TECHNICAL REPORT

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

Part 2: Explanation and justification of ISO 52120-1

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

Partie 2: Explication et justification de l'ISO 52120-1

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Foreword

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

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

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

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

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

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

Introduction

This document consolidates information that is considered important for users to properly understand, apply and nationally adapt the EPB standards.

The detailed technical rules in CEN/TS 16629 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, it is important that each EPB standard is accompanied by an informative technical report, like this document, where all informative contents are collected. Table 1 shows the relative position of this document within the EPB set of standards.

Table 1 — Position of this document within the EPB set of standards

	Over-arching	Building (as such)	Technical building system									
Sub module	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	
7	Aggregation of energy services and energy carriers	Internal heat gains	Storage and control								x	
8	Building partitioning	Solar heat gains	Generation and control								x	
9	Calculated energy performance	Building dynamics (thermal mass)	Load dispatching and operating conditions								x	
10	Measured energy performance	Measured energy performance	Measured energy performance								x	
11	Inspection	Inspection	Inspection									
12	Ways to express indoor comfort		BMS									
13	External environment conditions											
14[a]	Economic calculation											

[a] The shaded modules are not applicable.

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

Part 2: Explanation and justification of ISO 52120-1

1 Scope

This document contains information to support the correct understanding, use and adoption of ISO 52120-1.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 52120-1, *Energy performance of buildings — Contribution of building automation, controls and building management — Part 1: General framework and procedures*

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

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 7345, ISO 52000-1 and ISO 52120-1 apply.

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

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

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

4 Symbols and abbreviated terms

4.1 Symbols

For the purposes of this document, the symbols given in ISO 52000-1 and ISO 52120-1 apply.

4.2 Abbreviated terms

For the purposes of this document, the abbreviations in ISO 52120-1 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 should be maximal, and energy used to obtain this goal, which should 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.

Several categories of controls could be identified.

— 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 one controller exists by module, but sometimes one controller does 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 that do multidiscipline (heating, cooling, ventilation, DHW, lighting) optimization and complex control functions. For example, one of them is INTERLOCK, a control function that avoids heating and cooling at the same time.

— If all technical building systems 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 and are 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, taking 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, in this case 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 setpoint 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 needed 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 EN 15500-1:2017. The compliance with CA is also defined in EN 15500-1. This is an important input for EN 15316-2 and for EN 16798-7, where the effect of the control for heating, cooling and ventilation is taken into account.

The same standard (EN 15500-1:2017) describes also the four operations modes that deal with the levels of temperatures: comfort, pre-comfort, economy and frost/building protection. These four predefined operation modes are parameters that could be set by the users (occupant) (e.g. the temperature allocated 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 parametric or freely 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 ISO 52120-1:2021, Table 5. These functions are organized in the matrix given by the modular structure of EPB standards. ISO 52120-1:2021, Table 5 starts with heating emission, distribution, storage and generation (M3-5, M3-6, M3-7, M3-8) followed 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 that is the software language for BAC and TBM is also defined, as the destination of the module where the control function has its effect. An abstract from ISO 52120-1:2021, Table 5 is given below as an example.

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 should be retrofitted. New buildings should 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.

A building 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 ISO 52120-1:2021, Table B.1 are implemented.

To be in class B: building automation function plus some specific functions defined in ISO 52120-1:2021, Table 5 are implemented in addition to class C. Room controllers are able to communicate with a building automation system.

To be in class A: technical building management function plus some specific functions defined in ISO 52120-1:2021, Table 5 are implemented in addition to class B. Room controllers should 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 is properly balanced.

The functions assignment to the BACS efficiency classes is listed in ISO 52120-1:2021, Table 6.

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 this function is strictly required everywhere in the building: if the designer can give good reasons as to why the application of a function does not bring a benefit in a specific case then 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 ISO 52120-1:2021, Table 7. That table defines the minimum requirements of BACS functions according to BACS efficiency class C of ISO 52120-1:2021, Table 6.

Unless differently specified this list is 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 method 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 of a control function or a group of control functions. Examples of a control strategy implemented by a control function are optimum start, optimum stop, or night set back described in EN 12098-1 and EN 12098-3. The timer function is described in EN 12098-5.

An example of a control strategy that is realized by a group of control functions is the control strategy used by intermittence. This function uses several control functions, operation modes, optimum start-stop and timer at the 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 ISO 52120-1 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 that 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 reached in the emission area, the controller from the emission sends the message to the controller in charge of distribution to stop to distribute energy, then the controller in charge of distribution sends the message to the controller in charge of storage to either store the energy or if the storage cannot store more energy, then to send the message to the controller in charge of the generation to stop generating more energy.

Another important control strategy is the control strategy for multi generators either from the 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: for example depending on the generator's 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, for example 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 ISO 52120-1:2021, 6.4.2.

5.2 Description of BAC functions

5.2.1 General

The numbers in italics refer to the numbers in ISO 52120-1:2021, Table 5.

