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Energy performance of buildings — Contribution of building automation, controls and building management —

Part 1: General framework and procedures

Performance énergétique des bâtiments — Contribution de l'automatisation, de la régulation et de la gestion technique des bâtiments —

Partie 1: Cadre général et procédures

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 205, *Building environment design*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 247, *Building Automation, Controls and Building Management,* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

A list of all parts in the ISO 52120 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document belongs to the family of standards aimed at international harmonization of the methodology for the assessment of the energy performance of buildings. Throughout, this group of standards is referred to as a set of called “EPB set of standards”.

All EPB standards follow specific rules to ensure overall consistency, unambiguity and transparency. This document is clearly identified in the modular structure developed to ensure a transparent and coherent set of EPB standards, as set out in ISO 52000-1, the overarching EPB standard. BAC (building automation and control) is identified in the modular structure as technical building system M10. However, other International Standards issued by ISO TC 205 deal with control accuracy, control functions and control strategies using standards communications protocol (these last standards do not belong to the set of EPB standards).

To avoid a duplication of calculation due to the BAC (avoid double impact), no calculation is done in a BAC EPB standard set, but in each underlying standard of the set of EPB standards (from M1 to M9 in the modular structure), an identifier developed and present in the M10 covered by this document is used where appropriate. This way of interaction is described in detail in ISO/TR 52000-2, the Technical Report accompanying ISO 52000-1. As consequence, the concept of a normative template for specific (national) choices in Annex A, and Annex B with informative default choices, as commonly used in the set of EPB standards is not applicable for this document.

The main target groups of this document are all the users of the set of EPB set of standards (e.g. architects, engineers, regulators).

Further target groups are parties wanting to motivate their assumptions by classifying the building energy performance for a dedicated building stock.

More information is provided in the Technical Report accompanying this document (ISO/TR 52120-2[5]).

NOTE 1 Table 1 shows the relative position of this document within the set of EPB standards in the context of the modular structure as set out in ISO 52000-1.

NOTE 2 In ISO/TR 52000-2 the same table can be found, with, for each module, the numbers of the relevant EPB standards and accompanying technical reports that are published or in preparation.

NOTE 3 The modules represent EPB standards, although one EPB standard can cover more than one module and one module can be covered by more than one EPB standard, for instance a simplified and a detailed method respectively. See also Clause 2 and Tables A.1 and B.1.

Table 1 — Position of this document (in casu M10–4,5,6,7,8,9,10), within the modular structure of the set of EPB standards

	Over-arching	**Building (as such)**	**Technical building system**									
Submodule	**Descriptions**	**Descriptions**	**Descriptions**	**Heating**	**Cooling**	**Ventilation**	**Humidification**	**Dehumidification**	**Domestic hot waters**	**Lighting**	**Building automation and control**	**PV, wind, etc.**
sub1	**M1**	**M2**		**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**	**M11**
1	General	General	General									
a The shaded modules are not applicable.												

Table 1 *(continued)*

	Over-arching	Building (as such)	Technical building system									
Submodule	Descriptions	Descriptions	Descriptions	Heating	Cooling	Ventilation	Humidification	Dehumidification	Domestic hot waters	Lighting	Building automation and control	PV, wind, etc.
sub1	M1	M2		M3	M4	M5	M6	M7	M8	M9	M10	M11
2	Common terms and definitions; symbols, units and subscripts	Building energy needs	Needs									
3	Application	(Free) indoor conditions without systems	Maximum load and power									
4	Ways to express energy performance	Ways to express energy performance	Ways to express energy performance								x	
5	Building functions and building boundaries	Heat transfer by transmission	Emission and control								x	
6	Building occupancy and operating conditions	Heat transfer by infiltration and ventilation	Distribution and control								x	
7	Aggregation of energy services and energy carriers	Internal heat gains	Storage and control								x	
8	Building partitioning	Solar heat gains	Generation and control								x	
9	Calculated energy performance	Building dynamics (thermal mass)	Load dispatching and operating conditions								x	
10	Measured energy performance	Measured energy performance	Measured energy performance								x	
11	Inspection	Inspection	Inspection									
12	Ways to express indoor comfort		BMS									
13	External environment conditions											
14[a]	Economic calculation											

[a] The shaded modules are not applicable.

Energy performance of buildings — Contribution of building automation, controls and building management —

Part 1: General framework and procedures

1 Scope

This document specifies:

— a structured list of control, building automation and technical building management functions which contribute to the energy performance of buildings; functions have been categorized and structured according to building disciplines and building automation and control (BAC);

— a method to define minimum requirements or any specification regarding the control, building automation and technical building management functions contributing to energy efficiency of a building to be implemented in building of different complexities;

— a factor-based method to get a first estimation of the effect of these functions on typical buildings types and use profiles;

— detailed methods to assess the effect of these functions on a given building.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

ISO 50001:2018, *Energy management systems — Requirements with guidance for use*

ISO 52000-1:2017, *Energy performance of buildings — Overarching EPB assessment — Part 1: General framework and procedures*

ISO 7345:2018, *Thermal performance of buildings and building components — Physical quantities and definitions*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 7345:2018, ISO 52000-1:2017 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
auxiliary energy
electrical energy used by *technical building systems* (3.14) to support energy transformation to satisfy energy needs

Note 1 to entry: This includes energy for fans, pumps, electronics, etc. Electrical energy input to the ventilation system for air transport and heat recovery is not considered as auxiliary energy, but as energy used for ventilation.

Note 2 to entry: In ISO 9488 the energy used for pumps and valves is called "parasitic energy".

[SOURCE: ISO 13612-2:2014, 3.3, modified — Note 3 to entry was removed.]

3.2
building automation and control
BAC
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

[SOURCE: ISO 52000-1:2017, 3.4.4, modified — The term BAC was added.]

3.3
building automation and control system
BACS
system, comprising all products, software 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 to entry: BACS is also referred to as BMS (building management system).

Note 2 to entry: The use of the word 'control' does not imply that the system or device is restricted to *control functions* (3.5). Processing of data and information is possible.

Note 3 to entry: If a building control system, *building management* (3.4) system, or building energy management system complies with the requirements of the ISO 16484 series, it should be designated as a building automation and control system (BACS).

Note 4 to entry: Building services are divided in technical, infrastructural and financial building services and energy management is part of *technical building management* (3.13).

Note 5 to entry: Building energy management system is part of a BMS.

Note 6 to entry: The building energy management system comprises 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* (3.14), as well as optimize energy usage and reducing its cost.

[SOURCE: ISO 16484-2:2004, 3.31, modified — Notes to entry 1, 4, 5 and 6 have been added.]

3.4
building management
BM
totality of services involved in the management operation and monitoring of buildings (including plants and installations)

Note 1 to entry: Building management can be assigned as part of facility management.

[SOURCE: CEN/TS 15379:2009, 3.4, modified – Second part of the definition became Note 1 to entry.]

3.5
control function
BAC (3.2) effect of programs and parameters

Note 1 to entry: BAC functions are referred to as control functions, I/O, processing, optimization, management and operator functions. They are listed in the BAC FL (function list) for a specification of work.

Note 2 to entry: 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 as described in EN 61131–3.

3.6
delivered energy
energy, expressed per *energy carrier* (3.7), supplied to the *technical building systems* (3.14) through the assessment boundary, to satisfy the uses taken into account or to produce the exported energy

Note 1 to entry: Delivered energy can be calculated for defined energy uses or it can be measured.

[SOURCE: ISO 52000-1:2017, 3.4.6]

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

[SOURCE: ISO 52000-1:2017, 3.4.9]

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

Note 1 to entry: The energy need can include additional heat transfer resulting from non-uniform temperature distribution and non-ideal temperature control, if they are taken into account by increasing (decreasing) the effective temperature for heating (cooling) and not included in the heat transfer due to the heating (cooling) system.

[SOURCE: ISO 52000-1:2017, 3.4.13, modified — Note 1 to entry added and the term was originally "energy need for heating or cooling".]

3.9
energy efficiency
ratio or other quantitative relationship between an output of performance, service, goods or energy, and an input of energy

EXAMPLE Efficiency conversion; energy required/energy used; output/input; theoretical energy used to operate/energy used to operate.

Note 1 to entry: Both input and output need to be clearly specified in quantity and quality, and be measurable.

[SOURCE: ISO 50001:2018, 3.5.3, modified — "commodities" was removed from the definition and the example has been modified.]

3.10
integrated function
BAC (3.2) effect of programs, shared data points and parameters for multi-discipline interrelationships between various building services and technologies

3.11
measured energy performance
energy performance based on measured amounts of delivered and exported energy

Note 1 to entry: The measured rating is the weighted sum of all *energy carriers* (3.7) used by the building, as measured by meters or derived from measured energy by other means. It is a measure of the in-use performance of the building after correction or extrapolation. This is particularly relevant to certification of actual energy performance.

Note 2 to entry: Also known as “operational rating”.

[SOURCE: ISO 52000-1:2017, 3.5.16, modified — "weighted measured amounts" has been replaced by "measured amounts" in the definition and "energy performance" has been replaced by "rating".]

3.12
thermally activated building system
TABS
massive building fabric actively heated or cooled by integrated air- or water-based systems

3.13
technical building management
TBM
process(es) and services related to operation and management of buildings and *technical building system* (3.14) through the interrelationships between the different disciplines and trades

Note 1 to entry: 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 services, including communications and maintenance and to management.

[SOURCE: ISO 52127-1:2021, 3.2]

3.14
technical building system
technical equipment for heating, cooling, ventilation, humidification, dehumidification, domestic hot water, lighting and electricity production

Note 1 to entry: A technical building system can refer to one or to several building services (e.g. heating, heating and DHW).

Note 2 to entry: A technical building system is composed of different subsystems.

Note 3 to entry: Electricity production can include cogeneration and photovoltaic systems.

[SOURCE: ISO 52000-1:2017, 3.3.13, modified — The phrase "building automation and control" was deleted from the definition.]

3.15
EPB standard
standard that complies with the requirements given in ISO 52000-1, CEN/TS 16628 and CEN/TS 16629

Note 1 to entry: These three basic EPB documents were developed under a mandate given to CEN by the European Commission and the European Free Trade Association (Mandate M/480), and support essential requirements of EU Directive 2010/31/EC on the energy performance of buildings (EPBD). Several EPB standards and related documents are developed or revised under the same mandate. CEN/TS 16628[5] and CEN/TS 16629[6] are available as N-documents in ISO/TC 163 and ISO/TC 205.

[SOURCE: ISO 52000-1:2017, 3.5.14, modified — The last sentence of the Note 1 to entry has been added.]

4 Symbols, subscripts and abbreviated terms

4.1 Symbols

For the purposes of this document, the symbols given in ISO 52000-1 and Table 2 apply.

Table 2 — Symbols

Symbol	Quantity	Unit
a	normalized level, e.g. occupancy or gains	-
$\bar{\beta}$	mean part load	-
Φ	heat flow rate, thermal power	kW

4.2 Subscripts

For the purposes of this document, the subscript given in ISO 52000-1:2017, Clause 4 and Annex C and the specific subscripts listed in Table 3 apply.

NOTE Relevant subscripts already given in ISO 52000-1 are included if necessary for the understanding of this document.

Table 3 — Subscripts

Subscript	Term	Subscript	Term	Subscript	Term
amb	ambient	end	end	th	thermal
BAC	building automation and control	r	room	trans	transfer
cor	correction	ref	reference		
ctr	control	set	setpoint		
DHW	domestic hot water	sta	start		

4.3 Abbreviated terms

For the purposes of this document, the abbreviated terms given in ISO 52000-1 and Table 4 apply.

Table 4 — Abbreviated terms

AHU	air handling unit
BAC	building automation and control
BM	building management
COP	coefficient of performance
DHW	domestic hot water
HVAC	heating, ventilation and air conditioning
TABS	thermally activated building systems
TBM	technical building management
VFD	variable flow dependant
VRF	variable room flow

5 Description of the method

5.1 Output of the method

This document describes two methods of how to calculate the contribution of building automation and controls to the energy performance of buildings. The two methods are the following.

— The detailed method: output of the detailed method is a list of automation, control and management function types that is used to run a detailed calculation of building energy performance based on other EPB standards. In addition, the detailed method would also allow classification of a building automation and control system according to a set of criteria defined in this document. There is no limitation regarding the time interval.

— The factor-based method: output of the factor-based method is the energy demand of a building according to a given building automation and control classification. The time interval of the output is a yearly step.

5.2 General description of the method(s)

Two methods are given:

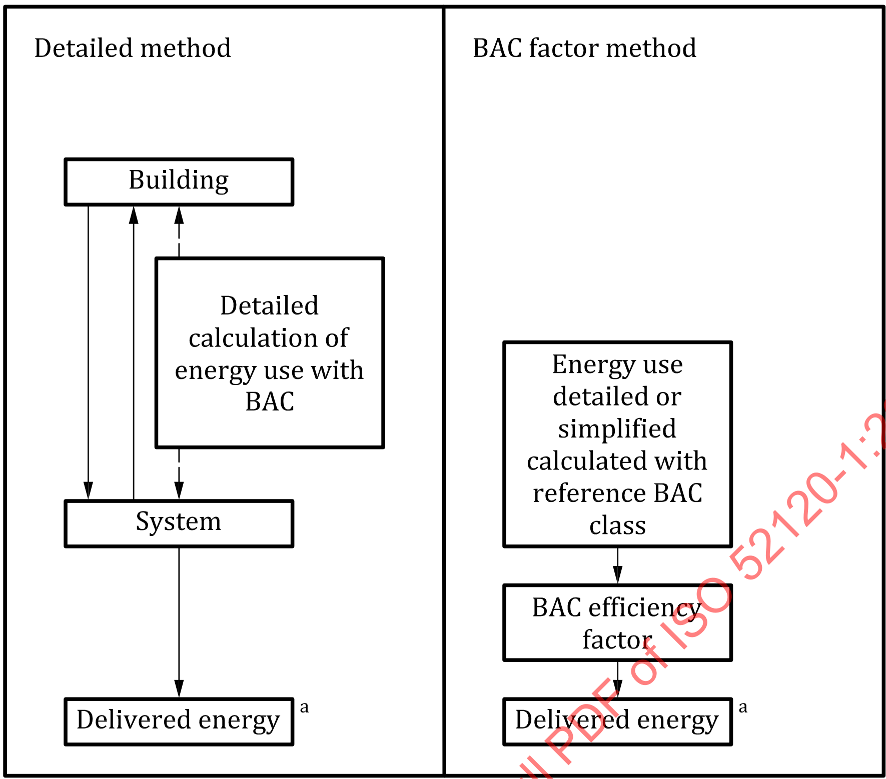
— method 1, defined in Clause 6, is meant for a detailed energy performance analysis of a building in case detailed information about the building, the HVAC systems and especially the type of automation, control and management functions are available that can be applied in a holistic EPB calculation method;

— method 2, defined in Clause 7, is intended for easily calculating a rough estimate of the impact of building automation, control and management on the energy performance of a building based on a given energy performance (either a consumption metered, or a demand calculated) correlated to a certain BAC efficiency classification of the building.

In this document, "factor-based method" is exemplified by "BAC factor method".

5.3 Selection criteria between the methods

For the calculation of the impact of building automation, control and management functions on the building energy performance the detailed method is method 1 in this document. Figure 1 illustrates how to use the detailed method compared to the simplified BAC factor method.



a Delivered energy is the total energy, expressed per energy carrier (gas, oil, electricity etc.) used for heating, cooling, ventilation, domestic hot water or lighting.

NOTE Arrows illustrate only the calculation process and do not represent energy and/or mass flows.

Figure 1 — Detailed method in comparison with BAC 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 accounted for the operation of a building and its energy systems are known. Clause 6 gives a general survey of those functions and describes how to use them in the context of energy performance calculations.

5.4 BAC and TBM functions having an impact on the energy performance of buildings

Building automation and control (BAC) provide effective control functions for any building energy system, for example, heating, ventilating, cooling, hot water and lighting appliances, 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) and provides information about operation, maintenance, services and management of buildings, especially for energy management, e.g. measurement, recording trending, and alarming capabilities and diagnosis of unnecessary energy use. Energy management provides requirements for documentation, controlling, monitoring, optimization, determination and to support corrective action and preventive action to improve the energy performance of buildings. This document can be used to evaluate the contribution of these building management functions to the energy performance of buildings.

The BAC functions described in Table 5 are based on the energy demand and supply model for a building in Figure 2.

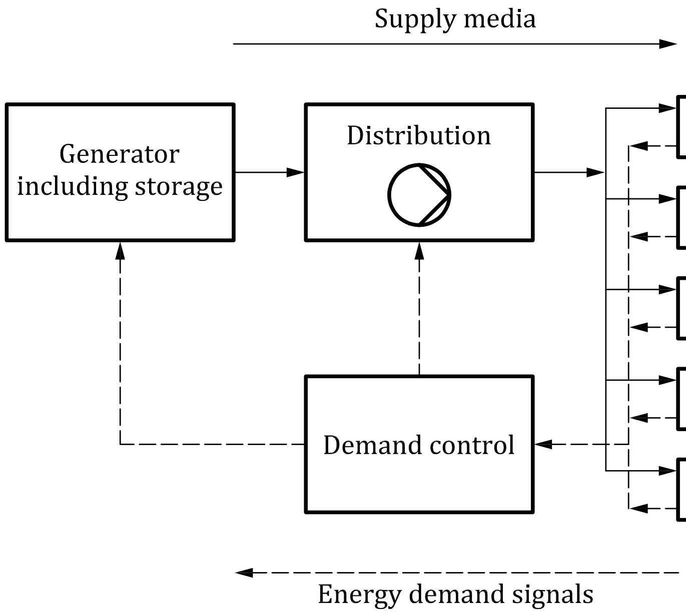


Figure 2 — Energy demand and supply model (example: heating plant)

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. Local regulations can specify minimum or maximum requirements.

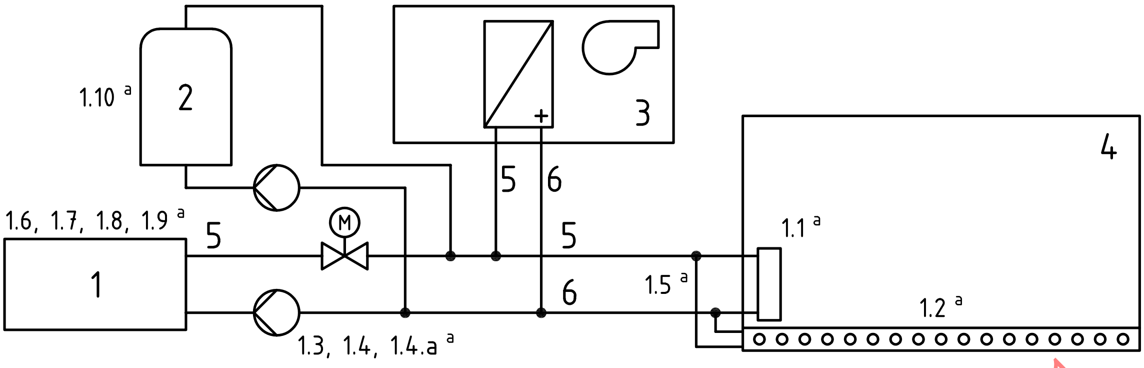
Supply media is provided to the consumer according to energy demand keeping losses in distribution and generation to an absolute minimum.

