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BSI Standards Publication

Energy performance of buildings

Part 2: Accompanying TR prEN 15232-1:2015 — Modules M10-4,5,6,7,8,9,10

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National foreword

This British Standard is the UK implementation of CEN/TR 15232-2:2016.

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Ref. No. CEN/TR 15232-2:2016 E

Contents

Page

European foreword

This document (CEN/TR 15232-2:2015) has been prepared by Technical Committee CEN/TC 247 “Building Automation, Controls and Building Management”, the secretariat of which is held by SNV.

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This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

This document is currently divided into the following parts:

— *Energy performance of buildings — Part 1: Impact of Building Automation, Controls and Building Management - Modules M10-4,5,6,7,8,9,10* [currently at Enquiry stage];

— *Energy performance of buildings — Part 2: Accompanying* prCEN/TR 15232-1:2015 *Modules M10-4,5,6,7,8,9,10* [the present Technical Report; currently at Voting stage].

Introduction

The CENSE project, the discussions between CEN and the Concerted action highlighted the high page count of the entire package due to a lot of "textbook" information. This resulted in flooding and confusing the normative text.

A huge amount of informative contents shall indeed be recorded and available for users to properly understand, apply and nationally adapt the EPB standards

The detailed technical rules in CEN/TS 16629, "Detailed Technical Rules" ask for a clear separation between normative and informative contents:

— to avoid flooding and confusing the actual normative part with informative content;

— to reduce the page count of the actual standard;

— to facilitate understanding of the package.

Therefore each EPB standard shall be accompanied by an informative technical report, like this one, where all informative contents is collected.

Table 1 — Position of this standard within the EPB set of 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, ..**
sub1	**M1**	**M2**		**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**	**M11**
1	General	General	General									
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	

	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, ..**
sub1	**M1**	**M2**		**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**	**M11**
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	Economic Calculation											

1 Scope

This Technical Report refers to prEN 15232-1, *Energy performance of buildings — Part 1: Impact of Building Automation, Controls and Building Management - Modules M10-4,5,6,7,8,9,10*.

It contains information to support the correct understanding, use and national adaption of standard prEN 15232-1:2015.

This technical report does not contain any normative provision.

2 Normative references

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

prEN 12098-1:2015, *Controls for heating systems — Part 1: Control equipment for hot water heating systems - Modules M3-5,6,7,8*

prEN 12098-3:2015, *Controls for heating systems — Part 3: Control equipment for electrical heating systems - Modules M3-5,6,7,8*

prEN 12098-5:2015, *Controls for heating systems — Part 3: Control equipment for electrical heating systems — Modules M3-5,6,7,8*

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

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

prEN 15232-1:2015, *Energy performance of buildings — Part 1: Impact of Building Automation, Controls and Building Management — Modules M10-4,5,6,7,8,9,10*

EN 15241:2007, *Ventilation for buildings - Calculation methods 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 15243:2007, *Ventilation for buildings - Calculation of room temperatures and of load and energy for buildings with room conditioning systems*

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

EN 15316-4-1:2008, *Heating systems in buildings - Method for calculation of system energy requirements and system efficiencies - Part 4-1: Space heating generation systems, combustion 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 15316-4-4, *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 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*

prEN 15500-1:2015, *Control for heating, ventilating and air-conditioning applications — Part 1: Electronic individual zone control equipment — Modules M3-5,M4-5,M5-5*

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

prEN 16798–5-1, *Energy performance of buildings — Modules M5-6, M5-8, M6-5, M6-8, M7-5, M7-8 — Ventilation for buildings — Calculation methods for energy requirements of ventilation and air conditioning systems — Part 5-1: Distribution and generation (revision of EN 15241) — Method 1*

prEN 16798–5-2:2015, *Energy performance of buildings — Modules M5-6, M5-8 — Ventilation for buildings — Calculation methods for energy requirements of ventilation systems — Part 5-2: Distribution and generation (revision of EN 15241) — method 2*

prEN 16798-7:2014, *Energy performance of buildings — Part 7: Ventilation for buildings — Modules M5-1, M5-5, M5-6, M5-8 — Calculation methods for the determination of air flow rates in buildings including infiltration*

prEN 16947-1:2015, *Building Management System — Module M10-12*

FprCEN/TR 16947-2:2015, *Accompanying TR for New Work Item — Building Management System*

EN ISO 7345:1995, *Thermal insulation - Physical quantities and definitions (ISO 7345:1987)*

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)*

prEN ISO 52000-1:2015, *Energy performance of buildings — Overarching EPB assessment — Part 1: General framework and procedures (ISO/DIS 52000-1:2015)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 7345:1995, prEN ISO 52000-1:2015 and prEN 15232-1:2015 (the accompanied EPB standard) apply.

4 Symbols and abbreviations

4.1 Symbols

For the purposes of this Technical Report, the symbols given in prEN ISO 52000-1:2015, in EN 15232-1:2015 (the accompanied EPB standard) apply.

4.2 Abbreviations

For the purposes of this Technical Report, the abbreviations in prEN 15232-1:2015 (the accompanied EPB standard) apply.

5 Method description

5.1 Effect of building automation and control (BAC) and technical building management (TBM)

5.1.1 General

The key-role of Building Automation and Control and TBM is to ensure the balance between the desired human comfort - which shall be maximal, and energy used to obtain this goal - which shall be minimal!

The scope of BAC and TBM covers in accordance with their role from one side all Technical Building Systems (where the effect of the BAC is used in the calculation procedures) and from another side the global optimization Energy Performance of a Building.

We could identify several categories of controls:

— Technical Building Systems specific controls; these controllers are dedicated to the physical chain of transformation of the energy, from Generation, to Storage, Distribution and Emission. We find them in the matrix starting with the Modules M3-5 to M9-5 and finishing with M3-8 till M9-8. We could consider that it exist one controller by module, but some time one controller do the control among several modules. More often, these controllers are communicating between them via a standardized open bus, such as BACnet, KNX or LON

— BAC used for all or several Technical Building Systems who do multidiscipline (heating, cooling, ventilation, DHW, lighting…) optimization and complex control functions. For example, one of them is INTERLOCK, a control function who avoids heating and cooling in same time.

— If all Technical Building System are used in the building, we have (depending of the size of the building) a Technical Building Management System. Specific global functions are implemented here, necessary to reach the key-role mentioned above. Usually, in this case, an interrelation with the

Building as such (Module M2) will occur, mainly to take in consideration the building needs; for example due to outside temperature, taken into account the inertia of the building when the control will reach the set point in a room.

In a control system dedicated to a building, who is BAC and TBM we can distinguish three main characteristics as described in 5.1.2, 5.1.3 and 5.1.4.

5.1.2 Control accuracy

Control accuracy is the degree of correspondence between the ultimately controlled variable and the ideal value in a feedback control system. The controlled variable could be any physical variable such as a temperature, humidity, pressure, etc. The ideal value is in fact the SET POINT established by the user (occupant) when he determines his level of comfort. It is clear that the entire control loop is concerned with all the elements constituent, such as sensors, valves and actuators. The equipment itself is another important element and usually specific equipment asks for a specific controller. For the energy carrier hot water, an important issue is the balancing of the hydraulic circuits. For that purposes, balancing hydraulic valves are need it.

The temperature control accuracy (CA) for a zone temperature is a key number that allows calculating the additional energy need for heating or cooling caused by the inaccuracy of zone temperature control. The temperature Control Accuracy (CA) can be calculated from Control Variation (CV) and Control Set point Deviation (CSD) as described in the main text of prEN 15500:2015. The compliance with CA is also defined in the standard. This is an important input for EN 15316-2 and for prEN 16798-7, where the effect of the control for heating, cooling and ventilation is taken into account.

The same standard (prEN 15500-1:2015) describes also the 4 operations modes who deal with the levels of temperatures: Comfort, Precomfort, Economy and Frost/Building Protection. These 4 predefined operation modes are parameters that could be set by the users (occupant) – the temperature allocate to each operation mode. These operations modes are important for the control strategy used for intermittence, which will be described below.

5.1.3 Control function

The control function is the ability of a controller (or set of communicative controllers) to perform a determined task(s). Usually the functions implemented in the controllers are parametrable or free programmable. The functions could be performed by a single controller or by a set of communicative controllers. A controller could perform several functions.

The CONTROL FUNCTIONS present in a BAC or TBM, are present in prEN 15232-1:2015 Table 4. These functions in Table 4 are organized in the matrix given by Modular Structure of EPB standards. Table 4 starts with Heating Emission, Distribution, Storage and Generation (M3-5, M3-6, M3-7, M3-8) follow by Domestic Hot Water, Cooling, Ventilation and Lighting (M9-5, M9-6, M9-7, M9-8). Each function is described in detail, in accordance with the type (level) of the function: from the lower type (NO AUTOMATIC CONTROL Type = 0) to most advanced types. For each function, an IDENTIFIER who is the software language for BAC and TBM is also defined, as the destination of the module where the control function gives his effect. An example of Table 4 is given bellow, as abstract from prEN 15232-1:2015 Table 4.

For practical reasons, four different BAC efficiency classes (A, B, C, D) of functions are defined both for non-residential and residential buildings. This is the fastest way to specify a BAC or a TBM.

— 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.

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 B.1 shall be implemented.

To be in class B: Building automation function plus some specific functions defined in Table 4 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 4 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.)

In addition, the hydraulic system should be properly balanced.

The functions assignment to the BACS efficiency classes are listed in prEN 15232-1:2015, Table 5.

BAC 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 BAC 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.

A reference list of BACS functions to reach is defined in prEN 15232-1:2015, Table 6. That table defines the minimum requirements of BACS functions according to BACS efficiency class C of 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 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.

5.1.4 Control strategy

The control function is the methods employed to achieve a given level of control to reach a goal. Optimal control strategies deliver a desired level of control at a minimum cost (minimum energy demand). A CONTROL STRATEGY could consist by a CONTROL FUNCTION or a group of CONTROL FUNCTIONS. An example of a CONTROL STRATEGY consist by a CONTROL FUNCTION is OPTIMUM START, OPTIMUM STOP, Night SET BACK described in the standards prEN 12098-1:2015 and prEN 12098-3:2015. The Timer function is described in prEN 12098-5:2015.

An example of a CONTROL STRATEGY who is realized by a group of CONTROL FUNCTIONS is the CONTROL STRATEGY used by INTERMITENCE. This function uses several CONTROL FUNCTIONS, OPERATION MODES, OPTIMUM START-STOP and TIMER in same time. All elements together are called either Building Profile or User Pattern. Usually, to implement such Building profile, a TBM is a prerequisite.

