BS EN 15316-1:2017

BSI Standards Publication

Energy performance of buildings — Method for calculation of system energy requirements and system efficiencies

Part 1: General and Energy performance expression, Module M3-1, M3-4, M3-9, M8-1, M8-4

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National foreword

This British Standard is the UK implementation of EN 15316-1:2017. It supersedes BS EN 15316-1:2007, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee RHE/24, Heating systems and water based cooling systems in buildings.

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

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Performance énergétique des bâtiments - Méthode de calcul des besoins énergétiques et des rendements des systèmes - Partie 1 : Généralités et expression de la performance, Modules M3-1, M3-4, M3-9, M8-1, M8-4

Energetische Bewertung von Gebäuden - Verfahren zur Berechnung der Energieanforderungen und Nutzungsgrade der Anlagen - Teil 1: Allgemeines und Darstellung der Energieeffizienz, Module M3-1, M3-4, M3-9, M8-1, M8-4

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Contents

Page

European foreword

This document (EN 15316-1:2017) has been prepared by Technical Committee CEN/TC 228 “Heating systems and water based cooling systems”, the secretariat of which is held by DIN.

This document supersedes EN 15316-1:2007.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by October 2017, and conflicting national standards shall be withdrawn at the latest by October 2017.

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

The main changes compared to EN 15316-1:2007 are:

— reference and coordination of all other modules (a module corresponds to a subsystem standard);

— inclusion of operating conditions calculation and load dispatching related to building automation control (BAC) and systems design (e.g. connection of distributions).

— inclusion of a monthly method based on BIN.

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

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

Introduction

This Standard is part of a series of standards aiming at international harmonization of the methodology for the assessment of the energy performance of buildings, called “set of EPB standards”.

EPB standards deal with energy performance calculation and other related aspects (like system sizing) to provide the building services considered in the EPB Directive.

All EPB standards follow specific rules to ensure overall consistency, unambiguity and transparency.

All EPB standards provide a certain flexibility with regard to the methods, the required input data and references to other EPB standards, by the introduction of a normative template in Annex A and Annex B with informative default choices.

For the correct use of this standard a normative template is given in Annex A to specify these choices. Informative default choices are provided in Annex B.

Use by or for regulators: In case the standard is used in the context of national or regional legal requirements, mandatory choices may be given at national or regional level for such specific applications. These choices (either the informative default choices from Annex B or choices adapted to national / regional needs, but in any case following the template of this Annex A) can be made available as national annex or as separate (e.g. legal) document (national data sheet).

NOTE So in this case:

— the regulators will **specify** the choices;

— the individual user will apply the standard to assess the energy performance of a building, and thereby **use** the choices made by the regulators.

Topics addressed in this standard can be subject to public regulation. Public regulation on the same topics can override the default values in Annex B of this standard. Public regulation on the same topics can even, for certain applications, override the use of this standard. Legal requirements and choices are in general not published in standards but in legal documents. In order to avoid double publications and difficult updating of double documents, a national annex may refer to the legal texts where national choices have been made by public authorities. Different national annexes or national data sheets are possible, for different applications.

It is expected, if the default values, choices and references to other EPB standards in Annex B are not followed due to national regulations, policy or traditions, that:

— national or regional authorities prepare data sheets containing the choices and national or regional values, according to the model in Annex A. In this case the national annex (e.g. NA) refers to this text;

— or, by default, the national standards body will consider the possibility to add or include a national annex in agreement with the template of Annex A, in accordance to the legal documents that give national or regional values and choices.

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 the Technical Report accompanying this standard (CEN/TR 15316-6-1).

CEN/TC 228 deals with heating systems and water based cooling systems in buildings. Subjects covered by TC 228 are:

— energy performance calculation;

— inspection;

— design of systems;

— installation and commissioning.

The first version of this standard was developed during the first EPBD mandate and published in 2008.

The revision for inclusion in the second EPBD mandate package was performed in 2014.

Default references to EPB standards other than EN ISO 52000-1 are identified by the EPB module code number and given an Annex A (normative template) and Annex B (informative default choice).

Table 1 associates the title of the EN EPB standards to the numbers and modules. It also remembers the replaced standards.

Table 1 — List of EN EPB standards related to the calculation of space heating and domestic hot water systems

No.	Module	*New EPBD numbering*	*Old standards replaced*	*Title of the new EPBD standard*
1	M1–14	EN 15459–1	EN 15459	Energy performance of buildings - Heating systems and water based cooling systems in buildings - Part 1: Economic evaluation procedure for energy systems in buildings, Module M1-14
		CEN/TR 15459–2	New	Energy performance of buildings - Economic evaluation procedure for energy systems in buildings - Part 2: Explanation and justification of EN 15459-1, Module M1-14)
2	M3–11 M8–11	EN 15378–1	EN 15378	Energy performance of buildings - Heating systems and DHW in buildings - Part 1: Inspection of boilers, heating systems and DHW, Module M3-11, M8-11
		CEN/TR 15378–2	New	Energy performance of buildings - Heating systems and DHW in buildings - Part 2: Explanation and justification of EN 15378-1, Module M3-11 and M8-11)
3	M3–10 M8–10	EN 15378–3	New	Energy performance of buildings - Heating and DHW systems in buildings - Part 3: Measured energy performance, Module M3-10, M8-10
		CEN/TR 15378–4	New	Heating systems and water based cooling systems in buildings - Heating systems and DHW in buildings - Part 4: Accompanying TR to EN 15378-3 (Measured energy performance))
4	M3–3	EN 12831–1	EN 12831	Energy performance of buildings - Method for calculation of the design heat load - Part 1: Space heating load, Module M3-3
		CEN/TR 12831–2	New	Energy performance of buildings - Method for calculation of the design heat load - Part 2: Explanation and justification of EN 12831-1, Module M3-3)

No.	Module	*New EPBD numbering*	*Old standards replaced*	*Title of the new EPBD standard*
5	M8–3	EN 12831–3	EN 15316–3-1	Energy performance of buildings - Method for calculation of the design heat load - Part 3: Domestic hot water systems heat load and characterisation of needs, Module M8-2, M8-3
		CEN/TR 12831–4	New	Energy performance of buildings - Method for the calculation of the design heat load - Part 4: Explanation and justification of EN 12831-3, Module M8-2, M8-3
6	M3–1 M8–1 M3–4 M8–4 M3–9 M8–9	EN 15316–1	EN 15316–1	Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 1: General and Energy performance expression, Module M3-1, M3-4, M3-9, M8-1, M8-4
		CEN/TR 15316–6-1	New	Heating systems and water based cooling systems in buildings — Method for calculation of system energy requirements and system efficiencies — Part 1: Explanation and justification of EN 15316-1, Module M3-1, M3-4, M3-9, M8-1, M8-4
7	M3–5 M4–5	EN 15316–2	EN 15316–2-1	Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 2: Space emission systems (heating and cooling), Module M3-5, M4-5
		CEN/TR 15316–6-2	New	Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 6-2: Explanation and justification of EN 15316-2, Module M3-5, M4-5
8	M3–6 M4–6 M8–6	EN 15316–3	EN 15316–2-3 EN 15316–3-2	Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 3: Space distribution systems (DHW, heating and cooling), Module M3-6, M4-6, M8-6
		CEN/TR 15316–6-3	New	Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 6-3: Explanation and justification of 15316-3, Module M3-6, M4-6, M8-6
9	M3–8-1 M8–8-1	EN 15316–4-1	EN 15316–4-1 EN 15316–3-3 EN 15316–4-7	Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 4-1: Space heating and DHW generation systems, combustion systems (boilers, biomass), Module M3-8-1, M8-8-1
		CEN/TR 15316–6-4	New	Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 6-4: Explanation and justification of EN 15316-4-1, Module M3-8-1, M8-8-1
10	M3–8-2 M4–8-2 M8–8-2	EN 15316–4-2	EN 15316–4-2	Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 4-2: Space heating generation systems, heat pump systems, Module M3-8-2, M8-8-2
		CEN/TR 15316–6-5	New	Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 6-5: Explanation and justification of EN 15316-4-2, Module M3-8

No.	Module	*New EPBD numbering*	*Old standards replaced*	*Title of the new EPBD standard*
11	M3–8-3 M8–8-3 M11–8-3	EN 15316–4-3	EN 15316–4-3 EN 15316–4-6	Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 4-3: Heat generation systems, thermal solar and photovoltaic systems, Module M3-8-3, M8-8-3, M11-8-3
		CEN/TR 15316–6-6	New	Energy performance of buildings - Method for calculation of system energy performance and system efficiencies - Part 6-6: Explanation and justification of EN 15316-4-3 Module M3-8-3 M8-8-3
12	M3–8-4 M8–8-4 M11–8-4	EN 15316–4-4	EN 15316–4-4	Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 4-4: Heat generation systems, building-integrated cogeneration systems, Module M8-3-4, M8-8-4, M8-11-4
	M3–7 / M8–7	CEN/TR 15316–6-7	New	Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 6-7: Explanation and justification of EN 15316-4-4, Module M8-3-4, M8-8-4, M8-11-4
13	M3–8-5 M4–8-5 M8–8-5 M11–8-5	EN 15316–4-5	EN 15316–4-5	Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 4-5: District heating and cooling, Module M3-8-5, M4-8-5, M8-8-5, M11-8-5
		CEN/TR 15316–6-8	New	Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 6-8: Explanation and justification of EN 15316-4-5 (District heating and cooling), Module M3-8-5, M4-8-5, M8-8-5, M11-8-5
14	M3–8-8	EN 15316–4-8	EN 15316–4-8	Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 4-8: Space heating generation systems, air heating and overhead radiant heating systems, including stoves (local), Module M3-8-8
		CEN/TR 15316–6-9	New	Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 6-9: Explanation and justification of EN 15316-4-8, Module M3-8-8
15	M3–7 M8–7	EN 15316–5	New	Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 5: Space heating and DHW storage systems (not cooling), M3-7, M8-7
		CEN/TR 15316–6-10	New	Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 6-10: Explanation and justification of EN 15316-5, Module M3-7, M8-7
16	M3–8-6 M8–8-6	EN 15316–4-9	New	Heating systems and water based cooling systems in buildings - Method for calculation of system energy requirements and system efficiencies - Part 4-9: Direct electric generation systems
17	M11–8-7	EN 15316–4-10	New	Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 4-10: Wind power generation systems, Module M11-8-7

1 Scope

This European Standard is the general frame for the calculation of the energy use and the energy performance of heating and domestic hot water systems. This standards is only dealing with the heat, provided by water based systems, needed for heating, domestic hot water and cooling (e.g. absorption chiller).

It specifies how to perform the calculation of the entire installation using the calculation modules (see Table 2) corresponding to the methods defined in the respective standards.

It deals with common issues like operating conditions calculation and energy performance indicators.

It standardises the inputs and outputs in order to achieve a common European calculation method.

It allows the energy analysis of the heating and Domestic hot water systems and sub-systems including control (emission, distribution, storage, generation) by comparing the system losses and by defining energy performance indicators.

The performance analysis allows the comparison between systems and sub-systems and makes possible to evaluate the impact of each sub-system on the energy performance of a building.

The calculation of the system losses of each part of the heating sub-systems is defined in subsequent standards.

Ventilation systems are not included in this standard (e.g. balanced systems with heat recovery), but if the air is preheated or an air heating system is installed, the systems providing the heat to the AHU (Air Handling Unit) are covered by this standard.

Table 2 shows the relative position of this standard within the set of EPB standards in the context of the modular structure as set out in EN ISO 52000-1.

NOTE 1 In CEN 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 may cover more than one module and one module may be covered by more than one EPB standard, for instance a simplified and a detailed method respectively. See also Clause 2 and Tables A.1 and B.1.

Table 2 — Position of this standard, within the modular structure of the set of EPB standards

Overarching			Building (as such)		Technical Building Systems										
	Descriptions			Descriptions		Descriptions	Heating	Cooling	Ventilation	Humidification	Dehumidification	Domestic Hot water	Lighting	Building automation and control	Electricity production
sub1		**M1**	**sub1**	**M2**	**sub1**		**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**	**M10**	**M11**
1	General		**1**	General	**1**	General	**15316–1**					**15316–1**			
2	Common terms and definitions; symbols, units and subscripts		**2**	Building Energy Needs	**2**	Needs						12831–3			
3	Applications		**3**	(Free) Indoor Conditions without Systems	**3**	Maximum Load and Power	12831–1					12831–3			
4	Ways to Express Energy Performance		**4**	Ways to Express Energy Performance	**4**	Ways to Express Energy Performance	**15316–1**					**15316–1**			
5	Building Functions and Building Boundaries		**5**	Heat Transfer by Transmission	**5**	Emission and control	15316–2	15316–2							
6	Building Occupancy and Operating Conditions		**6**	Heat Transfer by Infiltration and Ventilation	**6**	Distribution and control	15316–3	15316–3				15316–3			
7	Aggregation of Energy Services and Energy Carriers		**7**	Internal Heat Gains	**7**	Storage and control	15316–5					15316–5 15316–4-3			
8	Building Partitioning		**8**	Solar Heat Gains	**8**	Generation									
					8–1	Combustion boilers	15316–4-1					15316–4-1			
					8–2	Heat pumps	15316–4-2	15316–4-2				15316–4-2			
					8–3	Thermal solar Photovoltaics	15316–4-3					15316–4-3			15316–4-3
					8–4	On-site cogeneration	15316–4-4					15316–4-4			15316–4-4
					8–5	District heating and cooling	15316–4-5	15316–4-5				15316–4-5			15316–4-5
					8–6	Direct electrical heater	15316–4-9					15316–4-9			
					8–7	Wind turbines									15316–4-10
					8–8	Radiant heating, stoves	15316–4-8								
9	Calculated Energy Performance		**9**	Building Dynamics (thermal mass)	**9**	Load dispatching and operating conditions	**15316–1**								
10	Measured Energy Performance		**10**	Measured Energy Performance	**10**	Measured Energy Performance	15378–3					15378–3			
11	Inspection		**11**	Inspection	**11**	Inspection	15378–1					15378–1			
12	Ways to Express Indoor Comfort		**12**	–	**12**	BMS									
13	External Environment Conditions														
14	Economic Calculation	15459–1													

NOTE The shaded modules are not applicable

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.

EN 15316-3, *Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 3: Space distribution systems (DHW, heating and cooling), Module M3-6, M4-6, M8-6*

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

EN ISO 52000-1:2017, *Energy performance of buildings - Overarching EPB assessment - Part 1: General framework and procedures (ISO 52000-1:2017)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 7345:1995, EN ISO 52000-1:2017 and the following specific definitions apply.

3.1
feeding distribution circuit
circuit providing the node with energy delivered by sources

3.2
load distribution circuit
circuit that draw energy from the node and distribute it to the demand side

3.3
node
connection point between one or several feeding circuits (sources) and one or more load circuits (demand side)

Note 1 to entry: The requested energy is dispatched among the sources (e.g. generators) at the node.

4 Symbols and abbreviations

4.1 Symbols

For the purposes of this Standard, the symbols given in EN ISO 52000-1, (M1-9): and the specific symbols listed in Table 3 apply.

Table 3 — Symbols and units

Symbol	Name of quantity	Unit
GEN_FUEL	Fuel type	-
HEAT_XXXX_XXXX_XXX	BAC function identifier	-

4.2 Subscripts

For the purposes of this European Standard, the subscripts given in EN ISO 52000-1, (M1-9) and the specific subscripts listed in Table 4 apply.

Table 4 — Subscripts

Sub	Description	Sub	Description	Sub	Description
nod	node	flw	flow	ret	return
fin	final distribution	loop	distribution loop		

5 Description of the methods

5.1 General description of the calculation method

5.1.1 Calculation direction

The calculation direction is from the energy needs to the source (e.g. from the building energy needs to the primary energy). The calculation direction is the opposite of the energy flow in the system.

If a priority is defined between services or sub-systems these services or sub-systems are calculated according to the priorities.

The calculation structure shall follow the actual structure of the heating systems.

Thermal energy and auxiliary energy used by the heating and DHW systems are calculated separately.

5.1.2 Operating conditions

For each sub-system the operating conditions (e.g. temperatures, mass flows) are calculated according to the related operating conditions modules (see Annex C). The calculation of operating conditions takes into account controls (control identifier).

Only if the sub-systems are separated by a node they can have different operating conditions.

The calculation in the heating, domestic hot water or other sub-system standards applies to a specific part of the technical system with its specific operating conditions (e.g. pipe length, temperatures, etc.).

In complex buildings with complex technical systems there are more specific parts because there are more than one heating system zone and therefore more than one emission, distribution and generation sub-systems. For a technical system with several load circuits it is necessary to know the specific operating conditions of each part (e.g. the demand in each load circuit and the corresponding temperatures) and to apply the sub-systems standards accordingly to each of them.

“Input” versus “output” naming is related to the energy flow.

The calculation direction is the opposite of the energy flow (an “energy flow” input is a “calculation” output).

To make the distinction clear it is recommended to specify it (e.g. “flow” input, “calculation” output).

The operating conditions may for each sub-system include:

— the supply temperatures $\vartheta_{X;Y;in/out;sup}$

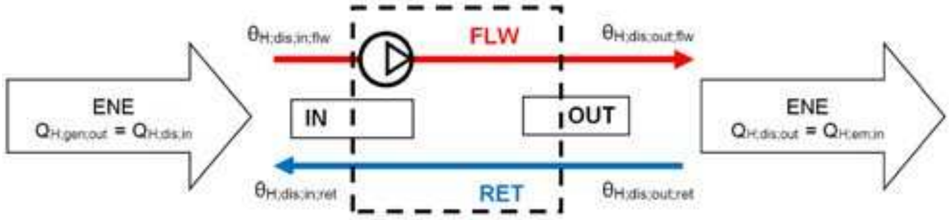
— the return temperatures $\vartheta_{X;Y;in/out;ret}$;

— the average temperatures $\vartheta_{X;Y;in/out;avg}$;

— the flow rates $V'_{\mathrm{X;Y;in/out}}$

Additional operating conditions parameters may be defined depending on the sub-system characteristics.

Figure 1 illustrates the naming conventions of operating conditions parameters



Key

FLW Supply (flow) pipe, hot water from generators to emitters

RET Return pipe of colder water from emitters to generators

IN Energy input (e.g. distribution input is generation output)

OUT Energy output

ENE Energy flow direction

Figure 1 — Naming conventions for energy flows and heating system operating temperatures

5.1.3 Maximum heat supply and power check

Often emitters are oversized whilst generation devices may be sized on average power. Therefore it is likely that the limitation of the power will not be on the emission sub-systems (an exception may be floor heating) but on the generation.

