning	Binary input state	Binary input counting	Analog input 2)	Binary value (output), switching	Analog value (output), positioning/setpt.	Binary value (input), state	Accumulated/totalized value (input)	Analog value (input), measuring	Fixed limit	Sliding / Floating limit	Run time totalization	Event counting	Command execution check	State processing 4)	Plant control	Motor control	Switchover 5)	Step control 5)	Safety / Frost protection control	P control loop	PI / PID control loop	Sliding / Floating / Curve setpoint	Proportional output stage	Proportional to on/off conversion 6)	Proportional to pulse width modulation	Setpoint / Output limitation	Switchover of parameters	h,x directed control 7)	Arithmetic calculation 7)	Event switching	Time schedule	Optimum start / stop	Duty cycling	Night cooling	Room temperature limitation	Energy recovery 7)	Backup power operation	Mains power recovery pogram	Peak load limitation	Energy tariff dependent switching	Input / output / value object types 9)	Complex object types 8), 9)	Event storage	Historical database	Graphic / static plant schematic	Dynamic display	Event instruction text	Remote messaging	NOTE For the definition of function types see EN ISO 16484-3. Indicate project-specific function descriptions in this column and in the points row, as e.g. row no., section no., column no., non standard function description no. BIBBs = BACnet Interop
	Data point — Section no.	1					2					3						4					5								6													7				8				
	Point name or designation — Column no.	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	6	1	2	3	4	5	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8	9	10	11	12	13	1	2	3	4	1	2	3	4	
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Issue date	jj-mm-dd	Author	Approved	Company:	Project:	Location of controls (MER):	File: [table_A2-1-BACS FL template-050513.xls]
Rev. 1							
Rev. 2						Control diagram no.:	Page no. 1
Rev. 3						Interlocks description:	of:

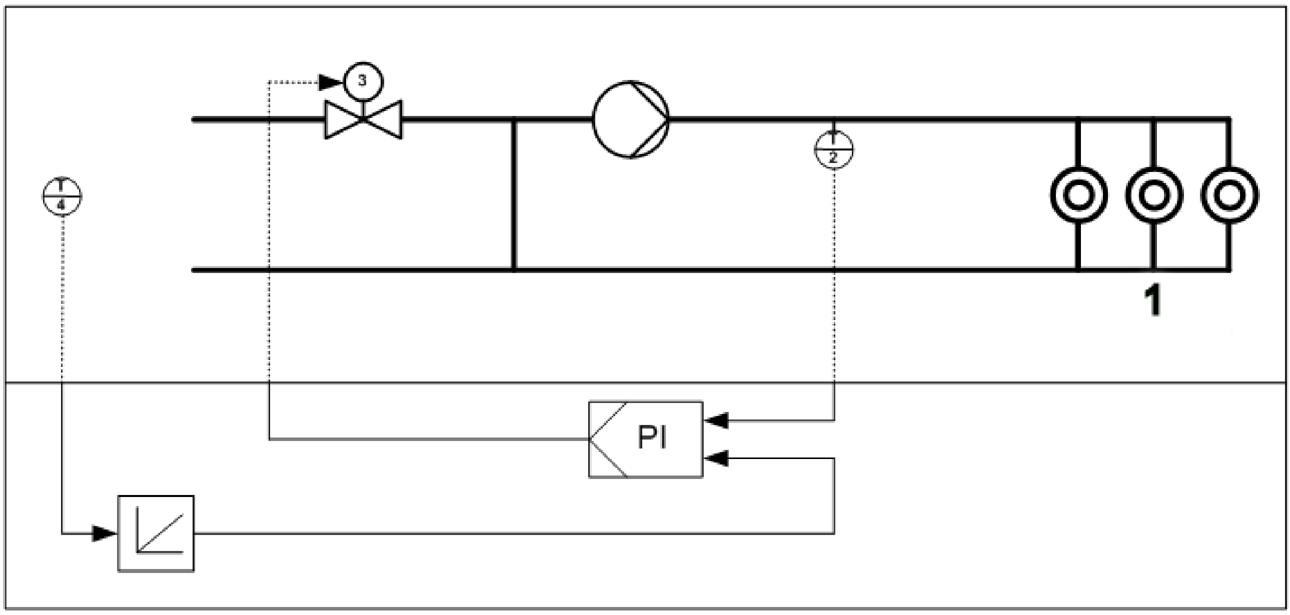
C.3.2 Example 4 - Outside temperature compensated control

Considered BACS and TBM Function in this Standard defined in 5.2, Table 1:

AUTOMATIC CONTROL		
1	**HEATING CONTROL**	
1.3	Control of distribution network temperature (supply or return)	
	Similar function can be applied to the control of direct electric heating networks	
	1	Outside temperature compensated control: Action lowered the mean flow temperature

Representation by using EN ISO 16484-3:

The function is described by two rows in the BACS function list of EN ISO 16484-3 and a control schematic, as shown in the following for the case of a valve drive with analogue input. Any required controller output functions as e.g. proportional output stages for sequences have to be added (see Figure C.2 and Table C.2).