The most important CONTROL STRATEGY described and implemented in prEN 15232-1:2015 is DEMAND ORIENTED CONTROL. Usually these strategies implement the sense of the energy flow (from GENERATION to EMISSION) with flow of calculation (from building needs to delivered energy). Usually for this complex CONTROL STRATEGY, a TBM is necessary with a distributed specific control for each Technical Building System who communicates in system architecture via a communication standardized bus such as BACnet, KNX or LON.

More clear, this Demand Oriented Control works as follows: When the comfort is reach in the Emission area, the controller from the Emission sent the message to the controller in charge of Distribution to stop to distribute energy, who sent the message to the controller in charge of Storage either to store the energy and if the Storage cannot store more energy sent the message to the controller in charge with the Generation to stop to generate more energy.

Another important Control Strategy is the control strategy for multi generators either from same type (e.g. several boilers) or different types (e.g. a boiler and heat pomp) including also the Renewable Energy Sources. The strategy could be based as follow:

— Priorities only based on running time

— Fixed sequencing based on loads only: e.g. depending on the generators characteristics, e.g. hot water boiler vs. heat pump

— 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. solar, geothermic heat, cogeneration plant, fossil fuels)

— Load prediction based sequencing: The sequence is based on e.g. efficiency and available power of a device and the predicted required power

The standards enabling to calculate the effect of BACS and TBM functions on energy consumption use different approaches to calculate this impact. The approaches are described in prEN 15232-1:2015, 6.4.2.

5.2 Description of BAC functions

5.2.1 General

The numbers in italics refer to the numbers in prEN 15232-1:2015, Table 4.

5.2.2 Heating control

1.1 Heating – Emission control

1.1.0 No automatic control

Description: No automatic control of the room temperature.

1.1.1 Central automatic control

Description: Central automatic control of temperature in rooms by means of heating, is acting either on the distribution or on the generation. Heating control is performed without consideration of local demand of different rooms, possibly by using one room as reference. This can be achieved for example by an outside temperature controller conforming to prEN 12098-1:2015 or prEN 12098-3:2015.

Target: To improve EP by minimizing emitted heat by emitters (e.g. radiators) or by air in the building using central control of temperature and/or flow. This control may be based on outside temperature and/or a reference sensor inside the building and assumes similar demands in different parts/rooms of the building.

1.1.2 Individual room control

Description: Individual room control by thermostatic valves or electronic controllers. The individual room control of heating temperature in rooms is performed either by thermostatic valves or local (non-communicating) electronic control units. The individual control should/may be combined with scheduler programs providing different operating modes.

Target: To improve EP by minimizing emitted heat by emitters (e.g. radiators) or by air in the building using local control of temperature and/or flow in the rooms, thereby adapting to local demand, i.e. different loads in different rooms.

1.1.3 Individual room control with communication

Description: Individual room control with communication between controllers and to BACS. Individual control of temperature in rooms by means of heating, with communication between controllers and to BACS, allows exchange of setpoints, demand and other status information.

Target: To improve EP by minimizing emitted heat by emitters (e.g. radiators) or by air in the building using local control of temperature and/or flow in the rooms, thereby adapting to local demand, i.e. different loads in different rooms. Furthermore to obtain energy demand for further use to control distribution and generators, keeping run time at minimum and setpoints optimal.

1.1.4 Individual room control with communication and presence control

Description: Individual room control with communication between controllers and to BACS, and presence control performed by occupancy. Individual control of temperature in rooms by means of heating, with communication between controllers and to BACS, allows exchange of setpoints, demand and other status information.

Target: To improve EP by minimizing emitted heat by emitters (e.g. radiators) or by air in the building using local control of temperature and/or flow in the rooms, thereby adapting to local demand, i.e. different loads in different rooms. Furthermore to obtain energy demand for further use to control distribution and generators, keeping run time at minimum and setpoints optimal.

1.2 Heating – Emission control for TABS

1.2.0 No automatic control

Description: There's no automatic control of the room temperature implemented.

Target: Manual controls of a loop apply.

1.2.1 Central automatic control

Description: 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 setpoint is dependent on the filtered outside temperature, e.g. the average of the previous 24 h.

Target: The supply water temperature shall be set according to the filtered outside air temperature (filtered -weather compensated supply water temperature).

1.2.2 Advanced central automatic control

Description: 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 setpoint). "Optimal" means that the room temperatures of all rooms of the TABS zone remain during operation periods in the comfort range, to meet comfort requirements, but also is as low as possible to reduce the energy demand for heating.

— If the TABS is used for heating and cooling: The central automatic control is designed and tuned to achieve an optimal self-regulating of the room temperature within the required comfort range (specified by room temperature heating and cooling setpoints). "Optimal" means that the room temperatures of all rooms of the TABS zone remain during operation periods in the comfort range, to meet comfort requirements, but also uses as far as possible the full range to reduce the energy demand for heating and cooling.

— If the TABS are 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.

One solution to achieve these requirements can be found in [2] and [3].

Target: Achieve temperatures within the desired bandwidth for all rooms in the heating/cooling group.

1.2.3 Advanced central automatic control with intermittent operation and/or room temperature feedback control

Description: Advanced central automatic control with room temperature feedback control:

— 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 are 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. One solution to achieve this requirement can be found in [2] and [4].

— 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 setpoint is corrected by the output of a room temperature feedback controller, to adapt the setpoint 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. One solution to achieve this requirement can be found in [2].

— Advanced central automatic control with intermittent operation and room temperature feedback control.

Target: The goal is to compensate room/zone behaviour into the supply water temperature control in order to optimize emissions taking into account heat gain and radiation.

1.3 Heating – Control of distribution network hot water (supply or return)

1.3.0 No automatic control

Description: The distribution network temperature of the hot water is not controlled.

1.3.1 Outside temperature compensated control

Description: Control of the temperature of the hot water distribution based on outside temperature compensation.

Target: To improve EP by lowering the mean temperature of the flow, thereby minimizing heat losses.

1.3.2 Demand based control

Description: Control of the temperature of the hot water distribution is based on indoor temperature measurements.

Prerequisite: Communicating system to room control units.

Target: To improve EP by lowering the mean temperature of the flow as well as decreasing the flow rate, thereby minimizing heat losses. In addition use energy demand information to keep run time at minimum and setpoints optimal.

1.4 Heating – Control of distribution pumps in networks

1.4.0 No automatic control

Description: Distribution pumps are not controlled (only protection functions).

1.4.1 On / off control

Description: On / off control. Pumps are switched on and off automatically but once switched the run no control at maximum speed.

Target: To improve EP by avoiding auxiliary energy consumption of pumps while no energy need to be circulated.

1.4.2 Multi-Stage control

Description: Speed of pumps is controlled by a multi-step control.

Target: To improve EP by reducing auxiliary energy consumption by adapting (in fixed steps) the speed of the pump depending on the system conditions.

1.4.3 Variable speed pump control

Description: Speed of pumps is controlled depending on different states of the system. This may be done with constant or variable Δp and with demand evaluation to reduce the auxiliary energy demand of the pumps.

Target: To improve EP by reducing auxiliary energy consumption of pumps by optimizing their speed according to the current system conditions.

1.4.4 Variable speed pump control

Description: Speed of pumps is controlled depending on different states of the system. This may be done with variable Δp following an external demand signal, e.g. hydraulic requirements, ΔT, energy optimization, demand evaluation to reduce the auxiliary energy demand of the pumps.

Target: To improve EP by reducing auxiliary energy consumption of pumps by optimizing their speed for the current system conditions.

1.5 Heating – Intermittent control of emission and/or distribution

1.5.0 No automatic control

Description: No intermittent control (always full energy consumption).

1.5.1 Automatic control with fixed time program

Description: Automatic control is realized to reach intermittent operation of the emission and/or distribution components.

Target: To improve EP by lowering the temperature setpoints during certain conditions (e.g. night). This leads to improved EP due to shortened operation time of the generation/distribution, lower losses of the room(s) due to lower temperature differences to the outside.

1.5.2 Automatic control with Optimum Start/Stop

Description: Automatic control is realized to reach optimized Start/Stop of intermittent operation of the emission and/or distribution components.

Target: To improve EP through optimized start/stop to maximize time for economy mode by considering energy capacity of the building in control.

1.5.3 Automatic control with demand evaluation

Description: Automatic control is realized to reach intermittent operation of emission and/or distribution based on demand (occupancy).

Target: To improve EP through maximizing "pre-comfort" and/or "economy" time periods by detecting or using information about real demand (e.g. occupancy).

1.6 Heating – Generator control for combustion and district heating

1.6.0 Constant Temperature Control

Description: Generator temperature is controlled to hold a predefined constant temperature within a defined control deviation.

Target: To improve EP by minimizing the generator operation temperatures and avoiding max boiler temperature (with highest losses), e.g. compared to thermostatic on/off control.

1.6.1 Variable temperature depending on outdoor temperature

Description: Generator temperature setpoint is variable depending on outdoor temperature.

Target: To improve EP by minimizing the generator operation temperatures using outdoor temperature information.

1.6.2 Variable temperature depending on the load

Description: Generator temperature setpoint is variable depending on the load of the system.

Target: To improve EP by minimizing the generator operation temperatures using information about current demand of the system.

1.7 Heating – Generator control for heat pumps

1.7.0 Constant Temperature Control

Description: Heat generation is not optimized to environmental conditions and control is always towards the maximum allowed temperature.

Inputs: Max allowed temperature setpoint.

1.7.1 Variable temperature depending on outdoor temperature

Description: The control temperature is calculated with the goal to operate the heat pump with minimized operating temperature setpoints depending on outdoor temperature.

Target: To improve EP by avoiding unnecessary electrical pumping energy by minimizing the generator operation temperatures using outdoor temperature information.

1.7.2 Variable temperature depending on the load or demand

Description: Heat pump temperature setpoint is variable depending on demand based on the load of the system.

Target: To improve EP by optimizing efficiency of the heat pump at given environmental conditions based on current demand of the system.

1.8 Heating – Generator control for outdoor unit

The goal consists generally in maximizing the heat generator efficiency

1.8.0 On/Off-control of heat generator

1.8.1 Multi-stage control of heat generator

Description: Output of heat generator is controlled depending on the load or demand (e.g. on/off of several compressors)

1.8.2 Variable control of heat generator

Description: Output of heat generator depends on the load or demand (e.g. hot gas bypass, inverter frequency control)

1.9 Heating – Sequencing of different generators

1.9.0 Priorities only based on running time

Description: Priority based sequencing of multiple heating generators. The priority of sequencing is only based on running times of the generators (in order to optimize maintenance).

1.9.1 Priorities only based on loads

Description: Priority based sequencing of multiple heating generators. The generators of higher priority are running first. A given generator in the priority list is running only if the generators of higher priority are running at full load. The sequence is fixed - the priority list is arbitrarily created.

Target: To improve EP by only using as many generators as needed at any point in time and drive each generator in its most efficient mode (full load).

