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Building Management System

Part 2: Accompanying prEN 16947-1:2015 — Modules M10-12

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National foreword

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European foreword

This document (CEN/TR 16947-2:2016) has been prepared by Technical Committee CEN/TC 247 "Building Automation, Controls and Building Management", the secretariat of which is held by SNV.

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

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This document is currently divided into the following parts:

— prEN 16947-12015, *Building Management System — Module M10-12* [currently at Enquiry stage];

— CEN/TR 16947-2:2016, *Building Management System —Part 2: Accompanying* prEN 16947-1:2015 *Modules M10-12.*

Introduction

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

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

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

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

— to reduce the page count of the actual standard;

— to facilitate understanding of the package.

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

Table 1 shows the relative position of tis standard within the EPB set of standards.

Table 1 — Position of this standard within the EPD set of standards

	Over-arching	**Building (as such)**	**Technical Building System**									
Submodule	**Descriptions**	**Descriptions**	**Descriptions**	**Heating**	**Cooling**	**Ventilation**	**Humidification**	**Dehumidification**	**Domestic Hot waters**	**Lighting**	**Building automation and control**	**PV, wind, ..**
sub1	**M1**	**M2**		**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**	**M11**
1	General	General	General									
2	Common terms and definitions; symbols, units and subscripts	Building Energy Needs	Needs									
3	Application	(Free) Indoor Conditions without Systems	Maximum Load and Power									
4	Ways to Express Energy Performance	Ways to Express Energy Performance	Ways to Express Energy Performance									
5	Building Functions and Building Boundaries	Heat Transfer by Transmission	Emission and control									

	Over-arching	**Building (as such)**	**Technical Building System**									
Submodule	**Descriptions**	**Descriptions**	**Descriptions**	**Heating**	**Cooling**	**Ventilation**	**Humidification**	**Dehumidification**	**Domestic Hot waters**	**Lighting**	**Building automation and control**	**PV, wind, ..**
sub1	**M1**	**M2**		**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**	**M11**
6	Building Occupancy and Operating Conditions	Heat Transfer by Infiltration and Ventilation	Distribution and control									
7	Aggregation of Energy Services and Energy Carriers	Internal Heat Gains	Storage and control									
8	Building Partitioning	Solar Heat Gains	Generation and control									
9	Calculated Energy Performance	Building Dynamics (thermal mass)	Load dispatching and operating conditions									
10	Measured Energy Performance	Measured Energy Performance	Measured Energy Performance									
11	Inspection	Inspection	Inspection									
12	Ways to Express Indoor Comfort		BMS								x	
13	External Environment Conditions											
14	Economic Calculation											

1 Scope

This Technical Report refers to prEN 16947-1:2015, *Building Management System — Module M10-12*.

It contains information to support the correct understanding, use and national adaption of prEN 16947-1:2015.

This Technical Report does not contain any normative provision.

2 Normative references

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

FprEN 15232-1:2016, *Energy performance of buildings — Part 1: Impact of Building Automation, Controls and Building Management — Modules M10-4,5,6,7,8,9,10*

prEN 15316-2:2015, *Heating systems and water based cooling systems in buildings — Method for calculation of system energy requirements and system efficiencies — Part 2: Space emission systems (heating and cooling)*

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

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

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

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

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

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 7345:1995, prEN ISO 52000-1:2015 and prEN 16947-1:2015 (the accompanied EPB standard) apply.

4 Symbols and abbreviations

For the purposes of this document, the symbols given in prEN ISO 52000-1:2015 and prEN 16947-1:2015 (the accompanied EPB standard) apply.

5 Method description

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

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

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

We could identify several categories of controls:

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

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

— If all Technical Building System are used in the building, we have (depending of the size of the building) a Technical Building Management System. Specific global functions are implemented here, necessary to reach the key-role mentioned above. Usually, in this case, an interrelation with the building as such (Module M2) will occur, mainly to take in consideration the building needs; for example due to outside temperature, taken into account the inertia of the building when the control will reach the set point in a room.