Key

1 heat emitters

Figure C.2 — Control schematic to example 4

Table C.2 — BACS-function list - Example 4

EN ISO 16484-3

Annex A (normative)

BACS function list

1) Steady-state output, e.g.: 0,I,II=2 BO
Pulsed output, e.g.: 0,I,II=3 BO
Positioning outp. close-0-open=2 BO
Pulse width modulation output=1 BO
2) Active or passive
3) Only shared (networked) I/O data points from foreign systems for interoperable functions
4) Per input point address for a) collected, b) delayed or c) suppressed information
5) Per output point address
6) For cooling / heating use 2 x on / off conversions
7) Per input point address
8) E.g. device, schedule, life safety, loop, file (see EN ISO 16484-5)
9) If required, indicate whether applies to client devices "A" or server devices "B" (see BIBBs)

Type of service (trade): Plant

I/O functions (Section 1 = Physical; Section 2 = Shared 3), 9))

Row No.	Data point: Point name or designation	1.1 Binary output switching/positioning1)	1.2 Analog output positioning	1.3 Binary input state	1.4 Binary input counting	1.5 Analog input 2)	2.1 Binary value (output), switching	2.2 Analog value (output), positioning/setpt.	2.3 Binary value (input), state	2.4 Accumulated/totalized value (input)	2.5 Analog value (input), measuring
1											
2	supply water temperature sensor					1					
3	control valve		1								
4	outdoor air temperature					1					
5											
6											
	Totals										

Processing functions — Monitoring (Section 3), Interlocks (Section 4)

Row No.	Data point: Point name or designation	3.1 Fixed limit	3.2 Sliding / Floating limit	3.3 Run time totalization	3.4 Event counting	3.5 Command execution check	3.6 State processing 4)	4.1 Plant control	4.2 Motor control	4.3 Switchover 5)	4.4 Step control 5)	4.5 Safety / Frost protection control
1												
2	supply water temperature sensor											
3	control valve											
4	outdoor air temperature											
5												
6												
	Totals											

Processing functions — Closed loop control (Section 5)

Row No.	Data point: Point name or designation	5.1 P control loop	5.2 PI / PID control loop	5.3 Sliding / Floating / Curve setpoint	5.4 Proportional output stage	5.5 Proportional to on/off conversion 6)	5.6 Proportional to pulse width modulation	5.7 Setpoint / Output limitation	5.8 Switchover of parameters
1									
2	supply water temperature sensor		1						
3	control valve								
4	outdoor air temperature			1					
5									
6									
	Totals								

Processing functions — Calculation / Optimization (Section 6)

Row No.	Data point: Point name or designation	6.1 h,x directed control 7)	6.2 Arithmetic calculation 7)	6.3 Event switching	6.4 Time schedule	6.5 Optimum start / stop	6.6 Duty cycling	6.7 Night cooling	6.8 Room temperature limitation	6.9 Energy recovery 7)	6.10 Backup power operation	6.11 Mains power recovery pogram	6.12 Peak load limitation	6.13 Energy tariff dependent switching
1														
2	supply water temperature sensor													
3	control valve													
4	outdoor air temperature													
5														
6														
	Totals													

Management functions (Section 7), **Operator functions** (Section 8), **Remarks**

Row No.	Data point: Point name or designation	7.1 Input / output / value object types 9)	7.2 Complex object types 8), 9)	7.3 Event storage	7.4 Historical database	8.1 Graphic / static plant schematic	8.2 Dynamic display	8.3 Event instruction text	8.4 Remote messaging	Remarks
										NOTE For the definition of function types see EN ISO 16484-3. Indicate project-specific function descriptions in this column and in the points row, as e.g. row no., section no., column no., non standard function description no. BIBBs = BACnet Interop
1										
2	supply water temperature sensor									
3	control valve									
4	outdoor air temperature									
5										
6										
	Totals									

Issue date	jj-mm-dd	Author	Approved	Company:	Project:	Location of controls (MER):	File: [table_A2-1-BACS FL template-050513.xls]
Rev. 1							
Rev. 2						Control diagram no.:	Page no. 1
Rev. 3						Interlocks description:	of:

Annex D
(informative)

The impact of innovative integrated BACS functions (examples)

D.1 General

The use of building automation and control systems leads in general to an improved energy performance of buildings. The automation of control devices gives an opportunity to save energy compared to a manual non-automated intervention of the occupants. The energy saving effect due to the application of BACS can be intensified if also integrated and complex control functions are taking into consideration. Furthermore, the implementation of technical building management is recommended to get a deeper knowledge about the energy consumption of a building and to optimise the operation of its energy systems. The energy consumption for running the building automation and control system has always to be taken into account.

The impact of building automation and control BACS and TBM functions not covered yet by other standards can be calculated in accordance with Annex A. For detailed calculations national calculation methods can be applied.

D.2 Examples of integrated functions

D.2.1 Overview

The integrated building automation and special control functions which are considered here are not yet covered by other standards. Nevertheless, they are worth to look at due to their innovative character. These functions to be described are:

a) individual room temperature control in heated zones affected by the use of window contacts;

b) optimized blind and lighting control.

D.2.2 The use of window contacts in individual room temperature control in heated zones

The individual room temperature control in heated zones provides an opportunity to improve the energy efficiency by the use of an integrated function between heating control and window contacts. The functionality is as follows: When the windows are opened by the occupants the heating system in the room is switched off automatically and no additional heat is supplied into the room. That reduces heating energy losses through open windows by preventing unnecessary heat supply into the room. After closing the window the heat supply is switched on again. To realise this operating mode an integrated building automation system is required. It is assumed that there is no interoperation between window contacts and the central management of the heating system, e.g. control of supply temperature or pump.