1.9.2 Priorities based on loads and demand

Description: Priority based sequencing of multiple heating generators considering their capacities. The generators of higher priority are running first. A given generator in the priority list is running only if the generators of higher priority are running at full load. The priority list is dynamically created based on load, considering the current capacities of the generators (max power).

Target: To improve EP by only using as many generators as needed at any point in time - to avoid generators to run at very low load (e.g. < 30 %), but there is also a target to avoid too short “cycle times” (e.g. as each burner start consumes additionally energy).

1.9.3 Priorities based on generator efficiency

Description: Priority based sequencing of multiple heating generators considering their capacities. The generators of higher priority are running first. A given generator in the priority list is running only if the generators of higher priority are running at full load. The priority list is dynamically created reflecting the generators current efficiency.

Target: To improve EP by only using as many as needed and drive each generator in its most efficient mode (full load), and only using the most efficient generators at any point in time.

*1.10*Heating – Control of Thermal Energy Storage (TES) charging

1.10.0 Continuous storage operation

Description: Thermal Energy storage system is enabled for charging all the time independently on the expected load. In case cooling energy is available it is charged to the TES.

1.10.1 2-sensor charging of storage

Description: Once the TES is enabled for operation it is charged if the lower temperature sensure indicates a minimum state of charge. Charging will be stopped based on the second sensor information at the top of the Storage

Target: To improve EP by reducing charging intervals. Based on that energy losses of the TES can be reduced.

1.10.2 Load prediction based storage operation

Description: Thermal Energy storage is operated taking into account load predictions.

Target: To improve EP by reducing state of charge when storage is not needed. Based on that energy losses of the TES can be reduced.

5.2.3 Domestic Hot Water supply control

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 DHW – Control of DHW storage charging with direct electric heating or integrated electric heat pump

2.1.0 Automatic control on / off (Standalone DHW)

Description: Control of DHW storage temperature with integrated or exclusively linked heat sources (standalone).

2.1.1 Automatic control on / off and charging time release

Description: Control of the DHW (standalone DHW) storage temperature avoiding early recharging using time based charging blocking.

Target: To improve EP by lowering mean DHW buffer temperature to reach less isolation losses from the buffer. This can be achieved by using up the full capacity of buffer heat before recharging. Less number of recharge cycles has also positive benefits for energy generators.

2.1.2 Automatic control on / off and charging time release

Description: Automatic control on / off and charging time release and multi-sensor storage management (Standalone DHW). Control of the DHW storage temperature thus avoids early recharging using multi sensing detection of remaining heat capacity of the buffer.

Target: To improve EP by lowering mean DHW buffer temperature to reach less isolation losses from the buffer. This can be achieved by using up the full capacity of buffer heat before recharging. Less number of recharge cycles has also positive benefits for energy generators.

2.2 Control of DHW storage temperature charging using heating water generation

2.2.0 Automatic control on/off

Description: Control of DHW storage temperature (DHW is one heat consumer in a heating system).

2.2.1 Automatic control on/off and charging time release

Description: Control of the DHW storage temperature avoiding early recharging using time based charging blocking.

Target: To improve EP by lowering mean DHW buffer temperature to reach less isolation losses from the buffer. This can be achieved by using up the full capacity of buffer heat before recharging. Less number of recharge cycles has also positive benefits for energy generators.

2.2.2 Automatic control on / off, charging time release, demand oriented, supply or return temperature control and multi-sensor storage management

Description: Control of the DHW storage temperature avoiding early recharging using time based charging blocking and multi sensing detection of remaining heat capacity of the buffer and transmitting demand information to the heat generation system.

Target: To improve EP by lowering mean DHW buffer temperature to reach less isolation losses from the buffer. This can be achieved by using up the full capacity of buffer heat before recharging. Less number of recharge cycles has also positive benefits for energy generators. Transmission of demand information enables optimized EP in heat generator systems.

2.3 Control of DHW charging with solar collector and supplementary heat generation

2.3.0 Manual control

Description: Manual selected control of solar energy source for DHW; manual selection of energy source which feeds the DHW.

2.3.1 Automatic control of solar storage charge (Prio. 1) and supplementary storage charge (Prio. 2)

Description: Control of the DHW storage temperature preferring Energy out of solar energy in combination with automatically supplementary recharging in case solar load is not sufficient.

Target: To improve EP by maximizing charging of solar energy and in case that no solar energy is available. Automatic switch to supplementary loading of buffer with other Heat generations

2.3.2 Automatic control of solar storage charge (Prio. 1) and supplementary storage charge (Prio. 2) plus demand-oriented supply or multi-sensor storage management

Description: Control of the DHW storage temperature preferring Energy out of solar energy in combination with automatically supplementary recharging in case solar load is not sufficient.

Target: To improve EP by maximizing charging of solar energy and in case that no solar energy is available control Supplementary load of buffer with other Heat generations with minimum losses and max efficiency of the generators. In "Supplementary operation mode" EP efficiency is reached by minimizing mean DHW buffer temperature to reach less isolation losses from the buffer. This can be achieved by using up the full capacity of buffer heat before recharging. Less number of recharge cycles has also positive benefits for energy generators. To improve EP through optimized selection of energy source which feeds the buffer at a given condition.

2.4 Control of DHW circulation pump

2.4.0 Control of DHW circulation pump, without time switch program

Description: Continuous operation of circulation pump

2.4.1 Control of DHW circulation pump, with time switch program

Description: Control of DHW circulation pump using time switch program

Target: To improve EP by avoiding energy losses in pipes as well as unnecessary energy consumption of circulation pump during time while no DHW comfort with circulation pump is needed.

5.2.4 Cooling control

3.1 Cooling – Emission Control

3.1.0 Cooling – No automatic control

Description: No automatic control of the room temperature.

3.1.1 Central automatic control

Description: Central control of temperature in rooms by means of cooling, it is acting either on the distribution or on the generation. Cooling control is performed without consideration of local demand of different rooms, possibly by using one room as reference.

Target: To improve EP by minimizing emitted cool by emitters (e.g. chilled beams) or by air in the building using central control of temperature and/or flow. This control may be based on outside temperature and/or a reference sensor inside the building and assumes similar demands in different parts/rooms of the building.

3.1.2 Individual room control

Description: Individual room control by thermostatic valves or electronic controller. The individual control of cooling temperature in rooms is performed either by thermostatic valves or local (non-communicating) electronic control units. The individual control may be combined with central timer program providing different operating modes.

Target: To improve EP by minimizing emitted cool by emitters (e.g. chilled beams) or by air in the building using local control of temperature and/or flow in the rooms, thereby adapting to local demand, i.e. different loads in different rooms.

3.1.3 Individual room control with communication

Description: Individual room automatic control with communication between controllers and the BACS.

Individual control of temperature in rooms by means of cooling with communication between controllers and to BACS, allows exchange of setpoints, demand and other status information.

Target: To improve EP by minimizing cooling by emitters (e.g. chilled beams) or by air in the building using local control of temperature and/or flow in the rooms, thereby adapting to local demand, i.e. different loads in different rooms. Furthermore to obtain energy demand for further use to control distribution and generators, keeping run time at minimum and setpoints optimal.

3.1.4 Individual room control with communication and presence control

Description: Individual room automatic control with communication between controllers and the BACS.

Individual control of temperature in rooms by means of cooling with communication between controllers and to BACS, allows exchange of setpoints, demand and other status information.

Target: To improve EP by minimizing cooling by emitters (e.g. chilled beams) or by air in the building using local control of temperature and/or flow in the rooms, thereby adapting to local demand, i.e. different loads in different rooms. Furthermore to obtain energy demand for further use to control distribution and generators, keeping run time at minimum and setpoints optimal.

3.2 Cooling – Emission control for TABS

3.2.0 No automatic control

Description: There’s no automatic control implemented.

Target: Manual controls of a loop apply.

3.2.1 Central automatic control

Description: 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 setpoint is dependent on the filtered outside temperature, e.g. the average of the previous 24 h.

Target: The supply water temperature shall be set according to the filtered outside air temperature (filtered - weather compensated supply water temperature).

3.2.2 Advanced central automatic control

Description: This is an automatic control of the TABS zone that fulfils the following conditions:

— If the TABS is used for heating and cooling: The central automatic control is designed and tuned to achieve an optimal self-regulating of the room temperature within the required comfort range (specified by room temperature heating and cooling setpoints). “Optimal” means that the room temperatures of all rooms of the TABS zone remain during operation periods in the comfort range, to meet comfort requirements, but also uses as far as possible the full range to reduce the energy demand for heating and cooling.

— If the TABS is used for heating and cooling: The automatic switching between heating and cooling is not done only dependent on the outside temperature, but also taking at least indirectly the heat gains (internal and solar) into account.

Target: Achieve temperatures within the desired bandwidth for all rooms in the heating/cooling group.

3.2.3 Advanced central automatic control with intermittent operation and/or room temperature feedback control

Description: Advanced central automatic control with room temperature feedback control:

— 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 are 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.

— 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 setpoint is corrected by the output of a room temperature feedback controller, to adapt the setpoint to non-predictable day-to-day variation of the heat gain. Since TABS react slowly, only day-to-day room temperature correction is applied, an instant correction cannot be achieved with TABS. The room temperature that is fed back is the temperature of a reference room or another temperature representative for the zone.

— Advanced central automatic control with intermittent operation and room temperature feedback control.

Target: The goal is to compensate room/zone behaviour into the supply water temperature control in order to optimize emissions taking into account heat gain and radiation.

3.3 Cooling – Control of distribution network water (supply or return)

3.3.0 Constant temperature control

Description: The distribution network of the cold water is controlled at a constant temperature or not controlled

3.3.1 Outside temperature compensated control

Description: Control of the temperature of the cold water distribution based on outside temperature compensation.

Target: To improve EP by lowering the mean temperature of the flow, thereby minimizing cooling losses.

3.3.2 Demand based control

Description: Control of the temperature of the cold water distribution is based on indoor temperature measurements.

Prerequisite: Communicating system to room control units.

Target: To improve EP by raising the mean temperature of the flow, thereby minimizing cooling losses. In addition use energy demand information to keep run time at minimum and setpoints optimal.

3.4 Cooling – Control of distribution pumps in hydraulic networks

3.4.0 No automatic control

Description: Distribution pumps are not controlled (only protection functions).

Target: To improve EP by distributing energy with pumps (just thermal circulation).

3.4.1 On / Off control

Description: Pumps are enabled only if flow temperature and return temperature are different.

Target: To improve EP by avoiding energy consumption of pumps while no energy need to be circulated.

3.4.2 Multi-stage control

Description: Speed of pumps is controlled to a constant pressure difference.

Target: To improve EP by reducing auxiliary energy consumption by adapting (in fixed steps) the speed of the pump depending on the system conditions.