In a control system dedicated to a building, who is BAC and TBM we can distinguish three main characteristics:

— Control Accuracy,

— Control Function,

— Control Strategy.

Technical Building management systems are implemented to realize an overall building operation strategy by interdisciplinary orchestration of building energy systems (heating, cooling, ventilation, lighting) whereas systems are controlled by BAC functions. Further information about control accuracy and control functions can be found in the technical report CEN/TR 15232-2. EN 15232 describes two approaches how to evaluate the contribution of building automation and control on the energy performance of buildings. This Technical report is dedicated to control strategy and Technical building management issues covered by EN 16947-1.

5.2 Control Strategy

The Control Strategy is applied to achieve a given level of control to reach a goal. Optimal control strategies deliver a desired level of control at a minimum cost. A Control Strategy could consist by a Control Function or a group of Control Functions. An example of a Control Strategy consist by a Control Function is Optimum Start, Optimum Stop, Night Set Back described in the standards EN 12098-1 and EN 12098-3. The Timer function is described in EN 12098-5.

An example of a Control Strategy who 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 in same time. All elements together are called either Building Profile or User Pattern. Usually, to implement such Building profile, a TBM is a prerequisite.

The most important Control Strategy described and implemented in EN 15232-1 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 who communicates in system architecture via a communication standardized bus such as BACnet, KNX or LON.

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

Another important Control Strategy is the control strategy for multi generators either from same type (e.g. several boilers) or different types (e.g. a boiler and heat pomp) including also the Renewable Energy Sources. This strategy is described in more detail in the Sequencing of multiple generators (BMS function 3) chapter later on.

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

5.3 Rationale

This method is meant for a detailed energy performance analysis of a building in case detailed information about the building, the HVAC system and especially the type of automation, control and management functions is available that can be applied in a holistic EPB calculation method. The method should be used only when a sufficient knowledge about automation, control and management functions used for the building and the energy systems is available. The application of the calculation procedures 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.

5.4 Time steps

5.4.1 General

The Method is compatible to any time step:

— yearly;

— monthly;

— hourly;

or the statistical BIN method can be applied.

Beside Bin method this is according to the time-step of the input. Normally it is designed for a monthly or hourly method.

5.4.2 Assumption

It is assumed that a calculation method is available that can be used to quantify the impact of Technical building management and building automation and control on the energy performance of a building. The EPBD holistic approach is an appropriate calculation method.

5.4.3 Data input — Item 1

Beside all technical input data providing information about the design and construction of both the building fabric as well as the HVAC systems further important information is required to evaluate the energy performance of a building, e.g. by applying an holistic calculation approach:

— How to use the building: e.g. occupancy pattern defining comfort requirements and internal gains. This information is provided by Module 2 and is used to calculate energy demands resp. needs of the building.

— How to operate the building energy systems to meet the comfort requirements. Setpoints and runtimes of all the technical systems have to be managed – either manually or automatically – to ensure maximum energy performance. Automated operation does require communication between the BAC and the TBM system.

Finally the way the building is operated will have a significant impact on building energy performance. The application of TBM in the calculation method is strongly based on selecting certain TBM functions to be taken into account when calculating building energy performance.

Data input = selection of BAC/TBM function level

BMS/TBM functions and their levels are described in FprEN 15232-1:2016, Table 4. Functions and levels are categorized into classes A, B, C and D. Default values for BMS functions are referring to the minimum requirements defined in Annex A of FprEN 15232-1:2016. As an alternative BAC efficiency class C related to BMS functions could be used as a default.

According to the BMS/TBM function level that has been initially selected numerical values as temperature setpoint-off-sets or runtime are defined that will be integrated in the calculation method.

5.4.4 Simplified input

The EN 15232 standard gives the opportunity to classify a building or different HVAC disciplines following a standardized classification scheme instead of defining specific BAC and TBM functions.

5.4.5 Calculation information

In a large number of buildings the BAC/TBM system supervises a certain part of the entire building only. Accordingly the contribution of TBM is restricted to the energy consumption related to this area only. The floor area infected by TBM can be estimated as follows: Use the supervised area to make an estimate of how much of the building is actually supervised/fault detected/reported on. In a building e.g. with limited communication to the BACS from the control devices in rooms, or sub-systems that are not connected to the BACS, the supervised area should be considerably lower than the total room area.