The maximum heat supply may also depend on the internal or external operating conditions (e.g. heat pumps).

For the monthly method and some special generators (like heat pumps) the bin method will be used to check if the generator is able to supply the requested heat. The needed running time to supply the heat will be compared to the effective bin time.

For the monthly method there should be a maximum average load (e.g. 70…80 %) because it is not likely that the installation may run full load for the whole month.

For the hourly method, the check of the heat supply is done for the emission and generation sub-system. Different possibilities are given to deal with a lack of energy supply:

— to add the missing energy production to the sub-system output (emission, generation) of the next time step. If the sub-system is not able to provide the requested energy after a defined number of time steps, then the calculation is stopped and the sizing of the generation sub-system should be reviewed by the designer,

— to calculate the variation of the internal temperature.

If there is lack of energy supply, the calculation will re-boucle at the emitter output calculation with the heat supply requested at the emitter output minus the difference of the requested energy supply and the maximum heat supply of the sub-system in the calculation interval.

5.1.4 Two emission sub-systems installed in the same heating system zone

In the same heating system zone different emission sub-systems may be installed (e.g. floor heating systems and radiators, both connected to the same heating system). One of the heat emitters can also be an independent heating device (e.g. electrical radiator, stove).

The operating conditions shall define if there is a priority (alternate mode) or if the emission subsystems work in parallel.

If a priority is defined between the emitters then the needed emission output is first calculated with the increased set point temperature related to the temperature increase of the priority emitter.

If no priority is defined, or if both emitter supply heat at the same time, then the increased set point temperature is the highest set point temperatures of both emitters.

The calculation procedure of these devices follows the general principles of the calculation procedure.

5.1.5 Multiservice and operating of multi generator systems (load dispatching)

A heat generator may provide heat for several services (e.g. heating, domestic how water). The heat may be provided by one or several heat generators (e.g. several gas boilers).

The operating of multi service or multi generator systems is determined by the system design and are characterized by:

the operating mode (e.g.)

— alternate operation;

— parallel (simultaneous) operation;

the respective temperatures (e.g.);

— balance point temperature.

5.1.6 Heating and domestic hot water system thermal losses

The system thermal losses are calculated in the related sub-system modules (e.g. distribution, generation). Systems thermal losses are recoverable or non-recoverable.

A distinction is made between:

— parts of the “system thermal losses which are recoverable for space heating”;

— parts of the “system thermal losses which are recovered directly” in the sub-system and which are therefore subtracted from the sub-system thermal losses of the sub-system.

The “recoverable system thermal losses for space heating” are input values for M2-2 in which the recovered system thermal loss is calculated.

The “system thermal losses recovered directly” in the sub-system (heat recovery) improves the performance of the sub-system, e.g. recovered stack losses for preheating the combustion air, water cooled circulation pumps where the cooling water is the distribution medium.

The location of recoverable system thermal loss shall be identified according to the thermal zones or tagged as unallocated and then distributed,

As a minimum the system thermal losses should be calculated according the following locations: heated space, unheated space and outside.

In the monthly calculation the heat losses of the domestic hot water sub-systems or of the space heating sub-systems may be send explicitly to the needs calculation module M 2.2 or subtract from needs with a recovery factor.

Non localized recoverable losses are distributed amongst heated space according to a building property specified according to the template given in Table A.2. A default specification is given in Table B.2.

5.1.7 Auxiliary energy

In heating and domestic hot water systems auxiliary energy is basically used for pumps, fans, controls, and other electrical components like transformers. To calculate the auxiliary energy, the respective power of the auxiliary components has to be given as input or calculated in the sub-systems.

A simplified approach to estimate auxiliary energy is to multiply the electrical power of the auxiliary by the relevant running or activation time of the respective auxiliary component.

It has to be taken care, if the auxiliary energies is already included in the performance evaluations of the standard testing procedures or not (e.g. in heat pump standards auxiliary energy for control during the running time of the heat pump is taken into account in the COP value, the boiler standards do not consider auxiliaries in the boiler efficiency).

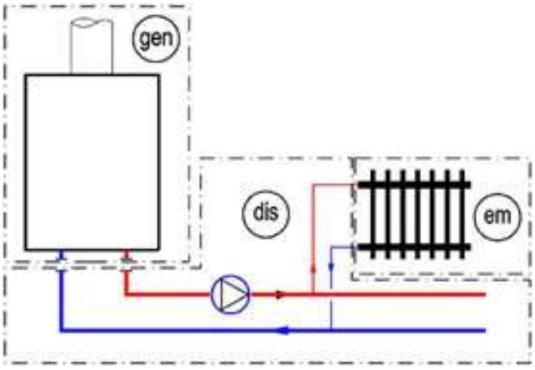
The running time of the auxiliary components depend on the control of each sub-system.

— Generation auxiliary running time is often linked to the running time of the generator which is a function of the power;

— Distribution pumps may be switched-on periodically or run all the time. The running time may also depend on the system configuration, e.g. linked to storage control in case of a heating buffer storage.

All devices using auxiliary energy shall be considered once and only once. Therefore the allocation of circulating pumps is defined according to the following principles.

If there is no pump within the generator, then the boundary between the generation and the distribution sub-systems is the hydraulic connection of the boiler, as shown in Figure 2 and the pump and its auxiliary energy use is attributed to the distribution sub-system.



Key

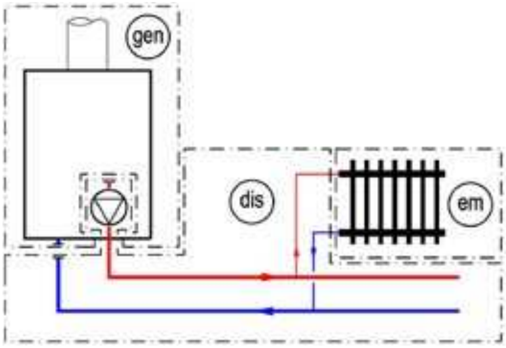
gen generation sub-system

dis distribution sub-system

em emission sub-system

Figure 2 — Sample sub-systems boundaries – example 1

A pump physically installed within the boiler may be considered either as part of the distribution sub-system or as part of the generation sub-system if it contributes directly to the flow of the heating medium to the emitters. An example is shown in Figure 3.



Key

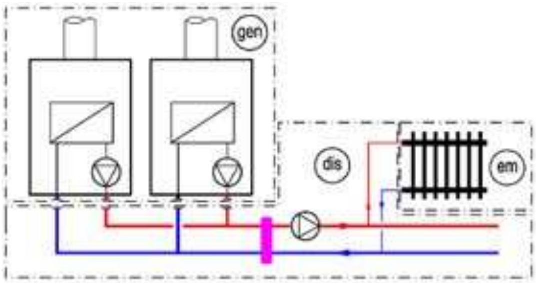
gen generation subsystem

dis distribution subsystem

em emission subsystem

Figure 3 — Sample sub-systems boundaries - example 2

Pumps included in the generators and dedicated only to the circulation of water inside the generators are considered within the generation sub-system. An example is shown in Figure 4.



Key

gen generation subsystem

dis distribution subsystem

em emission subsystem

Figure 4 — Sample sub-systems boundaries –example 3

5.1.8 Sub-system energy balance

The calculation of each module for sub-system Y for the service X shall be based on the required energies $Q_{X;Y;out}$, $Q_{X;Y;in}$ and other specific relevant data (i.e. temperatures, flow rates, etc).

The output (direction of calculation) of each sub-system module shall include:

— the required energy input $Q_{X;Y;in}$;

— the required auxiliary energy $W_{X;Y;aux}$;

— the recoverable losses for heating or cooling $Q_{X;Y;ls;rbl;H}$;

— the localization (thermal zone specification) of recoverable losses $TZ_{X;Y;ls;rbl;H}$

NOTE See also 6.3.3, Operating data and boundary conditions

Both auxiliary energy and heat losses may be recovered as a reduction of input or by contributing to recoverable losses for heating. This shall be calculated within the sub-system module.

NOTE 1 If the recovery of auxiliary energy and thermal losses is fully accounted in the sub-system, then $Q_{X;Y;ls;rbl;H}$ will be 0.

NOTE 2 For domestic hot water, thermal losses cannot be recovered within the sub-system calculation. Only auxiliary energy can be recovered directly.

NOTE 3 Recoverable losses also include the losses of systems that are active in summer and that will contribute to the cooling needs instead of reducing heating needs.

The basic equations of sub-system modules are:

$$Q_{X;Y;in} = Q_{X;Y;out} + Q_{X;Y;ls} - W_{X;Y;aux} \cdot f_{X;Y;aux;rh} - Q_{X;Y;ls} \cdot f_{X;Y;ls;rh} \tag{1}$$

where:

$Q_{X;Y;ls}$ are the subsystem losses;

$f_{X;Y;aux,rh}$ is the recovery factor of auxiliary energy directly within the sub-system (heat to the heated space or to the heating medium);

$f_{X;Y;ls,rh}$ is the recovery factor of heat losses directly within the sub-system.

$$Q_{X;Y;ls;rbl} = W_{X;Y;aux} \cdot f_{X;Y;aux;rbl;H} + Q_{X;Y;ls} \cdot f_{X;Y;ls;rbl;H} \tag{2}$$

where:

$f_{X;Y;aux,rbl;H}$ is the recoverability factor of auxiliary energy (heat to the environment);

$f_{X;Y;ls,rbl;H}$ is the recoverability factor of heat losses (heat to the environment not already accounted as het recovery by $f_{X;Y;ls,rh}$).

NOTE These are typical equations (e.g. not general equations) because the input of generation sub-systems is not calculated via the sum of losses.

5.1.9 Interaction with other technical building systems

Also other technical building systems (e.g. AHU, absorption cooling) may be connected to the heating system. If the required heat of the other technical building systems will be provided by the heating system it has to be taken into account as a heating circuit connected to the relevant node.

5.2 Optional methods

Different methods to deal with operating conditions like temperatures may be used for hourly and monthly methods (bin method).

The differences are indicated in the related clauses.

5.3 Application data

Application data shall be specified according to the template given in normative Annex A.

Default data for the application of this standard are given in informative Annex B.

6 Calculation procedure

6.1 Output data

The output data of this method are listed in Table 5.

The input data related to the energy flow of each module are calculation output data. The calculation output data can be used by any other module.

Table 5 — Output data of method

Description	Symbol	Computed unit	Validity interval	Varying
Connection with Overarching standard M1–9				
Energy carrier i input for space heating and per zone	$E_{H;gen;in;cr,j}$[b]	kWh	0…∞	YES
Energy carrier i identifier	GEN_FUEL,i	List	Not relevant	NO
Heating system auxiliary energy per zone	$W_{H;aux}$	kWh	0…∞	YES
Energy carrier j input for DHW system and per zone	$E_{W;gen;in;cr,j}$	kWh	0…∞	YES
Energy carrier j identifier	GEN_FUEL,j	List	Not relevant	NO
DHW system auxiliary energy per zone	$W_{W;aux}$	kWh	0…∞	YES
Connection with sub-systems				
Energy output required to sub-system Y for service X	$Q_{X;Y;out}$ [a]	kWh	0…∞	YES
Supply temperature at sub-system Y output for service X	$\vartheta_{X;Y;out;flw}$	°C	0…110	YES
Return temperature at sub-system Y output for service X	$\vartheta_{X;Y;out;ret}$	°C	0…110	YES
Connection with heating needs				
Actual heat supplied to each heating system zone	$Q_{H;sys;out;z}$	kWh	0…∞	YES
Recoverable losses to the conditioned space	$Q_{HW;sys;rbl;z}$	kWh	0…∞	YES
Location of losses to the conditioned space	TH_ZONE;z	List	Not relevant	NO
Connection with ventilation AHU				
Actual energy output to AHU	$Q_{H;sys;out;V}$	kWh	0…∞	YES

[a] X can be "H" or "W" or "C" ("C" only if there are absorbers) Y can be any subsystem type

[b] cr can be renewable and non-renewable energy carriers.

These outputs shall be defined monthly and yearly.

Table 6 — Partial indicators

Partial performance indicators				
Heating system expenditure factor	ε_H	-	0–10	NO
Heating system efficiency	$\eta_{H,m,y}$	-	0–10	
DHW system expenditure factor	ε_W	-	0–10	NO
DHW system efficiency	$\eta_{W;sys}$	-	0–10	NO

The partial performance indicators can be expressed by calculation interval (e.g. monthly, seasonal or yearly), by service, etc.

6.2 Calculation interval and calculation period

6.2.1 Calculation interval

The methods described are suitable for the following calculation intervals t_{ci}:

— month;

— hour;

— bin.

The same calculation interval shall be used for the calculation of all subsystems. Calculation intervals are indicated in Table A5. Informative default values are provided in Table B5.

6.2.2 Calculation period

The length of the calculation period, also depending on the calculation interval (e.g. month, hour, etc), is given in EN ISO 52000-1, (M1-9). There are two calculation periods: heating and domestic hot water. The calculation period is indicated in Table A5. Informative default values are provided in Table B5.

6.3 Input data

6.3.1 Product data

6.3.1.1 Product description data

No product description data are required by this standard.

6.3.1.2 Product technical data

If values from the manufacturer are not available, then default values shall be specified according to the template given in Table A14. Default product technical data are given Table B.14.

6.3.2 System design data

6.3.2.1 General

System zone areas should be put here:

$A_{H;SZ,I}$ Heating system zone i

$A_{DHW;SZ;I}$ DHW system zone i

6.3.2.2 Process design

6.3.2.2.1 Type of emitter circuit

The identifier of the type of emitter circuit is specified according to the template given in Table A.11.

Default identifiers corresponding to circuits in Annex C are given in Table B.11

6.3.2.2.2 Type of generation circuit

The identifier of the type of generation circuit is specified according to the template given in Table A.12.

Default identifiers corresponding to circuits in Annex D are given in Table B.12

6.3.2.3 Control

The process control options are given by BACS identifiers, see Table 7.

Table 7 — BACS identifiers

Code	Meaning
HEAT_EM_CTRL_DEF	Heating emission control
HEAT_EM_CTRL_TABS	Heating emission control for TABS (heating mode)
HEAT_DIS_CTRL_TMP	Heating distribution control
HEAT_DIS_CTRL_PMP	Control of distribution pumps in networks
HEAT_DIS_CTRL	Intermittent control of emission and/or distribution
HEAT_GEN_CTRL_CD	Heating generator control for combustion and district heating
HEAT_GEN_CTRL_HP	Heat generator control heat pump
HEAT_GEN_CTRL_OU	Heat generator control outdoor unit
HEAT_GEN_CTRL_SEQ	Sequencing of different heat generators
HEAT_TES_CTRL	Thermal Energy Storage (TES)

6.3.3 Operating data and boundary conditions

The required energy input is a calculation output of the sub-system.

$$Q_{X;Y;in} = Q_{X;Y;out} + Q_{X;Y;ls} - Q_{X;Y;ls,rvd} \quad (3)$$

where

$Q_{X;Y;out}$ is the energy output

$Q_{X;Y;ls}$ is the thermal losses

$Q_{X;Y;ls,rvd}$ is the recovered losses in the sub-system

This calculation shall be made within each sub-system.

The recoverable losses are collected in this standard. Then the values are passed to the building module (M2-2).

Table 8 — Operating conditions input data

Name	Symbol	Unit	Range	Origin	Varying
Domestic hot water energy needs	$Q_{W;nd}$	kWh	0…∞	M8–2	YES
Heating generator input i	E or $Q_{H,gen;in,i}$	kWh	0…∞	M3–8	YES
Heating generator Fuel type i	H_GEN_FUEL_i	List	Not relevant	M3–8	NO
DHW generator input i	E or $Q_{W;gen;in,i}$	kWh	0…∞	M8–8	YES
DHW generator Fuel type i	W_GEN_FUEL_i	List	Not relevant	M8–8	NO
Heating storage input i	$Q_{H;sto;in,i}$	kWh	0…∞	M3–7	YES
Heating distribution input i	$Q_{H;dis;in,i}$	kWh	0…∞	M3–6	YES
Heating emission input i	$Q_{H;em;in,i}$	kWh	0…∞	M3–6	YES
DHW storage input i	$Q_{W;sto;in,i}$	kWh	0…∞	M3–7	YES
DHW distribution input i	$Q_{W;,dis;in,i}$	kWh	0…∞	M3–5	YES
Maximum generator output i	$Q_{X;gen;out;max,i}$	kWh	0…∞	M3–8, M8–8	YES
Recoverable heating emission system losses with localization	$Q_{H;em;ls;rbl;z,i}$	kWh	0…∞	M3–5	YES
Recoverable heating distribution system losses with localization	$Q_{H;dis;ls;rbl;z,i}$	kWh	0…∞	M3–6	YES
Recoverable heating storage system losses with localization	$Q_{H;sto;ls;rbl,z,i}$	kWh	0…∞	M3–7	YES
Recoverable heating generation system losses with localization	$Q_{H;gen;ls;rbl,z,i}$	kWh	0…∞	M3–8	YES
Recoverable DHW emission system losses with localization	$Q_{W;em;ls;rbl;z,i}$	kWh	0…∞	M8–5	YES
Recoverable DHW distribution system losses with localization	$Q_{W;dis;ls;rbl;z,i}$	kWh	0…∞	M8–6	YES
Recoverable DHW storage system losses with localization	$Q_{W;sto;ls;rbl;z,i}$	kWh	0…∞	M8–7	YES
Recoverable DHW generation system losses with localization	$Q_{W;gen;ls;rbl,z,i}$	kWh	0…∞	M8–8	YES
Auxiliary energy of the heating emission sub-system	$W_{H;em;aux,i}$	kWh	0…∞	M3–5	YES
Auxiliary energy of the heating distribution sub-system	$W_{H;dis;aux,i}$	kWh	0…∞	M3–6	YES
Auxiliary energy of the heating storage sub-system	$W_{H;sto;aux,i}$	kWh	0…∞	M3–7	YES
Auxiliary energy of the heating generation sub-system	$W_{H;gen;aux,i}$	kWh	0…∞	M3–8	YES
Auxiliary energy of the DHW emission sub-system	$W_{W;em;aux,i}$	kWh	0…∞	M3–5	YES
Auxiliary energy of the DHW distribution sub-system	$W_{W;dis;aux}$	kWh	0…∞	M8–6	YES
Auxiliary energy of the DHW storage subsystem	$W_{W;sto;aux,i}$	kWh	0…∞	M8–7	YES
Auxiliary energy of the DHW generation sub-system	$W_{W;gen;aux,i}$	kWh	0…∞	M8–8	YES

The control modules, in which the operating conditions (e.g. temperatures, mass flow rates) for the emission – distribution and generation sub-systems are calculated, are treated as independent modules in Annex C and Annex D of this standard. The operating conditions input data are detailed there.