3.4.3 Variable speed pump control

Description: Speed of pumps is controlled depending on different states of the system. This may be done with constant or variable Δp based on pump unit (internal) estimations to reduce the auxiliary energy demand of the pumps.

Target: To improve EP by reducing auxiliary energy consumption of pumps by optimizing their speed for the current system conditions.

3.4.4 Variable speed pump control

Description: Speed of pumps is controlled depending on different states of the system. This may be done with variable Δp following an external demand signal, e.g. hydraulic requirements, ΔT, energy optimization, demand evaluation to reduce the auxiliary energy demand of the pumps.

Target: To improve EP by reducing auxiliary energy consumption of pumps by optimizing their speed for the current system conditions.

3.5 Cooling

Intermittent control of emission and/or distribution

3.5.0 No automatic control

Description: No Intermittent Control (always full energy consumption).

3.5.1 Automatic control with fixed time program

Description: Automatic control is realized to reach intermittent operation of the emission and/or distribution components.

Target: To improve EP by rising the temperature setpoints during certain conditions (e.g. night), this leads to improved EP due to shortened operation time of the generation/distribution, lower losses of the room(s) due to lower temperature differences to the outside.

3.5.2 Automatic control with optimum start/stop

Description: Automatic control is realized to reach optimized Start/Stop of intermittent operation of the emission and/or distribution components.

Target: To improve EP through optimized start/stop to maximize time for economy mode by considering energy capacity of the building in control.

3.5.3 Automatic control with demand evaluation

Description: Automatic control is realized to reach intermittent operation of emission and/or distribution based on demand (occupancy).

Target: To improve EP through maximizing “pre-comfort” and/or “economy” time by detecting or using information about real demand (e.g. occupancy).

3.6 Cooling – Interlock between heating and cooling control of emission and/or distribution

3.6.0 No interlock

Description: No automatic control.

3.6.1 Partial interlock

Description: Partial interlock (dependant of the HVAC system).

The control function is setup to minimize the possibility of simultaneous heating and cooling. Typically air conditioning and static heating/cooling are not totally interlocked. A typical root cause is that air conditioning is serving many rooms with one supply air temperature but rooms are controlled individually. During interlock conditions the setpoints for the centralized (Air) supply are changed towards lowering the “interlock”.

Target: To improve EP through avoiding energy waist by minimizing the time and magnitude of simultaneous heating and cooling.

3.6.2 Total interlock

Description: The control function ensures that there will be no simultaneous heating and cooling.

Target: To improve EP by ensuring that no energy is waist through simultaneous heating and cooling. Typically this is done by either Hydraulic mechanical construction or by total switchover on Supply level.

3.7 Cooling – Different generator control

3.7.0 Constant temperature

Description: Cool generation is not optimized to environmental conditions and control is always towards the maximum allowed temperature.

3.7.1 Variable temperature depending on outdoor temperature

Description: The control temperature is calculated with the goal to operate the generator with minimized operating temperature setpoints depending on outdoor temperature.

Target: To improve EP by avoiding unnecessary electrical pumping energy by minimizing the generator operation temperatures using outdoor temperature information.

3.7.2 Variable temperature depending on the load

Description: Generator temperature setpoint is variable depending on demand based on the load of the system.

Target: To improve EP by optimizing efficiency of cold water generator at given environmental conditions based on current load of the system.

3.8 Cooling – Sequencing of different generators

3.8.0 Priorities only based on running time

Description: Priority based sequencing of multiple cooling generators. The priority of sequencing is only based on running times of the generators (in order to optimize maintenance).

3.8.1 Fixed Sequencing based on loads only

Description: Priority based sequencing of multiple cooling generators. The generators of higher priority are running first. A given generator in the priority list is running only if the generators of higher priority are running at full load. The sequence is fixed - the priority list is arbitrarily created accounting for the generators characteristics, e.g. absorption chiller vs. centrifugal chiller.

Target: To improve EP by only using as many generators as needed at any point in time and drive each generator in its most efficient mode (full load).

3.8.2 Priorities based on generator efficiency and characteristics

Description: Priority based sequencing of multiple cooling generators considering their capacities. The generators of higher priority are running first. A given generator in the priority list is running only if the generators of higher priority are running at full load. The priority list is dynamically created reflecting the generators current efficiency.

Target: To improve EP by only using as many as needed and drive each generator in its most efficient mode (full load), and only using the most efficient generators at any point in time.

3.8.3 Priorities based on predicted loads and demand

Description: Priority based sequencing of multiple heating generators considering their capacities. The generators of higher priority are running first. The priority list is dynamically created based on load predictions, considering the efficiencies of the generators to serve the load.

Target: To improve EP by only using as many generators as needed at any point in time - to avoid generators to run at very low load (e.g. < 30 %), but there is also a target to avoid too short “cycle times” (e.g. as each start consumes additionally energy).

3.9 Cooling – Control of Thermal Energy Storage (TES) charging

3.9.0 Continuous storage operation

Description: Thermal Energy storage system is enabled for charging all the time independently on the expected load. In case cooling energy is available it is charged to the TES.

3.9.1 Time-scheduled storage operation

Description: Thermal Energy storage system is enabled for charging during certain time slots, e.g. during weekdays or during night. Once the TES is enabled for operation it is charged independently on the expected load

Target: To improve EP by reducing state of charge when storage is not needed. Based on that energy losses of the TES can be reduced.

3.9.2 Load prediction based storage operation

Description: Thermal Energy storage is operated taking into account load predictions.

Target: To improve EP by reducing state of charge when storage is not needed. Based on that energy losses of the TES can be reduced.

5.2.5 Ventilation and air conditioning control

4.1 Air flow control at the room level

This function focuses mainly on air flow (exchange of air in the room). Temperature and humidity controls are related but covered in section 4.6 and 4.7. Air handling (heating, cooling, humidification, and dehumidification) and circulating air is an energy consuming process so that the main goal for an energy efficient air flow control is to minimize air movement. Typical example is VAV type of equipment in rooms.

4.1.0 No automatic control

Description: No automatic control of ventilation or natural ventilation. There is no control; the system runs constantly or controlled by a manually operated switch.

4.1.1 Time control

Description: Time control [comfort, economy].

The system runs according to a given time schedule. Scheduled mechanical ventilation [comfort, economy] and / or motorized windows

Possible variants:

— Simple scheduler on a daily basis

— 7 day (weekly) scheduler with holiday and other pre-programming capabilities

— “Extended hours” manual intervention: An occupant could kick the system after hours (during “economy”) using a manual push button or similar. The system runs during a specified time and switches off automatically.

Target: To improve EP by intermittent or reduced flow through scheduled mechanical ventilation (on/off or off, step 1, step2) and/or motorized windows (optional).

4.1.2 Occupancy detection

Description: The room controls runs dependent on the occupancy e.g. of a light switch, infrared sensors, etc. (changeover of room status between “pre-comfort” and “comfort”).

Optional:

— “In use” scheduler

— Window contact that triggers “protection-mode” while window is open

— “Extended hours” manual intervention

— “Optimal start control”.

— Presence detector (people in space)

— Measuring air quality.

A scheduler switches the operation mode of a room between “economy” (= not in use) and “comfort” (=in use).

A presence detector switches the mode of a room between “comfort”- and “pre-comfort” mode while ”in use”. The air quality drives the supply air volume in addition to other comfort demands (e.g. temperature).

Target: To improve EP by switching room status to "pre-comfort" when not required (=no presence) and adapting ventilation needs to the demand.

4.2 Room air temperature control by the ventilation system

This function is related to all-air systems and/or combination of ventilation systems with static systems as cooling ceiling, radiators, etc. It is assumed that room air temperature depends on both air flow (controlled by functions 4.1 and 4.5) as well as supply air temperature (controlled by function 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.

4.2.0 On-off control

Description: Both air flow rate and supply air temperature are fixed at the room level; The ventilation is sitched on and off. Room temperature setpoints are set individually.

4.2.1 Continuous control

Description: Either air flow rate or supply air temperature at the room level can be varied continuously; Room temperature setpoints are set individually

Target: To improve EP due to more accurate room temperature control.

4.2.2 Optimized control

Description: Both air flow rate and supply air temperature at the room level are controlled dependent on heating/cooling load.

Target: Minimum energy demand by optimized control.

4.3 Coordination of room air temperature control by ventilation and by static system

This function is to coordinate the interaction of the different technical systems dedicated to maintain room temperature, e.g. ventilation and water based heating system (radiator, underfloor heating, TABS).

4.3.0 No coordination

Description: Interaction is not coordinated, e.g. closed loop controllers are dedicated to each system to maintain the room air temperature independently.

4.3.1 Coordination

Description: Interaction is coordinated, i.e. only one system is controlled by a closed loop controller for the room air temperature and the other system conditions the room only to that extent that allows the closed loop controller to benefit from internal and external heat gains.

Target: To improve EP by avoiding conflictive operation of systems.

4.4 Outside air flow control

This control function is applied to ventilation systems that allow varying the OA ratio or OA flow respectively.

4.4.0 Fixed OA ratio/OA flow

Description: The system runs according to a given OA ratio or OA flow, e.g. modified manually.

4.4.1 Staged (low/high) OA ratio/OA flow

Description: Flow depends on a given time schedule.

4.4.2 Staged (low/high) OA ratio/OA flow

Description: Flow depends on the occupancy. Information about occupancy is provided by e.g. light switch, infrared sensors etc.

4.4.3 Variable control

Description: The system is controlled by sensors which detect the number of people or indoor air parameters or adapted criteria (e.g. CO2, mixed gas or VOC sensors). The used parameters shall be adapted to the kind of activity in the space.

4.5 Air flow or pressure control at the air handler level

4.5.0 No automatic control

Description: No automatic control of ventilation or natural ventilation. There is no control; the system continuously runs and supplies of air flow for a maximum load of all rooms.

4.5.1 On / off time control ventilation

Description: The air handler or motorized windows are controlled via on/off mechanism while building is “in use”.

Target: To improve EP by scheduled mechanical (on/off) ventilation.

4.5.2 Multi-stage control

Description: The air handler is switched on while “in use” (step1). Based on the demand of supply air volume (pressure) the fan decreases the speed by a multi-step control (step 1 till step x).

Target: To improve EP by scheduled mechanical ventilation (on/off or off, step 1, step 2)

4.5.3 Automatic flow or pressure control

Description:

The air handler is enabled while “in use” and controlled based on the air flow demand from the rooms (e.g. occupancy detector, air quality, temperature, humidity).

Pressure setpoint could be either constant or variable (dynamic)

When all rooms are in pre-comfort and air quality, temperature and humidity are according to the setpoints the fan is then switched off. (Note that a prerequisite is that all rooms/zones are in class A.)

There is no pressure reset realized.

Target:

EP is achieved by maintaining a constant pressure or desired in the supply air that drives “air conditioning” as the demand in the emission spaces (rooms / zones) occurs, including a demand controlled fan speed down to 0.