The building automation and control functions described in Table 5 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.

The most common BAC and TBM functions having an impact on the energy performance of buildings have been described and summarized in Table 5.

Figures 3 to 7 illustrate basic system designs for heating, domestic hot water, cooling, ventilation and air conditioning purposes. The numbers refer to the control functions summarized in Table 5. These basic elements can be combined to more or less complex systems that also account for local, regional or national specifics. The building automation and control functions defined in Table 5 are according to these basic system designs. Air side system control of HVAC shall be treated as ventilation and air-conditioning control, separately from heat generators, chillers, terminal units and water and refrigerant side controls.

Annex D provides examples of how to use the BAC function list of ISO 16484-3 to describe functions from this document. In addition, Annex G gives informative control accuracy requirements.



Key

1 heat generator

2 thermal energy storage

3 air handling unit

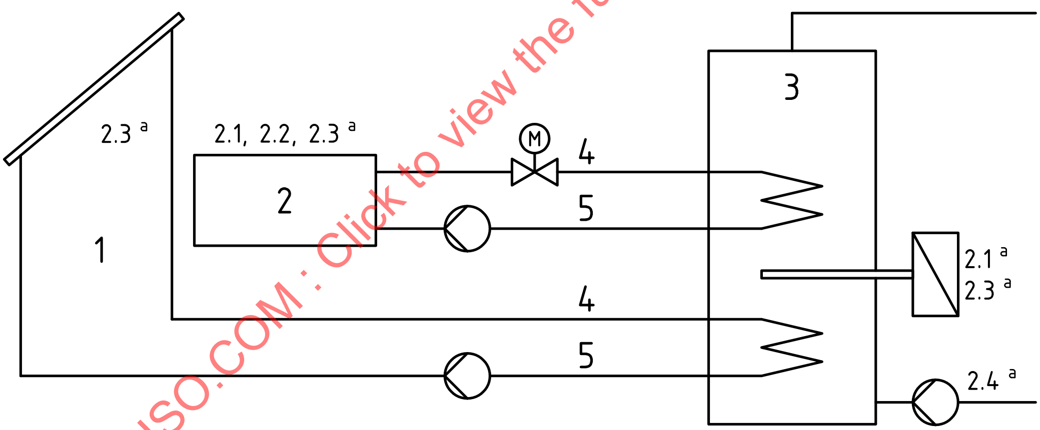
4 room

5 heating water supply

6 heating water return

a These numbers refer to the numbers in Table 5.

Figure 3 — Space heating system



Key

1 solar collector

2 boiler/district heating heat pump

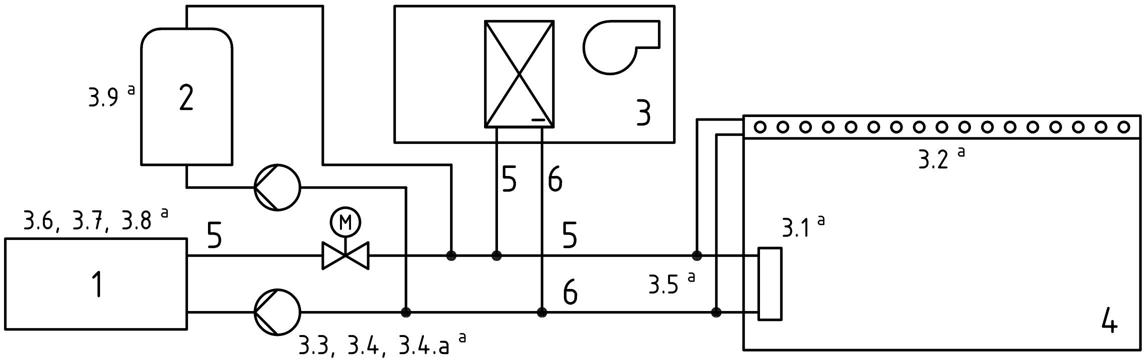
3 domestic hot water storage

4 heating water supply

5 heating water return

a These numbers refer to the numbers in Table 5.

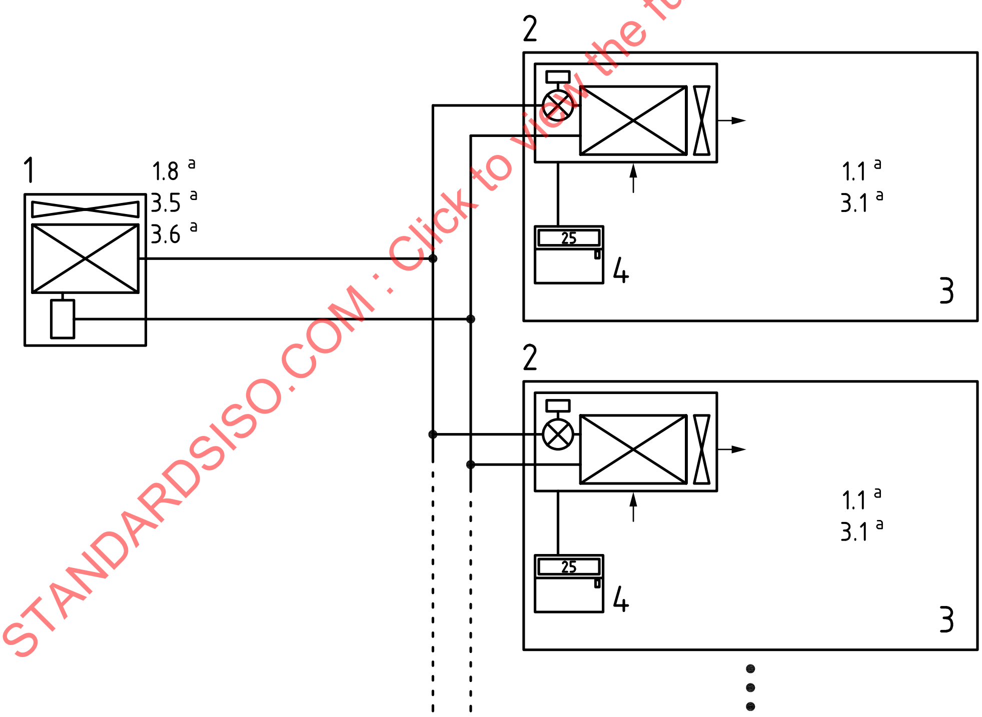
Figure 4 — Domestic hot water heating system



Key

1 chiller
2 thermal energy storage
3 air handling unit
4 room
5 chilled water supply
6 chilled water return
a These numbers refer to the numbers in Table 5.

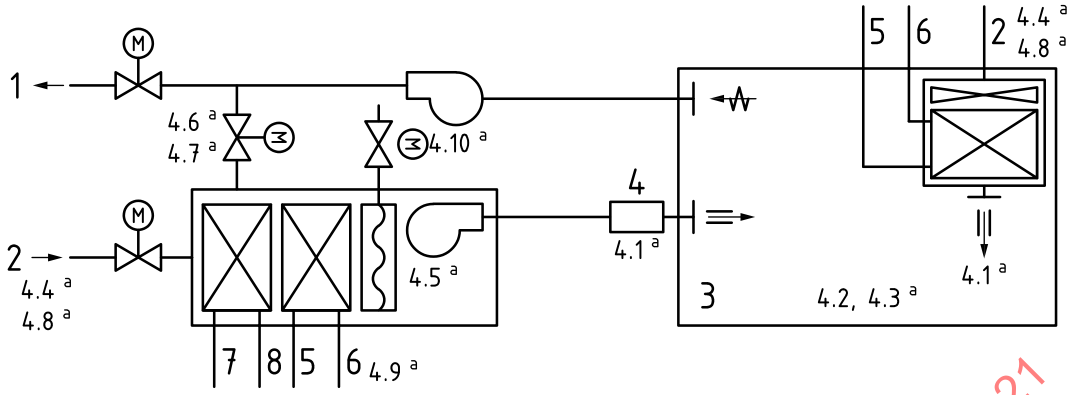
Figure 5 — Cooling system



Key

1 outdoor unit
2 indoor unit
3 room
4 controller
a These numbers refer to the numbers in Table 5.

Figure 6 — Split system/VRF (heating and/or cooling)



Key

1 exhaust air
2 outside air
3 room
4 variable air volume
5 chilled water supply
6 chilled water return
7 heating water supply
8 heating water return
[a] These numbers refer to the numbers in Table 5.

Figure 7 — Ventilation and air-conditioning system

Table 5 — BAC and TBM functions having an impact on the energy performance of buildings

Automatic control			
1	Heating control		
1.1	Emission control	HEAT_EMIS_CTRL_DEF	M3–5
		The control function is applied to the heat emitter (radiators, underfloor heating, fan-coil unit, indoor unit) at room level; for type 1, one function can control several rooms.	
	0	No automatic control of the room temperature	
	1	Central automatic control: there is only central automatic control acting either on the distribution or on the generation. Function is to be integrated in a system.	
	2	Individual room control: by thermostatic valves or electronic controller	
	3	Individual modulating room control with communication: between controllers and BACS (e.g. scheduler, room temperature setpoint)	
	4	Individual modulating room control with communication and occupancy detection: between controllers and BACS; demand control/occupancy detection (this function level is usually not applied to any slow reacting heat emission systems with relevant thermal mass, e.g. floor heating, wall heating)	
1.2	Emission control for TABS (heating mode)	HEAT_EMIS_CTRL_TABS	M3–5
	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 dependent on the filtered outside temperature, e.g. the average of the previous 24 h.	

Table 5 *(continued)*

Automatic control			
	2	Advanced central automatic control: this is a central automatic control of the TABS zone that is designed and tuned to achieve an optimal self-regulating of the room temperature within the required comfort range (specified by the room temperature heating set-point). "Optimal" means that the room temperatures of all rooms of the TABS zone remain during operation periods in the comfort range to meet comfort requirements, but also the temperatures are as low as possible to reduce the energy demand for heating.	
	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 h on/off cycle time - or with a slow frequency, corresponding to 24 h on/off cycle time. If the TABS is used for cooling, intermittent operation with 24 h 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 reacts 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)	HEAT_DISTR_CTRL_TMP	M3–6
		A similar function can be applied to the control of direct electric heating networks.	
	0	No automatic control	
	1	Outside temperature compensated control: actions generally lower the mean flow temperature.	
	2	Demand based control: for example. based on indoor temperature control variable, actions generally lower the mean flow temperature.	
1.4	Control of distribution pumps in networks	HEAT_DISTR_CTRL_PMP	M3–6
		The controlled pumps can be installed at different levels in the network. Control means to reduce the auxiliary energy demand of the pumps.	
	0	No automatic control	
	1	On/off control: switch on and off automatically, pumps run with no control at maximum speed.	
	2	Multi-stage control: speed of pumps is controlled by a multi-step control.	
	3	Variable speed pump control: constant or variable Δp based on pump unit (internal) estimations.	
	4	Variable speed pump control: variable Δp following an external demand signal, e.g. hydraulic requirements.	
1.4.a	Hydronic balancing heating distribution (including contribution to the balancing to the emission side)	HEAT_DISTR_CTRL _HYDR	M3–6
		Hydronic balancing is applied to an emitter or a group of heat emitters greater than 10.	
	0	No balancing	

Table 5 *(continued)*

Automatic control			
	1	Balanced statically per emitter, without group balance	
	2	Balanced statically per emitter, and a static group balance (e.g. with balancing valve)	
	3	Balanced statically per emitter and dynamic group balance (e.g. with differential pressure control)	
	4	Balanced dynamically per emitter (e.g. differential pressure controllers)	
1.5	Intermittent control of emission and/or distribution	HEAT_DISTR_CTRL	M3–5 / M3–6
		One controller can control different rooms/zones having same occupancy patterns.	
	0	No automatic control	
	1	Automatic control with fixed time program: to lower the operation time	
	2	Automatic control with optimum start/stop: to lower the operation time NOTE This can be achieved, for example, by an outside-temperature compensated controller conforming to EN 12098–1, EN 12098–3 or by an optimized start-stop scheduler conforming to EN 12098-5; one system can control several rooms.	
	3	Automatic control with demand evaluation: to lower the operation time	
1.6	Heat generator control for combustion and district heating	HEAT_GEN_CTRL_CD	M3–8
		The goal consists generally in minimizing the heat generator operation temperature.	
	0	Constant temperature control	
	1	Variable temperature control depending on outside temperature	
	2	Variable temperature control depending on the load: e.g. depending on supply water temperature setpoint	
1.7	Heat generator control (heat pump)	HEAT_GEN_CTRL_HP	M3–8
		The goal consists generally in minimizing the heat generator operation temperature and by doing this maximizing the heat generator efficiency.	
	0	Constant temperature control	
	1	Variable temperature control depending on outside temperature.	
	2	Variable temperature control depending on the load: e.g. depending on supply water temperature setpoint	
1.8	Heat generator control (outdoor unit)	HEAT_GEN_CTRL_OU	M3–8
		The goal consists generally in maximizing the heat generator efficiency.	
	0	On/off-control of heat generator	
	1	Multi-stage control of heat generator capacity depending on the load or demand (e.g. on/off of several compressors)	
	2	Variable control of heat generator capacity depending on the load or demand (e.g. hot gas bypass, inverter frequency control)	
1.9	Sequencing of different heat generators	HEAT_GEN_CTRL_SEQ	M3–8
		This control function only applies to a system with a set of different heat generator sizes or types including renewable energy sources.	
	0	Priorities are only based on running time.	
	1	Control according to fixed priority list: e.g. heat pump prior to hot water boiler	
	2	Control according to dynamic priority list (based on current efficiency and capacity of generators, e.g. solar, geothermal heat, cogeneration plant, fossil fuels).	
	3	Control according to prediction based dynamic priority list (based on current efficiency and capacity of generators, e.g. solar, geothermal heat, cogeneration plant, fossil fuels)	

Table 5 *(continued)*

Automatic control			
1.10	Control of thermal energy storage (TES) charging	HEAT_TES_CTRL	M3–7
		The TES is part of the heating system.	
	0	Continuous storage operation	
	1	2-sensor charging of storage	
	2	Load-prediction based storage operation	
2	Domestic hot water supply control		
2.1	Control of DHW storage charging with direct electric heating or integrated electric heat pump	DHW_STRG_CTRL_EL	M8–7 / M8–8
	0	Automatic on/off control	
	1	Automatic on/off control and scheduled charging enable	
	2	Automatic on/off control and scheduled charging enable and multi-sensor storage management	
2.2	Control of DHW storage charging using hot water generation	DHW_STRG_CTRL_HG	M8–7 / M8–8
	0	Automatic on/off control	
	1	Automatic on/off control and scheduled charging enable	
	2	Automatic on/off control, scheduled charging enable and demand-based supply temperature control or multi-sensor storage management	
2.3	Control of DHW storage charging with solar collector and supplementary heat generation	DHW_STRG_CTRL_SOL	M8–7 / M8–8
	0	Manual control	
	1	Automatic control of solar storage charge (Prio. 1) and supplementary storage charge (Prio. 2)	
	2	Automatic control of solar storage charge (Prio. 1) and supplementary storage charge (Prio. 2) plus demand-based supply temperature control or multi-sensor storage management	
2.4	Control of DHW circulation pump	DHW_CIRC_CTRL	M8–6
	0	No control, continuous operation	
	1	With time program	
3	Cooling control		
3.1	Emission control	CLG_EMIS_CTRL_DEF	M4–5
		The control function is applied to the emitter (cooling panel, fan-coil unit or indoor unit) at room level; for type 1, one function can control several rooms.	
	0	No automatic control of the room temperature	
	1	Central automatic control: there is only the central automatic control acting either on the distribution or on the generation. .	
	2	Individual room control: by thermostatic valves or electronic controller	
	3	Individual modulating room control with communication: between controllers and BACS (e.g. scheduler, room temperature setpoint)	
	4	Individual modulating room control with communication and occupancy detection: between controllers and BACS; demand control/occupancy detection (this function level is usually not applied to any slow reacting cool emission systems with relevant thermal mass, e.g. floor cooling).	
3.2	Emission control for TABS (cooling mode)	CLG_EMIS_CTRL_TABS	M4–5

Table 5 *(continued)*

Automatic control				
	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 dependent on the filtered outside temperature, e.g. the average of the previous 24 h.		
	2	Advanced central automatic control: this is a central automatic control of the TABS zone that is designed and tuned to achieve an optimal self-regulating of the room temperature within the required comfort range (specified by the room temperature 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.		
	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 h on/off cycle time - or with a slow frequency, corresponding to 24 h on/off cycle time. If the TABS is used for cooling, intermittent operation with 24 h 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 reacts 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 chilled water temperature (supply or return)		CLG_DISTR_CTRL_TMP	M4–6
		A 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: actions generally raise the mean flow temperature.		
	2	Demand-based control: e.g. based on indoor temperature control variable, actions generally raise the mean flow temperature.		
3.4	Control of distribution pumps in hydraulic networks		CLG_DISTR_CTRL_PMP	M4–6
		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: constant or variable Δp based on pump unit (internal) estimations to reduce the auxiliary energy demand of the pumps		
	4	Variable speed pump control: variable Δp following an external demand signal, e.g. hydraulic requirements, ΔT, energy optimization to reduce the auxiliary energy demand of the pumps		

Table 5 *(continued)*

Automatic control				
3.4.a	Hydronic balancing cooling distribution (including contribution to the balancing on the emission side)		CLG_DISTR _CTRL _HYDR	M4–6
		Hydronic balancing is applied to a group of cooling emitters (cooling panel, fan-coil unit or indoor unit) greater than 10.		
	0	No balancing		
	1	Balanced statically per emitter, without group balance		
	2	Balanced statically per emitter, and a static group balance (e.g. with balancing valve)		
	3	Balanced statically per emitter and dynamic group balance (e.g. with differential pressure controller)		
	4	Balanced dynamically per emitter (e.g. differential pressure control)		
3.5	Intermittent control of emission and/or distribution		CLG_DISTR_CTRL	M4–5 / M4–6
		One controller can control different rooms/zones having same occupancy patterns.		
	0	No automatic control		
	1	Automatic control with fixed time program: to lower the operation time		
	2	Automatic control with optimum start/stop: to lower the operation time		
	3	Automatic control with demand evaluation: to lower the operation time		
3.6	Interlock between heating and cooling control of emission and/or distribution		CLG_GEN_CTRL	M4–8
		To avoid at the same time heating and cooling in the same room depends on the system principle (e.g. cooling panel/heat emitter, TABS/ventilation, several indoor units)		
	0	No interlock: the two systems are controlled independently and can provide simultaneously heating and cooling.		
	1	Partial interlock (depending on 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 setpoint for the supply temperature of the centrally controlled system.		
	2	Total interlock: the control function enables to guarantee that there will be no simultaneous heating and cooling.		
3.7	Generator control for cooling		CLG_GEN_CTRL	M4–8
		The goal consists generally in maximizing the chiller water temperature.		
	0	Constant temperature control		
	1	Variable temperature control depending on the outside temperature		
	2	Variable temperature control depending on the load: this includes control according to room temperature.		
3.8	Sequencing of different chillers (generators for chilled water)		CLG_GEN_CTRL_SEQ	M4–8
		This control function only applies to a system with a set of different chiller sizes or chilled water generator types including free cooling and/or renewable energy sources.		
	0	Priorities are only based on running time.		
	1	Fixed sequencing based on loads only: for example, depending on the generator's characteristics, e.g. absorption chiller vs. centrifugal chiller.		
	2	Priorities based on generator efficiency and characteristics: the generator operational control is set individually to available generators so that they operate with an overall high degree of efficiency (e.g. outside air, river water, geothermic heat, refrigeration machines).		