As an effect of the functionality as described above the room temperature during the period the window is opened decreases faster compared to a continuously operating heating system. The transient deviation of room temperature from the desired temperature set point is accepted by the occupant but could also encourage the occupant to close the window as soon as the room is sufficiently infiltrated.

The energy efficiency improvements due to the application of window contacts in conjunction with a BACS can easily be summarized in an energy saving factor f_W. If no building automation system with such integrated functions is available the factor f_W is 1. On the other hand the application of automation systems that allows the interoperation of window contacts and individual room temperature control in a heated zone leads to values $f_{\mathrm{W}} < 1$.

The heating energy demand of a building energy system can that way be calculated with Equation (D.1).

$$Q'_H = Q_H \times f_W \quad \text{(D.1)}$$

where

Q'_H is the heating energy demand with application of window contacts;

Q_H is the heating energy demand without application of window contacts (EN ISO 13790);

f_W is the energy saving factor due to the use of window contacts.

The conventional case is the non-use of window contacts. Thus, the heating energy demand without application of window contacts shall be calculated first as standardised in EN ISO 13790. After that it is possible to assess the energy saving effect due to the use of window contacts with the help of f_{W}.

The energy saving factor f_{W} can be read from Figure D.1 and Figure D.2. It depends on the temperature difference ΔT_{m} between the averaged interior (room) and the exterior (outdoor) temperatures as calculated with Equation (C.2).

$$\Delta T_{\mathrm{m}} = \overline{T}_{\mathrm{int}} - \overline{T}_{\mathrm{ext}} \quad \text{(D.2)}$$

where

$\overline{T}_{\mathrm{int}}$ is the average interior temperature during the period under consideration;

$\overline{T}_{\mathrm{ext}}$ is the average exterior temperature during the period under consideration.

The thermal mass of the building as well as the heat transmittance U also have an impact on the energy saving effect that can be reached by the use of window contacts. The amount of internal loads does not have a significant impact on f_{W} but on the total heat energy consumption.

It is possible to interpolate missing data from the graphs given in Figure D.1 and Figure D.2. For high mass buildings a linear interpolation in dependence on the average U-value of the envelope is feasible whereas for new buildings with a low U-value a linear interpolation in dependence on the building mass could be performed.

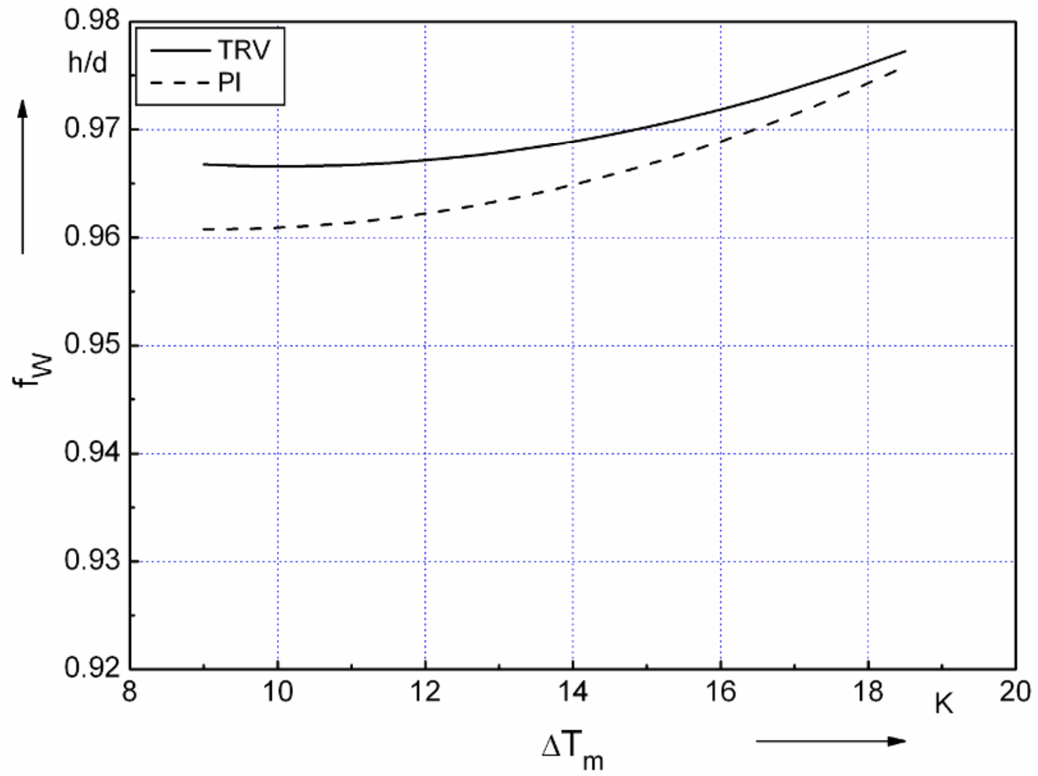
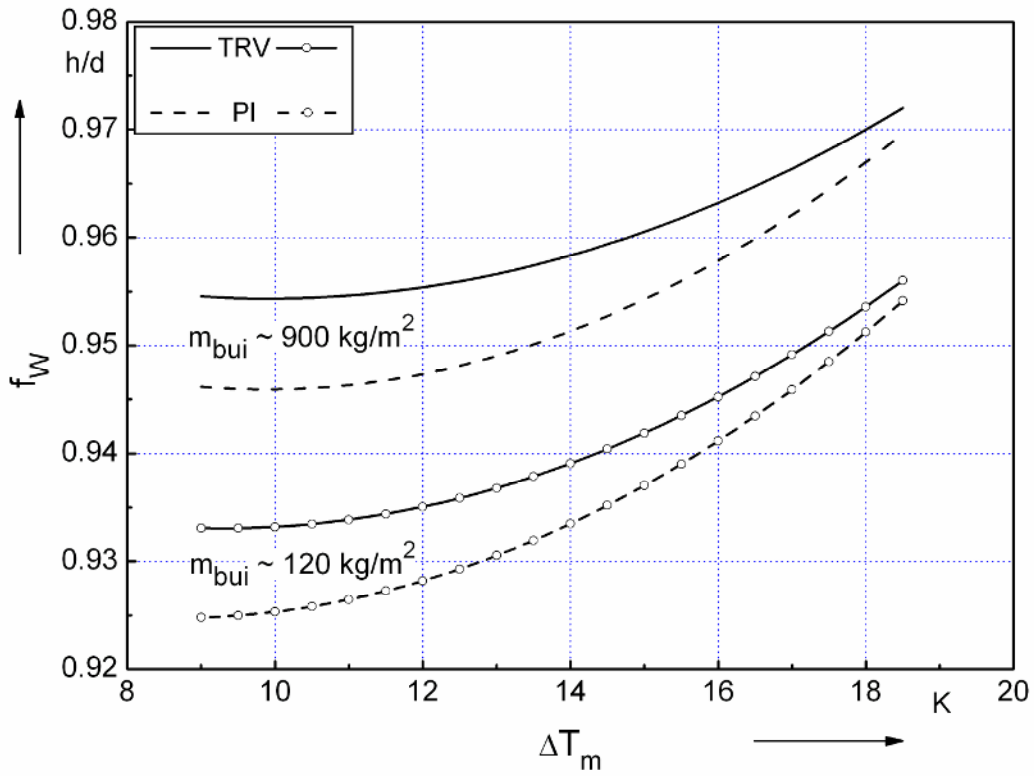


