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

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National foreword

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 It supersedes BS EN 15232:2007, which is withdrawn.

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

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

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

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

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

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English Version

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

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

Energieeffizienz von Gebäuden - Einfluss von Gebäudeautomation und Gebäudemanagement

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

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Foreword

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

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of an identical text or by endorsement, at the latest by July 2012, and conflicting national standards shall be withdrawn at the latest by July 2012.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 15232:2007.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Introduction

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

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

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

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

1 Scope

This European Standard specifies:

- a structured list of Building Automation and Control System (BACS) and Technical Building Management (TBM) functions which have an impact on the energy performance of buildings;
- a method to define minimum requirements regarding BACS and TBM functions to be implemented in buildings of different complexities;
- a factor based method to get a first estimation of the impact of these functions on typical buildings;
- detailed methods to assess the impact of these functions on a given building. These methods enable to introduce the impact of these functions in the calculations of energy performance ratings and indicators calculated by the relevant standards.

This European Standard is defined for:

- building owners, architects or engineers, defining the functions to be implemented for a given new building or for the renovation of an existing building;
- public authorities, defining minimum requirements for BACS and TBM functions for new buildings as well as for renovation, as defined in the relevant standard;
- public authorities, defining inspection procedures of technical systems as well as inspectors applying these procedures to check if the level of BACS and TBM functions implemented is appropriate;
- public authorities, defining calculation methods which take into account the impact of BACS and TBM functions on the energy performance of buildings as well as software developers implementing these calculation methods and designers using them;
- designers, checking that the impact of all BACS and TBM functions are taken into account when assessing the energy performance of a building.

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

2 Normative references

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

3 Terms and definitions

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

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

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

3.1

auxiliary energy

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

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

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

[CEN/TR 15615]

3.2

building automation and controls

BAC

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

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

[EN ISO 16484-2:2004]

3.3

building automation and control systems

BACS

comprising all products and engineering services for automatic controls (including interlocks), monitoring,

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

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

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

[EN ISO 16484-2:2004]

3.4 **building management** **BM**

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

[CEN/TS 15379:2006]

3.5 **building management system** **BMS**

cf. building automation and control system

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

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

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

[EN ISO 16484-2:2004]

3.6 **delivered energy**

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

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

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

[CEN/TR 15615]

3.7 **energy carrier**

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

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

[ISO 13600:1997]

3.8

energy need for heating or cooling

heat to be delivered to or extracted from a conditioned space to maintain the intended temperature conditions during a given period of time

3.9

energy use for space heating or cooling or domestic hot water

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

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

[EN 15306]

3.10

energy efficiency

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

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

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

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

[CEN/CLC/TR 16103]

3.11

energy efficiency improvement

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

[CEN/CLC/TR 16103]

3.12

energy use

manner or kind of application of energy

EXAMPLE Lighting, ventilation, heating, processes, transport.

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

[CEN/CLC/TR 16103]

3.13

control function

BACS effect of programs and parameters

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

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

[EN ISO 16484-2:2004]

3.14

integrated building automation and control systems

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

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

3.15

integrated function

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

3.16

measured energy rating

energy rating based on measured amounts of delivered and exported energy

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

NOTE 2 Also known as "operational rating".

3.17

technical building management

TBM

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

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

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

3.18

technical building system

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

NOTE A technical building system is composed of different subsystems.

[CEN/TR 15615]

3.19

set-point temperature of a conditioned zone

internal (minimum) temperature, as fixed by the control system in normal heating mode, or internal (maximum) temperature, as fixed by the control system in normal cooling mode

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

[CEN/TR 15615]

4 Abbreviations and acronyms

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

BAC	Building Automation and Control
BACS	Building Automation and Control System
BM	Building Management
DHW	Domestic Hot Water
EMS	Energy Management System
HVAC	Heating, Ventilation and Air Conditioning
TABS	Thermo-active Building Systems
TBM	Technical Building Management

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

5.1 General

Building Automation and Control Systems (BACS) provide effective control functions of heating, ventilating, cooling, hot water and lighting appliances etc., that lead to improve operational and energy efficiencies. Complex and integrated energy saving functions and routines can be configured based on the actual use of a building, depending on real user needs, to avoid unnecessary energy use and CO₂ emissions.