5.5 List of functions covered by the Method

Calculation methods to cover TBM functions described in EN 16947-1 are related to building operational data and information that could be influenced and optimized by a Building management or Technical Building System. Those data are exemplarily used to characterize:

— set points including set back,

— run times of heating, ventilation, cooling and lighting systems including start-stop-optimization,

— sequencing of multiple generators,

— energy management with regard to the utilization of local renewable energy and local energy production,

— heat recovery and heat shifting,

— smart grid interactions and peak shaving.

Calculation is in general independent from the time step chosen but is according to the time-step of the input.

From the above list the following BMS functions have been derived and described in EN 16947-1.

5.5.1 Setpoint Management (BMS function 1)

This BMS function can be used to calculate the impact of the room temperature setpoint management for heating and/or cooling on the building energy performance. The setpoint management by BMS function 1 is taken into account by introducing a temperature shift to any temperature setpoint reflecting the building use. Temperature setpoints for space heating and cooling are modified as follows:

$$\vartheta_{set} = \vartheta_{set,0} + \Delta\vartheta_{BMS} \quad (1)$$

Where

$\vartheta_{set,0}$ is the original Temperature setpoint predefined based on building user profile. This temperature is a user requirement. Normally buildings will either never be operated at this temperature from the beginning or there is a shift of room temperature setpoints over the time. This shift is caused by user interaction that is not set back but will lead to long term deviation of observed energy performance from the design value.

$\Delta\vartheta_{BMS}$ is a temperature shift of room temperature setpoints over the time accounting for user interaction that is not set back but will lead to long term deviation of observed energy performance from the design value. Building management systems are able to compensate setpoint shifting by setting back setpoints manually or automatically

ϑ_{set} is the effective room temperature setpoint to be used to calculate heating/cooling demands.

This approach of adjusting the setpoint differs from the setpoint approach as describe in EN 15232 in a way that the setpoint approach calculates as virtual setpoint accounting for control accuracy and deviation effects where the BMS function 1 (setpoint management) is focussing on real setpoint adaptation. This adaptation can be done based on the information provided by TBM functions

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

— Reporting information regarding energy consumption, indoor conditions

as listed in Table 4 of FprEN 15232 – 1:2016.

5.5.2 Runtime Management (BMS function 2)

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

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

— an optimum start-stop function

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

The adjustment of runtimes can be done based on the information provided by TBM functions

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

— Reporting information regarding energy consumption, indoor conditions

as listed in Table 4 of FprEN 15232 – 1:2016.

Any decision on runtime of building energy systems requires information about occupancy patterns or other relevant user request regarding the conditioning of the building. These patterns have to be defined in a scheduler. Beside this information about occupancy an information (input or parameter) is needed how to adjust operation of building energy systems to these patterns.

Run time (or operational time) of the HVAC systems is according to the modified setpoint profiles as calculated by BMS function 1. Normally runtime covers the occupied period of the building taking into account some additional preconditioning and start-stop periods.

BMS will allow optimizing the matching between building energy demand and system operation time by minimizing the time duration of preconditioning phase during unoccupied periods. Therefore runtime of the HVAC systems is adjusted.

5.5.3 Sequencing of multiple generators (BMS function 3)

This function provided information how to split the total energy demand for heating and cooling to different heat generators or chillers. Each generator has to supply the energy that is addressed to it.The management strategy could be realized by defining priorities. These priorities may be:

— Priorities only based on running time

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

— Priorities based on generator efficiency and characteristics: The generator operational control is set individually to available generators so that they operate with an overall high degree of efficiency (e.g. solar, geothermic heat, cogeneration plant, fossil fuels)

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

It is part of the building management function 3 to decide on the priority list. This again can be done either manually or in an automated way accounting for variable input data and operating conditions.

