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Energy performance of buildings — Building management system —

Part 1:
Module M10-12

Performance énergétique des bâtiments — Système de gestion technique des bâtiments —

Partie 1: Module M10-12

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Foreword

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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 52127 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 is part of a series of standards aiming at international harmonization of the methodology for the assessment of the energy performance of buildings called "EPB set of standards".

As part of the "EPB set of standards", it complies with the requirements for the set of basic EPB documents ISO 52000-1 (see Normative references), CEN/TS 16628 and CEN/TS 16629 (see References [4] and [5]) developed under a mandate given to CEN by the European Commission and the European Free Trade Association (Mandate M/480), and supports essential requirements of EU Directive 2010/31/EU on the energy performance of buildings (EPBD).

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

To avoid a duplication of calculation due to the BAC (avoid double impact), no calculations are done in BAC EPB standard set, but in each underlying standard of EPB set of standards (from M1 to M9 in the modular structure), an identifier, developed and presented in the M10 covered by ISO 52120-1, is used where appropriate. The way of interaction is described in detail in ISO/TR 52000-2 accompanying the over-arching standard. As a consequence, the Annex A and Annex B concept as Excel sheets with the calculation formulas used in the EPB standards are not applicable for this document.

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

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

More information is provided in ISO/TR 52127-2[3], the Technical Report accompanying this document.

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

NOTE 1 In ISO/TR 52000-2 the same table can be found, with, for each module, the numbers of the relevant EPB standards and accompanying Technical Reports that are published or in preparation.

NOTE 2 The modules represent EPB standards, although one EPB standard can cover more than one module and one module can be covered by more than one EPB standard, for instance a simplified and a detailed method respectively.

Table 1 — Position of this document (in casu M10–12), within the modular structure of the set of EPB 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									
5	Building functions and building boundaries	Heat transfer by transmission	Emission and control									▨
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									

NOTE The shaded modules are not applicable.

Table 1 *(continued)*

	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**
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[a]	Economic calculation											

NOTE The shaded modules are not applicable.

Energy performance of buildings — Building management system —

Part 1:
Module M10-12

1 Scope

This document specifies operational activities, overall alarming, fault detection and diagnostics, reporting, monitoring, energy management functions, functional interlocks and optimizations to set and maintain energy performance of buildings.

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

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

ISO 52120-1:—[1], *Energy performance of buildings — Contribution of building automation and controls and building management — Part 1: Modules M10-4,5,6,7,8,9,10*

3 Terms and definitions

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

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

- ISO Online browsing platform: available at https://www.iso.org/obp
- IEC Electropedia: available at http://www.electropedia.org/

3.1
building management system
BMS
products, software, and engineering services for automatic controls (including interlocks), monitoring and optimization, human intervention, and management to achieve energy-efficient, economical, and safe operation of building services equipment

Note 1 to entry: Building services is divided in technical, infrastructural and financial building services and energy management is part of *technical building management* (3.2).

Note 2 to entry: Building energy management system is part of a BMS.

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[1] Under preparation. Stage at the time of publication ISO/DIS 52120-1:2021.

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

3.2

technical building management

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

Note 1 to entry: The disciplines and trades comprise all technical building services for the purpose of optimized maintenance and energy consumption.

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

4 Symbols and subscripts

4.1 Symbols

For the purposes of this document, the symbols given in ISO 52000-1:2017, Clause 4, Annex C and the specific symbols listed in Table 2 apply.

Table 2 — Symbols and units

Symbol	Quantity	Unit
β	Load factor	-

4.2 Subscripts

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

Table 3 — Subscripts

Subscript	Term
BMS	building management system
boil	boiler
cgn	cogeneration
cmb	combustion

5 Description of the methods

5.1 Output of the method

This method covers the calculation of the building operation data that could be influenced and optimized by a building management system. Those data are mainly related to:

- setpoint including set back,
- operation times of heating, ventilation, cooling and lighting systems including start-stop optimisation,
- sequencing of multiple generators,

- building energy management and load management with regard to the utilisation of local renewable energy and local energy production,
- heat recovery and heat shifting,
- smart grid interactions, demand side management, and peak shaving.