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

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

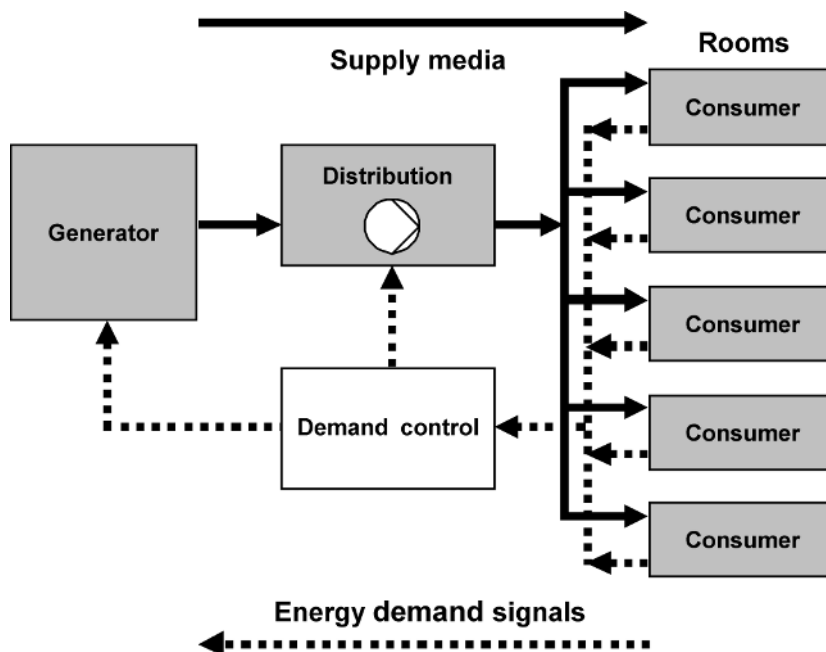


Figure 1 — Energy demand and supply model (Example: Heating plant)

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

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

The building automation and control functions described in Table 1 are aligned in accordance with the energy demand and supply model. The relevant energy-efficiency functions are handled starting with the room, via distribution up through generation.

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

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

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

AUTOMATIC CONTROL		
1	HEATING CONTROL	
1.1	Emission control	
		<i>The control system is installed at the emitter or room level, for case 1 one system can control several rooms</i>
	0	No automatic control of the room temperature
	1	<u>Central automatic control</u> : There is only central automatic control acting either on the distribution or on the generation. This can be achieved for example by an outside temperature controller conforming to EN 12098-1 or EN 12098-3
	2	<u>Individual room control</u> : By thermostatic valves or electronic controller
	3	<u>Individual room control with communication</u> : Between controllers and BACS (e.g. scheduler)
	4	<u>Individual room control with communication and presence control</u> : Between controllers and BACS; Demand / Presence control performed by occupancy
1.2	Emission control for TABS	
	0	No automatic control of the room temperature
	1	<u>Central automatic control</u> : The central automatic control for a TABS zone (which comprises all rooms which get the same supply water temperature) typically is a supply water temperature control loop whose set-point is dependant on the filtered outside temperature, e.g. the average of the previous 24 hours.
	2	<u>Advanced central automatic control</u> : This is an automatic control of the TABS zone that fulfils the following conditions: – If the TABS is used only for heating: The central automatic control is designed and tuned to achieve an optimal self-regulating of the room temperature within the required comfort range (specified by the room temperature heating set-point). "Optimal" means that the room temperatures of all rooms of the TABS zone remain during operation periods in the comfort range, to meet comfort requirements, but also is as low as possible to reduce the energy demand for heating. – If the TABS is used for heating and cooling: The central automatic control is designed and tuned to achieve an optimal self-regulating of the room temperature within the required comfort range (specified by room temperature heating and cooling set-points). "Optimal" means that the room temperatures of all rooms of the TABS zone remain during operation periods in the comfort range, to meet comfort requirements, but also uses as far as possible the full range to reduce the energy demand for heating and cooling. – If the TABS is used for heating and cooling: the automatic switching between heating and cooling is not done only dependent on the outside temperature, but also taking at least indirectly the heat gains (internal and solar) into account.
	3	<u>Advanced central automatic control with intermittent operation and/or room temperature feedback control</u> : a) Advanced central automatic control with intermittent operation. This is an advanced central automatic control according to 2) with the following supplement: The pump is switched off regularly to save electrical energy, either with a fast frequency - typically 6 hours on/off cycle time - or with a slow frequency, corresponding to 24 hours on/off cycle time. If the TABS is used for cooling, intermittent operation with 24 hours on/off cycle time can also be used to reject the heat to the outside air if the outside air is cold. b) Advanced central automatic control with room temperature feedback control. This is an advanced central automatic control according to 2) with the following supplement: The supply water temperature set-point is corrected by the output of a room temperature feedback controller, to adapt the set-point to non-predictable day-to-day variation of the heat gain. Since TABS react slowly, only day-to-day room temperature correction is applied, an instant correction cannot be achieved with TABS. The room temperature that is fed back is the temperature of a reference room or another temperature representative for the zone. c) Advanced central automatic control with intermittent operation and room temperature feedback control
1.3	Control of distribution network hot water temperature (supply or return)	
		<i>Similar function can be applied to the control of direct electric heating networks</i>
	0	No automatic control
	1	<u>Outside temperature compensated control</u> : Action lower the mean flow temperature
	2	<u>Demand based control</u> : E.g. based on indoor temperature; Actions leads generally to a decrease of the flow rate
1.4	Control of distribution pumps in networks	
		<i>The controlled pumps can be installed at different levels in the network</i>
	0	No automatic control
	1	<u>On off control</u> : To reduce the auxiliary energy demand of the pumps
	2	<u>Multi-Stage control</u> : To reduce the auxiliary energy demand of the pumps
	3	<u>Variable speed pump control</u> : With constant or variable Δp and with demand evaluation to reduce the auxiliary energy demand of the pumps

Table 1 (continued)