Table 9 — Specific data

Name	Symbol	Unit	Value
Water specific heat	c_W	J/(kg•K)	4 186
Water specific heat	c_W	Wh/(kg•K)	1,16

6.3.4 Other data

Simplified data input, if any, shall consist of correlations that provide the detailed input.

6.4 Domestic hot water energy use calculation

6.4.1 Domestic hot water needs per domestic hot water system zone

6.4.1.1 General

The DHW emission output (needs) per DHW needs zone $Q_{W;exp;Dzn,i}$ is calculated according to M8-2.

The parameter t_atap specifying time after a tapping before next tapping shall also be calculated with the data from M8.2 because this value is used in M8.6 to calculate the stub losses (final distribution).

The required hot water temperature $\theta_{\_W;em}$ is a system design data.

6.4.1.2 Simplification if DHW need zones (WNZ) and DHW system zones (WSZ) are different

As a simplification, the DHW emission output is obtained by dividing the DHW needs per DHW system zone according to the DHW system design. Subdivision rules are indicated in Table A.2. Informative default values are provided in Table B.2. For example dispatch the domestic hot water needs to each DHW system zone according to the useful area.

If a domestic hot water needs zone is served by several domestic hot water system zones, then the needs per each domestic hot water system zone $Q_{W;nd;wzs,i}$ is given by

$$Q_{W;nd;wzs,i} = Q_{W;nd;wzn,j} \cdot \frac{X_{wzs,i}}{\sum_k X_{wzs,k}} \quad (4)$$

where

$Q_{W;nd;wzn,j}$ are the calculated needs for the domestic hot water needs zone j;.

$X_{wzs,i}$ is the distribution property for domestic hot water system zone I;

$X_{wzs,k}$ are the distribution property for each domestic hot water system zone k belonging to the domestic hot water needs zone j.

Property X shall be specified according to the template given in Table A.2. A default specification is given in Table B.2

If a domestic hot water system zone serves several domestic hot water needs zones, then the needs of domestic hot water system zone $Q_{W;nd;wzs,i}$ is given by

$$Q_{W;nd;wzs,i} = \sum_k Q_{W;nd;wzn,j} \quad (5)$$

where

$Q_{W;nd;wzn,j}$	are the calculated needs for each domestic hot water needs zone k belonging to the domestic hot water system zone i.
WNZ	is the Domestic Hot Water Needs zone;
WSZ	is the Domestic hot water system zone.

6.4.1.3 Domestic hot water operating time

The operating schedules and the control options shall be specified in a table complying with the format specified by Table A.3 in Annex A. A default specification is given in Table B.3 in Annex B. The table shall take into account the BAC control identifiers. Monthly values will be a total of hours. It might be differentiated between distribution loop operation time and generator operation time.

6.4.1.4 Domestic hot water operating temperatures

The DHW operating temperatures will be passed by this European Standard and M8-2 to the sub-system standards

The domestic hot water temperatures for each subsystem shall be specified in a table complying with the format specified by Table A.4 in Annex A. A default specification is given in Table B.4 in Annex B. The BAC identifier may justify a selection within the table.

6.4.2 Domestic hot water distribution calculation

6.4.2.1 Final (stub) distribution calculation

Based on the following input values to M8-6.

— $Q_{W;dfin,i;out}$ expected DHW energy per DHW system zone I;

— $\theta_{W;dfin,i}$ DHW emission temperature;

— $n_{tap;dfin,i}$ time after last tapping.

and according to M8-6 for each domestic hot water final distribution j: the following data are calculated (feedback from M8-6).

— the required energy input $Q_{W;dfin;j;in}$;

— the required auxiliary energy $W_{W;dfin,j;aux}$;

— the recoverable losses $Q_{W;dfin,j;ls;rbl,z}$;

— the location of recoverable losses according to thermal zones $TH\_ZONE_{W;dfin,i;ls;rbl,z}$;

— the ribbon heating in EN 15316-3 is taken into account turning losses into auxiliary energy. That is also the reason for having the possibility of an auxiliary contribution even if there are no pumps.

The stub distribution can be connected directly to the generation system.

6.4.2.2 Domestic hot water circulation loop

For each domestic hot water circulation loop j, calculate the required output $Q_{W;dloop,j;out}$ as

$$Q_{W;dloop,j;out} = \sum_{k} Q_{W;dfin,gp;in,k} \tag{6}$$

where

$Q_{W;dfin;gp,in,k}$ are the energy input to the final distributions connected to the same distribution loop j

According to M8-6, and with the specific operating conditions calculate for each domestic hot water recirculation loop j:

— the required energy input — $Q_{W;dloop;in,j}$

— the required auxiliary energy — $Q_{W;dloop;aux,j}$

— the recoverable losses — $Q_{W;dloop;ls;rbl,j,z}$

— the location of recoverable losses according to thermal zones $TH\_ZONE_{W;dloop;ls;rbl,j,z}$

The domestic hot water distribution loop temperature $\vartheta_{W;dloop,j}$ is given by:

— the storage output temperature $\vartheta_{W;sto,j;out}$ if the distribution loop is connected to a storage;

— the generator device output temperature output $\vartheta_{W;gen,j;out}$ if the distribution loop is directly connected to a hot water generation device.

Also the domestic hot water circulation loop can be turned off. In this case the temperature of the loop decrease in the same way as a stub. This effect may be neglected.

6.4.3 Domestic hot water storage calculation

For each domestic hot water storage, calculate the required output $Q_{W;sto;out}$ as

$$Q_{W;sto;out} = \sum_{i} Q_{W;dloop,i;in} + \sum_{j} Q_{W;dfin,j;in} \tag{7}$$

where

$Q_{W;dloop,i;in}$ are the energy input to the distribution loops connected to the same storage;

$Q_{W;dfin,j;in}$ are the energy input to the final distributions directly connected to the same storage.

According to M8-7, and with the specific operating conditions calculate for each domestic hot water storage:

— the required energy input $Q_{W;sto;in}$

— the required auxiliary energy $Q_{W;sto;aux}$

— the recoverable losses $Q_{W;sto;ls;rbl;z}$

— the location of recoverable losses according to thermal zones $TH\_ZONE_{W;sto;rbl,j,z}$

When considering the storage as part of a node, then losses to be considered in the node are given by:

$$Q_{W;nod;ls} = Q_{W;sto;in} - Q_{W;sto;out} \tag{8}$$

6.5 Space heating energy use calculation

6.5.1 Generalities

In this standard two optional methods are described:

— an hourly method;

— a bin method based on monthly or annual calculation.

6.5.2 Space heating emission useful output per space heating system zone

6.5.2.1 Domestic hot water recoverable losses

Domestic hot water recoverable losses is taken into account:

— either explicitly (holistic approach), by passing them to the building thermal balance module;

— or in a simplified way by deducting recovered losses $Q_{W;sys;ls,rvd}$ from the needs for each TZ.

This simplified way is described hereafter.

This option is controlled by the identifier OPT_HEAT_REC which can have the values given in Table 10.

Table 10 — Identifiers of calculation option for recoverable losses from domestic hot water

Code	***Description***
OPT_HEAT_REC_SIMPLE	Simplified heat recovery
OPT_HEAT_REC_DETAIL	Explicit heat recovery (holistic)

If the simplified method is selected then:

a) the recoverable losses for each thermal zone tz,i $Q_{W;sys;ls;rbl;tz,i}$ are given by the following equation.

$$Q_{W;sys;ls;rbl;tz,i} = \sum_{Y,j} Q_{W;Y,j;ls;rbl;tz,i} + \sum_{Y,j} Q_{W;Y,j;ls;rbl;tz,0} \cdot \frac{X_{tz,i}}{\sum_k X_{tz,k}} \tag{9}$$

Property X shall be specified according to the template given in Table A.1. A default specification is given in Table B.1

NOTE This equation includes both localized recoverable heat losses and un-localized recoverable heat losses distributed according to parameter X. Parameter X may be area, volume or other properties of the building..

b) the recovered losses are calculated according to equation

$$Q_{W;sys;ls;rvd;tz,i} = Q_{W;sys;ls;rbl;tz,i} \cdot f_{W;rbl;rh} \tag{10}$$

where

$f_{W;rbl;rh}$ is the recovery factor for recoverable heat losses of domestic hot water system. The value shall be specified according to the template given in Table A.13. Default values are given in Table B.13.

c) the heating system output for each thermal zone is calculated with

$$Q_{H;sys;out;tz,i} = \max\left(Q_{H;nd;tz,i} - Q_{W;sys;ls;rvd;tz,i};0\right) \tag{11}$$

where

$Q_{H;nd;tz,i}$ is the heating needs for thermal zone tz,i calculated according to module M2.2.

d) the recoverable losses to the thermal zone calculation $Q_{W;sys;ls;rbl;tz,i}$ are set to 0.

$$Q_{W;sys;ls;rbl;tz,i} = 0 \tag{12}$$

If the holistic method is selected then:

a) the recoverable losses for each thermal zone tz,i $Q_{W;sys;ls;rbl;tz,i}$ are given by Formula (9);

b) the heating system output for each thermal zone is calculated with

$$Q_{H;sys;out;tz,i} = Q_{H;nd;tz,i} \tag{13}$$

6.5.2.2 Heating system zoning

Before starting the calculation the heating system zoning has to be done (see Clause Heating system zoning).

In the holistic hourly method the heating emission useful output is calculated according to M3-5 (Emission and control) by using the thermal model from M2-2. To calculate the emission useful output the set point temperature is increased by the temperature difference related to the heating emission sub-system.

Therefore before dispatching the heating emission sub-system useful output to the heating system zones the calculation shall be made first in the thermal zone.

Simplification if thermal zones and heating system zones are different

As a simplification, the heat emission output will be calculated with the maximum corrected set-point temperatures of the main emission system.

$$\vartheta_{\mathrm{H;set;crt}} = MAX_i\left(\vartheta_{\mathrm{H;set;crt;em},i}\right) = MAX_i\left(\vartheta_{\mathrm{H;set;HSZ},i} + MAX_j\left(\Delta\vartheta_{\mathrm{ctr;em},j}\right)\right) \tag{14}$$

Note: This simplification leads to a higher emission output compare to the case where the thermal zone is identical to the heating system zone

The useful emission output is first calculated by taking into account only the main emission system for the increase of the temperature in the thermal module M2-2.

The useful emission output is calculated for each thermal zone and then distributed to the heating system zones belonging to each thermal zone according to equation (distribution rule)::

$$Q_{\mathrm{H;em;main,HSZ},i\mathrm{;out}} = \frac{X_{\mathrm{HSZ},i}}{X_{\mathrm{HZ}}} Q_{\mathrm{H;em;\ out;\ main}} \tag{15}$$

where

X is a building property specified according to the template given in Table A.1. A default specification is given in Table B.1.

6.5.3 Heating system control

6.5.3.1 Heating system operating time

For the hourly method the system or sub-system operating time will be calculated depending on the calculation period (e.g. heating season), the operating schedules and the BACS function.

For the monthly method the operating time is a scheduled feature, i.e. input data. The bin method is useful to determine part load operation and ability to provide the required heat of special generators (heat pumps).

The operating time, including the criteria to run the system as a whole (heating season) shall be specified in a table complying with the format specified by Table A.5 in Annex A. A default specification is given in Table B.5 in Annex B.

6.5.3.2 Heat emitter priority (load dispatch) and power check

If several emitters are installed in the same heating system zone then the priority has to be defined according to the template given in Table A.7. A default specification is given in table B.7.

The next step in the calculation procedure is to check if the emission system can provide the expected energy. The calculation of M3-5 give the actual energy that the emission sub-system $Q_{H;em;act}$ is able to provide to the heating system zones.

This actual energy may be lower than the energy expected. If that is the case, the backup system may be called as follows:

$$Q_{\mathrm{H;em;back;out}} = Q_{\mathrm{H;em;\ out;exp}} - Q_{H;em;act} \qquad (16)$$

Where

$Q_{H;em;back;out}$	is the energy provide by the backup emission system
$Q_{H;em;out;exp}$	is the energy expected by the heating system zone
$Q_{H;em;act}$	is the energy that the main emission system is able to provide

If the provided energy is not sufficient, then the system is considered as undersized. Different possibilities are given to deal with a lack of energy supply:

— to add the missing energy production to the sub-system output (emission) of the next time step. If the sub-system is not able to provide the requested energy after a defined number of time steps, then the calculation is stopped and the sizing of the generation sub-system should be reviewed by the designer,

— to calculate the variation of the internal temperature. In that case the final temperature has then to be calculated in M2.2.

This simplified calculation is based on the hypothesis that the temperature variation of the backup emission systems is the same as those of the main systems to avoid to recalculate the expected emission output again with the thermal model.

6.5.3.3 Heating system emission circuits temperatures and flow rate calculation

For each heating emission circuit i, calculate:

— the required emitter supply (flow) temperature $\vartheta_{H;em,i;flw;req}$;

— the emitter return temperature $\vartheta_{H;em,i;ret}$;

— the required circuit supply (flow) temperature $\vartheta_{H;cr,i;flw;req}$;

— the circuit return temperature $\vartheta_{H;cr,i;ret}$;

— the emission flow rate $V'_{H;cr,i}$;

— the load factor $\beta_{H;em,i}$.

using the calculation module specified according to the template given in Table A.6. A default specification is given in Table B.6.

The same procedure applies for:

— domestic hot water preparation;

— AHU circuits calculation;

— Absorption cooling generators circuits calculation.

The calculation is described in Annex C. This module M3.9 requires three inputs:

1 The control identifier HEAT_EM_CTRL_DEF

2. The emission input $Q_{H;ctr;in}$

3. The time step time average indoor air temperature $\vartheta_{int;avg}$

6.5.3.4 Distribution calculation, auxiliaries and recoverable losses

The distribution module in EN 15316-3 describes the two pipes system. It requires the following operating conditions.

1. The input temperature of the heating circuit ϑH;in;

2. The output temperature of the heating circuit ϑH;out;

3. The mass flow rate $\dot{V}_H$;

4. The time step time average indoor air temperature.

The inputs come for M3.9 and M2.2.

NOTE To keep the balance of operating conditions and to simplify calculations, distribution losses are accounted for as an increase of flow rate instead of an increase of the temperature difference between flow and return.

6.6 Nodes calculation

6.6.1 General

The node calculation sequence is the following steps:

1) ∑load circuit;

2) $\vartheta_{node\ supply}$;

3) $\vartheta_{feeding\ return}$;

4) $Q_{node\ loss}$;

5) $Q_{\text{node input}}$;

6) $Q_{\text{node mass flow rate}}$.

If the distribution includes intermediate nodes and branching, equations of this clause can be used repeatedly.

6.6.2 Node output energy flow (load circuits)

The node energy output is the sum of the connected load (distribution) circuits. The total heat requirement of the connected load circuits $\Sigma_i Q_{X;disi;in}$ shall equal the total output of the connected sources $Q_{X;nod;out}$:

The node energy output is given by:

$$Q_{X;nod;out} = \sum_i Q_{X;dis,i;in} \tag{17}$$

where

$Q_{X;dis,i;in}$ are the energy inputs to the load circuits i (e.g. emitters, DHW, AHU) connected to the node;

For domestic hot water, the connected distribution circulation loops (dloop) and the final distributions (dfin) may be directly connected to the node.

NOTE X is used to indicate any of space heating, domestic hot water heating or other building services requiring heat from a generation subsystem.

6.6.3 Node supply (flow) temperature

Calculate the minimum node supply (flow) temperature $\vartheta_{X,nod,flw,min,,i}$, as the maximum temperature of connected load circuits temperatures and source (e.g. generation) temperatures.

$$\vartheta_{X;nod;flw;\min,i} = \max\left(\vartheta_{X;ld,i;in;flw}; \vartheta_{X;sc,in;flw}\right) \tag{18}$$

Where

$\vartheta_{X;ld,i;in;flw}$ is the supply (flow) temperature of load circuit i

$\vartheta_{X;sc,i;in;flw}$ is the supply (flow) temperature of source (feeding) circuit i

If alternate operation (e.g. Heating and DHW) is required there may be two different settings (separate calculation for space heating and DHW). If there is DHW priority, calculate first the node with the DHW characteristics and then with the space heating characteristics.

6.6.4 Node return temperature

The return temperature and the mass flow are calculated to maintain the energy balance. They depend on the generation control.

The node return temperature is calculated ignoring the feeding distribution losses. These could be later compensated by an increase in flow rate in order to keep the energy balance right.

Calculate node return temperature $\vartheta_{X;nod;ret}$ as

$$\vartheta_{X;nod;ret} = \vartheta_{X;nod;flw} - \frac{\sum_i Q_{X;nod;out}}{c_{p,w} \cdot \sum_i t_{X;dis,i} \cdot V'_{X;dis,i}} \tag{19}$$

where

$t_{X;dis,i}$ are the operating times of connected distribution circuits

$V'_{X;dis,i}$ are the flow rates of the connected distribution circuits

For domestic hot water nodes there is no return temperature.

6.6.5 Node losses

Node losses $Q_{X;nod;ls}$ consist of:

— any storage losses attached to the node and calculated according to M3-7;

— the distribution losses of the node itself, that may be calculated according M3-6.

NOTE Heat losses of the physical node (i.e. headers) can be neglected in the calculation or incorporated in the losses of the distribution section that supplies heat to the node.

The storage losses will be calculated directly in the storage sub-module.

6.6.6 Node gains

For the monthly method node gains $Q_{X;nod;gns}$ consist of the contribution of any thermal solar or other generation system that provides heat to the node and is calculated separately according to the relevant module.

EXAMPLE Thermal solar sub-system connected to a domestic hot water storage.

6.6.7 Node input (feeding circuit)

The node energy input is given by:

$$Q_{X;nod;in} = Q_{X;nod;out} + Q_{X;nod;ls} - Q_{X;nod;gns} \quad (20)$$

NOTE $Q_{X;nod,ls}$ can take into account the losses of a storage tank or buffer in the node.

6.6.8 Node input mass flow rate

$$V'_{X;nod} = \frac{Q_{X;nod;in}}{c_{p,w} \cdot \left(\vartheta_{X;nod;flw} - \vartheta_{X;nod;ret}\right) \cdot t_{X;nod;i}} \quad (21)$$

where

$t_{X;nod;i}$ is the operation time of the node supply.