Table 5 *(continued)*

Automatic control			
	3	Load prediction-based sequencing: the sequence is based on, e.g. COP and available power of a device and the predicted required power.	
3.9	Control of thermal energy storage (TES) charging	CLG_TES_CTRL	M4–7
		The TES is part of the cooling/chilled water system.	
	0	Continuous storage operation	
	1	Time-scheduled storage operation	
	2	Load prediction-based storage operation	
4	Ventilation and air-conditioning control		
	This section is for building energy systems that bring air into the building: both ventilation and air conditioning systems. Heating and cooling of air requires additional heating and cooling devices. Control functions related to heating/cooling systems are defined in sections 1 and 3 of this table respectively.		
4.1	Supply air flow control at the room level (e.g. fan on/off)	VENT_RMFLOW_CTRL	M5–5
	Control of supply air flow related to occupancy (availability of air flow, i.e. fan on/off control)		
	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	Occupancy based control: the system runs dependent on the occupancy (presence, light switch, infrared sensors etc.).	
	3	Demand based control: the system runs dependent on the air quality demand (measurement of CO_2, VOC, etc.).	
4.2	Room air temperature control by the ventilation system (all-air systems; combination with static systems as cooling ceiling, radiators, etc.)	VENT_RTEMP_CTRL	M5–5 / M5–6
	Room air temperature depends on air flow (4.1, 4.5) as well as supply air temperature (4.9). This control function is related to a closed-loop controller for the room air temperature acting on the air flow or supply air temperature. It can work with or without an additional static heating system (radiators etc.). Minimum air flow rates are maintained.		
	0	On-off control: fixed air flow rate and fixed supply air temperature at the room level, room temperature setpoints are set individually.	
	1	Continuous control: either air flow rate or supply air temperature at the room level can be varied continuously; room temperature setpoint s are set individually.	
	2	Optimized control: minimum energy demand by optimized control. Both air flow rate as well as supply air temperature at the room level are controlled dependent on heating/cooling load.	
4.3	Coordination of room air temperature control by ventilation and by static system	VENT_RTEMP_COORD	M5–5 / M5–6
	Interaction of the different systems shall be coordinated.		
	0	Interaction is not coordinated, e.g. closed loop controllers are dedicated to each system to maintain the room air temperature independently.	
	1	Interaction is coordinated, i.e. only one system is controlled by a closed loop controller for the room air temperature and the other system conditions the room only to the extent that allows the closed loop controller to benefit from internal and external heat gains.	
4.4	Outside air (OA) flow control	VENT_OAFLOW_CTRL	M5–6 / M5–8
	This control function is applied to ventilation systems that allow varying the OA ratio or flow respectively.		

Table 5 *(continued)*

Automatic control			
	0	Fixed OA ratio or OA flow: the system runs according to a given OA ratio, e.g. modified manually.	
	1	Staged (low/high) OA ratio or OA flow: depending on a given time schedule	
	2	Staged (low/high) OA ratio or OA flow: depending on the occupancy, e.g. light switch, infrared sensors, etc.	
	3	Variable control: the system is controlled by sensors which detect the number of people or indoor air parameters or adapted criteria (e.g. CO_2, mixed gas or VOC sensors). The used parameters shall be adapted to the kind of activity in the space.	
4.5	Air flow or pressure control at the air handler level	VENT_AHUFLOW_CTRL	M5–6 / M5–8
	0	No automatic control: continuously supplies air flow for a maximum load of all rooms.	
	1	On off time control: continuously supplies 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 without pressure reset: load dependent supplies of air flow for the demand of all connected rooms	
	4	Automatic flow or pressure control with pressure reset: load dependent supplies of air flow for the demand of all connected rooms (for variable air volume systems with VFD)	
4.6	Heat recovery control: icing protection	VENT_HRICE_CTRL	M5–5
	This control function is to avoid icing of the heat exchanger.		
	0	Without icing protection control: there is no specific action to avoid icing of the heat exchanger.	
	1	With icing protection control: a control loop enables to guarantee that the exhaust air temperature leaving the heat exchanger is not too low, to avoid frosting.	
4.7	Heat recovery control: prevention of overheating	VENT_HRHEAT_CTRL	M5–5
	This control function is to avoid overheating at the heat recovery unit.		
	0	Without overheating control: there is no specific action to avoid overheating.	
	1	With overheating control: during periods when the effect of the heat exchanger will no longer be positive, a control loop will switch between the “off”, “modulation” or bypass states of the heat exchanger.	
4.8	Free mechanical cooling	VENT_FREECOOL_CTRL	M5–8
	0	No automatic control	
	1	Night cooling: the amount of outside air is set to its maximum during the unoccupied period provided that firstly the room temperature is above the setpoint for the comfort period, and secondly the difference between the room temperature and the outside temperature is above a given limit. If free night cooling will be realized by automatically opening windows there is no air flow control.	
	2	Free cooling: both the amount of outside 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	Enthalpy based control: the amount of outside 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).	
4.9	Supply air temperature control at the Air Handling Unit (AHU) level	VENT_AHUSAT_CTRL	M5–5

Table 5 *(continued)*

Automatic control				
	There might be several supply air temperatures in an air conditioning system: the supply air temperature at the outlet of the AHU, the supply air temperature at the outlet of central re-heaters as well as the supply air temperature at the room level (terminal re-heat boxes). This control function allows to determine the supply air temperature setpoint (in case there is one) at the air handler level and not to control the temperature (e.g. enthalpy-based control).			
	0	No automatic control: no control loop enables to act on the supply air temperature.		
	1	Constant setpoint: a control loop enables to control the supply air temperature, the setpoint is constant and can only be modified by a manual action.		
	2	Variable setpoint with outside temperature compensation: a control loop enables to control the supply air temperature. The setpoint is a simple function of the outside temperature (e.g. linear function).		
	3	Variable setpoint with load dependent compensation: a control loop enables to control the supply air temperature. The setpoint 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.		
4.10	Humidity control		VENT_HUM_CTRL	M6–5 / M7–5
	The control of the air humidity can include humidification and/or dehumidification. Controllers can be applied as “humidity limitation control” or “constant control”.			
	0	No automatic control: no control loop enables to act on the air humidity.		
	1	Dew point control: supply air or room air humidity is expressed with the dew point temperature and reheat of the supply air to bring the relative humidity to the setpoint.		
	2	Direct humidity control: supply air or room air humidity, a control loop enables the supply air or room air humidity at a given setpoint. The setpoint is either fixed and predefined by the user or a fluctuating optimal value at a minimum energy but within min./max. limits of room air condition.		
5	Lighting control			
5.1	Occupancy control		LIGHT_OCC_CTRL	M9–5
	0	Manual on/off switch: the luminaire is switched on and off with a manual switch in the room..		
	1	Manual on/off switch plus additional sweeping extinction signal: the luminaire is switched on and off with a manual switch in the room. In addition, an automatic signal automatically switches off the luminaire at least once a day, typically in the evening to avoid needless operation during the night.		
	2	Automatic detection Auto on/dimmed off: the control system switches the luminaire(s) automatically on whenever the illuminated area is occupied, and automatically switches them to a state with dimmed status after the last occupancy in the illuminated area. Auto on/auto off: the control system switches the luminaire(s) automatically on whenever the illuminated area is occupied, and automatically switches them entirely off.		
	3	Automatic detection Manual on/ partial auto on /dimmed off: the luminaire(s) can only be switched on by means of a manual switch or automatically by occupancy detection sensor located in (or very close to) the area illuminated by the luminaire(s), and, if not switched off manually, is/are automatically switched to a state with dimmed status after the last occupancy in the illuminated area. Manual on/ partial auto on /auto off: the luminaire(s) can only be switched on by means of a manual switch or automatically by occupancy detection sensor.		
5.2	Light level/daylight control (daylight harvesting)		LIGHT_LEVEL_CTRL	M9–5
	0	Manual central: luminaires are controlled centrally, there is no manual switch in the room/zone.		

Table 5 *(continued)*

Automatic control			
	1	Manual: luminaires can be switched off with a manual switch in the room.	
	2	Automatic switching: the luminaires are automatically switched off when more than enough daylight is present to fully provide minimum illuminance required and switched on when there is not enough daylight.	
	3	Automatic dimming: the luminaires are dimmed down and finally fully switched off, e.g. when daylight is available or when scene based light level control is applied. The luminaires will be switched on again and dimmed up if the amount of daylight is decreasing or when scene based light level control is applied.	
6	Blind control		
6.1	Blind control	BLIND_CTRL	M2.5/M2.8/M9–5
	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.	
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 setpoints are also adapted to the needs. — Attention shall be paid to the tuning of all controllers, this includes setpoints as well as control parameters such as PI controller coefficients. — Heating and cooling setpoints of the room controllers shall be checked at regular intervals. The users often modify these setpoints. A centralized system enables to detect and correct extreme values of setpoints due to misunderstanding of users. — If the interlock between heating and cooling control of emission and/or distribution is only a partial interlock, the setpoint shall be regularly modified to minimize the simultaneous use of heating and cooling. — Alarming and monitoring functions will support the adaptation of the operation to user needs and the optimization of the tuning of the different controllers. This will be achieved by providing easy tools to detect abnormal operation (alarming functions) and by providing easy way to log and plot information (monitoring functions).		
7.1	Setpoint management	BMS_SP	M10–12
	Management, set back and adaptation of BAC setpoints according to the room/zone operating modes		
	0	Manual setting room by room individually	
	1	Adaptation from distributed/decentralized plant rooms only	
	2	Adaptation from a central room (e.g. work station, web operation; room operating units are excluded)	
	3	Adaptation from a central room (e.g. work station, web operation; room operating units are excluded) with frequent set back of user inputs	
7.2	Runtime management	BMS_RT	M10–12
	Adaptation of system/plant operating hours according to given time schedule and/or calendar		
	0	Manual setting (plant enabling)	

Table 5 *(continued)*

Automatic control			
	1	Individual setting following a predefined schedule including fixed preconditioning phases	
	2	Individual setting following a predefined schedule, adaptation from a central room (e.g. work station, web operation; room operating units are excluded), variable pre-conditioning phases	
7.3	Detecting faults of technical building systems and providing support to the diagnosis of these faults	BMS_FD	M10–12
	0	No central indication of detected faults and alarms	
	1	With central indication of detected faults and alarms	
	2	With central indication of detected faults and alarms including diagnosing functions	
7.4	Reporting information regarding energy consumption, indoor conditions	BMS_RPR	M10–12
	0	Indication of actual values only (e.g. temperatures, meter values)	
	1	Trending functions and consumption determination	
	2	Analysing, performance evaluation, benchmarking of indoor environment and energy	
7.5	Local energy production and renewable energies	BMS_RES	M10–12
	Managing local renewable energy sources and other local energy productions as CHP		
	0	Uncontrolled generation depending on the fluctuating availability of RES and or run time of CHP; overproduction will be fed into the grid.	
	1	Coordination of local RES and CHP with regard to local energy demand profile including energy storage management; optimization of own consumption	
7.6	Waste heat recovery and heat shifting	BMS_HRC	M10–12
	Using of waste heat recovery on the building level and heat shifting		
	0	Instantaneous use of waste heat or heat shifting	
	1	Managed use of waste heat or heat shifting (including charging/discharging TES)	
7.7	Smart grid integration	BMS_SG	M10–12
	Interactions between building and any smart grid including demand side management		
	0	No harmonization between grid and building energy systems; building is operated independently from the grid load.	
	1	Building energy systems are managed and operated depending on grid load; demand side management is used for load shifting.	

5.5 BAC efficiency class

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

— Class D corresponds to non-energy efficient BAC. Building with such systems shall be retrofitted. New buildings shall not be built with such systems.

— Class C corresponds to standard BAC.

— Class B corresponds to advanced BAC and some specific TBM functions.

— Class A corresponds to high-energy performance BAC and TBM functions.

The BAC implementation is categorized as class D if the minimum functions to be in class C are not implemented.

To be in class C: minimum functions defined in Table B.1 shall be implemented.

To be in class B: building automation function plus some specific functions defined in Table 5 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 5 shall be implemented in addition to class B. Room controllers shall be available for demand controlled HVAC (e.g. adaptive setpoint based on sensing of occupancy, air quality, etc.) including additional integrated functions for multi-discipline interrelationships between HVAC and various building services.

EXAMPLE Electricity, lighting, solar shading, etc.

5.6 BAC and TBM functions assigned to the BAC efficiency classes

BAC and TBM functions described and summarized in Table 5 are assigned to the BAC efficiency classes as defined in 5.5, depending on their use in residential or non-residential buildings. The assignment of functions to the BAC efficiency classes is listed in Table 6.

Table 5 and Table 6 should be applied in the following way.

a) For the definition of the building automation and controls (BAC) and technical building management (TBM) functions to be implemented for a new building or for the renovation of an existing building:

   1) building owners, architects or engineers can put a marker in front of each of the functions in Table 6 they want to be implemented. They will use the indicated boxes as a help tool to determine in which BAC class A, B, C, D the function they have specified is located;

      EXAMPLE To achieve BAC class B, the marker shall be in a line where indicated boxes cover classes D to B.

   2) it will be a simplified alternative to specify only the classes of function A, B, C, D, especially for specifications at an early stage of a project to help defining preliminary specifications of the functions and a certain function type to be implemented for a given new building or for the renovation of an existing building.

b) For the definition of minimum requirements for BAC and TBM functions for new buildings as well as for renovations of buildings:

   1) public authorities can define the minimum class to be achieved, unless differently specified this class is C.

c) For the definition of inspection procedures of technical systems as well as inspectors applying these procedures to check if the level of BAC and TBM functions implemented is appropriate:

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

   2) inspectors can put an X in front of each of the BAC functions in Table 6 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 in Table 6 shall correspond to the indicated boxes for this class.

d) For the definition and implementation of calculation methods which take into account the impact of BAC 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 BAC and TBM functions defined in Table 5 is taken into account;

2) software developers can develop software user interfaces enabling to input the list of BAC and TBM functions which are implemented according to Table 5. They can provide a simplified input mode based on the class of functions A, B, C, and D according to Table 6.

e) For checking that the impact of all BAC and TBM functions is taken into account when assessing the energy performance of a building, 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.

When determining the BAC efficiency class only those BAC and TBM functions having a relevant impact have to be considered.

— BAC 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 indicated for that class.

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 control function type is required to be in a certain BAC efficiency class, it does not necessarily mean that this function type has to be foreseen everywhere in the building; if the designer can give good reasons that the application of a function type does not bring a benefit in a specific case this function type can be ignored.

EXAMPLE If the designer can show that the heating load of a set of rooms depend on the outside temperature only 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 BAC and TBM functions in Table 5 are applicable to all types of building services. Therefore, a BAC or TBM function that has no substantial impact on the energy used for the corresponding service heating, cooling, ventilation, DHW or lighting will not be taken into account when classifying the BAC functionality. The impact is not seen as substantial if the share of energy consumption related to the service controlled by the function is less than 5 % of the total energy consumption of the building.

NOTE Further information is given in ISO/TR 52120-2.

Table 6 — Function list and assignment to BAC 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 function is applied to the heat emitter (radiators, underfloor heating, fan-coil unit, indoor unit) at room level; for type 1 one function can control several rooms.									
	0	No automatic control	x				x			
	1	Central automatic control	x				x			
	2	Individual room control	x	x			x	x		
	3	Individual modulating room control with communication	x	x	x	x[a]	x	x	x	x[a]

[a] In case of slow reacting heat and cool emission systems, for example, floor heating, wall heating, etc., functions 1.1.3 and 3.1.3 are allocated to BAC class A.

[b] In residential buildings, it is usually applied only to public areas (e.g. stair cases, corridors, etc.).

Table 6 *(continued)*

			Definition of classes							
			Residential				**Non residential**			
			D	**C**	**B**	**A**	**D**	**C**	**B**	**A**
	4	Individual modulating room control with communication and occupancy detection (not applied to slow reacting heating emission systems, e.g. floor heating)	x	x	x	x	x	x	x	x
1.2	Emission control for TABS (heating mode)									
	0	No automatic control	x				x			
	1	Central automatic control	x	x			x	x		
	2	Advanced central automatic control	x	x	x		x	x	x	
	3	Advanced central automatic control with intermittent operation and/or room temperature feedback control	x	x	x	x	x	x	x	x
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	x				x			
	1	Outside temperature compensated control	x	x			x	x		
	2	Demand based control	x	x	x	x	x	x	x	x
1.4	Control of distribution pumps in networks									
	The controlled pumps can be installed at different levels in the network.									
	0	No automatic control	x				x			
	1	On off control	x	x			x	x		
	2	Multi-stage control	x	x	x		x	x	x	
	3	Variable speed pump control (pump unit (internal) estimations)	x	x	x	x	x	x	x	x
	4	Variable speed pump control (external demand signal)	x	x	x	x	x	x	x	x
1.4.a	Hydronic balancing heating distribution (including contribution to the balancing to the emission side)									
	Hydronic balancing is applied to an emitter or a group of heat emitters greater than 10.									
	0	No balancing	x				x			
	1	Balanced statically per emitter, without group balance	x	x			x			
	2	Balanced statically per emitter, and a static group balance	x	x			x			
	3	Balanced statically per emitter and dynamic group balance	x	x	x		x	x		
	4	Balanced dynamically per emitter	x	x	x	x	x	x	x	x
1.5	Intermittent control of emission and/or distribution									

[a] In case of slow reacting heat and cool emission systems, for example, floor heating, wall heating, etc., functions 1.1.3 and 3.1.3 are allocated to BAC class A.

[b] In residential buildings, it is usually applied only to public areas (e.g. stair cases, corridors, etc.).