1.5	Intermittent control of emission and/or distribution
	<i>One controller can control different rooms/zones having same occupancy patterns</i>
0	<u>No automatic control</u>
1	<u>Automatic control with fixed time program</u> : To reduce the indoor temperature and the operation time
2	<u>Automatic control with optimum start/stop</u> : To reduce the indoor temperature and the operation time
3	<u>Automatic control with demand evaluation</u> : To reduce the indoor temperature and the operation time
1.6;	Different generator control for combustion and district heating
	<i>The goal consists generally in minimising the generator operation temperature</i>
0	<u>Constant temperature control</u>
1	<u>Variable temperature control depending on outdoor temperature</u>
2	<u>Variable temperature control depending on the load</u> : E.g. depending on supply water temperature
1.7	Generator control for heat pumps
	<i>The goal consists generally in minimising the generator operation temperature</i>
0	<u>Constant temperature control</u>
1	<u>Variable temperature control depending on outdoor temperature</u>
2	<u>Variable temperature control depending on the load</u> : E.g. depending on supply water temperature
1.8	Sequencing of different generators
0	<u>Priorities only based on running time</u>
1	<u>Priorities only based on loads</u>
2	<u>Priorities based on loads and demand</u> of the generator capacities
3	<u>Priorities based on generator efficiency</u> : The generator operational control is set individually to available generators so that they operate with an overall high degree of efficiency (e.g. solar, geothermic heat, cogeneration plant, fossil fuels)

Table 1 (continued)

2	DOMESTIC HOT WATER SUPPLY CONTROL	
	Term: Function Charging time release: Storage charging time release by time switch program Multi-sensor storage management: Demand-oriented storage management using two or more temperature sensors Heat generation: Boilers (fired with different types of fuels), heat pump, solar power, district heating, CHP. Demand-oriented supply: Information exchange to supply according storage temperature demand Return temperature control: Charging pump control for return temperature reduction Solar storage charge: Control of charging pump on / off to maximum DHW storage temperature during supply of free solar energy. Solar collector supplies the first priority energy. Supplementary storage charge: Release of supplementary control from heat generation with storage charging time release by time switch program to nominal DHW storage temperature or when going below the reduced DHW storage temperature. Heat generation supplies the second priority energy.	
2.1	Control of DHW storage temperature with integrated electric heating or electric heat pump	
	0	<u>Automatic control on / off</u>
	1	<u>Automatic control on / off and charging time release</u>
	2	<u>Automatic control on / off and charging time release and multi-sensor storage management</u>
2.2	Control of DHW storage temperature using heat generation	
	0	<u>Automatic control on / off</u>
	1	<u>Automatic control on / off and charging time release</u>
	2	<u>Automatic control on / off, charging time release and demand-oriented supply or multi-sensor storage management</u>
	3	<u>Automatic control on / off, charging time release, demand-oriented supply or return temperature control and multi-sensor storage management</u>
2.3	Control of DHW storage temperature, varying seasonally: with heat generation or integrated electric heating	
	0	<u>Manual selected control with charging pump on / off or electric heating</u>
	1	<u>Automatic selected control with charging pump on / off or electric heating and charging time release</u>
	2	<u>Automatic selected control with charging pump on / off or electric heating, charging time release and demand-oriented supply or multi-sensor storage management</u>
	3	<u>Automatic selected control with heat generation, demand-oriented supply and return temperature control or electric heating, charging time release and multi-sensor storage management</u>
2.4	Control of DHW storage temperature with solar collector and heat generation	
	0	<u>Manual selected control of solar energy or heat generation</u>
	1	<u>Automatic control of solar storage charge (Prio. 1) and supplementary storage charge</u>
	2	<u>Automatic control of solar storage charge (Prio. 1) and supplementary storage charge and demand-oriented supply or multi-sensor storage management</u>
	3	<u>Automatic control of solar storage charge (Prio. 1) and supplementary storage charge, demand-oriented supply, return temperature control and multi-sensor storage management</u>
2.5	Control of DHW circulation pump	
	<i>Continuous operation, time switch program controlled or demand-oriented on / off</i>	
	0	<u>Without time switch program</u>
	1	<u>With time switch program</u>
	2	<u>Demand-oriented control: Demand dependent on water usage (e.g. open/close tap)</u>

Table 1 (continued)