4.5.4 Automatic flow or pressure control

Description: Same function as 4.5.3 but with pressure reset.

4.6 Heat recovery exhaust air side icing protection control

4.6.0 Without defrost control

Description: In a heat recovery system there can be conditions where the heat exchange equipment could get icy (e.g. very humidity and very low outside temperatures).

No control of the heat recovery equipment in case of icy conditions at the exhaust of the heat recovery. There is no specific action during cold season required.

Target: EP not applicable

4.6.1 With defrost control

Description: In a heat recovery system there can be conditions where the heat exchange equipment could get icy (e.g. very humidity and very low outside temperatures). A control sequence avoids air leaving the heat exchanger producing icy conditions in the air outlet. Different solutions i.e. either heat the air up or control/bypass the heat exchanger to avoid the situation.

Target: EP is achieved by preventing ice on the outlet hindering air passing through.

4.7 Heat recovery control (prevention of overheating)

Heat recovery systems can recover more heat than needed (e.g. in cases where w large portion of the heat production is generated outside of the HVAC system).

4.7.0 Without overheating control

Description: No control of the heat recovery equipment to prevent overheating of supply air temperature. There is no specific action during hot or mild periods.

4.7.1 With overheating control

Description: Automatic control prevents the heat recovery to overheat the supply air temperature, either by stopping, modulating or by-passing the heat exchanger.

Target: EP is achieved by limiting of heat recovery (and re-cooling afterwards).

4.8 Free mechanical cooling

Free mechanical cooling is a method to cool a building applying mechanical ventilation while in unoccupied mode. This method is applicable under certain conditions and need to be designed in a way than not more energy is used by mechanical systems than gained with exchange of the air.

4.8.0 No automatic control

Description: No automatic cooling control is available.

4.8.1 Night cooling

Description: The amount of outdoor air is set to its maximum during the unoccupied period provided:

a) Room temperature is above the setpoint for the comfort period

b) Difference between the room temperature and the outdoor temperature is above a given limit; if free night cooling is realized by automatically opening windows there is no air flow control

Target: EP is achieved by using cool night air to prepare temperature condition in zones while “not in use”.

4.8.2 Free cooling

Description: 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.

Target: EP is achieved by using cool air to prepare temperature condition in zones during all times.

4.8.3 H,x-directed control

Description: 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).

Target: EP is achieved by applying both temperature and humidity to prepare temperature condition in zones while scheduled / occupied.

4.9 Supply air temperature control

This section applies for controls of rooms/zones where the “leading” setpoint of the air supply is room temperature (and not air quality, or air Flow - > see 4.1).

This temperature control shall be considered with a particular attention if the system principle does not prevent simultaneous heating and cooling (see 3.6).

4.9.0 No automatic control

Description: No control loop enables to act on the supply air temperature – also no controls to a fixed temperature value.

4.9.1 Constant setpoint

Description: A control loop enables to control the supply air temperature. Supply air temperature setpoint can be set but stays constant – no automatic adaptation.

Target: Supply air setpoint can be adjusted to fit needs of controls.

4.9.2 Variable setpoint with OTC

Description: Setpoint is modulated applying a scheme or rules to follow outside air temperature (OTC). The rules or algorithm to follow the outside air might be adjustable (e.g. linear function, curve, 2 point line).

Target: The controls strategy is that the supply setpoint follows the outside air temperature – applying algorithmic – in order to ensure comfort/production environment.

4.9.3 Variable setpoint with load dependant compensation

Description: The setpoint follows a strategy of the demand for e.g. colder or warmer air in order to ensure the required condition in a space supplied by the plant. The control strategy might need to follow several demand signals (e.g. temperature, air quality) from different rooms. This is typically used in rooms/zones where air conditioning and static heating and/or cooling are installed. In these cases the air flow controls towards:

— Priority 1: air quality (or Constant Flow) setpoint

— Priority 2: supply air temperature which is calculated together with information from/to static heating/cooling.

Possible variants: supply air temperature is dependent additionally on outside air temperature

Target: Improve EP by optimizing (lowest possible) temperature setpoint for supply air in combination with air flow/air quality control and static heating, respectively (highest possible) temperature setpoint for static cooling.

*4.10*Humidity control

It is used to ensure the comfort for the room users or as a building protection to prevent the growth of damp inside the building envelope.

4.10.0 No automatic control

Description: Humidifier/dehumidifier facilities run constantly or manually switched/on

4.10.1 Dew point control

Description: Supply air or room air humidity expresses the dew point temperature and reheat of the supply air.

Target: Improve EP through avoiding air handler operation in “high energy” operational state (above dew point)

4.10.2 Direct humidity control supply air or room air humidity

Description: a control loop enables the supply air or room air humidity at a constant value. Controllers may be applied as “humidity limitation control” or “constant control”.

Target: Improve EP through reducing operation time and/or operation setpoints of humidifier/dehumidifier facilities.

5.2.6 Lighting control

5.1 Lighting – Occupancy control

5.1.0 Manual on / off switch

Description: The luminaire is switched on and off with a manual switch in the room.

5.1.1 Manual on / off Automatic off switch – Additional sweeping extinction signal

Description: Manual On, manual off and automatic off switch with additional sweeping extinction signal. Lighting control is realized by manual on/off switch and additional sweeping extinction signal. The luminary is switched on and off with a manual switch in the room. In addition, an automatic signal automatically switches off the luminary at least once a day, typically in the evening to avoid needless operation during the night.

Target: To improve EP by switching off the light after business hours.

5.1.2 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 reduced light output (of no more than 30 % of the normal 'on' state) no later than 10 min after the last occupancy in the illuminated area. In addition, no later than 20 min after the last occupancy in the room as a whole is detected, the luminaire (s) is automatically and fully switched off.

Target: To improve EP by avoiding light where no light is needed and reduce light brightness in not used areas (open space office).

Auto on / Auto off. The control system switches the luminaire (s) automatically on whenever the illuminated area is occupied, and automatically switches them entirely off no later than 10 min after the last occupancy is detected in the illuminated area.

Target: To improve EP by avoiding light where no light is needed.

5.1.3 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 reduced light output (of no more than 30 % of the normal 'on state') no later than 10 min after the last occupancy in the illuminated area. In addition, no later than 20 min after the last occupancy in the room as a whole is detected, the luminaire(s) are automatically and fully switched off.

Manual On/ Partial Auto On /Auto Off: The luminaire(s) can only be switched on by means of a manual switch or automatically by occupancy detection sensor located in (or very close to) the area illuminated by the luminaire(s), and, if not switched off manually, is automatically and entirely switched off by the automatic control system no later than 20 min after the last occupancy is detected in the illuminated area.

5.2 Lighting – Light level daylight control (daylight harvesting)

This covers only the aspect of light level control (occupancy control is covered separately in 5.1). Typically light level and occupancy control are installed together (very often even in the same control device).

5.2.0 Manual central Control

Description: there is no automatic control to take light level into account. User can manually switch on lights. Luminaires are controlled centrally, there is no manual switch in the room/zone.

5.2.1 Manual control

Description: Luminaires can be switched off with a manual switch in the room.

Target: To improve EP by avoiding light if light level is available.

Automatic switching

Description: 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.

5.2.3 Automatic dimming

Description: The luminaires are dimmed down and finally fully switched off when daylight is available. The luminaires will be switched on again and dimmed up if the amount of daylight is decreasing.

5.2.7 Blind control

There are two different motivations for blind control: Solar protection to avoid overheating and to avoid glaring.

6.0 Manual operation of blinds

Description: Manual operation of blind. Mostly used only for manual shadowing, energy saving depends only on the user behaviour.

6.1 Motorized operation of blinds with manual control

Description: Mostly used only for easiest manual (motor supported) shadowing, energy saving depends only on the user behaviour.

Target: Improve EP through disburdening the user from manual (mechanical) shadowing which increases user's probability to shade in a way that it is more energy efficient.

6.2 Motorized operation of blinds with automatic control

Description: Automatically control the solar radiation by means of motorized blinds (roller blinds, Venetian blinds, blinds and awnings). Solar radiation sensing can be done individually in each room or collectively for many rooms by an outside solar sensor. Very often there are protection functions (e.g. wind protection) which interfere with the shading.

Target: To improve EP by reducing cooling energy.

6.3 Combined light/blind/HVAC control – with light level control

Description: Combined light/blind/HVAC control with light level control. Control the solar radiation by means of motorized blinds (roller blinds, Venetian blinds, blinds and awnings).

Target: Improve EP by maximizing gain of solar heat, light and minimizing cooling losses through solar heat by coordination of blinds control, automatic lighting control, automatic light level control, HVAC control (room temperature) and heat retention facility including alignment of zones/rooms.

5.3 Method 1 - Impact of BAC and TBM on the energy performance of buildings (Detailed method)

5.3.1 Rationale

This method is meant for a detailed energy performance analysis of a building in case detailed information about the building, the HVAC system and especially the type of automation, control and management functions is available that can be applied in a holistic EPBD calculation 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.

5.3.2 Time steps

Method 1 (detailed method) is compatible to different time steps:

— yearly

— monthly

— hourly

according to the time-step of the input. Normally it is designed for a monthly or hourly method. The method "bin" or any class interval method may also be applied.

5.3.3 Assumptions

It is assumed that a calculation method is available that can be used to quantify the impact of building automation and control.

5.3.4 Data input

Default values for functions are referring to the minimum requirements defined in Annex A of the standard. As an alternative BAC efficiency class C could be used as a default.

5.3.5 Simplified input

The standard gives the opportunity to classify a building or different HVAC disciplines following a standardized classification scheme instead of defining specific BAC functions.

5.3.6 Calculation information

5.3.6.1 Heating and cooling control

Emission control (HEAT_EMIS_CTRL_DEF) (CLG_EMIS_CTRL_DEF)

One shall differentiate at least the types of room temperature control described in prEN 15232-1:2015 Table 4, (1.1 and 3.1). The impact of the control system type is taken into account by considering an equivalent internal temperature set point.

$$\theta_{ei} = \theta + \vartheta\theta \tag{1}$$

where

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

θ is the set point temperature of the conditioned zone;

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

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

This approach is described in:

— EN 15316-2-1 for heating systems;

— EN 16789 for air conditioning systems;

— EN ISO 13790:2008.

For electronic controllers $\delta\theta$ is equal to the “control accuracy” determined according to prEN 15500-1:2015.