Figure D.1 — Efficiency factor for the use of window contacts; old buildings (U = 1,48 W/m²K); H-high mass building (~900 kg/m²)

NOTE The graphs were derived from the comparison of a huge number of simulation results for both cases: systems with and without window contacts.



Key

TRV = Thermostatic Radiator Valve (P-Controler)
PI = PI-Controler

Figure D.2 — Efficiency factor for the use of window contacts; new buildings (U = 0,61 W/m²K); H-high mass building (~900 kg/m²), L-low mass building (~120 kg/m²)

The factor f_{W} takes into account:

— weather conditions change during the heating period and differ about various climate zones. That is why f_{W} is affected by the average exterior temperature;

— the duration for opening a window $\Delta t_{\mathrm{win,o}}$ is dependent on exterior temperature Figure D.3 as known from measurements carried out at residential buildings [1]. In addition, EN 15242 defines a ratio of opening of a given window. The potential side effects of the use of window contacts stopping the heating which again would lead to shorter periods of opening due to much lower room temperatures or the prevention of permanent infiltration through opened windows are not considered. This is because reliable and generally accepted information about user behaviour are neither available nor standardised. That is also why it is assumed that daily time periods when windows will be opened are identical for both cases with and without window contacts;

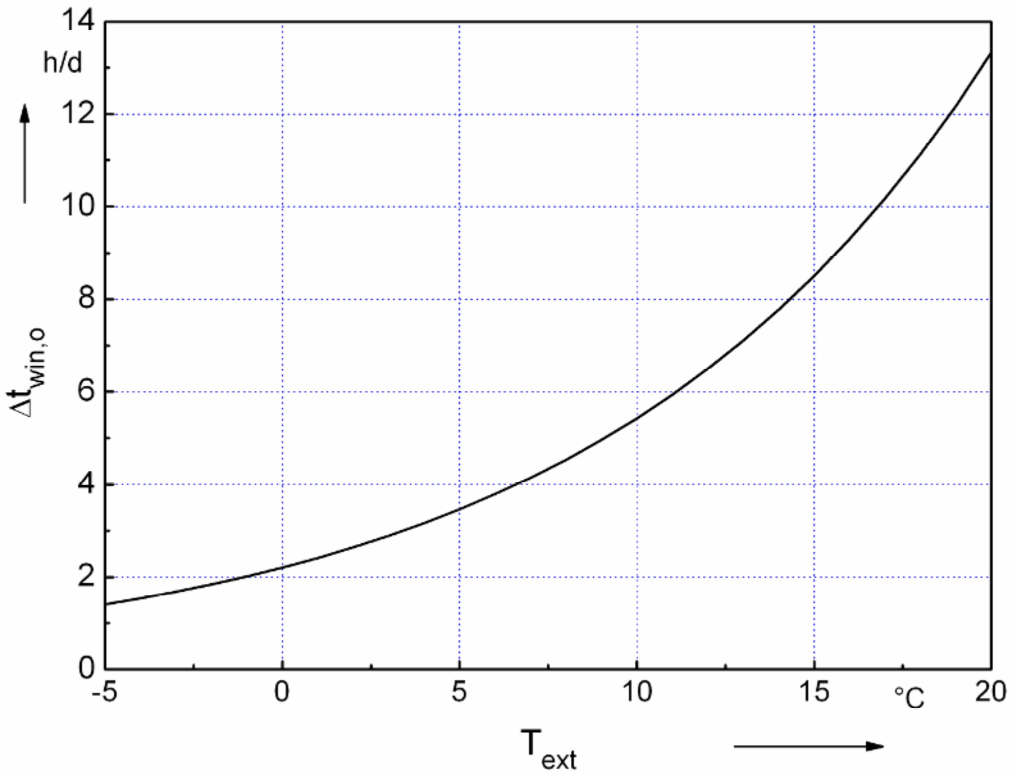


Figure D.3 — Duration of opening a window

— the air infiltration rate depends on the free cross-sectional area of an opened window. The daily profiles for ambient air infiltration rates are different for bottom hung and side hung windows;

— the infiltration rate depends on the inside-outside temperature difference;

— an individual room temperature controller is required. PI controller as well as thermostatic radiator valves have been considered. The impact of the type of individual room temperature controller on the energy saving factor f_W is less than 1 %.