3	COOLING CONTROL	
3.1	Emission control	
		<i>The control system is installed at the emitter or room level, for case 1 one system can control several rooms</i>
	0	<u>No automatic control</u> : Providing the room temperature
	1	<u>Central automatic control</u> : There is only central automatic control acting either on the distribution or on the generation. This can be achieved for example by an outside temperature controller conforming to EN 12098-1 or EN 12098-3
	2	<u>Individual room control</u> : By thermostatic valves or electronic controller
	3	<u>Individual room control with communication</u> : Between controllers and BACS (e.g. scheduler)
	4	<u>Individual room control with communication and presence control</u> : Between controllers and BACS; Demand / Presence control performed by occupancy
3.2	Emission control for TABS for cooling	
	0	<u>No automatic control</u> : Of the room temperature
	1	<u>Central automatic control</u> : The central automatic control for a TABS zone (which comprises all rooms which get the same supply water temperature) typically is a supply water temperature control loop whose set-point is dependant on the filtered outside temperature, e.g. the average of the previous 24 hours.
	2	<u>Advanced central automatic control</u> : This is an automatic control of the TABS zone that fulfils the following conditions: – If the TABS is used only for cooling: The central automatic control is designed and tuned to achieve an optimal self-regulating of the room temperature within the required comfort range (specified by the room temperature cooling set-point). "Optimal" means that the room temperatures of all rooms of the TABS zone remain during operation periods in the comfort range, to meet comfort requirements, but also is as high as possible to reduce the energy demand for cooling. – If the TABS is used for heating and cooling: The central automatic control is designed and tuned to achieve an optimal self-regulating of the room temperature within the required comfort range (specified by room temperature heating and cooling set-points). "Optimal" means that the room temperatures of all rooms of the TABS zone remain during operation periods in the comfort range, to meet comfort requirements, but also uses as far as possible the full range to reduce the energy demand for heating and cooling. – If the TABS is used for heating and cooling: the automatic switching between heating and cooling is not done only dependent on the outside temperature, but also taking at least indirectly the heat gains (internal and solar) into account.
	3	<u>Advanced central automatic control with intermittent operation and/or room temperature feedback control</u> : a) Advanced central automatic control with intermittent operation. This is an advanced central automatic control according to 2 with the following supplement: The pump is switched off regularly to save electrical energy, either with a fast frequency - typically 6 hours on/off cycle time - or with a slow frequency, corresponding to 24 hours on/off cycle time. If the TABS is used for cooling, intermittent operation with 24 hours on/off cycle time can also be used to reject the heat to the outside air if the outside air is cold. b) Advanced central automatic control with room temperature feedback control. This is an advanced central automatic control according to 2 with the following supplement: The supply water temperature set-point is corrected by the output of a room temperature feedback controller, to adapt the set-point to non-predictable day-to-day variation of the heat gain. Since TABS react slowly, only day-to-day room temperature correction is applied, an instant correction cannot be achieved with TABS. The room temperature that is fed back is the temperature of a reference room or another temperature representative for the zone. c) Advanced central automatic control with intermittent operation and room temperature feedback control
3.3	Control of distribution network cold water temperature (supply or return)	
		<i>Similar function can be applied to the control of direct electric cooling (e.g. compact cooling units, split units) for individual rooms</i>
	0	<u>Constant temperature control</u>
	1	<u>Outside temperature compensated control</u> : Action increase the mean flow temperature
	2	<u>Demand based control</u> : E.g. Indoor temperature; Actions generally lead to an increase of the flow rate

Table 1 (continued)

3.4	Control of distribution pumps networks
	<i>The controlled pumps can be installed at different levels in the network</i>
0	<u>No automatic control</u>
1	<u>On off control</u> : To reduce the auxiliary energy demand of the pumps
2	<u>Multi-Stage control</u> : To reduce the auxiliary energy demand of the pumps
3	<u>Variable speed pump control</u> : With variable Δp and with demand evaluation to reduce the auxiliary energy demand of the pumps
3.5	Intermittent control of emission and/or distribution
	<i>One controller can control different rooms/zones having same occupancy patterns</i>
0	<u>No automatic control</u>
1	<u>Automatic control with fixed time program</u> : To raise the indoor temperature and to lower the operation time
2	<u>Automatic control with optimum start/stop</u> : To raise the indoor temperature and to lower the operation time
3	<u>Automatic control with demand evaluation</u> : To raise the indoor temperature and to lower the operation time
3.6	Interlock between heating and cooling control of emission and/or distribution
	<i>To avoid at the same time heating and cooling in the same room depends on the system principle</i>
0	<u>No interlock</u> : the two systems are controlled independently and can provide simultaneously heating and cooling
1	<u>Partial interlock (dependant of the HVAC system)</u> : The control function is set up in order to minimize the possibility of simultaneous heating and cooling. This is generally done by defining a sliding set point for the supply temperature of the centrally controlled system
2	<u>Total interlock</u> : The control function enables to warranty that there will be no simultaneous heating and cooling.
3.7	Different generator control for cooling
	<i>The goal consists generally in minimising the generator operation temperature</i>
0	<u>Constant temperature control</u>
1	<u>Variable temperature control depending on outdoor temperature</u>
2	<u>Variable temperature control depending on the load</u> : This includes control according to room temperature
3.8	Sequencing of different generators
0	<u>Priorities only based on running time</u>
1	<u>Priorities only based on loads</u>
2	<u>Priorities based on loads and demand</u> : Depending on the generator capacities
3	<u>Priorities based on generator efficiency</u> : The generator operational control is set individually to available generators so that they operate with an overall high degree of efficiency (e.g. outdoor air, river water, geothermic heat, refrigeration machines)

Table 1 (*continued*)