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

It is important to be aware that the technical building management (TBM) functions not fully automated will have an impact on energy performance of the building only if they are not only installed but actively used, i.e. that actions are taken if monitoring results ask for it.

5.2 General description of the method(s)

This document covers several functions of the application of the building management system. These functions shall be taken from ISO 52120-1. Each function is represented by at least one calculation method.

This document covers six of the functions described in ISO 52120-1:—[2], Table 4. This list of capabilities of controls and BMS functions is not exhaustive. Energy efficiency performance of building depends on the choice of control and BMS functions related to expected performance (following methodology described in ISO 52000-1), their implementation, commissioning and exploitation. The functions are as follows.

- “Function 1 – setpoints”, is meant for setpoint definition and set back. This function refers to function 7.1 in ISO 52120-1:—, Table 4.
- “Function 2 – run-time” is intended for estimating run-times. This function refers to function 7.2 in ISO 52120-1:—, Table 4.
- “Function 3 – sequencing of generators” is intended for estimating the sequential arrangement of different generators. This function refers to function 1.9 in ISO 52120-1:—, Table 4.
- “Function 4 – local energy production and renewable energies” is intended for managing local renewable energy sources and other local energy productions as CHP. This function refers to function 7.5 in ISO 52120-1:—, Table 4.
- “Function 5 – heat recovery and heat shifting” is intended for shifting thermal energy inside the building. This function refers to function 7.6 in ISO 52120-1:—, Table 4.
- “Function 6 – smart grid” is meant for interactions between buildings and any smart grid. This function refers to function 7.7 in ISO 52120-1:—, Table 4.

All methods applicable to calculate the aforementioned functions are described in detail in Clauses 6 to 11. In general, functions could be used independently from each other depending on the BMS features installed in the building. Nevertheless, in some cases, methods do represent different levels of a similar function and will reference each other. More details are given in the relevant clauses.

A short description of BMS main functions is given in Annex A.

5.3 Calculation time steps

The calculation algorithms for all the functions described in Clause 6 are suitable for the following calculation time steps:

- yearly (seasonal);
- monthly;

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[2] Under preparation. Stage at the time of publication ISO/DIS 52120-1:2021.

— hourly;

or the statistical bin method can be applied.

Beside the bin method, the output time step is in general the same as the input time step. If the input data are available with a shorter time step than the output, a detailed description is provided on how to handle this mismatch.

This method can be used within a dynamic calculation scheme.

6 BMS function 1 (management of setpoints)

6.1 Output data

This BMS function is applied to manage the room temperature setpoints for heating and/or cooling. The output data of this function are listed in Table 4.

Table 4 — Output data of BMS function 1

Description	Symbol	Catalogue unit	Computed Unit	Validity interval	Intended destination module	Varying
Room temperature setpoint heating	$\vartheta_{\text{set,H}}$	°C	°C	10...30	M2–2	Yes
Room temperature setpoint cooling	$\vartheta_{\text{set,C}}$	°C	°C	10...30	M2–2	Yes
Room temperature setpoint shift	$\Delta\vartheta_{\text{BMS}}$	K	K	−1 ... +1	M3–5 M4–5 M5–5	

Setpoints are calculated according to the operation mode of the room or conditioned zone, respectively taking into account the type of the building.

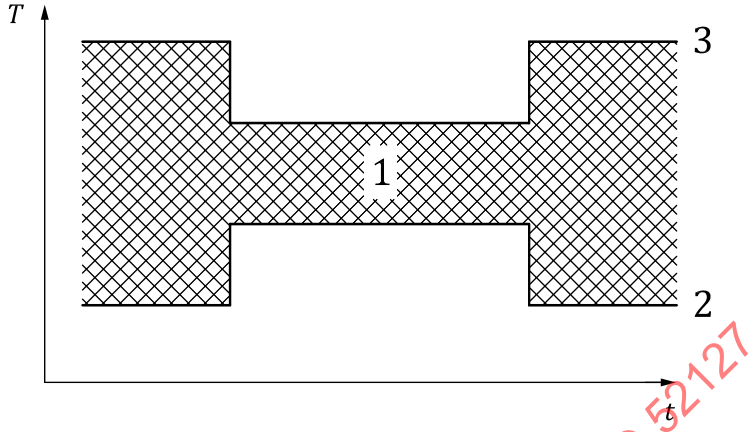
6.2 Input data – source of data

Input data are taken either as a feedback from the calculation process (dynamic input), or the scheduler (variable input).