D.2.3 Optimized blind and lighting control

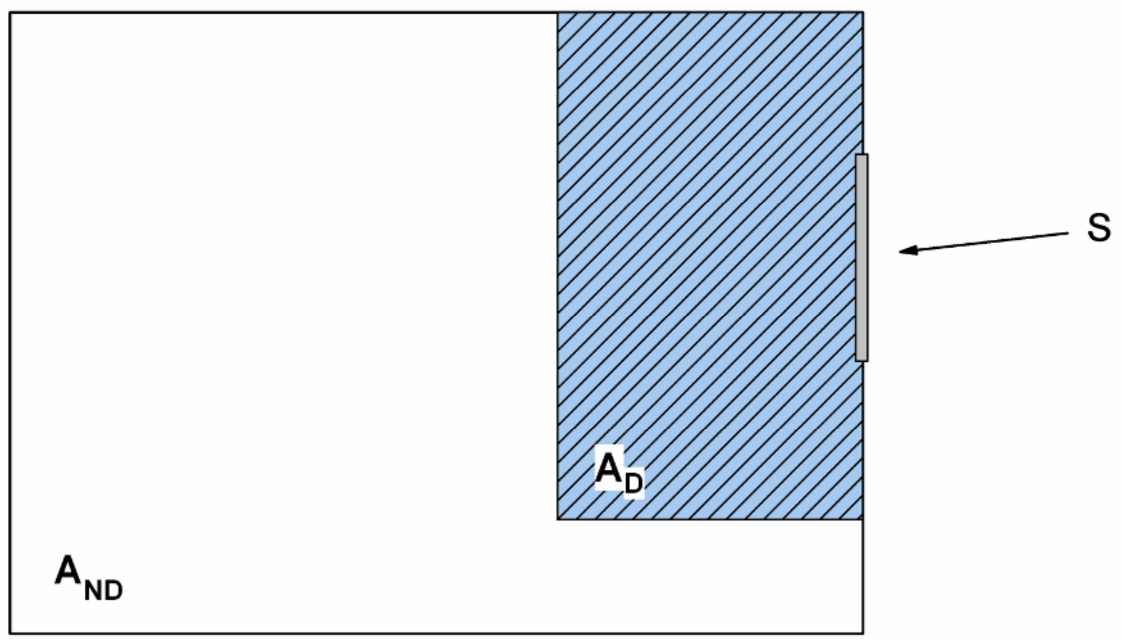
An optimized interaction of electric lighting, blind and HVAC control needs to be coordinated by a building automation system. The daylight transmission into a room is controlled to reduce electric energy consumption for artificial lighting. This is done with blinds. The application of blinds for daylight control but also has an effect on heating or cooling energy because solar energy loads are correlated to the blind's position. For this reason, the calculation procedure shall assess the efficiency of heating, cooling and lighting separately.

To estimate the impact of an integrated building automation system for blind and lighting control on the heating and cooling energy demand the solar gains and loads resulting from the blind's position have to be known. The blind control has to account for the availability of daylight as well as the part of the artificial lighting that is substitutable with day lighting. This part again can be calculated taking into account:

— operating time of artificial lights;

— specific energy consumption of lights;

— daylight efficiency as a function of shading effects of fixed external obstacles, transmittance of the windows and geometry of the room. (In a room only a part of the floor area can be provided sufficiently with daylight. The interaction of artificial lighting is therefore restricted to this limited area. For further details see Figure D.4.