4	VENTILATION AND AIR CONDITIONING CONTROL	
4.1	Air flow control at the room level	
	0	<u>No automatic control</u> : The system runs constantly (e.g. manual controlled switch)
	1	<u>Time control</u> : The system runs according to a given time schedule
	2	<u>Presence control</u> : The system runs dependent on the presence (light switch, infrared sensors etc.)
	3	<u>Demand control</u> : The system is controlled by sensors measuring 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.
4.2	Air flow or pressure control at the air handler level	
	0	<u>No automatic control</u> : Continuously supplies of air flow for a maximum load of all rooms
	1	<u>On off time control</u> : Continuously supplies of air flow for a maximum load of all rooms during nominal occupancy time
	2	<u>Multi-stage control</u> : To reduce the auxiliary energy demand of the fan
	3	<u>Automatic flow or pressure control</u> : With or without pressure reset, with or without demand evaluation: Load depending supply of air flow for the demand off all connected rooms.
4.3	Heat recovery exhaust air side icing protection control	
	0	<u>Without defrost control</u> : There is no specific action during cold period
	1	<u>With defrost control</u> : During cold period a control loop enables to warranty that the air temperature leaving the heat exchanger is not too low to avoid frosting
4.4	Heat recovery control (prevention of overheating)	
	0	<u>Without overheating control</u> : There is no specific action during hot or mild periods;
	1	<u>With overheating control</u> : During periods where the effect of the heat exchanger will no more be positive a control loop between "stops" and "modulates" or bypass the heat exchanger
4.5	Free mechanical cooling	
	0	<u>No automatic control</u>
	1	<u>Night cooling</u> : The amount of outdoor air is set to its maximum during the unoccupied period provided: 1) the room temperature is above the set point for the comfort period; 2) the difference between the room temperature and the outdoor temperature is above a given limit; if free night cooling will be realised by automatically opening windows there is no air flow control
	2	<u>Free cooling</u> : The amount of outdoor air and recirculation air are modulated during all periods of time to minimize the amount of mechanical cooling. Calculation is performed on the basis of temperatures
	3	<u>H,x- directed control</u> : The amount of outdoor air and recirculation air are modulated during all periods of time to minimize the amount of mechanical cooling. Calculation is performed on the basis of temperatures and humidity (enthalpy).
4.6	Supply air temperature control	
	0	<u>No automatic control</u> : No control loop enables to act on the supply air temperature;
	1	<u>Constant set point</u> : A control loop enables to control the supply air temperature, the set point is constant and can only be modified by a manual action
	2	<u>Variable set point with outdoor temperature compensation</u> : A control loop enables to control the supply air temperature. The set point is a simple function of the outdoor temperature (e.g. linear function)
	3	<u>Variable set point with load dependant compensation</u> : A control loop enables to control the supply air temperature. The set point is defined as a function of the loads in the room. This can normally only be achieved with an integrated control system enabling to collect the temperatures or actuator position in the different rooms

Table 1 (continued)

4.7	Humidity control
	<i>The control of the air humidity may include humidification and / or dehumidification. Controllers may be applied as "humidity limitation control" or "constant control"</i>
0	<u>No automatic control</u> : No control loop enables to act on the air humidity
1	<u>Dewpoint control</u> : Supply air or room air humidity expresses the Dewpoint temperature and reheat of the supply air
2	<u>Direct humidity control</u> : Supply air or room air humidity; a control loop enables the supply air or room air humidity at a constant value
5	LIGHTING CONTROL
5.1	Occupancy control
0	<u>Manual on/off switch</u> : The luminary is switched on and off with a manual switch in the room
1	<u>Manual on/off switch + additional sweeping extinction signal</u> : The luminary is switched on and off with a manual switch in the room. In addition, an automatic signal automatically switches off the luminary at least once a day, typically in the evening to avoid needless operation during the night
2	<u>Automatic detection</u> Auto On / Dimmed Off : The control system switches the luminary (ies) automatically on whenever there is presence in the illuminated area, and automatically switches them to a state with reduced light output (of no more than 20 % of the normal 'on state') no later than 5 min after the last presence in the illuminated area. In addition, no later than 5 min after the last presence in the room as a whole is detected, the luminary(ies) is automatically and fully switched off Auto On / Auto Off : The control system switches the luminary(ies) automatically on whenever there is presence in the illuminated area, and automatically switches them entirely off no later than 5 min after the last presence is detected in the illuminated area Manual On / Dimmed : The luminary(ies) can only be switched on by means of a manual switch in (or very close to) the area illuminated by the luminary(s), and, if not switched off manually, is/are automatically switched to a state with reduced light output (of no more than 20 % of the normal 'on state') by the automatic control system no later than 5 min after the last presence in the illuminated area. In addition, no later than 5 min after the last presence in the room as a whole is detected, the luminary(s) are automatically and fully switched off Manual On / Auto Off : The luminary(ies) can only be switched on by means of a manual switch in (or very close to) the area illuminated by the luminary(ies), and, if not switched off manually, is automatically and entirely switched off by the automatic control system no later than 5 min after the last presence is detected in the illuminated area
5.2	Daylight control
0	<u>Manual</u> : There is no automatic control to take daylight into account
1	<u>Automatic</u> : An automatic system takes daylight into account in relation to automatisms described in 5.1.
6	BLIND CONTROL
	<i>There are two different motivations for blind control: solar protection to avoid overheating and to avoid glaring</i>
0	<u>Manual operation</u> : Mostly used only for manual shadowing, energy saving depends only on the user behaviour
1	<u>Motorized operation with manual control</u> : Mostly used only for easiest manual (motor supported) shadowing, energy saving depends only on the user behaviour
2	<u>Motorized operation with automatic control</u> : Automatic controlled dimming to reduce cooling energy
3	<u>Combined light/blind/HVAC control</u> : To optimize energy use for HVAC, blind and lighting for occupied and non-occupied rooms

Table 1 (concluded)