Table 6 *(continued)*

			Definition of classes							
			Residential				Non residential			
			D	C	B	A	D	C	B	A
	One controller can control different rooms/zones having same occupancy patterns.									
	0	No automatic control	x				x			
	1	Automatic control with fixed time program	x	x			x	x		
	2	Automatic control with optimum start/stop	x	x	x		x	x	x	
	3	Automatic control with demand evaluation	x	x	x	x	x	x	x	x
1.6	Heat generator control (combustion and district heating)									
	0	Constant temperature control	x				x			
	1	Variable temperature control depending on outside temperature	x	x			x	x		
	2	Variable temperature control depending on the load	x	x	x	x	x	x	x	x
1.7	Heat generator control (heat pump)									
	0	Constant temperature control	x				x			
	1	Variable temperature control depending on outside temperature	x	x			x	x		
	2	Variable temperature control depending on the load	x	x	x	x	x	x	x	x
1.8	Heat generator control (outdoor unit)									
	0	On/off-control of heat generator	x				x			
	1	Multi-stage control of heat generator	x	x	x		x	x	x	
	2	Variable control of heat generator	x	x	x	x	x	x	x	x
1.9	Sequencing of different heat generators									
	0	Priorities only based on running time	x				x			
	1	Control according to fixed priority list	x	x			x	x		
	2	Control according to dynamic priority list	x	x	x		x	x	x	
	3	Control according to prediction based dynamic priority list	x	x	x	x	x	x	x	x
1.10	Control of thermal energy storage (TES) operation									
	0	Continuous storage operation	x				x			
	1	2-sensor charging of storage	x	x	x		x	x	x	
	2	Load prediction-based storage operation	x	x	x	x	x	x	x	x
2	Domestic hot water supply control									

[a] In case of slow reacting heat and cool emission systems, for example, floor heating, wall heating, etc., functions 1.1.3 and 3.1.3 are allocated to BAC class A.

[b] In residential buildings, it is usually applied only to public areas (e.g. stair cases, corridors, etc.).

Table 6 *(continued)*

			Definition of classes							
			Residential				Non residential			
			D	C	B	A	D	C	B	A
2.1	Control of DHW storage charging with direct electric heating or integrated electric heat pump									
	0	Automatic on/off control	x				x			
	1	Automatic on/off control and scheduled charging enable	x	x			x	x		
	2	Automatic on/off control and scheduled charging enable and multi-sensor storage management	x	x	x	x	x	x	x	x
2.2	Control of DHW storage charging using hot water generation									
	0	Automatic on/off control	x				x			
	1	Automatic on/off control and scheduled charging enable	x	x			x	x		
	2	Automatic on/off control, scheduled charging enable and demand-based supply temperature control or multi-sensor storage management	x	x	x	x	x	x	x	x
2.3	Control of DHW storage charging with solar collector and supplementary heat generation									
	0	Manual control	x				x			
	1	Automatic control of solar storage charge (Prio. 1) and supplementary storage charge (Prio. 2)	x	x			x	x		
	2	Automatic control of solar storage charge (Prio. 1) and supplementary storage charge (Prio. 2) plus demand based supply temperature control or multi-sensor storage management	x	x	x	x	x	x	x	x
2.4	Control of DHW circulation pump									
	0	No control, continuous operation	x				x			
	1	With time program	x	x	x	x	x	x	x	x
3	Cooling control									
3.1	Emission control									
	The control function is applied to the emitter (cooling panel, fan-coil unit or indoor unit) at room level; for type 1, one function can control several rooms.									
	0	No automatic control	x				x			
	1	Central automatic control	x				x			
	2	Individual room control	x	x			x	x		
	3	Individual modulating room control with communication	x	x	x	x[a]	x	x	x	x[a]

[a] In case of slow reacting heat and cool emission systems, for example, floor heating, wall heating, etc., functions 1.1.3 and 3.1.3 are allocated to BAC class A.

[b] In residential buildings, it is usually applied only to public areas (e.g. stair cases, corridors, etc.).

Table 6 *(continued)*

			Definition of classes							
			Residential				Non residential			
			D	C	B	A	D	C	B	A
	4	Individual modulating room control with communication and occupancy detection (not applied to slow reacting cooling emission systems, e.g. floor cooling)	x	x	x	x	x	x	x	x
3.2	Emission control for TABS (cooling mode)									
	0	No automatic control	x				x			
	1	Central automatic control	x	x			x	x		
	2	Advanced central automatic control	x	x	x		x	x	x	
	3	Advanced central automatic control with intermittent operation and/or room temperature feedback control	x	x	x	x	x	x	x	x
3.3	Control of distribution network chilled water temperature (supply or return)									
	Similar function can be applied to the control of direct electric cooling (e.g. compact cooling units, split units) for individual rooms.									
	0	Constant temperature control	x				x			
	1	Outside temperature compensated control	x	x			x	x		
	2	Demand based control	x	x	x	x	x	x	x	x
3.4	Control of distribution pumps in networks									
	The controlled pumps can be installed at different levels in the network.									
	0	No automatic control	x				x			
	1	On off control	x	x			x	x		
	2	Multi-stage control	x	x	x		x	x	x	
	3	Variable speed pump control [pump unit (internal) estimations]	x	x	x	x	x	x	x	x
	4	Variable speed pump control (external demand signal)	x	x	x	x	x	x	x	x
3.4.a	Hydronic balancing cooling distribution (including contribution to the balancing to the emission side)									
	Hydronic balancing is applied to a group of cooling emitters (cooling panel, fan-coil unit or indoor unit) greater than 10, in addition to static balancing at individual cooling emitters.									
	0	No balancing	x				x			
	1	Balanced statically per emitter, without group balance	x	x			x			
	2	Balanced statically per emitter, and a static group balance (e.g. with balancing valve)	x	x			x			
	3	Balanced statically per emitter and dynamic group balance	x	x	x		x	x		

[a] In case of slow reacting heat and cool emission systems, for example, floor heating, wall heating, etc., functions 1.1.3 and 3.1.3 are allocated to BAC class A.

[b] In residential buildings, it is usually applied only to public areas (e.g. stair cases, corridors, etc.).

Table 6 *(continued)*

			Definition of classes							
			Residential				Non residential			
			D	C	B	A	D	C	B	A
	4	Balanced dynamically per emitter	x	x	x	x	x	x	x	x
3.5	Intermittent control of emission and/or distribution									
	One controller can control different rooms/zones having same occupancy patterns.									
	0	No automatic control	x				x			
	1	Automatic control with fixed time program	x	x			x	x		
	2	Automatic control with optimum start/stop	x	x	x		x	x	x	
	3	Automatic control with demand evaluation	x	x	x	x	x	x	x	x
3.6	Interlock between heating and cooling control of emission and/or distribution									
	0	No interlock	x				x			
	1	Partial interlock (dependent on the HVAC system)	x	x	x		x	x	x	
	2	Total interlock	x	x	x	x	x	x	x	x
3.7	Generator control for cooling									
	The goal consists generally in maximizing the chilled water supply temperature.									
	0	Constant temperature control	x				x			
	1	Variable temperature control depending on outside temperature	x	x	x		x	x	x	
	2	Variable temperature control depending on the load	x	x	x	x	x	x	x	x
3.8	Sequencing of generators for chilled water									
	0	Priorities only based on running times	x				x			
	1	Fixed sequencing based on loads only	x	x			x	x		
	2	Priorities based on generator efficiency and characteristics	x	x	x		x	x	x	
	3	Load prediction-based sequencing	x	x	x	x	x	x	x	x
3.9	Control of thermal energy storage (TES) charging									
	0	Continuous storage operation	x				x			
	1	Time-scheduled storage operation	x	x			x	x		
	2	Load prediction-based storage operation	x	x	x	x	x	x	x	x
4	Ventilation and air-conditioning control									
4.1	Supply air flow control at the room level									
	0	No automatic control	x				x			
	1	Time control	x	x	x		x	x	x	

[a] In case of slow reacting heat and cool emission systems, for example, floor heating, wall heating, etc., functions 1.1.3 and 3.1.3 are allocated to BAC class A.

[b] In residential buildings, it is usually applied only to public areas (e.g. stair cases, corridors, etc.).

Table 6 *(continued)*

			Definition of classes							
			Residential				Non residential			
			D	C	B	A	D	C	B	A
	2	Occupancy based control	x	x	x		x	x	x	
	3	Demand based control	x	x	x	x	x	x	x	x
4.2	Room air temperature control (all-air systems)									
	0	On-off control	x				x			
	1	Continuous control	x	x			x	x		
	2	Optimized control	x	x	x	x	x	x	x	x
4.3	Room air temperature control (Combined air-water systems)									
	0	No coordination	x				x			
	1	Coordination	x	x	x	x	x	x	x	x
4.4	Outside air (OA) flow control									
	0	Fixed OA ratio or OA flow	x	x			x	x		
	1	Staged (low or high) OA ratio or OA flow (time schedule)	x	x	x		x	x	x	
	2	Staged (low or high) OA ratio or OA flow (occupancy)	x	x	x		x	x	x	
	3	Variable control	x	x	x	x	x	x	x	x
4.5	Air flow or pressure control at the air handler level									
	0	No automatic control	x				x			
	1	On off time control	x	x			x	x		
	2	Multi-stage control	x	x	x		x	x	x	
	3	Automatic flow or pressure control (without reset)	x	x	x	x	x	x	x	x
	4	Automatic flow or pressure control (with reset)	x	x	x	x	x	x	x	x
4.6	Heat recovery control: icing protection									
	0	Without icing protection	x				x			
	1	With icing protection	x	x	x	x	x	x	x	x
4.7	Heat recovery control: prevention of overheating									
	0	Without overheating control	x				x			
	1	With overheating control	x	x	x	x	x	x	x	x
4.8	Free mechanical cooling									
	0	No automatic control	x				x			
	1	Night cooling	x	x			x	x		
	2	Free cooling	x	x	x		x	x	x	
	3	Enthalpy based control	x	x	x	x	x	x	x	x
4.9	Supply air temperature control									
	0	No automatic control	x				x			
	1	Constant setpoint	x	x			x	x		
	2	Variable setpoint with outside temperature compensation	x	x	x		x	x	x	

[a] In case of slow reacting heat and cool emission systems, for example, floor heating, wall heating, etc., functions 1.1.3 and 3.1.3 are allocated to BAC class A.

[b] In residential buildings, it is usually applied only to public areas (e.g. stair cases, corridors, etc.).

Table 6 *(continued)*

			Definition of classes							
			Residential				Non residential			
			D	C	B	A	D	C	B	A
	3	Variable setpoint with load dependant compensation	x	x	x	x	x	x	x	x
4.10	Humidity control									
	0	No automatic control	x				x			
	1	Dew point control	x	x			x	x		
	2	Direct humidity control	x	x	x	x	x	x	x	x
5	Lighting control									
5.1	Occupancy control									
	0	Manual on/off switch	x	x			x			
	1	Manual on/off switch + additional sweeping extinction signal	x	x	x		x	x		
	2	Automatic detection (auto on)[b]	x	x	x	x	x	x	x	x
	3	Automatic detection (manual on)[b]	x	x	x	x	x	x	x	x
5.2	Light level/daylight control									
	0	Manual (central)	x				x	x		
	1	Manual (per room/zone)	x	x	X		x	x		
	2	Automatic switching [b]	x	x	x		x	x	x	
	3	Automatic dimming [b]	x	x	x	x	x	x	x	x
6	Blind control									
	0	Manual operation	x				x			
	1	Motorized operation with manual control	x	x			x			
	2	Motorized operation with automatic control	x	x	x		x	x		
	3	Combined light/blind/HVAC control	x	x	x	x	x	x	x	x
7	Technical home and building management									
7.1	Setpoint management									
	0	Manual setting room by room individually	x	x			x			
	1	Adaptation from distributed/decentralized plant rooms only	x	x	x		x	x		
	2	Adaptation from a central room	x	x	x	x	x	x	x	
	3	Adaptation from a central room with frequent set back of user inputs	x	x	x	x	x	x	x	x
7.2	Runtime management									
	0	Manual setting (plant enabling)	x	x			x			
	1	Individual setting following a predefined time schedule including fixed preconditioning phases	x	x	x		x	x		

[a] In case of slow reacting heat and cool emission systems, for example, floor heating, wall heating, etc., functions 1.1.3 and 3.1.3 are allocated to BAC class A.

[b] In residential buildings, it is usually applied only to public areas (e.g. stair cases, corridors, etc.).

Table 6 *(continued)*

			Definition of classes							
			Residential				Non residential			
			D	C	B	A	D	C	B	A
	2	Individual setting following a predefined time schedule; adaptation from a central room; variable preconditioning phases	x	x	x	x	x	x	x	x
7.3	Detecting faults of technical building systems and providing support to the diagnosis of these faults									
	0	No central indication of detected faults and alarms	x	x			x			
	1	With central indication of detected faults and alarms	x	x	x		x	x		
	2	With central indication of detected faults and alarms/diagnosing functions	x	x	x	x	x	x	x	x
7.4	Reporting information regarding energy consumption, indoor conditions									
	0	Indication of actual values only (e.g. temperatures, meter values)	x	x			x	x		
	1	Trending functions and consumption determination	x	x	x		x	x	x	
	2	Analysing, performance evaluation, benchmarking	x	x	x	x	x	x	x	x
7.5	Local energy production and renewable energies									
	0	Uncontrolled generation depending on the fluctuating availability of RES and or run time of CHP; overproduction will be fed into the grid.	x	x			x	x		
	1	Coordination of local RES and CHP with regard to local energy demand profile including energy storage management; optimization of own consumption	x	x	x	x	x	x	x	x
7.6	Waste heat recovery and heat shifting									
	0	Instantaneous use of waste heat or heat shifting	x				x			
	1	Managed use of waste heat or heat shifting (including charging/discharging TES)	x	x	x	x	x	x	x	x
7.7	Smart grid integration									
	0	No harmonization between grid and building energy systems; building is operated independently from the grid load.	x	x			x	x		

[a] In case of slow reacting heat and cool emission systems, for example, floor heating, wall heating, etc., functions 1.1.3 and 3.1.3 are allocated to BAC class A.

[b] In residential buildings, it is usually applied only to public areas (e.g. stair cases, corridors, etc.).

Table 6 *(continued)*

			Definition of classes							
			Residential				Non residential			
			D	C	B	A	D	C	B	A
	1	Building energy systems are managed and operated depending on grid load; demand side management is used for load shifting.	x	x	x	x	x	x	x	x

[a] In case of slow reacting heat and cool emission systems, for example, floor heating, wall heating, etc., functions 1.1.3 and 3.1.3 are allocated to BAC class A.

[b] In residential buildings, it is usually applied only to public areas (e.g. stair cases, corridors, etc.).

5.7 Applying BAC for EnMS and maintaining BAC energy efficiency

5.7.1 General

Once a BACS is installed two main questions arise, in view of this document:

a) How can a BAC support an energy management system (EnMS) for the building part?

b) Which related activities shall be provided to maintain and to improve the impact of BAC/TBM systems on the energy efficiency in buildings and to upgrade its current system class?

5.7.2 Applying BAC for EnMS

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

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

A good approach is described in Annex E. This annex explains in detail how to apply and use BAC/TBM systems for an EnMS for buildings.

Table E.1 outlines BAC/TBM systems requirements, options and functions used to support implementation and processing of the different stages of ISO 50001 concerning EnMS in buildings.

Annex E also shows that a dedicated skilled BAC/TBM systems team shall be dedicated to the project.

5.7.3 Maintaining BAC energy efficiency

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

The required BAC services on the project site to keep the functionality and the objectives of a system class (D), C, B, A. shall be provided.

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

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

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

Annex E describes the minimum activities of a commissioned BACS to ensure the maintainability of its current system class and also the procedure how to upgrade to a higher class at the request of the customer.

6 Method 1 - Detailed calculation procedure of the BAC contribution to the energy performance of buildings (detailed method)

6.1 Output data

The output data of this method is a list of building automation and control functions and to each such function the chosen function type. The following subclauses describe approaches to take into account the impact of BAC and TBM function in the assessment of energy performance indicators defined in ISO 52003-1, ISO 52000-1 and connected standards.

It will be explained:

— the main approaches used in these standards to take into account the contribution of the BAC and TBM functions;

— an overview of the links between these standards and the BAC and TBM functions;

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

The control functions defined in Table 5 shall be taken into account when applying the EPB standards defined in Tables 7 and 8.

NOTE ISO/TR 52120-2:2021, 5.3.6 gives more detailed information on the relations between the BAC and TBM functions in Table 4 and the standards referenced in Tables 7 and 8.

Table 7 — Automation and control functions

Function		EPB standard
Heating, cooling and domestic hot water control		
	Emission control	EN 15316-2:2017, 7.2, 7.3 EN 16798-9 EN 15316-2:2017, 6.5.1 ISO 52016-1
	Control of distribution network water temperature	EN 15316-2 EN 16798-9
	Control of distribution pump	EN 15316-3 EN 16798-9
	Intermittent control of emission and/or distribution.	ISO 52016-1 EN 15316-3 EN 16798-9
	Interlock between heating and cooling control of emission and/or distribution	EN 16798-9

Table 7 *(continued)*

Function		EPB standard
	Generation control and sequencing of generators	EN 15316-4-1 EN 15316-4-2 EN 15316-4-3 EN 15316-4-4 EN 15316-4-5:2017, 7.4.6 EN 16798-9 EN 16798-13 EN 16947-1
	Thermal energy storage control	EN 15316 series EN 16798-15
Ventilation and air conditioning control		
	Air flow control at the room level	EN 16798-7 EN 16798-3
	Air flow or pressure control at the air handler level	EN 16798-5-1
	Heat exchanger defrost and overheating control	EN 16798-5-1
	Free mechanical cooling	EN 16798-13
	Supply temperature control	EN 16798-5-1
	Humidity control	EN 16798-5-1
Lighting control		EN 15193-1
	Combined light/blind/HVAC control (also mentioned below)	None
Blind control		ISO 52016-1

Table 8 — Technical building management with energy efficiency functions overview

Function	EPB standard
Setpoint management	EN 16947 series
Run time management	EN 16947 series
Local energy production and renewable energies	EN 16947 series
Waste heat recovery and heat shifting	EN 16947 series
Smart rigd integration	EN 16947 series
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	ISO 52000-1

6.2 Calculation time intervals

The methods described in Clause 6 are suitable for the following calculation time intervals:

— yearly (seasonal);

— monthly;

— hourly;

or the statistical BIN-method can be applied.

This method can be used within a dynamic calculation scheme. It allows to use the monthly values in an hourly values method. It means, monthly value is divided by the number of hours per months and the output is introduced hour by hour.

Beside the BIN-method, the output time interval is the same as the input time interval.

6.3 Input data - Source of data

Input data about products that are required for the (calculation or test) method(s) described in this document shall be the data supplied by the manufacturer or any third party if they are declared according to relevant EN (or ISO) product standards (in the CEN area) or equivalent ISO or national standards (outside the CEN area).