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

There are different room temperature setpoints for heating and cooling depending on the operation modes. Figure 1 shows a typical setpoint temperature profile switching between comfort mode and economy mode. Frost protection mode does require feedback information (input) about either ambient air temperature or room temperature. In case the temperature falls below a given minimum value, frost protection mode is chosen by the BMS.

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



Key

T	temperature
t	time of the day
1	comfort band width
2	heating
3	cooling

Figure 1 — Typical set point temperature profile

6.3 Calculation procedure

6.3.1 Operating conditions calculation

Room temperature setpoint is the desirable space temperature used to calculate the energy need for heating and/or cooling in a thermally conditioned zone.

Switching between operation modes is normally done according to a given request to be defined by either the occupant or the intended use of the building. Setpoint temperatures will be used to calculate building energy demand.

Room temperature control functions are described in ISO 52120-1. These functions will allow heating, ventilation or cooling systems to maintain the room temperature according to predefined setpoints. The heat emitted (heating mode) or taken from the room (cooling mode) is calculated in EN 15316-2. Setpoint calculation there also accounts for the BMS system that will shift setpoint to maintain building energy performance by introducing $\Delta\vartheta_{\mathrm{BMS}}$. Figure 2 is illustrating this effect.

The setpoint management by BMS function 1 is taken into account by introducing a temperature shift to any temperature setpoint reflecting the building use in ISO 52016-1. Temperature setpoints for space heating and cooling are modified as follows in Formula (1):

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

where the differences to be shifted are fixed as described in the following Table 5.

Table 5 — Temperature shift BMS function 1

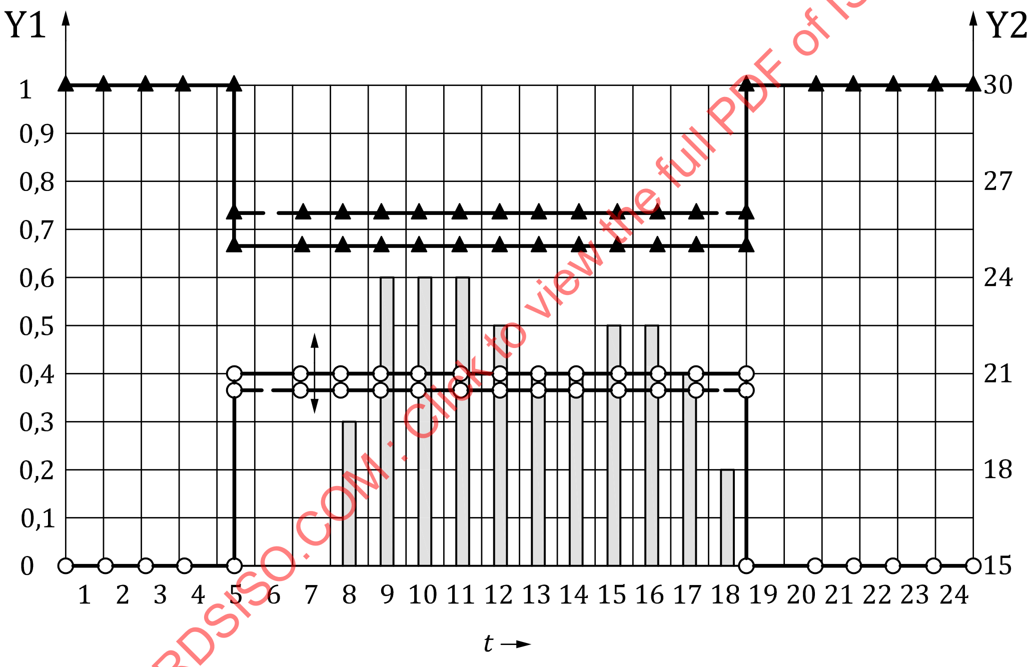
	Without BMS function 1	With BMS function 1
Setpoint for heating	$\Delta\vartheta_{BMS} = +1$ K	$\Delta\vartheta_{BMS} = 0$ K
Setpoint for cooling	$\Delta\vartheta_{BMS} = -1$ K	$\Delta\vartheta_{BMS} = 0$ K