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

Emission control for TABS (HEAT_EMIS_CTRL_TABS) (CLG_EMIS_CTRL_TABS)

One shall differentiate at least the types of room temperature control described in Table 4 (1.2 and 3.2):

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

Control of distribution network water temperature (HEAT_DISTR_CTRL_TMP) (CLG_DISTR_CTRL_TMP)

One shall differentiate at least the types of supply temperature control described in Table 4 (1.3 and 3.3):

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

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

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

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

Control of distribution pumps in networks (HEAT_DISTR_CTRL_PMP) (CLG_DISTR_CTRL_PMP)

One shall differentiate at least the types of pump control described in Table 4 (1.4 and 3.4):

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

Intermittent control of emission and/or distribution (HEAT_DISTR_CTRL) (CLG_DISTR_CTRL)

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

0) no automatic control;

1) automatic intermittent control without optimum start in conformity with prEN 12098-1:2015 or prEN 12098-3:2015 or prEN 12098-5:2015 or EN ISO 16484-3;

2) automatic intermittent control with optimum starts in conformity with prEN 12098-1:2015 or prEN 12098-3:2015.

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

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

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

— impact on the energy needs of the building.

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

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

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

In EN ISO 13790:2008, Formulae (48) and (49), replace:

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

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

where X is given in the following Table 2:

Table 2 — Factor X

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

— Impact on the energy use of the HVAC system.

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

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

Interlock between heating and cooling control of emission and/or distribution (CLG_GEN_CTRL)

For air conditioned buildings the function described in prEN 15232-1:2015 Table 4 (3.6) is one of the most important regarding energy savings.

The possibility to provide at the same time heating and cooling in the same room depends on the system principle and on the control functions. Depending on the system principle a full interlock can be achieved with a very simple control function or can request a complex integrated control function. One shall differentiate at least:

0) no interlock

1) partial interlock

2) total interlock

A total interlock can be achieved in different ways:

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

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

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

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

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

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

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

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

— no interlock: the supply air temperature set point is fixed to a constant value;

— partial interlock: the supply air temperature set point varies with the outdoor temperature;

— total interlock: the supply air temperature set point is automatically reset depending on the cooling request in the different zones (this requests and integrated control system).

— Example of methods to calculate this impact through a correction factor approach is given in EN 15243.

Generation control

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

Four main types of temperature control are described in Table 4 (1.6; 1.7; 1.8 and 3.7):

Heat generator control for combustion and district heating (HEAT_GEN_CTRL_CD)

Heat generator control heat pump (HEAT_GEN_CTRL_HP)

Heat generator control outdoor unit (HEAT_GEN_CTRL_OU)

Different chillers selection control (CLG_GEN_CTRL)

Details regarding specific systems are given in the following standards:

— boilers: The impact of the control system is calculated according to EN 15316-4-1. This standard includes three calculation methods: typology, case specific boiler efficiency method, boiler cycling method. The “case specific boiler efficiency method” describes explicitly how to assess the impact of the control system. This is dealt with in 5.3.9 running temperature of the generator and Annex H.

— heat pump systems: The impact of the control system is calculated according to EN 15316-4-2.This standard includes 2 calculation methods: a simplified method based on system typology and a detailed case specific method. The simplified methodology when existing is the subject of a national annex. It is developed by applying the detailed case specific method to cases representative of a national typology. The way to deal with control in this simplified methodology does then depend on the national annex.

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

0) constant temperature control;

1) variable temperature depending of the outdoor temperature;

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

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

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

a) a cut off temperature θltc: below this temperature the heat pump is switched off and the back up operates alone;

b) a balance temperature θbp: below this temperature the back up is started. This temperature is in all cases equal or higher than the cut off temperature.

The following mode shall be taken into account:

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

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

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

— cogeneration systems: The calculation method defined in EN 15316-4-4 does not differentiate different types of control systems.

— district heating systems: The impact of the generator control system is calculated according to EN 15316-4-5. The losses are calculated in 6.3.5 “Thermal Loss”. The loss depends on the mean temperature of the dwelling station. This temperature depends on the mean water temperature of the secondary circuit of the dwelling station which shall be calculated in the same way as in EN 15316-4-1, running temperature of the generator.

— other renewable systems: EN 15316-4-6;

— biomass generation system: The impact of the generator control system is calculated according to EN 15316-1. The method is similar to the “directive method” described in EN 15316-4-1. The generator operating temperature shall be calculated in the same way as in EN 15316-4-, running temperature of the generator.

— Radiant heaters and stoves: EN 15316-4-7.

Sequencing of different generators (HEAT_GEN_CTRL_SEQ)(CLG_GEN_CTRL_SEQ)

If different generators are available one can differentiate at least the types of sequence control described in prEN 15232-1:2015, Table 4 (1.8 and 3.8): This is calculated according to the BMS standard prEN 16947:2015.

5.3.6.2 Domestic hot water control

Their full functions are explained in prEN 15232-1, Table 4 (2.1 – 2.5).

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

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

5.3.6.3 Ventilation control

The impact of ventilation and air conditioning control is calculated according to prEN 16798–5-1 or prEN 16798–5-2 and prEN 16798-7. The following three tables show the BAC-functions and BAC-Function types covered by these standards and their relation to Table 4 in prEN 15232-1:2015.

Table 3 — Table of BAC-functions and BAC-functions types in prEN 16798–5-1

	Identifier	**Description**	**Module[a] Approach[b]**	**Restriction to specific system (Input data – process design)**	**Remarks**	**Comparison with Table 4 in** prEN 15232–1:2015
EN 16798-5-1 (Rev 15241 method 1) Calcul. interval: hourly, bin					Source: prEN 16798–5-2:2015 (FV version) (TC 156/WG21 N167)	
BAC-Function	AIR_FLOW_CTRL	Control of the volume flow rate	**M5-8 V Generation**			4.5 Air flow or pressure control at the air handler level VENT_AHUFLOW_CTRL – Variant 'air flow control'
Type	NO_CTRL	No flow rate control, continuous operation	Direct Approach	SYS_TYPE = SINGLE_ZONE	It reflects the fan control	0 No automatic control
Type	ON/OFF_CTRL	Time dependant flow rate control, continuous operation during occupancy time	Direct Approach	SYS_TYPE = SINGLE_ZONE	It reflects the fan control	1 On off time control
Type	MULTI_STAGE	Multi stage variable flow rate control	Direct Approach	SYS_TYPE = SINGLE_ZONE	It reflects the fan control	2 Multi-stage control
Type	VARIABLE	Continuously variable flow rate control	Direct Approach		For single zone system: It reflects fan control with variable speed drive. For multi zone system: It reflects pressure control	3 Automatic flow control 4 Automatic flow control
BAC-Function	SUP_AIR_TEMP_CTRL	Control of the supply air temperature	**M5-8 V Generation**		This BAC function is also used in prEN 16798-7	4.9 Supply air temperature control at the AHU level VENT_AHUSAT_CTRL

	Identifier	Description	Module[a] Approach[b]	Restriction to specific system (Input data – process design)	Remarks	Comparison with Table 4 in prEN 15232–1:2015
Type	NO_CTRL	No supply temperature control	Direct Approach			0 No automatic control
Type	CONST	Constant supply air temperature	Direct Approach			1 Constant set point
Type	ODA_COMP	Variable set point with outdoor temperature compensation	Direct Approach			2 Variable set point with outdoor temperature compensation
Type	LOAD_COMP	Variable set point with load dependant compensation	Direct Approach			3 Variable set point with load dependant compensation
BAC-Function	RCA_CTRL	Control of the air recirculation	**M5-8 V Generation**	Systems with equipment for air recirculation		
Type	FIX	Fixed proportion of recirculation air	Direct Approach			4.4 Outside air flow control VENT_OAFLOW_CTRL 0 Fixed OA ratio / OA flow Variant 'Fixed OA ratio'
Type	VARIABLE	Variable proportion of recirculation air	Direct Approach			4.8 Free mechanical cooling VENT_FREECOOL_CTRL 2 Free cooling
BAC-Function	HEAT_REC_CTRL	Control of the recovery device, depending on the heat recovery type	**M5-8 V Generation**	Systems with equipment for heat recovery		4.7 Heat recovery control: prevention of overheating VENT_HRHEAT_CTRL
Type	NO_CTRL	No heat recovery control , supply temperature is taken as it comes from the heat recovery	Direct Approach	HEAT_RECOVERY_TYPE = PLATE		0 Without overheating control
Type	BY_PASS	Heat exchanger is bypassed	Direct Approach	HEAT_RECOVERY_TYPE = PLATE		1 With overheating control
Type	SPEED	Control by changing the rotation speed	Direct Approach	HEAT_RECOVERY_TYPE = ROT_NH or ROT_HYG or ROT_SORP		1 With overheating control

	Identifier	**Description**	**Module[a] Approach[b]**	**Restriction to specific system (Input data – process design)**	**Remarks**	**Comparison with Table 4 in** prEN 15232–1:2015
Type	HYDR	Hydraulic control with bypass valve	Direct Approach	HEAT_RECOVERY_TYPE = PUMP_CIRC		1 With overheating control
Type	SPEED	Control by changing the pump speed	Direct Approach	HEAT_RECOVERY_TYPE = PUMP_CIRC		1 With overheating control
BAC-Function	DEFR_CTRL	Control of the frost protection	**M5-8 V Generation**			4.6 Heat recovery control: Icing protection VENT_HRICE_CTRL
Type	DIRECT	Defrosting is controlled directly by measurement of the pressure drop	Direct Approach			1 With icing protection control
Type	INDIRECT	Frost is prevented by controlling the leaving temperature from the heat recovery device	Direct Approach			1 With icing protection control
BAC-Function	FAN_CTRL	Control of the fan	**M5-8 V Generation**			
Type	NO_CTRL	No control, the fan reacts on the variable flow rate according to its characteristics	Direct Approach	No restriction (SYS_TYPE = SINGLE_ZONE or MULTI_ZONE)		4.5 Air flow or pressure control at the air handler level VENT_AHUFLOW_CTRL – Variant 'pressure control' 0 No automatic control

	Identifier	Description	Module[a] Approach[b]	Restriction to specific system (Input data – process design)	Remarks	Comparison with Table 4 in prEN 15232–1:2015
Type	CONST_PRES	The fan is controlled to achieve a constant pressure difference between a specific point in the distribution system and the surrounding	Direct Approach	No restriction (SYS_TYPE = SINGLE_ZONE or MULTI_ZONE)		4.5 Air flow or pressure control at the air handler level VENT_AHUFLOW_CTRL – Variant 'pressure control' 3 Automatic pressure control without pressure reset
Type	MIN_PRES	The fan is controlled to the minimum pressure difference necessary in the system	Direct Approach	SYS_TYPE = MULTI_ZONE		4.5 Air flow or pressure control at the air handler level VENT_AHUFLOW_CTRL – Variant 'pressure control' 4 Automatic pressure control with pressure reset
Type	DIRECT	The fan is controlled directly according to the variable flow rate	Direct Approach	SYS_TYPE = SINGLE_ZONE		4.5 Air flow or pressure control at the air handler level VENT_AHUFLOW_CTRL – Variant 'air flow control'; see above
BAC-Function	HUM_CTRL	Control of the humidifier	**M5-8 V Generation**			4.10 Humidity control VENT_HUM_CTRL, restricted to humidification, i.e. not covering dehumidification
Type	NO_CTRL	Uncontrolled or valve controlled	Correction Coefficient Approach			0 No automatic control or 1 Dew point control or 2 Direct humidity control - case valve controlled