6.4 Calculation procedure

6.4.1 Applicable calculation time interval

This procedure can be used with the following calculation time intervals:

— yearly;

— monthly;

— hourly.

This procedure is suitable for dynamic simulations.

6.4.2 Energy performance calculation

6.4.2.1 Energy calculation

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

Five approaches are common to different standards:

— direct approach;

— operating mode approach;

— time approach;

— setpoint approach;

— correction coefficient approach.

6.4.2.2 Direct approach

When the calculation of energy performance is performed using the detailed simulation method or even an hourly simulation method as described in ISO 52016-1, it is possible to directly calculate the impact of a number of functions, e.g. impact of intermittent heating, varying temperature between heating and cooling setpoints, movable solar shadings, etc.

6.4.2.3 Operating mode approach

Automatic control enables to operate climate systems under different operating mode, for example, 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/off.

6.4.2.4 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 luminaire).

The energy consumption for a certain time period is given by Formula (1):

$$E = P \cdot \Delta t \cdot k_{\text{ctr}} \tag{1}$$

where

E is the energy consumption for the time period;

P is the input power of the controlled system;

Δt is the duration of the time period;

k_{ctr} is a characteristic coefficient which represents the impact of the control system. It is the ratio between the time when 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. k_{ctr} represents in this case an equivalent operating time ratio.

6.4.2.5 Setpoint approach

This approach can be used when the control system has a direct impact on the control accuracy, i.e. the deviation between controlled variable and the corresponding setpoint.

For example, in the calculation of the energy needs according to ISO 52016-1, a deviation from the room temperature setpoint is applied, 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 Formula (2):

$$E = k_{\text{trans}} \cdot [(\vartheta_{\text{set}} + \Delta\vartheta_{\text{ctr}}) - \vartheta_{\text{ref}}]\, \Delta t \tag{2}$$

where

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

k_{trans} is a transfer coefficient;

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

$\Delta\vartheta_{ctr}$ 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_{ref} is a reference temperature, e.g. the outside temperature;

Δt is the duration of the time period.

In this approach:

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

$\Delta\vartheta_{ctr}$ 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;

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

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

$\vartheta_{set} + \Delta\vartheta_{ctr}$ is called the equivalent temperature setpoint.

6.4.2.6 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 Formula (3):

$$E = E_{ref} \cdot k_{ctr} \tag{3}$$

where

E is the energy demand or consumption;

E_{ref} is the energy consumption in the reference case, e.g. if the system is controlled ideally, or if a BAC 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;

k_{ctr} is the correction coefficient which represents the increase or decrease of energy consumption as compared to the energy consumption E_{ref} of the reference case.

The values of k_{ctr} depend on the control type but vary also with the climate, building type, etc. Tables or formulae should be provided, for example, in Annex A (normative template, with informative default tables or formulae in Annex B) of the relevant EPB standard to determine the impact of these parameters on k_{ctr}.

6.4.2.7 Equivalence between the different approaches

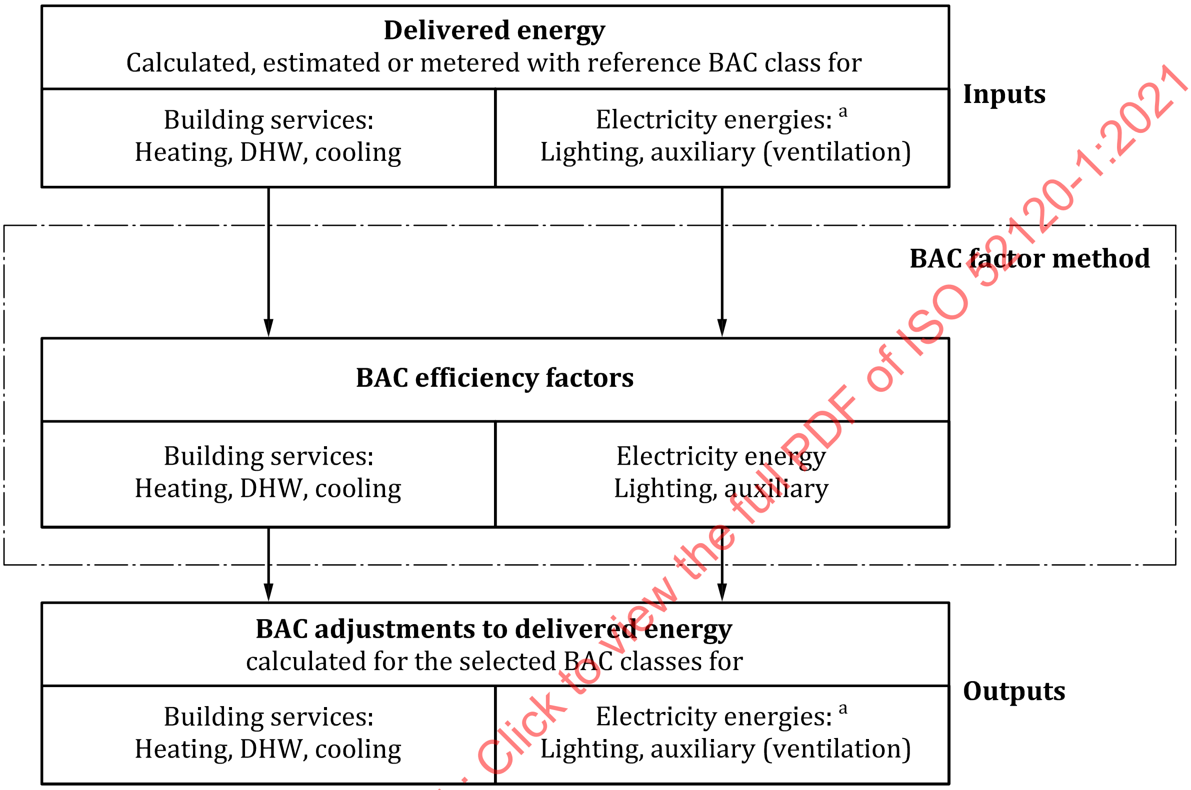
The parameters of the operating mode approach, times approach (k_{ctr}) and of the setpoint approach ($\Delta\vartheta_{ctr}$) can generally be determined from the description of the control system and of the user profile.

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

7 Method 2 - Factor based calculation procedure of the BAC impact on the energy performance of buildings (BAC factor method)

7.1 Output data

The BAC 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. Figure 8 illustrates how to use this approach.



[a] Electricity energy = overall energy use for auxiliary and lighting.

NOTE 1 Delivered energy is the total energy, expressed per energy carrier (gas, oil, electricity, etc.)

NOTE 2 Arrows illustrate only the calculation process and do not represent energy and/or mass flows.

Figure 8 — BAC factor method

The BAC factor method gives a rough estimation of the impact of BAC 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 BAC factor method is especially appropriate 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.

7.2 Calculation time interval

This procedure is designed for a yearly calculation period and yearly calculation time interval.

7.3 Calculation procedure — Energy calculation

7.3.1 General

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

— energy needs for heating and cooling, internal temperatures and sensible and latent heat loads, calculated according to ISO 52016-1;

— thermal and auxiliary energy input to the space heating system, calculated according to the EN 15316 series;

— thermal and auxiliary energy input to the cooling system, calculated according to EN 16798-9;

— thermal energy input to the domestic hot water system, calculated according to the EN 15316 series;

— electric energy input to the lighting system, calculated according to EN 15193-1;

— electric energy input to the ventilation system, calculated according to EN 16798-5.

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

The BAC efficiency factors were obtained by performing transient pre-calculations for different building types as mentioned in ISO 52003-1. Thereby each building type is characterized by a significant user profile of occupancy and internal heat gains due to people and equipment, respectively. The BAC efficiency classes A, B, C and D as defined in Clause 4 were represented by different levels of control accuracy and control quality. The impact of different climate conditions on the BAC 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 C.

Finally, four sets of BAC efficiency factors $f_{BAC,H}$, $f_{BAC,C}$, $f_{BAC,DHW}$ and $f_{BAC,el}$ were extracted from the results of the energy performance calculations. They are available for the assessment of:

— thermal energy for space heating and cooling ($f_{BAC,H}$, $f_{BAC,C}$ according to Tables A.5 and A.6), and

— thermal energy for domestic hot water generation ($f_{BAC,DHW}$ according to Tables A.7 and A.8), and

— electric energy for ventilation, lighting and auxiliary devices ($f_{BAC,el}$ according to Table A.9).

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 BAC factor taking into account the correlations given in Table 9.

Table 9 — Relations between building energy systems and BAC efficiency factors

Energy use		Energy need[a]		System losses[b]	Auxiliary energy[c]	BAC factor
Heating	=	$Q_{H,nd}$	+	$Q_{H,ls}$		$f_{BAC,H}$
			+		$W_{H,aux}$	$f_{BAC,el}$
Cooling	=	$Q_{C,nd}$	+	$Q_{C,ls}$		$f_{BAC,C}$
			+		$W_{C,aux}$	$f_{BAC,el}$
Ventilation	=				$W_{V,aux}$	$f_{BAC,el}$
Lighting[d]	=				W_{L}	$f_{BAC,el}$
DHW	=	$Q_{DHW,nd}$		$Q_{DHW,ls}$		$f_{BAC,DHW}$

[a] Energy need for heating and cooling should both be calculated with ISO 52016-1.

[b] 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 ISO 52016-1.

[c] The auxiliary energy required by the systems should be calculated by using the EN 15316 series (heating systems), EN 16798-5 (ventilation systems) and EN 15193-1 (lighting systems) respectively.

[d] The impact of lighting control should be evaluated separately with EN 15193-1.

The whole calculation sequence of the BAC efficiency factor method is depicted in Figure 9. As to be seen one of the BAC efficiency classes as described in Table 6 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 a 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 or it shall be measured. The BAC factors then allow to easily assess 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, building energy performance is also in relation to a reference case.

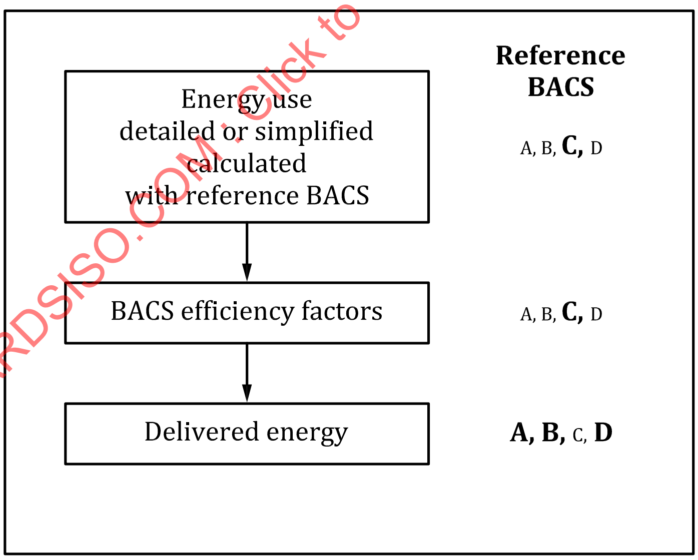


Figure 9 — Calculation sequence of BAC efficiency factor method

A set of BAC efficiency factor values is described in 7.3.2.

7.3.2 BAC efficiency factor values

Annex A provides the set of BAC efficiency factor values.

The BAC efficiency factors were obtained by performing transient pre-calculations for different building types as mentioned in ISO 52003-1. Thereby each building type is characterized by a significant user profile of occupancy and internal heat gains due to people and equipment, respectively. The BAC efficiency classes A, B, C and D as defined in Clause 4 were represented by different levels of control accuracy and control quality. The impact of different climate conditions on the BAC factors was treated as negligible, since the main impact of climatic conditions is on the energy input data which again are derived from preparatory energy performance calculations.

NOTE Further background information about these pre-calculations as well as boundary conditions is given in Annex C.

Finally, four sets of BAC efficiency factors $f_{BAC,H}$, $f_{BAC,C}$, $f_{BAC,DHW}$, and $f_{BAC,el}$ were extracted from the results of the energy performance calculations. They are available for the assessment of:

— thermal energy for space heating and cooling ($f_{BAC,H}$,$f_{BAC,C}$ according to Tables A.5 and A.6), and

— thermal energy for domestic hot water generation ($f_{BAC,DHW}$ according to Tables A.7 and A.8), and

— electric energy for ventilation, lighting and auxiliary devices ($f_{BAC,el}$ according to Table A.9).

7.3.3 Application of the BAC efficiency factors

The BAC efficiency factors shall be used as illustrated in the following formulae to calculate the BAC assessed energy inputs to the systems.

Heating system

$$Q_{H,tot,BAC} = (Q_{H,nd,B} + Q_{H,ls}) \cdot \frac{f_{BAC,H}}{f_{BAC,H,ref}} \quad (4)$$

$$W_{H,aux,BAC} = W_{H,aux} \cdot \frac{f_{BAC,el}}{f_{BAC,el,ref}} \quad (5)$$

Cooling system

$$Q_{C,tot,BAC} = (Q_{C,nd,B} + Q_{C,ls}) \cdot \frac{f_{BAC,C}}{f_{BAC,C,ref}} \quad (6)$$

$$W_{C,aux,BAC} = W_{C,aux} \cdot \frac{f_{BAC,el}}{f_{BAC,el,ref}} \quad (7)$$

Ventilation system

$$W_{V,aux,BAC} = W_{V,aux} \cdot \frac{f_{BAC,el}}{f_{BAC,el,ref}} \quad (8)$$

Lighting system

$$W_{L,BAC} = W_{L} \cdot \frac{f_{BAC,el}}{f_{BAC,el,ref}} \quad (9)$$

DHW system

$$Q_{DHW,BAC} = Q_{DHW} \cdot \frac{f_{BAC,DHW}}{f_{BAC,DHW,ref}} \quad (10)$$

where

$Q_{H,tot,BAC}$ is the total heating energy related to BAC efficiency class;

$Q_{H,nd,B}$ is the heating energy needs of the building;

$Q_{H,ls}$ is the energy losses of the heating system;

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

$Q_{C,nd,B}$ is the cooling energy needs of the building;

$Q_{C,ls}$ is the energy losses of the cooling system;

$W_{H,aux,BAC}$ is the electrical auxiliary energy for heating related to BAC efficiency class;

$W_{C,aux,BAC}$ is the electrical auxiliary energy for cooling related to BAC efficiency class;

$W_{V,aux,BAC}$ is the electrical auxiliary energy for ventilation related to BAC efficiency class;

$W_{L,BAC}$ is the electrical energy for the lighting related to BAC efficiency class;

$W_{H,aux}$ is the electrical auxiliary energy for heating;

$W_{C,aux}$ is the electrical auxiliary energy for cooling;

$W_{V,aux}$ is the electrical auxiliary energy for ventilation;

W_L is the electrical energy for the lighting;

$f_{BAC,H}$ is the BAC efficiency factor for thermal energy (heating);

$f_{BAC,C}$ is the BAC efficiency factor for thermal energy (cooling);

$f_{BAC,el}$ is the BAC efficiency factor for electric energy;

$f_{BAC,H, ref}$ is the BAC efficiency factor for thermal energy (heating) for reference BAC;

$f_{BAC,C, ref}$ is the BAC efficiency factor for thermal energy (cooling) for reference BAC;

$f_{BAC,el, ref}$ is the BAC efficiency for electric energy for reference BAC.

8 Simplified input data correlations

There is no simplified input data correlation.

9 Quality control

No quality control criteria have been established to check if this document has been correctly applied, i.e. that the calculation performed is credible and pertinent to the calculated building.

10 Compliance check

No provisions are supplied to check if the method was correctly applied.

Annex A
(informative)

BAC efficiency factors

A.1 Overall BAC efficiency factors for the thermal energy $f_{BAC,th}$

The BAC efficiency factors in Table A.1 and Table A.2 for thermal energy (heating, DHW and cooling) are classified depending on the building type and the efficiency class the BAC/TBM system is related to. The factors for efficiency class C are defined to be 1 as this class represents a standard functionality of BAC and TBM system. The use of efficiency classes B or A always leads to lower BAC efficiency factors, i.e. an improvement of building performance.

Table A.1 — Overall BAC efficiency factors $f_{BAC,th}$ – Non-residential buildings

Non-residential building types	Overall BAC efficiency factors $f_{BAC,th}$			
	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
Hospital	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 A.2 — Overall BAC efficiency factors $f_{BAC,th}$ – Residential buildings

Residential building types	Overall BAC efficiency factors $f_{BAC,th}$			
	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

A.2 Overall BAC efficiency factors for electric energy $f_{BAC,el}$

Electric energy in this context means lighting energy and electric energy required for auxiliary devices as defined in Table 5. The BAC efficiency factors in Table A.3 and Table A.4 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 BAC and TBM system. The factors for efficiency class C are defined to be 1 as this class represents a standard functionality of BAC and TBM system. The use of efficiency classes B or A always leads to lower BAC efficiency factors, i.e. an improvement of building performance.

Table A.3 — Overall BAC Efficiency factors $f_{BAC,el}$ – Non-residential buildings

Non-residential building types	Overall BAC efficiency factors $f_{BAC,el}$			
	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
Hospital	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 A.4 — Overall BAC efficiency factors $f_{BAC,el}$ – Residential buildings

Residential building types	Overall BAC efficiency factors $f_{BAC,el}$			
	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

A.3 Detailed BAC efficiency factors for heating and cooling

Table A.5 — Detailed BAC Efficiency factors $f_{BAC,H}$ and $f_{BAC,C}$ – Non-residential buildings

Non-residential building types	Overall BAC efficiency factors $f_{BAC,H}$ and $f_{BAC,C}$							
	D		C Reference		B		A	
	Non energy efficient		Standard		Advanced		High energy performance	
	$f_{BAC,H}$	$f_{BAC,C}$	$f_{BAC,H}$	$f_{BAC,C}$	$f_{BAC,H}$	$f_{BAC,C}$	$f_{BAC,H}$	$f_{BAC,C}$
Offices	1,44	1,57	1	1	0,79	0,80	0,70	0,57
Lecture 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	-
Hospital	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 A.6 — Detailed BAC efficiency factors $f_{BAC,H}$ and $f_{BAC,C}$ – Residential buildings

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

A.4 Detailed BAC efficiency factors for DHW

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

Detailed factors are accounting for the BAC 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 A.7) or for residential building types in (Table A.8).

Table A.7 — Detailed BAC efficiency factors $f_{BAC,DHW}$ - Non-residential buildings

Non-residential building types	Overall BAC efficiency factor $f_{BAC,DHW}$			
	D	C Reference	B	A
	Non energy efficient	Standard	Advanced	High energy performance
Offices Lecture hall Education buildings (schools) Hospital 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 A.8 — Detailed BAC efficiency factors $f_{BAC,DHW}$ – Residential buildings

Residential building types	Overall BAC efficiency factor $f_{BAC,DHW}$			
	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	1,11	1,00	0,90	0,80

A.5 Detailed BAC efficiency factors for lighting and auxiliary energy

Factors for non-residential building types are available as detailed factors (Table A.9) accounting for different BAC impacts on energy performance of electricity for lighting and auxiliary energy.