This approach of adjusting the setpoint is different from the setpoint approach described in ISO 52120-1 in that the setpoint approach calculates a virtual setpoint accounting for control accuracy and deviation effects, where the BMS function 1 (setpoint management) is focussing on real setpoint adaptation. This adaption can be done based on the information provided by TBM functions:

- 7.3: detecting faults of technical building systems and providing support to the diagnosis of these faults;
- 7.4: reporting information regarding energy consumption, indoor conditions,

as listed in ISO 52120-1:—, Table 4.

Runtime management of the building energy systems to fit these setpoint temperature profiles is described in Clause 7.



Key

▨ occupancy rate

—○— heating

—▲— cooling

Y1 occupancy rate

Y2 setpoint temperature in °C

t time of the day (h)

Figure 2 — Adaption of setpoint shifting

6.3.2 Energy calculation

Energy calculation is done by ISO 52016-1, where the energy needs for heating and cooling and heating cooling loads in a building or building zone are calculated.

7 BMS function 2 (runtime management)

7.1 Output data

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

This adaptation can be done based on the information provided by TBM functions:

- 7.3: detecting faults of technical building systems and providing support to the diagnosis of these faults;
- 7.4: reporting information regarding energy consumption, indoor conditions;

as listed in EN 15232-1:2017, Table 4.

The output data of this function are listed in Table 6.

Table 6 — Output data of BMS function 2

Description	Symbol	Catalogue unit	Computed unit	Validity interval	Intended destination module	Varying
Building energy system availability		-	-	On/off	M2–2 M3 to M11	Yes

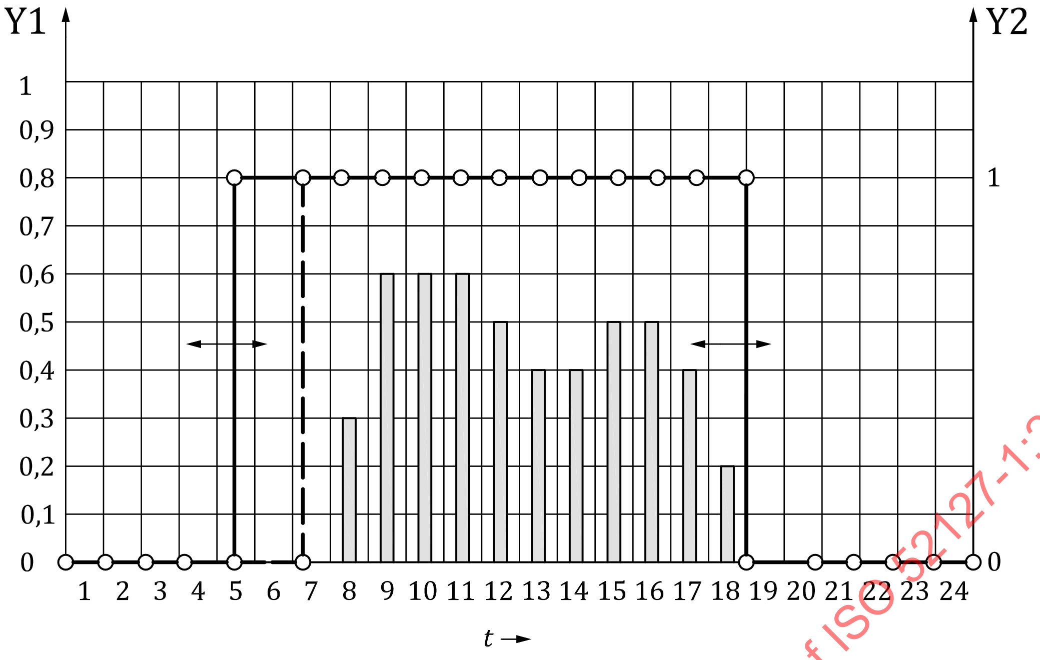
7.2 Input data

7.2.1 Source of data

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

7.2.2 Operating conditions

Run time (or operational time) of the HVAC systems is according to the set point profiles as calculated in Clause 6. Normally, run time covers the occupied period of the building taking into account some additional start-stop periods. Adaption of runtime is given as an example in Figure 3.