7	TECHNICAL HOME AND BUILDING MANAGEMENT
	<i>The Technical Home and Building Management enables to adapt easily the operation to the user needs.</i> <i>One shall check at regular intervals that the operation schedules of heating, cooling, ventilation and lighting is well adapted to the actual used schedules and that the set points are also adapted to the needs.</i> – <i>Attention shall be paid to the tuning of all controllers this includes set points as well as control parameters such as PI controller coefficients.</i> – <i>Heating and cooling set points of the room controllers shall be checked at regular intervals. These set points are often modified by the users. A centralised system enables to detect and correct extreme values of set points due to misunderstanding of users.</i> – <i>If the Interlock between heating and cooling control of emission and/or distribution is only a partial interlock. The set point shall be regularly modified to minimise the simultaneous use of heating and cooling.</i> – <i>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).</i>
7.1	<u>Detecting faults of home and building systems and providing support to the diagnosis of these faults</u>
7.2	<u>Reporting information regarding energy consumption, indoor conditions and possibilities for improvement</u>

5.3 BACS Efficiency Class

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

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

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

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

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

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

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

5.4 BACS and TBM functions assigned to the BACS efficiency classes

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

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

- a) building owners, architects or engineers defining the building automation and controls (BACS) and technical building management (TBM) functions to be implemented for a given new building or for the renovation of an existing building:
 - 1) they can put an X in front of each of the functions they want to be implemented. They will use the shaded boxes as a help tool to determine in which class A, B, C, D the function they have specified is located. To achieve for example category B the X shall all be put in a shaded box for category B;
 - 2) it will be a simplified alternative – especially for specification at an early stage of a project – to specify only the classes of function A, B, C, D;
- b) public authorities defining minimum requirements for BACS and TBM functions for new buildings as well as for renovations as defined in EN 15217:2005, D.3:
 - 1) they can define the minimum class to be achieved. Unless differently specified this class is C;
- c) public authorities defining inspection procedures of technical systems as well as inspectors applying these procedures to check if the level of BACS and TBM functions implemented is appropriate:
 - 1) public authorities can request the use of the table to inspect the BACS in place;
 - 2) inspectors can put an X in front of each of the BACS functions which is implemented;
 - 3) they will then be able to determine the class A, B, C, D of functions already implemented. To be in a given class all the X shall correspond to shaded boxes for this class;
- d) public authorities defining calculation methods which take into account the impact of BACS and TBM functions on the energy performance of buildings, as well as software developers implementing these calculation methods and designers using them:
 - 1) public authorities can request that the impact of the BACS and TBM functions defined in Table 1 is taken into account;
 - 2) software developers can develop software user interfaces enabling to input the list of BACS and TBM functions which are implemented according to Table 1. They can provide a simplified input mode based on the class of functions A, B, C, and D according to Table 2.
- e) designers checking that the impact of all BACS and TBM functions is taken into account when assessing the energy performance of a building:
 - 1) designers will only have to input either the class of functions (A, B, C, D) or the detailed list of functions in the software enabling assessment of the energy performance of a building.

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

BACS and TBM functions with the purpose to control or monitor a plant or part of a plant which is not installed in the building do not have to be considered when determining the class even if they are shaded for that class. For example, to be in class B for a building with no cooling system no Individual room control with communication is required for emission control of cooling systems.

- If a specific function is required to be in a specific BACS efficiency class, it is not required that it is strictly required everywhere in the building: if the designer can give good reasons that the application of a function does not bring a benefit in a specific case it can be ignored. For example, if the designer can show that the heating load of a set of rooms is only dependant on the outdoor temperature and can be compensated with one central controller, no individual room control by thermostatic valves or electronic controllers is required to be in class C.
- Not all BACS and TBM functions in Table 2 are applicable to all types of building services. Therefore, BACS and TBM functions which have no substantial impact (< 5%) within the kind of energy use for Heating, Cooling, Ventilation, DHW or Lighting do not have to be classified.

Table 2 — Function list and assignment to BACS efficiency classes

			Definition of classes							
			Residential				Non residential			
			D	C	B	A	D	C	B	A
AUTOMATIC CONTROL										
1	HEATING CONTROL									
1.1	Emission control									
	<i>The control system is installed at the emitter or room level, for case 1 one system can control several rooms</i>									
	0	No automatic control								
	1	Central automatic control								
	2	Individual room control								
	3	Individual room control with communication								
	4	Individual room control with communication and presence control								
1.2	Emission control for TABS									
	0	No automatic control								
	1	Central automatic control								
	2	Advanced central automatic control								
	3	Advanced central automatic control with intermittent operation and/or room temperature feedback control								
1.3	Control of distribution network hot water temperature (supply or return)									
	<i>Similar function can be applied to the control of direct electric heating networks</i>									
	0	No automatic control								
	1	Outside temperature compensated control								
	2	Demand based control								
1.4	Control of distribution pumps in networks									
	<i>The controlled pumps can be installed at different levels in the network</i>									
	0	No automatic control								
	1	On off control								
	2	Multi-Stage control								
	3	Variable speed pump control								
1.5	Intermittent control of emission and/or distribution									
	<i>One controller can control different rooms/zones having same occupancy patterns</i>									
	0	No automatic control								
	1	Automatic control with fixed time program								
	2	Automatic control with optimum start/stop								
	3	Automatic control with demand evaluation								
1.6	Generator control for combustion and district heating									
	0	Constant temperature control								
	1	Variable temperature control depending on outdoor temperature								
	2	Variable temperature control depending on the load								
1.7	Generator control for heat pumps									
	0	Constant temperature control								
	1	Variable temperature control depending on outdoor temperature								
	2	Variable temperature control depending on the load or demand								
1.8	Sequencing of different generators									
	0	Priorities only based on running time								
	1	Priorities only based on loads								
	2	Priorities based on loads and demand								
	3	Priorities based on generator efficiency								