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 EN 12098-1 or EN 12098-3.

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 occupancy detection

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 is 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, for example the average of the previous 24 h.

Target: the supply water temperature is 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 References [7] and [8].

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 References [7] and [9].

— 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 References [7] and [9].

— 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.

Water based systems in buildings usually supply thermal energy to more than one room or one zone (e.g. distribution network, risers) according to planned use patterns. Class B (or higher) room or zone controls send energy demand to the associated distribution network and require them to run while the demand is present.

Assuming that several rooms or zones are connected to the same network and the room or zone use change overtime, i.e. multiple use, this will result in inefficient operation of the distribution network because the distribution network (e.g. pumps) are eventually running for a very long active time (e.g. tending to 14 h/day to 16 h/day).

Recommendations: consider the space usage profile while modifying distribution networks. This is done in the planning stage prior to relocating people or business activities.

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 on it runs with no control at maximum speed.

Target: to improve EP by avoiding auxiliary energy consumption of pumps while no energy needs 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 a 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 the different states of the system. This may be done with variable Δp following an external demand signal, e.g. hydraulic requirements, ΔT, energy optimization or a 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 carried out 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 and 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 carried out 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 carried out 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 outside temperature

Description: generator temperature setpoint is variable depending on outside temperature.

Target: to improve EP by minimizing the generator operation temperatures using outside 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: maximum allowed temperature setpoint.

1.7.1 Variable temperature depending on outside temperature

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

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

1.7.2 Variable temperature depending on the load

Description: heat pump temperature setpoint is variable depending on the demand which is 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 Control according to fixed priority list

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 Control according to dynamic priority list

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 Control according to prediction based dynamic priority list

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 sensor 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 to 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 enable

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 enable and multi-sensor storage management

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 scheduled charging enable

Description: control of the DHW storage temperature by 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 enable, demand based, supply temperature control, or multi-sensor storage management

Description: control of the DHW storage temperature by avoiding early recharging using time-based charging blocking and multi sensing detection of the 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 from solar sources 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 from solar sources 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 maximum 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 No control, continuous operation

Description: continuous operation of circulation pump.

2.4.1 Control of DHW circulation pump, with time 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 occupancy detection

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 is 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 is 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 chilled water temperature (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 a 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 needs 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 the different states of the system. This may be done with variable Δp following an external demand signal, e.g. hydraulic requirements, ΔT, energy optimization or a 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 carried out 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 carried out 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 carried out 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 set up 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 waisted through simultaneous heating and cooling. Typically, this is done by either hydraulic mechanical construction or by total switchover on supply level.

3.7 Cooling –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 outside temperature

Description: the control temperature is calculated with the goal to operate the generator with minimized operating temperature setpoints depending on outside 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 the demand which is 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 chillers (generators or chilled water)

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 generator's 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 generators 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 Load prediction-based sequencing

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 running at a 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 energy losses of the TES that 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 Supply 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 4.6 and 4.7. Air handling (heating, cooling, humidification, and dehumidification) and circulating air is an energy consuming process, as a consequence 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, e.g. 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 based 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 required (=no presence) and adapting ventilation needs to the demand.

4.1.3 Demand based detection

The system runs dependent on the air quality demand (measurement of CO2, VOC, etc.).

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 switched 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 used to coordinate the interaction of the different technical systems dedicated to maintaining 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 the 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 or 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 or OA flow

Description: flow depends on a given time schedule.

4.4.2 Staged (low/high) OA ratio or 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 are 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 air flow for a maximum load of all rooms.

4.5.1 On/off time control

Description: the air handler or motorized windows are controlled via on/off mechanism while the 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" (step 1). 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 without pressure reset

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 carried out.

Target: EP is achieved by maintaining a constant, or desired, pressure 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 with pressure reset

Description: same function as 4.5.3 but with pressure reset.

4.6 Heat recovery control: icing protection

4.6.0 Without icing protection 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).

There is 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 icing protection 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. There are different solutions, for example 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: there is 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 that no 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 carried out 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 at the AHU level

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 is 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 outside temperature compensation

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 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 increase 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: 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 dimmed status (of no more than 20 % of the normal 'on' state) no later than 15 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 areas not being used (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 15 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 automatically switched to a state with dimmed status (of no more than 20 % of the normal 'on state') no later than 15 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.

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, e.g. when daylight is available or when scene based light level control is applied. The luminaires will be switched on again and dimmed up if the amount of daylight is decreasing or when scene based light level control is applied. During time intervals dynamic adapted lighting scenes are set in terms of illuminance level, different correlated colour temperature (CCT) and the possibility to change the light distribution within the space according to e. g. design, human needs, visual tasks.

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

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

6.1 Motorized operation 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 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

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 and that this information can be applied in a holistic EPBD calculation method. The detailed method is used only when 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 ISO 52120-1:2021, Table B.1. As an alternative BAC efficiency class C could be used as a default.