6.7 Generation sub-system calculation

6.7.1 Heat generator dispatch sequence

6.7.1.1 General

The dispatch of the load among generators shall be done according the defined priorities, relevant operating conditions (e.g. any limitation according to external temperature) and services. Generators may contribute to heating, domestic hot water or both with priority (alternate) or simultaneous (parallel) production.

The generator dispatch is based first on the service dispatch (service operating mode) and then on the multi generator dispatch (generator operating mode).

6.7.1.2 Generation dispatch

Generator dispatch is comparable to a node calculation.

At first, the total required energy $Q_{X;nod;in}$ and the node properties $\vartheta_{X;nod;flw}$, $\vartheta_{X;nod;ret}$ are calculated according to 6.6. Then the node input is allocated to the feeding generators according to the following.

6.7.1.3 Alternate control

If control is alternate, the services shall be prioritized. For example,

1) dhw;

2) heating;

3) cooling;

Inside a service, the generators shall be also be prioritized. For example:

1) DHW

    a) solar thermal;

    b) boiler;

2) heating;

    a) chp;

    b) boiler.

Consider the priority order specified in a table compliant with the template given in Table A.9. A default priority is given in Annex B, Table B.9.

For each generator in the sequence, by starting by the first generator according to the priorities defined in the control strategies, calculate:

— pass to the next generator j in the sequence the remaining required energy output $Q_{X;gen,j;out;req}$.

$$Q_{X;gen,j;out;req} = Q_{X;nod;in} - \sum_{k=1...j-1} Q_{X;gen;out;k} \tag{22}$$

When calculating the first generator (i.e. k = 1) then

$$Q_{X;gen,1;out;req} = Q_{X;nod;in} \tag{23}$$

— receive from each generator j the maximum energy that can be supplied $Q_{X;gen,j;out;max}$;

— Calculate the required output from generator j $Q_{X;gen,j;out}$ with

$$Q_{X;gen,j;out} = \min\left(Q_{X;nod;in} - \sum_{k=1...j-1} Q_{X;gen,k;out} ; Q_{X;gen,j;\max} \right) \tag{24}$$

until the sequence ends (all required energy supplied or last available generator).

6.7.1.4 Parallel control

If control is parallel, the required energy is sum over for all service, and dispatched to the generators proportionally to the maximum available output.

$$Q_{X;gen,j;out} = Q_{X;nod;in} \cdot \frac{Q_{X;gen,j;out;\max}}{\sum_k Q_{X;gen,k;out;\max}} \quad (25)$$

As a simplification, the required ouput can be split according to the nominal power of the generators

$$Q_{X;gen,j;out} = Q_{X;nod;in} \cdot \frac{\Phi_{X;gen,j;n}}{\sum_k \Phi_{X;gen,k;n}} \quad (26)$$

6.7.2 Generation sub-system operating conditions calculation

The total flow rate of the node $V'_{X;nod;in}$ is allocated to each generator circuit proportionally to the heat output. For each generator i, the circuit flow rate $V'_{X;gen;cr}$ is given by:

$$V'_{X;gen;cr;i} = V'_{X;nod;in} \cdot \frac{Q_{X;gen;out;I}}{\sum_k Q_{X;gen;out;k}} \quad (27)$$

For each heat generation circuit i, calculate:

— the generator supply (flow) temperature $\vartheta_{H;gen,i;flw}$;

— the generator return temperature $\vartheta_{H;gen,i;ret}$;

by using the calculation module specified according to the template given in Table A.8. A default specification is given in Table B.8.

The calculation modules are defined in Annex D.

6.7.3 Generation input calculation

For each generator i, calculate:

— the required energy input (fuel or electricity) $E_{X;gen,i;in}$;

— the required auxiliary energy $W_{X;gen,i;aux}$;

— the recoverable losses $Q_{X;gen,i;ls;rbl;z}$;

— the location of recoverable losses according to thermal zones $TH\_ZONE_{X;gen,i;rbl;z}$;

according to the relevant sub-module M8-8-X, and with the specific operating conditions $\vartheta_{H;gen,i;flw}$ and $\vartheta_{H;gen,i;ret}$.

6.8 Generation input per energy carrier and per service

6.8.1 General

This standard provides the generation input per energy carrier and per service to EN 52000-1 (M1-9) for the primary energy calculation in order to calculate the overall Energy performance indicator.

The dispatch depends on the control.

6.8.2 Alternate control

If control is alternate, then each output of M3.8 and/or M8.8 is directly related to a service.

6.8.3 Parallel control

If control is parallel, the generator output is divided proportionally to the energy required by the node (which is per service) as follows. The generation input per service X and per energy carrier cr,j is given by:

$$E_{X;gen;in;cr,j} = \sum_{Y,k} E_{Y;gen;in;k;cr,j} \cdot \frac{\sum_k E_{X;gen,k;out}}{\sum_{Y,k} E_{Y;gen;out;k}} \quad (28)$$

6.9 Auxiliary energy

6.9.1 Calculating the auxiliary energy of all sub systems

This standard provides the auxiliary energy of space heating, DHW and other connected systems (e.g. AHU) to EN 52000-1 (M1-9) for the primary energy calculation in order to calculate the overall Energy Performance indicator.

This standard sums up the auxiliary energy of all the related sub-systems. The auxiliary energy $W_{X;aux}$, shall be calculated as follows:

$$W_{X;aux} = \sum W_{X;em;aux,i} + \sum W_{X;dis;aux,j} + \sum W_{X;sto;aux,k} + \sum W_{X;gen;aux,l} \quad (29)$$

where

$W_{X;em;aux}$	is the auxiliary energy of related emission subsystem;
$W_{X;dis;aux}$	is the auxiliary energy of the related distribution subsystem;
$W_{X;sto;aux}$	is the auxiliary energy of the related storage subsystems;
$W_{X;gen;aux}$	is the auxiliary energy of the related generation subsystem.

6.9.2 Distribution rules auxiliary energy

During the heating season the auxiliary energy of the generator are not proportional for heating and DHW. In alternate mode the operation time for heating during a day is less the running time for DHW. So the auxiliary energy depends on those operation times. Those influence is considered in the relevant standards. For the monthly method this approach could be used.

The auxiliaries are dispatched in a slightly different way from the generation input to avoid a zero denominator.

$$W_{X;gen;aux} = \frac{\sum_k Q_{X;gen;out;k}}{\sum_{Y,k} Q_{Y;gen;out;k}} \sum_{\mathrm{i}} W_{gen;aux,i} \quad (30)$$

If the generation output is zero, dispatch equally on the number of the operating services.

6.10 Recoverable system thermal losses

6.10.1 Calculating the recoverable thermal losses of all sub systems

The thermal losses that are already taken into account in the related sub-systems (e.g. recovered combustion losses for combustion air preheating in the combustion boiler standards) are not considered here.

System thermal losses are not recoverable for space heating if they are not in the heated space or if they occur outside the heating season.

In this standard the recoverable system thermal losses of all the services and sub-systems, $Q_{X,ls;rbl}$ are summed up per thermal zone. The recoverable losses shall be associated with their locations in the different thermal zones z. The sum of all $Q_{X,ls;rbl}$ per thermal zone shall be calculated as follows:

$$\sum Q_{X;ls;rbl,z} = \sum Q_{X;em;ls;rbl,z,i} + \sum Q_{X,dis,ls;rblz,i} + \sum Q_{X;sto;ls;rbl,z,i} + \sum Q_{X;gen;ls;rbl,z,i} \quad (31)$$

where

$Q_{X;em;ls;rbl,z}$ is the recoverable system thermal losses of the related emission sub-system in thermal zone z;

$Q_{X;dis;ls;rbl,z}$ is the recoverable system thermal losses of the related distribution sub-system in thermal zone z;

$Q_{X;sto;ls;rbl,z}$ is the recoverable system thermal losses of the related storage sub-system in thermal zone z;

$Q_{X;gen;ls;rbl,z}$ is the recoverable system thermal losses of the related generation sub-system in thermal zone z;

The same procedure applies for recoverable auxiliary.

The recoverable heat includes contributions from both system losses and auxiliary energy. These contributions may be summed in the subsystem modules

6.10.2 Distribution rules recoverable losses

The following situations may occur:

1. The thermal zone where the recoverable losses occur is known;

2. The thermal zone where the recoverable losses occur is unknown;

All recoverable losses to known thermal zones are summed together.

All recoverable losses to an unknown thermal zone are dispatched according to a distribution rule.

$$Q_{X;sys;ls;rbl;tz,i} = \sum_{X,Y,j} Q_{X;Y,j;ls;rbl;tz,i} + \sum_{X,Y,j} Q_{X;Y,j;ls;rbl;tz,0} \cdot \frac{X_{tz,i}}{\sum_k X_{tz,k}} \quad (32)$$

This equation includes both localized recoverable heat losses and un-localized recoverable heat losses (index tz,0) distributed according to parameter X. Parameter X may be area, volume or other properties of the building. This option shall be specified according to the template given in Tables A.1 and A.2. Default options are given in Tables B.1 and B.2).

Domestic hot water recoverable losses that were already accounted in 6.5.2.1 shall not be accounted again.

7 Energy efficiency indicators of space heating and domestic hot water systems or sub-systems

The boundaries for the balance of the sub system are defined in the related sub system standards.

The system performance indicators are defined by the ratio of the energy output (useful energy) on the energy input (requested energy) of technical sub-systems or of the technical building system.

In order to add thermal and electrical energy the electrical energy is multiplied by a conventional total primary energy factor of 2,5.

NOTE This method and value is comparable to ecodesign standards to get comparable efficiencies as an indicator. If the total primary energy factor is linked to the values provided in M1–9 then the comparability is lost because depending on the national primary energy factors.

The energy efficiency η of a subsystem i and per calculation interval is defined as:

$$\eta_i = \frac{Q_{i,out} + f_i \cdot E_{el,i,out}}{Q_{i,in} + f_i \cdot W_{i,aux}} \qquad (33)$$

where

f_{i}	is the energy conversion factor (2,5);
$E_{\mathrm{el,i,out}}$	is the electricity output of sub-system i ;
$Q_{\mathrm{i,\ out}}$	is the heat output of sub-system i ;
$Q_{\mathrm{i,\ in}}$	is the heat input of sub-system i ;
	NOTE For heat pump the heat input to the evaporator is not counted. In that case the result is the annual COP;
$W_{\mathrm{i;aux}}$	is the auxiliary energy of sub-system i.

Formula (31) is a general equation. Not all parameters apply for every type of sub-system.

The energy input, energy output, auxiliary energy and produced electricity per calculation interval are summed up to get monthly, seasonal and yearly values. The efficiencies can be calculated per system or per sub-system (e.g. distribution efficiency, emission efficiency, generation efficiency).

Another way of expressing the energy performance of a system or subsystem is the expenditure factor, ε.

The expenditure factor ε is the reciprocal value of the efficiency.

Annex A
(normative)

Template for the specification of application data

It should be indicated if the proposed values in the annexes are:

— best practice values;

— average values (common practice);

— conservative values;

— penalty values.

The choices (i.e. why such type of values has been included) shall be documented.

Coordination is essential to ensure a maximum of consistency of choices over different technologies, to create a level playing field.

Table A.1 — Heating zoning criteria

1) Simplifications
Grouping allowed:
2) Heating system zoning needed
•
•
3) Allocation rules
Sub-division criteria (needs):
Distribution criteria (recoverable losses):

Table A.2 — Domestic hot water zoning criteria

1) Simplifications
Grouping allowed:
2) Domestic hot water system zoning needed
•
•
3) Allocation rules
Sub-division criteria (needs):
Distribution criteria (recoverable losses):

Table A.3 — Domestic hot water system operating schedules

Description	Circulation loop	…	Back-up heater (Storage)	…	Generator
Symbol	$t_{W;dloop;ON,ci}$		$t_{W;sto;bu;ON,ci}$		$t_{W;gen;ON,ci}$
Unit	h		h		h
BAC Identifier	**IF DHW_CIRC_CTRL = 0 then**		**IF DHW_STO_CTRL = 0 then**		**IF HEAT_ DHW_GEN_CTRL = 0 then**
Monthly calculation interval					
Typical hourly schedules (possibly not for all days)					
BAC Identifier	**IF DHW-CIRC-CTRL = 1 then**		**IF DHW_STRG_CTRL = 1 then**		**IF HEAT_ DHW_GEN_CTRL = 1 then**
…					
BAC Identifier	**IF DHW-CIRC-CTRL = 0 then**				
	All time “1”				

Table A.4 — Domestic hot water operating temperatures

Domestic hot water temperatures	**Symbol**	**Calculation interval**	**Type**	**Value or Origin**
storage	$\vartheta_{W;sto}$	**Monthly**		
circulation loop supply temperature	$\vartheta_{W;dloop}$			
temperature difference circulation loop	$\Delta\vartheta_{W;dloop}$			
storage	$\vartheta_{W;sto}$	**Hourly**		
circulation loop supply temperature	$\vartheta_{W;dloop}$			
temperature difference circulation loop	$\Delta\vartheta_{W;dloop}$			

Table A.5 — Heating system operating time (per building category)

Description	Emission i	...	Distribution i	...	Generator i
Symbol	$t_{H;em,i;ON,ci}$		$t_{H;dis,i;ON,ci}$		$t_{H;gen,i;ON,ci}$
Unit	h		h		h
Calculation period					
Heating season: Start: End:					
Monthly					
	IF HEAT_EM_CTRL_DEF = 0 then		**IF HEAT_DIS_CTRL_TMP = 0 then**		**IF HEAT_GEN_CTRL = 0 then**
...					
Hourly schedules (possibly not for all days)					
	IF HEAT_EM_CTRL_DEF = 1 then		**IF HEAT_DIS_CTRL_TMP = 1 then**		**IF HEAT_GEN_CTRL = 1 then**
...					

Table A.6 — Space heating operating water temperature calculation method selection

Circuit description	**Emitter type**	**Control type**	**Method**	**Ref. clause**
Space heat emitters	Radiator Panels	Heating curve		

Table A.7 — Emitter priority table (example)

Emitter operating	Simultaneously or in priority	Control Identifier
Emitter priority table		
Emitter	**Priority**	
Emitter 1 (e.g. floor heating system)		
Emitter 2 (e.g. electrical radiator)		

Table A.8 — Space heating operating water temperature calculation method selection - generation

Circuit description	**Control type**	**Method**	**Ref. clause**
Heat generator direct connection			

Table A.9a — Multiservice priority and operation mode selection

Dispatch	Operating mode	Control identifier
Per service		
Generator operating		

Table A.9 b — Default service priority table

Service	Service priority
Domestic hot water	
Space heating	
Other services	

Table A.9c — Default generator priority table (per service)

Generator type	Other services	Space heat priority	DHW priority

The references, identified by the module code number, are given in a table complying with the format given in Table A.10

Table A.10 — References

Reference	Reference document	
	Number	Title
M1–9		
M2–2		
M3–5		
M3–6		
M3–8-x		
M3–7 M8–7		
M8–2		

Table A.11 — Identifier of the type of emitter circuit

Code	*Description*	*Reference*
EM_CIRCUIT_TYPE_XXXXX.		
…		

Table A.12 — Identifier of the type of generation circuit

Code	*Description*	*Reference*
GEN_CIRCUIT_TYPE_XXXXX		
…		

Table A.13 — Template for the specification of values for $f_{W;rbl;rh}$

Description	*value*
………	…

Table A.14 — Default properties of space heating emitters

Description	Emitter nominal Δϑ air $\Delta\theta_{H,em,air}$ °C	Emitter exponent n $n_{H;em}$ -	Emitter nominal Δϑ water $\Delta\theta_{H,em,w}$ °C
…	…	…	…

Table A.15 — Default input data for emission circuits module (Annex C)

Description	Symbol	Unit	Value
Maximum flow temperature	$\theta_{H;em;flw;max}$	°C	…
Maximum Δθ flow / return	$\Delta\theta_{H;em;w;max}$	°C	…
Target return temperature	$\theta_{H;em;ret;req}$	°C	…
Mixing valve temperature overhead	$\Delta\theta_{H;em;mix}$	°C	…
Desired load factor with ON-OFF	$\beta_{H;em;req}$	%	…
Minimum flow temperature	$\theta_{H;em;flw;min}$	°C	…

Table A.16 — Default input data for generation circuits module (Annex C)

Description	Symbol	Unit	Value
Nominal Δθ flow / return	$\Delta\theta_{H;gen;w;n}$	°C	…

Annex B
(informative)

Default application data

The proposed values in the annexes are conservative values.

According to the following criteria a heating system zone has to be defined. Heating zoning is not needed for emission and distribution sub-systems if these systems cover less than a defined % of the useful floor area of the heating installation (see Table B.1).

Table B.1 — Heating zoning criteria

1) Simplifications
Grouping allowed: < 20 ¨% (% useful building or building unit floor area)
2) Heating system zoning needed
• Per building category
• Per heating emission sub-system
3) Allocation rules
Sub-division criteria (needs): Useful floor area of heating system zone
Distribution criteria (recoverable losses)**:** Useful floor area of thermal zone

According to the following criteria a Domestic hot water system zone has to be defined. Domestic hot water zoning is not needed if these systems cover less than a defined % of the useful floor area of the heating installation (see Table B.2).