Key

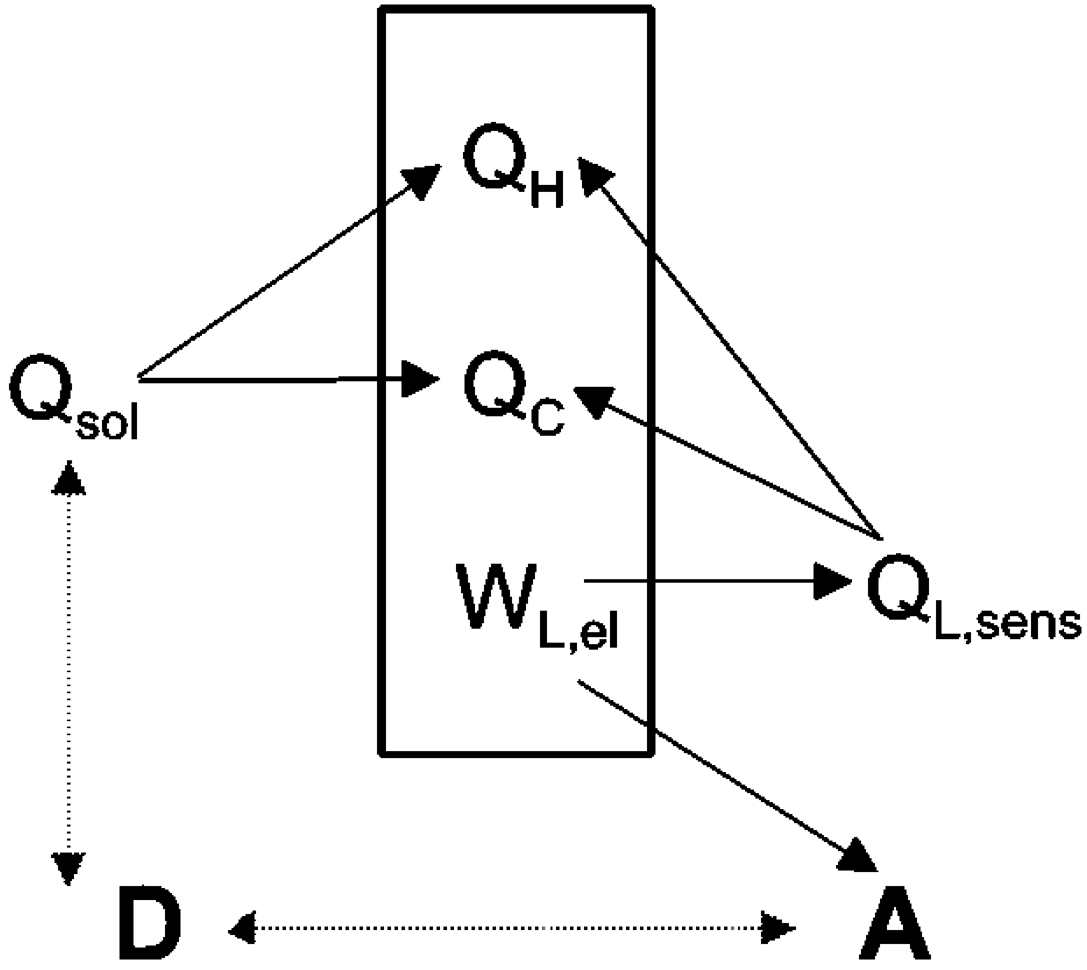
A_D floor area with impact of daylight

A_{ND} floor area with no impact of daylight

S solar

Figure D.4 — Definition of day lighting and non-day lighting areas in a room

The interaction between blind control, artificial lighting, heating and cooling is a very complex issue.



Key

A artificial light
D daylight
Q_{sol}- solar gains,
Q_H heating energy demand,
Q_C cooling energy demand,
$Q_{L,sens}$- sensible heat gains from artificial lighting,
$W_{L,el}$ electric energy demand for artificial lighting)

Figure D.5 — Interconnections between solar gains, heating, cooling and lighting energy

Therefore, in most cases it is necessary to use detailed simulation programs to get an insight into the building's energy performance. But there are also specific standardized calculation procedures available that allow to asses heating, cooling and energy demand for lighting in a building with a special regard to solar gains/loads and daylight respectively (EN 832, EN ISO 13790, EN 13791, EN 13363 etc.). Hence, only some additional advice how to handle integrated building automation and control functions for a combined blind and lighting control should be given here.

a) Heating
during the winter period solar gains are highly welcome to reduce heating demand. Artificial lighting is necessary only if the amount of daylight depending on solar radiation does not match the requirements. The impact of BACS on the energy efficiency is therefore limited to the level of accuracy the artificial lighting fits the (intermittent) demands.

b) Cooling
in case cooling is required the reduction of solar gains is a very simple method to reduce cooling energy

demand. The impact of an integrated building automation system for blind and lighting control on the cooling energy can be estimated with Equation (D.3).

$$Q_C = \eta_s Q'_C \qquad \text{(D.3)}$$

where

Q_C is the cooling energy demand (including solar gains reduced by the application of an automated shading control);

Q'_C is the cooling energy demand (including solar gains not reduced by any shading);

η_s is the utilisation ratio of solar gains depending on type of shading and its control (see Equation (D.4))

The utilisation ratio of solar gains depends on the type of shading and its control. That means the better the efficiency of the shading system the lower the utilisation ratio. It can be estimated with Equation (D.4).

$$\eta_s = 1 - \frac{Q'_{C,sol} - Q_{C,sol}}{Q'_C} \qquad \text{(D.4)}$$

where

$Q'_{C,sol}$ is the cooling energy demand due to solar gains without any shading (see Equation D.4);

$Q_{C,sol}$ is the cooling energy demand due to solar gains with shading (see Equation D.4).

On the other hand reduction of solar gains by shading devices also reduces daylight entering the room. This could demand to switch on artificial lighting which in turn produces heat gains (additional cooling demands) as well as electric energy consumption. The dependencies between solar radiation, daylight and artificial lighting may be estimated with EN 15193 or DIN V 18599/4 [2].

Normally both shading as well as lighting processes are calculated separately. Here the application of a building automation and control system offers the opportunity to optimise the control of shading devises with a special respect to the artificial lighting and its electric energy consumption. An interaction between shading and artificial lighting is therefore required. In that way, the minimisation problem (D.5) should be solved.

$$Q_{C,L} + Q_{C,sol} + W_{L,el} =! \min \qquad \text{(D.5)}$$

where

$Q_{C,L}$ is the cooling energy demand due to heat gains from artificial lighting

$Q_{C,sol}$ is the cooling energy demand due to solar gains with shading (see Equation D.4)

The part of cooling energy demand caused by solar gains is given by:

$$Q_{C,sol} = \sum_{windows} (1 - \alpha_s \cdot f_{sh}) \cdot A_W \cdot (1 - F_f) \cdot g_{eff} \qquad \text{(D.6)}$$

where

α_s is the shaded fraction of the window;

A_W is the total window area;

f_{sh} is the efficiency factor for solar shading (Table D.1);

F_f is the ratio of frame area to total window area

g_{eff} is the effective energy transmission of the window (glass).