5.3.5 Simplified input

The document 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)

At least the types of room temperature control described in ISO 52120-1:2021, Table 5, (1.1 and 3.1) are differentiated. The impact of the control system type is taken into account by considering an equivalent internal temperature set point.

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

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;

— ISO 52016-1.

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

Values of the control accuracy are given in EN 15500-1:2017, Table 9 “Temperature control accuracy compliance”.

Emission control for TABS (HEAT_EMIS_CTRL_TABS) (CLG_EMIS_CTRL_TABS)

At least the types of room temperature control described in ISO 52120-1:2021, Table 5 (1.2 and 3.2) are differentiated.

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)

At least the types of supply temperature control described in ISO 52120-1:2021, Table 5 (1.3 and 3.3) are differentiated.

Two effects are 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 are 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 lead generally to a decrease of the flow rate. This enables to reduce the auxiliary energy consumption. This is 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)

At least the types of pump control described in ISO 52120-1:2021, Table 5 (1.4 and 3.4) are differentiated:

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)

At least the following types of intermittent control of emission and/or distribution are differentiated:

0) no automatic control;

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

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

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 ISO 52016-1. 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 document does not differentiate the different types of controls.

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

In ISO 52016-1:2017, 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 ISO 52120-1:2021, Table 5 (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 should 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 a 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).

An 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 ISO 52120-1:2021, Table 5 (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 and 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 EN 15316-4-1:2017, 5.3.9 and Annex H.

— Heat pump systems: the impact of the control system is calculated according to EN 15316-4-2. This standard includes two 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. At minimum the following control types of the distribution are differentiated:

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 θ_{ltc}: below this temperature the heat pump is switched off and the backup operates alone;

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

The following modes are taken into account:

i) alternate mode: the cut off temperature and the balance point are equal. At this temperature the heat pump is stopped, and the backup operates alone;

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

iii) partly parallel mode: Above the balance temperature the heat pump operates alone. Between balance and cut off temperature, back up is started and the heat pump operates in parallel with the heat pump at its full power. Below the cut off temperature the backup 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 is 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 is 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 ISO 52120-1:2021, Table 5 (1.8 and 3.8). This is calculated according to EN 16947-1.

5.3.6.2 Domestic hot water control

Their full functions are explained in ISO 52120-1:2021, Table 5 (2.1 – 2.5).

Any determined DHW storage temperature function of ISO 52120-1:2021, Table 5, 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 EN 16798–5-1 or EN 16798–5-2 and EN 16798-7. Tables 3 to 5 show the BAC-functions and BAC-Function types covered by these standards and their relation to ISO 52120-1:2021, Table 5.

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

	Identifier	Description	Module[a] approach[b]	Restriction to specific system (Input data – process design)	Remarks	Comparison with ISO 52120-1:2021, Table 5
EN 16798-5-1 (Rev 15241 method 1) Calcul. interval: hourly, bin					Source: EN 16798–5-2:2015 (FV version)	
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_AHU-FLOW_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 EN 16798-7	4.9 Supply air temperature control at the AHU level VENT_AHUSAT_CTRL
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		

[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 ISO 52000-1:2017, 11.4).

Table 3 *(continued)*

	Identifier	Description	Module[a] approach[b]	Restriction to specific system (Input data – process design)	Remarks	Comparison with ISO 52120-1:2021, Table 5
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
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**			

[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 ISO 52000-1:2017, 11.4).

Table 3 *(continued)*

	Identifier	Description	Module[a] approach[b]	Restriction to specific system (Input data – process design)	Remarks	Comparison with ISO 52120-1:2021, Table 5
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_AHU-FLOW_CTRL – Variant ‘pressure control’ 0 No automatic control
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_AHU-FLOW_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_AHU-FLOW_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_AHU-FLOW_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
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 ISO 52000-1:2017, 11.4).

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

	Identifier	Description	Module[a] approach[b]	Restriction to specific system (Input data – process design)	Remarks	Comparison with ISO 52120-1:2021, Table 5
EN 16798–5-2 (Rev 15241 method 2) Calcul. interval: yearly, bin					Source: EN 16798–5-2:2015 (FV version)	
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
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_AHU-SAT_CTRL

[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 ISO 52000-1:2017, 11.4).

Table 4 *(continued)*

	Identifier	Description	Module[a] approach[b]	Restriction to specific system (Input data – process design)	Remarks	Comparison with ISO 52120-1:2021, Table 5
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
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

[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 ISO 52000-1:2017, 11.4).

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

	Identifier	Description	Module[a] approach[b]	Restriction to specific system (Input data – process design)	Remarks	Comparison with in ISO 52120-1:2021, Table 5
EN 16798–7 **Emission** Calcul. interval: hourly, monthly					Source: EN 16798–7	
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'
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 EN 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**			

[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 ISO 52000-1:2017, 11.4).