Table B.2 — Domestic hot water zoning criteria

1) Simplifications
Grouping allowed: < 20 ¨% (% useful building or building unit floor area)
2) Domestic hot water system zoning needed
• Per building category
• domestic hot water system configuration (centralized, decentralised systems)
3) Allocation rules
Sub-division criteria (needs): Useful floor area of heating system zone
Distribution criteria (recoverable losses)**:** Useful floor area of thermal zone

Table B.3 — Domestic hot water system operating schedules

Description	Circulation loop	…	Back-up heater (Storage)	…	Generator
Symbol	$t_{W;dloop;ON,ci}$		$t_{W;sto;bu;ON,ci}$		$t_{W;gen;ON,ci}$
Unit	h		h		h
BAC Identifier	**IF DHW_CIRC_CTRL = 0 then**		**IF DHW_STO_CTRL = 0 then**		**IF HEAT_ DHW_GEN_CTRL = 0 then**
Monthly calculation interval	Calculate t_{eff} according bin method		Calculate t_{eff} according bin method		Calculate t_{eff} according bin method
Typical hourly schedules (possibly not for all days)					
BAC Identifier	**IF DHW-CIRC-CTRL = 1 then**		**IF DHW_STRG_CTRL = 1 then**		**IF HEAT_ DHW_GEN_CTRL = 1 then**
6.00 – 7.00	1		1		1
7.00 – 8.00	1		1		1
8.00 – 9.00	0		1		1
…					
BAC Identifier	**IF DHW-CIRC-CTRL = 0 then**		**IF DHW-CIRC-CTRL = 0 then**		**IF DHW-CIRC-CTRL = 0 then**
	All time “1”		All time “1”		All time “1”

Table B.4 — Domestic hot water operating temperatures

Domestic hot water temperatures	**Symbol**	**Calculation interval**	**Type**	**Value or Origin**
storage	$\vartheta_{W;sto}$	**Monthly**	CONST	**IF DHW_STO_TEMP = 0 then** 60 °C
circulation loop supply temperature	$\vartheta_{W;dloop}$		CONST	**IF DHW_CIRC_CTRL = 0 then** 60 °C
temperature difference circulation loop	$\Delta\vartheta_{W;dloop}$		CONST	5 K
storage	$\vartheta_{W;sto}$	**Hourly**	CONST	**IF DHW_STO_TEMP = 0 then** 60 °C
circulation loop supply temperature	$\vartheta_{W;dloop}$		CONST	**IF DHW_CIRC_CTRL = 0 then** 60 °C
temperature difference circulation loop	$\Delta\vartheta_{W;dloop}$		CONST	5 K

NOTE In this version of the standard the DHW temperatures are assumed to be constant (this temperature e.g. 60°C, is an imput data). Varying temperatures depending on operating conditions can be calculated in related modules (e.g. storage) or in control modules.

Table B.5 — Heating system operating time (per building category)

Description	Emission i	...	Distribution i	...	Generator i
Symbol	$t_{H;em,i;ON,ci}$		$t_{H;dis,i;ON,ci}$		$t_{H;gen,i;ON,ci}$
Unit	h		h		h
Calculation period	Year		Year		Year
Heating season: Start: 1st of October End: 1st of April					
Monthly					
	IF HEAT_EM_CTRL_DEF = 0 then		**IF HEAT_DIS_CTRL_TMP = 0 then**		**IF HEAT_GEN_CTRL = 0 then**
Jan	744		744		744
Feb	672		672		672
...					
Hourly schedules (possibly not for all days)					
	IF HEAT_EM_CTRL_DEF = 1 then		**IF HEAT_DIS_CTRL_TMP = 1 then**		**IF HEAT_GEN_CTRL = 1 then**
6.00 – 7.00	1		1		1
7.00 – 8.00	1		1		1
8.00 – 9.00	0		1		1
...					
Other typical schedules					
ALL	24/24		24/24		24/24
ALL	5/7		5/7		5/7

Table B.6 — Space heating operating water temperature calculation method selection – emission

Circuit description	**Emitter type**	**Control type**	**Method**	**Ref. clause**
Space heat emitters	Radiator Panels	Heating curve	**IF HEAT_EM_CTRL_DEF = 1 then Module V-Tp / C_Mf**	**C.2**

The BACS function has to be coordinated (adapted) to the calculation methods taking also into account the distribution systems configuration.

Table B.7 — Emitter priority table (example)

Emitter operating	Simultaneously or in priority	Control Identifier
Emitter priority table		
Emitter	**Priority**	
Emitter 1 (e.g. floor heating system)	1	
Emitter 2 (e.g. electrical radiator)	2	

Table B.8 — Space heating operating water temperature calculation method selection - generation

Circuit description	**Control type**	**Method**	**Ref. clause**
Heat generator direct connection	constant	**IF HEAT_GEN_CTRL_CD = 1 then** **Module "Direct"**	D.1

Table B.9a — Multiservice priority and operation mode selection

Dispatch	**Operating mode**	**Control identifier**
Per service	Priority (alternate)	OPM-PRI
Generator operating	Priority (alternate)	OPM -PRI

Table B.9b — Default service priority table

Service	**Service priority**
Domestic hot water	1
Space heating	2
Other services	3

Table B.9c — Default generator priority table (per service)

Generator	**Other services**	**Space heat priority**	**DHW priority**
Thermal solar	1	1	1
Cogenerator	2	2	
Heat pump	3	3	
Combustion boiler, biomass	4	4	
Combustion boiler, other fuel than biomass	5	5	2

Table B.10 — References

Reference	Reference document	
	Number	Title
M1–9	EN ISO 52000-1	Energy performance of buildings – Overarching EPB assessment – Part 1: General framework and procedures
M2–2	prEN ISO 52016	Energy performance of buildings — Calculation of energy use for space heating and cooling
M3–5	EN 15316–2	Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 2: Space emission systems (heating and cooling), Module M3-5, M4-5
M3–6	EN 15316–3	Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 3: Space distribution systems (DHW, heating and cooling), Module M3-6, M4-6, M8-6
M3–8-x	EN 15316–4-x	Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 4-1: Space heating and DHW generation systems, combustion systems (boilers, biomass), Module M3-8-1, M8-8-1
M3–7 M8–7	EN 15316–5	Energy performance of buildings - Method for calculation of system energy requirements and system efficiencies - Part 5: Space heating and DHW storage systems (not cooling), M3-7, M8-7
M8–2	EN 12831–3	Energy performance of buildings - Method for calculation of the design heat load - Part 3: Domestic hot water systems heat load and characterisation of needs, Module M8-2, M8-3

Table B.11 — Identifier of the type of emitter circuit

Code	*Description*	*Reference*
EM_CIRCUIT_TYPE_CONST_FLW	Constant flow	C.2
EM_CIRCUIT_TYPE_VAR_FLW	Variable flow	C.3
EM_CIRCUIT_TYPE_ON_OFF	ON-OFF	C.4
EM_CIRCUIT_TYPE_BY_PASS	By bass	C.5

Table B.12 — Identifier of the type of generation circuit

Code	*Description*	*Reference*
GEN_CIRCUIT_TYPE_DIRECT	Direct connection	D.1
GEN_CIRCUIT_TYPE_INDEP	Independent flow	D.2

Table B.13 — Default values for $f_{W;rbl;rh}$

Description	*value*
All building categories	0,8

Table B.14 — Default properties of space heating emitters

Description	Emitter nominal Δϑ air $\Delta\theta_{H,em,air}$ °C	Emitter exponent n $n_{H;em}$ -	Emitter nominal Δϑ water $\Delta\theta_{H,em,w}$ °C
Radiator	50	1,3	20
Floor heating	15	1,1	5
Fan-coil	25	1	10
Special option 1	30	1,2	10
Last option	50	1,3	10

Table B.15 — Default input data for emission circuits module (Annex C)

Description	Symbol	Unit	Value
Maximum flow temperature	$\theta_{H;em;flw;max}$	°C	90
Maximum Δθ flow / return	$\Delta\theta_{H;em;w;max}$	°C	20
Target return temperature	$\theta_{H;em;ret;req}$	°C	20
Mixing valve temperature overhead	$\Delta\theta_{H;em;mix}$	°C	2
Desired load factor with ON-OFF	$\beta_{H;em;req}$	%	80
Minimum flow temperature	$\theta_{H;em;flw;min}$	°C	
Fan coil			50
Unit heaters			50
Other emitters			20

Table B.16 — Default input data for generation circuits module (Annex C)

Description	Symbol	Unit	Value
Nominal Δθ flow / return	$\Delta\theta_{H;gen;w;n}$	°C	20

Annex C
(normative)

Heating circuit calculation modules

C.1 General

Each module is designed to describe one hydraulic circuit type.

Each type of module is identified by a unique identifier.

Table C.1 — Heating circuit modules and identifiers

Module description (control parameter first)	**Module identifier**	**Suitable emitters**	**Control options**
varying **temperature** (constant mass flow)	CONSTV	Radiator Panels	Heating curve, mixing valve, variable generation temperature
Varying **mass flow** (constant temperature)	VARV	Radiator Panels Heating coils	Thermostatic valve, flow rate control with two way valve
ON-OFF and varying temperature	ONOFFV	Radiators, panels	On-Off control
Varying heat exchange	BYPASS	Fan-coil, heating coil with	emitters with on-off blower and continuous circulation, 3 way by-pass valve control

Emitters type list and control options list shall be coordinated with M3-5.

Using these modules in a system with several circuits connected to a node requires the following procedure:

— calculate the minimum required flow temperature of each circuit i connected to the node $\theta_{H;cr;flw;req,i}$;

— the actual flow temperature as the maximum amongst circuits connected to the same node

$$\theta_{H,cr,flw} = \max\left(\theta_{H,cr;flw;req,i}\right) \quad \text{(C.1)}$$

— calculate the actual operating condition for each circuit.

All modules allow the use of a mixing valve to allow different temperatures in the different circuits.

A distinction is made between:

— the emitter temperatures and flow rate;

— the circuit temperatures and flow rate.

They differ when there is a mixing or by-pass 3 way valve in the circuit.

Also, the temperature for the distribution heat loss calculation can be the emitter or the circuit temperature, depending on the position of the 3 way valve.

Sizing criteria are control parameters that has to be set to describe the operation of the circuit. They differ for each type of circuit. Default values are given in the tables.

NOTE For some circuit type, a mixing valve may be required. If it is required for consistency, a warning is issued and the calculation is forced to consider the mixing valve (otherwise the solution is unreal).

C.2 Constant flow rate and variable temperature module

C.2.1 General

C.2.1.1 Application

— Radiators and heating curve;

— Embedded panels and heating curve.

C.2.1.2 Control parameters

— Flow / return $\Delta\theta$

The circuit may be with mixing valve or varying boiler setting

C.2.1.3 Reference diagram

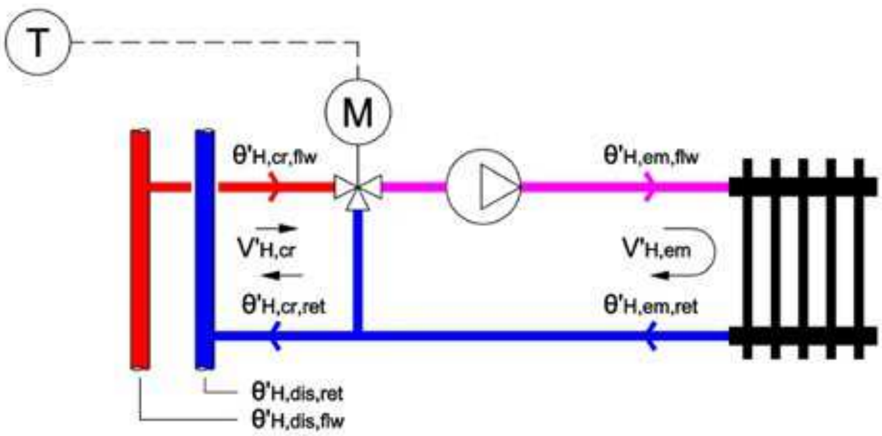


Figure C.1 — Sample heating circuit with varying temperature and constant flow, with mixing valve

C.2.2 Output data

Table C.2 — Output data

Description	Symbol	Units
Circuit flow temperature	$\theta_{H;cr;flw}$	°C
Circuit return temperature	$\theta_{H;cr;ret}$	°C
Circuit flow rate	$V'_{H;cr}$	m^3/h
Distribution flow temperature	$\theta_{H;dis;flw}$	h
Distribution return temperature	$\theta_{H;dis;ret}$	°C
Emission load factor	$\beta_{H;em}$	-
Minimum required flow temperature	$\theta_{H;em;flw;min}$	°C

C.2.3 Input data

Table C.3 — Input data

Description	Symbol	unit	Origin	Default	Acceptable
Product data					
Nominal (rated) emitter power	$\Phi_{H;em;n}$	kW	Heat load or custom input	1,0 x heat load	0,8…4 × heat load
Nominal Δθ water to air	$\Delta\theta_{H,em,air}$	°C	Default according to emitter type or input	See Table B.14	1…70
Emitter exponent	$n_{H;em}$		Default according to emitter type or input	See Table B.14	1,0…1,5
System design data					
Mixing valve	MIX_EM	n.a.		See Table B.15	
Process control data					
Design flow return Δθ	$\Delta\theta_{H,em,w}$	°C	Default according to emitter type or input	See Table B.14	2…40
Mixing valve temperature overhead	$\Delta\theta_{H;em;mix}$		Default or input	See Table B.15	0…10
Operating conditions					
Internal temperature	$\theta_{H;int}$	°C	Building calculation		5…25
Emitter heat output	$Q_{H;em;out}$	kWh	Energy calculation		
Operating time	$t_{H;em;on}$	h			
Distribution flow temperature	$\theta_{H;nod;out}$	°C	Maximum of circuits flow temperatures		
Constants					
Water specific heat	C_w	kWh/m^3K		1,16	

C.2.4 Calculation of minimum required temperature

The calculation procedure is described step by step.

Average emitter power $\Phi_{H,em,eff}$ [kW]

$$\Phi_{H,em;eff} = \frac{Q_{H,em,in}}{t_{H,em,on}} \quad (C.2)$$

Nominal flow rate $V'_{H,em,nom}$ [m³/h]

$$V'_{H;em;nom} = \frac{\Phi_{H;em;n}}{\Delta\vartheta_{H;em;n} \cdot c_{w}} \quad (C.3)$$

Actual flow rate $V'_{H,em,eff}$ [m³/h]

$$V'_{H,em,eff} = V'_{H,em,nom} \quad (C.4)$$

Emitter to air temperature difference $\Delta\theta_{H,em,air,eff}$ [°C]

$$\Delta\theta_{H,em,air,eff} = \Delta\theta_{H,em,air} * \left(\frac{\Phi_{H,em;eff}}{\Phi_{H,em;n}}\right)^{\frac{1}{n_{H,em}}} \quad (C.5)$$

Average emitter temperature $\theta_{H,em,avg}$ [°C]

$$\theta_{H,em,avg} = \theta_{H,int} + \Delta\theta_{H,em,air,eff} \quad (C.6)$$

Flow/return temperature difference $\Delta\theta_{H,em,w,eff}$ [°C]

$$\Delta\theta_{H,em,w,eff} = \frac{\Phi_{H,em;eff}}{V'_{H,em,eff} * Cp_{w}} \quad (C.7)$$

Emitter flow temperature $\theta_{H,em,flw}$ [°C]

$$\theta_{H,em,flw} = \theta_{H,em,avg} + \frac{\Delta\theta_{H,em,w,eff}}{2} \quad (C.8)$$

Return temperature $\theta_{H,em,ret}$ [°C]

$$\theta_{H,em,ret} = \theta_{H,em,avg} - \frac{\Delta\theta_{H,em,w,eff}}{2} \quad (C.9)$$

Minimum flow temperature $\theta_{H,em,flw,min}$ [°C]

If MIX_EM = MIX_EM_YES (Mixing valve present) then $\theta_{H,em,flw,min}$ is given by:

$$\theta_{H,em,flw,min} = \theta_{H,em,flw} + \Delta\theta_{H,em,mix} \quad (C.10)$$

otherwise $\theta_{H,em,flw,min}$ is given by:

$$\theta_{H,em,flw,\min} = \theta_{H,em,flw} \quad (C.11)$$

C.2.5 Calculation of actual operating conditions

Check if mixing valve required

If MIX_EM = MIX_EM_NO (missing mixing valve), then if

If $\theta_{H,nod,out} < > \theta_{H,em,flw,min}$

then

MIX_EM = MIX_EM_YES

Circuit flow temperature $\theta_{H,cr,flw}$ [°C]

$$\theta_{H,cr,flw} = \theta_{H,nod,out} \tag{C.12}$$

Circuit return temperature $\theta_{H,cr,ret}$ [°C]

$$\theta_{H,cr,ret} = \theta_{H,em,ret} \tag{C.13}$$

Circuit flow rate (before mixing valve) $V'_{H,cr}$ [m³/h]

$$V'_{H,cr} = \frac{\Phi_{H,em;eff}}{\left(\theta_{H,cr,flw} - \theta_{H,cr,ret}\right) * Cp_w} \tag{C.14}$$

Distribution flow temperature $\theta_{H,dis,flw}$ [°C]

$$\theta_{H,dis,flw} = \theta_{H,em,flw} \tag{C.15}$$

Distribution return temperature $\theta_{H,ret,ret}$ [°C]

$$\theta_{H,dis,ret} = \theta_{H,em,ret} \tag{C.16}$$

NOTE Distribution flow and return temperatures are used to calculate losses. The mixing valve is usually at the beginning of the distribution pipe

Emission load factor $\beta_{H,em}$ [-]

$$\beta_{H,em} = \frac{\Phi_{H,em,eff}}{\Phi_{H,em,n}} \tag{C.17}$$

C.3 Varying mass flow rate and constant temperature module

C.3.1 General

C.3.1.1 Application

— Radiators with thermostatic valve;

— AHU coil with series control;

— Panels with PID control.

C.3.1.2 Control parameters

— Maximum flow/return $\Delta\theta$;

— Maximum flow temperature;

— Target return temperature.