	Identifier	**Description**	**Module[a]** **Approach[b]**	**Restriction to specific system (Input data – process design)**	**Remarks**	**Comparison with Table 4 in** prEN 15232–1:2015
Type	ON_OFF	On/Off	Correction Coefficient Approach	Restricted to systems where the water flow is controlled with the pump		2 Direct humidity control – case valve controlled and pump off if valve closed
Type	SPEED	Pump speed control	Correction Coefficient Approach	Restricted to systems where the water flow is controlled with the pump		2 Direct humidity control

a Module to which the BAC-function is assigned (module to which the controlled variable is assigned or module on which the BAC-function acts), according to the modular structure

b Approach according to which the impact on the energy performance of the building is taken into account (see FprEN 15603:2014, 8.1.4 'Effect of building automation and control (BAC) and technical building management(TBM))

Table 4 — Table of BAC-functions and BAC function types in prEN 16798–5-2

	Identifier	**Description**	**Module[a]** **Approach[b]**	**Restriction to specific system (Input data – process design)**	**Remarks**	**Comparison with Table 4 in** prEN 15232–1:2015 **(Dec 2015)** **(PE draft)**
prEN 16798–5-2 (Rev 15241 method 2) Calcul. interval: yearly, bin					Source: prEN 16798–5-2:2015 (FV version) (TC 156/WG21 N167)	
BAC-Function		Control of volume flow rate	**M5–8 V Generation**			
Type	No identifier	Manual control				4.1 Supply air flow control at room level VENT_RMFLOW_CTRL Type 0: No automatic control 4.4 Outside air flow control VENT_OAFLOW_CTRL Type 0: Fixed OA flow, modified manually

	Identifier	**Description**	**Module[a]** **Approach[b]**	**Restriction to specific system (Input data – process design)**	**Remarks**	**Comparison with Table 4 in** prEN 15232–1:2015 **(Dec 2015)** **(PE draft)**
Type	No identifier	Clock Control (Time dependant, continuous operation during occupancy time)	Correction Coefficient Approach			4.1 Supply air flow control at room level VENT_RMFLOW_CTRL Type 1: Time control 4.4 Outside air flow control VENT_OAFLOW_CTRL Type 1: Staged OA flow, depending on time schedule
Type	No identifier	Central demand control (DCV)	Correction Coefficient Approach			4.4 Outside air flow control VENT_OAFLOW_CTRL Type 3: Variable control, with CO_2 or VOC sensor
Type	No identifier	Local demand control (DCV)	Correction Coefficient Approach			4.4 Outside air flow control VENT_OAFLOW_CTRL Type 3: Variable control, with CO_2 or VOC sensor
BAC-Function	No identifier	Control of supply air temperature	**M5–8 V Generation**			4.9 Supply air temperature control at the AHU level VENT_AHUSAT_CTRL
Type	No identifier	No control				0 No automatic control
BAC-Function	No identifier	Control of the air recirculation	**M5–8 V Generation**			4.4 Outside air flow control VENT_OAFLOW_CTRL
Type	No identifier	Fixed proportion of recirculation air				0 Fixed OA ratio / OA flow Variant 'Fixed OA ratio'
BAC-Function	No identifier	Control of the heat recovery device	**M5–8 V Generation**			4.7 Heat recovery control: prevention of overheating VENT_HRHEAT_CTRL
Type	No identifier	Without heat recovery control	Direct Approach	Flat plate heat exchanger		0 Without overheating control

	Identifier	**Description**	**Module[a]** **Approach[b]**	**Restriction to specific system (Input data – process design)**	**Remarks**	**Comparison with Table 4 in** prEN 15232–1:2015 **(Dec 2015)** **(PE draft)**
Type	No identifier	By bypassing the heat exchanger	Direct Approach	Flat plate heat exchanger with bypassing facility		1 With overheating control
Type	No identifier	By changing the rotation speed	Direct Approach	Rotary heat exchanger		1 With overheating control
BAC-Function	No identifier	Control of the heat pump				
Type	No identifier	On/Off compressor				
BAC-Function	No identifier	Control of the frost protection by controlling the leaving temperature of the heat recovery device	**M5–8 V Generation**			4.6 Heat recovery control: Icing protection VENT_HRICE_CTRL
Type	No identifier	Temperature/time or pressure increase controlled preheating	Correction Coefficient Approach			1 With icing protection control
Type	No identifier	Electronic controlled preheating (variable control on temperature)	Correction Coefficient Approach			1 With icing protection control
Type	No identifier	2-step controlled preheating (on/off, 2 power)	Correction Coefficient Approach			1 With icing protection control
Type	No identifier	1-step controlled preheating (on/off, 1 power)	Correction Coefficient Approach			1 With icing protection control
BAC-Function	No identifier	Control of the fan	**M5–8 V Generation**			4.5 Air flow or pressure control at the air handler level VENT_AHUFLOW_CTRL – Variant 'air flow control'
Type	No identifier	No control				0 No automatic control

	Identifier	Description	Module[a] Approach[b]	Restriction to specific system (Input data – process design)	Remarks	Comparison with Table 4 in prEN 15232–1:2015 **(Dec 2015)** **(PE draft)**

[a] Module to which the BAC-function is assigned (module to which the controlled variable is assigned or module on which the BAC-function acts), according to the modular structure

[b] Approach according to which the impact on the energy performance of the building is taken into account (see FprEN 15603:2014, 8.1.4 'Effect of building automation and control (BAC) and technical building management(TBM))

Table 5 — Table of BAC-functions and BAC-functions types in prEN 16798–7

	Identifier	Description	Module[a] Approach[b]	Restriction to specific system (Input data – process design)	Remarks	Comparison with Table 4 in prEN 15232–1:2015 **(Dec 2015)** **(PE draft)**
prEN 16798–7 **Emission** (Rev 15242) Calcul. interval: hourly, monthly					Source: prEN 16798–7:2014 (FV version) (TC 156/WG21 N160)	
BAC-Function	No identifier	Outdoor air flow control function	**M5–5 V Emission**			4.4 Outside air flow control VENT_OAFLOW_CTRL
Type	No identifier	On/off time control (depending on a given time program) Called in Table B.3 "All other sensors"	Correction Coefficient Approach		Definition of BAC-Function types only in Annex B on default choices. In the calculation dependent on the local operation requirement signal $f_{op;V}$, not on the occupancy factor f_{occ} coming from module M1–6	1 Staged (low/high) OA ratio / OA flow: depending on a given time schedule Variant 'OA flow'
Type	No identifier	Control with occupancy sensor	Correction Coefficient Approach		Definition of BAC-Function types only in Annex B on default choices	2 Staged (low/high) OA ratio / OA flow: depending on the presence Variant 'OA flow'

	Identifier	**Description**	**Module[a]** **Approach[b]**	**Restriction to specific system (Input data – process design)**	**Remarks**	**Comparison with Table 4 in** prEN 15232–1:2015 **(Dec 2015)** **(PE draft)**
Type	No identifier	control based on the number of people (with sensor which counts number of people)	Correction Coefficient Approach		Definition of BAC-Function types only in Annex B on default choices	3 Variable control Variant 'number of people'
Type	No identifier	Continuous control based on an IAQ sensor (e.g. CO_2 or VOC)	Correction Coefficient Approach		Definition of BAC-Function types only in Annex B on default choices	3 Variable control Variant 'indoor air parameter'
BAC-Function	SUP_AIR_TEMP_CTRL	Supply air temperature control	**M5–5 V Emission**		This BAC function is also used in prEN 16798–5-1	
Type	NO_CTRL	No supply temperature control	Direct Approach			
Type	CONST	Constant supply air temperature	Direct Approach			
Type	ODA_COMP	Variable set point with outdoor temperature compensation	Direct Approach			
Type	LOAD_COMP	Variable set point with load dependent compensation	Direct Approach			4.2 Room air temperature control by ventilation VENT_RTEMP_CTRL Type 1, Variant 'variable supply air temperature'
BAC-Function	SUP_AIR_FLW_CTRL	Supply air flow rate control	**M5–5 V Emission**			
Type	No identifier	No control	Direct Approach	CAV System (CAV = Constant Air Volume Systems)		4.1 Supply air flow control at room level VENT_RMFLOW_CTRL Type 0, No automatic control
Type	ODA	Flow rate controlled according to outdoor air requirement only	Direct Approach	Systems with fixed OA ratio or without equipment for air recirculation		4.4 Outside air flow control VENT_OAFLOW_CTRL Type 1, 2, 3

	Identifier	**Description**	**Module[a]** **Approach[b]**	**Restriction to specific system (Input data – process design)**	**Remarks**	**Comparison with Table 4 in** prEN 15232–1:2015 **(Dec 2015)** **(PE draft)**
Type	LOAD	Flow rate controlled according to heating/cooling load with a minimum set by outdoor air requirements	Direct Approach			4.2 Room air temperature control by ventilation system VENT_RTEMP_CTRL Type 1, Variant ‘variable air flow rate’

a Module to which the BAC-function is assigned (module to which the controlled variable is assigned or module on which the BAC-function acts), according to the modular structure

b Approach according to which the impact on the energy performance of the building is taken into account (see FprEN 15603:2014, 8.1.4 ‘Effect of building automation and control (BAC) and technical building management(TBM))

5.3.6.4 Building Management and TBM functions

Set point management (BMS_SP)

This BMS function is applied to calculate the room temperature set points for heating and/or cooling. Set point temperatures are defined according to the room/zone operating modes. As default operating modes are fixed according to a given schedule but could be also calculated depending on the input data. The following operating modes are known:

Comfort	room temperature is set to meet the comfort criteria of the occupants
Economy	room temperatures are set-back, i.e. in heating case the room temperature set point is reduced whereas in cooling mode the room temperature set point is increased to avoid heating or cooling, respectively
Pre-comfort mode	room temperature set points are in between comfort and economy temperature set points
Frost protection mode	minimum allowable room temperature set point to be maintained in case of low ambient air temperatures.

There are different room temperature set points for heating and cooling depending on the operation modes. Frost protection mode does require feedback information (input) about either ambient air temperature or room temperature. In case the temperature falls below a given minimum value frost protection mode is chosen by the BMS.

Building management systems will also allow to monitor room temperature profiles, thus also to check for long term temperature deviations and set point shifting. Based on this information the building management system will be able to overwrite and set back unrequested set points probably caused by the occupant. This functionality is needed to maintain energy performance (see BMS_FD).