Table D.1 — Efficiency of solar shading

$f_{sh} = 0$	No shading
$0 < f_{sh} < 1$	Variable (manual or automated) shading
$f_{sh} = 1$	Fully shaded; no solar gains

The efficiency factor for shading includes both variable shading devices as well as static shadings, i.e. overhangs or wing walls. The fraction of the window that is shaded as well as the factor for shading f_{sh} itself is depending on the sun's position and the time so that Equation (D.6) is not a constant but shall be calculated during each time step.

c) Lighting
The use of daylight reduces the electrical energy demand and also the thermal gain of the lightings. Due to the maximum use of daylight the solar energy gains are also a maximum. Therefore the shading reduces the use of daylight and over the period of a year the energy demand varies. The part of cooling energy demand due to lighting including the use of daylight is given by Equation (D.7).

$$Q_{C,L} = (1-\eta_L) \cdot p \cdot \left[A_D \cdot (t_{act,D} + t_{act,N}) + A_{ND} \cdot (t_{act,ND} + t_{act,N})\right] \quad \text{(D.7)}$$

where

η_L is the efficiency of artificial light equipment;

p is the installed power of artificial lighting in W/m²;

A_D is the floor area with impact of daylight in m²;

A_{ND} is the floor area with no impact of daylight in m²;

$t_{act,D}$ is the actual time of use of daylight in daytime in h;

$t_{act,N}$ is the actual time of use of artificial light in night time in h;

$t_{act,ND}$ is the actual time of use of artificial light in daytime (if there is not enough daylight) in h.

The terms in Equation (D.8) which contains the influence of the use of daylight are the effective time of use and the floor area with the impact of daylight. The effective time of use is given by:

$$t_{act,D} = t_{day} \cdot F_D \cdot F_P \quad \text{(D.8)}$$

with

t_{day} is the daytime (hours between sunrise and sunset);

F_D is the utilization factor of daylight;

F_P is the factor for present users in the zone.

The utilization factor of daylight depends on the orientation of the window as well as the relation of floor area with impact of daylight to the whole floor area $(A_D /(A_D + A_{ND})$. The kind of shading device as well as the shading due to overhang and wing wall shall be taken into account. That is why the effective time of use of daylight and the floor area with impact of daylight are changing each hour. The part of cooling energy demand due to solar gains and internal gains by lighting with impact of daylight each calculated by separate use of building automation system can be corrected by use of an integrated building automation system with a factor $f_{BAC,SD}$.

$$Q_{Sol.L} = \left(Q_{sol} + Q_{L,sens}\right) \cdot f_{BAC.SD} \quad \text{(D.9)}$$

As an approximation over a wide range of the variable influences with the boundary conditions

external shading device;

shading control by bus system;

minimum double glazing windows;

window height approximately 2 m (0,25 m from the ceiling – room height 3 m);

a factor $f_{BAC,SD}$ is given in Table D.2.

Table D.2 — Correction factor for BACS (Blind and lighting)

Correction factor for BACS	$f_{BAC,SD}$
integrated BACS (Blind and lighting)	0,94
Non integrated BACS (Blind and lighting)	1,00

Annex E
(informative)

Applying BACS for EMS specified in EN 16001

E.1 General

This Annex explains in greater detail 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.

E.2 Guideline for using BACS for EMS

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

Table E.1 outlines BACS options, requirements and functions use to support implementation and processing of EMS in buildings.

Table E.1 — Guideline to apply BACS for EMS

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**	
E 2.1	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;	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 EN 15232) for implementation and compliance.

	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.	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 organisation shall conduct an initial review of its energy aspects. The review of energy aspects shall be updated at predefined intervals. These reviews shall prioritise 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; 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 prioritisation of opportunities for improving energy efficiency. The organization shall maintain a register of opportunities for saving energy. Each review shall be documented.	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.: 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 programme(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 programmes 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 programme(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	The organization determines functions, tasks, roles, responsibilities, and priorities for using BACS to improve energy performance of buildings as part of EMS, including:

	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.	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 programmes; 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 behaviour 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	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.

	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 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	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

	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.	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 programme. 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	The organization considers suitable, multiplex BACS options to achieve and maintain the measurement and monitoring requirements of the EMS within buildings and specifies: An appropriate energy metering plan for buildings based on BACS to include an energy data repository for storing all types of energy data. It should include data entered at equal intervals (e.g. measured values for every 15 min, 30 min, or 60 min, etc.) and meter readings and also energy-related factors (operating times, occupancy, etc.). BACS measuring principles including calibration to ensure accuracy, high availability and reproducibility of the energy data and records.