Table A.9 — Detailed BAC Efficiency factors $f_{BAC,el,L}$ and $f_{BAC,el,aux}$ – Non-residential buildings

Non-residential building types	Overall BAC efficiency factors							
	D		C Reference		B		A	
	Non energy efficient		Standard		Advanced		High energy performance	
	$f_{BAC,el,L}$	$f_{BAC,el,aux}$	$f_{BAC,el,L}$	$f_{BAC,el,aux}$	$f_{BAC,el,L}$	$f_{BAC,el,aux}$	$f_{BAC,el,L}$	$f_{BAC,el,aux}$
Offices	1,1	1,15	1	1	0,85	0,86	0,72	0,72
Lecture 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
Hospital	1,2	1,1	1	1	1	0,98	1	0,96

Table A.9 *(continued)*

Non-residential building types	Overall BAC efficiency factors							
	D		C Reference		B		A	
	Non energy efficient		Standard		Advanced		High energy performance	
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	-	-	-	-

Annex B
(normative)

Minimum BAC function type requirements

Table B.1 defines the minimum functional type requirements of BAC and TBM functions described in Table 5.

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 BAC function to take into account for the calculation of energy consumption of a building when the BAC functions are not defined in detail;

— to calculate the energy use for the reference case in step 1 of the BAC efficiency factor method (first box in Figure 8 in Clause 7).

Unless differently specified by public authorities the minimum level of function types to be implemented corresponds to Table B.1.

Table B.1 — Minimum BAC function type requirement

			Residential	Non-residential
Automatic control				
1	Heating control			
1.1	Emission control			
	2	Individual room control	x	x
1.2	Emission control for TABS (heating mode)			
	1	Central automatic control	x	x
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	x	x
1.4	Control of distribution pumps in networks			
	The controlled pumps can be installed at different levels in the network.			
	1	On off control	x	x
1.4.a	Hydronic balancing heating distribution (including contribution to the balancing to the emission side)			
	Hydronic balancing is applied to an emitter or a group of heat emitters greater than 10.			
	1	Balanced statically per emitter, without group balance	x	
	3	Balanced statically per emitter and dynamic group balance		x
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	x	x
1.6	Heat generator control (combustion and district heating)			
	1	Variable temperature control depending on outside temperature	x	x
1.7	Heat generator control (heat pump)			

Table B.1 *(continued)*

			Residential	Non-residential
Automatic control				
	0	On/off control of heat generator	x	x
1.8	Heat generator control (outdoor unit)			
	1	Multi-stage control of heat generator	x	x
1.9	Sequencing of different heat generators			
	1	Priorities only based on loads	x	x
1.10	Control of thermal energy storage (TES) charging			
	1	2-sensor charging of storage	x	x
2	Domestic hot water supply control			
2.1	Control of DHW storage charging with direct electric heating or integrated electric heat pump			
	1	Automatic on/off control and scheduled charging enable	x	x
2.2	Control of DHW storage charging using heating water generation			
	1	Automatic on/off control and scheduled charging enable	x	x
2.3	Control of DHW storage charging with solar collector and supplementary heat generation			
	1	Automatic control of solar storage charge (Prio. 1) and supplementary storage charge (Prio. 2)	x	x
2.4	Control of DHW circulation pump			
	1	With time program	x	x
3	Cooling control			
3.1	Emission control			
	2	Individual room control	x	x
3.2	Emission control for TABS (cooling mode)			
	1	Central automatic control	x	x
3.3	Control of distribution network chilled water temperature (supply or return)			
	Similar function can be applied to the control of direct electric cooling (e.g. compact cooling units, split units) for individual rooms.			
	1	Outside temperature compensated control	x	x
3.4	Control of distribution pumps in networks			
	The controlled pumps can be installed at different levels in the network.			
	1	On off control	x	x
3.4.a	Hydronic balancing cooling distribution (including contribution to the balancing to the emission side)			
	Hydronic balancing is applied to a group of cooling emitters (cooling panel, fan-coil unit or indoor unit) greater than 10, in addition to static balancing at individual cooling emitters.			
	1	Static balancing	x	x
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	x	x
3.6	Interlock between heating and cooling control of emission and/or distribution			
	1	Partial interlock (dependent on the HVAC system)	x	x
3.7	Different chiller selection control			
	The goal consists generally in maximizing the chiller operation temperature.			

Table B.1 *(continued)*

			Residential	Non-residential
Automatic control				
	1	Variable temperature control depending on outside temperature	x	x
3.8	Sequencing of different chillers			
	1	Priorities only based on loads	x	x
3.9	Control of thermal energy storage (TES) operation			
	1	Time-scheduled storage operation	x	x
4	Ventilation and air-conditioning control			
4.1	Supply air flow control at the room level			
	1	Time control	x	x
4.2	Room air temperature control (all-air systems)			
	1	Continuous control	x	x
4.3	Room air temperature control (air–water systems)			
	0	No coordination		x
	1	Coordination	x	
4.4	Outside air flow control			
	0	Fixed OA ratio/OA flow	x	
	1	Staged (low/high) OA ratio/OA flow (time scheduled)		x
4.5	Air flow or pressure control at the air handler level			
	1	On off time control	x	x
4.6	Heat recovery control: icing protection			
	1	With icing protection	x	x
4.7	Heat recovery control (prevention of overheating)			
	1	With overheating control	x	x
4.8	Free mechanical cooling			
	1	Night cooling	x	x
4.9	Supply air temperature control			
	1	Constant setpoint	x	x
4.10	Humidity control			
	1	Dew point control	x	x
5	Lighting control			
5.1	Occupancy control			
	0	Manual on/off switch	x	
	2	Automatic detection (auto on)		x
5.2	Light level/daylight control			
	0	Manual (central)	x	x
6	Blind control			
	1	Motorized operation with manual control	x	
	2	Motorized operation with automatic control		x
7	Technical home and building management			
7.1	Setpoint management			
	0	Manual setting room by room individually	x	
	1	Adaptation from distributed/decentralized plant rooms only		x

Table B.1 *(continued)*

			Residential	Non-residential
Automatic control				
7.2	Run time management			
	0	Manual setting (plant enabling)	x	
	1	Individual setting following a predefined time schedule including fixed preconditioning phases		x
7.3	Detecting faults of technical building systems and providing support to the diagnosis of these faults			
	0	No central indication of detected faults and alarms	x	
	1	With central indication of detected faults and alarms		x
7.4	Reporting information regarding energy consumption, indoor conditions			
	0	Indication of actual values only (e.g. temperatures, meter values)	x	x
7.5	Local energy production and renewable energies			
	0	Uncontrolled generation depending on the fluctuating availability of RES and/or run time of CHP; overproduction will be fed into the grid	x	x
7.6	Waste heat recovery			
	0	Instantaneous use of waste heat or heat shifting	x	x
7.7	Smart grid interaction			
	0	Building is operated independently from the grid load	x	x

Annex C
(informative)

Determination of the BAC efficiency factors

C.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 BAC 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 BAC and TBM functionalities representing the BAC efficiency classes as defined in 5.3. The functionalities were represented by:

— time of operation for the heating and/or cooling system;

— definition of temperature setpoints for heating/cooling (energy dead band). Temperature setpoints are defined in dependence on the BAC efficiency class as described in Table 7 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:

1) dimensions: 5 m × 4 m × 3 m;

2) floor space: 20 m^2;

3) exterior wall:

   a) 15 m^2 (including windows of 8 m^2);

   b) orientation: west;

4) U-Values:

   a) 0,34 W m^{-2} K^{-1} (exterior wall);

   b) 0,65 W m^{-2} K^{-1} (internal wall);

   c) 0,4 W m^{-2} K^{-1} (floor/ceiling);

   d) 1,4 W m^{-2} K^{-1} (window, SHGC = 0,58);

5) thermal mass: medium C = 50 W h m^{-2} K^{-1}.

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 ISO 52003-1. The modelling approaches regarding user profiles as well as functionality of BAC efficiency classes are described in detail in C.2.

Simulations have been performed for average weather conditions represented by TRY04 (reference station Würzburg, Germany, (Deutscher Wetterdienst DWD, Offenbach, https://www.dwd.de/EN/climate_environment/climateenvironment_node.html).

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

— heating: operating hours and temperature setpoints as declared in Tables C.1 to C.7;

— cooling: operating hours and temperature setpoints as declared in Tables C.1 to C.7;

— air conditioning: operating hours and temperature setpoints as declared in Tables C.1 to C.7.

The operating hours and setpoints are determining the energy need. The expenditure energy for the 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 on 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.

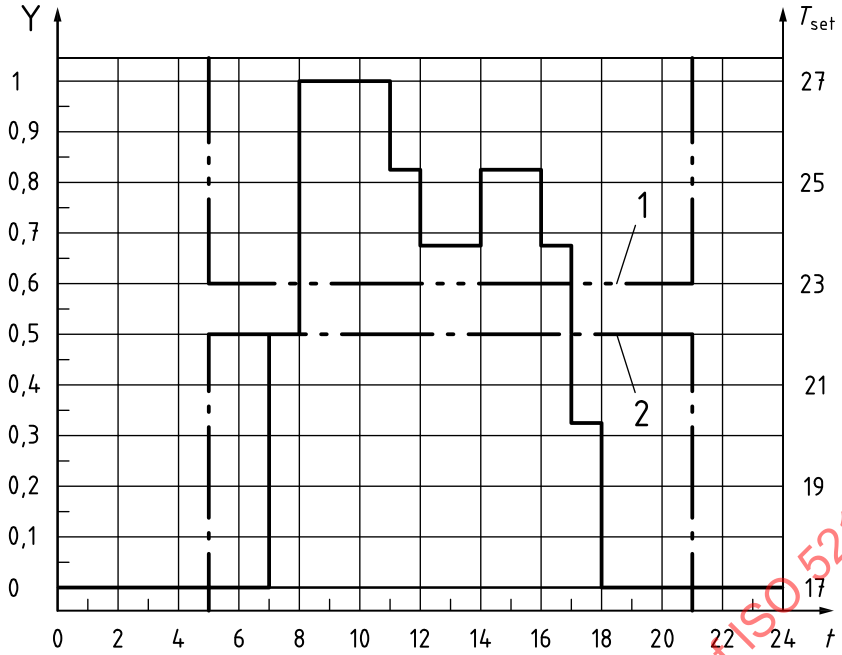
Energy required for artificial lighting was not taken into account when BAC efficiency factors were determined, because the impact of lighting control is evaluated separately within EN 15193-1; this effect is not taken into account when BAC efficiency factors were determined for artificial lighting.

C.2 Detailed modelling approaches and user profiles

C.2.1 General

BAC 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. Figures C.1 to C.12 exemplify the user profile of an office building. The user profiles of other buildings are described in C.3.

C.2.2 Efficiency class C (reference)



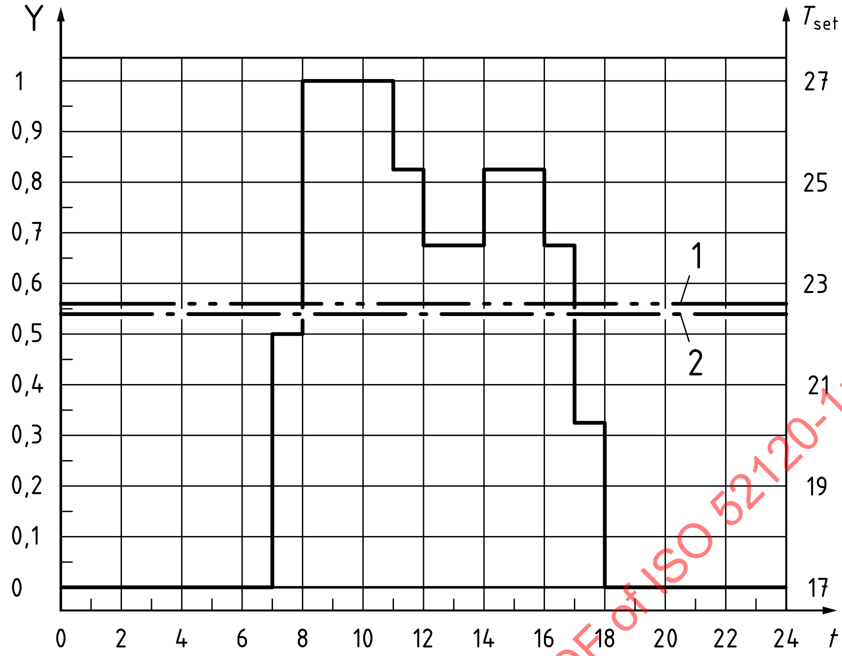
Key

Y	normalized level of occupancy
t	time
T_{set}	temperature setpoint
1	cooling
2	heating

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

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

C.2.3 Efficiency class D



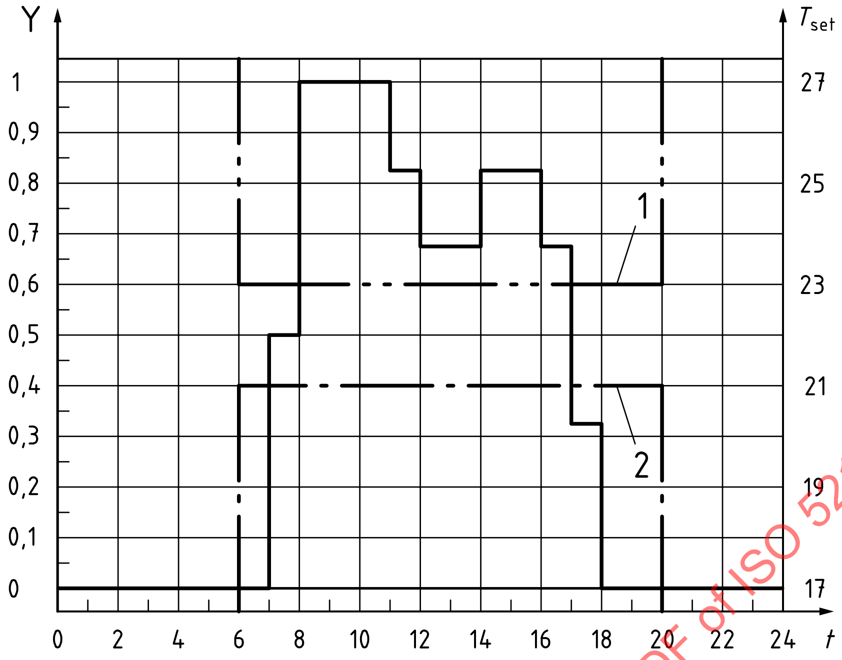
Key

Y	normalized level of occupancy
t	time
T_{set}	temperature setpoint
1	cooling
2	heating

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

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

C.2.4 Efficiency class B



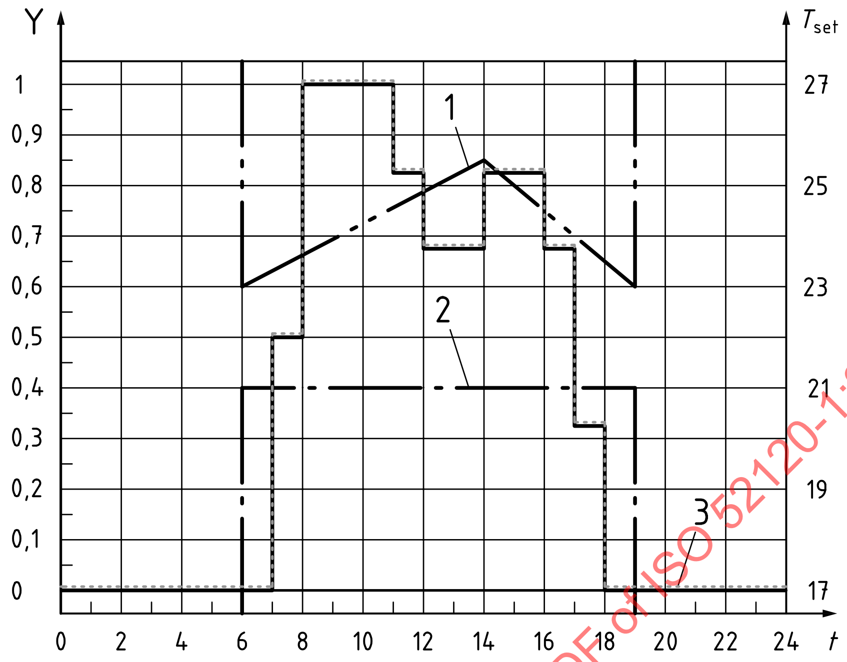
Key

Y	normalized level of occupancy
t	time
T_{set}	temperature setpoint
1	cooling
2	heating

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

Efficiency class B allows a better adaptation of operating time by optimizing start/stop times. The actual temperature setpoints 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.

C.2.5 Efficiency class A



Key

Y normalized level of occupancy
t time
T_{set} temperature setpoint
1 cooling
2 heating
3 normalized level of ventilation

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

Efficiency class A further improves energy performance by applying advanced BAC and TBM functions, e.g. adaptive cooling setpoints or ventilation air flows related to the occupancy detection.

C.3 Boundary condition

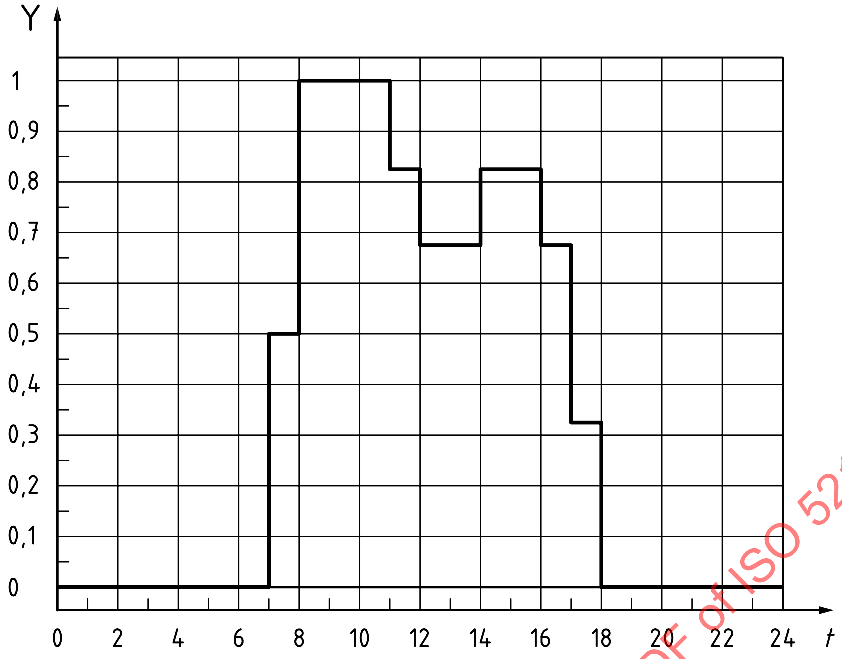
C.3.1 General

For each building type both the user profile and relevant boundary conditions are given in Tables C.1 to C.7. Boundary conditions include temperature setpoints 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 are defined according to VDI 2078[12]. 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 setpoint 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 BAC efficiency classes B and A depends on a threshold value for solar irradiation (200 W/m² and 130 W/m² resp.) when shading controller starts his/her activity.