Heating systems

If there are several generation sub-systems, the total heat demand of the distribution sub-system(s) shall be distributed among the available generation sub-systems. In general, sub-systems with multiple generators can be calculated as separated generation sub-systems in parallel. The calculation described in the relevant parts of EN 15316-4 shall be performed independently for each heat generation device. FprEN 15232-1:2016 describes a correlated BAC function:

1.9	Sequencing of different heat generators	HEAT_GEN_CTRL_SEQ	M3–8
		This control function only applies to a system with a set of different heat generator sizes or types including Renewable Energy Sources	
	0	Priorities only based on running time	
	1	Control according to fixed priority list: e.g. heat pump prior to hot water boiler	
	2	Control according to dynamic priority list (based on current efficiency and capacity of generators e.g. solar, geothermal heat, cogeneration plant, fossil fuels)	
	3	Control according to dynamic priority list (based on predicted and current load, efficiency and capacity of generators	

Cooling systems

If there are several generation sub-systems, the total cooling demand of the distribution sub-system(s) shall be distributed among the available chiller sub-systems. In general, sub-systems with multiple chillers can be calculated as separated generation sub-systems in parallel. FprEN 15232-1:2016 describes a correlated BAC function:

3.8	Sequencing of different chillers (chilled water generators)	CLG_GEN_CTRL_SEQ	M4–8
		This control function only applies to a system with a set of different chiller sizes or chilled water generator types including Free Cooling and/or Renewable Energy Sources	
	0	Priorities only based on running time	
	1	Fixed Sequencing based on loads only: e.g. depending on the generators characteristics, e.g. absorption chiller vs. centrifugal chiller	
	2	Priorities based on generator efficiency and characteristics: The generator operational control is set individually to available generators so that they operate with an overall high degree of efficiency (e.g. outside air, river water, geothermic heat, refrigeration machines)	

3.8	Sequencing of different chillers (chilled water generators)	CLG_GEN_CTRL_SEQ	M4–8
	3	Load prediction based sequencing: The sequence is based on e.g. COP and available power of a device and the predicted required power.	

5.5.4 Local energy production and renewable energies (BMS function 4)

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

Two Output data are provided:

— Load signal either as binary (on/off) or any instantaneous signal varying between min and max load used to orchestrate renewable energy production and any CHP.

— Battery management signal that manages charging and discharging of batteries taken into account both load and energy production predictions.

Different type of input data are needed:

— data about availability of renewable energy sources (e.g. solar, wind provided by weather files)

— information about energy demand (provided by other standardized calculation procedures related to M3-M10).

— data about performance of local energy production devices (provided by M11)

Energy calculation of CHP systems is done in EN 15316-4-4. Calculation of energy production and battery state of charge is done in M11. The devices are managed according to the signals provided by this BMS function.

5.5.5 Heat recovery and heat shifting (BMS function 5)

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

— Heat recovery:

  Benefit is taken of waste heat by recovering heat for preconditioning cold air flows or any other fluid to be heated. Installing heat exchangers or other intermediate run-around loops can realize heat recovery. Depending on temperatures also heat pumps or back-up heaters could be part of the heat recovery loop.

— Heat shifting

  Benefit is taken of parallel heating and cooling in either separated parts of the building or different HVAC systems. Heat shifting can be used to shift heat from the south façade of the building to the north facade to equalize heat and cooling demands due to disparate solar heat gains. Consequently heat shifting is suitable to reduce both heating and cooling demand. By using potable water as a heat sink, space cooling and DHW preheating are linked together. Heat shifting requires a building management system for coordination and optimization.

Input data for this method include information about the energy demand (heating and cooling) of rooms and/or zones. This information is provided by other standardized calculation procedures described in Module 2.

5.5.6 Smart grid interactions and peak shaving (BMS function 6)

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

6 Method selection

There is only one method covering several functions. Selection of functions is done according to the list of functions provided in prEN 16947-1:2015.

7 Information on the accompanying spreadsheet

The available spreadsheet is:

File name	Reference	Description
SPREADSHEET prEN 15233_20141005,xls	Method	BMS functions

Bibliography

[1] CEN/TS 16629, *Energy Performance of Buildings - Detailed Technical Rules for the set of EPB-standards*

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