C.3.1.3 Reference diagram

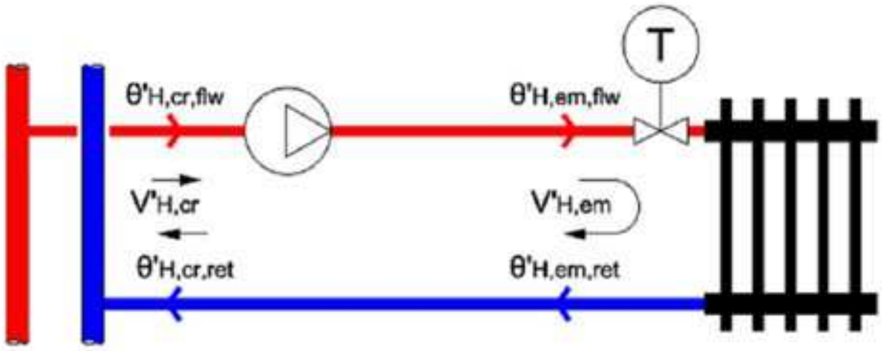


Figure C.2 — Sample heating circuit with varying flow rate

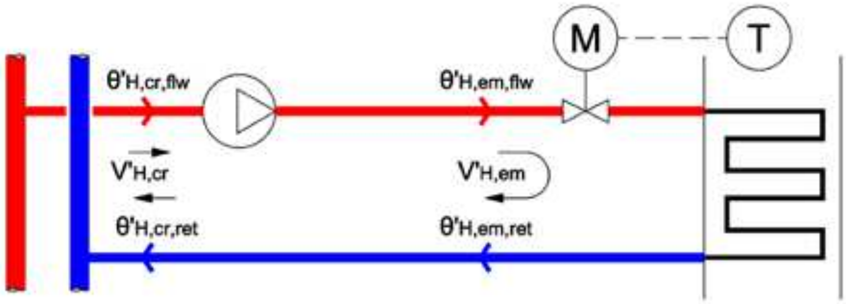


Figure C.3 — Sample heating circuit with series control (AHU coil)

C.3.2 Output data

Table C.4 — Output data

Description	Symbol	Units
Circuit flow temperature	$\theta_{H;cr;flw}$	°C
Circuit return temperature	$\theta_{H;cr;ret}$	°C
Circuit flow rate	$V'_{H;cr}$	m^3/h
Distribution flow temperature	$\theta_{H;dis;flw}$	h
Distribution return temperature	$\theta_{H;dis;ret}$	°C
Emission load factor	$\beta_{H;em}$	-
Minimum required flow temperature	$\theta_{H;em;flw;min}$	°C

C.3.3 Input data

Table C.5 — Input data

Description	Symbol	unit	Origin	Default	Acceptable
Product data					
Nominal (rated) emitter power	$\Phi_{H;em;n}$	kW	Heat load or custom input	1,0 x heat load	0,8…4 × heat load
Nominal Δθ water to air	$\Delta\theta_{H,em,air}$	°C	Default according to emitter type or input	See Table B.14	1…70
Emitter exponent	$n_{H;em}$		Default according to emitter type or input	See Table B.14	1,0…1,5
System design data					
Mixing valve	MIX_EM	n.a.			
Process control data					
Design flow return Δθ	$\Delta\theta_{H,em,w;n}$	°C	Default according to emitter type or input	See Table B.14	2…40
Mixing valve temperature overhead	$\Delta\theta_{H,em,mix}$	°C	Default or input	See Table B.15	0…10
Target return temperature	$\theta_{H,em,ret,set}$	°C	Default or input	See Table B.15	10…40
Maximum flow temperature	$\theta_{H;em;flw;max}$	°C	Default or input	See Table B.15	30…95
Max Δθ flow / return	$\Delta\theta_{H;em:w;max}$	°C	Default or input	See Table B.15	5…60
Operating conditions					
Internal temperature	$\theta_{H;int}$	°C	Building calculation	20	5...25
Emitter heat output	$Q_{H;em;out}$	kWh	Energy calculation		
Operating time	$t_{H;em;on}$	h			
Distribution flow temperature	$\theta_{H;nod;out}$	°C	Maximum of circuits flow temperatures		
Constants					
Water specific heat	C_w	kWh/m³K		1,16	

C.3.4 Calculation of minimum required temperature

Target return temperature $\theta_{H,em,ret,set}$ [°C]

$$\theta_{H,em,ret,set} = \max\left(\theta_{H,\text{int}};\theta_{H,em,ret,req}\right) \tag{C.18}$$

Average emitter power $\Phi_{H,em,eff}$ [kW]

$$\Phi_{H,em,eff} = \frac{Q_{H,ctr,in}}{t_{H,em,on}} \quad (C.19)$$

Emitter to air temperature difference $\Delta\theta_{H,em,air,eff}$ [°C]

$$\Delta\theta_{H,em,air,eff} = \Delta\theta_{H,em,air} \cdot \left(\frac{\Phi_{H,em,eff}}{\Phi_{H,em,n}}\right)^{\frac{1}{n_{H,em}}} \quad (C.20)$$

Average emitter temperature $\theta_{H,em,avg}$ [°C]

$$\theta_{H,em,avg} = \theta_{H,\mathrm{int}} + \Delta\theta_{H,em,air,eff} \quad (C.21)$$

Limited flow temperature $\theta_{H,em,flw,lim}$ [°C]

$$\theta_{H,em,flw,\mathrm{lim}} = \min\left(\theta_{H,flw,\mathrm{max}};\theta_{H,em,avg} + \frac{\Delta\theta_{H,em,wtr,\mathrm{max}}}{2}\right) \quad (C.22)$$

Emitter flow temperature $\theta_{H,em,flw}$ [°C]

$$\theta_{H,em,flw} = \min\left(\theta_{H,em,flw,\mathrm{lim}};2\cdot\theta_{H,em,avg} - \theta_{H,em,ret,set}\right) \quad (C.23)$$

Emitter return temperature $\theta_{H,em,ret}$ ***[°C]***

$$\theta_{H,em,ret} = +2\cdot\theta_{H,em,avg} - \theta_{H,em,flw} \quad (C.24)$$

Actual flow/return Δθ $\Delta\theta_{H,em,w,eff}$ [°C]

$$\Delta\theta_{H,em,eff} = \theta_{H,em,flw} - \theta_{H,em,ret} \quad (C.25)$$

Actual flow rate $V'_{H,em,eff}$ [m³/h]

$$V'_{H,em,eff} = \frac{\Phi_{H,em,eff}}{\Delta\theta_{H,em,eff}\cdot Cp_w} \quad (C.26)$$

Minimum distribution flow temperature $\theta_{H,em,flw,min}$ [°C]

If MIX_EM = MIX_EM_YES (Mixing valve present) then $\theta_{H,em,flw,min}$ is given by

$$\theta_{H,em,flw,\mathrm{min}} = \theta_{H,em,flw} + \Delta\theta_{H,em,mix} \quad (C.27)$$

otherwise $\theta_{H,em,flw,min}$ is given by

$$\theta_{H,em,flw,\mathrm{min}} = \theta_{H,em,flw} \quad (C.28)$$

C.3.5 Calculation of actual operating conditions

Circuit flow temperature $\theta_{H,cr,flw}$ [°C]

$$\theta_{H,cr,flw} = \theta_{H;nod;out} \quad (C.29)$$

If MIX_EM = MIX_EM_YES (mixing valve present) then

— Circuit return temperature $\theta_{H,cr,ret}$ [°C] is given by

$$\theta_{H,cr,ret} = \theta_{H,em,ret} \tag{C.30}$$

— Circuit flow rate before mixing valve $V'_{H,cr}$ [m³/h] is given by

$$V'_{H,cr} = \frac{\Phi_{H,em,eff}}{\left(\theta_{H,cr,flw} - \theta_{H,cr,ret}\right) \cdot Cp_w} \tag{C.31}$$

If MIX_EM = MIX_EM_NO (no mixing valve) then

— Circuit return temperature $\theta_{H,cr,ret}$ [°C] is given by

$$\theta_{H,cr,ret} = \max\left(\theta_{H,\mathrm{int}} ; 2 \cdot \theta_{H,em,avg} - \theta_{H,cr,flw}\right) \tag{C.32}$$

— Circuit flow rate before mixing valve $V'_{H,cr}$ [m³/h] is given by

$$V'_{H,cr} = \frac{\Phi_{H,em,eff}}{\left(\theta_{H,cr,flw} - \theta_{H,cr,ret}\right) \cdot Cp_w} \tag{C.33}$$

If MIX_EM = MIX_EM_YES (mixing valve present) then the ***distribution flow temperature*** $\theta_{H,dis,flw}$ is given by:

$$\theta_{H,dis,flw} = \theta_{H,em,flw} \tag{C.34}$$

otherwise $\theta_{H,dis,flw}$ is given by

$$\theta_{H,dis,flw} = \theta_{H,cr,flw} \tag{C.35}$$

Distribution return temperature $\theta_{H,cr,flw}$ [°C]

$$\theta_{H,dis,ret} = \theta_{H,em,ret} \tag{C.36}$$

Emission load factor $\beta_{H,em}$ [-]

$$\beta_{H,em} = \frac{\Phi_{H,em,eff}}{\Phi_{H,em,n}} \tag{C.37}$$

C.4 Intermittent flow rate module

C.4.1 General

C.4.1.1 Application

— ON-OFF zone control;

— ON-OFF room control.

C.4.1.2 Control parameters

— Nominal Δθ (flow rate);

— Target load factor.

C.4.1.3 Reference diagram

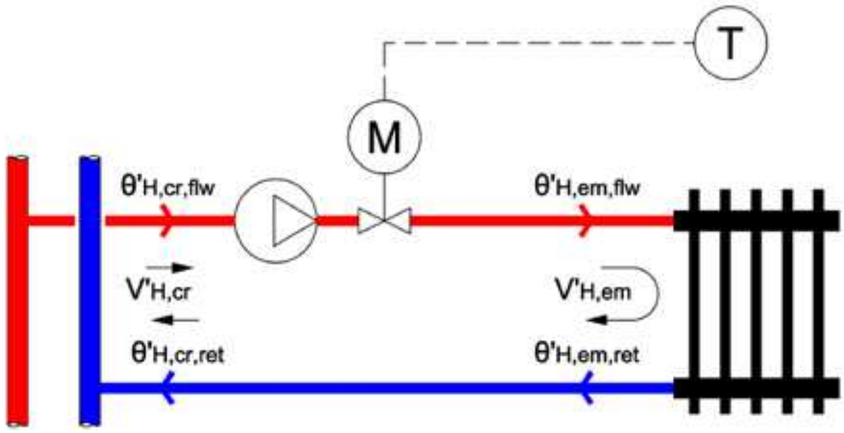


Figure C.4 — Sample heating circuit with intermittent operation

C.4.2 Output data

Table C.6 — Output data

Description	Symbol	Units
Circuit flow temperature	$\theta_{H;cr;flw}$	°C
Circuit return temperature	$\theta_{H;cr;ret}$	°C
Circuit flow rate	$V'_{H;cr}$	m^3/h
Distribution flow temperature	$\theta_{H;dis;flw}$	h
Distribution return temperature	$\theta_{H;dis;ret}$	°C
Emission load factor	$\beta_{H;em}$	-
Minimum required flow temperature	$\theta_{H;em;flw;min}$	°C

C.4.3 Input data

Table C.7 — Input data

Description	Symbol	unit	Origin	Default	Acceptable
Product data					
Nominal (rated) emitter power	$\Phi_{H;em;n}$	kW	Heat load or custom input	1,0 x heat load	0,8…4 × heat load
Nominal Δθ water to air	$\Delta\theta_{H,em,air}$	°C	Default according to emitter type or input	See Table B.14	1…70
Emitter exponent	$n_{H;em}$		Default according to emitter type or input	See Table B.14	1,0…1,5
System design data					
Mixing valve	MIX_EM	n.a.			
Process control data					
Design flow return Δθ	$\Delta\theta_{H,em,w;n}$	°C	Default according to emitter type or input	See Table B.14	2…40
Desired load factor	$\beta_{H;em;req}$	°C	Default or input	See Table B.15	20…100
Set flow temperature	$\theta_{H,em,flw,set}$	°C	Default or input	See Table B.15	30…90
Operating conditions					
Internal temperature	$\theta_{H;int}$	°C	Building calculation	20	5...25
Emitter heat output	$Q_{H;em;out}$	kWh	Energy calculation		
Operating time	$t_{H;em;on}$	h			
Distribution flow temperature	$\theta_{H;nod;out}$	°C	Maximum of circuits flow temperatures		
Constants					
Water specific heat	C_w	kWh/m³K		1,16	

C.4.4 Calculation of minimum required temperature

Nominal flow rate $V'_{H,em,nom}$ [m³/h]

$$V'_{H,em,eff} = \frac{\Phi_{H,em,n}}{\Delta\theta_{H,em,w} \cdot C_w} \tag{C.38}$$

Note: Insert here the input of any specific flow rate. The idea is constant flow rate operation during ON time.

Actual flow rate when ON $V'_{H,em,eff}$ [m³/h]

$$V'_{H,em,eff} = V'_{H,em,nom} \tag{C.39}$$

Average emitter power $\Phi_{H,em,eff}$ [kW]

$$\Phi_{H,em,eff} = \frac{Q_{H,em,in}}{t_{H,em,on}} \tag{C.40}$$

Emitter to air temperature difference $\Delta\theta_{H,em,air,eff}$ [°C]

$$\Delta\theta_{H,em,air,eff} = \Delta\theta_{H,em,air} \cdot \left(\frac{\Phi_{H,em,eff}}{\Phi_{H,em,n}} \right)^{\frac{1}{n_{H,em}}} \tag{C.41}$$

Theoretical flow temperature $\theta_{H,em,flw,calc}$ [°C]

$$\theta_{H,em,flw,calc} = \theta_{H,\text{int}} + \left(\Delta\theta_{H,em,air} + \frac{\Delta\theta_{H,em,w}}{2} \right) \cdot \left(\frac{\Phi_{H,em,eff}}{\Phi_{H,em,nom}} \cdot \frac{100}{FC_{H,em,\max}} \right)^{\frac{1}{n_{H,em}}} \tag{C.42}$$

Minimum distribution flow temperature $\theta_{H,em,flw,min}$ [°C]

If MIX_EM = MIX_EM_YES (Mixing valve present) then $\theta_{H,em,flw,min}$ is given by:

$$\theta_{H,em,flw,\min} = \theta_{H;em;flw;calc} + \Delta\theta_{H,em,mix} \tag{C.43}$$

otherwise $\theta_{H,em,flw,min}$ is given by:

$$\theta_{H,em,flw,\min} = \theta_{H,em,flw;calc} \tag{C.44}$$

C.4.5 Calculation of actual operating conditions

Actual flow temperature $\theta_{H,em,flw,eff}$ [°C]

If MIX_EM = MIX_EM_YES (Mixing valve present) then $\theta_{H,em,flw,eff}$ is given by:

$$\theta_{H,em,flw,\min} = \theta_{H,em,flw;calc} \tag{C.45}$$

otherwise $\theta_{H,em,flw,eff}$ is given by:

$$\theta_{H,em,flw,eff} = \theta_{H,nod,out} \tag{C.46}$$

Relative power when ON $\beta_{H;em;ON}$ [°C]

$$\beta_{H,em,ON} = \left(\frac{\theta_{H;em;flw} - \theta_{\text{int}}}{\Delta\theta_{H;em;air} + \frac{\Delta\theta_{H;em;w,n}}{2}} \right)^{\frac{1}{n_{H,em}}} \tag{C.47}$$

Power when ON $\boldsymbol{\Phi}_{H,em,ON}$ [°C]

$$t_{H,cr,ON} = \frac{Q_{H,ctr,in}}{\Phi_{H,em,w}} \tag{C.48}$$

ON time $t_{H,cr,ON}$ [°C]

$$t_{H,cr,ON} = \frac{Q_{H,em,in}}{\Phi_{H,em,ON}} \tag{C.49}$$

Load factor $\beta_{H,em}$ [°C]

$$\beta_{H,em} = \frac{t_{H,cr,ON}}{t_{H,em,ON}} \tag{C.50}$$

Emitter return temperature $\theta_{H,em,ret}$ [°C]

$$\theta_{H,em,ret} = \theta_{H,em,ret,new} \tag{C.51}$$

Circuit flow temperature $\theta_{H,em,flw}$ [°C]

$$\theta_{H,cr,flw} = \theta_{H,dis,flw} \tag{C.52}$$

Circuit return temperature $\theta_{H,em,ret}$ [°C]

$$\theta_{H,cr,ret} = \theta_{H,em,ret} \tag{C.53}$$

Circuit flow rate $V'_{H,cr}$ [m³/h]

$$V'_{H,cr} = \frac{\Phi_{H,em,eff}}{\left(\theta_{H,cr,flw} - \theta_{H,cr,ret}\right) \cdot Cp_w} \tag{.C54}$$

Distribution flow temperature $\theta_{H,dis,flw}$ [°C]

$$\theta_{H,dis,flw} = \theta_{H,em,flw} \tag{C.55}$$

Distribution return temperature $\theta_{H,ret,ret}$ [°C]

$$\theta_{H,dis,ret} = \theta_{H,em,ret} \tag{C.56}$$

Emission load factor $\beta_{H,em}$ [-]

$$\beta_{H,em} = \frac{\Phi_{H,em,eff}}{\Phi_{H,em,n}} \tag{C.57}$$

C.5 Constant flow rate and variable heat exchange

C.5.1 General

C.5.1.1 Application

— Fan-coil with room thermostat;

— Air heaters;

— Three way by-pass valve circuits.

C.5.1.2 Control parameters

— Nominal Δθ (flow rate);

— Constant flow temperature or target duty cycle.