C.3.2 Office



Key

Y normalized level of occupancy

t time in hours

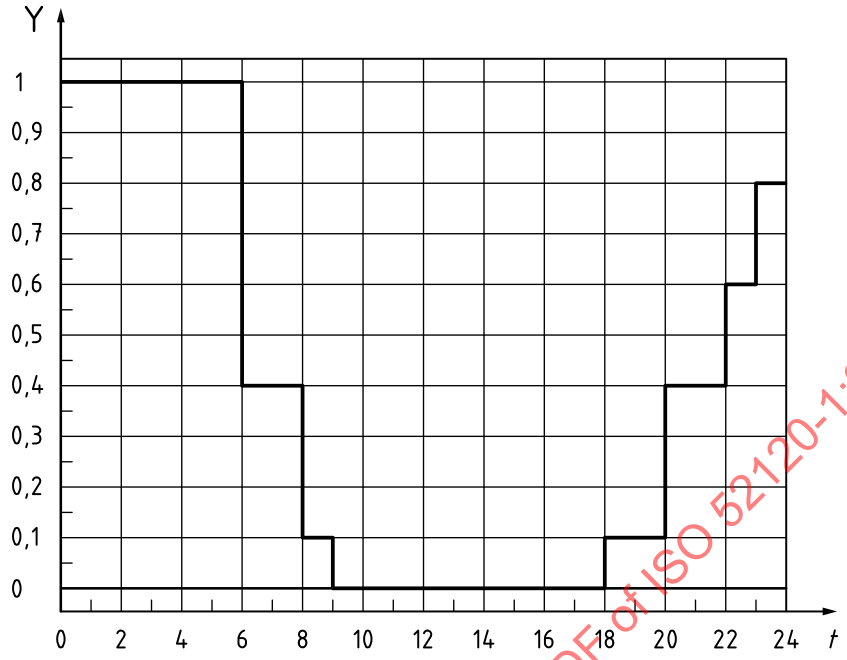
Figure C.5 — User profiles for an office

Table C.1 — Boundary conditions for BAC efficiency classes: office

Office		BAC efficiency class			
		D	**C**	**B**	**A**
Heating	Temperature setpoint	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 setpoint	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/m^2	13 W/m^2	13 W/m^2	13 W/m^2
	Operation time	07:00 - 18:00	07:00 - 18:00	07:00 - 18:00	07:00 - 18:00
Gains	Persons	13,3 m^2/Pers.	13,3 m^2/Pers.	13,3 m^2/Pers.	13,3 m^2/Pers.
	Equipment	10 W/m^2	10 W/m^2	10 W/m^2	10 W/m^2
Ventilation	Air change	0 /h	0 /h	0 /h	0 /h
Solar	Shading factor	0,3 manual	0,5 manual	0,7 (200 W/m^2)[a]	0,7 (130 W/m^2)[a]
User profile	Workday/weekend	5/2	5/2	5/2	5/2

[a] For further explanations refer to C.3.

C.3.3 Hotel



Key

Y normalized level of occupancy

t time in hours

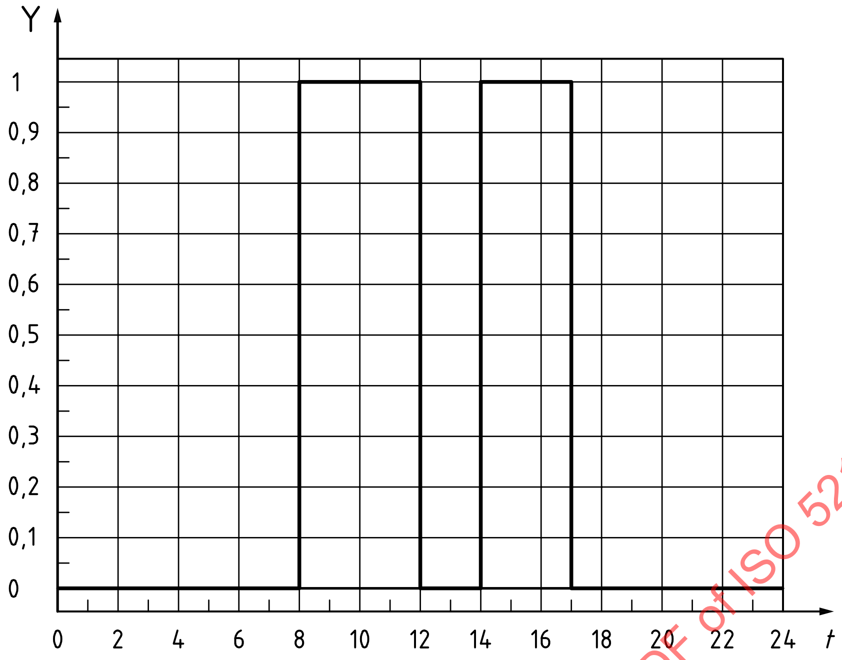
Figure C.6 — User profiles for a hotel

Table C.2 — Boundary conditions for BAC efficiency classes: hotel

Hotel		BAC efficiency class			
		D	C	B	A
Heating	Temperature setpoint	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 setpoint	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)[a]	0,7 (130 W/m²)[a]
User profile	Workday/weekend	7/0	7/0	7/0	7/0

[a] For further explanations refer to C.3.

C.3.4 Education, school



Key

Y normalized level of occupancy

t time in hours

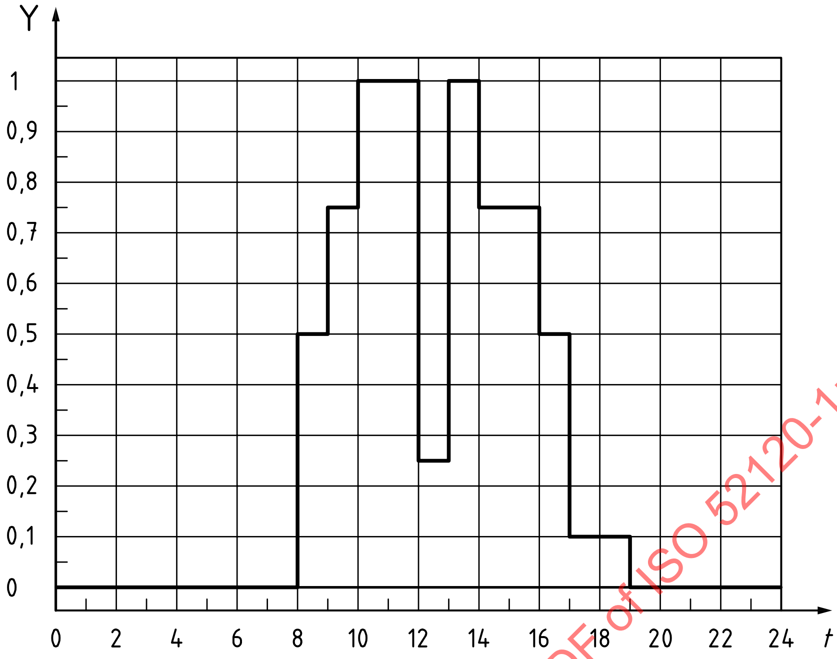
Figure C.7 — User profiles for a class room

Table C.3 — Boundary conditions for BAC efficiency classes: class room

Education/school		BAC efficiency class			
		D	C	B	A
Heating	Temperature setpoint	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 setpoint				
	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)[a]	0,7 (130 W/m²)[a]
User profile	Workday/weekend	5/2	5/2	5/2	5/2

[a] For further explanations refer to C.3.

C.3.5 Lecture hall



Key

Y normalized level of occupancy

t time in hours

Figure C.8 — User profiles for a lecture hall

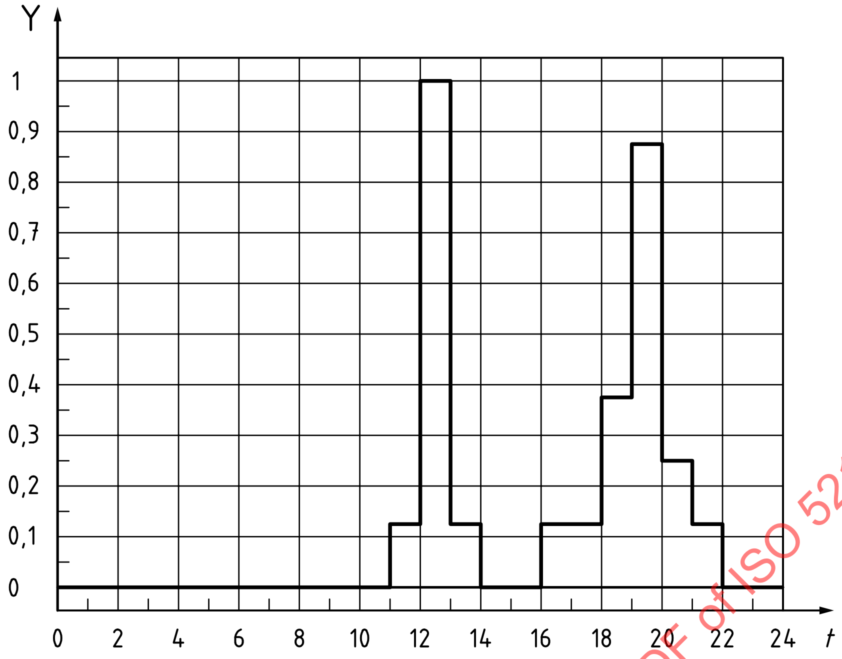
Table C.4 — Boundary conditions for BAC efficiency classes: lecture hall

Lecture hall		BAC efficiency class			
		D	C	B	A
Heating	Temperature setpoint	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 setpoint	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[b]
Solar	Shading factor	0,3 manual	0,5 manual	0,7 (200 W/m²)[a]	0,7 (130 W/m²)[a]
User profile	Workday/weekend	5/2	5/2	5/2	5/2

[a] For further explanations refer to C.3.

[b] Occupancy detection.

C.3.6 Restaurant



Key

Y normalized level of occupancy

t time in hours

Figure C.9 — User profiles for a restaurant

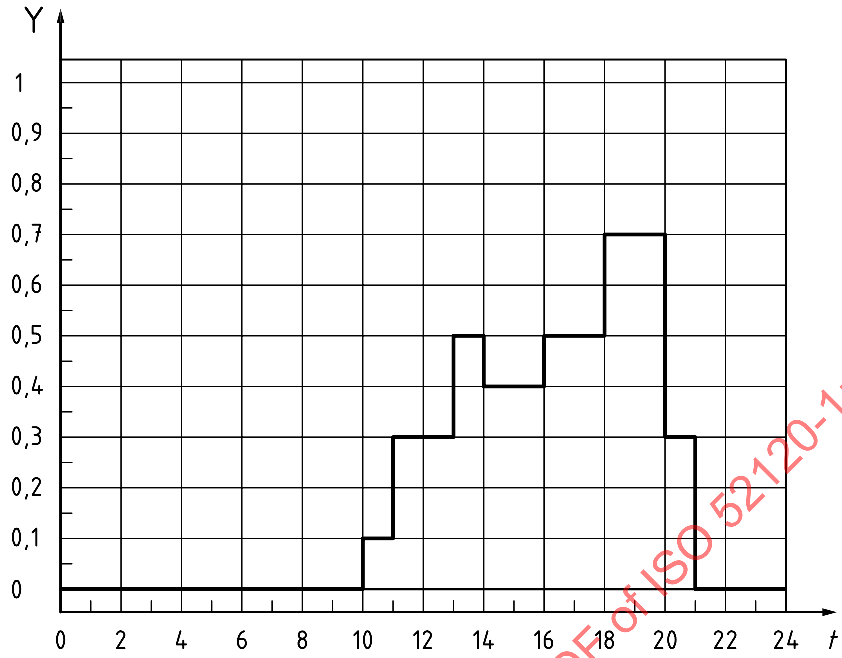
Table C.5 — Boundary conditions for BAC efficiency classes: restaurant

Restaurant		BAC efficiency class			
		D	**C**	**B**	**A**
Heating	Temperature setpoint	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 setpoint	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/m^2	10 W/m^2	10 W/m^2	10 W/m^2
	Operation time	10:00 - 23:00	10:00 - 23:00	10:00 - 23:00	10:00 - 23:00
Gains	Persons	1 m^2/Pers.	1 m^2/Pers.	1 m^2/Pers.	1 m^2/Pers.
	Equipment	2 W/m^2	2 W/m^2	2 W/m^2	2 W/m^2
Ventilation	Air change	8,5 /h	8,5 /h	8,5 /h	8,5 /h[b]
Solar	Shading factor	0,3 manual	0,5 manual	0,7 (200 W/m^2)[a]	0,7 (130 W/m^2)[a]
User profile	Workday/weekend	7/0	7/0	7/0	7/0

[a] For further explanations refer to C.3.

[b] Occupancy detection.

C.3.7 Wholesale centre



Key

Y normalized level of occupancy

t time in hours

Figure C.10 — User profiles for a wholesale centre

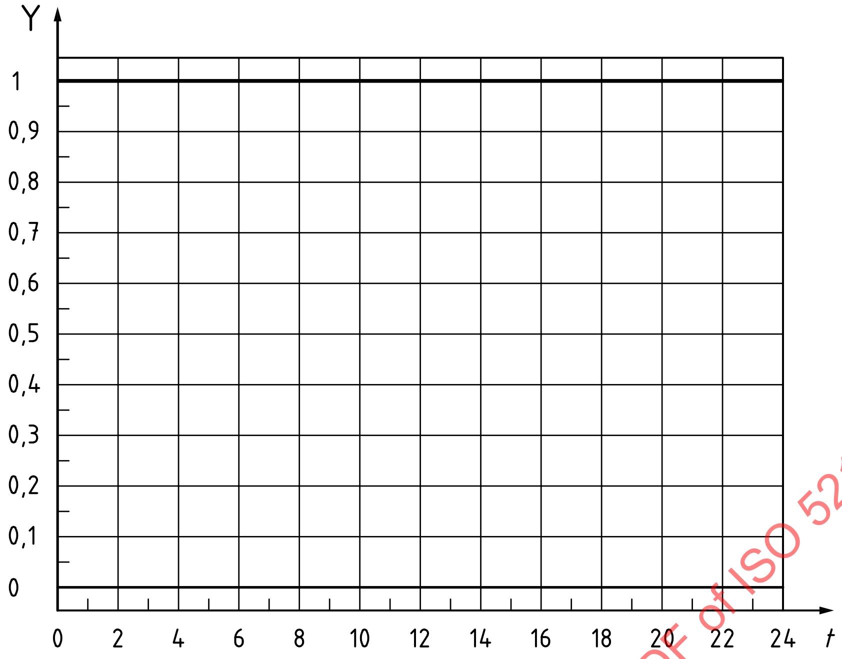
Table C.6 — Boundary conditions for BAC efficiency classes: wholesale centre

Wholesale centre		BAC efficiency class			
		D	**C**	**B**	**A**
Heating	Temperature setpoint	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 setpoint	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/m^2	15 W/m^2	15 W/m^2	15 W/m^2
	Operation time	10:00 - 23:00	10:00 - 23:00	10:00 - 23:00	10:00 - 23:00
Gains	Persons	5 m^2/Pers.	5 m^2/Pers.	5 m^2/Pers.	5 m^2/Pers.
	Equipment	3,5 W/m^2	3,5 W/m^2	3,5 W/m^2	3,5 W/m^2
Ventilation	Air change	1,3 /h	1,3 /h	1,3 /h	1,3 /h[b]
Solar	Shading factor	0,3 manual	0,5 manual	0,7 (200 W/m^2)[a]	0,7 (130 W/m^2)[a]
User profile	Workday/weekend	6/1	6/1	6/1	6/1

[a] For further explanations refer to C.3.

[b] Occupancy detection.

C.3.8 Hospital



Key

Y normalized level of occupancy

t time in hours

Figure C.11 — User profiles for a hospital

Table C.7 — Boundary conditions for BAC efficiency classes: hospital

Hospital		BAC efficiency class			
		D	**C**	**B**	**A**
Heating	Temperature setpoint	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 setpoint				
	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[b]
Solar	Shading factor	0,3 manual	0,5 manual	0,7 (200 W/m²)[a]	0,7 (130 W/m²)[a]
User profile	Workday/weekend	7/0	7/0	7/0	7/0

[a] For further explanations refer to C.3.

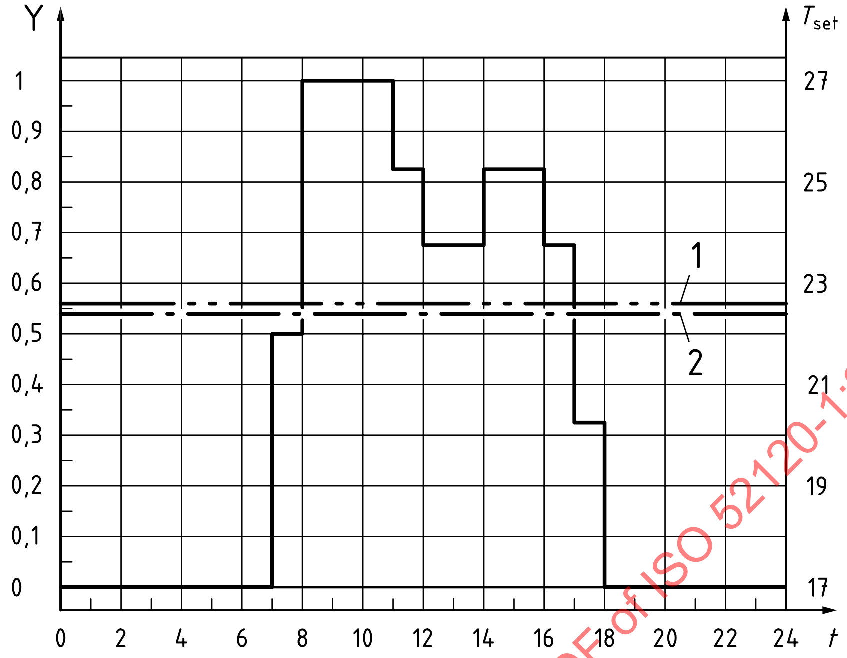
[b] Occupancy detection.

C.4 BAC efficiency classes - Domestic hot water (DHW)

The impact of BAC functions 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 setpoint temperature;

— mean DHW storage tank temperature.