Key

▨	occupancy rate
—○—	plant status on/off
Y1	occupancy rate
Y2	plant status on/off
t	time of the day (h)

Figure 3 — Adaption of run time

7.3 Calculation procedure

7.3.1 Operating conditions calculation

BMS will allow optimizing the matching between building energy demand and system operation time. To calculate the effective run time of the system, Table 7 shall be applied.

Table 7 — Output data of BMS function 2

	Without BMS function 2	With BMS function 2
Operating time with scheduler using a fixed time program	add 2,5 h per day	add 1,5 h per day
Operating time with optimum start-stop function	-	add 1 h per day

7.3.2 Energy calculation

Energy calculation is done by applying standardized algorithms related to other modules taking into account run time of the HVAC systems. Intermittent control of emission and/or distribution system on a room/zone level is used to fit the operation of heating and cooling systems to occupancy patterns. Control signals taken into account in the energy calculations are as follows:

— HEAT_DISTR_CTRL for M3-5 and M3-6,

— CLG_DISTR_CTRL for M4-5 and M4-6.

The calculation procedure is described in EN 15316-2 and EN 15316-3.

8 BMS function 3 (sequencing of generators)

8.1 Output data

This function provides information on how to split the total energy demand for heating and cooling to different heat generators or chillers. Each generator shall supply the energy that is addressed to it.

8.2 Input data

8.2.1 Source of data

Input data about total heating or cooling energy to be provided by a set of generators is needed. This information is supplied by the EN 15316 series.

8.2.2 Operating conditions

Operating conditions depend on either physical, efficiency or economic considerations as defined by HEAT_GEN_CTRL_SEQ in module 3-8.

8.3 Calculation procedure

8.3.1 Operating conditions calculation

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 the EN 15316-4 series shall be performed independently for each heat generation device *j*, on the basis of $Q_{\mathrm{H,gen,out},j}$.

Criteria are needed to split $Q_{\mathrm{H,gen,out}}$ amongst available generators. Criteria may be based on physical, efficiency or economic considerations as defined by HEAT_GEN_CTRL_SEQ in module 3-8.

EXAMPLE 1 Solar or heat pump sub-system maximum heat output.

EXAMPLE 2 Heat pumps or cogeneration optimum (either economic or energetic) performance range. Appropriate criteria for specific types of generation sub-systems can be found in the relevant parts of the EN 15316–4 series. Procedures to split the load among multiple combustion generators (boilers) are given for basic cases in 8.3.2.

EXAMPLE 3 Given $\Sigma Q_{\mathrm{H,dis,in,}}$,the maximum output of a solar generation system $Q_{\mathrm{H,sol,out}}$ can be calculated first, and subsequently the heat output that can be provided by a cogeneration system is added $Q_{\mathrm{cgn,gen,out}}$. The rest ($Q_{\mathrm{H,gen,out,boil}} = \Sigma Q_{\mathrm{H,dis,in}} - Q_{\mathrm{H,sol,out}} - Q_{\mathrm{cgn,gen,out}}$, see Figure 4) is attributed to boilers and can be further split among multiple boilers according to the following description.

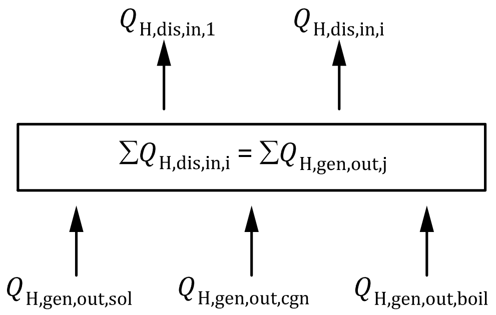


Figure 4 — Example of load splitting among generation sub-systems

8.3.2 Energy calculation

8.3.2.1 Multiple boilers generation sub-system

8.3.2.1.1 General

If there are several boilers installed, distribution of the load among boilers depends on control. Two types of control are distinguished:

- without priority,
- with priority.