C.5.1.3 Reference diagram

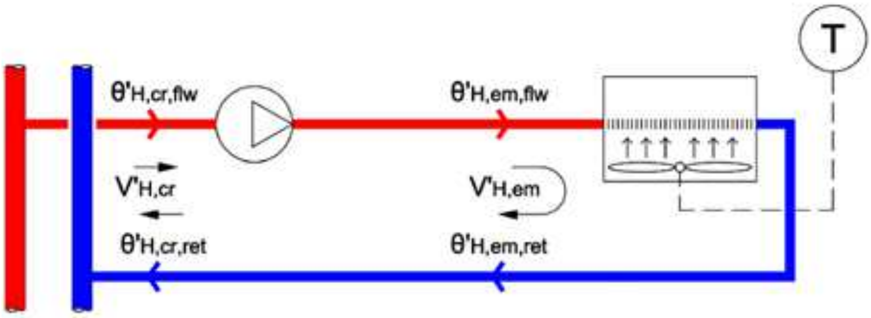


Figure C.5 — Sample heating circuit with varying heat exchange

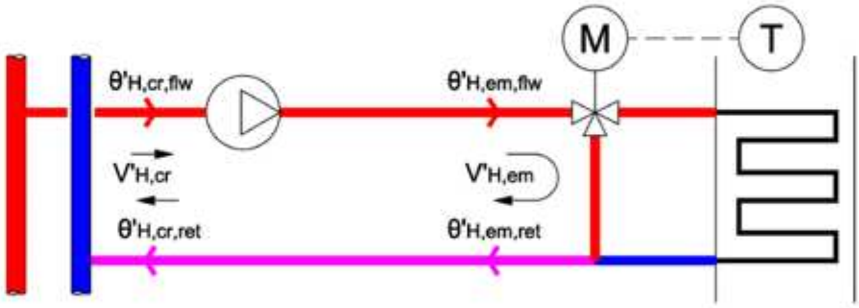


Figure C.6 — Sample heating circuit with three way by-pass control

C.5.2 Output data

Table C.8 — Output data

Description	Symbol	Units
Circuit flow temperature	$\theta_{H;cr;flw}$	°C
Circuit return temperature	$\theta_{H;cr;ret}$	°C
Circuit flow rate	$V'_{H;cr}$	m^3/h
Distribution flow temperature	$\theta_{H;dis;flw}$	h
Distribution return temperature	$\theta_{H;dis;ret}$	°C
Emission load factor	$\beta_{H;em}$	-
Minimum required flow temperature	$\theta_{H;em;flw;min}$	°C

C.5.3 Input data

Table C.9— Input data

Description	Symbol	unit	Origin	Default	Acceptable
Product data					
Nominal (rated) emitter power	$\Phi_{H;em;n}$	kW	Heat load or custom input	1,0 x heat load	0,8...4 × heat load
Nominal Δθ water to air	$\Delta\theta_{H,em,air}$	°C	Default according to emitter type or input	See Table B.14	1...70
Emitter exponent	$n_{H;em}$		Default according to emitter type or input	See Table B.14	1,0...1,5
System design data					
Mixing valve	MIX_EM	n.a.			
Process control data					
Design flow return Δθ	$\Delta\theta_{H,em,w;n}$	°C	Default according to emitter type or input	See Table B.14	2...40
Target load factor	$\beta_{H;em;req}$	°C	Default or input	See Table B.15	20...100
Minimum flow temperature	$\theta_{H,em,flw,min}$	°C	Default or input	See Table B.15	30...90
Set flow temperature	$\theta_{H,em,flw,set}$	°C	Default or input	See Table B.15	30...90
Operating conditions					
Internal temperature	$\theta_{H;int}$	°C	Building calculation	20	5...25
Emitter heat output	$Q_{H;em;out}$	kWh	Energy calculation		
Operating time	$t_{H;em;on}$	h			
Distribution flow temperature	$\theta_{H;nod;out}$	°C	Maximum of circuits flow temperatures		
Constants					
Water specific heat	C_w	kWh/m³K		1,16	

C.5.4 Calculation of minimum required temperature

Nominal flow rate $V'_{H,em,nom}$ [m³/h]

$$V'_{H,em,nom} = \frac{\Phi_{H,em,in}}{\Delta\theta_{H,em,w} \cdot Cp_w} \quad \text{(C.58)}$$

Actual emitter power $\Phi_{H,em,eff}$ [kW]

$$\Phi_{H,em,eff} = \frac{Q_{H,em,in}}{t_{H,sys,on}} \quad \text{(C.59)}$$

Calculated flow temperature $\theta_{H,em,flw,calc}$ [°C]

$$\theta_{H,em,flw,calc} = \theta_{H,\text{int}} + \left(\Delta\theta_{H,em,air} + \frac{\Delta\theta_{H,em,w}}{2}\right) \cdot \left(\frac{\Phi_{H,em,eff}}{\Phi_{H,em,nom}} \cdot \frac{100}{FC_{H,em,\max}}\right)^{\frac{1}{n_{H,em}}} \quad (C.60)$$

Selected distribution flow temperature $\theta_{H,em,flw,min}$ [°C]

$$\theta_{H,em,flw,\min} = \max\left(\theta_{H,em,flw,calc}; \theta_{H,em,flw,\min}; \theta_{H,em,flw,set}\right) \quad (C.61)$$

If MIX_EM = MIX_EM_YES (Mixing valve present) then $\theta_{H,em,flw,min}$ is given by:

$$\theta_{H,cr,flw,\min} = \theta_{H,em,flw,\min} + \Delta\theta_{H,em,mix} \quad (C.62)$$

otherwise $\theta_{H,em,flw,min}$ is given by:

$$\theta_{H,cr,flw,\min} = \theta_{H,em,flw,\min} \quad (C.63)$$

C.5.5 Calculation of actual operating conditions

Actual flow temperature $\theta_{H,em,flw,eff}$ [°C]

If MIX_EM = MIX_EM_YES (Mixing valve present) then $\theta_{H,em,flw,eff}$ is given by:

$$\theta_{H,em,flw,eff} = \theta_{H,em,flw,sel} \quad (C.64)$$

otherwise $\theta_{H,em,flw,eff}$ is given by:

$$\theta_{H,em,flw,eff} = \theta_{H,nod,out} \quad (C.65)$$

Return temperature $\theta_{H,em,ret}$ [°C]

$$\theta_{H,em,ret} = \theta_{H,em,flw} - \frac{\Phi_{H,em,eff}}{\dot{V}_{H,em,eff} \cdot cp_w} \quad (C.66)$$

Average temperature $\theta_{H,em,avg,w}$ [°C]

$$\theta_{H,em,avg} = \frac{\theta_{H,em,flw,eff} + \theta_{H,em,ret}}{2} \quad (C.67)$$

ON power $\Phi_{H,em,ON}$ [W]

$$\Phi_{H,em,ON} = \Phi_{H,em,n} \cdot \left(\frac{\theta_{H,em,avg} - \theta_{H,\text{int}}}{\Delta\theta_{H,em,air}}\right)^{n_{H,em}} \quad (C.68)$$

Circuit flow rate $V'_{H,em}$ [m³/h]

$$\dot{V}_{H,em} = \frac{\Phi_{H,em,eff}}{\left(\theta_{H,em,flw} - \theta_{H,em,ret}\right) \cdot cp_w} \quad (C.69)$$

Distribution flow temperature $\theta_{H,dis,flw}$ [°C]

$$\theta_{H,dis,flw} = \theta_{H,em,flw} \quad (C.70)$$

Distribution return temperature $\theta_{H,ret,ret}$ [°C]

$$\theta_{H,dis,ret} = \theta_{H,em,ret} \tag{C.71}$$

Emission load factor $\beta_{H,em}$ [-]

$$\beta_{H,em} = \frac{\Phi_{H,em,eff}}{\Phi_{H,em,n}} \tag{C.72}$$

Annex D
(normative)

Generation circuits calculation modules

D.1 Generation direct circuit

D.1.1 General

D.1.1.1 Application

Generators without hydraulic separation.

D.1.1.2 Control parameters

No control parameter.

D.1.1.3 Reference diagram

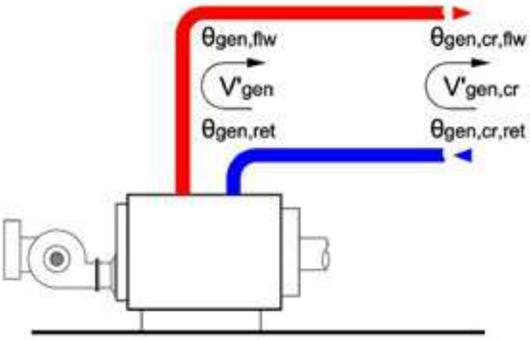


Figure D.1 — Example of direct circuit

D.1.2 Output data

Table D.1 — Output data of the module

Description	Symbol	Units
Generator flow temperature	$\theta_{H;gen;flw}$	°C
Generator return temperature	$\theta_{H;gen;ret}$	°C
Generator flow rate	$V'_{H;gen}$	m^3/h

D.1.3 Input data

Table D.2— Input data of the module

Description	Symbol	unit	Origin	Default	Acceptable
Product data					
None					
System design data					
None					
Process control data					
None					
Operating conditions					
Required generator output [a]	$Q_{X;gen;out}$	kWh		0 to ∞	0 to ∞
Operating time [a]	$t_{X;gen;on}$	h		t_{ci}	1 to 744
Generation circuit flow temperature	$\theta_{X;gen;cr;flw}$	°C			0 to 110
Generation circuit return temperature	$\theta_{X;gen;cr;ret}$	°C			0 to 110
Generation circuit flow rate	$V'_{X;gen;cr}$	m^3/h			0 to ∞
Constants					
Water specific heat	C_w	kWh/m^3K		1,16	

[a] These data are not required in this specific calculation module. They are kept for uniformity between module since these are the common interface data.

D.1.4 Calculation procedure

Generator flow temperature $\theta_{X;gen;flw}$:

$$\theta_{X;gen;flw} = \theta_{X;gen;cr;flw} \tag{D.1}$$

Generator return temperature $\theta_{X;gen;ret}$:

$$\theta_{X;gen;ret} = \theta_{X;gen;cr;ret} \tag{D.2}$$

Generator flow rate $V'_{X;gen}$:

$$V'_{X;gen} = V'_{X;gen;cr} \tag{D.3}$$

D.2 Generation independent flow rate circuit

D.2.1 General

D.2.1.1 Application

Generators with hydraulic separation

D.2.1.2 Control parameters

— Δθ between flow and return;

— Variable speed pump control.

D.2.1.3 Reference diagram

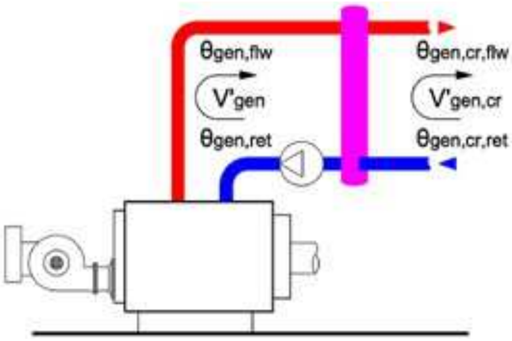


Figure D.2 — Example of independent flow rate

D.2.2 Output data

Table D.3— Output data of the module

Description	Symbol	Units
Generator flow temperature	$\theta_{H;gen;flw}$	°C
Generator return temperature	$\theta_{H;gen;ret}$	°C
Generator flow rate	$V'_{H;gen}$	m^3/h

D.2.3 Input data

Table D.4— Input data of the module

Description	Symbol	unit	Origin	Default	Acceptable
Product data					
Nominal (rated) generator power output	$\Phi_{Xgen;out;n}$	kW			0 to 10^4
Nominal Δθ flow / return	$\Delta\theta_{X,gen;w;n}$	°C		See Table B.16	1...40
System design data					
None					
Process control data					
Generator pump speed control	GEN_PMP_CTRL			See table	
Operating conditions					
Required generator output	$Q_{X;gen;out}$	kWh		0 to ∞	0 to ∞
Operating time	$t_{X;gen;on}$	h		t_{ci}	1 to 744
Generation circuit flow temperature	$\theta_{X;gen;cr;flw}$	°C			0 to 110
Generation circuit return temperature	$\theta_{X;gen;cr;ret}$	°C			0 to 110
Generation circuit flow rate	$V'_{X;gen;cr}$	m^3/h			0 to ∞
Constants					
Water specific heat	C_w	kWh/m^3K		1,16	

D.2.4 Calculation procedure

Generator power output $\Phi_{X;gen,out}$:

$$\Phi_{X;gen;out} = V'_{X;gen;cr} \cdot C_w \cdot \left(\theta_{X;gen;cr;flw} - \theta_{X;gen;cr;ret}\right) \tag{D.4}$$

Actual generator Δθ $\Delta\theta_{X;gen;eff}$:

If GEN_PMP_CTRL = GEN_PMP_CTRL_DT_CONST then

$$\Delta\theta_{X;gen;eff} = \Delta\theta_{X;gen;n} \tag{D.5}$$

If GEN_PMP_CTRL = GEN_PMP_CTRL_NONE then

$$\Delta\theta_{X;gen;eff} = \Delta\theta_{X;gen;n} \cdot \frac{\Phi_{X;gen;out}}{\Phi_{X;gen;out;n}} \tag{D.6}$$

Generator flow temperature $\theta_{X;gen;flw}$:

If $\Delta\theta_{X;gen;eff} < (\theta_{X;gen;cr;flw} - \theta_{X;gen;cr;ret})$ then

$$\theta_{X;gen;flw} = \theta_{X;gen;cr;flw} \tag{D.7}$$

If $\Delta\theta_{X;gen;eff} \geq (\theta_{X;gen;cr;flw} - \theta_{X;gen;cr;ret})$ then

$$\theta_{X;gen;flw} = \theta_{X;gen;cr;ret} + \Delta\theta_{X;gen;eff} \tag{D.8}$$

Generator return temperature $\theta_{X;gen;ret}$:

If $\Delta\theta_{X;gen;eff} < (\theta_{X;gen;cr;flw} - \theta_{X;gen;cr;ret})$ then

$$\theta_{X;gen;ret} = \theta_{X;gen;cr;flw} - \Delta\theta_{X;gen;eff} \tag{D.9}$$

If $\Delta\theta_{X;gen;eff} \geq (\theta_{X;gen;cr;flw} - \theta_{X;gen;cr;ret})$ then

$$\theta_{X;gen;ret} = \theta_{X;gen;cr;ret} \tag{D.10}$$

Generator flow rate $V'_{X;gen;flw}$:

$$V'_{X;gen} = \frac{\Phi_{X;gen;out}}{C_w \cdot \Delta\theta_{X;gen;eff}} \tag{D.11}$$

Annex E
(informative)

Bin method

E.1 General

E.1.1 General

To check if the heat capacity of a generator can match the heat energy demand of the distribution sub-system, the heat load for space heating and domestic hot water has to be known.

The maximum heating energy output for space heating can be calculated as:

$$\Phi_{H,\max} = \Phi^*_{H,\max} \tag{E.1}$$

where

$\Phi_{H,\max}$ is the maximum heating energy output, in kW;

$\Phi^*_{H,\max}$ is the maximum heating energy output on the basis of total losses, according to Formula (E.2), in kW;

$\Phi^*_{H,\max.}$ is thereby determined on the basis of the total loss and the weighted temperature differences between indoors and outdoors (Kelvin-hours):

$$\varphi_{H,\max} = Q_{tot} \bullet \frac{\theta_i - \theta_{e,0}}{\sum\left[t_{B,i} \bullet \left(\theta_i - \theta_{e,i}\right)\right]} \tag{E.2}$$

where

$\Phi^*_{H,\max}$ is the maximum heating energy output on the basis of the total loss, in kW

Q_{tot} is the total loss, in kWh

θ_i is the room temperature, in °C

$\theta_{e,i}$ is the bin temperature, in °C

$\theta_{e,0}$ is the standard external air temperature, in °C

$t_{B,i}$ is the bin duration, in h

The total in the denominator of Formula (E.2) is to be determined for those bins which have an external air temperature below room temperature.

For this check average monthly or annual values of the heat demand are not suitable because the variations of the heat demand around the average value of the monthly or annual calculation interval are in general too important. For example the average monthly heat demand of the distribution sub-system may be provided by one generator, but the monthly peak loads are not taken into account and therefore during same days or weeks within the month, the generator capacity of one generator is not enough to satisfy the energy demand of the distribution sub-system.

If only monthly or annual values of the heat energy demand are given, the monthly or annual values can be distributed within the months or the year by dividing the outdoor air temperature into temperature intervals (bins). This is called the bin – method.

This method is a simplification if the energy demand of the distribution system does dependent only on the outdoor temperature and not also on the indoor temperature (e.g night setback), on solar and internal gains etc.

Procedures taking into account e.g. solar and internal gains has been developed by distinguishing:

— Uniformly occurring heat gains;

— Non-uniformly occurring heat gains

E.1.2 Uniformly occurring heat gains

The uniformly occurring heat gains of the bin are calculated as:

$$Q_{ug,ev,i} = \min\left[t_{B,i} \bullet \varphi_{g,ev} \bullet A_E ; Q_{tot,i}\right] \quad \text{(E.3)}$$

where

$Q_{ug,ev,i}$ is the uniformly occurring, utilized heat gains of the bin, in kWh

$t_{B,i}$ is the duration of the bin i, in h

$\Phi_{g,ev}$ is the input of the uniformly occurring internal heat gains in kW/m^2

A_E is the energy reference area in m^2

$Q_{tot,i}$ is the total loss of the bin, in kWh

The input of the uniformly occurring internal heat gains $\Phi_{g,ev}$ is constant and thus the same for all bins.

Standards default values have been developed (see Table E.1).

Table E.1 — Standards default values

Building category	Input of the uniformly occurring internal heat gains $\Phi_{g,ev}$
Residential (multiple-family)	$3{,}1 \cdot 10^{-3}$ kW/m^2
Residential (single-family)	$2{,}4 \cdot 10^{-3}$ kW/m^2
Administrative	$3{,}3 \cdot 10^{-3}$ kW/m^2
Schools	$2{,}3 \cdot 10^{-3}$ kW/m^2
Hospitals	$4{,}0 \cdot 10^{-3}$ kW/m^2

E.1.3 Non-uniformly occurring heat gains

Solar heat gains are regarded as occurring non-uniformly.

In the case of temporarily used buildings or parts of buildings, those internal heat gains which only occur during the period of use should be regarded as non-uniform.