	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 organisation shall wherever possible compare their energy performance indicators against similar organisations or situations, externally and internally.	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 traceable to the relevant activity, product or service for the established retention period.	The organization considers BACS options to achieve and maintain the control of records requirements of EMS for buildings and specifies: BACS electronic records of significant energy consumption, energy performance indicators; effectiveness of energy saving measures, before and after comparisons, etc. BACS electronic records of important messages (e.g. fault, operational status, maintenance, limit violation, etc.) of equipment with an energy impact; installation, plan, etc. BACS maintenance program with scheduled inspections and servicing of equipment with an energy impact; installation, plan etc. BACS requirements that ensure that the records are legible, identifiable, traceable and readily retrievable.
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 programme, 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 organisation 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 organisation; 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.

Annex F
(informative)

Maintain BACS energy efficiency

F.1 Introduction

This Annex describes the minimum required activities to maintain and to improve the objectives of the designed energy efficiency class of an installed BACS.

Activities:

1. maintain and improve the impact of BACS on the energy efficiency in buildings
2. upgrading the current BACS efficiency class to a higher class

F.2 Activity 1 - Maintain and improve the BACS efficiency class

F.2.1 General

The experience - based on evaluation of running BACS installations shows that most of the original commissioned features are still working but efficiency effect occur in the areas:

— changing of operational concepts;

— different building users than originally planned;

— manual changes while operating building;

— drifting of equipment (e.g. through maintenance).

F.2.2 Monitoring

Energy use and operational parameters shall frequently (e.g. every year) be evaluated and compared with previous period values taking use changes into account.

F.2.3 Operation

BACS operators and managers of them shall frequently (e.g. every year) be offered training or brush up course on how to operate and configure the installed systems.

F.2.4 Energy Efficiency

Energy production, distribution and emission equipment shall frequently (e.g. yearly) be evaluated in regard to operations and energy use. The evaluations shall invoke changes in the operations and tuning of the system.

F.2.5 Modernizations, Upgrades and new Technologies

Upgrade capabilities and modernizations in order to maximize efficiency, operational methods and potential new technologies shall frequently (e.g. yearly) be considered in order to maintain / improve energy efficiency.

F.3 Activity 2 – Upgrading of the BACS efficiency class

F.3.1 General

Four different BACS efficiency classes (A, B, C, D) of the BACs and TBM functions are defined in 5.3 either for non–residential or residential building. The Functions are described and summarised in 5.2, Table 1. Their assignment to the BACS efficiency classes are listed in 5.4, Table 2.

Activity 2 describes the following procedures:

— Identify the current BACS efficiency class of an installed BACS (e.g. D, C, B, A)

— upgrading the current BACS efficiency class to a higher class (e.g. from D->C, C->B, B->A).

F.3.2 Procedure for meeting an BACS efficiency class

— Procedure to identify the current BACS efficiency class:

1. Functions relevant to installed BACS are checked of "+ "in column 1

2. The processing function has to be selected for each relevant function. It is marked by an "X" in column 1.

3. Draw a vertical line on the right-hand side of the lowest classification column (shaded part) of the selected processing functions. Afterwards, the line shows on the right side the installed BACS efficiency class.

— Procedure to upgrade the current BACS efficiency class to a higher class and to determine their requirements.

1. Functions relevant to installed BACS are checked of "+ "in column 1

2. Draw a vertical line on the right-hand side of the classification columns (shaded part) of the processing functions. The line has to reach all shaded parts.

3. The processing function has to be selected for each relevant function. It is marked by an "X" in column 1.

Example: Determine the requirements of the BACS efficiency class "B" for a Single-room store.

The non-residential building contains an open one-room store that is air-conditioned using a central air handling unit. Heating and cooling occurs on the airside using heat transfer water/air.

Procedure:

1. Determine the relevant functions to Single-room and marked it by "+ " in column 1

2. Draw a line on the right side of the column for the BACS efficiency class "B in Table 1

3. Select for each relevant function the processing functions concerned to class "B and marked it by a "X"

The result is shown in Table F 1.

Table F.1 — Requirements of the BACS efficiency class "B" for a Single-room store

Column 1

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 control								
		2	Time control								
X		3	Presence control								
		4	Demand control								
+	4.2	Air flow or pressure control at the air handler level									
		0	No automatic control								
		1	On off time control								
X		2	Multi-stage control								
		3	Automatic flow or pressure control with or without pressure reset								
+	4.3	Heat recovery exhaust air side icing protection control									
		0	Without defrost control								
X		1	With defrost control								
+	4.4	Heat recovery control (prevention of overheating)									
		0	Without overheating control								
X		1	With overheating control								
+	4.5	Free mechanical cooling									
		0	No automatic control								
		1	Night cooling								
X		2	Free cooling								
		3	H,x- directed control								
+	4.6	Supply air Temperature control									
		0	No automatic control								
		1	Constant set point								
X		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: supply air or room air								
		2	Direct humidity control: supply air								
		3	Direct humidity control: room air								

Annex G
(informative)

Control accuracy

Values of the control accuracy are given in the following Table G.1:

Table G.1 — Control accuracy

	Standard	Control accuracy $\delta\theta_{vt}$ (K)	
		Heating	Cooling
Direct electric emitter with built in controller	EN 60675	0,9	
Thermostatic radiator valve	EN 215	0,45*(hysteresis+ water temperature effect)	
Individual zone control equipment	EN 15500:2008	Cah defined in the standard and certified	Cac defined in the standard and certified
Other controller if emission can be totally stopped	No standard	1,8	1,8
Other controllers if emission can not be totally stopped	No standard	2	2

NOTE 1 EN 15316-2-1:2007 defines also a method using efficiency factor in 7.1.

NOTE 2 Set points for heating and cooling should be configured so that there is always a minimum dead band between heating and cooling.

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