Table 2 (continued)

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

Table 2 (continued)

		Definition of classes							
		Residential				Non residential			
		D	C	B	A	D	C	B	A
3	COOLING CONTROL								
3.1	Emission control								
	<i>The control system is installed at the emitter or room level, for case 1 one system can control several rooms</i>								
	0	No automatic control							
	1	Central automatic control							
	2	Individual room control							
	3	Individual room control with communication							
	4	Individual room control with communication and presence control							
3.2	Emission control for TABS for cooling								
	0	No automatic control							
	1	Central automatic control							
	2	Advanced central automatic control							
	3	Advanced central automatic control with intermittent operation and/or room temperature feedback control							
3.3	Control of distribution network cold water temperature (supply or return)								
	<i>Similar function can be applied to the control of direct electric cooling (e.g. compact cooling units, split units) for individual rooms</i>								
	0	Constant temperature control							
	1	Outside temperature compensated control							
	2	Demand based control							
3.4	Control of distribution pumps in networks								
	<i>The controlled pumps can be installed at different levels in the network</i>								
	0	No automatic control							
	1	On off control							
	2	Multi-Stage control							
	3	Variable speed pump control							
3.5	Intermittent control of emission and/or distribution								
	<i>One controller can control different rooms/zones having same occupancy patterns</i>								
	0	No automatic control							
	1	Automatic control with fixed time program							
	2	Automatic control with optimum start/stop							
	3	Automatic control with demand evaluation							
3.6	Interlock between heating and cooling control of emission and/or distribution								
	0	No interlock							
	1	Partial interlock (dependant of the HVAC system)							
	2	Total interlock							
3.7	Different generator control for cooling								
	<i>The goal consists generally in minimising the generator operation temperature</i>								
	0	Constant temperature control							
	1	Variable temperature control depending on outdoor temperature							
	2	Variable temperature control depending on the load							
3.8	Sequencing of different generators								
	0	Priorities only based on running times							
	1	Priorities only based on loads							
	2	Priorities based on loads and demand							
	3	Priorities based on generator efficiency							

Table 2 (continued)

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

Table 2 (continued)

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

5.5 Reference list of BACS functions

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

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

- to specify the minimum functions to be implemented for a project;
- to define the BACS function to take into account for the calculation of energy consumption of a building when the BACS functions are not defined in detail.
- to calculate the energy use for the reference case in step 1 of the BACS efficiency factor method (first box in Figure 2 in Clause 6).

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

Table 3 — Reference list of BACS functions for class C

			Residential	Non residential
AUTOMATIC CONTROL				
1	HEATING CONTROL			
1.1	Emission control			
		<i>The control system is installed at the emitter or room level, for case 1 one system can control several rooms</i>		
	1	Central automatic control		
1.2	Emission control for TABS			
	1	Central automatic control		
1.3	Control of distribution network hot water temperature (supply or return)			
		<i>Similar function can be applied to the control of direct electric heating networks</i>		
	1	Outside temperature compensated control		
1.4	Control of distribution pumps in networks			
		<i>The controlled pumps can be installed at different levels in the network</i>		
	1	On off control		
1.5	Intermittent control of emission and/or distribution			
		<i>One controller can control different rooms/zones having same occupancy patterns</i>		
	1	Automatic control with fixed time program		
1.6	Generator control for combustion and district heating			
	1	Variable temperature control depending on outdoor temperature		
1.7	Generator control for heat pumps			
	1	Variable temperature control depending on outdoor temperature		
1.8	Sequencing of different generators			
	1	Priorities only based on loads		

Table 3 (continued)

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

Table 3 (continued)

			Residential	Non residential
4	VENTILATION AND AIR CONDITIONING CONTROL			
4.1	Air flow control at the room level			
	1	Time control		
4.2	Air flow or pressure control at the air handler level			
	1	On off time control		
4.3	Heat recovery exhaust air side icing protection control			
	1	With defrost control		
4.4	Heat recovery control (prevention of overheating)			
	1	With overheating control		
4.5	Free mechanical cooling			
	1	Night cooling		
4.6	Supply air Temperature control			
	1	Constant set point		
4.7	Humidity control			
	1	Dewpoint control		
5	LIGHTING CONTROL			
5.1	Occupancy control			
	0	Manual on/off switch		
	1	Manual on/off switch + additional sweeping extinction signal		
5.2	Daylight control			
	0	Manual		
6	BLIND CONTROL			
	1	Motorized operation with manual control		
	2	Motorized operation with automatic control		
7	TECHNICAL HOME AND BUILDING MANAGEMENT			
7.1	Detecting faults of home and building systems and providing support to the diagnosis of these faults			
	0	No		
	1	Yes		
7.2	Reporting information regarding energy consumption, indoor conditions and possibilities for improvement			
	0	No		