Key

Y normalized level of occupancy

t time in hours

Figure C.12 — Operation time for DHW system for different BAC efficiency classes

The second impact on energy performance is coming from the mean storage tank temperature during operation. The mean temperatures for the different BAC efficiency classes are assumed as follows in Table C.8.

Table C.8 — Mean DHW storage tank temperature for BAC efficiency classes

BAC - Class	D	C	B	A
Storage tank temperature	48 °C	47 °C	46 °C	45 °C

C.5 Impact of geographical location on the BAC efficiency factors

All simulations in this document to calculate BAC efficiency factors are based on the weather conditions of the City of Würzburg (Germany) and are taken from the corresponding TRY (Test-reference-year). In the TRY there 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 directly in other countries because of the mean part load of the heating demand.

Figure C.13 shows the different outside temperatures for cities (from south to north) of Europe throughout the whole year (8,760 h/year). The cities are:

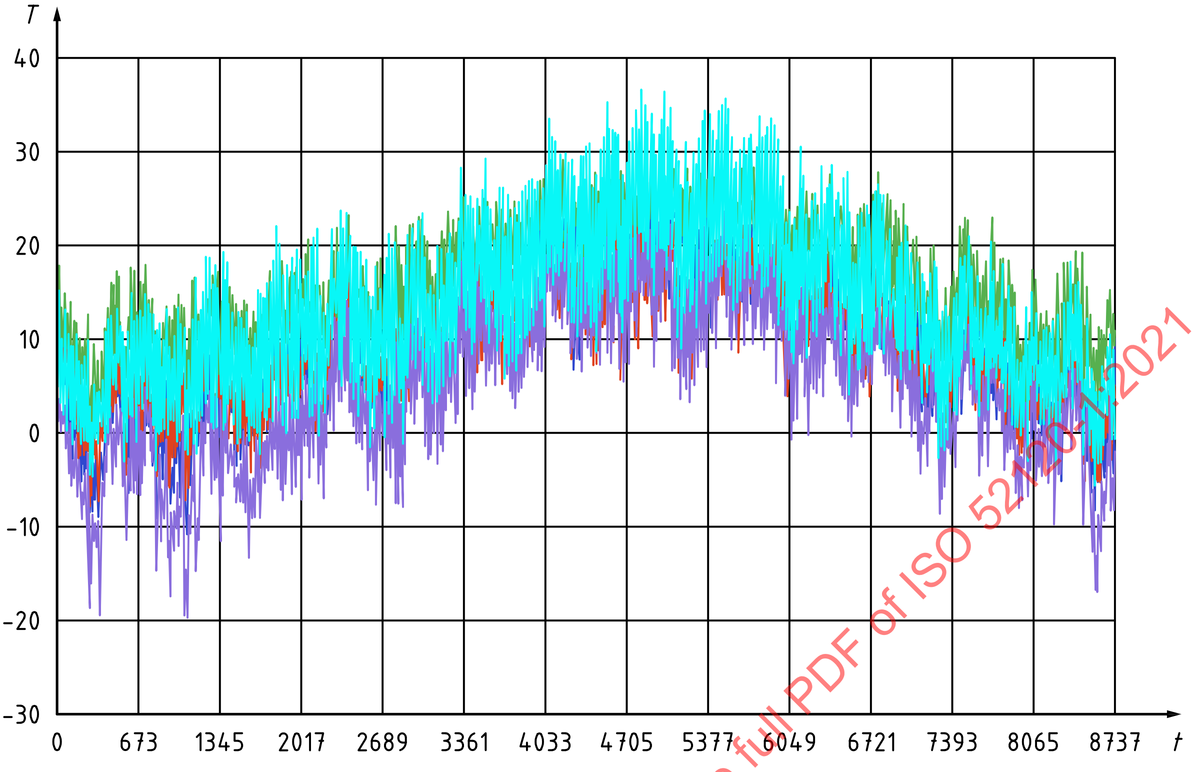
— Würzburg (Germany);

— Paris (France);

— Rome (Italy);

— Stockholm (Sweden);

— Madrid (Spain).



Key

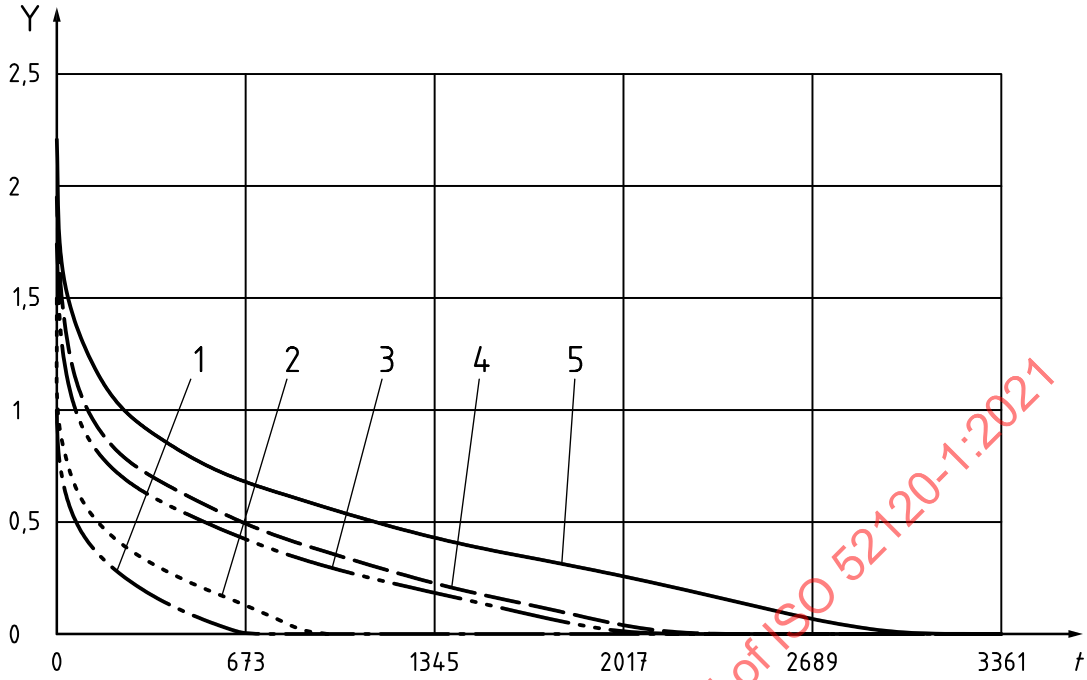
T temperature

t time in hours over a year

Figure C.13 — Outside 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 document.

By using the annual load duration curve (Figure C.14) of the same cities it is noticeable that the heating hours in the north are much 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.



Key

t	time in hours per year
Y	normalized heat load
1	Madrid, Spain
2	Rome, Italy
3	Paris, France
4	Würzburg, Germany
5	Stockholm, Sweden

Figure C.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:

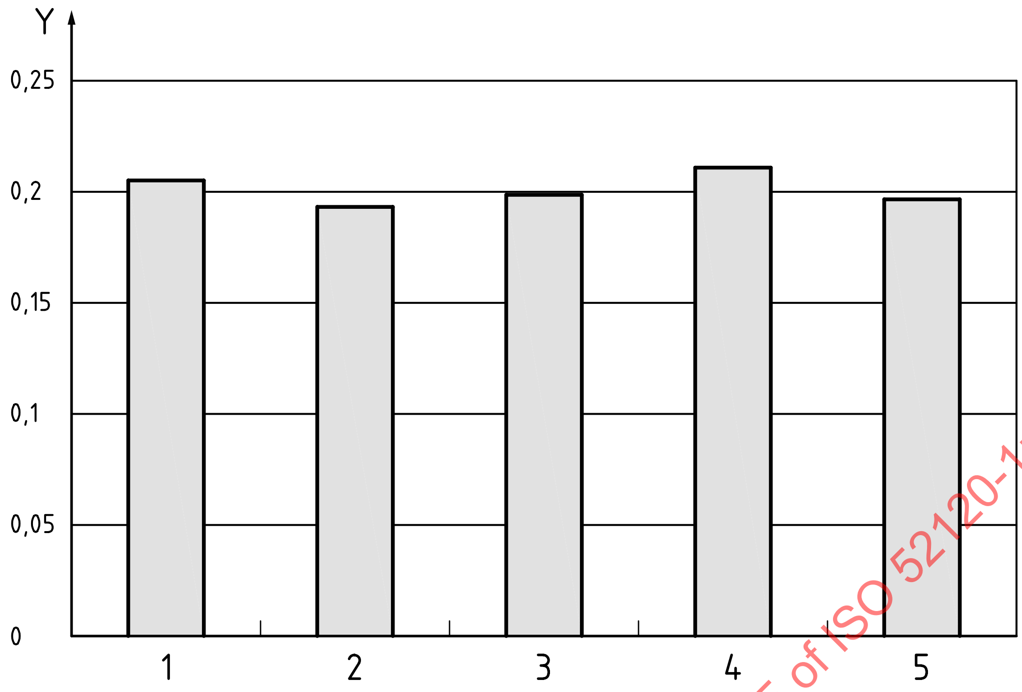
$$\bar{\beta} = \frac{\int_0^{t_\mathrm{H}} \dot{Q} \cdot \mathrm{d}t}{\Phi \cdot t_\mathrm{H}} \qquad \text{(C.1)}$$

where

Φ is the maximum heat load;

t_H is heating hours.

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



Key

Y	mean part load
1	Würzburg, Germany
2	Paris, France
3	Rome, Italy
4	Stockholm, Sweden
5	Madrid, Spain

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

The very small differences between the different cities in Europe which are noticeable in Figure C.15 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 depends on the mean part load of the energy demand, because the dynamic influence is in general a function of the mean part load.

C.6 Influence of the different user profiles on the BAC factors

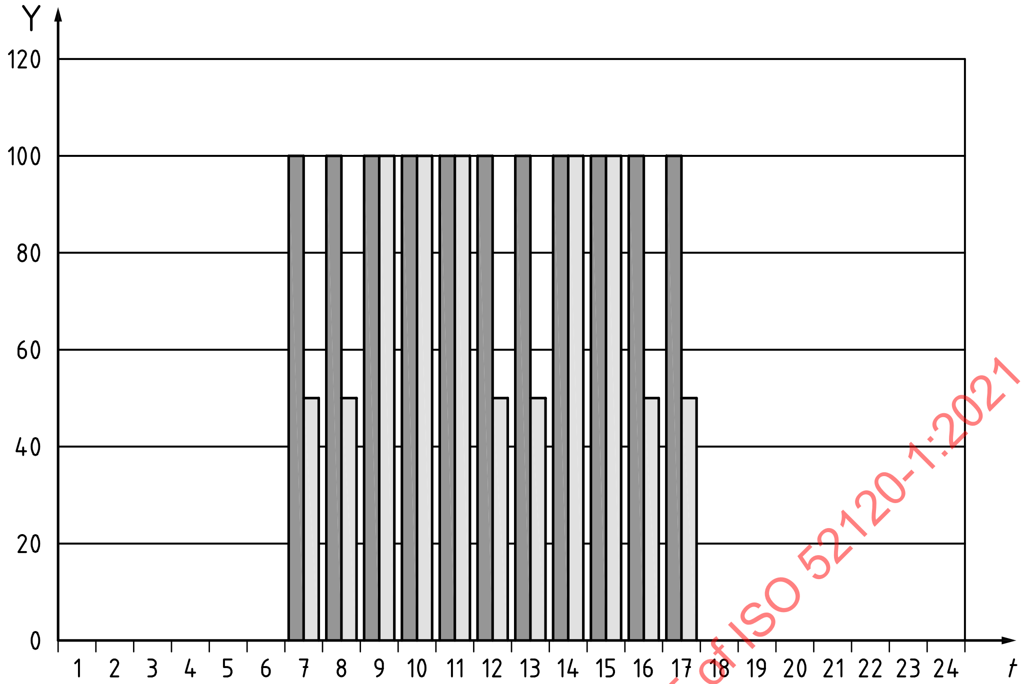
The BAC factors in this document are calculated with the user profiles which are listed in C.2.

For different user profiles (Figure C.16) a correction factor k_{cor} can be calculated.

For the standard profile A (in Figure C.16 Office - standard) a constant value $k_{us,A}$ can be calculated.

For the different user profile B (in Figure C.16 Office – new) a constant value $k_{us,B}$ 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.



Key

Y normalized user profile

t time

Figure C.16 — Different user profiles

The constant factor shall be calculated as:

$$k_{\text{us},k} = \frac{\sum_{i=t_{\text{us,sta}}}^{i=t_{\text{us,end}}} a_i}{t_{\text{us,day}}} t_{\text{us,sta}} \quad \text{(C.2)}$$

where

$t_{\text{us,sta}}$ start of use;

$t_{\text{us,end}}$ end of use;

$t_{\text{us,day}}$ daily use;

a_i part of occupancy/gains in %.

Then the correction factor shall be calculated as:

$$k_{\text{cor}} = \frac{k_{\text{us,A}}}{k_{\text{us,B}}} \quad \text{(C.3)}$$

Annex D
(informative)

Examples of how to use the BAC function list of ISO 16484-3 to describe functions from this document

D.1 General

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

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

D.2.1 Example 1 - Night cooling

Considered BAC and TBM function in this document defined in Table 5:

4	Ventilation and air-conditioning control	
4.8	Free mechanical cooling	
	1	Night cooling: the amount of outside air is set to its maximum during the unoccupied period provided that firstly the room temperature is above the setpoint for the comfort period and secondly that the difference between the room temperature and the outside temperature is above a given limit. If free night cooling will be realized by automatically opening windows there is no air flow control.

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

— This function relates to function 6.7 “Night cooling” in the BAC function list.

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

Considered BAC or TBM function in this document defined in Table 5:

4	Ventilation and air-conditioning control	
4.8	Free mechanical cooling	
	3	H,x- directed control: the amount of outside 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 BAC function list of ISO 16484-3:

— This function relates to function 6.1 “h,x-directed control” in the BAC function list.

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

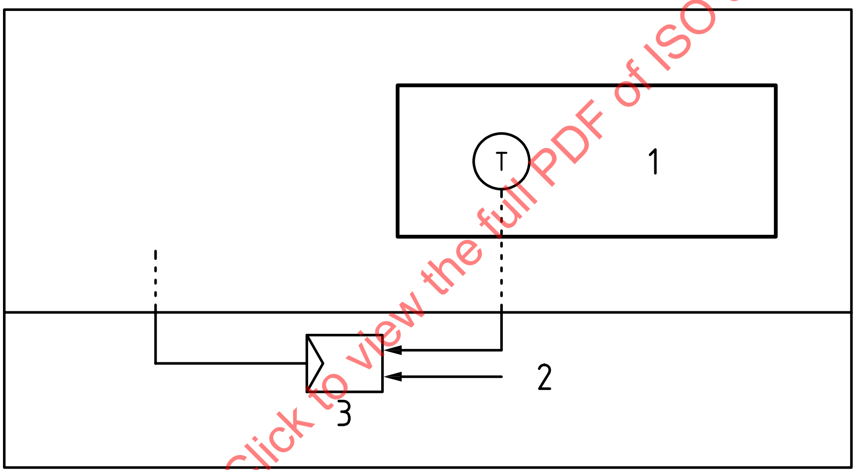
D.3.1 Example 3 - Individual room automatic control

Considered BAC and TBM function in this document defined in Table 5:

Automatic control		
1	Heating control	
1.1	Emission control	
	2	Individual room control: by thermostatic valves or electronic controller

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

The function is described by one row of the ISO 16484-3 BAC 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 shall be added (see Figure D.1).



Key

1 room

2 setpoint room

3 PI control algorithm

T temperature sensor

Figure D.1 — Control schematic to example 3

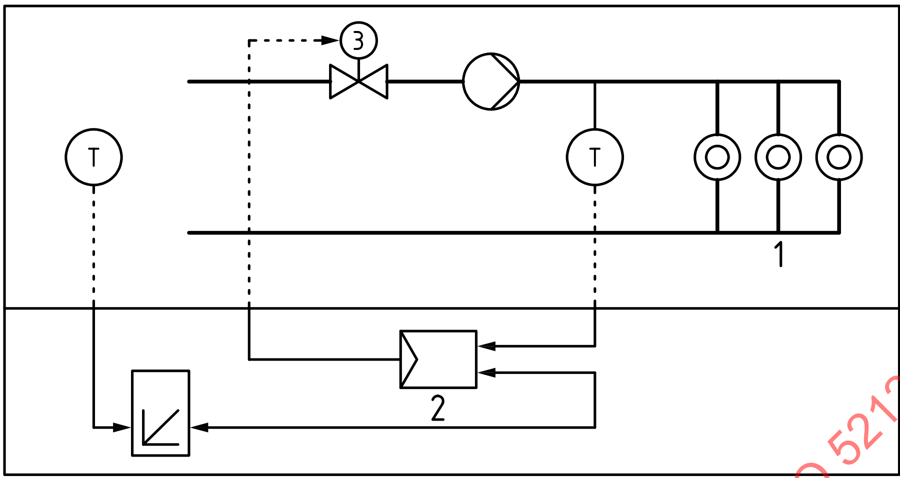
D.3.2 Example 4 - Outside temperature compensated control

Considered BAC and TBM function in this document defined in Table 5:

Automatic control		
1	Heating 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: action lowered the mean flow temperature.

Representation by using ISO 16484-3:

The function is described by one row in the BAC function list of 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 shall be added (see Figure D.2).



Key

1 heat emitters

2 PI control algorithm

3 valve

T temperature sensor

Figure D.2 — Control schematic to example 4

Annex E
(informative)

Applying BAC for EnMS specified in ISO 50001:2018

E.1 General

This annex explains in greater detail how to apply and use BAC (building automation and control) including TBM (technical building management) for an EnMS (energy management system) in buildings.

EnMS as specified by ISO 50001:2018 is intended to improve energy performance by managing energy use systematically. ISO 50001:2018 sets forth the requirements for continuous improvements in regard of more efficient and sustainable energy use for production/process, transportation and buildings (e.g. comfort, health and productivity of the building users).

E.2 Guideline for using BACS for EnMS

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

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

Table E.1 — Guideline to apply BACS for EnMS

No.	EnMS requirements according to ISO 50001:2018	Contribution of BACS for EnMS in building
1	4 Context of the organization (energy management system requirements)	
1.1	General requirements	
	The organization shall: a) establish, document, implement, maintain and improve an EnMS in accordance with the requirements of ISO 50001:2018; b) define and document the scope and boundaries of its EnMS; c) determine how it will meet the requirements of ISO 50001:2018 to achieve continual improvement of its energy performance and of its EnMS.	The organization should: a) take existing or planned BACS while establishing an EnMS; b) include existing BACS processes/documentation and especially monitoring/reporting; c) determine the general task to be performed by the BACS to support the EnMS regarding continual improvement energy performance of buildings.
2.2	5 Leadership (management responsibility)	
2.2.1	5.1 Leadership and commitment (top management)	