8.3.2.1.2 Multiple generators without priority

All generators are running at the same time and therefore the load factor β_{gen} is the same for all boilers, and is given by Formula (2):

$$\beta = \frac{\Phi_{\text{H,gen,out}}}{\sum_i \Phi_{\text{Pn},i}} \tag{2}$$

where

β_{gen} is the load factor representing the ratio between heat generator output and total heat capacity of all heat generators available;

$\Phi_{\text{Pn},i}$ is the nominal power output of generator *i* at full load.

8.3.2.1.3 Multiple generators with priority

Priority of the generators is defined by HEAT_GEN_CTRL_SEQ in module 3-8. 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 ($\beta_{\text{gen},i} = 1$). Priority list may change depending on the availability of generators, e.g. if a heat pump is switched off below low outside air temperatures.

If all heat generators have the same power output Φ_{Pn}, the number of running generators $N_{\text{gen,on}}$ is given by Formula (3):

$$N_{\text{gen,on}} = \text{int}\left(\frac{\Phi_{\text{H,gen,out}}}{\Phi_{\text{Pn}}}\right) \tag{3}$$

Otherwise running boilers shall be determined so that $0 < \beta_{\text{gen},i} < 1$ [see Formula (3)].

The load factor $\beta_{\text{gen},j}$ for the intermittent running generator is calculated by Formula (4):

$$\beta_{\text{gen},j} = \frac{\Phi_{\text{H,gen,out}} - \sum_{i=1}^{N_{\text{gen,on}}} \Phi_{\text{Pn},i}}{\sum_i \Phi_{\text{Pn},j}} \tag{4}$$

where

$\Phi_{\text{Pn},i}$ is the nominal power output of generator *i* running at full load;

$\Phi_{\text{Pn},j}$ is the nominal power output of intermittent running generator.

8.3.2.2 Modular systems

8.3.2.2.1 General

A modular system consists of N_{gen} identical modules or generators, each characterised by a maximum and a minimum combustion power $\Phi_{\text{cmb},i,\text{max}}$ and $\Phi_{\text{cmb},i,\text{min}}$, assembled as a single unit or connected to the same mains.

The combustion power of the entire system is calculated by Formula (5):

$$\Phi_{\text{cmb}} = \Phi_{\text{cmb},i,\text{max}} \cdot N_{\text{gen}} \tag{5}$$

8.3.2.2.2 Modular systems with hydraulic shutdown of stand-by modules

If there is an automatic control system applied, which shuts down and insulates stand-by generators and/or modules from the distribution network, the following procedure shall be followed.

The number $\text{N}_{\text{gen,on}}$ of running generators and/or modules is calculated by Formula (6):

$$N_{\text{gen,on}} = \text{int}(N_{\text{gen}} \cdot \beta_{\text{cmb}} + 1) \tag{6}$$

where the load factor β_{cmb} is calculated for a single stage generator of combustion power Φ_{cmb} and int is the integer function.

The actual performance of the modulating generator is calculated following the procedure for multistage generators and assuming:

- — $\Phi_{\text{cmb,max}} = \Phi_{\text{cmb},i,\text{max}} \cdot N_{\text{gen,on}}$,
- — $\Phi_{\text{cmb,min}} = \Phi_{\text{cmb},i,\text{min}}$.

8.3.2.2.3 Modular systems without hydraulic shutdown of stand-by modules

If there is no control system applied, which shuts down and insulates stand-by generators and/or modules from the distribution network, the following procedure shall be followed.

The actual performance of the modulating generator is calculated following the procedure for multistage generators and assuming:

- — $\Phi_{\text{cmb,max}} = \Phi_{\text{cmb},i,\text{max}} \cdot N_{\text{tot}}$,
- — $\Phi_{\text{cmb,min}} = \Phi_{\text{cmb},i,\text{min}} \cdot N_{\text{tot}}$.

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

9.1 Output data

This function provides information on 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 (see Table 8):

- — load signal either as binary (on/off) or any instantaneous signal varying between minimum and maximum load used to orchestrate renewable energy production and any CHP;
- — battery management signal that manages charging and discharging of batteries, taking into account both load and energy production predictions.