The non-uniformly occurring utilized heat gains of the bin are calculated as:

$$Q_{ug,ue,i} = \min\left[t_{B,i} \bullet \varphi_{g,ue} ; f_{g,ue} \bullet \left(Q_{tot,i} - Q_{ug,ev,i}\right)\right] \quad \text{(E.4)}$$

where

$Q_{ug,ue,i}$ is the non-uniformly occurring, utilized heat gains of the bin, in kWh;

$t_{B,i}$ is the bin duration, in h;

$\Phi_{g,ue,}$ is the average input of the non-uniformly occurring heat gains according to Formula 16, in kW;

$f_{g,ue}$ is the factor for maximum non-uniform heat gains in relation to the remaining losses of the bin. A standard assumption of 0,8 should be used for the factor $f_{g,ue}$

$Q_{tot,i}$ is the total heat loss of the bin, in kWh

$Q_{ug,ev,i}$ is the uniformly occurring heat gains of the bin, in kWh

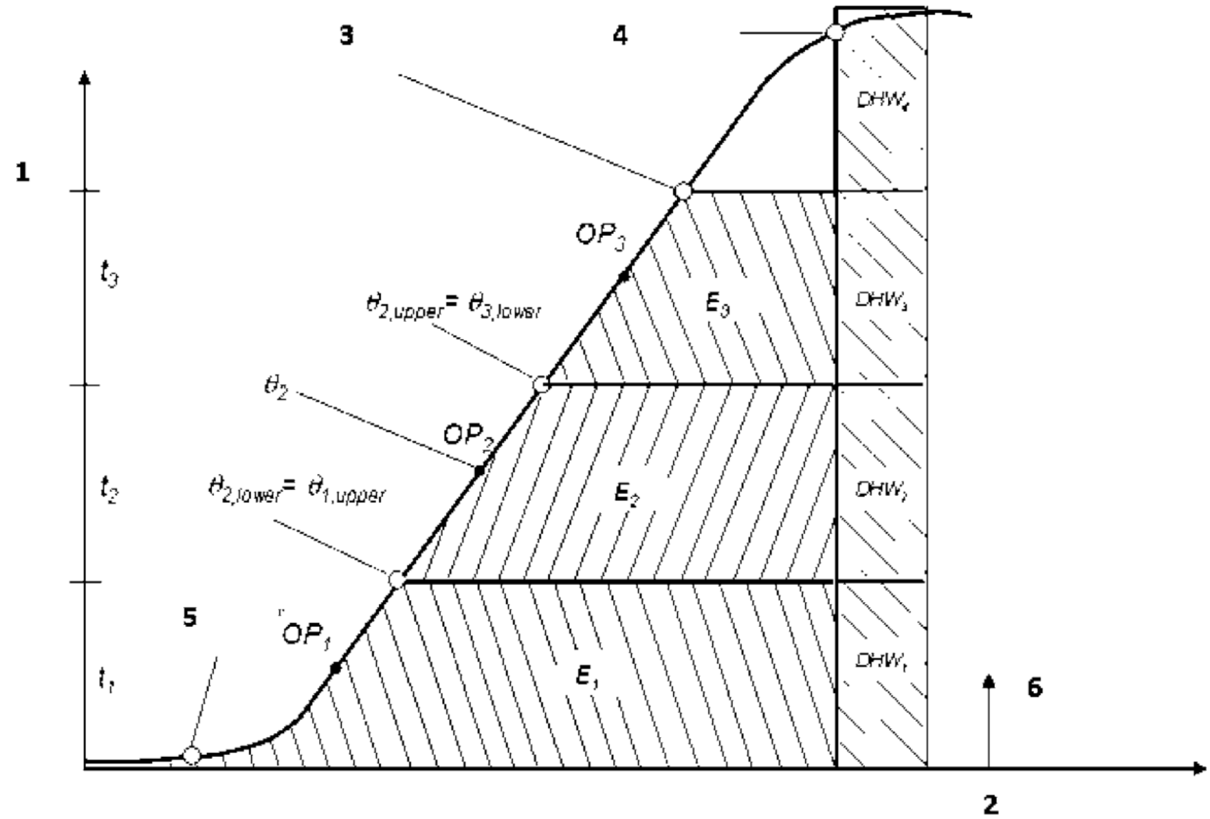
The bin method is a fit better for existing buildings with a high energy demand where the gains are not so important while for new solar passive houses the correlation of the heat demand with the outdoor air temperature may get worse. In these cases a detailed hourly calculation method is recommended.

E.2 Bin principles

The evaluation of the outdoor temperature is based on the **cumulative frequency of the outdoor air temperature.**

The annual frequency of the outdoor air temperature based on **hourly averaged values** is cumulated and divided into temperature intervals (bins). Each bin is limited by an upper temperature θ_{upper} and a lower temperature θ_{lower}.

Operating conditions of the bins are characterized by an operating point in the centre of each bin. For the calculation it is assumed that the operating point defines the operating conditions within the whole bin.



Key

1 cumulative bin hours (h)
2 outdoor air temperature (°C)
3 upper ambient temperature for heating
4 design indoor temperature
5 design outdoor temperature
6 direction of cumulation of temperature difference overt time

Figure E.1 — Bin hours vs. outdoor air temperature – sample with 3 bins and constant daily DHW heat energy requirement

E.3 Energy demand – heating loads

E.3.1 General

The temperature difference between the outdoor air temperature and the **indoor design temperature** defines a **heating degree hour**. It also called **time temperature difference TTD** according to EN ISO 15927-6 for a base temperature of the design indoor temperature (normally 20°C).

It reflects the heat load for space heating. Therefore the area under the cumulative frequency, the cumulative heating degree hours, corresponds to energy needs for space heating, since the temperature difference (= heat load) is cumulated over the time. The **cumulative heating degree hours** (CHDH) is also called accumulated time temperature difference **(ATTD)** in to EN ISO 15927-6.

Analogously, the DHW load depicted as constant daily profile (see Figure E.1).

E.3.2 Space heating mode

The heat energy demand of the all space heating distribution subsystem $Q_{H,dis,in}$ is calculated according to this European Standard.

The space heating demand of bin j can be calculated by a weighting factor which is derived from the cumulative heating degree hours (DH_H).

The weighting factors are calculated by the equation

$$k_{H,j} = \frac{Q_{H,gen,out,j}}{Q_{H,gen,out}} = \frac{DH_{H,\theta h\lim,j} - DH_{H,\theta l\lim,j}}{DH_{H,tot}} \quad [-] \qquad \text{(E.5)}$$

The space heating energy requirement of the respective bin is calculated by

$$Q_{H,gen,out,j} = k_{H,j} \bullet Q_{H,gen,out} \quad [\text{kWh}] \qquad \text{(E.6)}$$

where

$k_{H,j}$	is the weighting factor of the heat pump operation for space heating of bin j	(-)
$Q_{H,gen,out,j}$	is the heat energy requirement of the space heating distribution subsystem in bin j	(kWh)
$Q_{H,gen,out}$	is the total heat energy requirement of the space heating distribution subsystem	(kWh)
$DH_{H,\theta hlim,i}$	is the cumulative heating degree hours up to the upper temperature limit of bin j	(°Ch)
$DH_{H,\theta llim,i}$	is the cumulative heating degree hours up to the lower temperature limit of bin j	(°Ch)
$DH_{H,tot}$	is the total cumulative heating degree hours up to the upper temperature limit for space heating	(°Ch)

The cumulative heating degree hours for the respective climatic regions shall be given in a national Annex. It is also possible to define weighting factors for a fix bin scheme and standard locations in a national Annex.

E.3.3 Domestic hot water mode

The heat energy demand of the domestic hot water distribution sub-system $Q_{W,dis,in}$ is calculated according to EN 15316-3 (M8-6).

The domestic hot water heat demand in bin j is calculated with the weighting factor for domestic hot water operating according to the equation

$$k_{W,j} = \frac{Q_{W,gen,out,j}}{Q_{W,gen,out}} = \frac{t_j}{t_{tot}} \quad [-] \qquad \text{(E.7)}$$

and the DHW demand in bin j follows according to the equation

$$Q_{W,gen,out,j} = k_{W,j} \bullet Q_{W,gen,out} \quad [\text{J}] \qquad \text{(E.8)}$$

where

$k_{W,j}$	is the weighting factor for DHW operation in bin j;	(-)

$Q_{W,gen,out,j}$	is the heat energy requirement of the domestic hot water distribution subsystem in bin j;	(J)
$Q_{W,gen,out}$	is the total heat energy requirement of the DHW distribution subsystem;	(J)
t_j	is the bin calculation interval in bin j;	(s)
t_{tot}	is the total time of DHW operating (e.g. year round operation).	(s)

E.4 Calculation interval

E.4.1 Bin calculation interval

The bin calculation interval is calculated as difference of the cumulative time at the upper and lower bin limit according to the equation E.9

$$t_j = \left(N_{ho,\theta h\lim,j} - N_{ho,\theta l\lim,j}\right) \bullet 3600 s/h \quad [s] \qquad (E.9)$$

where

t_j	is the calculation interval in bin j	(s)
$N_{ho,\theta hlim,,j}$	is the cumulative number of hours up to the upper temperature limit of bin j	(h)
$N_{ho,\theta llim,,j}$	is the cumulative number of hours up to the lower temperature limit of bin j	(h)

NOTE The heating season is the summation of all bin calculation intervals t_i.

E.4.2 Effective bin time

There may be time restrictions to run some generation devices, so that not the entire bin calculation interval is available for operating, e.g. a possible cut-out time of the electricity supply on the background of particular tariff structures for heat pumps by the utility. Thus, the effective bin time in the bin calculation interval is the time in the bin diminished by the cut-out time per day and is calculated

$$t_{eff,j} = t_j \bullet \frac{24h - t_{co}}{24h} \quad [s] \qquad (E.10)$$

where

$t_{eff,j}$	is the effective bin time in bin j	(s)
t_j	is the calculation interval in bin j	(s)
t_{co}	is the cut-out hours per 24 h (1 day)	(h/d)

In the following Table E.2 an example of the distribution sub-system input dispatched according bin intervals is given.

Table E.2 — Example meteorological data of the site treatment based on hourly-averaged on-site measurements / Yearly method

Bin (ϑ)	**Bin time (h)**	**∑bin time (h)**	**DH_H 20/15** ϑ_{in} = 20°C ϑ_{out} = 15°C	**∑ DH_H 20/15**	Heating demand **Weigh. factor k** 1 K bins	DHW demand **Weigh. factor k** 1 K bins
−11	3	3	93	93	0,00	0,000
−10	7	10	210	303	0,00	0,001
−9	8	18	232	535	0,00	0,001
−8	12	30	336	871	0,00	0,001
−7	24	54	648	1519	0,01	0,003
−6	33	87	858	2377	0,01	0,004
−5	31	118	775	3152	0,01	0,004
−4	26	144	624	3776	0,01	0,003
−3	72	216	1656	5432	0,02	0,008
−2	114	330	2508	7940	0,03	0,013
−1	207	537	4347	12287	0,06	0,024
0	250	787	5000	17287	0,07	0,029
1	243	1030	4617	21904	0,06	0,028
2	306	1336	5508	27412	0,08	0,035
3	368	1704	6256	33668	0,09	0,042
4	230	1934	3680	37348	0,05	0,026
5	295	2229	4425	41773	0,06	0,034
6	331	2560	4634	46407	0,06	0,038
7	314	2874	4082	50489	0,06	0,036
8	293	3167	3516	54005	0,05	0,033
9	281	3448	3091	57096	0,04	0,032
10	376	3824	3760	60856	0,05	0,043
11	336	4160	3024	63880	0,04	0,038
12	373	4533	2984	66864	0,04	0,043
13	341	4874	2387	69251	0,03	0,039
14	322	5196	1932	71183	0,03	0,037
15	341	5537	1705	72888	0,02	0,039
16	426	5963	1704	74592		0,049
17	371	6334	1113	75705		0,042
18	393	6727	786	76491		0,045
19	376	7103	376	76867		0,043
20	295	7398	0	76867		0,034
21	291	7689	0	76867		0,033
22	246	7935	0	76867		0,028
23	171	8106	0	76867		0,020
24	163	8269	0	76867		0,019
25	100	8369	0	76867		0,011
26	103	8472	0	76867		0,012

Bin (ϑ)	**Bin time (h)**	**∑bin time (h)**	**DH_H 20/15** ϑ_{in} = 20°C ϑ_{out} = 15°C	**∑ DH_H 20/15**	Heating demand **Weigh. factor k** 1 K bins	DHW demand **Weigh. factor k** 1 K bins
27	74	8546	0	76867		0,008
28	67	8613	0	76867		0,008
29	56	8669	0	76867		0,006
30	42	8711	0	76867		0,005
31	26	8737	0	76867		0,003
32	8	8745	0	76867		0,001
33	11	8756	0	76867		0,001
34	2	8758	0	76867		0,000
35	2	8760	0	76867		0,000

E.5 Generator operating mode (priorities)

E.5.1 General

Generator priority energy can be required for several reasons, for example:

— a temperature operating limit of the generator, e.g. the temperature that can be reached with the heat pump is restricted to a maximum value.

— a multi generator design of the generator sub-system e.g. the heat pump is not designed for the total load.

The energy demand of the distribution sub-systems may be supplied by several generation sub-systems (e.g. heat pump and peak boiler).

The operating of multi generator systems is determined by the system design and are characterized by:

the operating mode (e.g.)

— alternate operation,

— parallel (simultaneous) operation,

the respective temperatures (e.g.)

— balance point temperature.

By these temperatures, the energy load of each generator can be determined and the energy demand can be calculated based on the bin method.

Note: There are other operation modes but only those mentioned before are worked out.

The calculation of the back-up operating due to a lack of capacity is based on the cumulative frequency, the balance point and the operation mode. The method in this document is based on a 1 K energy balance.

The balance point is determined by the required running time calculated from the energy balance (see clause E.6.1).

E.5.2 Alternate operating mode

In alternate operating mode the priority heat generator (e.g. heat pump for base load) is switched-off at the balance point temperature.

Only the next generator (e.g. peak boiler) in the load dispatch supplies the full heat energy demand below the balance point (e.g. lower outdoor temperatures).

The weighting factors are calculated as in clause "space heating mode – energy demand).

E.5.3 Parallel operating mode

In parallel operating mode of the generators, the priority generator (e.g. heat pump) is not switched-off at the balance point temperature, but runs at the respective heating capacity and contributes to cover the energy demand.

The next generator supplies only the part that the priority generator cannot deliver.

The fraction of for peak generator for parallel operation can be approximated by:

$$k_{H,bu,cap,j} = \frac{A_{bu,j}}{A_j} = \frac{DH_{H,\theta bal} - \left(\theta_{i,des} - \theta_{bal}\right) \bullet N_{ho,\theta bal}}{DH_{H,\theta h\lim,j}} \quad [-] \qquad \text{(E.11)}$$

where

$k_{H,bu,cap,j}$	is the fraction of space heating heat energy covered by the back-up heater in the lower bin j;	(-)
$A_{bu,j}$	is the fraction of total area BU in bin j;	(°Ch)
A_j	is the total area of bin j (between upper and lower temperature limit of bin j);	(°Ch)
θ_{bal}	is the balance point temperature;	(°C)
$\theta_{i,des}$	is the indoor design temperature;	(°C)
$N_{ho,\theta bal}$	is the cumulated number of hours up to the balance point temperature;	(h)
$DH_{H,\theta bal}$	is the cumulative heating degree hours up to the balance point θ_{bal}.	(°Ch)

NOTE The vertical limit of A_{bu} is an approximation, since the heating capacity of the generator may not be constant.

E.6 Operating conditions calculation

E.6.1 Running time of a heat generator

The running time of a generator depends on the heating capacity, given by the operating conditions (e.g temperatures), and on the heat energy demand, given by the distribution sub-system. The running time can be calculated by the equation

$$t_{gen,on,j} = \frac{Q_{gen,j}}{\varphi_{gen,j}} \quad [s] \qquad \text{(E.12)}$$

where

$t_{gen,on,j}$	is the running time of the generator pump in bin j	(s)
$Q_{gen,j}$	is the produced heat energy by the generator in bin j (heat energy demand of the distribution sub-system and generation sub-system losses)	(J)
$\phi_{gen,j}$	is the heating capacity of the generator in bin j	(W)

The generator input of the generator can be calculated by the equation

$$Q_{gen,j} = \left(Q_{gen,out,j} + Q_{gen,ls,j}\right)\left(1 - k_{bu,cap,j}\right) \text{ [J]} \tag{E.13}$$

where

$Q_{gen,j}$	is the generator input in bin j	(J)
$Q_{gen,out,j}$	is the heat energy demand of the distribution sub-system in bin j	(J)
$Q_{gen,ls,j}$	is the generation sub-system heat losses in bin j	(J)
$k_{bu,cap,j}$	is the fraction of heat energy covered by the peak generator in bin j	(-)

These equations can be applied for the different operating modes.

E.6.2 Generator running time depending on operating mode

E.6.2.1 General

The total running time in the bin j of the generator can be calculated by the equation

$$t_{gen,on,tot,j} = t_{H,gen,on,j} + t_{W,gen,on,j} \text{ [s]} \tag{E.14}$$

where

$t_{gen,on,tot,j}$	is the total running time of the generator in bin j	(s)
$t_{H,gen,on,sngl,j}$	is the running time in space heating mode operation in bin j	(s)
$t_{W,gen,on,sngl,j}$	is the running time in DHW mode operation in bin j	(s)

Depending on the operating mode only some of different contributions exist, while the others are zero, e.g. the running time for space heating in DHW-only systems.

E.6.2.2 Running time due to lack of heat capacity

If the calculated total running time is longer than the effective bin time, this is due to a lack of heat capacity of the generator. In this case the effective bin time is the running time and the missing energy is calculated according to the difference of the calculated total running time and the effective bin time.

E.6.2.3 Auxiliary running time

For the auxiliary energy calculation the total running time cannot be longer than the effective bin time. The total running time is calculated as follows

$$t_{gen,on,tot,j} = \min\left(t_{eff,j}, t_{H,gen,on,j} + t_{W,gen,on,j}\right) \text{ [s]} \tag{E.15}$$

where

$t_{gen,on,tot,j}$	is the total running time of the generator in bin j	(s)
$t_{eff,j}$	is the effective bin time in bin j	(s)
$t_{H,gen,on,j}$	is the running time in space heating-only operation in bin j	(s)
$t_{W,gen,on,j}$	is the running time in DHW-only operation in bin j	(s)

E.6.3 Generator sequence due to lack of heat capacity

Note: The generator sequence may also be linked to operating limit temperature of a generator (e.g. heat pump). This case is not worked out explicitly in this document yet

The evaluation of lack of heat capacity and the need of back-up energy provided by an additional generator is based on the evaluation of the running time according on the basis of 1 K bins.

The comparison of the total running time of a generator is accomplished, until the outdoor air temperature is reached, at which the effective time in the bin is longer than the required total running time. The sample balance and the required calculations are summarized in Table E.3.

At this outdoor temperature the heat capacity of the operating generators is not enough to supply the requested heat.

For the bins with a lack of running time the resulting back-up energy can be calculated based on the control strategy (operating modes) as described before.

Table E.3 — Table containing the required calculation for the detailed determination of back-up energy

θ_e 1 K bin	$Q_{H,gen,j}$ Formula (E.13)	$Q_{W,gen,j}$ Formula (E.13)	$\phi_{H,gen,j}$	$\phi_{W,gen,j}$	$t_{H,gen,on}$ Formula (E.12)	$t_{W,gen,on}$ Formula (E.14)	$t_{gen,tot,j}$ Formula (E.13)	$t_{eff,j}$ Formula (E.10) bin time	Difference total running time / effective bin time	$Q_{bu,cap,j}$ Formula (E.16) back-up energy
$\theta_{e,min}$										
$\theta_{e,min}$+ 1										
Σ										Σ Back-up

E.6.4 Calculation of needed back-up energy

The needed additional back-up energy due to a lack of capacity is calculated by multiplying the missing running time with the heating capacity of the generator in SH-only or DHW-only operation according to the equation

$$Q_{bu,cap,j} = \varphi_{gen,sngl,j} \bullet \left(t_{gen,out,tot,j} - t_{eff,j} \right) \quad [J] \qquad (E.16)$$

where

$Q_{bu,cap,i}$	is the additional back-up energy due a lack of capacity	(J)
$t_{hp,on,tot,j}$	is the total (calculated) running time of the generator in bin j	(s)
$t_{eff,j}$	is the effective bin time in bin j	(s)
$\phi_{hp,sngl,j}$	is the heating capacity of the generator in the respective single operation mode	

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