Run Time management (BMS_RT)

This function provides a signal to shut on/shut off the HVAC system in a building. The run time of the HVAC system could be arranged according to EN 12098 by:

— a scheduler using a fixed or any pre-defined time program

— an optimum start-stop function

— an adaptive start-stop function also accounting for presence of occupants.

Local Energy production and renewable energies (BMS_RES)

This function provides information how to manage local energy production and use of renewable energy sources. Local energy production covers energy from renewable energy sources and combined heat and power generation as well.

The functions are used:

— to orchestrate renewable energy production and any CHP.

— to manage charging and discharging of batteries taken into account both load and energy production predictions.

Heat recovery and heat shifting (BMS_HRC)

This function provides information how to compensate heating and cooling loads by applying heat recovery or heat shifting functions. Two operating conditions have to be distinguished:

— Heat recovery: to take benefit of waste heat

— Heat shifting: to take benefit of parallel heating and cooling.

Smart grid integration (BMS_SG)

This function is describing demand side management used to optimize building operation with respect to the smart grid requests. Both electric energies exported to (Eexp;el;grid) and delivered from the grid (Edel;el;grid) are controlled to optimize energy efficiency, energy costs or any other criteria that can be seen as relevant for a smart grid activities. Output of this function is a signal to energy generation devices (to increase energy provided to the grid) or a signal to consumption devices (e.g. heat pumps to increase energy delivered by the grid). This signal could be a set point (global temperature set point).

Fault Detection and Monitoring (BMS_FD)

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

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

a) Improper operation schedules

   This is especially necessary in buildings which are not permanently occupied such as offices, schools.

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

b) Improper set points

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

   The monitoring function shall include a graph or an indicator enabling to have a global view of the different set points of room temperature for heating and cooling.

c) Simultaneous heating and cooling

   If the system can lead to simultaneous heating and cooling monitoring functions shall be set to check that simultaneous heating and cooling is avoided or minimized.

   Fast switching between heating and cooling shall also be detected.

d) Priority to generator(s) having the best energy performance

   When several generation systems having different energy performances are used to do the same function (e.g. heat pump and back up, solar system and back up) a monitoring function shall be set to verify that the systems having the best energy performances are used before the others.

Reporting (BMS_RPR)

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

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

These reports can include:

a) energy certificate for the building;

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

   Using the on line monitoring function enables to obtain a rating fully in conformity with requirements of EN 15603:2008. Measurements of the meters can be done for an exact year according to 7.2. If a sufficient number of meters is installed the measurements can be done for each energy carrier. Energy used for other purposes than heating, cooling, ventilation, hot water or lighting can be measured separately according to 7.3. The measurement of outdoor temperature enables to perform the correction for outdoor climate defined in 7.4.

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

c) assessing the impact of improvement of building and energy systems

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

   Using the monitoring functions enables to take into account the actual values regarding climatic data, internal temperature, internal gains, hot water use, lighting use, according to EN 15603:2008, 9.2 and 9.3;

d) energy monitoring

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

e) room temperature and indoor air quality monitoring

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

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

   TBM is covered by prEN 16947-1:2015 and FprCEN/TR 16947-2:2015.

5.4 Method 2 – Impact of BAC and TBM on the energy performance of buildings (BACS factor method)

5.4.1 Rationale

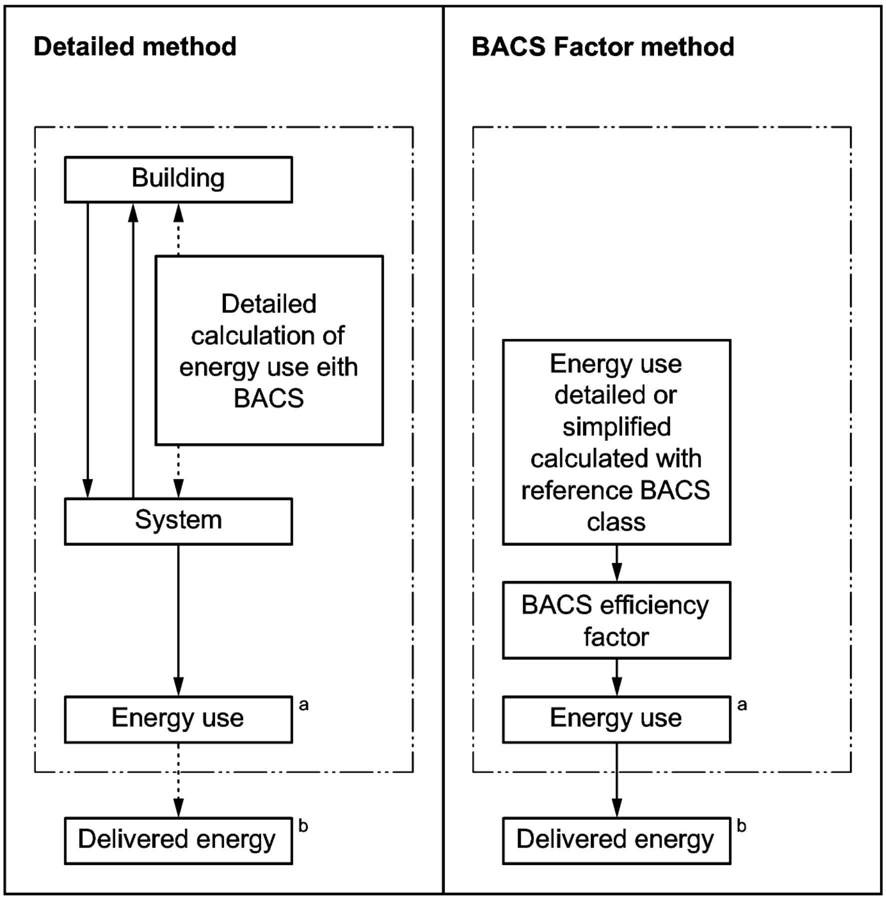
This method is intended for easily calculating the impact of building automation, control and management on the energy performance of a building just based on a given energy performance (either a consumption metered, or a demand calculated) in case there are no data available appropriate to run a detailed energy performance analysis of a building in a holistic EPBD calculation method..

5.4.2 Time steps

Method 2 (factor method) is preferred for a yearly time step.

5.4.3 Calculation information

As to be seen from Figure 1 one of the BAC efficiency classes as described in prEN 15232-1:2015 Table 4 shall be defined as a reference case first. Normally class C which corresponds to a state-of-the-art building automation and control system is set as reference case. For this reference case, the annual energy use of the building energy systems shall be calculated either in a detailed or a more simplified matter using an appropriate calculation method. The BAC factors then allow to easily asses the energy performance of a building operating with a building automation and control system different to that system defined as the reference case. Since the relevant efficiency factors shall be set in relation against each other also building energy performance is in relation to a reference case.



Key

a energy use

b 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 — Calculation sequence of BAC efficiency factor method

6 Method selection

Method 1 (Detailed method) can be used:

— only in case when sufficient and detailed knowledge about automation, control and management functions applied in 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.

— If a calculation method is available to quantify the impact of Building automation and control functions also covering interaction between automation and control functions and building energy systems.

Method 2 (BAC factor method) can be used:

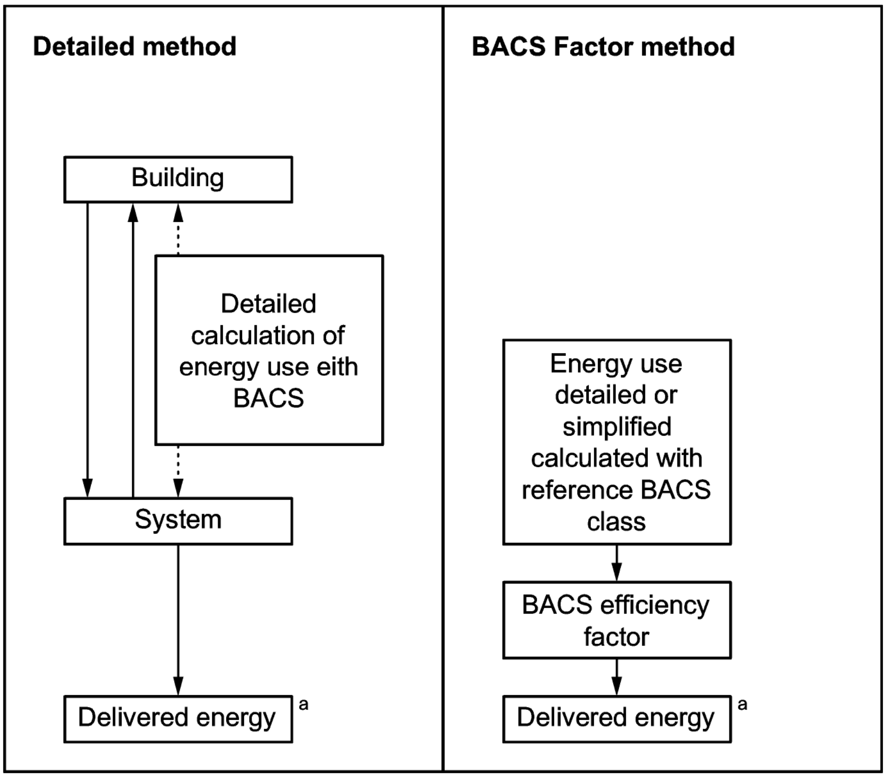
— when a simplified estimation of the impact of building automation and control function is sufficient.

— if annual energy consumption data or any building energy performance data are available that can be used as a reference related to any BAC efficiency class.

The BAC factor method should only be used for rough predictions of the energy saved by a change from one BAC efficiency class to another. But it should not be used for the post estimation of the saved energy based on the energy consumption measured after the change (by dividing the measured energy consumption by the BAC efficiency factor) in cases where this estimate is used in any way for rewarding those who implement the change. It would reward low quality implementation, because low quality implementation would result in a higher amount for the estimated energy saving.

The user of the BAC-factor method should be aware that it is implicitly assumed that those TBM function types that are relevant for the chosen BAC efficiency class are not only installed but actively used, i.e. that actions are taken if monitoring results ask for it.

The following Figure 2 shows different calculation paths of the two methods.



Key

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 2 — Detailed method compared to BAC Factor method

7 Worked out examples

The example will be given for Method 2 only. Method 1 is used with underlying EPBD standards.

Table 7 gives an example on how to use the overall BAC efficiency factors for calculating impact of BAC/TBM on the total energy performance of an office building. The efficiency class C was chosen as reference BAC. The improvement of energy efficiency when changing to BAC efficiency class B will be calculated.

Table 7 — Example of using the overall BACS factors

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

8 Information on the accompanying spreadsheet

The available spreadsheets is

File name	Reference	Description
SPREADSHEET prEN 15232_20140910.xls	Method 1 and 2	BAC functions identifiers

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