5.6 Applying BACS for EMS and maintaining BACS energy efficiency

5.6.1 GENERAL

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

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

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

5.6.2 Applying BACS for EMS

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

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

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

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

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

5.6.3 Maintaining BACS energy efficiency

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

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

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

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

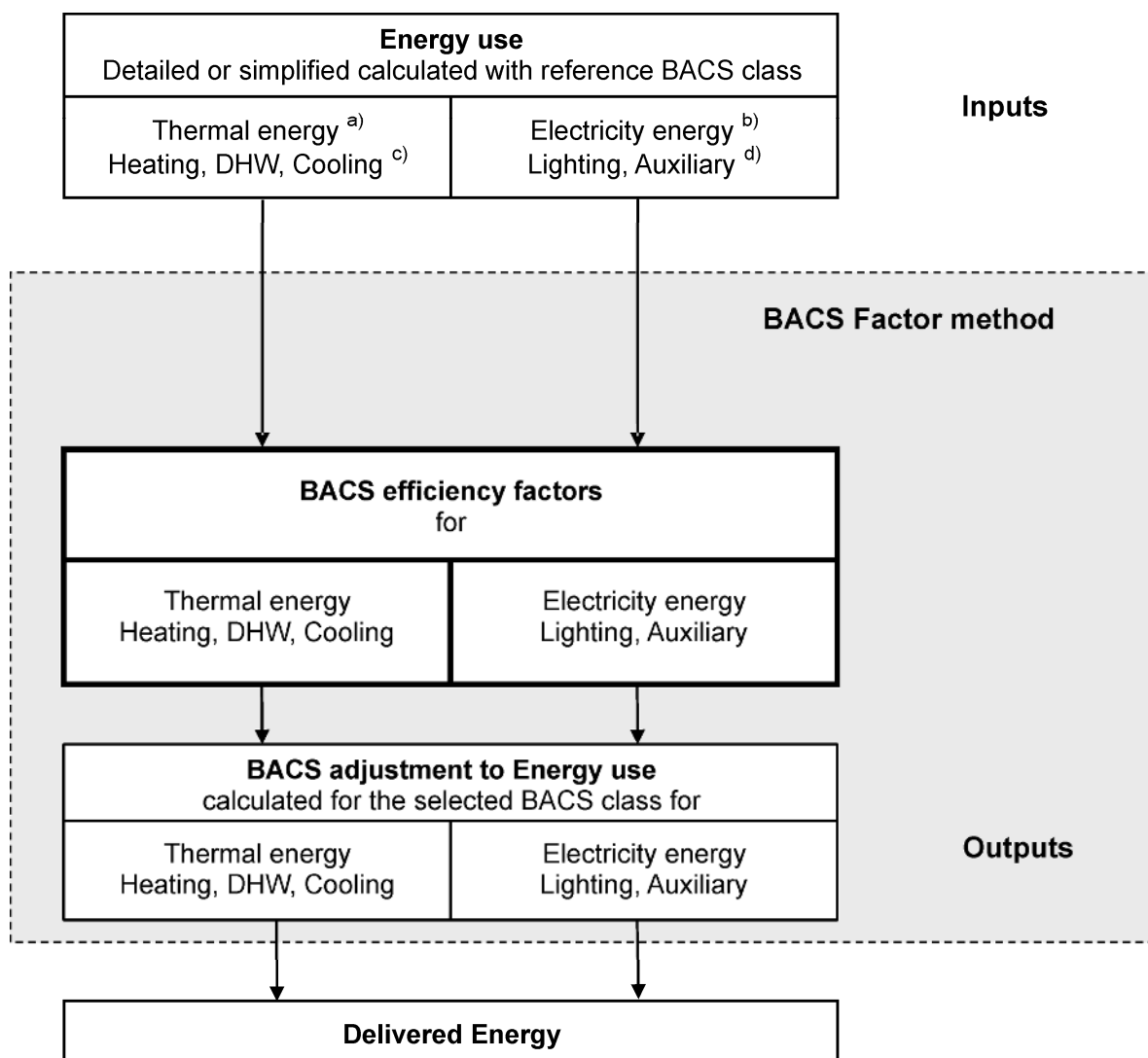
The required services for continuous improvement of the BACS impact concerning efficient and sustainable energy use in buildings are described in Annex F.

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

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

6.1 General

The BACS factor method described here has been established to allow a simple calculation of the impact of building automation, control and management functions on the building energy performance. The following Figure 2 illustrates how to use this approach.



Remarks:

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

a) Thermal Energy = overall Energy use for Heating, DHW and cooling, ventilation

b) Electricity Energy = overall Energy use for auxiliary and lighting

c) Specific energy use for heating, DHW or Cooling

d) Specific energy use for auxiliary or lighting

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

Figure 2 — BACS Factor method

The BACS factor method gives a rough estimation of the impact of BACS and TBM functions on thermal and electric energy demand of the building according to the efficiency classes A, B, C and D (defined in Clause 5). The BACS factor method is specially appropriated to the early design stage of a building because there is no special information needed about any specific control and automation function just the recent (if it is an existing building) or reference building automation class and the classification of the building as expected or predefined.

6.2 Description of BACS Factor method

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

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

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

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

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

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

The energy input to the building energy systems (energy use) accounts for building energy demand, total thermal losses of the systems as well as auxiliary energy required to operate the systems. Each of the energy systems installed in a building shall be assessed with the right BACS factor taking into account the correlations given in Table 6.